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Bioefficacy of Biopesticides for the Management of Bacterial Wilt Disease of Tomato under the Agro-Ecological Condition of North Bank Plain Zone of Assam

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Abstract

A field experiment was conducted in the farmer's field to evaluate the bioefficacy of four bioformulations viz. Biofor PF, containing *Pseudomonas fluorescens* and *Trichoderma harzianum*, Bioveer, containing *Trichoderma viride*, Biomonas, containing *Pseudomonas fluorescens* and Biozin PTB, containing *Pseudomonas aeruginosa*, *Trichoderma harzianum* and *Bacillus brevis* against the *Ralstonia solanacearum*, causing bacterial wilt disease of tomato. The bioformulations were applied as seed treatment, seedling root dip treatment, and soil treatment. The experiment was set up in Randomized Block Design with four replications. Among all the bioformulations, Biofor PF was found to be most effective bioformulation with the lowest disease incidence (18.12%) followed by Biozin PTB, and Biomonas with 22.16% and 25.28% disease incidence, respectively. The plot treated with Biofor PF recorded the highest reduction (76.42%) of disease incidence over the control plot followed by Biozin PTB, and Biomonas with 71.16% and 67.10% reduction of disease incidence over control, respectively. The plot treated with Biofor PF recorded the highest yield (232.68 qha⁻¹) which was followed by Biozin PTB, and Biomonas treated plot with an average yield of 226.62 qha⁻¹ and 221.42 qha⁻¹, respectively.

Key words : Bioformulations, bacterial wilt, bioefficacy, disease incidence.

Introduction

Tomato (*Lycopersicon esculentum*) is one of the most popular and widely cultivated vegetable crops all over the world. It is considered a nutritional crop because it contains vitamin A and C, minerals, sugar, organic acids, and lycopene (Rana *et al.*, 2014). Despite its economic importance, growers are not in a position to produce a good quality tomato with high productivity due to various biotic, abiotic, and crop factors (Waiba *et al.*, 2021). Vegetable crops are extremely prone to soil-borne and root diseases causing enormous yield losses and also deteriorate quality (Sharma *et al.*, 2006). In India, tomato is grown in an area of 7.89 lakh hectares with a productivity of 25.04 tonnes ha⁻¹ and in Assam also it is cultivated mainly during winter season in an area of 0.18 lakh hectares with a productivity of 21.67 tonnes ha⁻¹ (Anonymous, 2018). Diseases remain to be the main constraint in the production of tomatoes in many parts of the country including Assam. The crop is attacked by several fungal, bacterial, and viral diseases inflicting severe yield losses. Among all, bacterial wilt is a destructive and widespread soil-borne disease that limits tomato production in the tropics, sub-tropics, and warm temperate regions of the world (Ramesh *et al.*, 2014). The bacterium *Ralstonia solanacearum*, responsible for causing bacterial wilt of tomato is one of the most severe diseases of tomato because of having wide host ranges. In Assam, the disease causes severe yield losses ranging from 92 to 100 % under favourable environmental

conditions (Bora *et al.*, 2000). Severe yield loss of 25–75% was also reported by Dutta (2012) due to bacterial wilt of tomato caused by *R. solanacearum* under Tripura condition.

Use of resistant or tolerant varieties, cultural practices, chemical control, and biological control, are commonly employed methods to control bacterial wilt disease caused by *R. Solanacearum* (Dalal *et al.*, 1999). Tactics like crop rotation are not viable as the bacterium is soil inhabitant and persists indefinitely in infested fields, use of antibiotics often leads to the development of resistance in the pathogen, use of resistant cultivar was found to be the most rational solution but the occurrence of resistance breakdown is quite frequent due to intensive cultivation (Chellemi *et al.*, 1994). To tackle these limitations, present disease management practices have been shifted towards the development of environment-friendly and economically feasible methods as an alternative means of plant disease management. In this present perspective, the exploitation of antagonists as biological control agents has been considered an appropriate method, as these are environmentally safe and economically feasible. Several beneficial microorganisms have been used as biocontrol agents for control of *R. solanacearum* under laboratory and/or greenhouse conditions, which includes *Pseudomonas putida*, *P. fluorescens*, *Trichoderma* spp., Bacteriophages, *Streptomyces* spp., *Acinetobacter* spp., *Enterobacter* spp., *Bacillus* spp. and *Paenibacillus*

Table-1 : Efficacy of bioformulations on the bacterial wilt incidence and yield of tomato.

Treatment	Disease Incidence (%)	Disease reduction over control (%)	Yield (qh ⁻¹)
Biofor PF	18.12 (25.171) ^e	76.42	232.68 ^a
Biomonas	25.28 (30.183) ^c	67.10	221.42 ^c
Bioveer	28.64 (32.352) ^b	62.73	212.26 ^d
Biozin PTB	22.16 (28.077) ^d	71.16	226.62 ^b
Control	76.84 (61.248) ^a		92.64 ^e
CD(0.05)	1.474		4.284

*Data in the parentheses are arcsine transformed value, **Data are mean of two years and four replications.

macerans (Vanitha *et al.*, 2009; Ling *et al.*, 2010). *Trichoderma* isolates have strong antagonistic and mycoparasitic effects against phytopathogens and are capable of reducing disease severity (Elsharkawy *et al.*, 2012). The beneficial microbes have gained considerable interest as an eco-friendly and cost-effective method for inducing systemic resistance in plants and promoting plant growth for sustainable crop production (Abdelrahman *et al.*, 2016). *Trichoderma* spp. can induce plant growth by direct and indirect mechanisms (Zachow *et al.*, 2016). A decreased population of *R. solanacearum* was recorded in the soil amended with decomposed organic fertilizer (Scho *et al.*, 2003). The decomposed organic fertilizer or manure provides immediate nutrients to the microbes resulting in enhanced activity of biocontrol agents and makes them more competitive in the rhizosphere soil and on roots (Liu *et al.*, 2013). Root colonization by biocontrol agents is considered a prerequisite and is directly associated with their effectiveness in controlling soil-borne pathogens (Ji *et al.*, 2008). Several studies have revealed that *Trichoderma* spp., *Bacillus* spp., and *Klebsiella* spp. colonizes rhizoplane and rhizosphere more effectively, if they are applied to the soil with decomposed organic fertilizer or manure (Huang *et al.*, 2011). *Trichoderma* spp. are now regarded as the most important and widespread fungal biocontrol agents that have been principally studied and used throughout the world (Patil and Prajapati, 2017). The objective of the present study was to explore the efficacy of biopesticides formulations in combating bacterial wilt disease of tomatoes under the agro-ecological situation in the Lakhimpur district of Assam.

Materials and Methods

The field experiment was conducted at the farmer's field viz. Ranabari, Pukhuripuria, Khoga, and Gosanibari village of Lakhimpur district, Assam during the *rabi* season starting from October to March of 2016 and 2017. The experiment was set up in Randomized Block Design with four replications to compare 5 treatments including control. Individual plots of size 2.5 x 5 m² with 60 x 45 cm² spacing between rows and plants were prepared by following all the recommended agronomic practices of

Assam Agricultural University, Jorhat. Twenty days old seedlings of the variety Pusa Ruby were used for transplanting in this experiment. Four biopesticides formulations viz. Biofor PF, containing *Pseudomonas fluorescens* and *Trichoderma harzianum*, Bioveer, containing *Trichoderma viride*, Biomonas, containing *Pseudomonas fluorescens* and Biozin PTB containing *Pseudomonas aeruginosa*, *Trichoderma harzianum* and *Bacillus brevis* developed by Assam Agricultural University, Jorhat against the bacterial wilt disease of tomato were taken for evaluation.

Biopesticides formulations were applied as a seed treatment, root treatment, and soil treatment. For seed treatment, seeds were treated with the bioformulation@1 gm gm⁻¹ of seed along with rice glue. The coated seeds were then spread over a clean paper under shade for drying before sowing in the nursery bed. For the seedling's root dip treatment, the bioformulation was mixed with rice gruel to form fine slurry, and the roots of the seedlings were dipped in it for about 30 minutes before transplanting. One kg of bioformulation is required to treat 1000 numbers of seedlings. For soil application, 1 kg bioformulation was mixed with 10 kg dry cow dung and applied to the soil near the root zone@ 100 gm plant⁻¹ at the time of transplanting and was repeated 30 days after transplanting. The number of wilted plants per plot was recorded starting from 15 days after transplanting and at 15 days intervals by following the method described by Mew and Ho (1976). The bacterial wilt incidence (%) and yield (qha⁻¹) were calculated. The observed data were analyzed by the OPSTAT statistical software package (Sheoran, 2006) after angular transformation wherever necessary. The data were subjected to analysis of variance (ANOVA), and the means were analyzed, using Duncan's new multiple range post-test at p = 0.05.

Results and Discussion

All the bioformulations significantly reduced the bacterial wilt incidence as compared to control (Table 1). Among all the bioformulations, Biofor PF was found to be most effective bioformulation with the lowest wilt incidence (18.12%) which was followed by Biozin PTB, and Biomonas with 22.16% and 25.28% disease incidence,

respectively. The plot treated with Biofor PF recorded the highest reduction (76.42%) of disease incidence over the control plot followed by Biozin PTB, and Biomonas treated plot with 71.16% and 67.10% reduction of disease incidence over the control plot, respectively. The bioformulations besides reducing disease incidence also increased crop yield. All the bio formulations significantly enhanced crop yield as compared to the control, however, the plot treated with Biofor PF recorded the highest yield (232.68 qha⁻¹) which was followed by Biozin PTB, and Biomonas treated plot with an average yield of 226.62 qha⁻¹ and 221.42 qha⁻¹, respectively (Table-1).

The higher efficacy of Biofor PF might be attributed to the production of metabolites like siderophore by the *Pseudomonads* which have a strong inhibitory effect on *R. solanacearum* (Ciampi et al., 1997). Similar observations were also made by Kloepper and Schroth (1981) who reported that fluorescent pseudomonad could rapidly colonize and inhibit certain components of the root zone microflora and alter the composition of the rhizosphere leading to reduction of disease incidence. The application of microbial antagonists reduced the survival of soil-borne plant pathogens (Sakthivel and Gnanamanickam, 1986 a, b). They also mentioned that *P. fluorescens* decompose the organic phosphates and enhances the crop yield by reducing the density of the inoculum of soil-borne plant pathogens. The use of biocontrol agents *P. fluorescens* and *Bacillus subtilis* for the management of soil-borne pathogens were also reported by several other researchers (Benitez et al., 2004; Sakthivel and Gnanamanickam, 1987). The present findings are in conformity with the findings of Keswani et al. (2016) who mentioned that *Trichoderma* spp induces systemic resistance in plants by releasing not only proteins but also secondary metabolites.

Fluorescent pseudomonads also activate induce systemic resistance against various fungal, bacterial and viral diseases (Liu et al., 1995). In the present investigation, antagonism of *P. fluorescens* might be due to similar type of antibiosis, parasitism and ISR induced in tomato plant by *P. fluorescens*.

The highest yield recorded in the Biofor PF treated plot might be related to a reduction in disease incidence, increased availability, and uptake of nutrients, secretion of growth hormones. The decrease in disease incidence in tomato and increase in yield might be due to suppression of the pathogen by application of bioformulation of different bioactive microorganisms which is in agreement with the findings of Bustamanate et al. (1989). Li et al. (2) also reported that *Trichoderma* spp. enhances plant resistance against several phytopathogens, promotes plant growth by increasing the photosynthetic activity of plants. Das (1999) recorded that *T. viride* and *T. harzianum* could significantly reduce the bacterial wilt

severity caused by *R. solanacearum* in tomato. Similarly, Ranjan et al. (2002) reported that *Trichoderma* sp. could control rhizome rot of ginger caused by *Pythium*, *Fusarium* and *R. solanacearum*. Sutunya (1984) reported that *P. fluorescens* could effectively reduce the growth of *R. solanacearum* in rhizosphere of tomato plant. Many strains of *P. fluorescens* are known to enhance plant growth promotion and reduce the severity of various diseases (Sakthivel et al., 1986). Efficacy of *Trichoderma* based biopesticides against several plant pathogens was also reported by Rahman et al. (2021).

Conclusions

The Biofor PF was found to be most effective bioformulation among all the bioformulations with the lowest wilt disease incidence (18.12%) and recorded the highest reduction (76.42%) of disease incidence over the control. The plot treated with Biofor PF bioformulation recorded the highest yield (232.68 q ha⁻¹) compared to all other treatments.

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Water Management in Education System A Study on Water management as part of Curriculum in Schools

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Abstract

Water is one of the essential sources of human survival. Water covers 70% of our planet, and yet it is considered a scarce resource now. However, freshwater which is available for human use is incredibly rare, only 3% of the world's water and two-thirds of it is stuck in frozen glaciers or otherwise unavailable for our use. As a result, some 1.1 billion people worldwide lack access to water, and a total of 2.7 billion find water scarce for at least one month of the year. A 2019 NITI Aayog report says that India is suffering from the worst water crisis in its history, and almost 600 million of its population is deprived by water. The report goes on to add that 21 cities including Bangalore, Delhi, Hyderabad and Chennai have probably exhausted their groundwater resources in 2021. By 2025, two-thirds of the world's population may face shortage of water and ecosystems around the world will suffer to a vast extent. In this crucial movement of crisis, the role of education is fundamental. Indeed, we cannot train each and every person to be aware of the water problem but instead impart it as part of education and enable them to behave as rational water users and managers.

An increase in knowledge as part of education, lays the foundation for subsequent increases in knowledge that are necessary for an individual to effect meaningful behavioural and even systems changes. Achieving the Impact envisioned in SWEAP requires that individuals move from basic awareness knowledge to behaviour change, including participation in discourse and informed decision making. This, in turn, requires both individuals to think and take initiative and thus enabling and/or empowering conditions that water education can help provide through social marketing and systems thinking strategies. The purpose of imparting water management in education, is to change the paradigm that not all individuals will have the opportunity to act on the knowledge imparted in water management".

Key words : *Water scarce, education, schools, curriculum.*

Introduction

Managing and conserving water is the heart of concern of all economic stakeholders and observers. Indeed, scientific research around the world sounds the alarm about the future of this vital scarce resource. The reasons for scarcity of water are:

Following is some of the major causes of water shortage : Climate change. natural calamities such as droughts and floods, increased human consumption, overuse and wastage of water, a global rise in freshwater demand, over-use of aquifers and its consequent slow recharge. Although causes are many, pollution and overuse are the most destructive and adverse factors on the future of water sources. Y Jardioui · 2015- this work aims at the role of Management and water conservation. Bouchouata et al., 2012). In fact, this work aims to verify the role of education as a tool for a better water management

Objectives of the study

To analyse the National and international measures on water conservation and water management.

To assess role of Imparting water education as part of curriculum in K12 System.

Suggesting possible measures for an efficient water management system in India through the education system via curriculum.

Materials and Methods

The study based on secondary data. The various reports were review for the present work which are mentioned as follows :

Government publications : National water mission Report.

Public records : United Nations World Water Development Report (UN WWDR 2021).

News articles 12 Curriculum of State Board in India.

Results and Discussion

National water mission : The Government of India has established the National Water Mission as one of the eight National Missions under the National Action Plan on Climate Change. The main objective of NWM is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". NWM has identified five goals as under :

Comprehensive water data base in public domain

and assessment of the impact of climate change on water resource.

Promotion of citizen and state actions for water conservation, augmentation and preservation.

Focused attention to vulnerable areas including over-exploited areas.

Increasing water use efficiency by 20%, and

Promotion of basin level integrated water resources management.

Various strategies for achieving the goals have been identified which lead to integrated planning for sustainable development with active participation of the stakeholders.

Important campaigns run by National Water Mission :

1. Catch the Rain
2. Water Talk
3. Water Tech Talk
4. Dialogues with DMs
5. SahiFasal

The 2021 edition of the United Nations World Water Development Report (UN WWDR 2021) entitled 'Valuing Water' groups current methodologies and approaches to the valuation of water into five interrelated perspectives: valuing water sources, in situ water resources and ecosystems; valuing water infrastructure for water storage, use, reuse or supply augmentation; valuing water services, mainly drinking water, sanitation and related human health aspects; valuing water as an input to production and socio-economic activity, such as food and agriculture, energy and industry, business and employment; and other socio cultural values of water, including recreational, cultural and spiritual attributes. These are complemented with experiences from different global regions; opportunities to reconcile multiple values of water through more integrated and holistic approaches to governance; approaches to financing; and methods to address knowledge, research and capacity needs.

Role of Educational institutions in imbibing water education among children

Water education as part of curriculum in K12 System :

The education system in India is typically K-12, meaning a graduation from kindergarten to class 12th. A student who wishes to join the college has to complete the 12 years or grades and the kindergarten. Excluding the kindergarten, the schooling has further been divided in primary, secondary and higher secondary level of education. From grade I to VIII, the level is primary; from VIII to X, it is secondary and from X to XII it is higher secondary. The last two, i.e., secondary and higher secondary education is looked after by state boards of education or any other

board recognised by the Indian government. There are over 30 state boards and central boards of education in India. In almost every state, there is at least one education board which caters to the secondary and higher secondary education. Important Functions of State Boards :

Advise the State Government on policy matters.

See the implementation of Education Policies, as laid down by the Central Government.

Maintain a uniform standard of education in schools all over the state.

Lay guiding principles for curriculum and syllabus. The syllabus is prescribed by the state boards.

Conduct Examinations (board examinations), at the completion of secondary and higher secondary

Water education in school curricula: impact on children knowledge, attitudes and behaviours changes of future generation towards water use Primary school curriculum includes: reading, writing, mathematics, social studies, music, physical education, and art.

The Secondary curriculum is a skills-focused programme that provides students with a broad and balanced knowledge of key subjects, as well as effective critical thinking and communication skills.

Senior Secondary Schools in India include classes 11th to 12th and consist of students aged between 16-18 years usually. At this level of education, students can choose their preferred stream and subjects. They can pursue Arts, Commerce, Science (medical & M

Measures to Imparting water education in Schools and Colleges : The following are the few possible measures to create an awareness on efficient water management.

Observing World Water Day : Giving importance to world water day and celebrating it in schools and colleges will create awareness on the importance of water resources

Showing Documentaries related to water resources : Creating awareness by Showing the videos on clean water and sanitation and its favourable impact on biodiversity and also explaining the present scenarios of water scarcity and its consequences on human survival.

Creating a water diary : It is a method to generate intra-household water use data, as a tool to promote water use behaviour change which will enable users to their water behaviours and practices. Collecting the per capita water usage of child will help to monitor the water usage of an individual and also promote the sustainable water usage practices.

Create a Water Campaign : Creating awareness on importance of water conservation by organizing various Campaigns Such as processions to save water, organizing marathons to prevent and control water pollution, distributing pamphlets, display boards etc.

Host a Clean Water Talk Show Activity: Hold talk shows frequently by connecting to the right people and encouraging and giving opportunity to students to become a host in talk shows. This will encourage them and make them feel responsible in conserving water.

Conclusions

The analysis of the National water mission programmes and United nations world development report clearly show the approach to solve and improve or proposed solutions to address the issue of Water. These measures and programmes can be effective only via education. Educating people on scarcity of water and how to manage such scarce resources must be initiated from the root and hence it must start from School. This is possible only through a change in the education system and certainly via curriculum. The K12 education system must include

the syllabus on water management which will help to create citizens who will work towards reducing this scarce and managing this valuable resource in such a manner that it is left for our next generations. This kind of approach will break the paradigm, “not all individuals will have the opportunity to act on the knowledge imparted in water management through water education.

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Contribution of Different Ecotourism Sites to the Local Livelihood of Bhubaneswar City, Odisha

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Abstract

Indeed, ecotourism is one of the rapidly growing tourism business sectors with a renewed significance in spending leisure time in nature and raising awareness of environmental problems (United Nations, 2001). Odisha, the eighth largest state of India has the best-kept secret of heritage sites and enthralling views created opportunities in the ecotourism sector. Bhubaneswar, the capital of Odisha has more than a dozen ecotourism sites contributing to the state economy and environmental conservation. The present research entitled "Contribution of different ecotourism sites to the local livelihood of Bhubaneswar City, Odisha" was carried out in the year 2022 in order to find out the contribution of ecotourism to the locality in Bhubaneswar in order to generate profit and maintain the permanence of ecosystem; for which two sites of wildlife sanctuary namely, Nandankanan and Chandaka, were taken to examine the business cycle of the ecotourism sites through the numbers of tourist inflow and the amount of revenue it generated. Both primary and secondary data were recorded to meet our objectives. A total of 10 management personnel were interviewed from both ecotourism destinations to collect primary information. The collected data were analysed and the percentage of contribution of every component of ecotourism was found. In Nandankanan in the year 2021-22 adult visitors were 126411 (86.43%), followed by children in 194618 (13.30%), school children 2097 (0.14%) and 388 foreign nationals (0.02%). In Chandaka 2021-22, For safari, Godibari welcomed 8331 visitors (67.50%) followed by Bharatpur 2233 (18.10%), then Deras 1778 (14.40%). For the nature camp, Deras welcomed 714 (72.63%) visitors while Godibari got 269 (27.37%). In Nandankanan 2021-22, the highest percentage of revenue collected from entry permits was 82.78%, followed by the rent of safari at 6.94%, the rent of BOV at 4.34%, revenue collected from Botanical garden at 3.15%, rent of boating 0.95%, rent of toy train 0.67%, rent of OTDC counters 0.38%, rent of souvenir shop 0.25%, and the least amount of revenue came from camera charges 0.02%. In Chandaka 2021-22, the total revenue collected was 4706392/- with the addition of boating facilities in Deras. The highest percentage came from safari again which was 35.02%, followed by entry fee at 32.09%, Nature camp at 26.52% and boating at 6.43%. Unlike Nandankanan, here all the components of revenue have more or less equal shares. The study has demonstrated some authentic observations that are logically conveyed. Tourists are a crucial component in the development of tourist industry. Directly and indirectly, tourism spending generates jobs and revenue, provision of infrastructure, engagement between hosts and tourists, financial resources for conservation and preservation of nature.

Introduction

The World Conservation Union (IUCN, 1996) defines eco-tourism as an environmentally sustainable journey to natural areas to experience and appreciate nature and cultural concomitant characteristics (past and present), which promote conservation, have a low visitor effect and contribute to socio-economic benefits of local people. Ecotourism is indeed one of the fast-growing sectors of the tourism business with a renewed importance in spending leisure time in nature and awareness of environmental issues (United Nations, 2001). Particularly in comparison to 'mass' and 'old' tourism, ecotourism has improved sectoral relations, reduced leakage, provided job opportunities, and encouraged sustainable development. These alternative tourism differ in many ways from mass tourism and are labeled using "eco," "responsible" and "sustainable" tourism, to monitor the negative impacts of mass tourism and to support sustainability, maximizing significant contribution towards a destination where a number of

social and environmental challenges exist. It is a distinct form of tourism growth that replaces conventional 'mass tourism' and has strong moorings in sustainable, fair, community-based efforts to strengthen the host society's quality of life and preserve natural and cultural heritage. Its basic values are that the negative environmental impact is minimized, local cultures are portrayed, and that the hosts and their stakeholders are actively positively impacting their economic wellbeing. Ecotourism has the potential to become an impetus in sustainable tourism growth and to provide opportunities to develop disadvantaged, marginalized and rural areas to play a key role in alleviating poverty. Ecotourism is focusing on the same major issues: ecology, society and a systemic development process. Sustainable ecotourism reduces environmental degradation, retains uniqueness and homogeneity of resources, renewability and efficiency over time and seeks, on local, regional and global levels, to mitigate the overall negative effects of tourism.

In the world scenario, India has occupied one of the leading positions among the top 50 countries with tourist

Table-1 : Details of the study sites.

Parameters	Nandankanan Biological Park (Site I)	Chandaka Wildlife Sanctuary (Site II)
Latitude and Longitude	20.3958N 85.8260 E	20.3667 N 85.7667 E
Area	437 ha	175.79 sq km
Distance from :		
(a) Bus stand	16 km	13 km
(b) Railway station	18 km	21 km
(c) airport	20 km	14 km
Major attraction	Safaris, Theme based gardens, Boating, Picnic facilities	Jungle safari, Nature camp, Boating

Table-2 : Tourist inflow in Nandankanan.

Year	Item	Number	Percentage (%)
2019-20	Adult	2245465	85.4
	Children	338983	12.7
	Foreign Visitor	1105	0.04
	School Children	41993	1.5
	Total	2627546	100
2020-21	Adult	702483	85.6
	Children	117807	14.35
	Foreign Visitors	194	0.02
	School Children	-	-
	Total	820484	100
2021-22	Adult	1264111	86.43
	Child	194618	13.3
	Foreign Visitors	388	0.02
	School Children	2097	0.14
	Total	1462474	100

destinations. India has been one of the most favorite ecotourism destinations in the world (Goodwin & Chaudhary, 2017). India's Tourism Philosophy "Atithi Devo Bhavah" together with new National Tourism Policy (2015) seeks physical strengthening of the tourist, psychological refreshments, enrichment in cultural value and spiritual enhancements.

Materials and Methods

Study Area : Bhubaneswar, the capital city of Odisha was selected using purposeful sampling for studying sustainable ecotourism because of following reasons :

1. The city has become an important center of educational, commercial, political, administrative and socio-cultural activity.
2. Nearby heritage sites Puri and Konark together with this place develop one of the parts of the Golden Triangle of tourism in eastern India.
3. The town has magnificent appearing monuments, architectural wonders and proximity to the Nandankanan Zoo and Chandaka Forest making the town a popular destination for both domestic and international tourists.
4. Well-connected to all other major Indian cities by air, road and rail.

The collection process is by using different techniques and sources to acquire adequate and accurate information with respect to the study objective. Two broad research tools, i.e. primary information and secondary data collection, were used to conduct research surveys.

Primary data were collected from tourists who visited ecotourism destinations and service providers like restaurant owners, eco-guide, safari drivers, and official management using structured questionnaires. Secondary data (Annual report of concerned WLS, Govt. database, news articles, research papers, etc.) pertaining to sustainable urban tourism and ecotourism and its impact on the socio-economic development of local people were obtained from various sources of government departments (both state and center) namely, Department of Tourism, publications and broadcasting department, Forest, environment and climate change department and Odisha Forest Development Corporation.

Depending upon the primary data collected from various sources, percentage frequency is calculated for various aspects of information that we need.

Percentage frequency = (observed frequency/Total sampling) $\times 100$ (Gupta and Kapoor, 2007)

Table-3 : Tourist Inflow in Chandaka.

Year	Experiences	Godibari		Bharatpur		Deras		Total
		Absolute	%	Absolute	%	Absolute	%	
2019-20	Safari	3396	50.62	1128	16.81	2184	32.57	6708
	Boating	-		-		-		-
	Nature Camp	173	41	-	-	253	59	426
2020-21	Safari	6560	60.3	2135	19.62	2185	20.08	10880
	Boating	-		-		-		-
	Nature Camp	192	30.8	-	-	432	69.2	624
2021-22	Safari	8331	67.5	2233	18	1778	14.5	12342
	Boating	-	-	-	-	3254	100	3254
	Nature camp	269	27.37	-	-	714	72.63	983

Table-4 : Revenue Collection in Nandankanan.

Sl. No.	Items	Amount in Different Years (INR)		
		2019-20	2020-21	2021-22
1.	Entry Fee	115773320/-	35735330/-	56878300/-
2.	Camera Charge	3400/-	8400/-	17300/-
3.	Boating Rent	1084621/-	418036/-	655659/-
4.	Safari Rent	8799556/-	247015/-	4771022/-
5.	OTDC Rent	364690/-	59414/-	263483/-
6.	BOV Rent	12926534/-	290718/-	2987323/-
7.	Souvenir Shop Rent	214664/-	103088/-	175559/-
8.	Botanical Garden	6122300/-	2911970/-	2169810/-
9.	Toy Train Rent	-	-	465180/-
	Total	14,52,89085/-	3,97,73971/-	6,83,83636/-

Table-5 : Revenue Collection in Chandaka.

Year	Experiences	Amount (INR)			
		Godibari	Bharatpur	Deras	Total
2019-20	Entry	817609	89500	1671539	2578648
	Safari	426000	16000	246000	688000
	Boating	-	-	-	-
	Nature Camp	387181	-	642547	1029728
2020-21	Entry	32553	50420	977559	1060532
	Safari	1199955	308650	294825	1803430
	Boating	-	-	-	-
	Nature Camp	198046	-	553341	751387
2021-22	Entry	13087	36420	1456981	1506488
	Safari	1005111	281500	362000	1648611
	Boating	-	-	302900	302900
	Nature Camp	333951	-	914442	1248393

Results and Discussion

Tourist Inflow :

Site 1 : From table no. 2, it was observed that in 2019-20, adult visitors were 2245465 (85.4%), followed by children 338983 (12.7%), school children 41993 (1.5%) and 1105 foreign Nationals (0.04%). In 2020-21, adult visitors were 702483 (85.6%), followed by children 117807 (14.35%), and 194 foreign nationals (0.02%). In 2021-22, adult visitors were 1264111 (86.43%), followed by children in 194618 (13.30%), school children in 2097 (0.14%), and 388 foreign nationals (0.02%).

In Nandankanan, the total number of tourists was higher in 2019-20 in the last 3 years (2627546). Due to Covid 19 in 2020 and some months of 2021, the number dropped. It was only 820484 in 2020-21 due to the Covid pandemic in the peak winter days. But after the pandemic got over, it regained the number (1462474) but not to the number it was in 2019-20. The same result was found by Hosseini *et al.*, 2021 found that the Coronavirus disease has been posing serious challenges to all parts of the ecotourism supply chain causing disruptions in the ecotourism industry. In all these three years, the number of adult visitors are the highest followed by children, then

school children, and the least number of foreign nationals and only in 2020-21, there were no school children due to the pandemic but there were some foreign nationals on the research entitled "Ecotourism Supply Chain During the Covid-19 Pandemic: A Real Case Study".

Site II: From table 3, it was found that, in 2019-20, For safari, Godibari welcomed 3396 visitors (50.62%) followed by Deras 2184(32.57%), then Bharatpur 1128(16.81%) and for nature camp, Deras welcomed 253(59%) visitors while Godibari got 173 (41%). In 2020-21, for safari, Godibari welcomed 6560 visitors (60.3%) followed by Deras 2185(20.08%), then Bharatpur 2135(19.62%). Due to the reasons above mentioned(advertising and proximity to the city), the number of visitors to Bharatpur safari is almost equal to Deras. For nature camp, Deras welcomed 432(69.2%) visitors while Godibari got 192(30.8%). In 2021-22, for safari, Godibari welcomed 8331 visitors (67.50%) followed by Bharatpur 2233 (18.10%), then Deras 1778 (14.40%) and for nature camp, Deras welcomed 714 (72.63%) visitors while Godibari got 269 (27.37%).

Analyzing the above table, it can be interpreted that, in Chandaka, there are 3 important destinations; Bharatpur, Godibari and Deras. The main experiences are Jungle safari, nature camp, and boating. In the last 3 years, for safari, the number of visitors is the highest in Godibari, followed by Deras and then Bharatpur. But due to the proximity of Bharatpur to the city and increased advertisements, the number of visitors in Bharatpur is increasing year by year and it was more than Deras in 2021-22. For nature camp, Deras has more visitors than Godibari. It may be due to Deras has more experiences to offer like boating than Godibari. Also, the nature camp is situated on a mountain which makes it worth staying.

Revenue Collection : In Nandankanan: In 2019-20, the highest percentage of revenue came from entry permits which were 79.698%, followed by rent of BOV 8.9%, rent of Safari 6.05%, the revenue of botanical garden 4.21%, rent of boating 0.74%, rent of OTDC restaurant and snack center 0.25%, rent of souvenir shop 0.15% and the least amount of revenue from camera charge 0.002%. In 2020-21, the highest percentage of revenue came from entry permits which was 89.8% followed by revenue from the Botanical garden 7.32%, rent of Boating 1.05%, rent of BOV 0.73%, rent of safari 0.62%, rent of souvenir shop 0.25%, rent of OTDC counters 0.14%, and the least amount of revenue came from camera charges 0.02%. In 2021-22, the highest percentage of revenue collected from entry permit which was 83.2%, followed by the rent of safari 6.97%, the rent of BOV 4.36%, revenue collected from Botanical garden 3.17%, rent of boating 0.95%, rent of toy train 0.68%, rent of OTDC counters 0.4%, rent of souvenir shop 0.25%, and the least amount of revenue came from camera charges 0.02%.

In above table 4, it was calculated that in Nandankanan, the major portion of the revenue comes from the entry fee, followed by the rent of safari, rent of BOV and revenue from the botanical garden. But the order varies from year to year. It can be observed that in the last two years, the least amount of revenue is coming from camera charges. This can be observed that due to the pandemic, the revenue share collected from Safari and BOV decreased to a large extent. According to IMF, 2020-21, the Covid-19 pandemic has impacted ecotourism and the revenue coming from it negatively. It said that tourism-dependent countries will likely feel the negative impact of the crisis for much longer than other economies around the world. The percentage share of Safari, BOV in revenue regained its place after the pandemic is over in the last financial year. The revenue of state botanical gardens plays a great share in the total revenue.

In Chandaka: In 2019-20, the total revenue collected was Rs4296376/-. Entry fee contributed 60.01% followed by nature camp which was 23.98% and then safari at 16.01%. In 2020-21, the total revenue collected was Rs3615349/-. Safari contributed the highest percentage which was 49.88%, followed by entry fee 29.33% and nature camp 20.79%. The drop-in revenue was justified by the pandemic. In 2021-22, total revenue collected was Rs4706392/- with the addition of boating facilities in Deras. The highest percentage came from safari again which was 35.01%, followed by entry fee 32.07%, Nature camp at 26.51% and boating 6.41%.

Unlike Nandankanan, the highest percentage share in revenue in Chandaka varies from year to year (Table 5). In 2019-20, it was the entry permit, in 2020-21 and 2021-22, it was jungle safari. Boating started last year in Deras and it contributes a good share of the total revenue of Chandaka WL. Unlike Nandankanan, here all the components of revenue have more or less equal shares.

Conclusions

Human's most concern, the growing population, and competition inflicted him to find amenities for leisure and entertainment in order to assuage the mental and physical coercion derived from his restive life. Ecotourism as a responsible form of niche tourism that has been fostering awareness, education and enjoyment could sustainably preserve the local values and natural environment (Weaver, 2001). The study has demonstrated some authentic observations that are logically conveyed. Tourists are a crucial component in the development of the tourist industry. Directly and indirectly, tourism spending generates jobs and revenue, provision of infrastructure, engagement between hosts and tourists, and financial resources for the conservation and preservation of nature. Tourist service providers are direct

users and consumers of natural resources. Their responsible conduct can minimise negative impacts and maximise the positive impacts that can significantly contribute to setting and achieving sustainable goals. To this end, the government should reconfigure and reshape its ecotourism policies to create a healthy environment and encourage a positive impact on the economic, ecosystem and society development in Bhubaneswar. So, putting tourism in a sustainable path is a major challenge which must be brought with the collusion of partnership and cooperation within tourism industry and among industries, government, servicers and tourists themselves. Local livelihoods, socio-personal, agro-economic and psychological attribution very often motivate the people for proper management and sustainable use of forest resources (Nayak, 2021; Nayak, 2019; Sahoo, 2019).

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Economic Value of Provisioning Services produced by Bannerghatta National Park in Karnataka, India

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Abstract

Forest Ecosystems provide invaluable services to the forest-dependent communities. Provisioning services is one among them and they are the direct services provided by forests to their dwellers. The present study looks into the various provisioning services provided by Bannerghatta National Park (BNP) to its dependent forest dwellers. The economic value of the provisioning services by BNP was calculated using the Market Price method and Household Survey method. The total value of provisioning services received by the 200 households is Rs 8,55,39,387 which is Rs 4,27,696.9 per household per year. In US dollars this is \$1,125,518.25. And the value of provisioning services per hectare is the total value of provisioning services divided by the area accessible to the forest dwellers. This is 7,851.3 hectares taking 30 percent of the national park as accessible (at 2020-21 prices).

Key words: Bannerghatta national park, ecosystem services, valuation, provisioning services.

Introduction

As per the World Database on Protected Areas (WDPA) there are 2,66,561 protected areas spread across 245 countries across the globe. India has 981 protected areas spreading over 1,71,921 sq km on October 2020. This includes 104 National Parks, 566 wildlife sanctuaries, and 214 community and conservation reserves. All these constitute about 5.03 coverage percentage of the country (Envis report, 2020). Though a 5.03% coverage percentage is a small number yet in most developing countries, especially in forest ecosystems, provisioning services are crucial in contributing direct use values to the forest-dependent dwellers and communities (Mullan, 2014). The poorest people in society, around the world, mostly extract non-timber forest products (NTFPs; Neumann & Hirsch, 2000). Non-Timber Forest Products (NTFPs) help forest dwellers to meet domestic expenditure as sources of earnings (Cavendish, 2002; Kristensen & Balslev, 2003) and as basic economic security in times of crisis such as crop failure (Angelsen & Wunder, 2003).

Bannerghatta National Park (BNP) is one of the few national parks in India, adjacent to an urban conglomerate. In general, it's a known fact that ecosystems provide services that are local, regional and global in nature. In the recent past ecosystem services and studies on this gained momentum among policymakers and scientists across the globe as it studies the human dependency on ecological systems which provide life-supporting ecosystem services (Bastian *et al*, 2012, Martinez *et al*)

Forest Ecosystems provide innumerable goods and direct services not only to the dwellers and the

communities in the vicinity of them but also indirect services to distant communities. The forest ecosystem of BNP provides many provisioning services like food (both from the forest and through agriculture), water, NTFPs, grazing for livestock etc. NTFPs from BNP are honey (apis), amla (*Phyllanthus emblica*), shikakai (*Acacia concinna*), soapnut (*Sapindus*), tamarind (*Tamarindus indica*), bamboo (bamboo - both dried bamboo for fences and tender shoots used for cuisines), seasonal fruits like jackfruit (*Artocarpus heterophyllus*), bael (*Aegle marmelos*), Jamun (*Syzygium cumini*), and sea tamarind (*Annona squamosa*). These provisioning services contribute to the economic well-being as well as for the livelihood of the forest dwellers and also the people of the fringe villages of BNP (Seppala *et al*, 2009).

Objective

The objective of this paper is to determine forest use and the level of dependency of the forest enclosure and fringe villages on Bannerghatta National Park (BNP) through the provisioning services received by them in economic terms.

Importance of Provisioning services for the livelihood of Forest Dwellers

The forest dwellers residing in and around terrestrial ecosystems are predominantly homesteaders. Forest ecosystems not only support the lives and livelihoods of the dependent enclosure and fringe villages but play a vital role in the reduction of poverty of the dependent dwellers. Forest dwellers depend on forests due to a lack of alternative livelihood opportunities in the regions they reside (Soe & Yeo-Chang, 2019). In the case of underdeveloped and developing countries the provisioning services provided by forest ecosystems are crucial as they are the direct

consumable benefits to dependent communities (Mullan, 2014). Vulnerable and poor communities around the globe are dependent on the ecosystem services provided by different ecosystems (marine and terrestrial). In the ecosystem services the NTFPs are the most important as they not only feed but also provide for housing and other livelihood activities (NTFPs; Neumann & Hirsch, 2000). NTFPs contribute to meeting the expenditure of households and can be a good source of income where NTFP sale is allowed (Cavendish, 2002; Kristensen & Balslev, 2003) and additionally act as insurance in times of unforeseen incidents such as crop raids by animals or crop failure (Angelsen & Wunder, 2003).

As per the published literature, NTFPs were observed as the main income sources among tribal households in Karnataka, in southern India by Ganapathy et al in 2008. Blomback and Poschen (2003) pointed out that forestry activity was the last resort of locals in times of hardship. Agrawal *et al.* (2013) underlined the economic contribution of forests, which help to ameliorate shocks to household incomes. Cavendish (2000), Fisher (2004), and Sunderlin *et al.* (2005) found that forests are means to eradicate poverty among rural households by providing livelihoods. The possibilities and constraints of forests in the context of poverty alleviation have been investigated and their probable roles as safety nets to eradicate poverty are explored in the study of Angelsen and Wunder (2003).

From the literature it is clear that provisioning services like food, water, and NTFPs directly contribute to the forest household income and also livelihoods in the form of subsistence consumption and any interference in this process may be detrimental to the forest dwellers' well-being.

Materials and Methods : This study was conducted over a period of three years (2018 to 2021) in ten (10) selected forest enclosure and fringe villages in four different ranges of Bannerghatta National Park which is situated in Bangalore, Karnataka. In BNP, the study was conducted in twelve (12) villages in both enclosure villages and in few fringe villages situated in the Ecological Sensitive Zone 1 (ESZ 1) of BNP. These are Anekal range in the North east part of BNP, Harohalli range in the middle of BNP; Bannerghatta range in the northern part of BNP which is the closest to Bengaluru city and Kodihalli range in the southern part were selected. The choice for villages in this study was based on location of the village (within the national park or the fringe, areas of high dependence on forest resources, forest degradation and undergoing vegetation change).

Data Collection : Socio-Economic and market survey instruments were used to collect the data for this study. A systematic sampling technique was used for collecting

data through interviewing the farmers (forest dwellers) across the study sites. A structured interview schedule was administered for collecting data from farmers (Sarker *et al*). Household survey was done using a schedule to collect data on Socio- Economic and Demographic Data, data on provisioning services they obtain from forests which include agricultural produce and NTFPs, Data on Human-Wildlife Conflicts(HWC) they experience, loss due to animal raids, perceptions about the ecosystem services provided by BNP and the general awareness about BNP. The Questionnaire was written in English language for the sake of research convenience but was administered in local language which is Kannada for the understanding of the farmers. No other enumerators were used for the study. In most cases the family head was interviewed and in his absence the eldest child was interviewed as most women shared that they do not have adequate information on the house hold related income or expenses.

A total of twelve (12) villages out of which ten (10) are enclosure villages and two (2) fringe villages of the BNP forest were selected through the random sampling method. These villages are spread in all the four (4) ranges of BNP. A researcher, based on subjective judgement, must ensure that the sample relatively reflects the population of the study. Forest households residing in the enclosures of BNP collect NTFPs due to proximity of the villages to the forest. Focus group discussions and discussions with the village heads in the pilot survey phase confirmed this kind of forest produce collection as well as that the villages both in the enclosures and fringes of BNP were homogeneous in terms of forest dependency.

Sample size : A total of 204 households were surveyed in 10 villages inside BNP, of which a final 200 were taken for the study from 12 villages.

Tools for estimating the value of Forest Resources : The MarketPrice (MP) was used to calculate the value of forest produce. And two kinds of market prices were taken, one was from the nearest market i.e., MP1, and the second being price at the nearest city (Bengaluru city market). Cost for collection and payments to laborers if any is included in the overall cost borne by the farmer for agricultural practices. And the market prices of each crop and NTFP is collected from the nearest market to the villages. In addition, the resource-abundant areas of the eight resources were identified based on the information of the resource collectors from which areas of the forest they collect the respective resources.

Time period of the study : The values in this study are for the year 2020-2021.

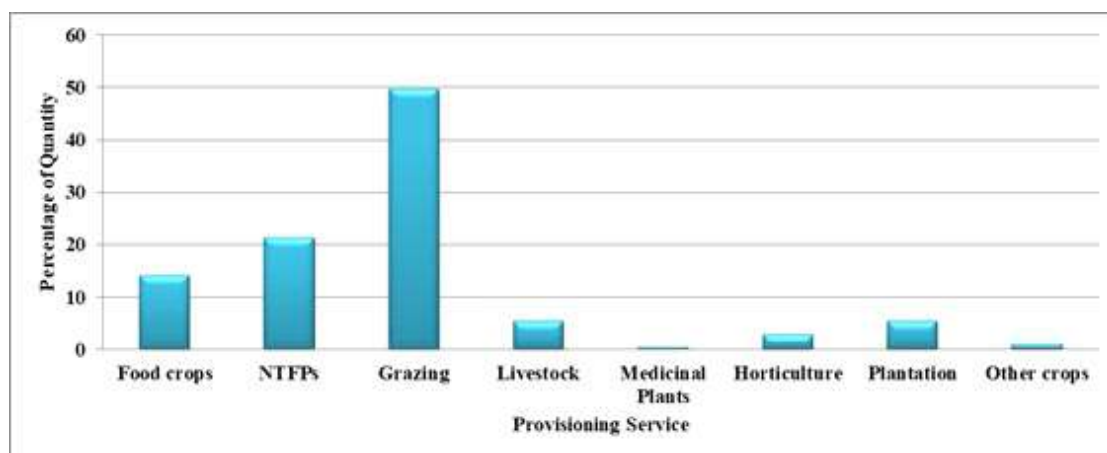
Results and Discussion

The data collected from the field was compiled and analyzed using Microsoft Excel. The total income to the

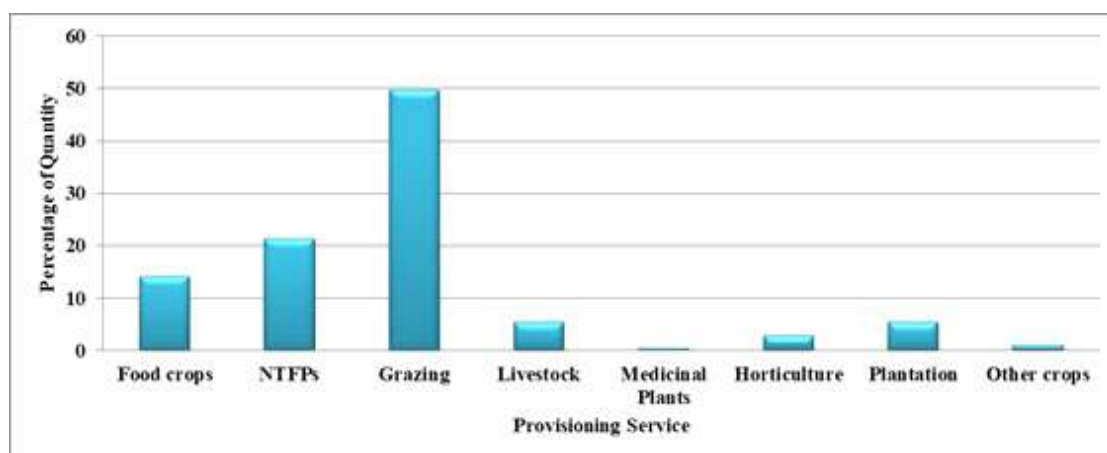
Table-1 : Value of provisioning services by Bannerghatta National Park.

Provisioning Service	Quantity(q)	Value of Output(Rs)	Percent of Quantity	Percent of Output
Food crops	6169.4	2,47,11,750	14.11	28.67
NTFPs	9281.63	2,04,25,855	21.23	23.70
Grazing	21752.5	1,08,76,250	49.75	12.62
Livestock	1273.23	89,71,680	5.41	10.41
Medicinal Plants	199.6	20,95,000	0.46	2.43
Horticulture	1199.33	60,12,252	2.74	6.98
Plantation	2337.1	35,55,200	5.35	4.12
Other crops	417.54	88,91,400	0.95	11.07
Total	42630.33	8,55,39,387	100.00	100.00

Source : Author's field data, 2021.

Fig.-1 : Provisioning services as a percentage of the total quantity.

Source : Author's primary data, 2021.

Fig.-2 : provisioning services of BNP as a percentage of output.

Source : Author's field data, 2021.

farmer constitutes both cash income and subsistence income which is accrued annually. For the study purpose, 2020-21 data is collected and analyzed to calculate the income accrued to a farmer from provisioning services from BNP. BNP has sixteen (16) enclosure villages depending directly and entirely on the forest resources provided by the forest.

Household Annual Income: Household annual income is taken as an aggregate of Forest Income, Agricultural income, income from grazing, livestock income, and Wage income, which is given as

Household annual income = {Forest Income+ Agricultural Income+ Livestock Income}

Table-2 : Value of Agriculture in BNP villages.

Name of Crop	Quantity (qts)	Value of Output (Rs.)	Rate per quintal (Rs.)	Percentage of families
Ragi	4931	16272300	3300	100
Maize	582.5	1747500	3000	69.5
Millets	5.5	44000	8000	5.5
Pulses	185.2	1852000	10000	55
Mustard	146.4	2196000	15000	85
Horse gram	113.85	455400	4000	72
Jowar	103.3	619800	6000	52
Groundnut	101.65	1524750	15000	47.50
Castor	163.5	654000	4000	98.55
Total		2,47,11,750		

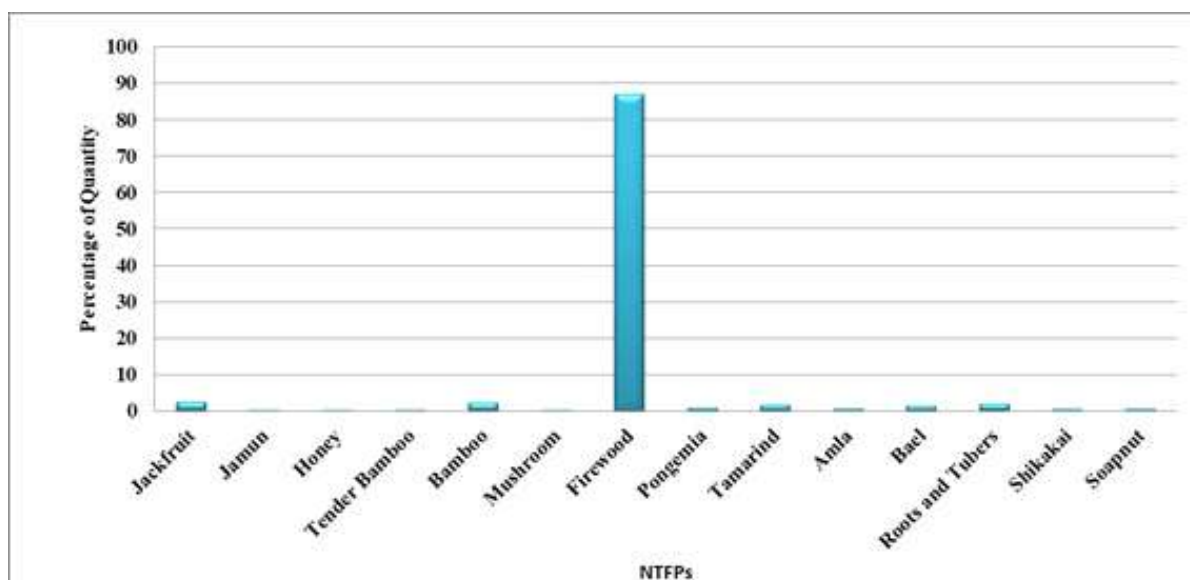
Source : Author's field data, 2021.

Table-3 : Value of NTFPs collected by Households of BNP.

NTFP	Qty (qtls)	Value of Output (Rs)	Percentage of qty	Percentof HH collecting	Price per kg	Income per HH (Rs/year)	Qty per household (year)
Jackfruit	234.50	1172500	2.53	96.5	50	5862.5	117.25kgs
Jamun	25.54	257100	0.28	86	80	1021.6	12.17kgs
Honey	7.43	743000	0.08	60	1000	3715	3.7 kgs
Tender Bamboo	38.34	1150200	0.41	68.5	300	5751	19.17kgs
Bamboo	212.16	2121600	2.29	96	100	10608	40.3 qts
Mushroom	15.69	548975	0.17	72.5	350	2744	7.84kgs
Firewood	8061	8061600	86.85	99	10	483696	40.3 qts
Pongamia	81.78	245340	0.88	87	30	1226.7	40.89kgs
Tamarind	143.3	2866000	1.54	75	200	14330	71.65kgs
Amla	62.1	745200	0.67	49.5	120	3726	31.05kgs
Bael	136.2	408600	1.47	87.5	30	2043	68.1kgs
Roots and Tubers	172.96	345920	1.86	78.5	20	1729.6	86.48kgs
Shikakai	44.37	887400	0.48	46.5	200	4437	22.18kgs
Soapnut	46.26	925200	0.50	42	200	4626	23.13kgs
Total		2,04,25,855					

Source : Author's field data, 2021, Note: Kgs – Kilograms; qts - Quintals

Fig.-3 : NTFPs from BNP (percentage of quantity).



Source : Author's field data, 2021.

Table-4 : Value of livestock and fish provisioning service by BNP households.

Livestock	Qty(Qts)/year	Value of Output/year	percent of HHs collecting	Qty per HH/year	Income per HH/year	Cost per kg
Milk	2,187.84	55,12,000	94	1093.9 kgs	27,560.5	26 per litre
Egg	5.58	1,11,480	95.5	55.86 kgs	557.4	5 per egg
Ghee	29.69	11,87,600	92	14.85	5938	2,000
Fish	144.04	21,60,600	88.5	72.02	10803	150
Total		89,71,680				

Source : Author's field data, 2021.

Table-5 : Value of Medicinal plants foraged by BNP households.

Medicinal Plants	Quantity(qts)	Value of Output	Percentage	Qty per HH	Income per HH(Rs)	Cost per kg (Rs)
Neem	83.9	419500	89.5	41.95	2097.5	50
Turmeric	51.85	1037000	84	25.92	5185	200
Local Herbs	31.92	638500	71.5	31.9	3192.5	100
Total		20,95,000			10,475	

Source : Author's field data, 2021.

Table-6 : Value of plantations cultivated by BNP households.

Plantations	Quantity	Value of Output	Percentage	Qty per HH	Income per HH	Cost
Coconut	9910 units	198200	14	49.55 units	991	20 per unit
Banana	2238 qts	3357000	9.5	1119 kgs	16785	15 per kg
Total		35,55,200			17,776	

Source : Author's field data, 2021.

Table-7 : Value of other crops cultivated by BNP households.

Other Crops	Quantity qts	Value of Output (Rs)	Percentage of HHs growing	Qty per HH	Income per HH (Rs)	Cost per kg
Mulberry	254.04	88,91,400	64.5	127	44,457	350

Source : Author's primary data, 2021.

The value of forest grazing was estimated based on a substitute approach using the cost of fodder bought from the market in summer months when there is no availability of agricultural waste or grass from forests.

Bannerghatta National Park provides provisioning services like wild fruits (Amla, Bael, Jamun, jackfruit) roots & tubers, wild vegetables (drumsticks, green leafy vegetables, mushrooms), non-timber forest products (NTFPs) like wild honey, shikakai, soapnuts, tamarind, Pongamia, fodder for grazing of livestock, firewood for cooking, and medicinal plants.

In this study, we try to analyze the value of provisioning services provided by BNP and what is the income from this kind of service to each household. From table 1, it is seen that the various provisioning services are grouped into the categories like agriculture (food crops), NTFPs, Grazing, Livestock, Medicinal Plants, Horticulture, Plantation, and other crops.

Agriculture inside the BNP villages is predominantly Ragi-dominant. Ragi is the staple crop for the forest dwellers of BNP. And along with Ragi, they grow Castrol, mustard, horse gram, and hyacinth beans as mixed crops.

The agricultural waste post-harvesting is again used as feed for livestock.

Medicinal plants chosen for the study area are local herbs used to treat ailments both for humans as well as cattle, neem, and turmeric. Turmeric is used for cooking as well as for medicinal purposes and for storing grains. Neem is used for medicinal as well as for storing and preserving purposes.

Agriculture constitutes about 14.11 percent. And the value from NTFPs is 21.23 percent of the total quantity. Value from livestock is 5.41 percent of the output. Horticulture plantations and othercrops constitute 2.74 percent and 0.95 percent respectively. Grazing is the highest among all the provisioning services as the dwellers are predominantly agriculture and livestock herders. The interior regions of BNP are almost cut off from the outside world for day-to-day activities and hence the dependency on livestock is high along with agricultural activities.

From the above figure, we can see that grazing is highest among the provisioning services but this isn't totally from the forest, some portion of this grazing is met

from the agricultural waste post every harvest. Grazing is the highest among all the provisioning services as the dwellers are predominantly agriculture and livestock herders. The interior regions of BNP are almost cut off from the outside world for day-to-day activities and hence the dependency on livestock is high along with agricultural activities.

In the above figure, the value from agricultural activities and livestock is 28.67 percent and 10.41 percentage respectively. Most of this produce is used for self-consumption. NTFPs constitute 23.7 percent of total output. Firewood is part of NTFP but again the rate in the local market is less. The least is from the medicinal plants i.e.; 2.43percent. Horticulture, plantation, and other crops constitute 6.98, 4.12, and 11.07 percent of the total output. Most of this produce is used for self-consumption. NTFPs constitute 11 percent of total output. Firewood is part of NTFP but again the rate in local market is less, Rs 10 per kilo. The least is from medicinal plants i.e. 1.2%. Horticulture plantations and other crops constitute 3.43, 2.03, and 5.45 percent of the total output.

The above table-2, shows various crops grown by the households in the surveyed villages. Ragi is the staple food crop of forest-dependent dwellers and hence the yield of 4,931 quintals by 200 households. And this is grown by all the households surveyed in the Kharifseason. The minimum support price for Ragi is Rs 3,300 per quintal. The total value of the Ragi grown by the households is Rs1,62,72,300 which forms the major part of the entire agricultural produce by the dwellers.

Along with ragi, mustard, horsegram castor and hyacinth beans are grown in the kharif season. Horse gram is grown by 72 percent of households with an annual yield of 113.85 quintals. The cost of horsegram is Rs. 4,000 per quintal.

Along with the above crops, crops like groundnut jowar, maize, and pulses are grown, by households who either have access to a waterbody or have bores in their crops. The reason why only 47.5 percent of households cultivate groundnut and 69.5 percentof households cultivate maize.

Millet are cultivated by a mere 5.5 percent of the households producing a yield of 5.5 quintals. Though millets like foxtail and kodo are grown, farmers reported huge losses due to birds. Reason why very few prefer to grow these crops. Pulses are grown in the kharif season in the summer months, by 55 percent of the households and the annual yield of the pulses is 185 quintals. Castor oil seeds are grown alongside the ragi crop by almost 98.5 percent of farmers and harvested a yield of 163 quintals. This is used to extract oil. This oil is used for oral application for skin and hair.

A study by Nanjundaih C in 2004 has found that local communities of Nagarhole National Park depend to a great extent on National Park for a wide range of NTFPs in supporting their livelihood needs as in many other PAs. NTFPs are the Non- timber Forest Products obtained from the forests. BNP being a national park, timber sale is banned. The various NTFPs provided by BNP are specified in the above table no 3. Firewood is a major NTFP collected by the surveyed households. It constitutes 86 percent of the total NTFPs and output wise its 4,83,696 quintals per annum and 40.3 quintals per household per annum. This is because a majority of households depend on firewood for cooking and also for heating water for bathing purposes.

Jackfruit constitutes the next highest collected NTFP with a total of 234.5 quintals per annum and constitutes 2.53 percent of the total output. Per household, this is about 117 kgs per annum. Some of this is sold in the nearby markets. And 96% of the households collect jackfruits. Income from jackfruits is Rs. 5,862.5 per annum per household.

Soapnuts and shikakai are collected by around 40 percent of households. And this is used for washing hair and other cleaning purposes. Some households specified that even washing cows and buffaloes with the concussion of soapnuts and shikakai.

Along with agriculture, the households depend on livestock for their sustenance, and milk is also sold in the nearest dairies which add to the family household income. The total liters produced are converted to kilograms (1 liter milk =1.032 kgs) and the final quantity per year is 3,868.5 quintals after converting it into kilograms.

Most villages have water bodies near the village and hence fish is consumed in the available seasons. Post monsoons it is available in plenty. 144 quintals of fish were consumed by 85 percentof households.

Medicinal plants locally available in the forest of Bannerghatta are collected and used by the forest dwellers for treating the ailing people as well as livestock. Neem is used for storing crop produce and turmeric is used for various purposes ranging from cooking to treating ailments. Local medicinal herbs like Eshwari Beru, Bevunu soppu, Ankale soppu, Nilgiri Soppu, Mutrumunuga soppu, Mulu mutuka soppu, Kakkere soppu, Bavanegadde, Kaadu kumura – for controlling diarrhea in livestock are foraged by the local communities for their wellbeing.

Local edible greens like Seege soppu, Vangave soppu, Honagane soppu, Anne soppu, Mudigere soppu, Donike soppu, Bendle soppu, Kadulu soppu are also foraged from the lake surroundings, and the forest areas. Lake catchment areas are enriched with different varieties of edible greens which form a significant part of the local cuisine.

Household Annual Income : Household annual income is taken as an aggregate of Forest Income, Agricultural income, income from grazing, livestock income, which is given as :

$$\text{Household annual income} = \{\text{Forest Income} + \text{Agricultural Income} + \text{Livestock Income}\}$$

The value of forest grazing was estimated based on a substitute approach using the cost of fodder bought from market in summer months when there is no availability of agricultural waste or the grass from forests.

$$\text{Forest Income} = \{\text{Fire wood income} + \text{wild fruits Income} + \text{Grazing Income} + \text{Income from NTFPs} + \text{Medicinal Plants income}\}$$

$$= 2,04,25,855 + 1,08,76,250 + 20,95,000$$

$$= \text{Rs } 3,33,97,105$$

$$\text{Income per household} = \text{Forest Income} / \text{No of households}$$

$$= \text{Rs } 1,66,985.5$$

The forest income is an indicator of the dependency of households on the forest. The total dependency of the households on forests is Rs. 1,66,985 and a huge chunk of this income is from grazing of livestock in the forest and gomala areas.

$$\text{Agricultural Income} = \{\text{Horticulture Income} + \text{plantation income} + \text{other crop income} + \text{Food crops income}\}$$

$$\text{Agricultural income} = 60,12,252 + 35,55,200 + 95,45,400 + 2,47,11,750$$

$$= \text{Rs } 4,38,24,602$$

$$\text{Per household income} = \text{Rs } 2,19,123$$

$$\text{Livestock \& Fish Income} = \{\text{Income from milk} + \text{income from ghee} + \text{income from Fish} + \text{income from egg}\}$$

$$= \text{Rs } 89,71,680$$

$$\text{Income per household} = \text{Rs } 44,858.4$$

Total value of Provisioning services by BNP : The total value of the provisioning services both collected and cultivated by the local communities of BNP is

$$\text{Total Value of Provisioning Services in BNP} = \text{Agricultural output} + \text{NTFP output} + \text{Grazing output} + \text{Livestock output} + \text{Medicinal plants output} + \text{Horticultural output} + \text{Plantation output} + \text{other crops output}$$

$$= 8,55,39,387$$

The total value of provisioning services used by the 200 households is Rs 8,55,39,387 which is Rs 4,27,696.9 per household per year. In US dollars this is \$11,25,518.25.

And the value of provisioning services per hectare is

total value of provisioning services divided by the area accessible to the forest dwellers. This is 7851.3 hectares if 30 percent of the national park is accessible (at 2020-21 prices). Hence the value at 30 percent accessibility is Rs 10978.23 per year per hectare. This will give us a total value of Rs 8,61,93,377.2 which is US \$ 1,134,123.

The households surveyed spent about 5.33 hours for the collection of provisioning services and on average 2 people from each household collected the provisioning services. The average landholding for each household is 3.4 acres.

Total number of hours spent in collecting provisioning services	5.33 per day
Average number of family members involved in collecting provisioning services	2.22 per family
Land holding	685 acres (avg 3.4 acres per household)

The households surveyed spent about 5.33 hours for the collection of provisioning services and on average two (2) people from each household collected the provisioning services. The average landholding for each household is 3.4 acres.

Conclusion

BNP has a shape index of 4.85 and is one of India's most fragmented and irregularly shaped national parks. It is also very close to India's 6th largest city, Bengaluru. The shape of the BNP is irregular and fragmented but it also houses 16 enclosure villages and 77 fringe villages that are directly dependent on the ecosystem services provided by the BNP. This being the case, this study considers the accessibility of the forest at 30 percent of the entire BNP area as fairly more accessible than other national parks due to its fragmented structure and presence of enclosure villages.

Only 3 percent of the surveyed households studied beyond 10th standard and 69 percent of them are completely illiterate. This could be the reason why most of them are forest dependent for their livelihood. There are no Eco-Development committees in BNP for developing alternative income means for the forest dwellers. Establishments of Eco-Development Committees on a priority basis for creating alternative income for farmers living in this area to reduce their dependency on the forest for their livelihood. The farmers use very traditional methods for cultivating crops and improvements in the agricultural know-how and techniques to improve their farm yield efficiency so that their income from farm produce will considerably increase.

Policy on Agro-Forestry in the farms to ease the pressure on Bannerghatta National Park. This can provide essential timber and cater to the firewood needs of the farmers residing in BNP's enclosure and fringe villages.

Promotion of micro and small village-level agro-based firms to process the farm produce which is predominantly Ragi in this region into end products like energy drink mix, baby food mix, etc. to add to the income of the farmers and to employ the women in the region for this kind of food processing.

There is a need for establishing a market channel for the farmers to sell their produce at a better rate to the nearest market which is Bengaluru City. The best part about BNP and the farmers residing in the BNP is that they are near the city. A proper channel to sell their agricultural produce can fetch them better rates and can add to their family income and simultaneously reduce the dependency on forest products for their livelihood. An important shift for improving livelihood and reducing dependence on forests is through enhancing agricultural income (Godoy & Bawa, 1993). This requires investment in water management to raise yields and for better management of natural resources (Tiffen et al., 1994). Similarly, the adoption of off-farm livelihood diversification strategies, especially in the lean seasons (Kassie et al., 2017), advanced off-farm livelihood options and agriculture production, and the availability of credit to generate higher household income and wealth are important interventions to reduce the dependence on forests (Angelsen & Kaimowitz, 1999). In the study area, agriculture and livestock rearing activities were found to be not profitable, which makes fringe dwellers, especially in the enclosure villages, more forest dependent. Therefore, for forest dwellers' well-being, they should be assisted by providing easy access to loans and training (e.g., for production and adoption of better marketing strategies) to make agricultural production profitable and to generate non-farm employment opportunities.

Mishra (2020) found that the sustenance of forest-fringe dwellers depended mostly on forestry activities, agriculture, and wage labor, and that income from other sources, such as services and business, was insignificant. Ghosal (2013) et al. came out with the finding that formulating forest governance policies that are sustainable in nature by states are backed by academic research on the indigenous social lives of forest-dependent people is vital for this. In BNP there is no emphasis on ecological governance in their management plan. It would be crucial to develop proper governance of forest areas to ensure proper management of resources.

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Germination and Initial Seedling Growth Performance of *Albizia saman* (Jacq.) Merr. on Fly Ash Substratum

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Abstract

Impact of fly ash (FA) on germination and initial seedling growth performance of *Albizia saman* (Jacq.) Merr was studied. Growing media was prepared by mixing FA to forest soil (S) at five concentrations 20%, 40%, 60%, 80% and 100% (w/w). The experimental design was CRD with six treatments and three replications. Freshly collected seeds were treated with warm water followed by cold water and sown at 5.0-7.0 cm depth in germination trays containing media of different treatments. Significant ($P < 0.05$) variation in germination (G) period, G. rate, G. capacity and G. Index with respect to FA concentration in media was observed ($n=100$). Maximum G. rate (91.00%) and G. index (28.90) were found in media having 40% FA (T_2) after 30 days of sowing. After 90 days of transplanting in poly pots containing the mentioned substrates, significant difference ($P > 0.05$) in seedling survival rate, plant height, diameter growth, leaf number, nodules per plant and seedling quality index were observed. The survival rate (94.37 %), plant height (74.14 cm), root length (44.50 cm), nodule number per plant (66.00) and seedling quality index (0.75) were at maximum in growing media having 20% FA (T_1). It is concluded from the present investigation that FA can be admixed @ 40% (w/w) in forest nurseries for improving germination and @ 20% for promoting seedling growth and quality improvement of *Albizia saman*.

Key words : Forest nursery, solid waste management, tree seedling, potting mixture, growing media, substrate, multipurpose tree species.

Introduction

Since the advent of industrial era coal based power generation is the prime source of electricity supply in India and it will continue for another few decades. Presently more than two hundred numbers of power plants are operating in India and supplying 209990.50 MW of electricity (Central Electricity Authority, 2021). Indian thermal power plants are mostly lignite based ones, as a result ash production rate is high from which the major fraction is fly ash (FA). As per an estimate a coal based power plant of 500 MW capacities produces 500 tons of FA every day (Senapati, 2011). During 2020-21, FA production in India was 232.56 million tons (CEA, 2021). FA is grey in colour, consists of fine solid particles of ashes, dust and shoot. Depending upon the source of coal metals such as arsenic (As), barium (Ba), mercury (Hg), cadmium (Cd), selenium (Se), chromium (Cr), nickel (Ni), vanadium (V), lead (Pb) and zinc (Zn) are also found mixed with FA (Dwivedi and Jain 2014). Hence FA is a potential dangerous solid waste for environment pollution if not utilized properly or disposed off. Presently FA is being utilized for manufacturing of cement, concrete bricks, wood substitute products, in road construction, wasteland reclamation; filling of underground mine spoils (Ahmad *et al.*, 2014, Kaur and Goyal 2015). Still ample quantities remain unutilized and needs large area of precious land for its disposal (Rawat *et al.*, 2018). In India major areas of FA utilization include construction of roads

and embankments, production of cement, mine-filling, reclamation of low-lying areas, making bricks and tiles (Environment Annual Reports, 2014-15).

Based on the coal source many plant nutrients except nitrogen and phosphorous are found in FA (Sharma and Karla 2006). Hence there exists a vast scope for utilization in agriculture and forestry sector. In forestry sector FA can be utilized in nurseries as growing media, reclaiming sites of afforestation and reforestation. Apart from improving rhizosphere soil improvement, it can lock the metallic toxins in the woody biomass (Cheung *et al.*, 2000). Addition of FA in potting mixture enhanced the seedling quality in *Leucaena leucocephala*, *Peltophorum ferruginum*, *Sesbania grandiflora* (Behera *et al.*, 2018, Behera *et al.*, 2020, Lachungpa *et al.*, 2020).

Albizia saman (Jacq.) Merr. (Syn. name *Samanea saman* (Jacq.) Merr. Fabaceae) commonly known as rain tree is a nitrogen fixing multipurpose tree species possessing rapid growth potential and diverse ecological significance. It is a most promising species for reclamation of mine overburden soils, water logged wastelands and canal bank plantation. Tolerance in infertile, over exposed, acid, alkaline or seasonal waterlogged soil, and mine overburden soil makes it very useful species for reclamation purpose. Rudimentary information relating to impact of FA on germination and seedling growth limits its use in reclamation of ash ponds

and lagoons. The present work was conducted to develop base line information with this respect.

Materials and Methods

The experiment was conducted in College of Forestry, Odisha University of Agriculture and Technology, Bhubaneswar situated at 20° 15' N latitude and 85° 52' E longitude with altitude 25.9 m amsl. FA was collected from one of the silages of Indian Metals and Ferro Alloys (IMFA) Limited, Choudwar, Cuttack (Odisha). The mean monthly temperature, relative humidity and rainfall of the experimental site is given in Fig.-1.

Growing media preparation and analysis for physicochemical properties : Growing media was prepared by mixing FA to forest soil (S) at concentrations 20%, 40%, 60%, 80% and 100% W/W. There were six treatments (T₁-20% FA+S, T₂-40% FA+S, T₃-60% FA+S, T₄-80% FA+S, T₅-100% FA) including control (T₆-S). The growing media was analysed for physical and chemical properties. Bulk density (BD) and water holding capacity (WHC) was determined by using the protocol given by Piper (1966). pH and electrical conductivity (EC) were measured following protocol given by Jackson (1967), organic carbon (OC) was estimated as per Walkley and Black (1934). Available nitrogen, phosphorus and ammonium acetate extractable potassium were estimated as per the procedure given by Subbiah and Asija (1956), Olsen et al. (1954) and Merwin and Peech (1951) respectively. The physical and chemical properties of growing media are given in table-1.

Seed treatment and sowing : Freshly collected seeds were given hot water treatment prior to sowing. Seeds were soaked in cold water (at room temperature 25°C) for 24 hours (Alamgir and Hossain., 2005). Eighteen germination trays having dimension 90 cm (L) × 45 cm (B) × 15 cm (H) were filled with above six mentioned growing media to the brim leaving 3.0 cm. Hundred seeds per replication (totalling 300 seeds per treatment) were sown at 1.0-2.0 cm depth, covered with paddy straw and kept at open nursery condition. Regular watering was made during morning hours as per the requirement. Observations pertaining to germination parameters were recorded daily up to 30 days after sowing. Germination period was determined by observing the day taken for first germination (DTFG) to 30th day when about 80-85% seeds have germinated. Based on the number of seeds germinated the following parameters were calculated as per the standards given by Czabatore (1962) and AOSA (1983).

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

Germination capacity

$$= \frac{\text{Total seeds germinated + viable seeds}}{\text{Total No. of seeds sown in all replications}} \times 100$$

$$\text{Germination Value} = \text{PV} \times \text{MDG}$$

Where, PV = Peak value of Germination

MDG = Mean daily Germination

$$\text{Germination Index} = \frac{\sum_{i=1}^n \frac{\text{Number of seeds Germinated}}{\text{Days}}}{n}$$

Where i = day of first count n = day of last count

Seedling growth and quality : After completion of germination study, seedlings were transplanted into poly pots (22.86 × 12.7 cm) containing growing media of above mentioned treatment combinations. Growth parameters such as shoot length, collar diameter and number of leaves were assessed monthly after 30 days of transplanting for 3 months. Total shoot length was measured by using ruler (taken from the apical bud of the plant to the base of the shoot) and stem diameter by using electronic digital calliper (6"/150 mm, accuracy ± 0.01 mm, Mitutoyo- CD-6?ASX:500-196-30).

For recording the quantitative parameters pertaining to root growth, the entire seedling was dipped in a bucket of water at 90 days to remove adhering soil from it. It was then carefully washed so that no damage was made to root system. Length of roots (starting from collar region to the end point) and number of root nodules were recorded. Thoroughly washed seedlings (without damage to root and shoot) were dried under sun for 30 minutes. The shoot was cut from the collar portion and weighed. Then the root and shoot sample were put in paper bags separately and were oven dried at 80°C until constant weight observed. Growth observation was based on 45 numbers of randomly selected plants from each treatment. The seedling quality index (SQI) was calculated by using the formula as described by Dickson *et al.*, (1960).

$$\text{SQI} = \text{Seedling dry wt. (gm)} / \frac{\text{Height (cm)}}{\text{Diameter (mm)}} \times \frac{\text{Shoot dry Wt. (gm)}}{\text{Root dry Wt. (gm)}}$$

The experiment was completely randomized design (CRD) with six treatments and three replications. The collected data were analysed by using SPSS software version 20 for windows operating system. Analysis of variance (ANOVA) was carried out to determine the treatments effect on seed germination and early seedling growth. Means were analysed according to the Duncan Multiple Range Test (DMRT) at P < 0.05 (Duncan 1955).

Results and Discussion

Fly ash is a noxious solid waste seeking proper disposal and management. It has some multifarious utility. Still ample amount left unutilised at disposal sites of thermal power plants polluting air and water. There exists a vast scope for utility in forestry sector as potting mixture

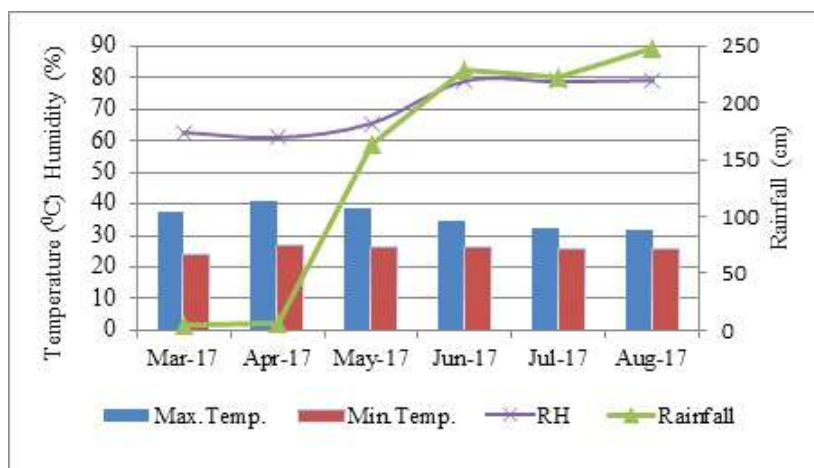


Fig.-1 : Climatic parameters of the experimental site.

ingredient and soil improvement material at difficult sites prior to plantation. The matrix of application depends upon the elemental composition of FA to be used, tolerance limit of plant species selected and physiochemical property of plantation site soil or growing media in which FA need to be added. Fertility status of poor degraded waste lands and problematic soils are successfully improved by FA addition to varying degrees in different agro-climatic situation. Enhancement in crop yield and vegetative growth tree species have been reported by many workers when applied judiciously (Kumar *et al.*, 2002, Sinha *et al.*, 2005, Ramesh *et al.*, 2008, Chaudhary *et al.*, 2009, and Krzaklewski *et al.*, 2012, Behera *et al.*, 2018.)

Effect of FA mixed substrate on seed germination : A success of plantation programs needs uninterrupted supply of quality seedlings. Growth media have a profound impact on germination and subsequent growth of embryo. Seedlings raised on good media ensure better establishment and growth when planted to the main field. The ultimate advantage of a suitable substrate is good drainage, water holding capacity and adequate supply of nutrients thereby, producing excellent disease-free seedlings (Noble 1993). Property of growing media especially pH and water retention capacity have a marked impact on germination. pH affects germination either by increasing the osmotic pressure of the media to a plant that will retard or prevent the intake of water or by causing toxicity to the embryo (Rashid 2004). Addition of FA to growing media modifies the physical and chemical property of growing media and produced a significant ($P < 0.05$) impact on seed germination parameters viz. g. rate, g. capacity and g. Index (Table 2). Similar type of observations was reported by Behera *et al.*, (2020) in *Leucaena leucocephala*.

The highest seed germination rate (91.00%) was observed in substrate having 40% FA (T_1) and statistically at par with ($P > 0.05$) treatment T_1 (89.782%) and T_3 (88.73%). The germination rate of 71.82% in T_5 and

66.56% in control (T_6) are statistically at par ($P > 0.05$) with each other. The increased germination rate (91.00%) in 40% FA admixed growing media was attributed to the improvement in the physicochemical condition of germinating media over control (66.56%, Table-2).

Fathurrahmana *et al.*, (2015) reported maximum 76.66% germination for hot water treatment (Immersion in hot water at 50°C for 4 min) of seeds of *A. saman*. The increased germination by addition of FA (up to 60%) is a promising way of improving germination of *A. saman*. The reduced rate of germination beyond 60% FA addition (w/w) in growing media was due to enhanced pH and elemental toxicity. Reduced biological activities at elevated pH of growing media and metallic ions have been reported by Gupta *et al.*, (2000). There existed negative relationship between FA rate with DTFG, germination percentage, germination capacity and germination index but it was positive with, germination period (Table-2).

Effect of FA mixed substrate on seedling growth : After 90 days of transplanting significant difference ($P > 0.05$) in survival rate, plant height, diameter growth, number of leaves, mean root length, nodules per plant and seedling quality index of *A. saman* was observed (Table-3).

Highest seedling survival rate (94.37%) was found in growing media containing 20% FA (T_1) which was statistically ($P > 0.05$) indifferent from control (93.07%). The maximum survival rate (94.37%) of seedlings in treatment T_1 was due the improved aeration, water retention capacity and favourable pH of substrate (Table-1). The survival rate decreased linearly with increased concentration of FA up to minimum 66.03% in growth media having 100% FA (Table-3). The maximum height (74.14 cm) was found in treatment having 20% FA (T_1) and was statistically different from all other treatments. The diameter growth of 1.14 cm in control was

Table-1 : Physicochemical properties of fly ash, forest soil and fly ash substratum.

Property	Forest Soil (S)	Fly ash (FA)	FA substrate (Forest soil + FA % (w/w))			
			S + 20% FA	S + 40% FA	S + 60% FA	S + 80%FA
pH	6.95	7.67	7.08	7.34	7.52	7.82
EC (dS m ⁻¹)	0.674	0.212	0.240	0.282	0.320	0.467
N (kg ha ⁻¹)	0.003	125.50	109.17	98.67	82.50	37.80
P (kg ha ⁻¹)	6.80	56.13	47.34	36.92	20.59	14.38
oK (kg ha ⁻¹)	156.43	474.36	466.20	509.92	546.2	607.17
OC (%)	0.006	0.570	0.529	0.464	0.382	0.264
BD (g cm ⁻³)	0.68	1.48	1.44	1.24	0.95	0.76
Pore space (%)	49.52	32.8	44.2	46.4	48.25	49.35
WHC (%)	59.2	42.05	45.34	47.22	48.85	56.21

Values are Mean (N=Arithmetic mean); FA- fly ash; S- Forest Soil, EC- Electrical conductivity, NPK-Available Nitrogen, Phosphorous and Potash, OC-Organic carbon, BD-Bulk density, WHC-Water holding capacity.

Table-2 : Effects of substrates on germination of *Albizia saman* seeds at 30 days after sowing.

Parameters Treatments	DTFG	G. Period	GP (%)	GC	GV	GI
T ₁	12.33 ^a	12.00	89.78 ^a	92.87 ^a	202.65 ^a	25.24 ^{ab}
T ₂	11.33 ^{ab}	8.00	91.00 ^a	96.79 ^a	208.23 ^a	28.90 ^a
T ₃	8.67 ^b	8.00	88.73 ^a	94.00 ^a	191.36 ^a	20.37 ^c
T ₄	7.67 ^c	8.00	81.30 ^b	84.66 ^b	163.94 ^b	20.84 ^{bc}
T ₅	7.33 ^c	7.00	71.82 ^c	82.56 ^b	112.03 ^c	18.37 ^c
T ₆	5.67 ^c	6.00	66.56 ^c	65.74 ^c	138.94 ^b	17.36 ^c
Statistical analysis						
P (0.05)	0.04	NS	0.015	0.022	0.09	0.045
SE	0.67		2.38	2.57	8.95	1.09
F	5.79		2.37	6.88	2.12	1.93
Linear regression analysis (y = concerned parameter, x = FA rate)						
y=	12.14-0.07x	-	90.99-0.19x	99.51-0.27x	166.29+0.06x	25.49-0.07x

Treatments T₁=(20% FA+S), T₂=(40% FA+S), T₃=(60% FA+S), T₄=(80% FA+S), T₅=(100% FA), T₆=(Soil/Control), FA- fly ash, S- Forest Soil, DTFG- Days taken for first germination, GP- Germination Percentage, GC- Germination Capacity, GV- Germination Value, GI- Germination index. Mean values followed by same letter are statistically indifferent.

statistically at par with T₁ (0.92 cm). The number of leaves (24.07) and mean root length (44.50 cm) in treatment T₁ were statistically at par with the corresponding observations in treatment T₂. The number of nodules per plant (66.00) in treatment T₁ was in comparable with control (60.33). The seedling quality index in treatment T₁ (0.75) was significantly different from other treatments and it was in line with the observations of Gupta *et al.*, (2000) and Pandey *et al.*, (1996).

The vigour in seedling height, diameter and root growth of this species at 20% FA was due to optimum pH, improvement in availability of nutrients in ionic form at rhizosphere solum, increased nodulation and nitrogen fixation rate (Table -2). Goyal *et al.*, (2002) observed 10% increase in the growth of *Eucalyptus tereticornis*, *Acacia auriculiformis* and *Casuarina equisetifolia* during early 6 months, grown in FA amended soils (ESP FA@18–24% (v/v)). The maximum root nodulation per plants (66.00) in growing media having 20 % FA could be attributed due to uptake of optimum amount of metals by the roots. However, the nodulation rate decreased with increased

concentration of FA in a dose dependent manner up to 100% FA. This is due to the reduced ability of nitrogen fixing bacteria with increasing stress level (Faizan and Kaushar 2010).

The depressive nodulation effect was substantiated by reduced plant height, collar diameter growth and SQL. Further the plants grown in 20% FA were observed very healthy. Better seedling quality index in T₁ (0.75) was obviously due to the improved availability of micro-nutrients that supported higher biomass production and shoot: root ratio (Gupta *et al.*, 2000). Ariful Islam *et al.*, (2019) observed seedling quality index in the range of 0.61-1.81 for *Acacia auriculiformis* after eight months grown on different substrates. The present SQL after three months of transplanting is within that range.

Conclusions

Albizia saman is a fast growing multipurpose legume tree species and much preferred for wasteland reclamation, social forestry, canal bank plantation, as shade tree roads, multipurpose wood lots and energy plantations. Robust and healthy propagule is indispensable for raising a

Table-3 : Effects of substrate on growth and quality of *Albizia saman* seedlings at 90 DAT.

Parameters Treatments	Survival (%)	Plant height (cm)	Collar diameter (cm)	Number of leaves	Mean root length (cm)	Nodules/ Plant (No.)	SQI
T ₁	94.37 ^a	74.14 ^a	0.92 ^a	24.07 ^a	44.50 ^a	66.00 ^a	0.75 ^a
T ₂	89.73 ^b	70.01 ^b	0.58 ^b	22.10 ^a	38.00 ^{ab}	43.50 ^b	0.59 ^b
T ₃	85.07 ^c	56.05 ^c	0.56 ^b	22.83 ^{ab}	23.50 ^{bc}	41.00 ^b	0.57 ^b
T ₄	73.40 ^d	42.18 ^d	0.61 ^b	15.33 ^c	23.00 ^{bc}	21.00 ^c	0.29 ^{cd}
T ₅	66.03 ^e	29.31 ^e	0.36 ^c	18.27 ^c	12.66 ^c	9.33 ^c	0.24 ^d
T ₆	93.07 ^a	58.64 ^c	1.14 ^a	18.72 ^{bc}	33.50 ^{ab}	60.33 ^a	0.44 ^{bc}
Statistical analysis							
P (0.05)	0.003	0.017	0.012	0.024	0.009	0.018	0.011
SE	2.55	3.76	0.06	0.83	3.07	5.06	0.05
F	23.71	17.65	16.44	8.68	5.64	27.24	14.85
Linear regression analysis (y = concerned parameter, x = FA rate)							
y =	98.27-.29x	68.21-.26x	0.96-.003x	22.2-.04x	38.21-.18x	68.23-.56x	0.62-.003x

Treatments T₁=(20% FA+S), T₂=(40% FA+S), T₃=(60% FA+S), T₄=(80% FA+S), T₅=(100% FA), T₆=(S/Control), FA- fly ash, S-Forest Soil, SQI-Seedling Quality Index, Mean values followed by same letter are statistically indifferent.

successful plantation. It also reduces the beating up cost. It was observed in the present course of investigation that FA has a positive impact on germination and early seedling growth at certain limit 20% (w/w). It is recommended that FA should be admixed at 20-40% (w/w) level in nursery beds for early sprouting, improving germination percentage, and for production quality planting material.

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Influence of Nutrient and Irrigation Management Practices on Mango + Pineapple Agroforestry System

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Abstract

Fruit based agroforestry system is a highly sustainable, self-reliant and most adoptive practice in Coastal Odisha. A field experiment was conducted at the experimental site of AICRP on Agroforestry Research Farm, OUAT, Bhubaneswar, Odisha during May 2020 to June 2021. The experiment comprised of three main plots including three irrigation systems i.e., sprinkler, drip & ridge furrow and four subplots including nutrient management such as organic [FYM + Dry leaf mulch + biofertilizer (Azotobacter: Azospirillum: PSB in 1:1:1){4 kg each/ha}], recommended dose of fertilization (RDF) (75%) + FYM, RDF (100%) + FYM, RDF (125%) + FYM. The treatments were replicated thrice and the experiment was carried out in split plot design. The mango trees planted at a distance of 6 x 6 m² and spacing between the intercrop pineapple 75 x 60 cm². During the investigation period The biometric observation of Pineapple such as D-leaf length (67.3 cm), plant height (93.9 cm), crown spread (151.7 cm) and number of leaves (49.3) were observed highest with RDF (125%) + FYM and similar trend also followed in pineapple with drip irrigation system. The application of RDF (125%) + FYM was found the best with the highest yield of mango and pineapple (72.39 q ha⁻¹ and 93.82 q ha⁻¹) and gave highest net return of Rs 4.02 lakhs per year per ha and BCR 3.46.

Key words : Mango, pineapple, agroforestry system, nutrient and irrigation management.

Introduction

Fruit based agroforestry system is a highly sustainable, self-reliant and most adoptive system. Now-a-days the land areas are expanding under fruit based agroforestry system. It is a promising strategy for enhancement of productivity of the land and to encounter the needs of the growing population by producing more nutritious food. The interspaces can be efficiently utilized to grow short duration horticultural & agricultural crop for income generation during the initial period of tree establishment. Fruit based agroforestry system integrates fruit trees as woody perennials and intercrops of short duration annuals in the same piece of land. According to Franzel *et al.* (1996), it has been found that farmers generally prefer for fruit producing trees when compared to other trees because of early and uninterrupted flow of income. Studies carried out by Chadha (2002) lead to the conclusion that the fruit based cropping system emerged as the most ideal system to come up with food, nutrition and income security to humankind. To meet the irrigation needs of the mango crop, a variety of irrigation techniques are used, including drip, sprinkler, basin, ring, furrow and flood. Similarly, a lack of fertilisers and nutrients, or improper application of fertilizers and nutrients, can cause a loss of vigour in crops, as well as a reduction in their nutritional content and the onset of various illnesses in crops as a result of a lack of nutrients, or even a specific nutrient. The pineapple is one of the best choice for intercrop because its water use efficiency is three times higher when compared to C4 plants and six times higher

when compared to C3 plants. Despite multiple studies on the production characteristics of diverse crops in agroforestry systems, there is a need to standardise the irrigation and fertilisation regime required to attain optimal output and productivity in fruit-based agroforestry systems.

Materials and Methods

The present experiment was conducted at the experimental site of All India Co-ordinated Research Project on Agroforestry, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar during May 2020 to June 2021. The experimental plot is geographically positioned at 20°15' N longitude and 85° 52' East latitude having an elevation of 25.9 meter above mean sea level. The soil is chiefly red lateritic, that has loamy sand to sandy loam texture. The rainfall received during the observation phase of May 2020 to June 2021 was 1493.7 mm in a 113 rainy days. The experiment was laid in split plot design. & replicated thrice which was consisted of three main plots and four sub plots. There were three irrigation systems (sprinkler irrigation, drip irrigation and ridge-furrow irrigation) along with combination of four types of nutrient management [Organic (FYM 10t/ha) + Dry leaf mulch 01 ton/ha) + Biofertilizer (Azot:Azos:PSB 1:1:1 Kg/ha), RDF 75% + FYM, RDF 100% + FYM and RDF 125% + FYM]. The experimental plot was laid out into small plots of size of 12m x 6m for different treatments as per the plan of layout. Pineapple plants at 75 x 60 cm were intercropped with a twenty years old mango orchard. A

dose of N - P_2O_5 - K_2O - 12 - 8 - 10 g per pineapple plant was applied in the form of Urea, Diammonium phosphate (DAP) and Murate of Potash (MOP), respectively. For chemical analysis, top soil samples were collected of each plot before planting and after harvesting of pineapple. Three types of irrigation systems were used for water application micro irrigation (Sprinkler and Drip) and ridge-furrow irrigation. Irrigation was provided as per the need of the plants. The yields of mango and pineapple were recorded from each plot and the total yield was calculated at the end of fruiting season and converted to yield per hectare. Economics was calculated from the profitability of different treatments.

Results and Discussion

Influence of irrigation and fertilizer treatments on biometrics of pineapple

Influence of irrigation : During the observation period (420 to 540 days), the height of the pineapple plant was significantly impacted by different irrigation techniques, although the maximum plant height was noted in drip system, which was 86.37, 87.04, and 90.35 cm at 420, 480, and 540 days, respectively followed by sprinkler irrigation system.

Different irrigation techniques had a significant impact on pineapple plant crown spread, with drip irrigation recording the largest crown spread (145.24, 147.24 and 147.87), followed by sprinkler irrigation which showed a crown spread of 136.87, 139.43 and 139.66 and the minimal crown spread were found to be 124.66, 125.05, and 125.51 at 420, 480, and 540 days, respectively.

When different water management systems were applied, the number of leaves of the pineapple plant changed dramatically over time. At 420 days and 480 days, irrigation had a significant effect on the number of leaves of the plant whereas, at 540 days, irrigation doesn't have any significant effect on it. Application of drip irrigation produced most leaves at 420, 480, and 540 days, i.e. 47.58, 48.83, and 46.92, respectively, preceded by sprinkler irrigation, i.e. 46.08, 47.33, and 45.33.

The D leaf length was significantly influenced by the irrigation system. Under drip irrigation, however, the highest D-leaf length was recorded at 59.43, 60.44 and 60.93 cm followed by sprinkler irrigation under which 56.81, 57.77 and 58.61 at 420, 480 and 540 days whereas the minimum value was observed under ridge furrow irrigation i.e., 50.64, 51.54 and 52.71 at 420 days, 480 days and 540 days. This is consistent with Mantell *et al.* (1985), who found that drip irrigation was preferred over conventional irrigation systems due to the high water application efficiency.

Influence of fertilization : At 420, 480, and 540 days, the maximum plant height was recorded to be 89.84, 90.58, and 93.87 cm, respectively under RDF (125%) + FYM fertilization, followed by 84.16 cm, 84.94 cm and 88.69 cm under RDF (100%) + FYM. Similarly, with organic fertilisation, the lowest plant height was 69.49, 70.26 and 73.27 respectively. A significant impact of fertilization was recorded on plant height. This is synonymous with the observations of Godi *et al.* (2020), who stated that, the rise is attributable to the efficient use of fertilizers along with optimal irrigation rates.

Throughout the time of the experiment i.e., from 420 days to 540 days, the fertilizer dose had impacted significantly the crown spread, with the highest recorded with RDF (125%) + FYM at 149.31, 151.90 and 151.73 preceded by RDF (100%) + FYM (138.34, 140.74 and 140.9) and RDF (75%) + FYM (133.31, 135.94 and 136.29) and lowest recorded in organic application i.e., 122.72, 120.91 and 121.8 at 420, 480 and 540 days respectively. The steady supply of water to the plant via drip irrigation accounts for higher canopy spread, since this keeps the soil moist and eliminates water stress on the plant, resulting in increased vigour (Subramanian *et al.*, 1997).

RDF (125%) + FYM fertilisation produced the maximum number of leaves per pineapple plant, that was recorded to be 49.07, 50.11, and 48.33, respectively, followed by RDF (100%) + FYM, under which 46.22, 47.78, and 45.56, and under RDF (75%) + FYM 44.11, 45.78, and 44.33 was recorded respectively. Darnaudery *et al.* (2018) also found that pineapple yield was lower with organic fertiliser than with integrated or conventional fertilization.

At 420, 480, and 540 days, RDF (125%) + FYM treated was observed to have the maximum D-leaf length were found to be 65.75, 66.09 and 67.34 cm followed by application of RDF (100%) + FYM which recorded 59, 59.94 and 60.95 cm and application of RDF (75%) + FYM, which were noted 51.93, 52.94 and 53.80 cm. The minimum D-leaf length of pineapple plant was observed to be 45.81, 46.76 and 45.57 at 420, 480, and 540 days with organic fertilization.

Yield of mango-pineapple agroforestry system

Impact of irrigation : The influence of drip irrigation system recorded the highest yield in mangoes and pineapples i.e. 67.31 and 85.16 q per ha, followed by sprinkler system i.e. 63.67 and 79.46 q per ha while the least productivity was observed under the under the ridge furrow system of irrigation i.e. 59.56 and 73.06 q per ha.

Impact of fertilization : The different nutrient management regime had a significant impact on yield of mango and pineapples. Highest yield was achieved with

Table-1 : Influence of irrigation and fertilization treatments on Plant height, crown spread, Number of leaves & D-leaf length of pineapple.

Treatment	420 days (cm.)				480 days (cm.)				540 days (cm.)			
	Plant height	Crown spread	Number of leaves	D-leaf length	Plant height	Crown spread	Number of leaves	D-leaf length	Plant height	Crown spread	Number of leaves	D-leaf length
I ₁	81.76	136.87	46.08	56.81	82.39	139.43	47.33	57.77	85.63	139.66	45.33	58.61
I ₂	86.37	145.24	47.58	59.43	87.04	147.24	48.83	60.44	90.35	147.87	46.92	60.93
I ₃	72.88	124.66	41.83	50.64	73.46	125.05	43.17	51.54	76.76	125.51	41.42	52.71
CD at 5%	0.751	1.123	1.499	2.021	0.989	1.494	NS	1.675	0.285	1.19	1.726	1.461
F ₁	69.49	122.72	41.33	45.81	70.26	120.91	42.11	46.76	73.27	121.8	40.29	45.57
F ₂	77.85	133.31	44.11	51.93	78.06	135.94	45.78	52.94	81.16	136.29	44.33	53.80
F ₃	84.16	138.34	46.22	59.00	84.94	140.74	47.78	59.94	88.69	140.9	45.56	60.95
F ₄	89.84	149.31	49.07	65.75	90.58	151.9	50.11	66.69	93.87	151.73	48.33	67.34
CD at 5%	0.666	1.411	0.99	0.697	1.025	1.27	1.903	0.618	0.154	1.15	2.162	0.540
CD at 5%	1.431	2.751	2.42	2.608	2.097	2.782	6.62	2.193	0.42	1.45	NS	1.913

Table-2 : Yield and economics of mango and pineapple under different irrigation and fertilizer application.

Treatment	Mango productivity (qha ⁻¹)	Pineapple productivity (qha ⁻¹)	Gross return per year (in 00,000) (Rs. ha ⁻¹)	Net return per year (in 00,000) (Rs.ha ⁻¹)	BCR
Irrigation					
I ₁	63.67	79.46	4.9	3.45	2.97
I ₂	67.31	85.16	5.2	3.62	3.19
I ₃	59.56	73.06	4.53	3.03	3.02
CD at 5%	0.52	4.42	0.2	0.31	0.09
Fertilization					
F ₁	52.19	57.28	3.73	2.6	2.58
F ₂	62.09	78.84	4.84	3.2	2.96
F ₃	67.37	86.95	5.27	3.63	3.23
F ₄	72.39	93.82	5.65	4.02	3.46
CD at 5%	3.53	5.21	0.3	0.19	0.17
Interaction (I × F)					
CD at 5%	2.28	2.9	0.18	0.49	0.31

RDF (125%) + FYM i.e. 72.39 and 93.82 q per ha followed by RDF (100%) + FYM i.e. 67.37 and 86.95 q per ha and RDF (75%) + FYM i.e. 62.09 and 78.84 q per ha and organic nutrient management recorded lowest yield i.e. 52.19 and 57.28 q per ha for mango and pineapple.

The findings are synonymous with the observations of Godi *et al.* (2020) who recommended that higher amounts of water supply and fertilizer management at 60 per cent, 90 per cent, and 120 per cent E pan (mm day⁻¹) and 125 per cent recommended dose of fertilization have a beneficial impact on yield parameters in papaya cv. red lady. This was attributed to the rise of productivity features that are assisted for the boost of production of carbohydrates needed in fruit development.

Economics of mango-pineapple agroforestry system

Impact of irrigation : The highest gross return value was recorded in case of drip irrigation i.e. Rs 5.2 lakhs per ha ensuing sprinkler irrigation i.e. Rs 4.9 lakhs per ha and least achieved in ridge furrow i.e. Rs 4.53 lakhs per ha.

This is synonymous to the observation of Singh *et al.* (2013), according to whom, mechanised water supply enhanced the yield of fruit by 17.6 - 23.1%, in contrast to traditional methods of water supply.

The highest net return value was recorded in case of drip irrigation i.e. Rs 3.62 lakhs per ha ensuing sprinkler irrigation i.e. Rs 3.45 lakhs per ha and least achieved in ridge furrow i.e. Rs 3.03 lakhs per ha.

The maximum net BCR value was recorded in case of drip irrigation i.e. 3.19, followed by ridge furrow i.e. 3.02 and least achieved in sprinkler system i.e. 2.97.

Impact of fertilizer application : The maximum gross return value was achieved with treatment RDF (125%) + FYM i.e. Rs 5.65 lakhs per ha, ensued by RDF (100%) + FYM i.e. Rs 5.27 lakhs per ha and RDF (75%) + FYM Rs 4.84 lakhs per ha and least value was observed Rs 3.73 lakhs per ha.

The maximum net return value was achieved with treatment RDF (125%) + FYM i.e. Rs 4.02 lakhs per ha, followed by RDF (100%) + FYM i.e. Rs 3.63 lakhs per ha

and RDF (75%) + FYM Rs 3.2 lakhs per ha and least value was observed Rs lakhs per ha. Similar result was also reported by Behera *et al.* (2021), that among the four fertilizer treatment {[STD (100%) + FYM], [STD (75%) + FYM], [STD (50%) + FYM] and organic fertilization (FYM+ dry leaf mulch + biofertilizer)} STD (100%) + FYM with drip irrigation obtained the highest net return of Rs. 5.81 lakh and BC ratio (3.44).

The maximum BCR value was observed with treatment RDF (125%) + FYM i.e. 3.46, ensued by RDF (100%) + FYM i.e. 3.23, RDF (75%) + FYM i.e. 2.96 and least value was observed 2.58 under organic fertilization.

Conclusions

The highest D-leaf length, plant height, leaves number and crown spread observed in RDF (125%) + FYM in nutrient management and under drip irrigation among water supply system. RDF(125%) + FYM found to be the best & this resulted the highest yield of mango and in pineapple (72.39 q ha⁻¹ and 93.82 q ha⁻¹) with highest gross return of Rs 5.65 lakhs per year per ha, net return of Rs 4.02 lakhs per year per ha and BCR 3.46.

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Study of Genetic Variability Parameter and Correlation in Groundnut

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Abstract

The present investigation was carried out during season 2019-20 at Research Farm, College of Agriculture, Gwalior. The materials comprised of 42 genotypes and 6 cultivars of groundnut in randomized complete block design with three replications. Analysis of variance revealed that genotypes were found statistically significant for all characters. Estimation of high heritability value coupled with high genetic advance was recorded for number of pods per plant followed by number of kernels no per plant, kernel yield per plant, days to maturity, plant height, 100 kernel weigh and number of primary branches per plant indicating that the inheritance of these characters were most likely due to additive gene effects and direct selection for these traits would be more effective for desired genetic improvement. The correlation analysis in the present study revealed significant and negative correlation between flowering parameter days to 50% flowering with kernel suggesting that early flowering and high yield could be simultaneously selected. Pod yield presented a positive correlation with kernel yield per plant, and shelling percent in both genotypic as well as phenotypic correlation, indicating a favorable association between yield and its components. The phenotypic correlation between kernel yields exerted the highest positive direct effect on pod yield.

Key words : Estimation, characterization, evolution, clustering, morphology.

Introduction

Groundnut (*Arachis hypogaea* L.) is a member of Leguminosae family and Papilionaceae sub family. It is native of Brazil to Peru, Argentina and Ghana. Groundnut was introduced in India during the sixteenth century of the Pacific islands of China. It produces edible oil. Used as a cooking medium as refined oil and also as Vanaspati Ghee. It is a segmental allopolyploid and self-pollinated legume. It is popularly known as the "King" of oilseeds or "Wonder nut" or "Poor man's cashew nut" (Thamaraikannan *et al.*, 2009). The botanical name for groundnut, *Arachis* meaning a legume and *hypogaea* meaning below ground. It is an important protein supplement in cattle and poultry ration. Groundnut is rich in protein and vitamins A, B. Its calorific value about 349 per 100 gram. Groundnut kernels are exported to foreign countries which were produced using the Hand-Picked Selection (HPS).

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in protein and vitamins A, B. Its calorific value about 349 per 100 grams. Groundnut kernels are exported to foreign countries which were produced using the Hand-Picked Selection (HPS).

Materials and Methods

Experiment was carried out during the kharif season 2019-20 at Research Farm, Department of Genetics and Plant Breeding, RVSKVV, College of Agriculture, Gwalior (M.P.). Gwalior is located in the Grid region (Agro climatic zone No. VI, wheat-pearl millet crop zone) and situated at an altitude of 211.52 mean sea levels, 26° 13' N Latitude and 78° 14' E Longitude. The soil is sandy loam which is low in available nitrogen, medium in phosphorus and high in potash with P^H of 8.5.

Experimental material consists of 42 genotypes and 6 cultivar of groundnut received from different originations, which were obtained from Shivpuri Region of M.P. Department of Genetics and Plant Breeding, RVSKVV, COA, Gwalior.

Results and Discussion

Analysis of variance revealed highly significant differences among the genotypes for all the traits indicating thereby sufficient variability present in the material studied (Table-1).

The nature and magnitude of the variation was assessed by phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (H %) and genetic advance over mean (GAM) as presented in table 2. The estimates of phenotypic coefficient of

Table-1 : List of genotypes used in the present study.

Genotypes	Source	Genotypes	Source
RGnG-1	Shivpuri local	RGnG-14	Shivpuri local
RGnG-2	Shivpuri local	RGnG-15	Shivpuri local
RGnG-3	Shivpuri local	RGnG-16	Shivpuri local
RGnG-4	Shivpuri local	RGnG-17	Shivpuri local
RGnG-5	Shivpuri local	RGnG-18	Shivpuri local
RGnG-6	Shivpuri local	RGnG-19	Shivpuri local
RGnG-7	Shivpuri local	RGnG-20	Shivpuri local
RGnG-8	Shivpuri local	RGnG-95	Shivpuri local
RGnG-9	Shivpuri local	RGnG-96	Shivpuri local
RGnG-10	Shivpuri local	RGnG-97	Shivpuri local
RGnG-11	Shivpuri local	RGnG-98	Shivpuri local
RGnG-12	Shivpuri local	RGnG-99	Shivpuri local
RGnG-13	Shivpuri local	RGnG-100	Shivpuri local
RGnG-101	Shivpuri local	RGnG-109	Shivpuri local
RGnG-102	Shivpuri local	RGnG-110	Shivpuri local
RGnG-103	Shivpuri local	RGnG-111	Shivpuri local
RGnG-104	Shivpuri local	RGnG-112	Shivpuri local
RGnG-105	Shivpuri local	RGnG-113	Shivpuri local
RGnG-106	Shivpuri local	RGnG-114	Shivpuri local
RGnG-107	Shivpuri local	RGnG-115	Shivpuri local
RGnG-108	Shivpuri local	RGnG-116	Shivpuri local

Table-2 : Analysis of variance for yield and different attributing traits.

S. No.	Source of variation	df	DF 50%	DM	PH	NPB	NPPP	KN/P	KY/P	100 KW	SMK	SH%	PY/P
1.	Replication	2	0.65	0.22	24.31	0.02	28.63	6.13	2.73	0.19	9.51	40.64	2.89
2.	Treatment	47	49.17**	15.55**	122.71**	2.02**	77.7**	125.6**	10.49**	97.96**	83.19**	34.62**	40.38**
3.	Error	94	2.09	3.08	5.67	0.56	2.05	4.47	1.01	9.8	6.22	12.14	2.27
4.	S. Ed ±	-	0.84	1.01	1.37	0.43	0.83	1.22	0.58	1.81	1.44	2.01	0.87
5.	CD 5%	-	2.35	2.85	3.85	1.2	2.32	3.43	1.64	5.07	4.04	5.65	2.44
6.	CD 1%	-	3.11	3.77	5.11	1.58	3.07	4.54	2.17	6.72	5.35	7.48	3.23

variation were always higher than genotypic coefficient of variation signifying the influence of environmental factors, while in certain cases low magnitude of difference observed indicated that these characters were less influenced by the environments. Genotypic coefficient of variation measures the amount of variation present in a particular character. However, it does not determine the proportion of heritable variation present in the total variation. Therefore, heritability which represents the heritable variation existing in the character was calculated.

High heritability and genetic advance expressed as percentage of mean was high for pod per plant, kernel yield per plant, and plant height. It revealed that the characters are governed by additive gene effects and hence, selection would be effective in improvement of this trait. The present findings are in conformation with the findings of John *et al.*, (2007) and Khote *et al.*, (2009). Whereas high heritability along with low GAM and GCV was observed for sound mature kernel (%) indicated the

role of non-fixable genetic variance in the expression of this trait and selection for this trait would be ineffective. The estimates of high heritability for *Aspergillus* seed colonization were in conformation with Upadhyaya *et al.*, (1997) and late leaf spot and rust also showed high heritability.

The genetic and phenotypic correlations among the various characters are presented in Table 4. The pod yield per plant showed strong and positive association with kernel yield per plant, shelling percentage and SMK percent at both genotypic and phenotypic levels indicating that pod yield per plant could be used as preliminary criteria for selecting high yielding genotypes. A similar result of significant positive association of pod yield per plant with shelling per cent was reported by Abhay Darshora *et al.*, (2002). While, the significant positive association of pod yield per plant with sound mature kernel per cent was reported by Francis and Ramalingam (1997) and Vasanthi *et al.*, (1998). The Shelling per cent had significant positive association with sound mature

Table-3 : Parameters of genetic variability for yield traits in genotypes of groundnut.

S. N.	Character	Mean	Range		PCV (%)	GCV (%)	h ² b (%)	GA as % of mean 5%
			Min.	Max.				
1.	Days to 50% flowering	34.46	23.33	39	11.75	11.49	95.73	23.17
2.	Days to maturity	109.91	102.33	114	2.07	1.85	80.15	3.42
3.	Plant height	48.32	36	66.86	13.23	12.92	95.38	26.00
4.	Number of primary branches per plant	5.30	4	7.33	15.48	13.24	73.07	23.32
5.	Number of pods per plant	19.51	7.66	28.66	26.73	25.73	97.36	52.30
6.	Number of kernels per plant	22.30	10	37.33	29.02	28.50	96.44	57.65
7.	Kernel yield per plant	5.93	2.80	11.30	31.52	29.95	90.29	58.62
8.	100 kernel weight	33.36	18.66	47.33	17.13	16.25	90	31.75
9.	Sound mature kernel	87.03	71.66	93.66	6.05	5.82	92.52	11.53
10.	Shelling %	65.15	58.36	76.28	5.21	4.20	64.95	6.98
11.	Pod yield per plant (gm)	10.88	4.56	19.63	33.71	32.75	94.38	65.54

Table-4 : Phenotypic correlation coefficient for seed yield and its 12 attributing characters in groundnut.

Characters	Days to 50% flowering	Days to maturity	Plant height	Number of primary branches per plant	Number of pods per plant	Number of kernels per plant	Kernel yield per plant	100 kernel weight	Sound mature kernel	Shelling %	Pod yield per plant (gm)
Days to 50% flowering											
Days to maturity	0.252**										
Plant height	0.215**	0.078 ^{NS}									
Number of branches per plant	-0.205*	-0.147 ^{NS}	-0.006 ^{NS}								
Number of pods per plant	-0.331**	-0.064 ^{NS}	-0.042 ^{NS}	0.313**							
Number of kernel per plant	-0.324**	-0.271**	-0.007 ^{NS}	0.368**	0.661**						
Kernel yield per plant	-0.151 ^{NS}	-0.172*	-0.091 ^{NS}	0.260**	0.630**	0.572**					
100 kernel weight	0.116 ^{NS}	0.277**	0.075 ^{NS}	-0.089 ^{NS}	0.197*	-0.064 ^{NS}	0.078 ^{NS}				
Sound mature kernel	-0.228**	0.065 ^{NS}	0.108 ^{NS}	-0.023 ^{NS}	0.492**	0.206*	0.235**	0.322**			
Shelling %	0.137 ^{NS}	-0.160 ^{NS}	0.034 ^{NS}	0.134 ^{NS}	0.112 ^{NS}	0.242**	0.291**	0.008 ^{NS}	-0.036 ^{NS}		
Pod yield per plant (gm)	-0.017 ^{NS}	-0.189*	0.116 ^{NS}	0.273**	0.569**	0.604**	0.754**	0.091 ^{NS}	0.191*	0.266**	

kernel per cent and 100 seed weight as reported by Vasanthi et al., (1998). The late leaf spot also showed positive association with rust indicate that some of the genotypes have resistance to both the diseases. *Aspergillus* seed colonization exhibited significant desirable negative association with test weight revealing that the resistant genotypes in general had higher seed size.

These relationships indicate that the trait, pod yield per plant, which was found to show higher heritability and positively correlated with kernel yield per plant, shelling percentage and SMK percent, can be a good criterion to be used in selection programmes to improve yield of peanuts. Test weight, although giving a high heritability estimate, however did not show good correlations with the yield traits, and thus, is not a good criterion for selection.

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Cost Comparative Analysis of Buffalo Milk Production by Members and Non-Members of Dairy Cooperative Societies in Karnataka-A Case Study of Kalaburgi KMF

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Abstract

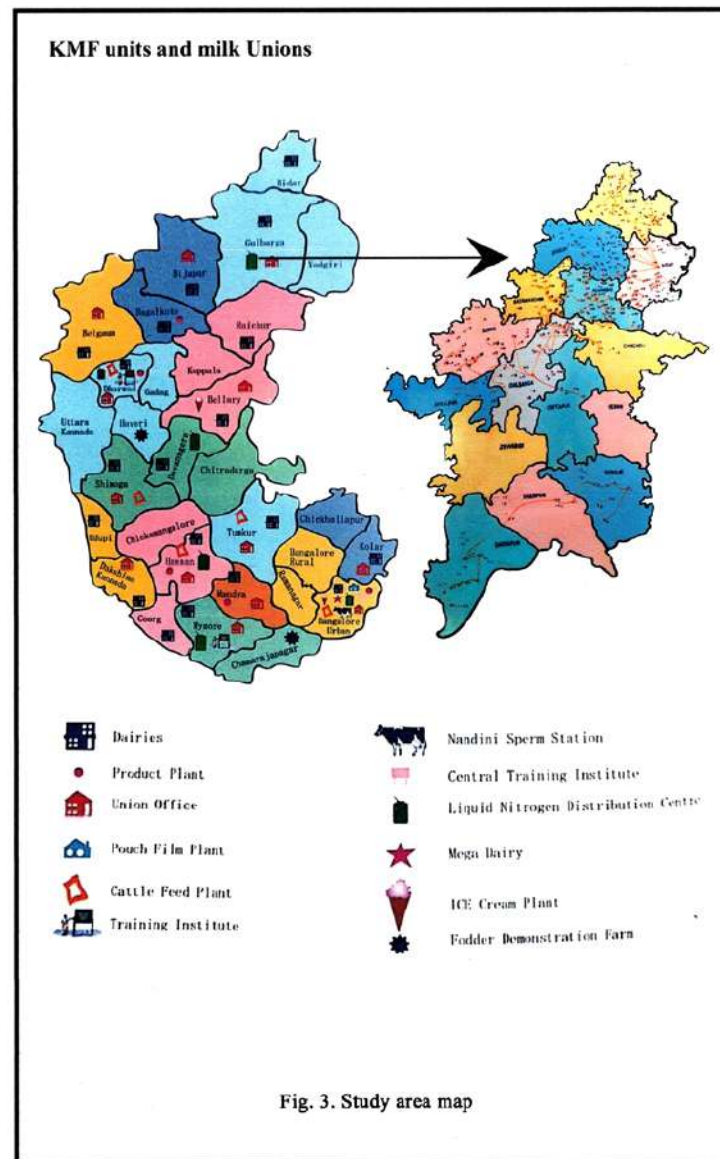
Karnataka Co-operative Milk Producers' Federation Limited (KMF) is that the apex body for the dairy co-operative movement in Karnataka. It's the second largest dairy co-operative amongst the dairy cooperatives within the country. One among the core functions of the federation is marketing of milk and milk products. The brand "Nandini" is that the household name for pure and fresh milk and milk products. KMF has 14 milk unions covering all the districts of the state which procure milk from Primary Dairy Cooperative Societies (DCS) and distribute milk to the consumers in various towns/cities/rural markets in Karnataka. The unions contain 468, 868 and 433 dairy cooperative societies respectively with a membership of 27,085, 72,001 and 44,012. Over a period of your time, these unions are improving the socio economic conditions of the dairy entrepreneurs. Hence, through this paper an effort has been made to analyse the cost of buffalo milk production by the members and non-members of DCS. The findings of the research revealed that the members of DCS have lower cost of milk production and fetched higher returns than the non-members. The major reasons behind this was the member farmers having the benefit of subsidies over feed and fodder as well as the incentives from the co-operative and govt. of Karnataka.

Introduction

Livestock and livelihood are very intimately related in our country and crop livestock integrated farming is the pathway of farmers well-being. Crop residue forms the major source of feed to the livestock and livestock sector, support the crop sector in the form of draught power and organic manure; supplies hides, skin, bones, blood and fibers to the industrial sector and provides transportation. Livestock sector also plays an important and vital role in providing nutritive food rich in animal protein. Supplementing family income and generating gainful employment in the rural sector, particularly among the landless, small, marginal farmers and women and thus is a dependable "bank on hooves" in times of need. Milk co-operatives are an integral part of the milk marketing and dairy development programme in India. White revolution popularly known as "Operation Flood" launched by the Government of India in collaboration with the world food programme of the United Nations in July 1970. It was the world's biggest dairy development programme. It transformed India from a milk deficient nation into the world's largest milk producer. Dairy farming is making a significant contribution to the national economy and socio-economic development in the country. The operation flood aimed at the setting up of modern dairy industry to meet India's rapidly increasing need for milk and its products and making it capable of viable and self-sustaining growth. Operation flood helped dairy farmers to direct their own development, placing control of the resources they create in their own hands. A national milk grid links milk producers throughout India with

consumers in over 700 towns and cities, reducing seasonal and regional price variations while ensuring that the producer gets fair market prices in a transparent manner on a regular basis. The bedrock of operation flood has been village milk producer's co-operatives, which procure milk and provide inputs and services, making modern management and technology available to members. Operation flood objectives included: (a) Increase milk production ("a flood of milk") (b) Augment rural incomes and (c) Reasonable prices for consumers.

In 1964, when late Prime Minister Lal Bahadur Shastri spent a night at Ajarpur, during his visit to Gujarat, was impressed with working of the village milk co-operative society. He requested Mr. Verghese Kurien, the general manager of AMUL, to extend Anand type of dairy co-operatives to other parts of the country. He also wrote to the Chief Ministers of different states to take the initiatives to set up Anand type milk co-operative societies. This led to the establishment of National Dairy Development Board (NDDB) in 1965 and its sister organization called Indian Dairy Cooperation in 1970 to implement a well-known programme known as Operation Flood which essentially entails the setting up of Anand type of dairy co-operatives throughout the country (Shrikant, 2007). In 1973, the Government of Karnataka prepared a dairy development project and submitted it to the World Bank for funding. The total project cost of Rs.509.9 million was to be met by the Government of Karnataka and the World Bank. The project report stipulated that the project should adopt Anand type dairy co-operative societies and NDDB should act as consultant to the project. The actual fieldwork was taken



up in 1975. The project under Operation Flood-II organized the Karnataka Dairy Development Corporation (KDDC) which covered eight districts under four milk unions, namely Bengaluru (Bengaluru and Kolar), Mysuru (Mysuru, Mandya and part of Kodagu), Hassan (Hassan, Chikmagalur and part of Kodagu) and Tumkur (Tumkur and part of Mandya). Later during 1983 under Operational Flood-II all the districts were covered.

Karnataka Co-operative Milk Producers' Federation Limited (KMF) : Karnataka Co-operative Milk Producers' Federation Limited (KMF) is the apex body for the dairy co-operative movement in Karnataka. It is the second

largest dairy co-operative amongst the dairy cooperatives in the country. In South India it stands first in terms of procurement as well as sales. One of the core functions of the federation is marketing of milk and milk products. The brand "Nandini" is the household name for pure and fresh milk and milk products. KMF has 14 milk unions covering all the districts of the state which procure milk from Primary Dairy Cooperative Societies (DCS) and distribute milk to the consumers in various towns/cities/rural markets in Karnataka.

Karnataka Dairy Development Corporation (KDDC), the first ever World Bank/ International Development

Table-1 : Distribution of sample respondents in the study area. (n=240)

Zones	DCS villages	Members	Non-Members	Total
North Eastern Dry Zone (Zone-I)	Pattan	10	10	20
	Mallabad	10	10	20
	Kognoor	10	10	20
	Niloor	10	10	20
	Hirapur	10	10	20
	Melakunda(K)	10	10	20
Total (A)	06	60	60	120
North Eastern Transitional Zone (Zone-II)	Huliyur	10	10	20
	Bhoosnoor	10	10	20
	Saramba	10	10	20
	Tadol	10	10	20
	Dudknal	10	10	20
	Khazoori	10	10	20
Total (B)	06	60	60	120
Total (A+B)	12	120	120	240

Survey year (2019)

Table-2 : Categorization of sample respondents across the herd size held by them. (n=240)

Category	Zone-I (n=120)			
	Members (n=60)		Non-Members (n=60)	
	Number of respondents	Per cent	Number of respondents	Per cent
Small (1-3)	15	25.00	29	48.33
Medium (4-6)	24	40.00	21	35.00
Large (above 6)	21	35.00	10	16.67
Total	60	100	60	100.00
	Zone-II (n=120)			
Small (1-3)	18	30.00	24	40.00
Medium (4-6)	20	33.33	16	26.67
Large (above 6)	22	36.67	20	33.33
Total	60	100.00	60	100.00

Agency funded Dairy Development Programme in the country started in Karnataka on co-operative lines with the organisation of Village Level Dairy Co-operatives in 1974. The AMUL pattern of dairy co-operatives started functioning in Karnataka from 1974-75 with the financial assistance from World Bank/IDA, Operation Flood II & III. The Anand pattern three tier organisation structure – Dairy Cooperative Societies at the village level, District Milk Unions at the district level to take care of the procurement, processing and marketing of milk and provide technical input services for Enhancing milk production at producers level and Federation at the state level to co- ordinate the growth of the sector in the state, are resolutely and harmoniously working hand-in-hand in creating self-sustaining rural economy based on cooperative dairying. KMF is one of the few federations in the country, who have converted dairying from a subsidiary occupation into an industry.

Research Methodology

The present study was undertaken in North Eastern Dry Zone and North Eastern Transitional Zone of Karnataka,

where, dairy farming is taken up extensively by the farmers.

The Dairy Cooperative Societies : Dairy cooperative society is a basic organisation unit functioning at village level. All milch animal owners are eligible to become members of the dairy cooperative societies (DCS). The DCS act as a marketing outlet for the milk produced in the village. Input facilities are also channelized to the dairy farmers through these societies. There are 13,862 DCS which are the members of 14 milk unions.

Each DCS is managed by the management committee consisting of nine members elected by the members of the general body. The tenure of committee is three years. The president of the management committee is elected annually and is eligible to contest for the elections to the milk union board of directors. The management committee appoints a paid secretary who is responsible for the day-to-day operations of DCS.

District Milk Producers' Cooperative Union Limited (DMPCUC) : Milk union is the middle tier of the co-operative organisation network. The milk unions are

Table-3 : Average daily feed intake of milch buffaloes and cows by members and non-members groups across herd size categories in Zone-I (kg/day/animal).

Zone-I											
Buffalo											
Particulars	Members				Non-members				Recom- mended	Overall difference (members)*	Overall difference (non- members)*
	Small	Medium	Large	Overall	Small	Medium	Large	Overall			
Green fodder	5.43	6.58	7.26	6.53 (46.98)	4.83	4.03	5.06	4.59 (40.16)	9.10	-2.57	-4.51
Dry fodder	5.58	5.77	5.93	5.78 (41.58)	6.12	5.31	5.30	5.70 (49.87)	7.02	-1.24	-1.32
Concentrate	1.53	1.23	2.03	1.59 (11.44)	1.07	1.11	1.43	1.14 (9.97)	3.33	-1.74	-2.19
Total	12.53	13.58	15.22	13.90 (100)	12.02	10.45	11.79	11.43 (100)	19.45	-5.98	-8.02

Note : The figures in parenthesis are percentage to the total.

Table-4 : Average daily feed intakes of milch buffaloes and cows by members and non-members groups across herd size categories Zone-II. (kg/day/animal)

Particulars	Zone-II								Recom- mended	Overall difference (mem bers)*	Overall difference (non-mem bers)*
	Buffalo										
	Members				Non-members						
	Small	Medium	Large	Overall	Small	Medium	Large	Overall			
Green fodder	6.22	7.62	8.33	7.46	4.23	4.34	6.62	5.06	9.10	-1.64	-4.04
Dry fodder	6.88	6.19	7.41	6.22	6.85	7.04	8.99	7.61	7.89	-1.67	-0.28
Concentrate	1.89	2.00	2.42	2.12	1.53	1.09	1.86	1.52	3.33	-1.21	-1.81
Total	14.99	15.81	18.16	15.80	12.61	12.47	17.47	14.19	19.45	-3.65	-5.26

formed by federating the DCS in earmarked geographical area. The milk unions are organised to make them economically viable and the jurisdiction extends from one revenue districts to three districts. There are 14 milk unions whose territories cover the entire state. The milk unions organise new DCS, assist DCS with their management including audit of accounts, supervise, purchase, process and market the liquid milk. Provision of input facilities are also made by the union and channelized to the dairy farmers through DCS.

The productivity of resources need to be enhanced in this zone. The differential of private and social profit `5.99 indicates reverse flow of resources to the sector. The Nominal Protection Coefficient (NPC) of 1.02 indicates that the zone does not have any price competitiveness. However, the DRC and EPC indicate that the zone has comparative advantage for exports.

Hence, the KBY Milk Producers Societies Union Limited was selected for the study to know the role of DCS in doubling the farmer's income in this region.

Sampling procedure : The KBY Milk Producers Societies Union was selected for the study as it covers three districts of North Eastern region of Karnataka. Further, the milk union was divided in two major zones namely North Eastern Dry Zone and North Eastern Transitional Zone, considered as Zone-I and Zone-II respectively. From each

Zone, six dairy co-operative societies were selected based on highest milk procurement per day. Zone-I consists of Pattan (1138 lit./day), Mallabad (980 lit./day), Kognoor (764 lit./day), Niloor (738 lit./day), Hirapur (694 lit./day) and Melakunda. K. (578 lit./day) DCS villages, from each DCS village 10 members and 10 non-members were selected randomly. Hence, the total sample size of Zone-I was 120. Similarly, Zone-II consists of Huliur (1379 lit./day), Bhoosnoor (1376 lit./day), Sarsamba (944 lit./day), Tadol (846 lit./day), Dudkna (763 lit./day) and Khazoori (738 lit./day) DCS villages. From each DCS village 10 members and 10 non-members were selected randomly. Hence, the total sample size of Zone-II was 120. Thus the total sample size for the study was 240. The distribution of the sample was presented in the Table-1.

All the milk producing households were classified into three categories, viz., small (1-3 milch animals), medium (4-6 milch animals) and large (more than 6 milch animals) on the basis of number of milch animals owned by them using cumulative frequency square root technique. Similar methodology was followed by Meena (2008). The distribution of households with in each category is presented in Table-2.

Nature and sources of data

Primary data : For evaluating the objective of study, necessary data were collected from both respondent

Table-5 : Cost of buffalo milk production in Zone-I. (Rs./day/buffalo)

Items of cost	Zone-I							
	Members				Non-Members			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall
Fixed Cost								
Depreciation on fixed assets	34.70 (26.35)	33.26 (23.78)	35.73 (24.04)	34.49 (24.48)	32.23 (22.59)	33.5 (24.17)	34.1 (22.46)	33.19 (22.95)
Interest on fixed assets	23.12 (17.56)	22.78 (16.29)	23.01 (15.48)	22.95 (16.29)	23.68 (16.6)	23.20 (16.74)	22.96 (15.12)	23.32 (16.12)
Total Fixed Cost (A)	57.82 (43.90)	56.04 (40.07)	58.74 (39.52)	57.43 (40.76)	55.91 (39.19)	56.70 (40.92)	57.06 (37.58)	56.51 (39.07)
Variable cost								
Green fodder	25.89 (19.66)	31.95 (22.84)	33.94 (22.84)	31.13 (22.1)	30.95 (21.69)	26.15 (18.87)	32.33 (21.29)	30.13 (20.83)
Dry fodder	8.81 (6.69)	9.05 (6.47)	9.25 (6.22)	9.06 (6.43)	16.24 (11.38)	14.36 (10.36)	14.32 (9.43)	15.10 (10.44)
Concentrate	8.12 (6.17)	6.92 (4.95)	8.72 (5.87)	7.85 (5.57)	8.42 (5.90)	8.66 (6.25)	10.58 (6.97)	9.20 (6.36)
Imputed family labour	13.78 (10.46)	15.56 (11.12)	13.41 (9.02)	14.36 (10.19)	13.87 (9.72)	14.74 (10.64)	13.91 (9.16)	14.12 (9.76)
Hired labour	12.24 (9.29)	14.44 (10.32)	17.89 (12.04)	15.09 (10.72)	11.69 (8.19)	12.09 (8.72)	16.46 (10.84)	13.39 (9.26)
Medical expenses	1.57 (1.19)	2.01 (1.44)	2.58 (1.74)	2.10 (1.49)	2.13 (1.49)	2.26 (1.63)	3.11 (2.05)	2.49 (1.72)
Miscellaneous expenditure	3.459 (2.63)	3.901 (2.79)	4.09 (2.75)	3.86 (2.74)	3.47 (2.43)	3.61 (2.6)	4.05 (2.67)	3.69 (2.55)
Total variable cost (B)	73.88 (56.10)	83.83 (59.93)	89.88 (60.48)	83.46 (59.24)	86.77 (60.81)	81.87 (59.08)	94.76 (62.42)	88.13 (60.93)
Gross cost (A+B)	131.70 (100)	139.87 (100)	148.62 (100)	140.89 (100)	142.68 (100)	138.57 (100)	151.82 (100)	144.63 (100)
Milk production per day (liter)	4.63	5.42	6.98	5.77	3.89	4.60	4.91	4.31
Cost per liter of milk	28.44	25.81	21.29	24.42	36.68	30.12	30.92	33.56

Note : The figures in parenthesis are the percentage of its gross cost.

members and non-members of DCS including data on general information about socio economic status of individual farmer, various costs and returns in dairy farming, also about constraints in production of milk.

Cost of milk production : It is pertinent to study the cost of milk production, since it enables to comprehend the intricate issues involved in milk production and is the most important indicator of economic efficiency of milk production. The various cost components identified can be broadly classified into 'fixed costs' and 'variable costs'. An attempt has been made in this section to briefly elaborate these costs.

Fixed costs : Fixed costs include the cost, which remain unchanged over the short period of time. The relevant components of fixed cost that go into milk production are:

Depreciation costs : It is loss in the value of an asset due to normal wear and tear, resulting out of its use over time and technological obsolescence. The depreciation on cattle sheds and dairy equipments was worked out by using straight-line method considering their useful economic life. An annual depreciation of 5 per cent on 'Pucca' shed and fodder stores, 10 per cent on 'Kuccha' shed and fodder stores were assumed. The depreciation on equipments like milking cans, water cans, buckets, wooden feed manger and utensils was taken as 20 per

cent. The depreciation rates for consumable items like gunny bags, rope etc. was taken as 100 per cent considering that the farmer replaces the above items annually. Depreciation rates for manual (or power driven) and bullock drawn chaff cutters were assumed as 10 and 20 per cent, respectively. The depreciation on milch local cows, and buffaloes were calculated by straight line method and rates of deprecation were considered as 12 and 10 per cent, respectively, assuming a productive life of 8 years for local cows and 10 years for buffaloes. The annual depreciation expenses were apportioned on the basis of per Standard Animal Units (SAUs).

Interest on fixed capital : The value of animals, cattle shed and dairy equipments related to milk production was taken as fixed capital. The interest on fixed capital was calculated at the prevailing rate of 9.50 per cent per annum that matches the interest rate being currently charged by the commercial banks in the study area. The annualized interest amount was calculated and apportioned per standard animal unit per day. The interest on working capital was not taken into consideration as the households get income from milk sold everyday.

Variable costs : By definition, variable costs are those costs that vary with the levels of milk production. Variable costs included those recurring components in milk

Table-6 : Cost of buffalo milk production in Zone-II. (Rs./day/buffalo)

Items of cost	Zone-II							
	Members				Non-Members			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall
Fixed Cost								
Depreciation on fixed assets	33.57 (24.18)	34.20 (23.08)	36.22 (22.54)	34.75 (23.16)	32.45 (23.33)	32.62 (22.45)	33.05 (20.25)	32.70 (21.98)
Interest on fixed assets	23.10 (16.64)	22.16 (14.96)	23.45 (14.59)	22.92 (15.27)	22.78 (16.38)	23.06 (15.87)	23.91 (14.65)	23.23 (15.61)
(A) Total fixed cost	56.67 (40.81)	56.36 (38.04)	59.67 (37.13)	57.60 (38.38)	55.23 (39.70)	55.68 (38.32)	56.96 (34.89)	55.93 (37.58)
Variable cost								
Green fodder	29.35 (21.14)	35.53 (23.98)	38.65 (24.05)	34.82 (23.2)	27.35 (19.66)	28.01 (19.28)	40.72 (24.94)	31.98 (21.49)
Dry fodder	10.40 (7.49)	9.56 (6.45)	12.27 (7.63)	10.81 (7.20)	15.92 (11.44)	16.92 (11.65)	19.09 (11.69)	17.24 (11.59)
Concentrate	9.56 (6.89)	10.00 (6.75)	11.68 (7.27)	10.48 (6.98)	8.06 (5.79)	8.94 (6.15)	9.43 (5.78)	8.75 (5.88)
Total feed cost	49.31 (35.51)	55.09 (37.19)	62.60 (38.95)	56.27 (37.50)	51.33 (36.90)	53.87 (37.08)	69.24 (42.41)	57.98 (38.97)
Imputed family labour	16.60 (11.96)	13.38 (9.03)	12.06 (7.50)	13.86 (9.24)	17.75 (12.76)	18.14 (12.49)	14.45 (8.85)	16.75 (11.26)
Hired labour	10.89 (7.84)	16.83 (11.36)	19.37 (12.05)	15.98 (10.65)	9.07 (6.52)	11.45 (7.88)	15.76 (9.65)	11.93 (8.02)
Medical expenses	1.76 (1.27)	2.52 (1.70)	2.89 (1.80)	2.43 (1.62)	2.13 (1.53)	2.26 (1.56)	2.81 (1.72)	2.39 (1.61)
Miscellaneous expenditure	3.63 (2.61)	3.97 (2.68)	4.13 (2.57)	3.93 (2.62)	3.60 (2.59)	3.89 (2.68)	4.03 (2.47)	3.82 (2.57)
(B) Total variable cost	82.18 (59.19)	91.79 (61.96)	101.05 (62.87)	92.47 (61.62)	83.88 (60.30)	89.61 (61.68)	106.29 (65.11)	92.88 (62.42)
Gross cost (A+B)	138.85 (100)	148.15 (100)	160.72 (100)	150.06 (100)	139.11 (100)	145.29 (100)	163.25 (100)	148.80 (100)
Milk production per day (liter)	5.84	6.49	7.84	6.79	4.18	4.97	6.11	5.03
Cost per liter of milk	23.78	22.83	20.50	22.10	33.28	29.23	26.72	29.56

Note : The figures in parenthesis are the percentage of its gross cost.

production, which are incurred on green fodder, dry fodder, concentrates, labour and miscellaneous expenses. The procedure followed to work out the various variable cost components is provided as under.

Cost of feeds and fodder : Cost of green fodder, dry fodder and concentrates were estimated by multiplying the quantity fed by prevailing market price in the winter, summer and rainy seasons in the study area. In case of grazing of animals for feeding, the charges paid by the households as well as wages paid to labour were taken into account to determine its cost.

Labour cost : The labour expenses comprised of hired and family labour cost. However, hired labour was not engaged in the dairy activities in the study area. Hence, labour cost comprised of only value of family labour imputed at the prevailing wage rate in the study area. Total time devoted for various dairy operations was taken into account while estimating labour cost.

Veterinary expenses : The actual expenses incurred on health care, veterinary medicine, vaccination of milch animals during the past three seasons was recorded by personnel enquiry method.

Miscellaneous expenses : These expenses included cost of repairs, electricity and water charges, etc., incurred by the selected households.

Gross cost : The gross cost of milk production was computed as the sum total of fixed costs and variable costs. It reflects total implicit and explicit costs that are incurred in milk production.

Unit cost of milk production : The net cost of maintenance per milch animal per day was divided by the respective average milk yield per milch animal per day to arrive at per litre cost of milk production.

Income from milk production : The income from milk production was calculated as follows

Gross income : It was worked out by adding the value of milk and imputed value of dung produced by milch bovines in the sample household.

Net income : This is the true income to the household from different sources apart from dairy and crop activities. In case of dairy activity, it was computed by deducting gross cost from gross income.

Result and Discussion

Zone-I : Average daily feed intake of buffalo and cow in Zone-I was depicted in the Table 3. The perusal of a table indicated that, overall feed and fodder fed was higher by member than the non-member. The quantity of dry matter given to buffalo was 13.90 and 11.43 kgs by member and non-members, respectively. An analysis of the table explained that the members have applied high percentage of green fodder out of total dry matter but non-member had given dry fodder as high per cent of total dry matter, which indicated that member have fed better feed and fodder to milch animals than non-members. This may be attributable to the subsidies used by members for the procurement of feed and fodder and contribute to better awareness of fodder management than non-member, and milk cooperative societies have also provided the DCS member training programme.

Zone-II : Average daily feed consumption of buffalo and cow per day in Zone-II is depicted in the Table-4. The average amount of feed and fodder used to be higher in the member (15.80 kg per day) than in the non-member (14.19 kg per day) for the buffalo, according to the perusal of the table. An evaluation of the table confirmed that member had used higher amount of green fodder (7.46 kg) than dry matter (6.22 kg). However, non-member had given higher quantity of dry fodder (7.61 kg) than green fodder (5.06 kg), indicating member had fed higher feed and fodder to milch animals than non-members.

Cost of milk production in Zone-I

Buffalo : Table-5 illustrated the average cost of milk production for buffaloes across the categories of herd size. Table perusals revealed that the average cost per day per animal for the non-member group (Rs.144.63) was higher than the member group (Rs.140.89). The average daily cost increased with an increase in the herd size category for both the member and non-member groups. The similar results were reported by Hymajyoti *et al.* (2003) and Bharadwaj *et al.* (2006).

The component wise cost analysis showed that, in the case of the member group, overall the fixed and variable costs accounted for 40.76 and 59.24 per cent of total costs, respectively, the corresponding figures for the non-members group were, 39.07 and 60.93 per cent. Sharma and Singh (1994) and Kalra *et al.* (1995) found that the share of variable and fixed costs was approximately 85 and 15 per cent of the total cost, respectively. Shiyani and Singh (1994) have observed a feed cost of 55 to 70 per cent of the total cost. The comparatively lower cost of sustaining the animals by the member respondents may be due to subsidy availed from Dairy Co-operative Societies (DCS) on feed and fodder.

It is also important to note that the cost per litre of milk was reduced with an increase in herd size, even though the total cost increased with an increase in herd size. These findings are in conformity with findings of Hymajyoti *et al.* (2003).

Cost of milk production in Zone-II

Buffalo : The average cost of buffalo milk production for all herd group sizes was presented in Table-6. The results showed that the average cost per day per animal (Rs.150.06) for the member respondents was higher than the cost per day for the non-member respondents (Rs.148.80). The average daily cost increased with an increase in the herd size group in both the member and non-member categories. In the case of the member group, the part wise cost analysis showed that 38.38 and 61.62 per cent of total costs for the overall category were fixed and variable costs, while 37.58 and 62.42 per cent were for the non-member group. In addition, the breakup study of cost components revealed that, major share was allocated to feed and fodder, of which the cost on green fodder was higher than dry fodder and feed concentrates in both the groups. This might be due to higher application of input variable and better management practices to enhance the milking yield in the study area. Dwaipayan *et al.* (2005) and Meena (2008) also reported similar findings.

Compared to Zone-I, the cost per litre of milk was decreased with an increase in herd size, but the total cost increased with an increase in herd size. Since milk production has additionally elevated with increase in value. These findings are comparable with findings of Meena (2008).

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Diversity of Dominant Plant Parasitic Nematodes in Sugarcane (*Saccharum officinerum*) in Meerut Region

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Abstract

Phytonematodes found to be one of the most distributed all over world diseases in the last two decades that attract the attention of researchers, especially those in the field of plant protection. Phytonematodes have been variously reported to be associated with decline in sugarcane crop production. A field survey of the sugarcane plantation in Meerut was conducted to identify the diverse phytonematodes species associated with the soils & roots of sugarcane and to determine their population densities on the sugarcane field. Several species of dominant plant parasitic nematodes were found in association with the roots and rhizosphere of the sugarcane plants. They include *Hoplolaimus* spp., *Rotylenchus reniformis*, *Helicotylenchus dihystra*, *Pratylenchus zea*, *Tylenchorhynchus nudus*, *Longidorus elongates*, *Xiphinema attenuatus*, *Scutellonema brachyurus* and *Tylenchus arcuatus*. *Hoplolaimus* spp. was the most ubiquitous, occurring at a 98% frequency rating in all the samples. The investigation observed a large diversity of important phytonematodes on the sugarcane field, thus there is a need the appropriate management tools and practices to control the population of plant parasitic nematodes by applying to the cropping patterns in the particular agriculture areas.

Key words : Plant parasitic nematodes, *Rotylenchus reniformis* & *Pratylenchus zea*. *S. officinerum* etc.

Introduction

The most famous and distractive genus of plant parasitic nematode found all over the world. The root-knot nematode (*Meloidogyne* spp.), Because of its wide host range, which included more than 2100 hosts, such as vegetables, fruit trees, oil crops and grains such as rice and wheat crops. Plant parasitic nematodes found to be one of the most widespread diseases in the last two decades that attract the attention of nematologists & researchers, especially those in the field of plant protection and management.

Hence, the nematologists & researchers are concerned by the root-knot nematodes which are found to be the most important and being responsible for damage of agriculture. Phytonematodes have been variously reported to be associated with decline in sugarcane production.

In India, Uttar Pradesh is the major sugarcane growing state, contributing about 48% of the area and 40% of the production. Maharashtra is the second largest producer of sugarcane after Uttar Pradesh in area and after Tamilnadu in productivity. India produced around 350 million tons of sugar in 2013-14. As per 3rd Advance Estimate (2014-15) of DAC released on 13/5/2015, India is expected to produce 356 million tons of Sugarcane and 25 million tons of sugar in 2014-15. A field survey of the sugarcane plantation in Meerut district was conducted to identify the diverse species of plant parasitic nematodes associated with the soils & roots of sugarcane field and to

determine their population densities on the sugarcane field.

Sugarcane is cultivated under varied conditions ranging from the tropics to the subtropics. Sugarcane is the World's major cash crops providing about 75% of the sugar harvested for human consumption (FAO 2004). FAO estimates it was cultivated on about 23.8 million hectares, with a worldwide harvest of 1.69 billion tones. India was the second largest producers with 277,750,000 tones than Brazil. The yield gap of sugarcane in India with respect to 10 major sugarcane producing countries during the last 5 years is ranges 1.33 – 31.22t/ha.

Sugar is one of the most valuable products of the plant world obtained from *Saccharum* species. *S. officinarum* is widely cultivated in India because of high sucrose content. The juice Sugarcane per serving (28.35 grams) contain Energy-111.13 kJ (26.56 kcal), Carbohydrates-27.51 g, Protein-0.27 g, Calcium-11.23 mg (1%), Iron-0.37 mg (3%), Potassium-41.96 mg (1%), Sodium-17.01 mg (1%). (Nutrient Information from ESHA Research).

In India, sugarcane is mainly used for the production of white sugar (50%), Gur & Khandsari (40%), Molasses, Bagasse, press mud and green top, etc. Molasses is an important product of sugarcane industry which is used as a cattle feed and for preparation of rim, industrial alcohol, vinegar, glycerol, lactic acid, monosodium glutamate and many Pharmaceutical products.

One of the outstanding problems of sugarcane

cultivation caused by phytonematodes has been the rapid yield decline of successive ratoon crops (Bock *et al.*, 1968). Phytonematodes diversity on sugarcane is greater than most other cultivated crops, with more than 48 genera and 310 species of endo and ecto parasitic nematodes species have been reported to be associated with rhizosphere soil and root of various crops including sugarcane (Cadet and Spaull, 2005).

The estimated annual yield loss of World's major crops due to plant parasitic nematodes has been reported to the extent of 12.3% (Sasser and Freckman, 1987) and the latest estimated annual yield loss of national major crops due to plant parasitic nematodes has been reported to the extent of Rs 21,068.73 million. In economic terms, nematodes cause an estimated loss of about \$ 157 billion annually to world agriculture (Abad *et al.*, 2011). It is estimated that annual crop loss due to parasitic nematodes in India accounts for about 21 million. However, in India it was estimated as 21068.73 million rupees from the 24 major crops growing in the Country.

Large and consistent yield responses were obtained when populations of plant parasitic nematodes were reduced by soil fumigation, crop rotation and fallowing (Stirling *et al.*, 2001). Lesion nematode (*Pratylenchus Zeae*) is probably the most important of the community of plant parasitic nematodes that are commonly found in sugarcane fields. It occurs at high population densities in a wide range of soil types (Blair *et al.*, 1999a, 1999b) and was the predominant plant parasite at many of the sites where sugarcane responded to nematicide treatment (Blair and Stirling, 2007).

In view of above aspect the present study was taken to evaluate the distribution and prevalence of different species of plant parasitic nematodes associated with sugarcane crop in district Meerut. It was helpful to the farmers, agricultural scientists and policy makers for proper extension of nematode control programmes.

Materials and Methods

Experimental site : Meerut division is an administrative geographical unit of Uttar Pradesh state, India. The division consists of three tehsil i.e. Meerut, Sardhana and Mawana. Western Uttar Pradesh is known for its cereal production and also extensively known for sugarcane (*Saccharum officinerum*), cultivation Extensive survey was conducted through the Meerut districts to collect soil & root sample from sugarcane fields in the Western Uttar Pradesh.

Soil sampling : Soil samples were collected randomly, from September 2013 to March 2014, for the distribution pattern of some dominant ectoparasitic and endoparasitic. Soil samples and plant material were kept moist and stored in well labeled polythene bags at 13°C. Samples

were placed in plastic bags labeled with information on the area, variety, date & name of fauna. Sample bags were prevented from direct sunlight as this can overheat the bag resulting in increased of nematode mortality. The idea behind storing the samples in polythene bags was to prevent the evaporation and loss of moisture from the soil during the period of examination in the laboratory so that the nematodes can survive for a longer time. Samples were stored separately for edaphic factors analysis at (5-10°C) temperature.

Nematode extraction from soil : The method, used for the extraction of nematodes from the soil samples, varied with the number of samples to be analyzed and the type of nematodes present. Soil samples, each 500cc were processed for nematode extraction by Cobb's sieving and Decanting method (Cobb, 1918). Soil was placed in a bucket, filled with water and agitated the content for homogenous suspension. The suspension was allowed to settle down for few minutes. The nematodes float on the upper surface of the suspension. The suspension was passed through a series of sieves i.e. 60, 100, 150, 200, 240, 300, 350 and 400 meshes. The residue of each sieve was condensed and poured into 250 ml beaker through cotton sieve containing tissue paper. 25ml of solution containing the nematodes was placed in a glass petridishes (9 cm in diameter) under the dissecting microscope and the nematodes counted with the help of a Syracuse counting dish.

Nematodes identification : Identification of plant parasitic nematodes into the various genera was done under a high-resolution microscope with the aid of plant Nematology manuals (Mai and Lyon, 1975; Zuckerman *et al.*, 1990). Microphotographs and Measurement was taken using Phase Contrast Microscope and diagrams were also drawing with the help of Camera Lucida by using light microscope.

Data analysis : Percentage frequency of occurrence was determined using the following formula :

$$\frac{n}{N} \times 100$$

n = number of times an individual occurred in all samples.

N = sample size (380)

Also, the percentage nematode population was calculated using the formula :

$$\frac{In}{TN} \times 100$$

In = individual nematode population in all the samples

TN = the total population of all the nematodes extracted in all samples.

Statistical analysis of data : Analysis of variance

(ANOVA) was carried out after nematodes counts using statistical analysis systems (SAS) and means separate by Fishers least significance difference test at a 5% probability level ($p=0.05$) and other indices using MS Excel and correlations using SPSS (21version).

Results and Discussion

Nematode species isolated from soil of sugarcane fields : Nine species of dominant plant parasitic nematodes were isolated from the soil of sugarcane fields in Meerut, Uttar Pradesh. They include: *Hoplolaimus spp.*, *Rotylenchus reniformis*, *Helicotylenchus dihystra*, *Pratylenchus zea*, *Tylenchorhynchus nudus*, *Longidorus elongates*, *Xiphinema attenuatus*, *Scutellonema brachyurus* and *Tylenchus arcuatus*.

Population densities of plant parasitic nematodes associated with sugarcane field : The population densities of the phytonematodes species recovered from the soil and roots sugarcane crop is described in tables-1 and 2. High population of *H. indichus* was observed from the soil and root samples, constituting about 22% of the total species of plant parasitic nematodes associated with the root samples and soil samples of sugarcane field. Also found in high population were *Meloidogyne* species (RKT) from the root samples. A field survey of the sugarcane in Meerut was conducted to identify the diverse species of plant parasitic nematode associated with the soils and roots of sugarcane field and to determine their population densities on the field of sugarcane crop, these are following: *Hoplolaimus spp.*, *Rotylenchus reniformis*, *Helicotylenchus dihystra*, *Pratylenchus zea*, were found in high population in the soil however, *Scutellonema brachyurus* and *Tylenchus arcuatus* were not recorded in low population from the soil and root samples.

Frequency of occurrence of plant parasitic nematodes from the soil samples : The dominant plant parasitic nematodes found on the rhizosphere of the sugarcane field were *Hoplolaimus spp.*, *Rotylenchus reniformis* which were most ubiquitous with 100% frequency ratings in all frequency ratings of 80% and 70% respectively (Figure- 2). Low population of *Scutellonema brachyurus* and *Tylenchus arcuatus*.

Population densities of plant parasitic nematodes species associated with sugarcane field : The population densities of the nematodes species recovered from the rhizosphere of sugarcane plants is described in tables-1 and 2.

Frequency of occurrence of plant parasitic nematodes from soil samples of sugarcane field : The prominent plant parasitic nematodes found on the soil samples of the sugarcane field were *Hoplolaimus* and *Rotylenchus* were found in all locations with a prominence value ranging from 92 % to 82.50 % respectively, whereas

Table-1 : Study site in different location with different varieties of Sugarcane crop in Meerut.

S.No.	Tehsil	Village	Varieties of Sugarcane
1.	Meerut	Rithani Gaggol Naval Phapunda Lalpur Kharkhoda	Var.67,31,32,64 Var.67,64 Var.64,67, 32 Var.68, 64, 67
2.	Sardhana	Kheri Sarswa Sivaya Meethepur Mavi Jainpur Daurala	Var.32.64.67,10 Var.64, 67, 10, Var.67,31,32,64 Var.67, 32, var.10, 68,
3.	Mawana	Hastinapur Nangli Nangla Kastila Sdharnpur Incholi Khikera Ulkipur	Var.67,64 Var.64,67,108 Var.64, 67, 10, Var.67, 32,64 Var.67, 31,32,64 Var.64, 32,68 Var.68, 67, 10, Var.67, 31, 32,64

population of *Helicotylenchus dihystra* was recorded at 65%. In addition, other genera isolated included *Pratylenchus spp.*, *Tylenchorhynchus nudus*, *Longidorus*, *Meloidogyne incognita*, *Xiphinema spp.*, *Scutellonema brachyurus* and *Tylenchus arcuatus* were identified in 61.50%, 38%, 34 %, 22.50%, 16%, 9.50% and 3.50% respectively. *Hoplolaimus* and *Rotylenchus* were widespread in the sugarcane field of Meerut district.

Frequency of occurrence of plant parasitic nematodes from the roots of sugarcane : The most prevalent plant parasitic nematodes extracted from the root samples of sugarcane field. *Meloidogyne incognita* was the most frequently encountered species 87.50% and a population of 7588/250g root, followed by *Pratylenchus zea* with 67.50% frequency ratings and a population of 5203/250g root, *Helicotylenchus dihystra* with 45% frequency ratings and a population of 1325/250g root, *Tylenchorhynchus nudus* with 20% frequency ratings and a population of 587/250g root.

My study concludes that the presence of plant parasitic nematodes population of ecto and endo plant parasitic nematodes in sugarcane field might be more damaging. The ecto-parasitic nematodes minimize the capacity of the roots to absorb water and nutrients by pruning primary and secondary roots and endo- parasitic nematodes damage cortex and vascular tissues at time feeding alter uptake of water and nutrients & interference of minerals and photosynthesis. These findings effect of mixed plant parasitic nematodes feedings consequently lead to poor growth. Plant parasitic nematodes have been observed to constitute serious hindrance to sugarcane

Table-2 : Morphometric characters of nematode population (specimen) collected from different Sugarcane fields of district Meerut and their comparison with the species of *Hoplolaimus indicus*, *Hoplolaimus citri* and *Hoplolaimus geleatus*.

Characters	<i>H. indicus</i>	<i>H. indicus</i>	<i>H. citri</i>	<i>H. citri</i>	<i>H. geleatus</i>	<i>H. geleatus</i>
	Nematode specimen	Dady 1905	Nematode specimen	Filipjev 1876	Nematode specimen	Sher, 1963
L	1.2±.21 (.91-1.5)	0.95-1.6	1.3±.10 (1.2-1.4)	0.94-1.3	1.2±0.167 (1.1-1.5)	1.2-1.9
a	31±1.2 (30-32)	25-37	30.20±1.5 (28-32)		34.48±6.8 (27-42)	
b	9.6±1.8 (7.3-11.9)	9.2-11	7.06±1.3 (6-9)		9.47±1.8 (7-12)	
c	46±14 (32-69)	45-72	47.24±8 (37-55)		60.83±28 (32-106)	
c'	1.33±.40 (.78-1.86)		1.14±.32 (.65-1.5)		1.02±0.48 (0.67-1.8)	
Stylet	36.54±1.95 (33-38)	33-47	36.50±1.9 (34-37)	35-37	43.71±5.8 (38-52)	43-52
Oesophagus length	104.77±10.5 (94-118)		145.04±27 (123-181)		150.96±30 (103-186)	
GBW	38.92±6.02 (30-44)		43.60±3.4 (39-48)	39-54	37.53±4.4 (32-42)	
Tail length	24.79±10.52 (10-36)		28.68±2.1 (25-31)	19-23	23.43±7.4 (14-34)	
ABW	24.76±5.6 (18-32)		25.38±2.1 (21-28)		23.89±4.3 (18-30)	
V	47±7.8 (42-56)	49-57	54.64±.71 (54-55)		45.24±9.4 (30-56)	
SL	46±5.9 (41-50)	34-42	43.82±00 (43.82-43.82)	38-47	NIL	40-52
GL	9.4±.88 (8-10)	16-20	15.46±00 (15.46-15.460)		NIL	20-28

All measurements are in m.

production in various parts of the World. Of these lance nematode is the most predominantly and economically important genus. This nematode is widely prevalent in both subtropical and tropical regions and reduces yield and quality of sugarcane in both light and heavy soil types.

In the present studies observed that population of plant parasitic nematodes were found higher in ratoon crop as compared to the planting crop. Our findings are co-relate with the findings of Shahzad *et al.*, (2010) the also observed the nematode population was higher in ratoon crop as compared to the planting crop. *Helicotylenchus* and *Tylenchorhynchus* were the most frequently occurring species of plant parasitic nematodes in all the locations.

Accordingly Srinivasan *et al.*, (2011) conclude that Analysis of the soil sample revealed the presence of 12 genera of plant parasitic nematode. Prakash *et al.*, 2009 observed most critical problems of plant parasitic nematodes which are damage about 40% sugarcane production in Uttar Pradesh. Mahmoud Ahmadi *et al.*, (2016) reported morphological observations on several

populations of *Hoplolaimus indicus* and *Hoplolaimus seinhorsti*, recovered from rhizosphere of mango, tamarind, sour orange and sugarcane crop from the southern regions of Iran.

This study correlated with Chirchier *et al.*, (2008) observed that fifteen genera of phytonematodes were observed in the West Kenya, of these, *Meloidogyne*, *Pratylenchus* and *Scutellonema* were predominant. At present 48 genera and 310 species of endo and ecto parasitic nematodes species have been reported to be associated with rhizosphere soil and root of sugarcane (Cadet and Spaull, 2005). Species of five genera namely *Hoplolaimus*, *Tylenchorhynchus*, *Pratylenchus*, *Helicotylenchus*, *Pratylenchus* and *Meloidogyne* is listed as the major phytonematodes with a wide distribution and common occurrence in sugarcane soils of India (Mehta, *et al.*, 1992). Various workers studied on community analysis on plant parasitic nematodes (Steven *et al.*, 2014; Bhattacharya, 2012; Tan and Kilic, 2012; Haougui, 2011; Chirchier *et al.*, 2008; Shahina and Firoza, 2007; Holterman *et al.*, 2009; Jordan, 2006; Weimin and Robbins, 2004; Stirling and Blair, 2000; Bond *et al.*, 2000; Joseph *et al.*, 2012).

Table-3 : Morph metric characters of nematode population collected from different Sugarcane fields of district Meerut and their comparison with the species of *Helicotylenchus dihystra*, *Rotylenchus reniformis* and *Pratylenchus* spp.

Characters	<i>H. dihystra</i>	<i>H. dihystra</i>	<i>P. Zeae</i>	<i>P. Zeae</i>	<i>R. reniformis</i>	<i>R. reniformis</i>
	Nematode specimen	Steiner, 1945	Nematode specimen	Sher, 1967	Nematode specimen	Filipjev, 1936
L	0.82±.36 (0.56-1.4)	0.50-0.90	0.48±.34 (39-56)	0.38-0.57	1.25±.21 (0.92-1.5)	1.5-1.6
a	28.24±9.4 (19-41)		26.57±.1.26 (17-27)	19-29	33.06±4.06 (27-40)	30-37
B	6.4±1 (5-7)		5.36±2.3 (2-8)		10.29±2.81 (7-14)	6-8
c	42.54±17 (25-62)	27-67	15.45±.57 (13-18)	13-19	53.41±19.59 (51-56)	63-67
c'	1.35±.65 (0.63-2.11)		2.1±0.49 (1-3)		1.08±0.46 (.67-1.9)	
Stylet	22.17±3.76 (19-28)	20-30	18.22±2.02 (14-19)	15-17	27.76±7.91 (16-38)	43-52
Oesophagus Length	122.14±40 (76-186)		147±31 (105-176)		132.73±23.72 (94-165)	
GBW	33.88±4.7 (28-41)		29.74±4.4 (22-33)		39.28±4.02 (33-42)	
Tail length	20.70±7.6 (9-30)		22.55±11 (15-27)	21-26	22.73±7.36 (14-32)	
ABW	16.30±4.79 (10-23)		10.36±3.68 (6-16)		25.38±4.25 (21-32)	
V	65±9.86 (55-74)	56-71	71.09±3.48 (67-73)	69-75	51.37±5.72 (44-57)	55-57
SL	42.36±.22 (42-43)				42.52	32-42
GL	9.9±2.7 (7-11)				7.93	16-20

Table-4 : Nematode population and Frequency in Sugarcane crop in Meerut.

S. No.	Plant Parasitic Nematodes	Plant Parasitic Nematodes Population/500g in soil	Percentage Frequency	Percentage Nematode Population
1.	<i>Hoplolaimus</i> spp.	42183	92.00	60.40
2.	<i>Rotylenchus reniformis</i>	8590	82.50	12.30
3.	<i>Helicotylenchus dihystra</i>	5030	65.00	7.20
4.	<i>Pratylenchus Zeae</i>	4330	61.50	6.20
5.	<i>Tylenchorhynchus nudus</i>	4050	38.00	5.80
6.	<i>Longidorus elongatus</i>	2235	34.00	3.20
7.	<i>Meloidogyne incognita</i>	1327	22.50	1.90
8.	<i>Xiphinema Attenuatus</i>	1047	16.00	1.50
9.	<i>Scutellonema brachyurus</i>	768	9.50	1.10
10.	<i>Tylenchus Arcuatus</i>	279	3.50	0.40
	Total	69839		

In present study the total populations ranged from 42183 to 279 per 500 grams of soils in different cane crop in Meerut district, Uttar Pradesh. The highest population was found in Mawana tehsil, which was significantly higher as compared to other locations. The minimum numbers of nematodes were recorded from Daurala. The maximum numbers of plant parasitic nematodes 179 per 250 grams of roots were collected from Partapur site, which was significantly higher as compared to other locations. This study correlated with study of Abdul

Rashid (2001) they found in the Survey of nematode fauna associated with sugarcane roots conducted at 29 locations of eastern Uttar Pradesh indicated the occurrence of stunt nematode, *Tylenchorhynchus* spp., the spiral nematode, *Helicotylenchus* spp, the lesion nematode, *Pratylenchus* spp. and lance nematode, *Hoplolaimus* spp were found in different sugarcane varieties.

Plant parasitic nematodes have been reported to form serious barrier to intensified production of sugarcane

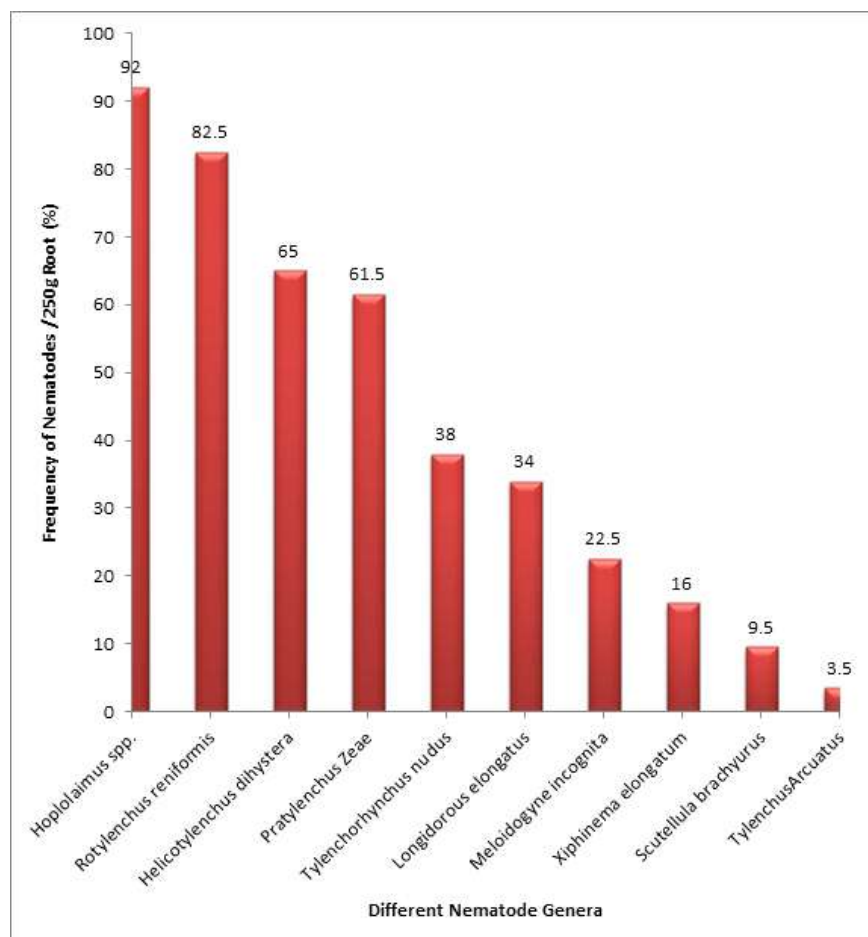


Fig.-1: Frequency rating of Plant parasitic nematodes associated with soil of Sugarcane field.

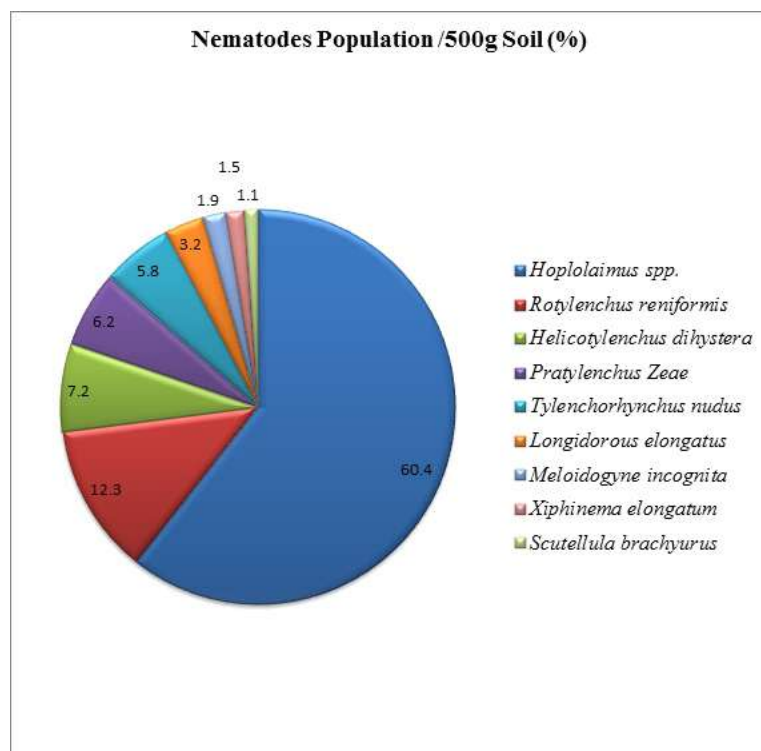


Fig.-2 : Population of Plant parasitic nematodes in Sugarcane field.

crop in various part of the India. In the present study various fertilizers have been used for centuries for better crop health and productivity. Application of fertilizers such as the actions of Azadirachtin (a neem product) as insecticides are based on multiactions pathway such as toxicity, anti-mitotic effects, antifeedant activity, insect growth regulator fecundity suppression, sterilization ovipositor repellency, including harmful effects on endocrine system and damage of the cuticle of larvae, preventing them from moulting. Modify phsico-chemical characteristic of the soil which may affect the extremity of plant parasitic nematodes and the diseases caused by them.

There is a need to educate all local farmers on the large diversity of plant parasitic nematodes concerned with sugarcane crop and their damage potentials by creating awareness programmers. Screening of seed plants and regular plant quarantine services should be employed previous to the introduction of new varieties to sugarcane farmers and also effective plant parasitic nematodes management strategies should be considered in order to improve yield in sugarcane crop.

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Rajmah Based Intercropping System Under Rainfed Condition of Assam

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Abstract

The feasibility of intercropping of rajmah with toria, linseed, lentil and buckwheat was studied in the experimental field, AICRP on Dryland Agriculture, Biswanath Chariali centre, Biswanath College of Agriculture, AAU during the *rabi* season of 2020-21. The soils of the experimental site were sandy loam in texture, acidic in reaction (pH 4.98), medium in organic carbon (5.80 g kg⁻¹), available N (330.10 kg ha⁻¹), available P₂O₅ (23.26 kg ha⁻¹) and available K₂O (171.35 kg ha⁻¹). The experiment was laid out in randomized block design involving three replications. The crop rajmah was sown as sole crop which was intercropped with toria (TS-38), linseed (T-397), lentil (KLS 218) and buckwheat (local) in two proportions each viz. 1:1 and 2:1 ratio. The treatment consists of T₁: Sole rajmah, T₂: Sole toria, T₃: Sole linseed, T₄: Sole lentil, T₅: Sole buckwheat, T₆: rajmah + toria (1:1), T₇: rajmah + linseed (1:1), T₈: rajmah + lentil (1:1), T₉: rajmah + buckwheat (1:1), T₁₀: rajmah + toria (2:1), T₁₁: rajmah + linseed (2:1), T₁₂: rajmah + lentil (2:1) and T₁₃: rajmah + buckwheat (2:1). The results of the experiment revealed that, the plant height at 30DAS was not influenced by different treatment combination. The plant height (60, 90 DAS and at harvest), number of branches per plant, dry matter accumulation, total chlorophyll content, relative leaf water content, pod per plant, number of seeds per pod, 1000 seed weight, grain yield, stover yield, biological yield, rajmah equivalent yield and harvest index of rajmah varied significantly among different intercropping system. Growth parameter, yield attributing character and yield of the crops are found to be better when they are grown solely as compared to intercropping systems. Among different intercropping systems, rajmah intercropped with lentil in 2:1 ratio was found superior over the other combinations. Highest seed yield (13.38 qha⁻¹) of rajmah was observed in sole rajmah while the lowest grain yield of rajmah (3.03 qha⁻¹) was obtained under rajmah + toria (1:1) intercropping system.

Key words : Equivalent yield, intercropping, leaf chlorophyll content and leaf water content.

Rajmah (*Phaseolus vulgaris* L.) or kidney bean is one of the most important pulse crops grown all over the country. As it possess very high amount of nutrients, it is honoured with “king of nutrition” (Parmer *et al.*, 2016). Although it is mostly grown for seed but extensively grown as green vegetable due to good sources of vitamins and minerals. Generally pulse crops including rajmah are grown as a sole crop with wide spacing due to which they yielded less return. Therefore intercropping of pulse crops with cereals, oilseed and other pulses may significantly lead to higher profit especially in adverse weather conditions. The crop also fits well in the intensive cropping system under *rainfed* agro-ecological situation of the state.

Intercropping has been found to be advantageous in maximizing land use efficiency through efficient use of resources like moisture, nutrients and light (Coll *et al.*, 2012), stabilizing the yield through risk minimization of crop failure and also reduced pest and disease problems. In Assam, rajmah is a popular crop particularly in Barak valley Zone of Assam and intercropping of rajmah with other crops may be additional advantages for the farmers particularly in *rainfed* situation. Considering the fact, the rajmah based intercropping with four *rabi* crops (toria, linseed, lentil and buckwheat) was undertaken for evaluation at AICRP for Dryland Agriculture, BN College of Agriculture, AAU, Biswanath Chariali, Assam during *rabi* season of 2020-21.

Materials and Methods

The experiment was conducted in the research experimental field, All India Coordinated Research Project for Dryland Agriculture, Biswanath College of Agriculture, Biswanath Chariali, Assam Agricultural University, during *rabi* season of 2020-21. The experiment site was situated at 26°43'30" N latitude and 93°08'01"E longitude having an elevation of 86.70m above mean sea level. The soil of experimental field was sandy loam in texture and the proportion of sand, silt and clay was 57.62%, 20.70% and 19.46%, respectively with a p^H 4.98 and 0.58% organic carbon. The available nitrogen, phosphorus and potassium were 330.10 kg ha⁻¹, 23.26 kg ha⁻¹ and 171.35 kg ha⁻¹, respectively which was medium in range. The experiment was laid out in randomized block design with 3 replication and comprises of 13 treatments viz. sole rajmah, sole toria, sole linseed, sole lentil, sole buckwheat, rajmah + toria (1:1), rajmah + linseed (1:1), rajmah + lentil (1:1), rajmah + buckwheat (1:1), rajmah + toria (2:1), rajmah + linseed (2:1), rajmah + lentil (2:1), rajmah + buckwheat (1:1).

The variety selected for rajmah was ‘Uday’, TS-38 for toria, T-397 for linseed, KLS-218 for lentil and Local variety for buckwheat. The seed rate of rajmah, toria, linseed, lentil and buckwheat were 75 kg ha⁻¹, 10 kg ha⁻¹, 20 kg ha⁻¹, 30 kg ha⁻¹ and 20 kg ha⁻¹ respectively. The

experimental plot was ploughed by tractor drawn plough followed by harrowing. Laddering was done properly to retain water uniformly in the field. Weeds and other stubbles were removed from the field at the time of final land preparation. The depth of sowing was maintained at about 3-5cm and seeds were covered with soil. Rows were prepared for sowing manually at 30 cm and plant to plant distance was kept at 10 cm. The fertilizer was applied as per recommendation following package of practices of Assam in terms of Urea, SSP and MOP. The crops were sown in the field within 12.11.2020 and 13.11.2020. Harvesting of the crops was differed according to the duration of the crops and rajmah was harvested on 10.03.2021, lentil was on 08.03.2021, linseed on 19.03.2021, toria on 12.02.2021 and buckwheat was on 27.02.2021.

Weekly meteorological data in standard meteorological week (SMW) during the period of experimentation was recorded at the meteorological observatory of the department of Agricultural Meteorology, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali and presented graphically in Fig.-1.

Considerable fluctuation was noticed in case of observed weather parameters throughout the crop period. The mean relative humidity ranged from 87% to 96 % in the morning hours and 44% to 73.7% in the evening hours and the weekly average maximum and minimum temperature ranged from 21.6° to 32.5°C and 5.9°C to 18°C, respectively. The total rainfall received during crop growing period was 83.2 mm out of which the highest amount (32.4mm) was recorded during 7th to 13th March, 2021. The mean bright sunshine hours varied from 1.0 to 9.3 hours per day during the crop growing period and the average wind speed varies from 0.97 to 5.09 km/hr.

Results and Discussion

Plant height and number of primary branches per plant : The plant height and number of primary branch per plant were recorded maximum in sole rajmah irrespective of all intercropping treatment. This superiority of sole rajmah over other treatments might be due to the absorption more essential nutrients, water, sunlight etc. in sufficient quantity that finally led to vigorous vegetative growth of rajmah. Among different intercropping treatments two rows of rajmah alternating with one row of lentil plant gave maximum plant height and primary number of branch per plant. Being a leguminous crop, it could help rajmah to maintain superiority over other inter crops (linseed, toria and buckwheat). Thus rajmah + lentil (2:1) could perform better among the intercropping treatments. However, there might be a competition for the available resources between rajmah and lentil grown as intercropped, which led to lower growth of rajmah as

compared to sole rajmah. The lowest plant height and number of primary branch per plant of rajmah was noticed in T₆ i.e. intercropped with 1:1 ratio with toria followed by intercropped with toria 2:1 ratio i.e. in T₁₀. Rajmah and toria intercropping did not perform well might be due to higher competition among rajmah and toria. As the plant height of toria was more as compared to rajmah, there might have been shading effect which probably adversely affected growth and yield of rajmah. Tuti *et al.* (2012) also found lower plant height and number of primary branches of toria in case of wheat + toria intercropping with 2:1 ratio than 1:1 ratio.

Dry matter accumulation in root, shoot and pod : Dry matter accumulation in root, shoot and pod of rajmah were significantly influenced by various intercropping systems. All intercrops significantly reduced the dry matter accumulation of rajmah, so maximum dry matter accumulation was obtained in sole rajmah. As there was no competition with other crops in sole rajmah, the crop could utilize the inputs like solar radiation, soil water and nutrients etc. by sole rajmah which ultimately led to vigorous growth of rajmah. Among different intercropping, rajmah + lentil (2:1) recorded the highest dry matter accumulation in root, shoot and pod. This treatment also maintained the highest dry matter partitioning for achieving the economic yield. Lentil could help the rajmah to maintain superiority over other inter crops by providing additional nitrogen for the growth and development of rajmah. Therefore, rajmah with lentil (2:1) intercropping system was found to be the best compared to the rest. Kumawat *et al.* (2015) recorded the higher dry matter, yields and harvest index in pigeonpea and black gram grown as sole crops compared to intercropping system.

Chlorophyll and leaf water content : The highest leaf chlorophyll and relative leaf water content was exhibited in sole rajmah among different treatments. Lack of competition of different crops in case of sole rajmah might help the rajmah plant to utilize the available raw materials for synthesis of photosynthetic pigments in a better way. The higher photosynthetic pigments again might trigger the anabolic processes of rajmah plants including the process of photosynthesis that lead to production and accumulation of more sucrose in leaf and young shoot of the crop. Raushan *et al.* (2020) also observed that chlorophyll content of plant was significantly influenced by different nutrition and improved the growth and yield of black gram.

Rajmah and toria intercropping did not performed well as height of toria was more as compared to rajmah and due to shading effect, so there was reduction in height of rajmah and number of branching. Similarly rajmah + lentil (2:1) recorded the highest dry matter accumulation in root, shoot and pod. This treatment also

Table-1 : Growth parameter of sole crop (Rajmah) as influenced by intercropping system.

Treatment	Plant height (cm)				Branch plant ⁻¹	Dry matter accumulation (g plant ⁻¹)			Total Chlorophyll (mgg ⁻¹ fw)	RLWC (%)
	30 DAS	60 DAS	90 DAS	At harvest		Root	Shoot	Pod		
Sole Rajmah	17.57	36.92	41.17	43.17	3.98	4.89	45.90	55.99	1.98	82.33
Sole Toria	-	-	-	-	-	-	-	-	-	-
Sole Linseed	-	-	-	-	-	-	-	-	-	-
Sole Lentil	-	-	-	-	-	-	-	-	-	-
Sole Buckwheat	-	-	-	-	-	-	-	-	-	-
Rajmah + Toria (1:1)	16.03	30.57	32.20	33.27	3.03	3.78	42.25	46.66	1.39	50.33
Rajmah + Linseed (1:1)	16.40	35.88	38.13	40.83	3.47	3.99	42.46	50.64	1.67	63.67
Rajmah + Lentil (1:1)	16.61	36.02	39.03	41.05	3.53	4.02	44.91	53.27	1.70	67.67
Rajmah + Buckwheat (1:1)	16.31	32.71	37.23	38.10	3.23	3.95	42.94	50.37	1.59	57.33
Rajmah + Toria (2:1)	16.13	31.43	35.15	37.67	3.15	4.10	42.54	50.03	1.49	55.33
Rajmah + Linseed (2:1)	16.20	36.16	39.47	41.17	3.60	4.35	44.64	53.70	1.79	67.67
Rajmah + Lentil (2:1)	16.90	36.38	40.43	41.77	3.68	4.50	45.07	54.57	1.90	73.33
Rajmah + Buckwheat (2:1)	16.39	32.96	37.83	39.13	3.27	3.92	42.96	50.63	1.63	60.00
SEd	0.09	0.11	0.17	0.16	0.04	0.01	0.33	0.14	0.02	0.40
CD at 5%	NS	0.23	0.34	0.33	0.08	0.02	0.68	0.30	0.04	0.80

Table-2 : Yield attributing characters of sole and intercrops as influenced by intercropping system.

Treatment	Rajmah			Intercrops			
	Pod plant ⁻¹	Seed pod ⁻¹	Test wt. (g)	Branch plant ⁻¹	Pod plant ⁻¹	Seed Pod ⁻¹	Test wt.(g)
Sole Rajmah	8.71	3.83	318.40	-	-	-	-
Sole Toria	-	-	-	4.33	140.9	14.68	3.67
Sole Linseed	-	-	-	3.22	24.3	8.98	6.11
Sole Lentil	-	-	-	3.33	32.06	1.95	14.27
Sole Buckwheat	-	-	-	3.92	35.81	10.8	12.51
Rajmah + Toria (1:1)	6.10	3.00	299.46	3.80	112.67	14.58	3.32
Rajmah + Linseed (1:1)	7.78	3.33	307.62	2.98	23.87	8.93	5.8
Rajmah + Lentil (1:1)	8.10	3.34	309.94	3.25	30.27	1.87	13.88
Rajmah + Buckwheat (1:1)	7.19	3.09	303.74	3.33	31.8	9.8	11.7
Rajmah + Toria (2:1)	6.71	3.04	301.36	3.83	84.07	13.6	3.28
Rajmah + Linseed (2:1)	8.29	3.45	312.75	2.28	22.98	8.53	5.5
Rajmah + Lentil (2:1)	8.54	3.53	314.33	3.17	30.19	1.85	13.56
Rajmah + Buckwheat (2:1)	7.38	3.13	306.65	2.89	30.24	9.5	11.3
S.Ed±	0.03	0.03	0.08	-	-	-	-
CD(P=0.05)	0.07	0.07	0.18	-	-	-	-

maintained highest dry matter partitioning to the economic yield. The lentil could help the rajmah to maintain superiority over other inter crops by providing additional nitrogen for the growth and development of rajmah. Leaf chlorophyll content and relative leaf water content was maximum in, rajmah with lentil (2:1) intercropping which may be due to higher uptake of nutrient from the soil and nitrogen addition by lentil in soil through root nodulation which might help to accelerate the growth with larger canopy and more chlorophyll content. Again, these increase the photosynthetic efficiency of the crop plant

that in turn elevates the leaf water content in plants. On the other hand the inter crops like toria, buckwheat and linseed might compete with rajmah for the available resources and thus reduced the growth potential of rajmah resulting in poor performance in morpho-physiological characteristics of rajmah including chlorophyll content and overall growth of the crop plant.

Yield and yield attributing characters

Main crop : The stover yield, biological yield, yield attributing characters of rajmah like pod plant⁻¹, number of

Table-3 : Yield of sole and intercrops as influenced by intercropping system.

Treatment	Rajmah			Intercrops			Rajmah Equivalent Yield (qha ⁻¹)
	Seed yield (qha ⁻¹)	Stover yield (qha ⁻¹)	Harvest index (%)	Seed yield (qha ⁻¹)	Stover yield (qha ⁻¹)	Harvest index (%)	
Sole Rajmah	13.38	15.34	46.58	-	-	-	13.38
Sole Toria	-	-	-	10.04	22.71	30.66	6.97
Sole Linseed	-	-	-	8.89	24.34	26.75	4.94
Sole Lentil	-	-	-	6.66	18.32	26.66	7.40
Sole Buckwheat	-	-	-	13.73	32.46	29.73	8.20
Rajmah + toria (1:1)	3.03	5.12	37.20	6.01	14.65	29.09	7.20
Rajmah + linseed (1:1)	7.17	9.98	41.79	4.94	16.44	23.11	9.91
Rajmah + lentil (1:1)	8.18	10.42	43.97	3.13	11.27	21.76	11.66
Rajmah + buckwheat (1:1)	4.21	6.54	39.16	8.16	21.32	27.68	9.08
Rajmah + toria (2:1)	3.49	5.70	37.99	4.07	10.77	27.43	6.32
Rajmah + linseed (2:1)	9.65	11.52	45.58	3.33	13.22	20.12	11.51
Rajmah + lentil (2:1)	10.56	12.39	46.02	2.61	10.22	20.34	13.46
Rajmah + buckwheat (2:1)	6.25	8.58	42.15	5.5	16	25.58	9.54
S.Ed±	0.08	0.08	0.29	-	-	-	0.09
CD(P=0.05)	0.18	0.18	0.61	-	-	-	0.20

Table-4 : Soil nutrient status as influenced by sole and intercropping of rajmah.

Treatment	N	P ₂ O ₅	K ₂ O
		Kg ha ⁻¹	
Sole Rajmah	327.53	23.70	140.15
Sole Toria	317.24	23.83	123.90
Sole Linseed	331.71	24.33	122.07
Sole Lentil	337.64	26.73	148.71
Sole Buckwheat	309.42	24.86	137.47
Rajmah + Toria (1 : 1)	314.45	23.69	132.70
Rajmah +Linseed (1 : 1)	330.39	25.49	127.04
Rajmah + Lentil (1 : 1)	335.50	26.61	141.61
Rajmah + Buckwheat (1 : 1)	292.69	23.64	120.04
Rajmah + Toria (2 : 1)	314.63	25.27	131.32
Rajmah + Linseed (2 : 1)	326.14	26.40	123.58
Rajmah + Lentil (2 : 1)	334.50	23.70	140.29
Rajmah + Buckwheat (2: 1)	304.42	24.77	134.34
S.Ed±	39.82	1.03	9.16
CD(P=0.05)	NS	NS	NS

seed pod⁻¹, test weight of seed and harvest index were significantly influenced by different intercropping systems. They were recorded the maximum in sole rajmah (T₁) which might be due to the best performance of sole rajmah recorded in terms of plant height, number of branches per plant, dry matter accumulation, total chlorophyll content as well as relative leaf water content of the rajmah leaf. Since, these characteristics could regulate the yield and yield attributes of crop plants hence the best performance was found in sole rajmah. As lentil is a leguminous crop it could help the rajmah to maintain superiority over linseed, toria and buckwheat thus rajmah + lentil (2:1) could performed better among the intercropping treatments. The lowest performance was found in rajmah intercropped with toria in 1:1 ratio followed by rajmah intercropped with toria in 2:1 ratio.

Intercrop : Among different treatment, sole cropping of all

the intercrops viz. toria, linseed, lentil and buckwheat emerged as the best treatment as it produced maximum plant height (cm), number of branches per plant, dry matter accumulation (root, shoot and pod), leaf chlorophyll content, relative leaf water content, number of siliqua per plant, number of seeds per siliqua, test weight of seeds (g), seed yield (qha⁻¹), stover yield (qha⁻¹), biological yield (qha⁻¹) and harvest index (%) of toria, which was superior over the intercropping ratios (1:1 and 2:1). The probable reasons might be due to efficient utilization of available growth resources in favour of producing maximum growth as well as yield attributing characters without any competition resulting in higher yield of the crop.

Equivalent yield of the system : Rajmah + lentil intercropping (2:1) produced the maximum equivalent yield (13.92 qha⁻¹) and it was followed by the treatment rajmah + linseed (1:1) which were found to be superior

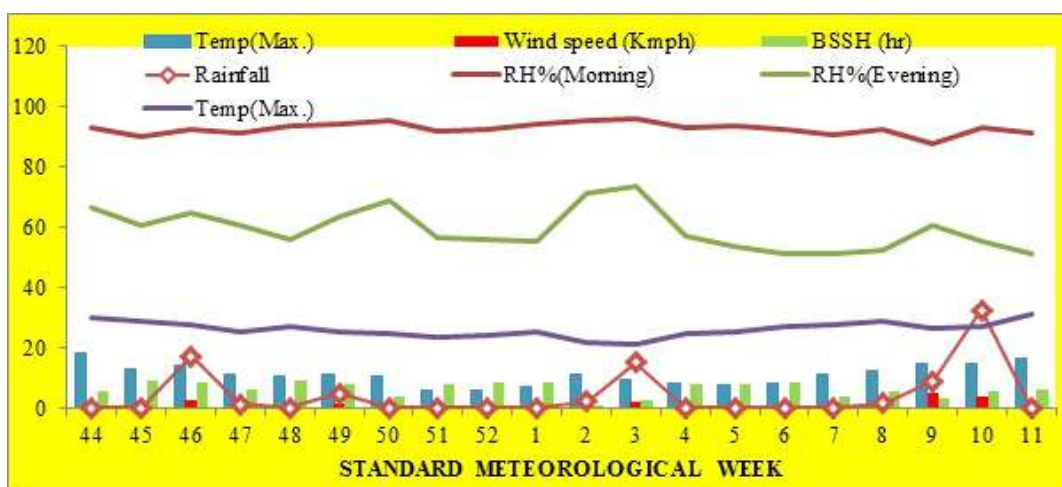


Table-5 : Meteorological data during crop growing period in Standard Meteorological week.

over rest of the treatments. Among different treatments of sole crops, sole rajmah (T1) produced maximum seed (13.38 qha^{-1}) yield. This was due to higher yield performance of rajmah in sole and intercropping system and extra yield of lentil as bonus in intercropping system. Since the yield and market rate of lentil had an edge over the rate of rajmah, sole rajmah ranked next to rajmah + lentil in 2:1 ratio. The lower yield of component crops in double row ratios resulted in lower rajmah equivalent yield. Thus, the possible reason of maximum rajmah equivalent seed yield of rajmah in sole crop as well as in intercrop with lentil among different treatments was due to higher yield and prices of both crops.

Soil nutrient status : In present study, although there was no significant difference in NPK content of soil among the treatments combinations, rajmah + lentil of 2:1 ratio has comparatively higher available soil NPK status ($335.50 \text{ kg ha}^{-1}$, 26.61 kg ha^{-1} and $141.61 \text{ kg ha}^{-1}$ respectively). The increase in Nitrogen might be due to symbiotic nitrogen fixation as lentil belongs to the family leguminosae and the increased level of available soil P may be due to more root proliferation of lentil. The lowest soil NPK status ($292.69 \text{ kg ha}^{-1}$, 23.64 kg ha^{-1} and $120.04 \text{ kg ha}^{-1}$ respectively) was recorded in rajmah + buckwheat of 1:1 ratio. Bhuva *et al.* (2017) reported that the maximum available Nitrogen (220.2 kg ha^{-1}) and Potassium (310.4 kg ha^{-1}) was recorded with groundnut + green gram (1:1) and highest available phosphorus (29.2 kg ha^{-1}) with sole moth bean. Padhi and Panigrahi (2006) found that maize + soybean followed by maize + blackgram recorded the highest available soil N at 1:1 row ratio and available soil P and K at 2:1 row ratio among various intercropping systems grown during rainy season at Kalimela, Orissa.

Conclusion

Among all five different *rabi* crops, lentil and linseed was found to be more efficient when intercropped with rajmah. Under all treatment combinations of sole and inter-

cropping treatments, the rajmah equivalent yield was recorded highest in the treatment rajmah + lentil (2:1). Rajmah as sole crop and its intercropping with lentil and linseed system proved themselves superior to all other treatment combination of intercropping systems tried in the experiment. Toria and buckwheat was not found to be compatible with rajmah in both 1:1 and 2:1 ratio of intercropping system.

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Assessment of Kharif Onion Varieties under Nimar Plains Conditions of Madhya Pradesh

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Abstract

On-farm trial (OFT) was conducted during Kharif in 2020 and 2021, respectively on the 07 farmers' fields to evaluate different varieties of onion (*Allium cepa* L.) for growth and yield attributes and their economics under the Nimar Plains conditions of Madhya Pradesh. Two varieties, namely N-53 and Bhima Super were evaluated during experimentation. T₂ (Bhima Super) recorded significantly higher plant height (64.33 cm), number of leaves/plant (13.67), bulb diameter (5.71 cm), bulb weight (96.10 g) and yield/ha (266.86 q) than T₁ (N-53). The maximum net return of Rs 339628/ ha and benefit cost ratio of 3.90 were recorded for T₂. Whereas, the minimum net return of Rs 243928/ ha and benefit cost ratio of 3.15 were recorded in T₁.

Key words : Kharif onion, economics, growth, variety, yield.

Introduction

Onion (*Allium cepa* L.) is one of the important bulb as well as cash vegetable crop under family Alliaceae. It is perishable in nature under high temperature. The onions are used as condiments, salad, chutneys, pickles, curries, soups, sauces and seasoning foods. The crushed bulb contains colourless, odourless volatile essential oil known as allyl propyl disulphide. India is prominent in its production and export in the world. In India area of onion is 1285 thousand hectares with the total production of 23262 thousand MT. In Madhya Pradesh, onion registered an area of about 150.87 thousand hectares with total production of 3701.01 thousand MT (Department of Agriculture, Cooperation & Farmers Welfare, 2018).

In India, onion is predominantly cultivated during *rabi* about 60% followed by 20% each in *kharif* and late *kharif* season (Tripathy *et al.*, 2013). The higher productivity could be determined by selection of suitable varieties, balanced nutrition, optimum water management as well as need based plant protection measures. Among these factors, selection of suitable cultivar plays an important role in enhancing the yield as well as productivity. Production of onion in *kharif* and late *kharif* season is more important to have continuous supply of onion round the year. During the last decade many new varieties of onion have been released by the public and private sectors for the cultivation however, information on their performance, especially under Nimar plains, is meagre. Farmers opt for specific hybrids/varieties solely on recommendation of vendors, which leads to uncertainty in yield and, sometimes, total crop failure. Therefore, it is necessary to evaluate the yield performance of new

varieties before recommendation so that farmers can fetch remunerative returns. Thus, to identify promising varieties an on farm trial was conducted during Kharif 2020 and 2021 on the seven farmers' fields to evaluate different varieties of onion.

Materials and Methods

The trial was conducted at 07 farmers' field in West Nimar region of M.P. during the *Kharif* season of 2020 and 2021. Treatments comprised T₁ (N-53) and T₂ (Bhima Super). The seeds were sown in nursery during the first week of July. After 489 days of sowing healthy seedlings were transplanted in the main field. Recommended package of practices was adopted to raise a good crop. FYM was used @ 250q/ha and fertilizer 100 Kg N, 50 Kg P₂O₅ and 50 Kg K₂O were applied per hectare. FYM was used during land preparation and the full dose of phosphorus and potash and 50% of total nitrogen were applied at the time of transplanting. Remaining nitrogen was top dressed in two splits doses. The observations were recorded on ten randomly selected plant from each field on different growth and yield attributes. Cost of cultivation/ha, gross return/ha, net return/ha and BC ratio were worked out as per standard methods. Various parameters were compared as per paired "t" test of significance.

Results and Discussion

Growth parameters : Results revealed the performance of *kharif* onion cultivars for vegetative, yield attributes and economics are presented in Table 1-3. There were significant differences between the cultivars tested for various aspects. Maximum plant height (64.33 cm), number of leaves per plant (13.67) at 90 DAP were

Table-1 : Response of different onion varieties on growth parameters (average of two years).

Treatments	Plant height (cm) 90 DAT	No of leaves/plant 90 DAT	Days required for maturity
T ₁	60.24	13.07	101
T ₂	64.33	13.67	116
t-value	33.893034	10.172425	13.05102

The means of T₁ and T₂ are significantly different at p ≤ 0.05.

Table-2 : Response of different onion varieties on yield parameters (average of two years).

Treatments	Neck thickness of bulb (mm)	Bulb diameter (cm)	Bulb Weight (g)	Marketable yield per hectare (q)
T ₁	1.23	5.31	82.78	210.86
T ₂	0.97	5.71	96.10	266.86
t-value	14.71841	9.371319	76.359579	11.664738

The means of T₁ and T₂ are significantly different at p ≤ 0.05.

Table-3 : Response of different onion varieties on economics (average of two years)

Treatments	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Benefit Cost : ratio
T ₁	124929	368857	243928	3.15
T ₂	127193	466821	339628	3.90
t-value	3.246702	11.614439	11.69965	11.701405

The means of T₁ and T₂ are significantly different at p ≤ 0.05.

recorded in T₂ (Bhima Super). Significantly lower plant height (60.24 cm), number of leaves per plant (13.07) at 90 DAP were recorded with T₁ (N-53). The Bhima Super required 116 days to mature however, N-53 recorded 101 days for maturity. Similar results were reported by Mohanty *et al.* (2002), Hirave *et al.* (2015) and Sahoo *et al.* (2020) under different climatic conditions with different varieties.

Yield attributes : In onion, neck thickness of harvested bulb plays key role for shelf life and rate of rotting under storage condition. Usually, bulbs with relatively thin neck are preferred for better storage life than thick bulbs which have lower storage life. Hence maximum precaution should be taken while selecting the better onion variety for cultivation. Variety Bhima Super recorded minimum (0.97 cm) neck thickness. Whereas, N-53 recorded the maximum neck thickness (1.23 cm). These results are in close conformity with the findings of Mohanty *et al.* (2002), Dewangan *et al.* (2012) and Sahoo *et al.* (2020).

The results on bulb parameters, i.e. average bulb weight and bulb diameter showed significant variations among the tested cultivars (Table-2). The Variety Bhima Super (T₂) recorded significantly maximum diameter of bulb (5.71 cm) and bulb weight (96.10 g). Whereas, minimum diameter of bulb (5.31 cm) and bulb weight (82.78 g) recorded at T₁ (N-53). Variety, Bhima Super produced significantly highest marketable bulb yield of 266.86 q/ha than N-53 (210.86 q/ha). Marketable bulb yield in onion is more important than that of the total bulb yield. Therefore, due consideration is necessary while

selecting variety for commercial cultivation, particularly during *kharif* and late *kharif* seasons. The maximum bulb yield from these varieties during *kharif* season may be attributed due to the accumulation of maximum photosynthates in the bulbs. Variations in the bulb yields of different varieties of onion have been reported from several places (Patil *et al.*, 1991; Bhonde *et al.*, 1992; Khan, 1997; Mohanty and Prusty, 2002, Hirave *et al.*, 2015). Superiority of Bhima Super as *kharif* onion has also been reported by Lawande *et al.* (2011) and Sahoo *et al.* (2020).

Economics : The economic analysis over the years revealed that Bhima Super variety fetched higher gross return (Rs. 466821/ha), net return (Rs. 339628/ha) and B:C ratio of 3.90 as compared to N-53. Better economic return Bhima Super variety was reported by Kerure *et al.* (2016) also.

Conclusions

On the basis of experimentation over two consecutive years, it has been concluded that the cultivar Bhima Super is far-far superior not only for growth, but also performed well in terms of yield performance and ultimately raises the income of the farmers in the Nimar valley. It may be recommended for *kharif* season cultivation to obtain the maximum bulb size and the bulb yield.

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Priming Techniques for Enhancing Seed Quality in Soybean [*Glycine max* (L.) Merrill.]

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Abstract

The present investigation entitled, "Studies on enhancing seed quality by priming techniques in soybean [*Glycine max* (L.) Merrill.]" was carried out during kharif season of 2020 at experimental farm of Regional Research Centre Amravati, (Dr.PDKV)(MS), India. The experiment was laid out in Randomized Block Design with three replications involving different seed priming treatments with different chemicals viz., (T1) (untreated seeds) as control, (T2) hydro priming for 2 hr, (T3) hydro priming with 100 ppm GA₃ for 2 hr, (T4) hydro priming with CaCl₂ @1% for 2 hr, (T5) hydration with KNO₃ @1 % for 2 hr, (T6) Seed treatment with IAA - @ 100ppm for 2hrs, (T7) Seed treatment with Carbendazim @ 0.2 % , (T8) seed priming with Rhizobium Culture @ 2.5%. The soybean variety was AMS-1001. The data obtained were analyzed by using Randomized Block Design (RBD). From the experimental observations, it may be concluded that soybean seeds positively responded to treatments of priming. Nevertheless, priming generally improves the seed quality parameters of soybean through improving germination percentage, seedling length, seedling dry weight, vigour index, field emergence, initial plant stand, days to 50 per cent flowering, plant height, and yield per hectare. The highest benefit of priming can be obtained from seeds primed with CaCl₂ (1% for two hours) treatment.

Key words : Soybean, seed priming, germination, seed quality.

Introduction

Soybean (*Glycine max* L.) popularly known as "Golden bean" Soja bean, Soya bean, Chinese pea and Manchurian bean which belongs to family Leguminaceae, sub family fabaceae and genus glycine is one of the most important oil seed crop known for its excellent protein (42-45%), oil (22%) and starch content (21%). The crop is one of the likely solutions for overcoming the world's protein hunger and a good source of vitamin B complex, particularly thiamine and riboflavin. Soybean protein is rich in valuable amino acids like lysine (5%) in which, most of the cereals are deficient. It is reported that the seed priming is one of the most important developments to help rapid and uniform germination and emergence of seeds and to increase seed tolerance to adverse environmental conditions (Heydecker *et al.*, 1973, 1975; Harris *et al.*, 1999). Seed priming has presented promising and even surprising results, for many seeds including the legume seeds (Bradford, 1986). The advantage of seed priming in reducing the germination time and improving emergence uniformity is well established under laboratory conditions. The direct benefits of seed priming in all crops included faster emergence, better, more and uniform stands, less need to re-sow, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield. The indirect benefits reported were: earlier sowing of crops, earlier harvesting of crops and increased willingness to use of fertilizer because of reduce risk of crop. Considering the beneficial effects of seed priming on moisture use efficiency and seed quality

parameters like, germination and vigour which help in maintenance of optimum plant population and to obtain expected yield level the present study was undertaken with the objectives as to study the effect of seed priming on seed quality of soybean.

Materials and Methods

The present investigation entitled, "Studies on enhancing seed quality by priming techniques in soybean [*Glycine max* (L.) Merrill.]" was carried out during kharif season of 2020 at experimental farm of Regional Research Centre Amravati, (Dr. PDKV)(MS), India and the laboratory test was conducted at Seed Technology Research Unit Dr. PDKV Akola. The experiment was laid out in Randomized Block Design with three replications and eight treatment involving different seed priming treatments with different chemicals viz., (T1)(untreated seeds) as control, (T2)hydro priming for 2 hr, (T3) hydro priming with 100 ppm GA₃ for 2 hr, (T4) hydro priming with CaCl₂ @1% for 2 hr, (T5) hydration with KNO₃ @1 % for 2 hr, (T6) Seed treatment with IAA - @ 100ppm for 2hrs , (T7) Seed treatment with Carbendazim @ 0.2 % , (T8) seed priming with Rhizobium Culture @ 2.5%. The soybean variety was AMS-1001. the sowing is done by dibbling method with spacing of 45x5 cm spacing. The data collected from the experiment were analyzed statistically by Randomized Block Design as per procedure given by Pansen and Sukhatme (1967) and sundarrajan *et al.* (1972).

Results and Discussion

Quality seeds are those which germinate evenly, imbibe

Table-1 : Effect of seed priming on Germination percent(%), Seedling length (cm), Seedling Dry Weight (g), Vigour Index I and Vigour Index II.

Treatments	Germination percent	Seedling length (cm)	Seedling Dry Weight (g)	Vigour Index I	Vigour Index II
T ₁ : Control	73.26	14.10	0.414	1032.98	30.36
T ₂ : Hydro priming for 2 hrs	75.34	14.40	0.421	1085.64	31.73
T ₃ : Seed priming GA ₃ @ 100 ppm for 2 hrs	79.16	18.70	0.634	1480.29	50.16
T ₄ : Seed priming with 1 th CaCl ₂ @ 1 % for 2 hrs	81.13	20.10	0.678	1630.71	55.10
T ₅ : Seed priming with KNO ₃ @ 1% for 2 hrs	78.36	17.40	0.592	1339.95	46.36
T ₆ : Seed treatment with IAA @100 ppm for 2hrs.	78.06	17.10	0.531	1334.82	41.43
T ₇ : Seed treatment with Carbendazim @ 0.2%	77.66	16.50	0.510	1281.39	39.60
T ₈ : Seed treatment with Rhizobium spp.@ 2.5%	76.33	15.20	0.481	1160.27	36.73
Mean	77.41	16.70	0.532	1293.26	41.43
F test	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.90	0.45	0.02	10.88	1.69
CD at 5%	2.73	1.37	0.06	32.86	5.11

Table-2 : Effect of seed priming treatments on Days to field emergence, Initial plant stand , Days to 50% flowering,Plant height at flowering (cm), pods per plant.

Treatments	Days to field emergence	Initial plant stand	Days to 50% flowering	Plant height at flowering (cm)	Pods per plant
T ₁ : Control	6.43	182.0	43.23	39.03	35.56
T ₂ : Hydro priming for 2 hrs	5.60	183.4	41.33	42.06	39.33
T ₃ : Seed priming with GA ₃ @ 100 ppm for 2 Hrs	4.86	194.5	39.53	45.96	41.36
T ₄ : Seed priming with CaCl ₂ @ 1% for 2 Hrs	4.63	197.3	38.16	44.66	43.16
T ₅ : Seed priming with KNO ₃ @ 1% for 2Hrs	5.13	190.1	41.16	42.96	40.53
T ₆ : Seed treatment with IAA @100 ppm for 2hrs.	5.26	188.3	40.30	43.63	39.16
T ₇ : Seed treatment with Carbendazim @ 0.2%	5.96	186.8	41.33	39.73	38.23
T ₈ : Seed treatment with Rhizobium spp.@ 2.5%	5.80	185.8	40.83	40.43	37.83
Mean	5.46	188.5	40.73	41.90	39.40
F test	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.12	2.39	0.81	0.30	0.51
CD at 5%	0.36	7.22	2.46	0.90	1.54

water rapidly and produces stand in the shortest possible time under wide range of field conditions (Dighe *et al.*, 1982). Seed priming provides physical and microbial protection to seeds. Similarly it also gives protection against stress and acts as an efficient carrier for nutrients and pesticides. The seed priming can thus be helpful to obtain good crop stand through improved germination and seed vigour. In the present investigation, seed priming with T₄ (hydration with CaCl₂ @ 1 % for 2 hr) exhibited higher germination 81.13% followed by T₃ (hydration with 100 ppm GA₃ for 2 hr) 79.16% over control and other treatments. Remaining treatments also contributed in improving the germination. Beneficial effects of priming treatment may be through the improved physiological process for germination and protection against pests. Lower value for seed germination recorded by untreated control. The present finding confirms the finding of Agawane *et al.* (2015) in soybean and Pulok *et al.* (2015) in lentil. Christiansen and Fay (1979) and Hecht Buchholz (1979) reported seed calcium concentration and germination percentage were positively related suggesting the role of calcium as an important component

in membrane stabilization and as an enzyme cofactor. Significant variation in seedling length, seedling dry weight, vigour index I and vigour index II were observed due to different seed priming treatments. Highest seedling length were observed in treatment T₄ (hydration with CaCl₂ @ 1 % for 2 hr) (20.10 cm) and treatment T₃ (hydration with 100 ppm GA₃ for 2 hr) (18.70 cm) which were statistically similar. All other treatment recorded higher seedling length than untreated control. Control treatment recorded lower value of seedling length (14.10 cm). All the seed priming treatments have significant effect on total dry weight over control at all stages of crop growth. The treatment T₄ (hydration with CaCl₂ @ 1 % for 2 hr) (0.678 gm) was found superior over rests of treatments followed by treatment T₃ (hydration with 100 ppm GA₃ for 2 hr) (0.634 gm). Lower seedling dry weight was recorded by untreated control. All the seed priming treatments have the significant effect on vigour index I&II. The highest seed vigour index I&II was recorded by treatment T₄- seed priming with CaCl₂ @ 1% Vigour index-I (1630.71) and vigour index-II (55.10) followed by seed priming with T₃-seed priming with GA₃ @ 100ppm vigour index-I

Table-3 : Effect of seed priming treatments on Yield per hectare (qt/ha) & Harvest index (%).

Treatments	Yield per hectare (qt/ha)	Harvest index (%)
T ₁ : Control	20.93	29.16
T ₂ : Hydro priming for 2 hrs	23.53	30.66
T ₃ : Seed priming with GA ₃ @ 100 ppm for 2 Hrs	28.82	37.20
T ₄ : Seed priming with CaCl ₂ @ 1 % for 2 Hrs	29.80	38.43
T ₅ : Seed priming with KNO ₃ @ 1 % for 2Hrs	28.50	35.83
T ₆ : Seed treatment with IAA @100 ppm for 2 hrs	27.21	36.10
T ₇ : Seed treatment with Carbendazim @ 0.2%	26.52	34.60
T ₈ : Seed treatment with Rhizobium spp.@ 2.5%	24.80	32.60
Mean	26.21	34.32
F test	Sig.	Sig.
SE (m)±	1.46	0.82
CD at 5%	4.41	2.49

(1480.29) and vigour index-II (50.16). The lowest vigour index was recorded by control T₁ vigour index-I (1032.98) and vigour index-II (30.36). The present findings are in accordance with Naraynreddy and Biradarpatil (2008) in sunflower and Kasra Maroufi *et al.*, (2011) in soybean. Field emergence is an important parameter and is a major factor of yield and the data on field emergence and all the priming treatments significantly affected the days required for field emergence. The treatment T₄ was observed that minimum days required for field emergence i.e. (4.63 days) and the treatment T₄ (hydration with CaCl₂ @ 1 % for 2 hr), found significantly superior over all the remaining treatments for field emergence followed by T₃ (hydration with 100 ppm GA₃ for 2 hr) (4.86 days). All the treatments were significantly superior over control (T₁). In respect of growth initial plant stand was recorded significantly highest initial plant stand (197.33) was recorded by seed priming with CaCl₂ @ 1.5 % while lowest initial plant stand (181.06) was recorded in control. All treatments recorded higher plant stand than control. More days required to 50% flowering (43.23) in control, while less days required to 50% flowering (38.16) was recorded by seed primed with T₄ (hydration with CaCl₂ @ 1 % for 2 hr). Assefa *et al.* (2008) also reported that 50 % flowering was earlier in case of calcium chloride as compared to other priming treatments and mentioned that this could be because of their effect in the fast emergence of the seeds at the beginning. among the seed priming treatments T₃ (hydration with 100 ppm GA₃ for 2 hr), priming with treatment with T₄ (hydration with CaCl₂ @ 1% for 2 hr) maintained significantly more plant height i.e. 45.96, 44.66cm respectively, than control (T₁). Similar findings reported by Bensen *et al.*, (1990) in soybean, Rehman *et al.* (2014) who reported that osmo-priming with CaCl₂ reduced crop branching and flowering and maturity times and had the maximum plant height and Chavan *et al.*, (2014) in soybean. All seed priming treatments bared significantly more number of pods than control T₁ (35.56). Seeds priming with T₄-CaCl₂ @1%- 2hrs and T₃-GA₃

@100ppm - 2hrs recorded significantly higher number of pods, i.e. 43.16 and 41.36 respectively. Rest of the seed priming treatments was also statistically produced more number of pods and those were significantly higher than the control. Highest value for seed yield per hectare was recorded by treatment T₄ (hydration with CaCl₂ @ 1 % for 2 hr) was recorded significantly more yield (29.80 qt.) over rest of treatments followed by the treatment T₃ (hydration with 100 ppm GA₃ for 2 hr) (28.82) and lowest seed yield was recorded with untreated control. Seed priming treatment increase the seed yield per hectare. The results are in accordance with the findings of Assefa *et al.* (2008) in soybean, Narayan Reddy and Biradarpatil (2012) in sunflower, Chavan *et al.* (2014) and Agawane *et al.* (2015) in soybean. Harvest index (%) also noticed significantly more in T₄-CaCl₂ @1% (38.43%), numerically more as compare to other treatments. The lowest H.I. (%) was noted by treatment T₁ (29.16%). The present findings are in line with Shete *et al.*, (2018) in soybean.

Conclusions

On the basis of these observations, it may be concluded that soybean seeds positively responded to treatments of priming. Nevertheless, priming generally improves the seed quality parameters of soybean varieties through improving germination percentage, seedling length, seedling dry weight, vigour index, field emergence, initial plant stand, days to 50 per cent flowering, plant height, pods per plant and yield per hectare. The highest benefit of priming can be obtained from seeds primed with CaCl₂ (1% for two hours) treatment.

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Evaluation of the Bio-efficacy of Native Isolates of Entomopathogenic Nematodes against Fall Armyworm, *Spodoptera frugiperda*

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Abstract

The bio-efficacy test of native EPNs, *Heterorhabditis* sp. (Anand H-I) and *Steinernema* sp. (Anand St-I) isolated from Anand city were carried out against the fourth instar larva of *S. frugiperda* in laboratory condition. The per cent larval mortality of *S. frugiperda* at different inoculum levels, i.e., 20, 40, 60, 80 and 100 IJs per larva of *Heterorhabditis* sp. (Anand H-I) and *Steinernema* sp. (Anand St-I) as recorded every 24 hrs up to 120 hrs. The maximum 91.65 per cent mortality was observed after 96 hrs for 80 and 100 IJs of *Heterorhabditis* sp. per larva, while after 120 hrs in the case of *Steinernema* sp. For *Heterorhabditis* sp., all the treatments gave maximum mortality (91.65 %) after 120 hrs., whereas for *Steinernema* sp., inoculum levels i.e. 60, 80 and 100 IJs per larva achieved maximum mortality (91.65 %). In the laboratory study, the fourth instar larva of *S. frugiperda* was found highly susceptible to *Heterorhabditis* sp. compared to *Steinernema* sp.

Key words : Entomopathogenic nematodes, EPNs, bio-efficacy, *Heterorhabditis* sp., *Steinernema* sp., fall armyworm, *Spodoptera frugiperda*.

Introduction

Nematodes associated with insects referred to as entomophilic, entomogenous, entomophagous and entomopathogenic are known to parasitize, cause disease and kill insects. Biological control of insects with EPNs (Entomopathogenic nematodes) progressed in 1932 with the discovery of *Steinernema glaseri* (Glaser, 1932) infecting the Japanese beetle (*Popillia japonica*, Newman). The primary objective of biological control is to reduce the pest population below the economic threshold by using natural enemies. They are notably more virulent against lepidopterous and coleopterous pests.

The EPNs of the families Steinernematidae and Heterorhabditidae are potentially useful for biological control in agriculture systems. The infective juveniles of these families are free-living, non-feeding, and have the ability to search out their hosts. They have the potential for long-term establishment in the soil through recycling infected insect larvae. EPNs-based pesticides are marketed mainly in western countries compared to other organisms, apart from the bacteria *Bacillus thuringiensis*.

The EPNs possess unique attributes like complex nematode-bacterium mutualistic symbiosis, broad host range and their amenability to be cultured *in-vivo* and *in-vitro* on large scale, making them very suitable to be used as a biocontrol agent and at a same time inhibition of fall armyworm (FAW) larvae in the whorl of maize plant and its pupae in the soil provide a favourable environment for the EPNs to act upon. Therefore, EPNs can be potential biocontrol agents for the management of FAW. With a view to the above facts, the present study was

conducted under laboratory conditions to test the bio-efficacy of isolated EPNs, *Heterorhabditis* sp. (Anand H-1) and *Steinernema* sp. (Anand St-1) against the larvae of fall armyworm, *Spodoptera frugiperda*.

Materials and Methods

The experiment was carried out at the Department of Nematology, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat). The details of materials used and methods employed during experimentation are elucidated under different headings. The bio-efficacy test of native EPNs, *Heterorhabditis* sp. (Anand H-I) and *Steinernema* sp. (Anand St-I) was carried out against *S. frugiperda*. For the requirement of larvae, the rearing of larvae was done in the laboratory.

Rearing of *S. frugiperda* : Larvae of *S. frugiperda* were collected from the field and sustained under a vial for artificial rearing in the laboratory. Hatched larvae were separated in another vial with fresh maize leaf feed, which was covered with a lid. First-generation fourth-instar larvae were used for the pathogenicity test.

The bio-efficacy test of native EPNs, *Heterorhabditis* sp. (Anand H-I) and *Steinernema* sp. (Anand St-I) isolated from Anand city were carried out against the fourth instar larva of *S. frugiperda* in laboratory condition. First, the 48 sterilized Petri plates (with 3 compartments) were kept in sequence according to treatments and repetitions. A total of 24 Petri plates were used for the bio-efficacy test of *Heterorhabditis* sp. (Anand H-I) and another 24 Petri plates were used for *Steinernema* sp. (Anand St-I). The EPNs suspension consisting of infective juveniles (IJs)

Table-1: Bio-efficacy of *Heterorhabditis* sp. (Anand H-I) against *S. frugiperda*.

Tr. No.	Treatments (IJs/larva)	Mortality (%) of <i>S. frugiperda</i> after indicated hrs of inoculation			
		48	72	96	120
T ₁	20	1.62 (0.08)	26.85 (20.04)	54.74 (66.67)	88.38 (99.92)
T ₂	40	1.62 (0.08)	35.26 (33.33)	63.15 (79.60)	88.38 (99.92)
T ₃	60	1.62 (0.08)	45.00 (50.00)	79.97 (96.97)	88.38 (99.92)
T ₄	80	35.26 (33.33)	54.74 (66.67)	88.38 (99.92)	88.38 (99.92)
T ₅	100	45.00 (50.00)	79.97 (96.97)	88.38 (99.92)	88.38 (99.92)
T ₆	Distilled water	1.62 (0.08)	1.62 (0.08)	1.62 (0.08)	1.62 (0.08)
	S.Em ±	2.30	5.37	4.86	0.00
	C.D. (0.05)	6.82	15.96	14.43	0.00
	C.V. %	31.75	26.47	15.49	0.00

Note : Figures in parentheses are retransformed values and those outside are arc sin transformed values.

Table-2 : Bio-efficacy of *Steinernema* sp. (Anand St-I) against *S. frugiperda*.

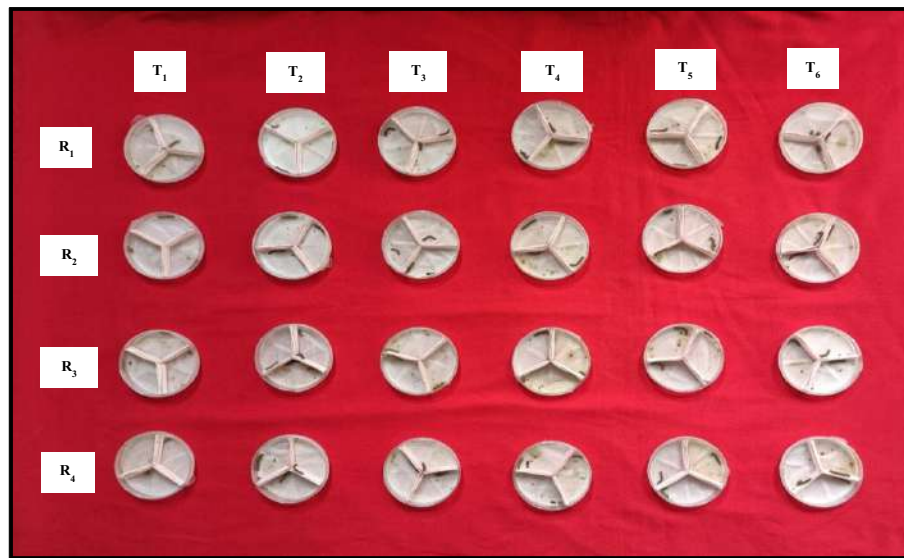
Tr. No.	Treatments (IJs/larva)	Mortality (%) of <i>S. frugiperda</i> after indicated hrs of inoculation		
		72 hrs.	96 hrs.	120 hrs.
T ₁	20	18.44 (10.01)	49.87 (58.46)	71.56 (89.99)
T ₂	40	26.85 (20.40)	49.87 (58.46)	79.97 (96.97)
T ₃	60	26.85 (20.40)	54.74 (66.67)	88.38 (99.92)
T ₄	80	35.26 (33.33)	63.15 (79.60)	88.38 (99.92)
T ₅	100	45.00 (50.00)	79.97 (96.97)	88.38 (99.92)
T ₆	Distilled water	1.62 (0.08)	1.62 (0.08)	1.62 (0.08)
	S.Em ±	6.68	5.61	5.24
	C.D. (0.05)	19.83	16.67	15.58
	C.V. %	52.01	22.50	15.05

Note : Figures in parentheses are retransformed values and those outside are arc sin transformed value.

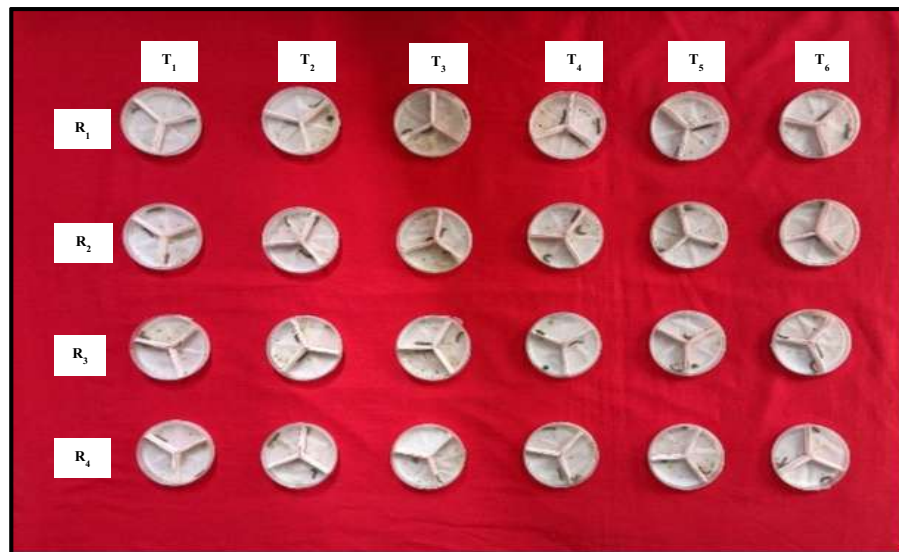
stored in sterile distilled water was first examined under the stereoscopic microscope to check the activity of the juveniles and diluted with a known quantity of sterile distilled water for making the suspension according to the required number of IJs. The different inoculum levels were used i.e. 20, 40, 60, 80 and 100 IJs/larva. The three larvae of *S. frugiperda* (fourth instar) were placed on Whatman filter paper No. 1 in Petri plates and the required number IJs of *Heterorhabditis* sp. (Anand H-I) and *Steinernema* sp. (Anand St-I) was released in each Petri plates and treatments were repeated four times. The treatments were mentioned as under :

- T₁ : 20 IJs/larva
- T₂ : 40 IJs/larva
- T₃ : 60 IJs/larva
- T₄ : 80 IJs/larva
- T₅ : 100 IJs/larva
- T₆ : Distilled water

The observations were taken on the mortality of the host larvae after 24, 48, 72, 96 and 120 hrs from the time of inoculation. The experimental data were analyzed



Bio-efficacy of *Heterorhabditis* sp. (Anand H-1)



Bio-efficacy of *Steinernema* sp. (Anand St-I)

Plate-1 : Bio-efficacy of isolated native EPNs against *S. frugiperda*.

statistically as per the procedure given by Steel and Torrie (1980). for a completely randomized design (Factorial). The data were analyzed according to arcsine transformation. The standard error of the mean (S.Em. $\pm$) and critical difference (CD) at 5 % percent level of probability were calculated.

Results and Discussion

Bio-efficacy of *Heterorhabditis* sp. (Anand H-1) against *S. frugiperda* : The data of the experiment on bio-efficacy of *Heterorhabditis* sp. (Anand H-1) against *S. frugiperda* is presented in Table-1. There was no mortality of *S. frugiperda* found for all the treatments after 24 hrs of

inoculation so, the analysis was not done. After 48 hrs of inoculation, the maximum mortality (50.00 %) of *S. frugiperda* was recorded at 100 IJs per larva followed by 33.33 per cent mortality at 80 IJs per larva. No mortality was observed in 60, 40 and 20 IJs per larva. After 72 hrs of inoculation, inoculum level with 100 IJs per larva gave the maximum 96.67 per cent mortality followed by 66.67, 50.00 and 33.33 per cent mortality of *S. frugiperda* was recorded by 80, 60 and 40 IJs of *Heterorhabditis* sp., respectively. The minimum mortality (20.04 %) was recorded at an inoculum level of 20 IJ per larva. After 96 hrs of inoculation, the result showed that the highest mortality (99.92 %) was recorded at inoculum levels with 100 and 80 IJs per larva. The next effective treatment was

inoculum level with 60 IJs per larva causing 96.67 per cent mortality, followed by 79.60 per cent mortality at 40 IJs per larva. The lowest (66.67 %) mortality of *S. frugiperda* was observed at an inoculum level of 20 IJs per larva, but it was superior to the control. After 120 hrs of inoculation, the highest 99.92 per cent mortality at all inoculum levels was 100, 80, 60, 40 and 20 IJs per larva, respectively.

Bio-efficacy of *Steinernema* sp. (Anand St-I) against *S. frugiperda* :

The data on per cent mortality of *S. frugiperda* due to *Steinernema* sp. (Anand St-I) are presented in Table 2. *Steinernema* sp. (Anand St-I) was unable to cause mortality of *S. frugiperda* within 48 hrs. After 72 hrs of inoculation, the maximum (50.00 %) mortality of *S. frugiperda* was observed at inoculum levels with 100 IJs per larva, while 33.33 per cent mortality at 80 IJs per larva. Inoculum levels of 60 and 40 IJs per larva showed equal 20.40 per cent mortality. The minimum (10.01 %) mortality of *S. frugiperda* was recorded at 20 IJs per larva. After 96 hrs of inoculation, an inoculum level with 100 IJs per larva caused the highest 96.67 per cent mortality followed by 80 and 60 IJs per larvae caused 79.60 and 66.67 per cent, respectively. Inoculum levels with 40 and 20 IJs per larva gave the lowest (58.46 %) mortality. After 120 hrs of inoculation, the highest 99.92 per cent mortality of *S. frugiperda* was observed at inoculum levels of 100, 80 and 60 IJs per larva followed by 40 and 20 IJs per larva gave 96.97 and 89.99 per cent mortality of *S. frugiperda*, respectively. In the control set, no mortality was recorded.

The data of present investigations are in agreement with the finding of Acharya *et al.* (2020), observed that 50 IJs of *H. indica*, *S. arenarium*, *S. carpocapsae*, and *S. longicaudum* caused cent per cent mortality of fourth and fifth instar larvae of *S. frugiperda* within 72 hrs. Similarly, Prajapati and Maru (2021) recorded the maximum (99.95%) mortality for all the inoculum levels *i.e.* 20, 40, 60, 80 and 100 IJs of *Steinernema* sp. after 120 hrs of inoculation. Further, Cassia *et al.* (2014) reported that *S. diaprepesi* (100 IJs) caused a cent per cent mortality of *S. frugiperda* within four days of inoculation. The outcome of the present investigation indicated that the mortality of in *S. frugiperda* was significantly increased with an increase in inoculum level and incubation time which is in accordance with Meka *et al.* (2020) who pointed out that the mortality rate was increased with an increase in number of infective juveniles and exposure time to *S. frugiperda*. Similarly, Lalramnghaki *et al.* (2021) observed that the mortality rate of *S. frugiperda* significantly varied with nematode concentrations and incubation time. Furthermore, Andalo *et al.* (2010) identified *S. arenarium*

and *Heterorhabditis* sp. RSC02 as the most virulent species against *S. frugiperda*. Wattanachaiyingcharoen *et al.* (2021) stated that *H. indica* isolates AUT 13.2 was more effective than *S. siamkayai* isolate APL 12.3. Thus, these previous findings are consistent with the current findings.

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ICT Based E-Resources and it's Challenges in Libraries

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Abstract

E-Resources are defined as resources that include print resources in Resource Centre in digital format. E-resources and information technology plays important role in improving the learning Resources Centre facilities. This paper enumerates definition, objectives, advantages, types of e-resources.

Key words : E-resources, E-books, E-journals, E-databases.

Introduction

Information is recognized as an important resources and currency of 21st century, but ICT has revolutionized the information handling activities in the library and information centres during the past few years. The information society demands that all the relevant technologies that are involved in information, processing, consolidation, repackaging, communication and retrieval be merged so as to evolve an integrated system capable of providing diversified services. library services are expected to user various types of technology to provide information more easily, effectively it reveals the Dr. S.R. Ranganathans fourth law of library to save the time of the reader ⁽¹⁾

An electronic resource means that publication and dissemination of information by electronic means, especially by the use of optical disk format such as CD-ROMs and networking. E Resources include electronic journals, online databases and electronic books, video texts, e-mail and electronic newsletter. E-Resources are which requires computer access or any electronic product that delivers a collection of data, be it text referring to full text databases, electronic journals, image collections, other multimedia products and numerical, graphical or time based.

Objectives

- (1) To study need of e-resources
- (2) To study types of e-resources.
- (3) To study utility of e-resources
- (4) To study resources to retrieve e-resources
- (5) To study the advantages, problems and Challenges of online learning

Advantages of e-resources :

- (1) Access anytime and anywhere.
- (2) Effective retrieval search.
- (3) Multiple access of some material.
- (4) Downloading the text, image, audio with the web concept.
- (5) Vast statistical data.
- (6) No physical boundary.
- (7) Cost effective.
- (8) Compact format.
- (9) It is easy to maintain and non-costly as compared to traditional printed materials.
- (10) Remote access to the resources from outside a single physical Resources Centre.
- (11) Reduced cost for binding, storage and stack maintenance.
- (12) Hyperlink which moves beyond the linearity of print within document and link citations with full text documents. ⁽⁵⁾

Types of E-Resources : Use of e-books and e-journals needs access to internet and www not for profit institutions may provide free access to these sources. Resources which are originally created in a digital format, such as electronic books or electronic journals and data sets.

Electronic Resources consist of E-mail, browsing with multimedia applications, OPAC, e-books, e-journals etc.

(1) E-Books : E-books are books that are available in digital format. E book can be accessing anywhere any time it defined as a text in digital format. E-book can be defined as a text in digital form, digital reading material, a

book in computer file format, an electronic file of word and images to be deployed on computer screen, or read on a computer over a network, or viewed on a desktop/portable device or read on all types of computers or formatted for display on e-book readers. E-books are book in file format in the computer, which can be read with specific software such as Acrobat e book reader/glass book reader. E books are quickly becoming an important alternative to papers books and thousands of e-books are downloaded every day. e.g., N-List it is available 310000+. ⁽²⁾

(2) E-Journal : Now Electronic Journals available in various platforms. Electronic journals are serial publications available in digital format such as on CD-ROMS etc. Some e-journals are distributed via e-mail or on CD ROMs: most of the journals are now available through internet. Some are free and some are available only by subscriptions. e.g., N-List E-journals provides 6000+ journals and DOAJ etc.

(3) E-Magazines : E-magazines is a regular publication on some particular topic distributed in digital form, via the World Wide Web. It is also sometimes called webzines. E-magazines are also distributed for free or paid service.

(4) E-Newspaper : E-Newspaper provide provides food for knowledge to users E-Newspaper is often associated with an existing newspaper in print most e-newspapers maintain archives of back issue online. So many Newspapers are available in Electronic form. So, user can be access achieve and current issue also

(5) E-Documents : E-document is a document that is stored in media or in digital formats. Just copied of usual books, journals special types of media or electronic media are used in publishing e-document.

(6) E-Database : An E-Database is a collection of information that is organized so that it can easily be accessed, managed and updated. SCOPUS etc.

(7) CD Rom Database : CD-ROM Databases are increasing day by day in almost all fields due to their many advantages in information storage and retrieval. Majority of publishers of books and journals, on line vendors and various learned societies are bringing out new titles in CD format with powerful retrieval software. Electronic information resources in CD format include abstracting and indexing services, encyclopaedias, dictionaries, directories, yearbooks, back volumes, standards, patents and many other reference works.

(8) DVD ROM Database : The advent of DVD-Digital Video Disc or Digital Versatile Disc, with its 17 GB of high data storage capacity, has made it possible to include more multimedia elements like video and sound and to integrate many reference sources on single disc. The other features like higher quality of sound and video, higher rate of data transfer data security etc. ⁽³⁾

Access of E-Resources : Access is providing after the registration, which is the part of the licenses by which the resource centre provides information to the publishers to, enables them to the sure that the users from the organization have the right to access, can provide link to e-resources through the proxy server after authentication by IP address. Users can also use e-resources by login through institutional networks by user name and password.

Many resource centres provide access of e-resource on the website through A to Z list or subject wise list. The alphabetical lists of e-journals on web pages are maintained via text editor, HTML editor. ⁽⁶⁾

E-Resources Challenges for Smart Libraries : The challenges that come with e-resources includes technical issues, cost, copyright, equity of access, security, bibliographic control, licensing, user instruction and issues of authority, quality accuracy, instability and mutability and mobility of information. Slow response time can be much more frustrating for users than waiting for another patron to return a print index to the shelf. Remote users trying to connect from outside the library may experience technical problems with no assistance available. Searching success depends upon the quality of indexing, key words and text markup and the effectiveness the search engine.

Authorization and authentication issues may be complex. Resource Centre typically loses access to back files at the termination of a contract for an e-resources. E-resources can be extremely expensive. Information Officers who seek to identify, monitor and direct user to free web seek to identify, monitor and direct users to free web-based resources face particular challenges tracking, organizing and maintaining access to such online materials.

Problems of e-resources : E-learning has certain weaknesses in the form that it can hamper the communication between the learner and the educator, that is, direct communication and human touch are lost. Users can face many technical difficulties that hinder and slow-down the teaching-learning process. Time and location flexibility, though it is the strength of online learning these aspects are fragile and create problems. Student's nonserious behaviour in terms of time and flexibility can cause a lot of problems. All students and learners are not the same, they vary in degrees of their capabilities and confidence level. Some do not feel comfortable while learning online, leading to increased frustration and confusion. Inadequate compatibility between the design of the technology and component of psychology required by the learning process; and inadequate customization of learning processes can obstruct the teaching process and creates an imbalance. ⁽⁷⁾

There are other problems also related to identification, selection and acquisition stage regarding the electronic resources. There are also some language problems. Most of these E-Journals are available in English. Languages it is not available in regional languages so these users cannot access these e-resources so there is a problem in front of the librarian how to provide these sources to the users there is also problem of speed internet access in the rural place, load shading problem etc. There is also another problem is that these various resources available in the digital form so some resources cannot download only we can read it due to these problems we cannot make digital repository for providing services to the users. So, there are so many problems while providing these various services in front of the librarian for providing better services in short span of time. Librarian should overcome these problems by find out the solution for that it can be possible.

Conclusions

This paper has discussed the advantages, types, issues and challenges of e-resources, it is very familiar among the various fields of peoples, in fact, it is now hard to envisage a world without e-resources. The stipulation and use of e-resources is element of the complete system, to both the students, institutions and information professionals. The e-resources assist to deliver the sources to their user very fast, so the user time was saved. Nowadays e-resources have totally reduced the usage of paper material. These resources are convenient to use,

reachable at a reasonable cost and can be accessed from anywhere and by many users concurrently, these databases are most advantageous utilize to put in to the academic excellence and achievement of its user community.

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Impact of Library Resources Utilization on Undergraduate Students of College of Agriculture Bheemarayanagudi : A Study

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Abstract

The present study tried to identify the use and impact of library services on BSc. Agri. students. The students of College of Agriculture, Bheemarayanagudi were the target group for the study whose views were taken into consideration with the help of questionnaires. 100 questionnaires were distributed among the students belonging Agriculture College to know their problems and suggestions about the library resources and services. It was found that most of the students spends nearly five to six hours in library to access resources. The investigators also found that, majority of them are responded that, the lack of time was the reason for not using the library services.

Key words : Library resources, library services, print books, e-books, users' satisfaction and bsc. agri. Students.

Introduction

Library has been playing a vital role since man started storing every event as it is managing resources apart from collecting the documents. The basic purpose of every library is to update and enhance services and to rise to the expectations and satisfaction of the users. He has to strive for library's integrated development, planning of library services and for the enrichment of existing collection. For the development of effective services, the librarian has to develop a strong communication channel with his customers / users so as to maintain rapport with the library users. Secondly, he has to monitor the quality services provided to the users. Continued monitoring of services would help the librarian to modify and re-study the concept of quality which is the primary aim of quality service. Present day users have to depend on the library's physical resources, but they have to seek information from the global computer networks. In order to satisfy the users, the library should transform itself either by subscribing to the resources or by developing electronic library services. It is the Librarian's responsibility to ensure that the use of its resources is maximised to benefit its users. Hence the Librarian has to take feedback using survey methods or any other methods to collect their opinion.

Impact can be defined as the effect on the users. The change in the state of mind that takes place before the use of service and after using service can be termed as impact. It can be positive or negative depending on user satisfaction. If the user satisfaction is negative, it shows a negative impact. It is also based on users' awareness on services. If the user is aware of the services, he or she can utilise the services effectively and

helps us in giving valuable positive feedback. In the initial stages or at the stage of joining there is more scope negative impact. More over most of the students comes from private colleges. Since most of the institutions the students come from do not have no library facilities more awareness needs to be created among the students their colleges about the library.

History of college of agriculture Bheemarayanagudi :

The College of Agriculture, Bheemarayanagudi was started in the year 2001-02 with the mandate of imparting quality agriculture education, research and extension to foster the speedy development of North Eastern region of Karnataka, known for its socio-economic and educational backwardness. To accelerate speedy economic development, the largest irrigation project (Upper Krishna Project) was commissioned during the year 1982. The region is characterized by major soil types such as black cotton and red soils in the drier regions and late rites in the transitional zone of the region. Mono cropping viz., pigeon pea, sunflower and Rabi sorghum in the dry lands, sugarcane in the transitional, rice-rice and cotton in the irrigation command remains a dominant cropping sequence. The problems associated with mono crops are well known. The research and extension programmes adopted by the college have immensely benefited the farmers in solving the problems through appropriate participatory demonstrations on resource management IPM and ICM etc. Earlier efforts made through the water management project and research on the control of water logging and Stalinization in agricultural lands by Indo-Dutch Project and associated network organizations such as Central Soil Salinity Research Institute, Karnal, International Institute for Land Reclamation and

Improvement, Wageningen, The Netherlands and the University of Agricultural Sciences, Dharwad have developed suitable technologies to mitigate the problems of irrigated agriculture. The college offers four-year residential B.Sc. (Agri) degree programme. The college has well qualified faculty in imparting quality teaching, research and extension activities. It has well equipped laboratories and well maintained 450 acres of experimental farm (both dry and irrigated). The library collection in agriculture college Bheemaryanagudi :

Table-1 : Library Resource in the Agriculture College Bheemaryanagudi :

Library resources	Numbers
Books	16006
SC/ ST Book Bank Books	1423
Journals Bound volumes	523
Loose volumes	36
Magazines	06
CD-ROMs	24
News papers	08
E- books	141

Review of Literature

Afebende and Ebaje (2008) reveal that the success of the library depends on the effective exploitation and use of resources by the users and not only depend on collection and facilities provided by library. While the librarian has the responsibility of creating awareness among the users about collection and organization of information materials.

Kadli and Kumbar (2011) investigated information seeking behaviour of the faculty members of 46 commerce colleges in the changing ICT environment among. The finding of the study revealed that majority of the faculty seeks information to prepare class note. It was also observed that information was scattered in too many sources and much information on Internet is the problem often faced by the users in information seeking. Changing ICT environment also affected information seeking behaviour for majority of users. Authors suggested that library should start information literacy programme to make users aware of library services.

Kaur and Verma (2006) conducted a survey to explore purpose of using library vary from person to person. Majority of users visit library for issue/ return of books, then for consulting periodical/journals, and many were for photocopying work.

Larson and Owusu (2012) their study based on sample method by distributed questionnaire to the users. The findings of the study reveal that majority of users satisfied with Library service; Library budget should be increased. The findings of the study also suggested the users regarding extending the opening hours of the library and provide Xerox facilities for the users.

Norliya (2009) conducted a study and pointed out that the university libraries need to adopt the direction of

the vital planning in creation and delivery of service according to the satisfaction of the users which plays a vital role and also found that the average respondents were fairly satisfied with the collection of the library infrastructure, space, place and library services.

Pandey and Singh (2014) in their study found that a large number of respondents were satisfied with library resources and services and books are most widely used resources and most preferred services used by the users is circulation service. Respondents have given suggestions to make library resources and services effective and can be used in an efficient manner.

Prabhavathi(2011) studied the information seeking behaviour of post graduate students of SPMV, Tirupati to examine the information need, seeking behaviour and availability of information resources that affect the information seeking pattern and communication process. He found that half of the respondents visited library every day and main purpose of visiting the library was to prepare for examination. About 94.6% of respondents were using books to support their curriculum and examination. He emphasized the need for orientation programme on library resources and services.

Ranganathan and Babu (2012) studied the awareness and use of library resources and services at Osmania University, Hyderabad. They studied the adequacy of library resources, opinion on e-resources or print sources, reasons for using e-resources and satisfaction in sources of information provision.

Sohail (2012) in his study the use of library resources by the students of University of Kalyani. Authors found that instruction given in the use of library resources and services was necessary to help students to meet their information needs. They also found that journals, text books and lecture notes were the most popular sources of information for the students. They have suggested that the latest edition of text books and reference materials should be added to the library collection and users should be guided towards the use of the library resources.

Objectives of the study

To take the overview of library resources by BSc. Agri. Students, College of Agriculture Bheemaryanagudi.

To analyze the use of library resources by UG Students.

To analyze the impact of library resources on UG Students.

To know the opinion of UG students on library facilities

To know the frequency of visit to the library.

To know the satisfaction level of students towards the library services.

To offer suggestions for the effective utilization of library resources.

Research Methodology

For the collection of primary data, the survey method has been suitable and prepared a structured questionnaire distributed randomly among 100 UG Students and all the 100 filled questionnaires were received back. Each and every data gave by the respondents was investigated carefully and needed data were filled in the MS-Excel format to achieving the objects of the study. The collected data were organised, tabulated, calculated, analysed and presented by using simple arithmetic and statistical tools.

Scope and limitations of the study :

The scope and limitations of present study is to identify the impact of library resources utilization on BSc. Agri. undergraduate students of college of agriculture Bheemaranagudi.

Data Analysis

Table-2 : Gender wise distribution.

Sl. No.	Gender	No. of Respondents	%
1.	Male	58	58%
2.	Female	42	42%
	Total	100	100%

The above table-2 shows that, the 58 (58%) of the frequency are the male while 42 (42%) are female in the use of library resources.

Table-3 : Numbers of hours spent on using Library services.

Sl. No.	Time Spent	No. of Respondents	%
1.	More than seven hours	22	22%
2.	5-6hrs.	15	15%
3.	5-3 hrs.	40	40%
4.	Less than two hrs.	23	23%
	Total	100	100%

The above table-3: shows that, the 40(40%) respondents spend 5-3 hours in library, 23 (23%) respondents spend less than two hours in the library, 22 (22%) students responded saying they spend more than seven hours in the library. There are 15 (15%) respondents who spend 5-6 hours in the library.

Table-4 : Frequency of using Library services.

Sl. No.	Frequency	No. of respondents	%
1.	Daily	37	37%
2.	Alternate day	28	28%
3.	Once in a week	10	10%
4.	When necessary	25	25%
5.	Not at all	00	00%
	Total	100	100%

Table-4: shows that majority of students 37(37%) visit the library daily, 28 (28%) students visit alternate days 25(25) of them visit, when necessary, 10 (10%) visit once in a week and 00 (00%) of responded to not at all. It shows that 100% respondents visit to the library.

Table-5 : Type of resource used.

Sl. No.	Resource Name	No. of respondents	%
1.	Text Books	82	82%
2.	Reference Books	77	77%
3.	Journals	17	17%
4.	Newspapers	87	87%
5.	E- Resources	23	23%

Table-5: shows that 87(87%) of students visit to the library for only reading newspapers, 82(82%) of them use textbooks, 56(56%) visit to the library to refer reference books, 23(23%) of them for using e-resources and 17(17%) visit to referred journals.

The above table-6: shows that, regarding circulation services 68(68%) responded fully satisfied, 15(15%) responded not satisfied and 10(10%) responded partially satisfied. Regarding reference service 70(70%) are fully satisfied, 15(15%) are partially satisfied and 10(10%) are not satisfied. 40(40%) are fully satisfied, 24(24%) not satisfied and 20(20%) are partially satisfied towards journal services. 39(39%) are fully satisfied 24(24%) are partially satisfied and 20(20%) are not satisfied towards online Public Access Catalogue 75(75%) are fully satisfied, 55(55%) are partially satisfied and 17(17%) are not satisfied towards the reprographic services. 50(50%) are fully satisfied, 20(20%) are partially satisfied and 15(15%) are not satisfied towards digital library services. 40(40%) are fully satisfied, 25(25%) are partially satisfied and 17(17%) are not satisfied towards online lectures. 75(75%) are fully satisfied, 15(15%) are partially satisfied and only 05(05%) are not satisfied towards general reading.

Table-7: Shows that, the 80(80%) feel that they do not find lack of cooperation for not using the library services and only 20(20%) feel that, there is a lack of co-operation from library staff is the reason for not using the services, 80(80%) of respondent feel that resources available in the library are sufficient for their studies and 20(20%) are responded that there are no sufficient resources are available in the library is the reason for not using the library services, 50(50%) of responded that the lack of time is the reason and 50(50%) are responded that lack of time is not the reason, 70(70%) responded that the lack of awareness and lack of knowledge is not the reason and 30(30%) are responded that the lack of awareness and lack of knowledge is not the reason for using the library services.

Table-8 : Shows that about 70(70%) are responded

Table-6 : Satisfaction levels toward Library services.

S. No.	Library Services	Fully Satisfied	%	Partially Satisfied	%	Not Satisfied	%
1.	Circulation service	68	68%	10	10%	15	15%
2.	Reference service	70	70%	15	15%	10	10%
3.	Journals	40	40%	20	20%	24	24%
4.	Online public Accesses Catalogue	39	39%	24	24%	20	20%
5.	Reprographic services	75	75%	55	55%	17	17%
6.	Digital Library services	50	50%	20	20%	15	15%
7.	Online lectures	40	40%	25	25%	17	17%
8.	General reading	75	75%	15	15%	05	05%

Table-7 : Reasons for not using the services.

Sl. No.	Reason	Yes	%	No	%	Total	%
1.	Resources are sufficient	80	80	20	20%	100	100%
2.	Lack of awareness	30	30%	70	70%	100	100%
3.	Lack of knowledge	30	30%	70	70%	100	100%
4.	Lack of staff cooperation	20	20%	80	80%	100	100%
5.	Lack of time	50	50%	50	50%	100	100%

Table-8 : Opinion on Library Facilities.

Sl. No.	Facilities	Excellent	%	Very Good	%	Good	%	Satisfactory	%	Not Good	%	Total	%
1.	Library collection	70	70%	10	10%	5	5%	10	10%	5	5%	100	100%
2.	Physical facilities	60	60%	10	10%	10	10%	10	10%	10	10%	100	100%
3.	Organization of collection	70	70%	10	10%	10	10%	10	10%	10	10%	100	100%
4.	Staff cooperation	60	60%	20	20%	5	5%	5	5%	10	10%	100	100%
5.	Library services	70	70%	10	10%	5	5%	5	5%	10	10%	100	100%
6.	IT based services	60	60%	10	10%	10	10%	10	10%	10	10%	100	100%

that, the library collection is excellent, 10(10%) are responded very good, 10(10%) are responded satisfactory, 5(5%) responded good, and similarly, 5(%) are responded not good. Regarding library services 70(70%) are responded that services are excellent, 10(10%) are responded very good, 10(10%) are responded good, 10(10%) are responded satisfactory and 10(10%) are responded not good. 70(70%) are responded organization of collection is excellent, 10(10%) are responded very good, 10(10%) are responded good, 10(10%) are responded satisfactory and 10(10%) are responded not good, 60(60%) are responded physical facilities are excellent, 10(10%) are responded very good, 10(10%) are responded good, 10(10%) are responded satisfactory and 10(10%) are responded not good, 60(60%) are responded IT based services are excellent 60(60%), 10(10%) are responded very good, 10(10%) are responded good, 10(10%) are responded satisfactory and 10(10%) are responded not good, 60(60%) are responded staff co-operation is excellent, 20(20%) are responded very good, 5(5%) are responded good, 5(5%) are responded satisfactory, and 10(10%) are responded not good.

Table-9 : Purpose of visit to the library.

Sl. No.	Purpose	No. of Respondents	%
1.	Reference	83	83%
2.	Browsing	37	37%
3.	Notes	65	65%
4.	Use of Internet/Browsing	22	22%
5.	Read Newspapers/Magazines/Journals	81	81%
6.	Fiction	09	09%
7.	Update knowledge to complete assignment and project	66	66%

The above table-9 : shows that, the 83(83%) of responded that, they visit to the library for referring the resources, 81(81%) are responded for reading newspapers/magazines/journals, 66(66%) responded to update their knowledge to complete assignments and projects, 65(65%) are responded for making notes, 37(37%) are responded for browsing, 22(22%) are responded for using the internet/browsing, 09(09%) are responded to read fiction books.

Table-10 : User's satisfaction in the library.

Sl. No.	Satisfaction in the library	Excellent	%	Very Good	%	Good	%	Satisfactory	%	Not Good	%	Total	%
1.	Reading materials	62	62%	08	08%	10	10%	10	10%	10	10%	100	100%
2.	Photocopying services	55	55%	15	15%	10	10%	10	10%	10	10%	100	100%
3.	Seating capacity	60	60%	10	10%	10	10%	10	10%	10	10%	100	100%
4.	Cleanliness	70	70%	10	10%	5	5%	5	5%	10	10%	100	100%
5.	Library staff	70	70%	10	10%	5	5%	5	5%	10	10%	100	100%
6.	Opening hours	60	60%	10	10%	10	10%	10	10%	10	10%	100	100%

Table – 10: shows that the, 62(62%) are responded that, reading materials are excellent, 08(08%) are responded very good, 10(10%) are responded good, 10(10%) are responded satisfactory, 10(10%) are responded not good, 70(70%) are responded that the cleanliness maintained in the library is excellent, 10(10%) are responded very good, 5(5%) are responded good, 5(5%) are responded satisfactory 10(10%) are responded not good, 70(70%) are responded staffs are excellent, 10(10%) responded very good, 5(5%) are responded good, 5(5%) are responded satisfactory, 10(10%) are not good. 60(60%) are responded that the seating capacity is excellent, 10(10%) are responded very good, 10(10%) are responded good, 10(10%) are responded satisfactory, 10(10%) are responded not good. 60(60%) are responded opening hours are excellent, 10(10%) are responded very good, 10(10%) are responded good, 10(10%) are responded satisfactory, 10(10%) are responded not good. 60(60%) are responded opening hours are excellent, 55(55%) are responded photocopying services are excellent, 15(15%) are responded very good, 10(10%) are responded good, 10(10%) are responded satisfactory, 10(10%) are responded not good. 60(60%) are responded opening hours are excellent, 10(10%) are responded very good, 10(10%) are responded good, 10(10%) are responded satisfactory, 10(10%) are responded not good.

Table-11 : Difficulties facing in obtaining the required information.

Sl. No.	Difficulties	Total No. of Respondents	%
1.	Lack of time	67	67%
2.	Inadequate resources	34	34%
3.	Information scattered in the library	30	30%
4.	Lack of access to library materials	28	28%
5.	Poor library services	30	30%

Table-11: shows that 67(67%) are responded that, due to lack of time they are facing difficulties to obtain required information, 34(34%) responded that due to inadequate resources, 30(30%) are responded that, due to information scattered in the library, similarly 30(30%) are responded that, due to poor library services and only 28(28%) are responded that, due to lack of access to library materials.

Table-12 : Reading of materials borrowed from the library.

Sl. No.	Materials borrowed from the library	No. of Respondents	%
1.	Yes	92	92%
2.	No	08	08%
	Total	100	100%

Table-12: shows that, about 92(92%) are responded that, they read the materials borrowed from the library and only 08(8%) are responded that they do not read the materials borrowed from the library.

Table-13 : Satisfaction with the resources of the library.

Sl. No.	Satisfaction with the resources	No. of Respondents	%
1.	Yes	73	73%
2.	No	27	27%
	Total	100	100%

The above table-13: shows that, about 73(73%) are responded that, they are satisfied with the resources available in the library and only 27(27%) are responded that, they are not satisfied with the resources available in the library.

Major Findings

Majority of the responded that is 58(58%) are male, 40 (40%) respondents spend 5-3 hours in library, 37(37%) visit the library daily, regarding circulation services 68(68%) responded fully satisfied, 80(80%) feel that they do not find lack of cooperation for not using the library services, 80(80%) of respondent feel that resources available in the library are sufficient for their studies, 50(50%) of responded that the lack of time is the reason for not using the library services, 70(70%) responded that the lack of awareness and lack of knowledge is not the reason, about 70(70%) are responded that, the library collection is excellent, 70(70%) are responded that services are excellent, 60(60%) are responded IT based services are excellent 60(60%), 60(60%) are responded staff co-operation is excellent, 83(83%) of responded that, they visit to the library for referring the resources, 62(62%) are responded that, reading materials are excellent, 70(70%) are responded that the cleanliness maintained in the library is excellent, 70(70%) are responded staffs are excellent, 60(60%) are responded that the seating capacity is excellent, 60(60%) are responded opening hours are excellent, 55(55%) are responded photocopying

services are excellent, 60(60%) are responded opening hours are excellent, 67(67%) are responded that, due to lack of time they are facing difficulties to obtain required information, 92(92%) are responded that, they read the materials borrowed from the library and 73(73%) are responded that, they are satisfied with the resources available in the library and only 27(27%) are responded that, they are not satisfied with the resources available in the library.

Conclusions

The present study reveals that, the greater part of the respondents' access resources on daily basis. It was found that most of the students spends nearly five to six hours in library to access resources. The investigators also pointed out that majority of respondent were felt that the resources available in the library are sufficient and excellent for their studies, it was found that, majority of them are responded that, the lack of time is the reason for not using the library services. Majority of students are responded that, they are satisfied with the resources available in the library.

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Knowledge of the Farm Women Regarding Improved Maize Production Technologies

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Abstract

The present study was planned to study the knowledge of the rural women regarding improved maize production technologies. The study was conducted in purposively selected Badgaon and Girwa panchayat samiti of Udaipur district, Rajasthan. Total 4 villages were selected on basis of random sampling technique. A sample of 30 farm women from each village was selected for the study. The total sample of study consisted of 120 farm women. For accomplishing the present investigation, interview technique was used to collect information from the rural women. The findings of the study revealed that majority (69.17 %) of the respondents possessed medium-level knowledge regarding improved maize production technologies with MPS 53.23 followed by 17.50 per cent of respondents possessed low level knowledge with MPS 20.46 and only 13.33 per cent of respondents belonged to high level knowledge category with MPS 69.32.

Key words : Farm women, maize, knowledge, technologies.

Introduction

Maize is one of the most versatile emerging crops with wider adaptability in different agro- climatic conditions. Globally, maize is known for highest genetic yield potential among the cereals. it is cultivated in about 160 international locations having wider range of soil, weather, biodiversity and control practices that contributes 36 per cent in the international grain production.

The poor performance of the agricultural sector observed in recent times had partly been blamed on low technology adoption and lack of modernization of agricultural practices. However, agricultural growth has been aptly demonstrated to have a positive link with overall national development. To harness the potential of agricultural sector to propel national development, successive and current governments have been implementing policies, programmes and reforms aimed at promoting technology adoption and overall modernization of agricultural production. Low technology adoption and poor agricultural investment have accounted for the low yield and low productivity observed among major crops such as maize. As observed in IFPRI (2013) and also in MOFA (2011), yields are generally less than half of economically attainable yields for staple crops such as maize and rice. National average yields of maize stands at 1.7 metric tons/hectare, far below on-station and on-farm trials average yield of 4 tons/hectare. High technology adoption and agricultural mechanization, particularly use of improved varieties, best agronomic practices, use of fertilizer, post-harvest management and access to market, have been noted as the only way to improve maize productivity and bridge this huge yield gap.

Research and extension are two important pillars of agricultural development. During the post- independence period, considerable research efforts were made in the country, resulting in a noticeable increase in agricultural production. Intensive efforts by scientists have led to the development of improved maize varieties that have a much higher production potential compared to local ones. Similarly, the extension scientists of KVKs/ field functionaries under Broad Based Agriculture Extension System are actively engaged in dissemination of technologies among the farming community. Despite active involvement of research and extension scientists, the expected results in crop productivity could not be achieved and there exists a vast gap in productivity between the highest yield recorded at the farmer's field and those representing the mean performance in the state. In addition, various pre-harvest and post-harvest operations result in significant losses of food grains. This is basically due to lack of knowledge and non- acceptance of improved technologies by the farming community. Till now no systematic research efforts have been made to know the knowledge of farm women in regarding improved maize production technologies. Therefore, it becomes essential to find out the knowledge of farm women regarding improved maize production technologies.

Research Methodology

The present study was conducted in Udaipur district of Rajasthan. Two Panchayat samities were selected purposively from the district. For selection of sample, two villages from each panchayat samiti i.e. Madar and Brahmano ki Hundar from Badgaon panchayat samiti and

Pai and Peepalawas from Girwa panchayat samiti were selected randomly. A list of farm women was prepared separately for each village with the help of Krishi Vigyan Kendra (KVK), Badgaon. From the list, 30 farm women from each village were selected for the study. The total sample of the study consisted of 120 farm women. To collect the required information the personal interview technique was used by the researcher. After establishing good rapport with the respondents, data were collected by the researcher with the help of developed interview schedule in an informal manner using local dialect.

Results and Discussion

One of the most crucial elements of behavior, which is crucial for the adoption of technology is knowledge. Having knowledge makes it easier to adopt a positive outlook and take specific actions, like accepting an innovation. To enable farm women to adopt the necessary technology for increasing agricultural production, it is crucial to provide them with the most recent agricultural knowledge. In the current study, an effort was made to ascertain farm women's knowledge of newer technologies for producing maize. Therefore, the knowledge of farm women regarding improved maize production technologies was assessed using fourteen components.

It is evident from the Table-1 indicates that most of the respondents (95.83%) had a good knowledge about the advantages of seed treatment followed by 80 per cent respondents knew the chemicals along with the quantity used for the treatment of seed treatment, container is used for seed treatment by (78.33%), sequence of seed treatment by (76.67%), rhizobium culture should be put in jaggery water by (67.50%) and drying of seed after washing (60.83%). The findings are in line with Das (2022) who found that 50 per cent of the respondents were not correct about how to interpret the soil test report and 41.66 per cent respondents were aware about the soil testing before sowing the crop.

Data in Table-1 further depicts that 86.67 per cent of the respondents had knowledge regarding field preparation for maize cultivation followed by seeds used for sowing (56.67%), chemicals along with quantity used for termite control in maize crop (55%), new hybrid seed purchased every year (53.33%), use of composite seed (47%), correct method of taking soil sample for checking soil and treatment of saline soil (45.83%). Sharda *et al.* (2018) in her study reported that 91.66 per cent of respondents had knowledge about suitable soil for cultivation of kharif maize crop, 97.50 per cent of them had knowledge of recommended ploughing and harrowing and 87.50 per cent of them had knowledge about application of compost / FYM for kharif maize crop.

The observations from the Table-2 depict that most

of the respondents (93.33%) possessed good knowledge regarding name of manures and fertilizers which should be applied in the maize crop followed by 85.83 per cent had a good knowledge about the advantages of applying FYM, 67.50 per cent knew about recommended quantity of farm yard manure i.e., 8-10 t/ha and 64.17 per cent respondents were exposed about best time for applying manure and fertilizers. The study conducted by Khan (2017) stated that the management of FYM and inorganic-N had a profound bearing on maize productivity and improved yield and yield traits. A linear increase in each yield and yield trait was observed with each increment in FYM at both levels of urea-N. Plants were taller in plots that received FYM as well as urea compared to sole FYM or control.

Regarding inter cultivation and inter cropping 75-95.33 per cent of the respondents had good knowledge about recommended proportion of mixed cropping systems in maize, recommended pulse crop to be intercropped with maize and advantages of inter-cultivation. Table 2 further shows that 68.33 per cent of the respondents knew about recommended row to row spacing in maize and 53.33 per cent had knowledge of recommended seed rate of maize per ha. About 60 per cent of the respondents possessed knowledge regarding appropriate time of sowing.

Knowledge assessment of the respondents regarding weed management in Table-3 depicts that majority of the respondents (86.67%) knew about common weeds found in maize i.e. saama, congress grass, motha and doob whereas only 11.67 per cent had good knowledge regarding name and quantity of weedicide. When examined their knowledge about cultural operation, most of the respondents (94.17%) knew about the advantages of inter cultivation followed by 90 per cent respondents showed a fair knowledge in terms of the cultural operations in maize. Further, 87.50 per cent of the respondents had knowledge about hoeing and earthing up stage for maize and 86.67 per cent respondents possessed knowledge about type of cultural operations which should be preferred in maize.

The knowledge scores of respondents in the component of insect pest and disease control revealed that 75.83 per cent respondents had a fair knowledge about major insects along with the quantity used to control insects and 66.67 per cent respondents knew about the main diseases along with the fungicide used to control the diseases (Table 3).

Data in Table-4 revealed that cent per cent of the respondents had knowledge about required improved agriculture implements for maize cultivation i.e. nayala, desh plough, disc plough, harrow, cultivator, maize sheller, improved sickle and seed drill. Regarding

Table-1 : Knowledge of the respondents regarding seed variety, field preparation land treatment and seed treatment for maize cultivation. n=120

S. No.	Practices	f	%
1.	Seed variety		
	Seed used for sowing	68	56.67
	New hybrid seed purchased every year	64	53.33
	Use of composite seed	57	47.50
2.	Field preparation		
	Field prepared for maize cultivation	104	86.67
3.	Land treatment		
	Correct method of taking soil sample for checking soil	55	45.83
	Chemicals along with quantity used for termite control in maize crop	66	55.00
	Treatment to improve saline soils.	55	45.83
4.	Seed treatment		
	Advantages of seed treatment	115	95.83
	Chemicals along with quantity used for seed treatment maize crop.	96	80
	Container is used for seed treatment	94	78.33
	Sequence of seed treatment	92	76.67
	Rhizobium culture should be put in jaggery water	81	67.50
	Drying of seed after washing	73	60.83

Table-2 : Knowledge of the respondents regarding time of sowing, seed rate inter-cultivation and intercropping and manure and fertilizers for maize cultivation. n=120

S. No.	Practices	f	%
1.	Time of sowing	72	60
2.	Seed rate		
	Recommended seed rate of maize per ha.	64	53.33
	Recommended row to row spacing in maize	82	68.33
3.	Inter-cultivation and intercropping		
	Recommended pulse crop to be intercropped with maize	95	79.17
	Recommended proportion of mixed cropping systems in maize	90	75
	Advantages of inter-cultivation	112	93.33
4.	Manure and fertilizers		
	Manure and fertilizer applied in maize crop	112	93.33
	Recommended quantity of farm yard manure in maize	81	67.50
	Advantages of applying FYM in soil before sowing	103	85.83
	Best time for applying manure and fertilizers	77	64.17

irrigation management 90 per cent of the respondents had good knowledge regarding critical stages of irrigation in maize (90%) whereas 87.50 per cent knew about number of irrigations required in maize. Majority of the respondents (84.17%) had good knowledge about method used for harvesting and 76.67 per cent knew about appropriate time of harvesting the maize crop. The findings are in line with study conducted by Singh *et al.* (2012) that 62.50 per cent of the farmers had a medium level of knowledge regarding recommended maize production technology followed by low level of knowledge possessed by 61.66 per cent farmers.

Component wise knowledge of farm women regarding improved maize production technologies : Component wise knowledge of the respondents was assessed and the extent of knowledge possessed by the respondents in different components related to organic farming practices

is presented in three categories low, medium and high along with Mean Percent Score in Table-5.

Component wise knowledge of respondents regarding improved maize production technologies is presented in Table 5. Majority of the respondents (85.83%) were found in medium level knowledge category of weed management practices with overall MPS 53.85. It is clearly apparent from the table that majority of the respondents (78.33%) found in medium level of knowledge followed by 21.67 per cent were in low level of knowledge and none of the respondents were in high knowledge category of cultural operation and insect pest and disease. Regarding improved agriculture implements, data presented in the table depicts that majority of the respondents (72.50%) were in medium level of knowledge category with overall MPS 48.88. More than half of the respondents were found in medium level knowledge category of time of sowing (58.33%), seed rate (56.67%),

Table-3 : Knowledge of the respondents regarding weed management, cultural operation, insect pest and disease control in maize cultivation. n=120

S. No.	Practices	f	%
1.	Weed management		
	Common weeds in maize	104	86.67
	Weedicide along with quantity to be used in maize	14	11.67
2.	Cultural operation		
	Type of cultural operations preferred in maize	104	86.67
	Right stage of hoeing	105	87.50
	Stage of earthing up of maize crop	105	87.50
	Advantages of cultural operations in maize	108	90.00
	Advantages of inter-cultivation after 25 days of sowing	113	94.17
3.	Insect pest and disease control		
	Major insects of maize along with insecticides and its quantity used to control the insects.	91	75.83
	Main diseases of maize along with the fungicide and its quantity used to control the diseases.	80	66.67

Table-4 : Knowledge of the respondents regarding irrigation management, required improved agriculture implements and harvesting in maize cultivation. n=120

S. No.	Practices	f	%
1.	Irrigation management		
	Irrigations required in maize	105	87.50
	Critical stages of irrigation in maize	108	90.00
2.	Improved agriculture implements	120	100.00
3.	Harvesting		
	Appropriate time of harvesting the maize crop	92	76.67
	Method used for harvesting	101	84.17

Table-5 : Component wise distribution of the respondents by their knowledge regarding improved maize production technologies. n=120

S. No	Components	Low		Medium		High		MPS
		f	%	f	%	f	%	
1.	Seed Variety	56	46.67	51	42.50	13	10.83	52.50
2.	Field Preparation	70	58.33	32	26.67	18	15.00	47.78
3.	Land Treatment	65	54.17	52	43.33	3	2.50	48.89
4.	Seed Treatment	36	30	65	54.17	19	15.83	63.25
5.	Time of Sowing	29	24.17	70	58.33	21	17.50	60.00
6.	Seed Rate	25	20.83	68	56.67	27	22.50	60.83
7.	Inter-cultivation & Intercropping	35	29.17	85	70.83	0	0.00	61.07
8.	Manures and Fertilizers	20	16.67	84	70.00	16	13.33	73.42
9.	Weed Management	17	14.17	103	85.83	0	0	53.85
10.	Cultural Operation	26	21.67	94	78.33	0	0	75.08
11.	Insect Pest & Disease	26	21.67	94	78.33	0	0.00	18.15
12.	Irrigation	56	46.67	64	53.33	0	0.00	59.17
13.	Improved agriculture implements	29	24.17	87	72.50	4	3.33	41.88
14.	Harvesting	28	23.33	92	76.67	0	0.00	99.17

Table-6. Distribution of the respondents by their knowledge regarding improved maize production technologies. n=120

S. No.	Categories	f	%	MPS
1.	Poor	21	17.50	20.46
2.	Average	83	69.17	53.23
3.	Good	16	13.33	69.32

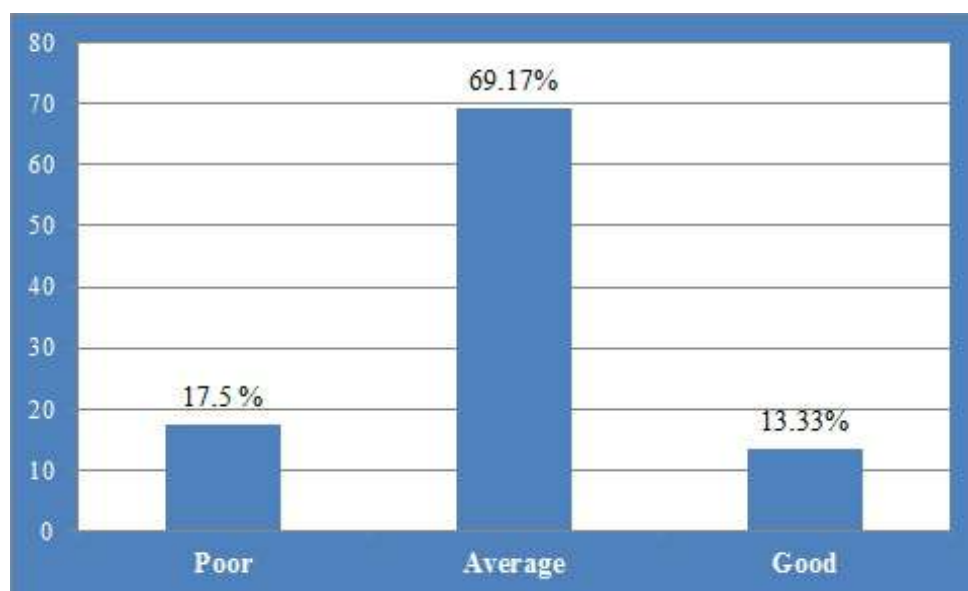


Figure-1 : Overall knowledge of the respondents regarding improved maize production technologies.

seed treatment (54.17%) and irrigation (53.33%) with overall MPS 60, 60.83, 63.25 and 59.17, respectively. Only 2.50 to 22.50 per cent respondents were in high knowledge category of land treatment, improved agriculture implements, seed variety, manures and fertilizers, field preparation, time of sowing and seed rate. Similar findings were reported by Kumar and Bose (2022) that 50.83 per cent of the respondents had a medium level of knowledge about improved maize production practice measures followed by 26.67 per cent and 22.50 per cent of the respondents with low and high levels of knowledge respectively.

Overall knowledge of the respondents regarding improved maize production technologies : To find out overall knowledge of the respondents about organic farming, mean per cent score was calculated and on the basis of MPS the respondents were categorized into three knowledge categories viz. Good, average and poor.

Table-6, majority of the respondents (69.17%) exhibited average knowledge about improved maize production technologies with MPS 53.23 followed by 17.50 per cent respondents exhibited low knowledge with MPS 20.46, only 13.33 per cent respondents exhibited good knowledge with MPS 69.32 respectively. The findings are in line with Singh (2012) who stated that majority of the farmers (62.50%) had a medium level of knowledge about recommended maize production technology. The findings revealed by Netam (2019) stated that 72.96 per cent of respondents had medium level of knowledge regarding improved maize production technologies.

Conclusions

From the research findings it divulge that all the respondents possessed good or average knowledge in various components of improved maize production technologies. Hence, there is a need to pay more emphasis on improved maize production technologies. For exposure to new technologies, regular visits of women should be organized at KVK and ATIC center, etc.

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Nutritional and Organoleptic Evolution of Value added Products of Oyster Mushroom (*Pleurotus florida*)

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Introduction

Oyster mushroom is highly perishable and starts deteriorating after few hours depending upon the storage conditions. Shelf life of this mushroom varies from 1-2 days at the ambient temperature due to its high moisture content, delicate texture and unique physiology. Edible mushrooms have been widely utilized as human foods for centuries and have been appreciated for texture, flavor as well as some nutritional and medicinal attributes (Manzi *et al.*, 2001). Now a day; mushroom is being relished throughout the world as food and medicine. Researcher reports revealed that mushrooms being a complete food source are rich in proteins, vitamins, fats, carbohydrates, dietary fibers, and minerals (Alam and Raza, 2001). The off seasonal use of the mushroom can be achieved by adopting appropriate post-harvest technology to process the fruiting bodies into novel value added products. The production of value-added products are the need of the hour for the mushroom growers not only to reduce the losses but also to enhance their income by value-addition and boost the consumption of this important horticultural crop. Kulshreshtha *et al.* (2009). Present study deals with the formulation and evaluation of value added products such as mushroom Bari and mushroom pickles. Nutritional assessment was carried out to assess the effect of value addition of mushroom Bari and mushroom pickles on organoleptic test (Hedonic scale) of developed value added products.

Material and Methods

1. Composition of value added products

Mushroom Bari - Fresh mushroom-1.2 kg, urad dal-1 kg, Ginger-50 gm, Green chilli-50 gm, Red chili powder -1teaspoon, Black piper powder-1/2 teaspoon.

Mushroom pickles - Fresh mushroom-1.5 kg, Salt-90gm, Brown mustard powder-20 gm, Funnel seed powder-100 gm, Garlic-15 gm, Red chili powder-10 grams, Ajawain-10grams, Mustard oil-200ml.

Fresh oyster Mushroom- Fresh oyster mushroom was collected from selected farmers for research purpose of adopted village. The mushroom was cleaned from

extraneous matter to remove dirt, sand and undesirable matter to from it.

Urad dal, Green chili, Red chili powder, Black piper, Brown mustard, Funnel seed powder, salt, Ajawain, Garlic and Mustard oil were procured from the local market. High density polyethylene bags and air tight glass container were used for packaging and storage of food materials.

2. Preparation of Mushroom Bari

In India different type of Bari are popular according to used of different ingredients. Mushroom Bari was prepared by selected rural women in experimental field. 1/2 kg fresh oyster mushroom were clean with fresh water, cut into small chopped pieces (1-1.5 cm), urd dal (Black gram) 1kg soaked in fresh water overnight, and in morning were washed 2-3 times and drained of water through sieve and muslin cloths. Soaked urd dal grinded and prepared fine paste with mix chopped fresh mushroom, ginger (50 gm), red chili (1tsp), black pepper (1/2 tsp), green chili (50 gm) and salt according to taste. Sun drying methods were available at village level in open space for drying Bari ball but some precautions were maintained from contamination. Dried mushroom Bari ball packed in PP bag and kept in air tight container.

3. Preparation of Mushroom pickles

One and half kg freshly harvested oyster mushrooms were graded based on size and washed thoroughly in clean water to remove the foreign matters. The cleaned mushrooms were cut into small pieces and blanched immediately by dipping them in boiling solution of 0.05% KMS+ 0.1% of citric acid and 2% brine solution for 10 minutes (Rat and Arumuganathan, 2008). The blanched mushrooms were subjected to salt curing process in 10% NaCl and kept for overnight. Next day the excess water oozed out from mushrooms was removed and appropriate preservatives (acetic acid and citric acid), salt (90 g) black mustard seed powder (rat) (35.0 g), turmeric powder (20.0 g), red chili powder (10.0 g), cumin seed powder (1.5 g), fennel seed powder (100.0 g), garlic (1.5 g), carom seed (ajwain) (10.0 g), nigella seed (kalonji) (50.0 g), turmeric powder (20 g) and mustard oil (200 ml) were mixed to get organoleptically acceptable mushroom pickle

4. Determination of Acceptability Quality

All three value added products (Mushroom Bari and Mushroom Pickles) evaluated by sensory evaluation using a score card of 9 point hedonic scale (Table II and Table III). Some amount of value added products developed from fresh oyster mushroom served separately to 10 selected panel members for organoleptically testing and 30 selected farm women and family for acceptability testing. The sensory score was converted into equivalent score out of 100.

Table-1 : Score card of Acceptability and organoleptic characteristics of value added Products developed from Fresh oyster Mushroom (*Pleurotus Florida*).

Products	Colour	Flavour	Taste	Texture	General acceptability
Mushroom Bari					
Mushroom Pickles					

Note : Score as given below :

Like extremely	: 1
Like very much	: 2
Like moderately	: 3
Like slightly	: 4
Neither like nor dislike	: 5
Dislike slightly	: 6
Dislike moderately	: 7
Dislike very much	: 8
Dislike extremely	: 9

5. Chemical evaluation

Mushroom Bari and pickles were analyzed for protein, Energy carbohydrate and crude fat as per the methods of AOAC (2010).

Results and Discussion

The proximate composition of two value added products developed from fresh oyster Mushroom (Mushroom Bari and Pickles). Highest protein content of mushroom Bari (20.18) was observed than mushroom pickles (3.43).The

fat content more varied from both value added products. In nutritive point of view fat was negligibly found in mushroom Bari (0.69) but in mushroom pickles the fat was found to be 15.33. In Mushroom Bari (62.74) carbohydrate was highest percent in compare than mushroom pickles (37.94). Energy (K.cal) percentage was more and less high in value added products of fresh oyster mushroom. These value added products can surely kept in good condition for long period if stored in tight container and pp bag after sealing.

Acceptability and organoleptic testing of value added products developed from fresh oyster mushroom were determined by the score given for sensory characteristics such as colour, flavor, taste ,texture and general acceptability and equivalent score of hundred has been presented table-II and III.

Table II find out the performance of mushroom Bari was better for colour, texture, flavor, taste and texture than mushroom Pickles. The acceptability of value added products developed from fresh oyster mushroom by farm women has been determined by the acceptance and rejection of food products by the selected farm women. The score of acceptability of the product using 9 point hedonic scale has been expressed in equivalent score out of 100.The data obtained has been presented in table-II. The score for general acceptability of mushroom Bari followed by mushroom Pickles. In case of mushroom pickles the equivalent score was 91.25 for colour, 88.75 for flavuor, 91.25 for taste, 88.75 for texture and 88.75 for general acceptability. The equivalent score for colour, flavor taste, texture and score for general acceptability was 91.25, 93.75, 96.25, 88.75 and 92.50 in respectively mushroom bari .The equivalent score for colour, flavor, taste, texture and general acceptability was above 30 in all three value added products has been liked very much by farm women and their family member for as products

Table-I : Nutritional Analysis of value added products of Oyster Mushroom (*Pleurotus Florida*).

Food products	Nutritional contents (Per 100 gm)			
	Protein	Fat	CHO	Energy
Mushroom Bari	20.18	0.69	62.74	343.42
Mushroom Pickles	3.43	15.33	37.04	303.99

Table-II : Acceptability test for sensory characteristics of value added products developed from fresh oyster mushroom (*Pleurotus florida*).

Products	Colour	Flavour	Taste	Texture	General acceptability
Mushroom Pickles	1.7(91.25)	1.9(88.75)	1.7(91.25)	1.9(88.75)	1.9(88.75)
Mushroom Bari	1.7(91.25)	1.5(93.75)	1.3(96.25)	1.9(88.75)	1.6(92.50)

Table-III : Organoleptic test for sensory characteristics of value added products developed from fresh oyster mushroom (*Pleurotus florida*).

Products	Colour	Flavour	Taste	Texture	General acceptability
Mushroom Pickles	1.4(95.0)	2.3(83.75)	2.5(81.25)	2.7(82.5)	2.7(82.5)
Mushroom Bari	1.3(96.25)	1.4(95.0)	2.0(87.5)	2.0(87.5)	2.3(83.75)

has been developed at home scale level. The equivalent score for acceptance for all sensory parameters for value added products acceptance was above 80.

Table II find out the performance of mushroom Bari was better for colour, texture, and flavor, taste and texture than mushroom Pickles and mushroom dry powder. The acceptability of value added products developed from fresh oyster mushroom by farm women has been determined by the acceptance and rejection of food products by the selected farm women. The score of acceptability of the product using 9 point hedonic scale has been expressed in equivalent score out of 100. The data obtained has been presented in table-II. The score for general acceptability of mushroom Bari followed by mushroom Pickles. In case of mushroom pickles the equivalent score was 95.0 for colour, 83.75 for flavuor, 81.25 for taste, 82.5 for texture and 82.5 for general acceptability. The equivalent score for colour, flavor taste, texture and score for general acceptability was 96.25, 95.0, 87.5, 87.5 and 83.75 in respectively mushroom bari .The equivalent score for colour, flavor, taste, texture and general acceptability was above 80 in all two value added products has been liked very much by farm women and their family member for as products has been developed at home scale level.. The equivalent score for acceptance for all sensory parameters for all two value added products acceptance was above 80. In case of mushroom Bari was more liked than mushroom Pickles followed. Table no-III, that all two value added products were well accepted by the selected panel member.

Conclusions

The study revealed that the value added products developed from fresh oyster mushroom (*Pleurotus Florida*) as mushroom pickles, mushroom dry powder and mushroom bari gets wide acceptability more than 80% by farm women and their family member as well as selected panel member. Mushroom pickles and mushroom bari get 92.50% acceptability score while general acceptability on brief of organoleptic test for mushroom pickles in highest (86.25%). Value added products of mushroom enhance farming community interest to grow mushroom during peak season period and get different type of benefit viz. home scale off season value added produce consumption as well as sell of produce to get monetary benefits.

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Impact Study of Disseminating Agro Advisory Bulletin among Farmers in Different District of M.P.

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Abstract

GKMS was started by the Ministry of Earth Sciences in 2015 to facilitate the farmers about crop planning, live stock management and efficiently use of natural resources. It is used to farmer awareness about real time weather event which may effective to prevent the crop failure and achieve the higher yield and economic gain. The accurate weather information given at right time to the farmers of Neemuch&Guna district of Madhya Pradesh, biweekly. The present study was undertaken to evaluate the impact of weather based agricultural advisories on agricultural practices of selected farmers in both referred district. A random sample survey (on 60 farmers of each district) was conducted from both the district in present study during 2020-21. The result indicated that the advisories given to the farmers on agricultural, horticultural crop & livestock is very useful to prevent the crop from extreme weather event as well as insect pest. The information regarding weather forecast through AAS is helpful to the farmers for avoiding losses in crop yield by adverse weather circumstances in both the district of Madhya Pradesh.

Key words : Agro-Advisories services, GKMS (Graminkrishi Mousam Sewa), crops & live stock.

Introduction

Agriculture in India depends on weather and climatic conditions. Weather through various atmospheric factors plays a significant role in reaping good agricultural output (Bal and Minhas, 2017). Variable and uncertain weather is a pervasive fact that farmers have to cope up with it and this has bearing on the livelihoods of farmers. Lack of timely and reliable agrometeorological information is a serious limitation for effective farm planning operations (Prasad Rao and Manikandan, 2008). Weather forecasts are essential for taking decisions regarding crop choice, crop variety, sowing/harvesting dates, and judicious management of agricultural operations such as seedbed preparations, ploughing, irrigation, scheduling and application of fertilizers, pesticide, herbicide and harvesting. In addition, timely weather information enables the farmers to plan their farm operations in way that not only minimize the cost and crop losses but also help in maximizing yield gains. Agriculturally relevant forecast is not only useful for efficient management of farm inputs but also leads to precise impact assessment.

Agrometeorological services is the need of emerging climatic situation to overcome the adverse effect of extreme weather event. It helps the farmer community by improving the efficient use of natural resources. The losses due to climate situation can be minimized and improve agricultural production by improving quantity and quality. Accurate weather forecast helping the farmer to select the cultivar fertilization and adopt appropriate agronomical practices.

Objective

It is observed that there is now much attention in the state MP on the aspects for knowledge of Weather Forecasting and Agro Advisory Bulletin of weather condition. Therefore, these facts the present review research study was undertaken :

To study the impact of disseminating Agro Advisory Bulletin (AAB) in district.

To study the Farmers feedback on Agro Advisory Bulletin (AAB).

Research Methodology

Collection of data has given Medium Range Weather Forecast (MRWF) issued by IMD, Pune and daily weather data recorded at Meteorological Observatory, KVK, Neemuch&Guna for last year i.e. 2020-2021 was collected in Rabi season. The study of agro advisory bulletins issued by AAS unit, IMD Pune collected for last year (2020-2021). Selection of farmer and preparation of questionnaire has sixty progressive farmers selected from GKMS-DAMU villages of Neemuch&Guna district and a questionnaire as suggested by IMD Delhi was circulated to them. The data collected through personal contact to selected farmers was analysed to study the impact of AAB. The mean was calculated and presented in table.

Results and Discussion

Weather based agro advisory bulletin (AAB) : The Weather based Agro Advisory Bulletin (AAB) available from the Agromet-Advisory Services (AAS) unit Delhi observed that following disciplines are covered under

AAB. Inrabi season of year 2020-21total 44 number of AAB was disseminating to the farmers in respected both district. The advisories covers the major rabi crops like wheat,chickpea& mustard in neemuch and Gunadistrict respectively. The horticultural crops, like vegetable crops, Brinjal, Tomato & spices Coriandermainly covered &crop area of both district under the AAB given in below table no. 1.

Table-1 : Area (ha) of major crops in Neemuch and Guna District.

Crop	Area (ha) Neemuch	Area (00 ha) Guna
Chickpea	59000	83700
Mustard	12100	11200
Wheat	41000	91800
Brinjal	350	240
Tomato	550	472
Coriander	15200	56094

In rabi season 2020-21 fromtotal 44 AAB covers 216 number of advisories on different crops in Neemuch district and 48 AAB covers 325numberof advisories on different crops in Guna district. 100% bulletins covers observed maximum and minimum temperature, wind speed and wind direction covers observed rainfall from KVKNeemuch&Guna respectively. The data is given in below table no. 1& 2.

Table-2 : Area wise advisories under Agromet Advisory Bulletins issued by KVKNeemuchduring Rabi 2020-21.

S. No.	Area	Number	Percent (%)
1.	Agronomy Crop	42	19.44
2.	Horticultural Crop	40	18.51
3.	Plant protection	38	17.59
4.	Weather Forecasting	44	20.37
5.	Live stock	35	17.59
6.	Covid-19	12	02.89
7.	Others	15	3.61
Total	07	216	100

Table-3 : Area wise advisories under Agromet Advisory Bulletins issued by KVK Gunaduring Rabi 2020-21.

S. No.	Area	Number	Percent (%)
1.	Agronomy Crop	56	17.23
2.	Horticultural Crop	48	14.76
3.	Plant protection	52	16.03
4.	Weather Forecasting	48	14.76
5.	Live stock	58	17.84
6.	Covid-19	46	14.15
7.	Others	17	5.23
Total	07	325	100

Impact of Agro Advisory Bulletin (AAB) : By the study of Rabi AAB and annual reports of Agro-Advisory Services (AAS) the following events of economic gain or loss formulated. Useability of AAB specify selected cases when advisories were helpful or otherwise. The forecast of parameters match satisfactorily with actual observations and entirely effect in crop & livestock management. Specific occurrences of profit or loses due to AAS with cultural practices, sowing, spraying, pesticides, weedicide, irrigation, fertilizer application and labour saving etc. modified as per advisories.

Form the above Table no 3 & 4 it is formulated that the forecasted information through the AAB is economically helpful to farmer for avoiding the losses of production & productivity due to abnormal weather condition circumstances.

Farmer feedback : In all 60-60 progressive farmers from selected both district villages under KrishiVigyan Kendra (KVK) of Neemuch & Guna district were selected. Maximum farmers were satisfied with the information received through agro advisory bulletins. The majority of farmers form both districts (85%, 87%) were agree that the information received from AAB were beneficial to achive more economic benefits from cagriculture practices. Thus, it can be concluded that most of the respondents were perceived medium effectiveness of farm broadcast category in seeking of agricultural information for doubling

Table-4 : Economic impact of the AAS (2020-21) by KVK Neemuch.

Sr. No.	Forecasted Weather event Date	Crop cultural operations recommended in Advisory	Economic Gain/Loss
01	Prediction of first heavy rainfall/thunderstorm during 23 June to 24 June 2020-21	Farmers advised for Make drainage channels and join with main drainage channel Maintain slope opening of furrows. Do not tie the animals down to the trees in the event of a thunderstorm	Farmers make drain to remove excess water from crop field.
02	Prediction of dry spell during 11 July to 15 July 2020-21	Farmers advised for late sowing, If germination is less than 50% then farmers should go for re-sowing with early maturing varieties with 25% higher seed rate.	Hoeing by Dora/Kolpa to develop soil mulch removal of weeds in time. Use organic mulch in the crop rows, Life saving irrigation through sprinkler.
03	Prediction of frost during 31 December to 05 January 2020-21	Farmers advised for specially sulphur dust and smoke around the highly value crop field.	Timely smoke and dust in field by farmer & protect from frost.
04	Prediction of Cyclone during 19 May to 20 May 2020-21	Farmers advised for Keep Storage of local available food grains/feed ingredients, Prepare an emergency first-aid kit.	Farmers make drain to remove excess water in crop field.

Table-5 : Economic impact of the AAS (2020-21) by KVK Guna.

Sr. No.	Forecasted Weather event Date	Crop cultural/ Livestock operations recommended in Advisory	Economic Gain/Loss
01	Prediction of High Humidity during 11 November to 16 November	If there is wilt affected plants observed in chickpea, then farmers should postpone their irrigation scheduling, because as there is occurrence of dew at many places over the district, which congenial for development of bacterial wilt in chick pea.	Farmers postpone irrigation scheduling which reduce bacterial growth
02	Forecast of minimum temperature during 11 December to 16 December 2020-21	Take special care of the temperature to protect the chickens from winter. Ideal temperature for chicks should be around 30 to 35°C. Therefore, it is advisable to use a brooder or electric bulb/ heater to maintain the temperature.	Farmers used heater for brooder and saved their lives by low temperature
03	Prediction of Cold wave during 22 December to 27 December 2020-21	Due to low temperature during night followed by morning dew the pod borer incidence was noticed in the redgram crop. for the management farmers should go for spraying of indoxacarb 14.5 SC @ 0.5 ml/lit or spinosad 45 SC @ 0.15ml/lit.	Farmers followed advisory and control incidence of Pod borer
04	Prediction of frost during 05 January to 10 January 2020-21	Farmers advised for specially sprinkler irrigation and smoke around the chickpea crop field.	Timely irrigated the field by farmer & protect from frost

Table-6 : Feedback of farmers against the use of agro advisory Bulletin.

S. No.	Question Asked	Satisfied	Partially Satisfied	Not Satisfied
01	Do you receive bi-weekly Forecast and agromet Advisory Bulletin	94%	5%	1%
02	If yes, regularity of bi-weekly Forecast and agromet Advisory Bulletin	96%	4%	-
03	Do you follow weather Forecasts based agromet Advisory bulletin for your farm operation	84%	12%	4%
04	How relevant/useful are the weather based advisories	87%	10%	3%
05	Farm operation for which weather forecast/ agromet advisories are used	90%	8%	2%
06	Weather event most important for your farm operation	95%	5%	-
07	Your satisfaction by the agromet advisory services	89%	9%	2%
08	Average percentage of production lost during the crop season due to bad weather	10%	25%	20%
09	Economic benefit of advisory bulletin	85%	8%	7%
10	Suggestions for improvement in agromet advisories	10%	-	-

Table-6 : Feedback of farmers against the use of agro advisory Bulletin.

S. No.	Question Asked	Satisfied	Partially Satisfied	Not Satisfied
01	Do you receive bi-weekly Forecast and agromet Advisory Bulletin	96%	3%	1%
02	If yes, regularity of bi-weekly Forecast and agromet Advisory Bulletin	97%	3%	-
03	Do you follow weather Forecasts based agromet Advisory bulletin for your farm operation	87%	10%	3%
04	How relevant/useful are the weather based advisories	90%	8%	2%
05	Farm operation for which weather forecast/ agromet advisories are used	86%	11%	3%
06	Weather event most important for your farm operation	96%	4%	-
07	Your satisfaction by the agromet advisory services	87%	9%	4%
08	Average percentage of production lost during the crop season due to bad weather	08%	25%	20%
09	Economic benefit of advisory bulletin	87%	8%	5%
10	Suggestions for improvement in agromet advisories	12%	-	-

the income of farmers. This finding was similar to finding reported by Kasana and Singh, (2015).

Conclusion

The present study summarized and concluded that, Agromet Advisory Services (AAS) has effective in different district communication media whatsapp radio television etc for transfer of technology for climate change as well as forecasted information through the AAB is economically helpful to farmer for avoiding the losses of crop yield due to abnormal weather circumstances of MP.

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Genetic Variability Study in Clonal Seed Orchard of Teak (*Tectona grandis* Linn. f.) in Khurda District of Odisha

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Abstract

The present investigation was carried out on an experiment of 25 clones planted in the year 1995 in RBD with 3 replications. Observations on nine different characters viz; of Plant height, volume, no. of branches, inter nodal length, clear bole length, crown length, crown width, DBH and basal area were recorded. Statistical parameters like mean, phenotypic variance and genotypic variance, phenotypic coefficient of variation and genotypic coefficient of variation, heritability, genetic advance and genetic advance as percentage of mean, correlation coefficients. The results revealed significant differences among different clones in the characters studied. All growth characters under study like Plant height, volume, no. of branches, inter nodal length, clear bole length, crown length, crown width, DBH and basal area had high genotypic coefficient of variation than their environmental component. Heritability was high for the traits such as plant height, volume, no. of branches, inter nodal length, clear bole length, crown length, crown width, DBH and basal area. Heritability ranged from 90.566% to 97.100%. Crown length showed the highest percentage of heritability (97.100%) and the lowest (90.566%) was found in DBH. Genetic advance (% mean) was found to be moderate to high in all characters except plant height. Significant positive correlation was observed between plant height-crown length, volume with DBH, internodal length with crown width and DBH with basal area indicating scope of selection the above traits having positive association.

Key words : *Growth characters, genetic parameters, correlation.*

Introduction

Teak (*Tectona grandis* L.f.) belongs to family Lamiaceae. It is a big deciduous tree prevails in moist and dry deciduous forest of India. It produces exquisite quality wood with long durability and stability. Usually, the tree grows up to 30 metres in height and 100 cm or more in dbh. It has solid quadrangular branches and two-thirds of tree height is cylindrical bole.

The heartwood is yellow brown to dark brown in colour. The unique features of the wood like colour, grain, hardness, lightness, strength, easy to season, free from seasonal defects, easy to work, convenient to carving, resistance to fungi and weathering, etc. place it as the most magnificent wood. It is used for the design of vessels, exterior building, furniture, painting, turning and other small wood projects. It has multiple utility, simple operability and consistent durability, it is the Paragon of Indian timber.

Teak occurs under tropical and subtropical conditions in India with an annual rainfall of 100cm to 150 cm. and can thrive with wide stretch of rainfall 75 to 500 cm. it grows well between mean temperature between 21°C to 28°C and can survive in wide temperature range between 2°C to 45°C. It prefers sandy well drained and fertile soil. Teak requires overhead sunlight and can't withstand shade at any stage of its growth throughout its life cycle. It has strong coppicing ability. Teak has a rotation period in southern and central India of 50 to 60 years and 70 to 80 years, respectively.

Teak plantations are developed throughout the world since 1850 for its easy domestication and huge market for its high quality timber. Teak contributes 75% of good quality timber world wide. In India, Teak is distributed in moist and deciduous forest with abundant genetic diversity. The Indian subcontinent is known as the centre of diversity for teak and is endowed with wide genetic diversity of different characters like bole form, wood quality, biochemical characteristics etc.(Anmol Kumar *et al.*,1997).

One of the significant facts of the teak enhancement programme is the production of acceptable clones of short rotation for unique agro climatic conditions. The efficiency of short teak rotation is high, with an estimated annual range of 10 and 20 cubic meters per hectare per year. The wood quality like density and strength is not affected by the age of the Teak plant for structural uses. The production of high-yielding teak plantations lacks quality planting materials. Adequate data on the genotypic and phenotypic variability of planting stock produced from various teak clones should be generated for tree improvement programme.

Materials and Methods

The experiment was conducted from December 2019 September 2020 at Barbera forest and Chulijhinka forest which spreads over Khurda district in coastal Odisha situated between 19.48'06" north latitude, 85.02'39" east longitude with an altitude of 107m msl. The site

experiences hot and sub-humid type climate. The average annual temperature is 28° c in this area. The average annual rainfall is 1400 mm. Humidity is generally high which is from 36 to 85 % throughout the year.

The experimental plot was of size 19 hectare. Topography of the site was almost flat. Soil of the site was laterite and sandy loam in texture. The experiment was conducted in a Randomised block design (RBD) with 3 replications and 25 treatments (clones) of *Tectona grandis* L.F.

Observations in respect of 9 characters were recorded on sample plants for statistical analysis. The characters for recording observation are Plant height, volume, no. of branches, inter nodal length, clear bole length, crown length, crown width, DBH and basal area. The volume of tree was obtained by allometric equation developed by Forest Survey of India, 1982 as given below :

$$V = 0.1657 - 1.1235D + 10.107586D^2$$

V = Volume in meter³, D = Diameter In meter

The data recorded from the different characters was subjected to different statistical analysis for the estimation of parameters like mean, analysis of variance, Phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, genetic advance, phenotypic and genotypic correlation following standard procedures.

Results and Discussion

The nine characters showed significant difference among treatments. The results obtained are presented as follows:

Plant height : Perusal of the Table-1 showed that clone UP-H recorded maximum height (18.90m) which was statistically at par with clone MHAL-A-1(18.65m). The minimum height was recorded in clone TNT-7(16.55m) and MHSL-A-J-2(16.55m) which was statistically at par with APT-6(16.65m), ORPUB-19(16.60m) and ORPUB-2(16.70m).

Volume : Perusal of the Table-1 showed that clone ORPUB-33 recorded maximum volume (1.67 m³) which was statistically at par with clone APKCC-2 (1.59m³). The minimum volume was recorded in clone MHSL-A-J-2(0.76m³) which was statistically at par with ORPUB-6(0.84m³) .

Number of branches : Perusal of the Table-1 showed that clone ORPUB-6 recorded maximum no. of branches (7.67) which was statistically at par with clone MYHV-5(7.34) and ORPUB-2(7.17). The minimum no. of branches was recorded in clone MHAL-P-2(3.67) and APNPL-11(3.67) which was statistically at par with DRAHP-13(3.84).

Inter-nodal length: Perusal of the Table-1 showed that

clone MHAL-P-2 recorded maximum inter-nodal length (2.50 m) which was statistically at par with clone APT-5(2.47m) and ORNAP-7(2.47m). The minimum Inter-nodal length was recorded in clone TNT-7(0.80 m).

Clear bole length: Perusal of the Table-1 showed that clone MHAL-P-2 recorded maximum clear bole length (6.40m) which was statistically at par with clone DRAHP-13(6.30m) and MHAL-P-1(6.30m). The minimum clear bole length was recorded in clone ORNAP-7(3.75m) which was statistically at par with UP-H (3.80m).

Crown length : Perusal of the Table-1 showed that clone UP-H recorded maximum crown length (15.10m). The minimum crown length was recorded in clone ORPUB-19(10.45m).

Crown width : Perusal of the Table-1 showed that clone APKCC-2 recorded maximum crown width (9.25m) which was statistically at par with clone MHSL-A-J-2(9.05m) and ORNAP-7(9.05m). The minimum crown width was recorded in clone ORPUB-12(6.20m) which was statistically at par with ORPUB-34(6.25m).

DBH (Diameter at breast height) : Perusal of the Table-1 showed that clone APKCC-2 recorded maximum DBH (0.44m) which was statistically at par with clone MYHV-5(0.43m). The minimum DBH was recorded in clone MHSL-A-J-2(0.31m) which was statistically at par with ORPUB-6(0.30m).

Basal Area: Perusal of the Table-1 showed that clone ORPUB-33 recorded maximum Basal area (0.16m²) which was statistically at par with clone APKCC-2(0.15m²). The minimum Basal area was recorded in clone MHSL-A-J-2(0.07m²) which was statistically at par with ORPUB-6(0.083m²).

Sharma and Bakshi (2014) reported high degree of variation (0.1% level) was observed in height and GBH after 13 years of plantation in *Dalbergia sissoo*. These variations in growth characteristics of clones may be attributed to inherent genetic factors as well as the effect of environmental conditions, which may vary from provenance to provenance. Rawat and Nautiyal (2007) also suggested that variation in growth characteristics of the plants of *Dalbergia sissoo* is essentially genetic in nature if it differs in identical environmental conditions. Pathak *et al.*(1984) have also reported that the genetic and environmental factors influenced the growth performance of plants of *Leucaena leucocephala*.

Coefficient of Variation : In terms of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) and environmental coefficient of variation (ECV), the degree of variability among the studied clones with regard to growth characters was calculated. The PCV estimates ranged from 3.727 % in plant height to 22.839 % in inter nodal length (Table-4.2). Similarly, the GCV

Table-1 : Growth characters of different clones of *Tectona grandis*.

Clones	Plant Height(m)	Volume (m ³)	No. of branches	Inter nodal length(m)	Clear bole length(m)	Crown length(m)	Crown width (m)	DBH (m)	Basal area (m ²)
APT-5	17.45	1.63	5.84	2.47	5.40	12.05	8.90	0.44	0.150
APT-6	16.65	1.26	5.50	1.50	4.60	12.05	8.60	0.39	0.120
APNPL-10	17.85	1.37	4.50	1.60	6.10	11.75	7.90	0.41	0.130
APNPL-11	17.68	1.20	3.67	2.17	5.35	12.33	8.20	0.38	0.113
MYHV-5	17.20	1.51	7.34	2.20	5.40	11.80	7.80	0.43	0.143
TNT-7	16.55	1.44	5.34	0.80	4.70	11.85	8.15	0.42	0.140
APKCC-2	18.25	1.59	5.84	1.67	4.70	13.55	9.25	0.44	0.150
UP-H	18.90	1.13	4.34	1.67	3.80	15.10	8.25	0.37	0.107
MHAL-P-2	17.45	1.01	4.84	2.50	4.30	13.15	7.65	0.35	0.097
MHAL-A-1	18.65	1.01	5.84	2.27	4.35	14.30	7.65	0.35	0.100
MHAL-A-4	17.40	0.90	5.17	2.17	5.40	12.00	8.10	0.33	0.087
MHSL-A-J-2	16.55	0.76	6.84	2.07	5.40	11.15	9.05	0.31	0.073
MHAL-P-1	17.15	1.13	3.34	2.27	6.30	10.85	8.55	0.37	0.107
MHAL-P-2	17.60	1.33	3.67	2.07	6.40	11.20	7.45	0.40	0.127
DRAHP-13	17.35	1.37	3.84	1.47	6.30	11.05	7.30	0.41	0.130
ORPUB-19	16.60	1.33	4.84	1.47	6.15	10.45	6.45	0.40	0.127
ORPUB—12	17.80	1.04	6.84	1.57	5.45	12.35	6.20	0.36	0.100
ORPUB-34	17.40	1.37	5.84	1.50	5.30	12.10	6.25	0.41	0.130
ORPUB-33	17.90	1.67	4.67	1.67	5.60	12.30	7.40	0.45	0.160
ORPUB-17	18.10	1.20	4.84	1.87	5.20	12.90	7.55	0.38	0.113
ORPUB-26	17.35	1.01	5.84	1.67	5.70	11.65	7.60	0.35	0.097
ORPUB-8	17.55	0.95	6.84	1.70	5.45	12.10	8.10	0.34	0.090
ORPUB-6	18.50	0.84	7.67	1.47	5.45	13.05	7.25	0.32	0.083
ORPUB-2	16.70	0.98	7.17	1.77	4.80	11.90	8.40	0.35	0.093
ORANP-7	17.60	1.13	6.34	2.47	3.75	13.85	9.10	0.37	0.107
OVER ALL MEAN	17.53	1.21	5.47	1.84	5.25	12.27	7.88	0.38	0.11
CV	0.859	5.909	4.486	6.052	2.65	1.553	2.073	2.679	6.126
CD(5%)	0.248	0.117	0.404	0.183	0.229	0.31	0.229	0.017	0.012

Table-2 : Genetic parameters of different growth characters in clones of *Tectona grandis*.

Character	Phenotypic variance	Genotypic variance	Environ-mental variance	PCV	GCV	ECV	Heritability %	GA%	Genetic advance
Plant Height (Meter)	0.426	0.403	0.023	3.727	3.625	0.102	94.644	7.265	1.273
Volume (In m cube)	0.066	0.061	0.005	21.309	20.473	0.836	92.310	40.521	0.489
No. of branches	1.54	1.48	0.06	22.730	22.283	0.447	96.106	45.000	2.461
Inter nodal length (IN M)	0.176	0.164	0.012	22.839	22.023	0.816	92.978	43.745	0.805
Clear bole length (IN M)	0.549	0.530	0.019	14.123	13.872	0.251	96.481	28.070	1.475
Crown length (In meter)	1.218	1.182	0.036	8.996	8.864	0.132	97.100	17.993	2.208
Crown width (in m)	0.700	0.673	0.027	10.619	10.414	0.205	96.186	21.041	1.659
DBH (in M)	0.0014	0.0013	0.0001	10.144	9.654	0.49	90.566	18.926	0.072
Basal Area (In m square)	0.022	0.0004	0.0216	20.742	19.817	0.925	91.281	39.003	0.045

estimate of the characters varied between 3.625 % in plant height to 22.283 % in no. of branches. Environmental component of variation (ECV) for basal area (0.925%) while plant height had low estimates of 0.102% (Table-4.2).

Heritability (%) : The heritability % estimates for different characters ranged from 90.566 in DBH to 97.100 % in crown length. High heritability was found for all the characters under study. (Table-4.2).

Genetic advance : For each character, predicted genetic advance (GA) was calculated under selection (5 percent selection intensity) among the clones. The estimated GA for characters under selection ranged from 0.045 percent to 2.461 percent for no. of branches and basal area respectively (Table-4.2).

Genetic advance (% of mean) : Data persuaded in Table-2 revealed that there was significant variation

Table-3 : Genotypic/Phenotypic Correlations Matrix among different growth characters of Teak.

	Plant height	Volume	No of Branches	Inter Nodal Length	Clear Bole Length	Crown Length	Crown Width	DBH	Basal Area
Plant Height	1								
Volume	-0.018/ -0.010	1							
No of Branches	-0.069/ -0.064	-0.317**/ -0.295**	1						
Inter Nodal Length	0.142/ 0.135	-0.167 /-0.176	-0.063/ -0.061	1					
Clear Bole Length	-0.268*/ -0.249*	0.156/ 0.170	-0.302**/ -0.297**	-0.146/ -0.146	1				
Crown Length	0.764**/ 0.759***	-0.115/ -0.120	0.162/ 0.162	0.180/ 0.178	-0.827**/ -0.820***	1			
Crown Width	-0.096/ -0.087	-0.007/ -0.008	0.044/ 0.029	0.376**/ 0.346**	-0.392**/ -0.373***	0.207/ 0.199	1		
DBH	-0.037/ -0.028	0.998/ 0.977**	-0.341**/ -0.305**	-0.176/ -0.186	0.152/ 0.156	-0.124/ -0.122	-0.017/ -0.015	1	
Basal Area	-0.013/ -0.008	1.000/ 0.994**	-0.314**/ 0.994**	-0.202/ -0.207	0.156/ 0.171	-0.112/ -0.119	-0.038/ -0.036	0.996**/0.9 69***	1

Note : *indicates significant correlation at 5% level of significance and ** indicates significant correlation at 1% level of significance
*** indicates significant correlation at 0.1% level of significance.

obtained with reference to genetic GA% of different growth parameters of Teak. The maximum genetic GA% value 45.0% was recorded in no of branches whereas plant height claimed the least GA% of 7.265%.

Considering the importance GCV value simultaneously with heritability and genetic advance in increasing the reliability and response of selection, efforts were also made to indicate both heritability and genetic advance values along with GCV for various traits during the present investigation (Table-2). The characters like Volume, Number of branches and inter nodal length exhibited high GCV coupled with high heritability and high genetic advance, indicates the preponderance of additive gene and hence selection based on phenotypic performance for these traits would be effective. Plant height exhibited high heritability value and low genetic gain suggested that inheritance of such traits might be under the control of both additive and non additive gene effects. Therefore, selection of genotypes on the basis of phenotypic performance of the above trait may not be effective. High heritability estimates in broad sense for growth characters is in confirmation with earlier findings by Gera *et al.* (2001) in Teak, Singh *et al.* (1995), Bangraw (1993), and Dhillon *et al.* (1995) in Sissoo.

Genotypic correlation : Perusal of data from Table-3 indicated that height was positively and significantly correlated with crown length (0.764**) and negatively correlated with clear bole length (-0.268*). Similarly in volume it is negatively correlated with number of branches (-0.317**) and positively correlated with DBH (0.998**) and basal area. No. of branches was negatively correlated

with clear bole length (-0.302**), with DBH (-0.341**) and with basal area(-0.314**). In inter nodal length it was positively correlated with crown width(0.376**). Clear bole length was negatively correlated with crown length (-0.827**) and with crown width (-0.392**). DBH was significantly and positively correlated with basal area (0.996**).

Phenotypic correlation : Persual of data from Table-4 indicated that height was positively and significantly correlated with crown length (0.759***) and negatively and significantly correlated with clear bole length(-0.249*). Volume was positively significantly correlated with basal area(0.994***) and DBH (0.977**) and negatively correlated with number of branches (-0.295**). Number of branches was negatively correlated with basal area (-0.291), DBH(-0.305**) and clear bole length (-0.297**). Internodal length was positively and significantly correlated with crown width (0.346**). Clear bole length was negatively and significantly correlated with crown length (-0.820**) and crown width (-0.373***). DBH was positively significantly correlated with basal area(0.969***).

The positive correlation of tree volume with DBH and basal area suggests DBH could be a reliable selection parameter. Tree volume is basically a function of tree height and DBH. Thus, DBH could be reliable selection parameter for tree volume. Khosla *et al.*(1985) in *Pinus roxburghii*, Rawat(2006) in *Pinus wallichina*, Gautam (2006) in *Dalbergia sissoo* reported positive correlation among growth characteristics.

Lots of variability in growth characters was observed among different clones of *Tectona grandis*. Different clones showed superiority in different growth characters. From economic point of view volume was found maximum 1.67 m³ in clone ORPUB 33 followed by the clone APKCC-2 (1.59 m³). The maximum diameter at breast height (0.45 m) was also recorded in clone ORPUB 33 followed by APKCC-2 (0.44 m). From correlation it was found that volume was positively correlated with diameter at breast height. The growth characters like volume, no. of branches, and intermodal length under study showed high heritability, GCV and genetic advance indicates these characters could be selected as phenotypic traits for improvement programme.

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Energy Evaluation and Relative Economics of Green Fodder Yield of Fodder Maize Genotypes in Response to Sowing Dates

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Abstract

A field experiment was carried out at Agronomy research farm, FoA, Wadura, Sopore, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during *kharif* 2019. The experiment comprised of two factors with four dates of sowing viz. 30th April, 10th May, 20th May and 30th May as main plot treatments and three genotypes viz. SFM-1, PMC-6 and J-1006 as sub-plot treatments laid in split plot experimental design replicated thrice with the aim to find out optimum sowing date and genotype for maximum energy evaluation and relative economics of fodder maize. The economic analysis showed that highest net profit of 57890.00 with benefit cost ratio of 1.64 recorded on 30th April sowing date with genotype SFM-1, whereas lowest net profit of 45670.99 and benefit cost ratio of 1.52 reported on 30th May sowing in genotype J-1006. The highest energy output of 84000 (MJ ha⁻¹), energy ratio of 1.64, net energy of 57899 (MJ ha⁻¹) and energy intensity of 23.64 (MJ ha⁻¹) with genotype SFM-1. Whereas lowest energy output of 81000 (MJ ha⁻¹), energy ratio of 1.57, net energy of 46899 (MJ ha⁻¹) and energy intensity of 21.64 (MJ ha⁻¹) with sowing date of 30th May in genotype J-1006 was obtained.

Key words : Sowing dates, genotypes, green fodder yield relative economics, energy evaluation.

Introduction

Maize (*Zea mays* L.) is the third major cereal crop of the world and in India ranks third after wheat and rice. Maize is considered as extensive cereal crop primarily due to highest productivity among cereals and acquires wider adaptability in varied agroclimatic conditions hence, known as 'Queen of Cereals' [1]. In world around 190 million hectares of area with production of about 1438 million tonnes is under maize cultivation [2]. In India about 9.50 million hectares with annual production of 27.23 million tonnes and productivity of 2870 kg hectare⁻¹ is under maize cultivation [3]. The area under fodder production in India is around 9.85 million hectares and accounts only 4 percent of cultivated area and production of about 462 million tonnes for green fodder and 394 million tonnes for dry fodder respectively [4.] In the union territory of Jammu and Kashmir maize is the second most important cereal crop after rice and is grown on an area of 0.31 million hectare with production of 0.51 million tonnes with an average productivity of 1650 kg ha⁻¹ [3]. In union territory of Jammu and Kashmir, about 90.6% of the total area under maize is planted under rainfed conditions [5].

Maize (*Zea mays* L.) is considered as important double-purpose crop grown widely in *kharif* season used in human diet as grain as well as animal feed. Maize forage supplies large amounts of energy rich forage for dairy animal diets; free from anti nutritional factors so can

be fed to cattle at any growth stage [6]. The maize crop is having many desirable fodder qualities due to which it is preferred as compared to other cultivated non fodder crops viz; high productivity, high production potential, broader adaptability, rapid growing nature, succulence, palatability, free from toxicants, rich in protein and minerals and having high digestibility than non-legume fodder, body weight and milk quality increases in cattle [7]. Hence, it is widely known as ready-made fodder crop. Maize is highly nutritive, excellent, and sustainable fodder for livestock [8]. The green fodder of maize possesses lactogenic properties and therefore, suited for milch cattle [9].

There is modifying effect on the growth and development of maize plants with the environmental changes (sunshine, temperature) associated with different sowing dates. Growth and yield of maize is significantly affected by sowing dates. Greater the deviation from optimum date of sowing of each hybrid greater the reduction in yield [10]. One of the challenges for maize growers at present is to find the narrow interval between sowing earlier and sowing later [11]. Maize sown earlier performs better and yields more due to the fact that the vegetative phase of life cycle prevails in the cooler part of the season with less moisture stress [12]. Early sowing is beneficial compared to late sowing due to long growth span which allows more choice of hybrid maturities and more chances for re plant. In earlier sowing

Table-1 : Relative economics of maize (₹ ha⁻¹) as influenced by various treatment combinations.

Treatment	Green Fodder Yield (q ha ⁻¹)	Cost of cultivation (₹ ha ⁻¹)	Gross profit (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	B : C ratio
(30 th April) × SFM-1	471.32	35729	94263.33	58534.33	1.64
(30 th April) × PMC-6	470.15	35729	94030.00	58301.00	1.63
(30 th April) × J-1006	469.15	35729	93830.00	58101.00	1.63
(10 th May) × SFM-1	465.63	35729	93126.67	57397.67	1.61
(10 th May) × PMC-6	461.15	35729	92230.67	56501.67	1.58
(10 th May) × J-1006	461.51	35729	92301.33	56572.33	1.58
(20 th May) × SFM-1	456.77	35729	91354.00	55625.00	1.56
(20 th May) × PMC-6	455.59	35729	91117.33	55388.33	1.55
(20 th May) × J-1006	454.65	35729	90929.33	55200.33	1.54
(30 th May) × SFM-1	456.18	35729	91236.00	55507.00	1.55
(30 th May) × PMC-6	449.17	35729	89833.33	54104.33	1.51
(30 th May) × J-1006	448.11	35729	89621.33	53892.33	1.51

Cost of seed = ₹ 47 kg⁻¹, Cost of MOP = ₹ 26 kg⁻¹, Cost of urea = ₹ 5.5 kg⁻¹,
Cost of DAP = ₹ 19 kg⁻¹, Green fodder @ ₹ 2 kg⁻¹

Table-2 : Energy Evaluation of fodder maize as influenced by various treatment combinations.

Treatment	Energy input (M J ha ⁻¹)	Energy output (M J ha ⁻¹)	Energy ratio	Net energy (M J ha ⁻¹)	Energy intensity (M J ₹ ⁻¹)
(30 th April) × SFM-1	13734.26	848370	61.77	834635.70	23.74
(30 th April) × PMC-6	13734.26	846270	61.62	832535.70	23.69
(30 th April) × J-1006	13734.26	844470	61.49	830735.70	23.64
(10 th May) × SFM-1	13734.26	838140	61.03	824405.70	23.46
(10 th May) × PMC-6	13734.26	830076	60.44	816341.70	23.23
(10 th May) × J-1006	13734.26	830712	60.48	816977.70	23.25
(20 th May) × SFM-1	13734.26	822186	59.86	808451.70	23.01
(20 th May) × PMC-6	13734.26	820056	59.71	806321.70	22.95
(20 th May) × J-1006	13734.26	818364	59.59	804629.70	22.90
(30 th May) × SFM-1	13734.26	821124	59.79	807389.70	22.98
(30 th May) × PMC-6	13734.26	808500	58.87	794765.70	22.63
(30 th May) × J-100	13734.26	806592	58.73	792857.70	22.58

Energy output = 18 Mega Joules (M J) kg⁻¹ of green fodder yield.

tasseling and silking period lies before to moisture stress risk and drought damage [13]. Harvesting is done earlier in the season when conditions are better which minimize time losses [14]. One of the advantages of early sowing is that female flowering happens before month of July which is the month of stress because of water deficiency. Late sowing adversely decline maize production viz; the effective growing season is shortened, crop photosynthesis is declines and crop is exposed to high risk lethal cold temperatures before grain maturation late in the season, insect and disease stress and moisture and heat stress during pollination. There is accelerated crop development in late sowings due to presence of increased temperatures during crop duration which decline assembled solar radiation causing reduction in biomass production [13]. Choosing of appropriate sowing date with a good variety guarantee higher maize production in addition to recommended agro management practices [15]. For achieving higher efficiency from available nutrients, water, and solar energy, selection of optimum

sowing date for already existing varieties is unavoidable [16].

Materials and Methods

The present investigation was carried at the Agronomy Research Farm, FoA, Wadura, Sopore, SKUAST-Kashmir during *kharif* 2019 that lies between 34° 21' N latitude and 74° 23' E longitude having an altitude of 1590 m above the mean sea level. The climate is temperate and continental type characterized by hot summers and severe winters with average annual precipitation is 812 mm (average of past thirty years) and more than 80 percent of precipitation occurs during December to April in the form of rains and snow received from western disturbances. The mean maximum and minimum temperatures during crop growth season were 33.34 °C and 6.81 °C respectively. The total precipitation amounted to 398.1 mm during crop growth season. The soil of the experimental site was silty clay loam in texture, with

medium in available nitrogen, phosphorus and potassium and neutral pH. The experiment consisting of two factors viz., four sowing dates (30th April, 10th May, 20th May and 30th May) and three genotypes (SFM-1, PMC-6 and J-1006) laid out in split plot design (SPD) taking sowing dates as main plots treatments and genotypes as sub plot treatments with three replications. A fertiliser dose of 10 t ha⁻¹ FYM, 120 kg ha⁻¹ nitrogen, 60 kg P₂O₅ ha⁻¹ and 40 kg K₂O ha⁻¹ was applied uniformly to each plot.

Relative Economics : The relative economic was worked out in terms of cost of cultivation, gross returns, net returns and benefit: cost ratio. The cost of cultivation was worked out for each treatment based on price of inputs. Gross returns was computed bases on existing price of output (green fodder).

Net returns = Gross returns – Total cost of cultivation

Benefit: cost ratio = Net returns ÷ Total cost of cultivation

Energy Evaluation : All the operations carried out from sowing to harvesting were converted into Mega Joules using conversion table [18]. The energy input ha⁻¹ was calculated by converted the amount of different field operations done during cultivation of maize into mega joules using conversion table. The energy output ha⁻¹ was calculated from average green fodder yield in each treatment combination by multiplying it with 18 Mega joules kg⁻¹ of green fodder. The energy ratio, energy intensity and net energy were calculated using the following formula

Energy ratio = Energy output (MJ ha⁻¹) / Energy input (MJ ha⁻¹)

Net energy (MJ ha⁻¹) = Energy output- Energy input.

Energy intensity (MJ⁻¹) = Energy Output (MJ ha⁻¹) / Cost of cultivation (ha⁻¹)

Results and Discussion

Relative economics : It was evident that highest and lowest gross profit, net profit and benefit cost ratio of and lowest was recorded by sowing maize on 30th April and 30th May with genotype J-1006 (Table 1). The higher net profit and benefit cost ratio is due to higher green fodder yield recorded on 30th April sowing. The results are in according with the studies of [18] and [19] who noticed that early sowing of sweet corn resulted in higher net profit and benefit cost ratio in contrast to delayed sowing.

Energy evaluation : It was concluded that highest energy output energy ratio, energy intensity and net energy obtained by sowing maize On 30th April with SFM-1 genotype. While as lowest energy output energy ratio energy intensity and net energy obtained on 30th May sowing with genotype J-1006 (Table 2). The maximum values of energy output, net energy, energy ratio and

energy intensity could be attributed to highest green fodder yield obtained on 30th April sowing with said SFM-1 genotype. [20] reported that for obtaining maximum energy output, energy ratio and net energy, sowing of maize should be carried round 15th April. Also [21] reported that higher energy output, energy use efficiency, net energy return and energy intensity in summer mung bean sowing carried around 20th March and 25th April.

Conclusions

The investigation revealed that to obtain higher monetary values and energy evaluation, sowing of fodder maize must be done around 30th April in combination with SFM-1 genotypes under temperate Kashmir valley.

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Study of Growth Indices of Pearl Millet under Different Sowing Environments

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Abstract

Field experiment was conducted during *kharif* season 2019 at research farm, Department of Agricultural Meteorology, CCS HAU, Hisar located at 29° 10' N latitude, 75° 46' E longitude and 215.2 m altitude. CGR and LAD were computed for different treatments at various intervals of days. Among date of sowing early sown crop under 2nd fortnight of June had maximum value of CGR (45.8) at 41 to 60 days interval and among pearl millet hybrids HHB 299 had maximum value of CGR (60.9) at 41 to 60 days. Maximum LAD value was observed among early sown crop *i.e.* 2nd fortnight of June (66.1) at 41 to 60 days and among pearl millet hybrids maximum LAD value was observed in HHB 299 (69.6) at 41 to 60 days.

Key words : CGR, LAD and pearl millet.

Introduction

The sixth most important cereal of the world is Pearl millet [*Pennisetum glaucum* (L.) R. Br.] and more than 90 million people in agriculturally marginal in West and Central Africa and the Indian sub-continent areas dependent on pearl millet as a staple food. It can be grown as fodder crop in the regions of high rainfall. Particularly during flowering heavy rains and high humidity are detrimental, leads to the poor seed-set due to wash away of pollen and prevent dehiscence. Reduction in crop yield may be due to prolonged warm spells, rainless weather. Low productivity of pearl millet is due to natural causes involving diminutive rainy season that varies spatially and temporally (Graef and Haigis, 2001). Dry and warm weather is most suitable at the time of harvesting. During the period of vegetative growth, the crop has a great adaptation to drought stress (Mahalakshmi *et al.*, 1988); however, the dry spells that occur at the beginning of the growing season not only affect the crop establishment but also reduce the plant population while dry spells during the flowering period lead to a complete yield failure (Burroughs, 2003). With short developmental phases and rapid regrowth potential in pearl millet thus making it efficient in use of asynchronous tillering under drought stress to make efficient use of diminutive periods of water availability. Among the world's poorest countries pearl millet plays role as a staple diet for farm households (Basavaraj *et al.*, 2010). Identifying suitable time of sowing for pearl millet during summer was important to have proper growth and development of plants. Keeping in view of the importance the study was aimed to investigate the effect of different sowing environments on performance of pearl millet.

Materials and Methods

Field experiment was conducted during *kharif* season 2019 at research farm, Department of Agricultural Meteorology, CCS HAU, Hisar located at 29° 10' N latitude, 75° 46' E longitude and 215.2 m altitude. The experiment was put in a split plot design and comprised of three date of sowings (main plot treatments) viz. D₁- 2nd fortnight of June, D₂- 1st fortnight of July, D₃- 2nd fortnight of July and four sub plot treatments comprising four varieties viz. V₁- HHB 67 Improved, V₂-HHB 197, V₃-HHB 272 and V₄-HHB 299 with three replications.

Crop growth observations

Crop growth rate (g m⁻²day⁻¹) : The daily increment in plant biomass is termed as crop growth rate (Watson, 1952) or rate of dry matter production. Crop growth rate (CGR) was calculated by using the formula of Watson (1952). It is expressed as g m⁻²day⁻¹.

$$\text{Crop growth rate} = \frac{1}{S} \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where,

S is ground area covered by plant (m²)

W₂ and W₁ are dry weight of plant at time t₂ and t₁, respectively.

Leaf area duration (days) : Leaf area duration (LAD) is the integral of leaf area index (LAI) over the growth period (Watson, 1952) and calculated by the formula :

$$\text{Leaf area duration} = \frac{LAI_2 - LAI_1}{2} (t_2 - t_1)$$

Where,

Table-1 : Effect of different sowing environments on CGR ($\text{g m}^{-2} \text{ day}^{-1}$) of pearl millet hybrids at different growth intervals during 2019.

Treatments	CGR between ($\text{g m}^{-2} \text{ day}^{-1}$)			
	0-20 DAS	21-40 DAS	41-60 DAS	61-Harvest
2 nd fortnight of June	3.8	30.0	45.8	24.1
1 st fortnight of July	4.0	32.5	38.3	12.5
2 nd fortnight of July	4.2	26.7	26.8	10.1
SEm $\pm$	0.0	0.05	0.05	0.01
CD at 5%	0.0	0.20	0.20	0.04
HHB 67 Improved	5.0	33.0	19.1	7.1
HHB 197	3.7	32.2	43.5	11.3
HHB 272	4.4	31.2	24.4	8.1
HHB 299	2.9	22.4	60.9	35.8
SEm $\pm$	0.01	0.06	0.06	0.01
CD at 5%	0.03	0.18	0.17	0.03

DAS=Days after sowing.

Table-2 : Effect of different sowing environments on LAD (days) of pearl millet hybrids at different growth intervals during 2019.

Treatments	LAD (days)			
	0-20	21-40	41-60	61-HARVEST
2 nd fortnight of June	12.9	48.8	66.1	48.7
1 st fortnight of July	13.3	51.7	64.5	44
2 nd fortnight of July	11.6	44	50.8	32.1
SEm $\pm$	0.19	0.15	0.21	0.26
CD at 5%	0.78	0.61	0.84	1.04
HHB 67 Improved	12.3	49.1	52.6	29.5
HHB 197	13.3	48.9	62.4	42.5
HHB 272	12.8	47.7	57.2	36.6
HHB 299	11.8	47	69.6	57.7
SEm $\pm$	0.20	0.16	0.23	0.28
CD at 5%	0.60	0.47	0.69	0.85

DAS=Days after sowing.

LAI₂ = Leaf Area Index at time t₂LAI₁ = Leaf Area Index at time t₁

Results and Discussion

Crop growth rate ($\text{g m}^{-2} \text{ day}^{-1}$) : The relevant data in respect of crop growth rate (CGR) of dry matter as influenced by different sowing environments were presented in the Table 1. It was evident from the data that the values of CGR were higher in early sown crop than late sown crop except during 0-20 and 21-40 DAS.

Between 0-20 DAS in the crop seasons 2019, delay sown crop under 2nd fortnight of July ($4.2 \text{ g m}^{-2} \text{ day}^{-1}$) had highest values of CGR followed by 1st fortnight of July ($4.0 \text{ g m}^{-2} \text{ day}^{-1}$) and 2nd fortnight of June ($3.8 \text{ g m}^{-2} \text{ day}^{-1}$). Among pearl millet hybrids HHB 67 'Improved' ($5.0 \text{ g m}^{-2} \text{ day}^{-1}$) had highest values of CGR followed by HHB 272 ($4.4 \text{ g m}^{-2} \text{ day}^{-1}$), HHB 197 ($3.7 \text{ g m}^{-2} \text{ day}^{-1}$) and HHB 299 ($2.9 \text{ g m}^{-2} \text{ day}^{-1}$).

Between 21-40 DAS in crop season 2019, crop sown under 1st fortnight of July ($32.5 \text{ g m}^{-2} \text{ day}^{-1}$) had highest values of CGR followed by 2nd fortnight of June ($30.0 \text{ g m}^{-2} \text{ day}^{-1}$) and 2nd fortnight of July ($26.7 \text{ g m}^{-2} \text{ day}^{-1}$). Among pearl millet hybrids HHB 67 'Improved' ($33.0 \text{ g m}^{-2} \text{ day}^{-1}$) had highest values of CGR followed by HHB 197 ($32.2 \text{ g m}^{-2} \text{ day}^{-1}$), HHB 272 ($31.2 \text{ g m}^{-2} \text{ day}^{-1}$) and HHB 299 ($22.4 \text{ g m}^{-2} \text{ day}^{-1}$).

Between 41-60 DAS in crop season 2019, higher values of CGR were recorded with the early sown crop under 2nd fortnight of June ($45.8 \text{ g m}^{-2} \text{ day}^{-1}$) followed by 1st fortnight of July ($38.3 \text{ g m}^{-2} \text{ day}^{-1}$) and 2nd fortnight of July ($26.8 \text{ g m}^{-2} \text{ day}^{-1}$). Among pearl millet hybrids higher values of CGR were recorded with HHB 299 ($60.9 \text{ g m}^{-2} \text{ day}^{-1}$) followed by HHB 197 ($43.5 \text{ g m}^{-2} \text{ day}^{-1}$), HHB 272 ($24.4 \text{ g m}^{-2} \text{ day}^{-1}$) and HHB 67 'Improved' ($19.1 \text{ g m}^{-2} \text{ day}^{-1}$). Higher values of CGR in early sown crop might due to more dry matter in later stages of growth and similar type of findings was reported by Maurya *et al.*, 2016)

Leaf area duration (days) : The periodical changes in leaf area duration as influenced by different environments were presented in Table-2. A perusal of the data demonstrated leaf area duration increased consistently from sowing upto 60 days of crop growth and then decreased at harvest.

Between 0-20 DAS in crop season 2019, crop sown under 1st fortnight of July (13.3 days) had statistically highest values of LAD followed by 2nd fortnight of June (12.9 days) and 2nd fortnight of July (11.6 days). Among pearl millet hybrids, higher LAD values was observed in HHB 197 followed by HHB 67 'Improved', HHB 272 both were statistically at par with each other and HHB 299.

Between 21-40 DAS in crop season 2019, crop sown under 1st fortnight of July (51.7 days) had statistically highest values of LAD followed by 2nd fortnight of June (48.8 days) and 2nd fortnight of July (44.0 days). Among pearl millet hybrids HHB 197 had higher LAD values followed by HHB 67 'Improved', while HHB 299 and HHB 272 were statistically at par with each other.

Between 41-60 DAS in crop season 2019, early sown crop under 2nd fortnight of June (63.8 and 66.1 days) had highest LAD values followed by 1st fortnight of July (64.5 days) and 2nd fortnight of July (50.8 days). In crop season 2019, among pearl millet hybrids HHB 299 had higher LAD values followed by HHB 197, HHB 272 and HHB 67 'Improved'.

From 61 DAS to harvest in crop season 2019, early sown crop under 2nd fortnight of June (48.7 days) had highest LAD values followed by 1st fortnight of July (41.0 and 44.0 days) and 2nd fortnight of July (32.1 days). In crop season 2019, among pearl millet hybrids HHB 299 had higher LAD values followed by HHB 197, HHB 272 and HHB 67 'Improved'. LAD among different genotypes may be due to difference in their genetic makeup and similar results were also reported by Parihar (2005).

Conclusions

Early sown crop under 2nd fortnight of June had higher values of CGR as compared to delay sown crop and HHB 299 had the higher values of CGR as compared to other pearl millet hybrids. LAD increase upto 41-60 DAS then decrease and maximum values of LAD were recorded with the early sown crop under 2nd fortnight of June as compared to delay sown crop and HHB 299 had the higher values of LAD as compared to other pearl millet hybrids.

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Influence of Organic Manure Addition to Soil on the Behavior of Alkaline Phosphatase

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Abstract

The soil enzymatic activities play a key role in soil nutrient cycling and essential for both the mineralisation and transformation of organic matters and plant nutrients in soil ecosystem. The phosphatase enzyme is used to describe a broad group of enzymes that hydrolyse organic phosphorus compounds to inorganic polyphosphates which occur in soils, which is essential for P cycling for soils deficient in phosphorus. Under laboratory conditions, the potential impact of various organic manures on alkaline phosphatase (AP) activity was investigated. In control AP activity decreased from 0 to 15 DAT and increased thereafter. When organic manures were added, AP activity increased significantly more than in the control. The average AP activity in different amended treatments followed the order: control (362.3) < BGC (494.6) < MC (496) < FYM (609.2) < VC (640.3).

Key words : Soil enzymes, organic manures, alkaline phosphatase, mineralization.

Introduction

The sustainability of agricultural systems has emerged as a critical issue all over the world. Many sustainability issues are related to soil quality and how it changes over time (Karlen *et al.*, 1997). Soil quality and degradation are determined by a variety of physical, chemical, biological, microbiological, and biochemical properties, with the latter two being the most sensitive because they respond quickly to changes. It is well known that intensive farming has resulted in a rapid decline in organic matter and nutrient levels, as well as a change in soil physical properties. Organic management practices, on the other hand, influence agricultural sustainability by improving the physical, chemical, and biological properties of soils. A better understanding of nutrient cycling and the factors governing their decomposition in soil, on the other hand, is required for implementing sustainable management practices. Nutrient cycling in soil involves chemical, biochemical, and physicochemical reactions, with biochemical reactions catalysed by soil enzymes associated with viable microbial cells and plant roots (Kiss *et al.*, 1975). A soil's microbiological activity has a direct impact on ecosystem stability and fertility, and it is widely accepted that a high level of microbiological activity is required to maintain soil quality. Soil microbiological activity, specifically enzymatic activity, plays an important role in soil nutrient cycling; it is required for both the mineralization and transformation of organic matter and plant nutrients in soil ecosystems (Dick and Tabatabai, 1993). The phosphatase enzyme is used to describe a broad group of enzymes that hydrolyse organic phosphorus compounds to inorganic polyphosphates which occur in soils, which is essential for P cycling for soils deficient in phosphorus. It is measured as both acid

and alkaline phosphatase (AP) which is based on the differences in the pH ranges soil (pH 4-6 and 9-11). Phosphatase activity depends on soil physicochemical properties. The aim of present study was to examine the impact of various organic manures on alkaline phosphatase (AP) activity under laboratory conditions.

Materials and Methods

Soil samples : Based on preliminary data, soil (up to 15 cm depth) was collected using a soil auger from the CCS Haryana Agricultural University's Regional Research Station in Kaul, Kaithal (29°84' N latitude and 76°66' E longitude), Haryana, India. Soil was characterised for physicochemical properties using methods proposed by Sherrod *et al.*, (2002), Rayment and Lyons (2011). Clay loam with 0.64% organic carbon (w/w), pH 8.3 (water 1: 2.5), EC 0.41 dS/m, sand 26%, silt 40%, and clay 34% was described.

Organic manures : Vermi compost (VC), mushroom compost (MC), biogas compost (BGC) and farmyard manure (FYM) used as soil amendments were collected from collected from CCS Haryana Agricultural University's agricultural research farm in Hisar (29°10' N latitude and 75°46' E longitude), Haryana, India. The bioprocessed materials were air dried, grounded, passed through 4 mm mesh sieve and kept in sterilized bags. Characterization of different bioprocessed materials was done using standard methods (Gupta, 2000). Various properties are mentioned in Table-1.

Experimental plan : The experiments were conducted in 500 g capacity beakers, each having 400 g dried soil. The calculated quantity (i.e. 7.5 g/kg for FYM and 3.5 g/kg for VC, MC and BGC) of different soil amendments was added in respective treatment beakers and mixed well.

Table-1 : Average nutrient composition of various organic manures used (oven dry basis).

Organic manure	pH	OC (%)	Electrical conductivity EC (dS/m)	Available N (%)	Available P (%)	Available K (%)	C/N
VC	8.3	19.3	4.5	0.8	0.3	1.5	24.4
MC	7.7	17.5	4.7	0.8	0.4	2.4	23.3
BGC	8.4	21.1	3.3	1.7	0.7	1.7	12.3
FYM	8.3	38.1	2.9	1.2	1	1.9	31.8

Table-2 : Effect of time of incubation (days) and organic manures on AP activity, reported by two-way ANOVA.

Factors	C.D.	SE(d)	SE(m)	P-value
Days	35.74	17.825	12.604	< 0.05
Organic manure	32.63	16.272	11.506	< 0.05
Days x Organic manure	79.93	39.857	28.183	< 0.05

Amount of bioprocessed material was decided on the basis of recommended dose (i.e. 15 t/ha for FYM and 9 t/ha for VC, MC and BGC) followed in agronomical practices. The control was also prepared in similar way without addition of organic manure. Throughout the experiment, the beakers were covered with aluminium foils and kept at a constant room temperature ($25 \pm 2^\circ\text{C}$) with a relative humidity of 90%. To keep soil moisture at field capacity (1/3 bar tension), all samples, including the control, were sprayed with a calculated amount of water every 2-3 days until the experiment was completed. About 50 g of soil was collected from the appropriate treatments on 0, 7, 15, 30, 45 and 60 days after treatment (DAT).

Enzymatic activity : Alkaline phosphatase (AP) activity was determined as per the method suggested by Tabatabai and Bremner (1969). 1 g of soil was incubated with 0.2 ml toluene, 4 ml modified universal buffer (MUB, pH 11) and 1 ml of p-nitrophenyl phosphate (PNP) at 37°C for 1 hour followed by addition of 4 ml NaOH (0.5 M) and 1 ml CaCl_2 (0.5 M). Soil suspension was filtered through Whatman No. 1 and absorbance of yellow colour was measured at 420 nm.

Calculations and statistical analysis of data : AP activity was analysed by measuring the concentration of para-Nitrophenol in the test samples as :

Concentration (g) of para-Nitrophenol (PNP) in test sample = $\frac{(y - c) A}{(m) w t}$

Where, y = Absorbance on y-axis of standard curve

c = intercept of standard curve

A = Dilution factor

t = Time of incubation (hour)

w = Dry weight of soil in gram

-m = Slope from standard curve

Enzymatic activities were analysed by one-way analysis of variance (one-way ANOVA) test with the

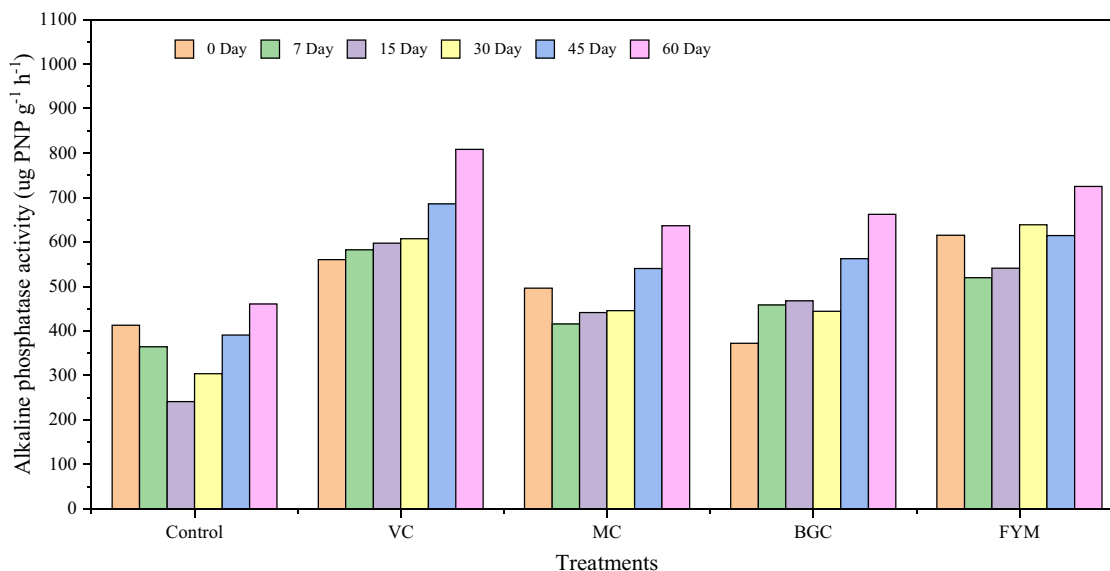
significant set at 5% probability to identify possible differences between treatments using Excel 2016 programme.

Results and Discussion

Alkaline phosphatase activity in different treatments (expressed as $\text{ig PNP g}^{-1} \text{ soil h}^{-1}$) is presented in Figure-1. In control, the activity ranged between 241 to $460.3 \text{ g PNP g}^{-1} \text{ soil h}^{-1}$. The activity decreased from 412.8 on 0 day to $241 \text{ g PNP g}^{-1} \text{ h}^{-1}$ on 15 days and increased thereafter upto 60 DAT. AP activity increased after addition of various amendments. In each type of amendment, AP activity increased gradually throughout the experimental period. The behavior of VC and BGC was found similar while MC and FYM followed a similar behavior towards AP activity and was significantly ($p < 0.05$) different from control.

In VC amended treatments, AP activity increased from 560.7 on 0 day to $808.1 \text{ g PNP g}^{-1} \text{ h}^{-1}$ on 60 DAT. In MC and FYM, slight decrease in AP activity was observed on 7 DAT followed by gradual increase upto 60 DAT. In BGC amended treatments, AP activity followed a similar trend as observed in VC amended treatments. Regardless of the type of amendments used, the average AP activity ($\text{ig PNP g}^{-1} \text{ h}^{-1}$) in different amended treatments followed the order: control (362.3) < BGC (494.6) < MC (496) < FYM (609.2) < VC (640.3). The overall effect of time of incubation and organic manures was analysed by two-way ANOVA as shown in Table-2. AP activity was significantly ($p < 0.05$) affected by time of incubation and organic manures. The inclusive effect of days x organic manures was also significant ($p < 0.05$).

When organic manures were added, AP activity increased significantly more than in the control. It could be because organic acids produced during organic matter decomposition must have lowered soil pH and resulting in increasing the enzyme activity (Reddy and Reddy, 2008). Organic manures provide C, N, and P sources for soil microorganisms, which may increase AP activity (Heidi et



al., 2011; Sriramachandrasekharan and Ravichandran, 2011). Organic manures also increase phosphorus-dissolving bacteria in the soil, which increase AP activity.

Our results corroborate with the study of who observed increased activity of phosphatase, urease and -glucosidase in soils with higher organic carbon and nutrient contents.) also reported increased enzymatic activity after sludge addition in soil.) described increased stability of soil enzymes via complexation to humic material.) also reported the increased enzymatic activity and higher capacity of soil to protect the soil enzymes in clay sized fractions after addition of organic amendments.

The higher activity in different compost amended treatments might be due to increased microbial population because of increased availability of substrate (soil nutrients) after compost addition.) also suggested that presence of carbon substrates induces and stimulates biosynthesis of the enzymes by soil micro-organisms. Also the FYM had more organic carbon content (38.1%) than BGC (21.08%), VC (19.29%) and MC (17.45%). Total nitrogen was significantly higher in BGC followed by VC, MC and FYM which created the unlike C/N ratio in all the composts. Irrespective of herbicides/metabolites and incubation time, urease activity was highest in FYM followed by VC, MC, BGC and UA soil. The higher activity in FYM may be due to comparatively higher OC content (Table-1) (Cook, 1987).

Conclusions

In control AP activity decreased from 0 to 15 DAT and increased thereafter. When organic manures were added, AP activity increased significantly more than in the control. The average AP activity in different amended treatments followed the order: control (362.3) < BGC (494.6) < MC

(496) < FYM (609.2) < VC (640.3). Organic manures provide C, N, and P sources for soil microorganisms, which may increase AP activity. The FYM had more organic carbon content (38.1%) than BGC (21.08%), VC (19.29%) and MC (17.45%). Total nitrogen was significantly higher in BGC followed by VC, MC and FYM which created the unlike C/N ratio in all the composts leading to variation in enzymatic activities.

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Diamond Back Moth, *Plutella xylostella* a Major Insect Pest of Cabbage-A Review

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Abstract

This experiment was performed on the diamond back moth, *Plutella xylostella* (Linnaeus) (Insecta: Lepidoptera: Plutellidae), their ecology and integrated management to achieve essential conclusion about the most appropriate techniques to reduce pest infestation for higher yield and productivity with as little damage to the environment as possible. Therefore, current knowledge about the diamond back moth, *Plutella xylostella* (L.) and their natural enemies on cabbage, *Brassica oleracea*, is a prerequisite for the introduction of effective and successful management tactics against them. The judicious use of new mode of action chemicals must be introduced to control this insect pest. There are many insecticides that have a different mode of action than the conventional ones. These novels insecticides in conjunction with other IPM approaches can play a key role in designing effective management strategies against diamondback moth.

Introduction

The diamond back moth is a major pest of cruciferous plants, especially *Brassica oleracea* crops such as cabbage, cauliflower, broccoli, Brussels sprouts and turnips in the world. It causes serious yield losses to cruciferous vegetables. In India, estimated annual crop losses due to this pest amounts to US\$16 million. It was first recorded in North America in 1854 the most important insect pest of cabbage is the diamond back moth recorded from more than 128 countries of the world. The major cabbage growing states in the country are Uttar Pradesh, Orissa, Bihar, West Bengal, Assam, Karnataka, Maharashtra, Madhya Pradesh and Tamil Nadu recorded this pest for the first time in India on cruciferous vegetables and a review of the literature revealed that the pest is widespread throughout India. In India, diamond back moth is of national importance on cabbage because it causes 50-80% of annual market losses yield also reported a 52% yield loss due to diamondback attack moth. The most destructive pest that causes serious damage in the production of cabbage is the bollworm diamond back moth (DBM). In other words, the insecticide market for more than three decades dominated by organophosphates, carbamates and synthetic pyrethroids, while only 1% of the global insecticide market is occupied by two bio insecticides and insecticides of plant origin. The development of resistance problems has limited the use of these synthetic insecticides. Therefore, it is desirable to develop alternative methods of pest control based on biological pesticides that are safe for both humans and the environment.

Identification of the diamond back moth : Eggs are oval, somewhat flattened, approximately 0.4 mm long, 0.2 mm wide and yellow to pale green. The eggs are hatching approximately five to six days under normal field conditions. Larvae develop in four instars and usually require from nine to 30 days to complete development. Early instars are small, colorless to yellow, and have a dark head capsule. Middle to later instars are green. Pupation occurs in a loose silk cocoon usually formed on the lower or outer leaves. The pupa is yellow to green and approximately 7 to 9 mm long. The pupal stage requires five to 15 days complete development. An adult DBM is 6 mm long, a slender, grey-brown moth with prominent antennae. The moth is marked with a broad cream or light brown stripe along its back, which is sometimes clasped to form one or more bright diamonds on the back, which is the basis for the common name of this moth. Adults can live for seven or eight weeks, but the usual lifespan is around two weeks. Single the female usually lays 18 to 356 eggs. The moth measures about 8-12 mm in length and are brown or grey, conspicuous white spots on the forewings that look like diamond patterns when the wings lie flat over the body. When fully grown, the larvae measure about 8 mm in length and are pale yellow-green with fine black hair scattered all over body.

Diamond back moth Damage symptom : Much damage is caused by the construction of tunnels in the head as in cabbage and Brussels sprouts. In addition, crop damage is usually first seen on plants growing on ridges in a cruciferous field. A heavy population of *P. xylostella* can cause more than 90% crop loss, and just a few fourth instar larvae on cabbage can make it unmarketable.

Resistance of Insecticide in diamondback moth : Over the past 50 years, *P. xylostella* has become one of the most difficult to control insects in the world. Worldwide, management of DBM is mainly with the use of insecticides reliance on this single approach led to increasingly large application doses, reduced effectiveness and eventual breakdown of regulation effectiveness. Farmers often increase dose of insecticides and applied spraying up to 25 times in the harvest season. DBM showed resistance to 91 active components of agricultural chemicals worldwide, including 12 strains of *Bacillus thuringiensis* (Bt), between 1953 and 2014 (IRAC 2005). In Punjab observed that the DBM population collected from Jalandhar were less susceptible to parathion than those found in Ludhiana. Relatively high tolerance to parathion, fenitrothion, malathion, DDT and endrin were also reported from Punjab Chawla and high degree of resistance cypermethrin, decamethrin and quinalphos have been reported Resistance has have also been reported against many groups of insecticides, e.g. organochlorines, organophosphates, carbamates, synthetic pyrethroids, Bt products Failure of new groups from insecticides see chlorantraniliprole and flubendiamide as leaf application was recently reported.

Table-1 : List of insecticides for which the DBM resistance monitored.

Alpha-cypermethrin	5.16%
Spinosad	2.50%
Fipronil	5.46%
Indoxacarb	15.00%
Abamection	2.00%
Chlorfluazuron	5.59%
Diafenthiuron	21.84%
Tebufenozide	10.64%
Chlorfenapyr	10.26%
Cartap	97.10%
Cry1Ac	3.00%

Source: Srinivasan, et al. (2011)

Integrated management of diamondback moth

Cultural Methods

Pre-season cleanup : Remove all plant debris and weeds from the greenhouse. Many pests are also found on other crops or broadleaf weeds. For this reason it is important to avoid further cultivation of other crops into the greenhouse and to prevent the strong growth of deciduous leaves weeds around the outer edges of the greenhouse.

Use of fertilizer : Fertilization schedules based on balanced nutrient use should be followed. Nitrogen should only be applied as needed for optimal growth. Regular demanding applications are set up excesses of nitrogen, which cause excessive growth, which favors population growth of aphids and other pests. Application it has been found that potassium in the required levels reduces occurrence of insect pests.

Pinching and Pruning : Cutting off damaged parts of plants, flowers and spotted leaves can be very an effective way to limit the spread of pests in greenhouse. Plant debris should be disposed of immediately before disposal in a closed container. This practice can help reduce the population of all pests targeted pests.

Trap crop : For early detection and capture of target pests, some of beneficial hosts of target pests may be used. Planting crop calendula as a trap crop stop to increase population diamondback moth. Rainfall has been identified as a major factor in mortality young larvae, so it is not surprising that cruciferous crops with overhead sprinklers tend to have fewer diamondbacks moth larvae than drip or furrow irrigated crops. Tomato, when intercropped with cabbage, it has been reported to inhibitor reduce DBM egg laying. Reduction in egg laying and subsequent development of the pest was essentially due to emissions of volatile compounds.

Genetic control of the diamondback moth : Strategies for the development of varietal resistance in cruciferous plants against DBM have not yet been fully exploited. Modifications biochemical and morphological characteristics of plants was also unsuccessful. So despite its potential as alternative non-chemical DBM control method, resistant the development of varieties is still a great challenge for biochemists and plant breeders in SA. We found no research identifying chemical compounds or genes that are essential manipulate and make brassicas completely non-preferred hosts for DBM.

Botanical insecticide for the diamondback moth : *A. sativum*, *A. indica* and *M. balsamina* extracts significantly reduced population of *P. xylostella*, leaf and head damage cabbage in increasing plant height and yield who stated that *Zingiber officinales*, *Piper retrofractum*, *Allium sativum*, *Solanum spp.*, *Citrus sinensis* peels and turmeric rhizomes were more effective against *P. xylostella* than synthetic insecticides.

Chemicals for the diamondback moth : The LC₅₀ value of dichlorvos 76 EC (15.63, 31.82 and 22.51 g a.i. ml⁻¹) and lowest LC₅₀ Bengaluru, Kolar and Chikkaballapura population recorded for emamectin benzoate 5 SG (3.13 g a.i. ml⁻¹), cyantraniliprole 10.26 OD (4.48 g a.i. ml⁻¹) and Spinosad 45 SC (2.48 g a.i. ml⁻¹) was found to be highly toxic to third instar larvae. The activities of the different compounds varied depending on the presence of different substituents on different position of both aromatic rings A and B. Between test compounds, 8, N-(3-bromo-4-methoxyphenethyl) cinnamamide showed the best larvicidal activity with LC₅₀ = 62.13 mg/l followed by 6, N-(3 x-bromophenethyl) cinnamamide (LC₅₀=128.49 mg/l) and 2 N-(4 -methoxyphenylethyl) cinnamamide (LC₅₀ = 225.65 mg/l). Pyridalyl was least effective against

P. xylostella on cabbage. Fenvalerate showed higher efficacy against *P. xylostella* reducing the pest population. Average population of *P. xylostella* after two sprays, the fenvalerate was found to be 0.004%. effective and better. Spinosad was found to be the most effective reduction to 94.33 percent of the population and subsequently indoxacarb (91.00%) and Flubendiamide (78.66%). The insecticides, e.g. fipronil, emamec benzoate and chlorantraniliprole was found to be moderately effective led to a reduction of 70.66, 70.33 and 68.66 percent, in that order and chlorfenapyr, pyridalyl and acephate proved least effective reduced to 55.33, 56.66 and 56.00 percent, respectively. Rynaxypyr was most effective in reducing larval population (96.41%) closely followed flubendiamide (94.86%) and spinetoram (92.62%). The combination of novaluron and indoxacarb also gave good results reduction of larval population (92.04%). Bio-pesticides *Bacillus thuringiensis* var *kurstaki* and *Beauveria bassiana* gave 55.82% and 32.24% reduction in DBM larvae respectively.

Conclusions

In addition, pollution concerns are growing the environment and its resulting effects on health humans and animals resulting from the continued use of these substances pesticides. Although the agro-climatic conditions Uttar Pradesh is very favorable for successful cultivation cabbage, this has not yet manifested itself mainly in a higher yield due to the attack of insect pests, especially the diamondback moth. Although the pest is increasingly becoming a threat caused great economic loss, little work was done and the information currently available is very meager little relevance. Reasons for optimism that more effective and sustainable DBM management is achievable over a longer period of time and there are solutions :

- Dynamics of crop colonization and source identity
- DBM populations and key natural enemies
- Weather based predictive DBM model
- Plant resistance
- More selective insecticides with different modes of action
- Improved spray application technology

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Overview of Life Cycle, Losses and Integrated Management Strategy of Melon Fruit Fly on Bitter Gourd

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Abstract

Bitter gourd (*Momordica charantia*) is the emerging commercial vegetable crop and is very well known for its medicinal properties. The melon fruit fly, *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae) is prominent insect pest in bitter gourd. The fly females oviposit their egg inside the fruit, after emerging of maggots instantly begins to excavate and feed the fruit. Due to the voracious feeding of maggots, fruit starts to decay and emits bad odor. Oviposition puncture of female flies also damage the fruit quality in market. The yield losses tend to vary between 30 to 100%, depending on the cucurbit species and the season. *Bactrocera cucurbitae* can be managed or suppressed in the fields, by local area and wide area management programmes. Regional area management programme, which aims at suppressing, rather than eradicating the *Bactrocera cucurbitae*, involves the integration of various management tactics, including, bagging fruits, application of field sanitation measures, installation of protein baits and cue lure traps, growing fruit fly resistant genotypes, augmentation of bio-control agents and cover spray of soft insecticides

Introduction

Cucurbits, belongs to family Cucurbitaceae, which mostly possess trailing habit, are the vegetable crops which are primarily consumed as food worldwide. They constitute the largest group of the summer vegetables. Cucurbits are rich in iron, vitamins, proteins and minerals. They are known for numerous medicinal properties as bitter gourd juice being used to cure diabetes; bottle gourd fruit juice has high blood pressure and heart valve blockage ameliorating properties. Cucurbit seeds are valued for their high oil and protein contents comparable to that of legumes and are richer in methionine, a crystalline amino acid containing sulphur and essential for nutrition. Fruit fly (*Bactrocera cucurbitae*) is the most destructive pests of cucurbits causing direct yield loss. In India, because of the polyphagous nature of their larvae, fruit flies are considered as one of the ten most serious insect pests of the entire agriculture. Out Of 207 species of fruit flies found in India, nine are identified to be the major and economically important. The melon fruit fly has more than 80 hosts plants and their economic importance cannot be evaluated entirely from standpoint of the direct damage to the various crops attached. Its abundance increases when the temperature falls below 32 °C and the relative humidity ranges from 60% to 70% (Dhillon *et al.*, 2005 and Sapkota *et al.*, 2010).

Life cycle of fruit fly : The melon fruit fly remains active in a variety of hosts throughout the year. During the severe winter months, they hide and huddle together under dried

leaves of bushes and trees. During harsh winters, they hide and huddle under the dry leaves of bushes and trees. During the hot and dry seasons, the flies take refuge in moist, shady places and feed on the honeydew of aphids that live on fruit trees. The lower and upper developmental thresholds for eggs were 11.4 and 36.4° C (Messenger and Flitters, 1958). This species actively breeds when the temperature falls below 32.2° C and the relative humidity ranges between 60 to 70%. Fukai (1938) reported that adults survived for one year at room temperature when fed fruit juice. In general, its life cycle lasts from 21 to 179 days (Fukai, 1938; Narayanan and Batra, 1960). At 29°C in the Solomon Islands, it takes 13 days for an egg to become an adult. (Hollingsworth *et al.*, 1997).

High temperatures, long hours of sunshine, and plantation activity affect the abundance of *B. cucurbitae* in northeastern Taiwan (Lee *et al.*, 1992). Bhatia and Mahto (1969) reported that the life cycle is completed in 36.3, 23.6, 11.2 and 12.5 days at 15, 20, 27.5 and 30 °C, respectively. Eight to ten generations occur per year (White and Elson-Harris, 1994; Weems and Heppner, 2001). Egg incubation time for pumpkin, bitter gourd, and squash gourd has recorded 4.0–4.2 days at 27 ± 1 °C (Doharey, 1983); 1.1 to 1.8 days on bitter gourd, cucumber and sponge gourd (Gupta and Verma, 1995); 1.0 to 5.1 days on bitter gourd (Koul and Bhagat, 1994; Hollingsworth *et al.*, 1997). The larval period lasts for 3 to 21 days (Renjhan, 1949; Narayanan and Batra, 1960; Hollingsworth 1997), depending on temperature and the

host. Larval duration varies from 3 to 6 days in different cucurbit species (Chawla, 1966; Chelliah, 1970; Doharey, 1983; Koul and Bhagat, 1994; Gupta and Verma, 1995). Egg viability and larval and pupal viability in cucumber were reported to be 91.7, 86.3 and 81.4%, respectively. In pumpkin, these were 85.4, 80.9, and 73.0%, respectively, at $27 \pm 1^\circ\text{C}$ (Samalo *et al.*, 1991). Adult larvae emerge from the fruit by burrowing one or two exit holes in the ground for pupation. The larvae pupate in the soil at a depth of 0.5-15 cm. The depth to which larvae migrate to pupate and survive in the soil depends on soil conditions and moisture (Jackson *et al.*, 1998; Pandey and Misra, 1999). Doharey (1983) observed a pupal period of 7 days in bitter melon and 7.2 days in pumpkin and squash melon at $27 \pm 1^\circ\text{C}$. The pupation period generally lasts 6 to 9 days in the rainy season and 15 days during winter (Narayanan and Batra, 1960). Depending on the temperature and the host, pupation time can vary from 7 to 13 days (Hollingsworth *et al.*, 1997). On different hosts, the pupation period ranges from 7.7 to 9.4 days for bitter melon, cucumber and sponge melon (Gupta and Verma, 1995) and 6.5 to 21.8 days for bottle melon (Koul and Bhagat, 1994; Khan *et al.*, 1993).

Loss caused by fruit flies in different cucurbit crops :

Global and India yield loss typically ranges between 30 to 100% depending on cucurbit species and season. Fruit attack by melon fruit fly in bitter melon ranges from 41 to 89% (Lall; Kushwaha *et al.*, 1973; Gupta and Verma 1978 ;). Dhillion *et al.*, (2005) reported 33% damage on bitter melon and 29% on watermelon in India. Hollingsworth *et al.*, (1997) reported that the melon fruit fly attacked 95 percent of bitter melon fruits in Papua New Guinea.

Strategies for integrated management of melon fruit fly :

The fruits of cucurbits, of which the melon fly is a serious pest, are collected at short intervals for marketing and self-consumption. Therefore, it is difficult to rely on insecticides as a means of controlling this pest. In situations where chemical control of melon fruit fly is necessary, soft insecticides with low residual toxicity and short withdrawal periods must be relied upon. Therefore, considering pest and crop importance, melon fruit fly can be managed by local or large-scale management.

Local area management : Local area management means the minimum extent of pest control in a limited area such as field level/crop level/village level which has no natural protection against reinvasion. The goal of local management is to suppress the pest rather than eradicate it. Under this management option, a number of methods such as fruit bagging, field sanitation, protein baits and baited traps, host plant resistance, biological control and soft insecticides can be used to maintain pest populations

below economic thresholds in a particular crop for a period of time to it prevented crop losses without endangering health and the environment, which is the immediate concern of farmers.

Bagging of fruit : Bagging fruit on the tree (3 to 4 cm long) with 2 layers of paper bags at 2 to 3 day intervals minimizes fruit fly infestation and increases net yields by 40 to 58% (Fang, 1989a, b; Jaiswal *et al.*, 1997). Akhtaruzzaman *et al.* (2000) suggested that cucumber fruits should be bagged 3 days after anthesis and the bags should be kept for 5 days for effective control. This is an environmentally safe way of controlling this pest.

Field sanitation : The most effective method in melon fruit fly management is the primary component – field sanitation. To break the reproductive cycle and increase the population, growers must remove any unharvested fruit or vegetable from the field by completely burying it deep into the soil. Burying damaged fruit 0.46 m deep into the soil prevents adult fly eclosion and reduces population growth (Klungness *et al.*, 2005).

Monitoring and control with parapheromone lures/cue-lure traps :

The principle of this particular technique is to deny the resources needed for laying female flies, such as protein food (protein bait control) or parapheromone baits, which eliminate males. There is a positive correlation between baited trap catches and weather conditions such as minimum temperature, precipitation and minimum humidity. The sex attractant cue-lure traps are more effective than the food attractant tephritid traps for monitoring the *B. cucurbitae* in bitter melon. Methyleugenol and baited traps have been reported to attract male *B. cucurbitae* from mid-July to mid-November (Ramsamy *et al.*, 1987; Zaman, 1995; Liu and Lin, 1993). *Ocimum sanctum* leaf extract containing eugenol (53.4%), beta-caryophyllene (31.7%) and beta-elemene (6.2%) as major volatiles when placed on cotton pads (0.3 mg) attract flies from a distance of 0.8 km (Roomiet *et al.*, 1993). So, melon whitefly can also be controlled by using *O. sanctum* as a border crop sprayed with a protein bait (protein obtained from corn, wheat or other sources) containing spinosad as a toxicant. A range of commercially produced attractants (Flycide® with 85% cue-lure content; Eugelure® 20%; Eugelure® 8%; Cue-lure® 85% + naled; Cue-lure® 85% + diazinon; Cue-lure® 95% + naled) are commercially available and proven effective in controlling this pest (Iwaizumi *et al.*, 1991). Chowdhury *et al.* (1993) caught 2.36 to 4.57 flies/trap/day in poison baits containing trichlorfon in bitter melon. The use of male bait cearlure B1® (Ethylcis-5-Iodo-trans-2-methylcyclohexane-1-carboxylate) was found to be 4-9 times more effective than trimedlure® for attracting male medfly, *Ceratitidis capitata* (Mau *et al.*, 2003b), and thus could be tried for male

annihilation strategies of area-wide melon fruit fly control programs. A new protein bait, GF-120 Fruit Fly Bait® containing spinosad as a toxicant, has been found to be effective in area management of the melon fruit fly in Hawaii (Prokopy *et al.*, 2003, 2004). GF-120 Fruit Fly Bait® would be highly effective when applied to sorghum plants surrounding cucumbers against protein-hungry melon flies, but would be less effective in preventing protein-fed females from landing on cucumbers. Corn can also be used as a marginal crop to attract melon fruit flies by applying protein bait. Although protein baits, parapheromone baits, lures, and baited traps have been successful in monitoring and controlling the melon fruit fly, immigration of protein-satiated females is a risk. In principle, the risk of immigration of already satiated females could be managed by increasing the distance these satiated immigrants have to travel (Stonehouse *et al.*, 2004).

Chemical Control : Chemical control of the melon fruit fly is relatively ineffective. However, insecticides such as malathion, dichlorvos, phosphamidon and endosulfan are moderately effective against melon fly (Agarwal *et al.*, 1987). Bhatnagar and Yadava (1992) reported malathion (0.5%) to be more effective than carbaryl (0.2%) and quinalphos (0.2%) on bottle gourd, sponge gourd and ridge gourd. Application of molasses + malathion (Limthion 50 EC) and water at a ratio of 1:0.1:100 provides good control of melon fly (Akhtaruzzaman *et al.*, 2000). Application of either 0.05% fenthion or 0.1% carbaryl at 50% male flower emergence and again 3 days after fertilization helps reduce damage to melons (Srinivasan, 1991). Gupta and Verma (1982) reported that fenitrothion (0.025%) combined with protein hydrolyzate (0.25%) reduced fruit fly damage to 8.7% compared to 43.3% damage in the untreated control. Application of carbofuran granules at 1.5 kg a.i./ha at seeding, vine and flowering time provided 83.35% protection of bitter melon against *B. cucurbitae* (Thomas and Jacob, 1990). Formathion is more effective than trichlorfon (Talpur *et al.*, 1994). Diflubenzuron has also been reported to be effective in controlling melon fly (Mishra and Singh, 1999). The highest yield and lowest damage were observed in pumpkin when treated with carbofuran at 1.5 kg a.i./ha 15 days after germination (Borah, 1998). Acorus calamus extract (0.15%) reduced the lifespan of adults from 119.2 days to 26.6 days when fed continuously with sugar mixed with the extract (at a concentration of 1 ml/g sugar) (Nair and Thomas, 1999). Neem oil (1.2%) and neem cake (4.0%) were also reported to be as effective as dichlorvos (0.2%) (Ranganath *et al.*, 1997).

Conclusions

Considering the pest's and crop's importance, the melon fruit fly can be managed or suppressed locally at growers'

fields using any of the available option combinations, such as fruit bagging, field sanitation, cue-lure traps, spray of toxicant-laced protein baits, growing fruit fly-resistant genotypes, augmentative releases of biological control agents, and soft insecticides. In addition to the available local area management options, the incorporation of a number of different techniques, such as the sterile insect technique, transgene-based embryo-specific lethality system, and quarantine, could be used to achieve better results in melon fruit fly wide area management. Local area management focuses on suppression rather than eradication. Wide-area management is used to coordinate and combine activities.

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Biochemical Characterization of Resistant and Susceptible Genotypes of Pigeonpea (*Cajanus cajan* L.) Against *Fusarium* Wilt

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Abstract

Pigeonpea (*Cajanus cajan*) is an important legume crop widely used as food grain as it is rich source of protein, carbohydrate, essential amino acids, minerals and fibres. *Fusarium udum* is considered as the most important fungal pathogen causing considerable economic loss in India and all over the world. Biochemical changes were studied in *Fusarium* wilt resistant (ICP-8863, BDN-1 and BDN-2) and susceptible (ICP-2376 and BAHAR) genotypes of pigeonpea after 7 days of infection. The average percent decrease in total soluble sugar content of the resistant genotypes and the susceptible genotypes was found to be 10.29 % & 27.56 % respectively. The average percent increase in protein content of the resistant genotypes and the percent decrease in susceptible genotypes was found to be 14.43 % & 6.74 % respectively. Among all the genotypes, maximum increase in percentage protein content was recorded in the wilt resistant genotype BDN-2 with 22.01 % over healthy and maximum decrease was observed in wilt susceptible genotype BAHAR with 18.21 % over healthy. The average percent increase in total phenol content of the wilt resistant and the susceptible genotypes was found to be 22.02 % & 4.79 % respectively. The average percent increase in flavonoids content of resistant genotypes over healthy was found to be 29.89 % whereas, the average percent decrease in the susceptible genotypes over healthy was recorded as 2.27 %. The higher level of metabolites wilt resistant genotypes is clearly revealing their direct or indirect function in plant defence response to *fusarium udum*.

Key words : *Fusarium udum*, wilt, pigeonpea, resistant, total soluble sugar, total protein, total phenol, flavonoid.

Introduction

Pulses are the chief source of protein, so also known as "Protein tablets", especially in the third world countries, which include India also. Among different pulse crops, pigeonpea (*Cajanus cajan* L), commonly known as red gram, tur, arhar etc., is the fifth prominent pulse crop in the world and second most important pulse crop after chickpea in India. Pigeonpea is extensively used as food grain due to its high value of protein, carbohydrates, essential amino acids and certain minerals (1). There are several constraints to pigeonpea production. The lower productivity of pigeonpea in India is due to different biotic and abiotic stress (2). *Fusarium* wilt caused by *fusarium udum* is considered as the most important soil borne pathogen (3). The pathogen can survive in soil under wilted plant stubble over a long period. It was detected up to 2.5 years in vertisols and up to 3 years in alfisols (4). Infection to pigeonpea plant was reported as early as 18 days after sowing under high inoculums and optimum disease condition (5). The aggressiveness of *fusarium udum* is observed mostly in the wilt susceptible genotypes (6). The fungus enters at root tips through wounds or invasion by nematodes and enters the host vascular system leading to progressive chlorosis of leaves, wilting of branches and finally collapse of the root system (7). A number of defence mechanisms against attack of

pathogens have been gradually developed by plants. Plants produce several toxic substances against pathogen or they create an environment that inhibits growth of pathogen in plant. *Fusarium* wilt resistant cultivars produce phenolic acids, pathogen related (PR) proteins, sugars and phytoalexins. One of the most common metabolic stress responses in plants is the activation of the phenylpropanoid pathway. Sugars are precursor molecule for synthesis simple and complex forms of phenols, phytoalexins and lignin. The amount of phenolic content and degree of plant disease resistance frequently show a positive correlation. Only the leaves of pigeonpea have been found to possess flavones, which is probably related to their function as antifungal compound. The aim of the present study was to estimate biochemical metabolites viz, total soluble sugars, total protein, total phenol and flavonoids contents in wilt resistant and susceptible genotypes of pigeonpea during – *fusarium udum* interaction.

Materials and Methods

Infection of *fusarium udum* on pigeonpea genotypes by root dip method : The experimental material for the present study comprised of five genotypes including three resistant checks (ICP-8863, BDN-1 and BDN-2) and two susceptible checks (ICP-2376 and BAHAR). The seeds of pigeonpea genotypes were sown in sterilized soil filled in

plastic bags. The fungal isolate were grown on sterilized potato dextrose agar media by incubating for 7 days at $27 \pm 2^\circ\text{C}$. The inoculum concentration was adjusted by microscopic enumeration with a cell-counting hemacytometer (Neubauer chamber). The spore suspension was diluted with tween-20 solution to obtain the desired inoculum concentration 1×10^6 spores per millilitre (8). Fifteen days old seedlings were removed carefully and dipped in spore suspension at 1×10^6 spores per millilitre concentration for 20 minutes (8).

Biochemical analysis : Infected and non-infected leaves and roots were washed with sterilized distilled water and analyzed in triplicate for biochemical estimation.

Biochemical analysis were carried out after seven days of infection from leaves of healthy and infected pigeonpea genotype. Total soluble sugar in 70% ethanol extract was estimated according to the Anthrone reagent method of Yoshida and co-workers, (1997). Leaves extract prepared in phosphate buffer (pH 7.0) was used for estimation of soluble proteins by Lowry and co-workers, (1951). 0.5 g leaf sample was grinded in 5 ml of 80% methanol were further used for the estimation of total phenols and flavonoid. The total phenolic contents was estimated by using the Folin-Ciocalteu (FC) method (1927) with gallic acid reference standard. Total flavonoid content of extract was measured by aluminium chloride colorimetric method was modified from the method reported by Chang and co-workers (2002) with quercetin reference standard.

Results and Discussion

Biochemical constituents :

The total soluble sugar content : The total soluble sugar content in healthy and infected leaves of pigeonpea plants (Figure-1) was quantified seven days after infection (DAI). It was observed that the total soluble sugar content decreased more in infected plants over healthy (Table-1).

The average total soluble sugar content in healthy and infected genotypes was found to be 3.23 and 2.70 mg/g leaf fresh weight respectively. A decrease in total soluble sugars was observed when *F. udum* was inoculated at 7 DAI in all the genotypes. Maximum decrease in total sugars was recorded in the wilt susceptible genotype BAHAR with 35.75 % decrease over healthy and then by the wilt resistance holding genotype BDN-1 with 17.29 % decrease over healthy followed by the wilt resistance genotype ICP-8863 and BDN-2 with 7.85 and 5.72 % decrease over healthy respectively. The average percent decrease in total soluble sugar content of the resistant genotypes and the susceptible genotypes was found to be 10.29 % & 27.56 % respectively (Figure-2). The fold decrease in resistant genotypes was found to be 1.24 as compared to

susceptible genotypes. The content of sugar in certain plants has been linked to the disease response. In general, it is believed that the host plant's high amounts of total sugars are responsible for disease resistant.

Similar observations recorded by Swami *et al.* (2015) showed total sugar content of resistant genotype ICP-8863 was 2.87 mg/g in non-infected and 2.85 mg/g in infected with the *fusarium udum* and concluded that these may be attributed due to utilization of sugar by the pathogen for its growth. The positive association of sugar and phenol with resistant may prove useful for identification of resistant genotypes. Infection by some pathogens bring changes in respiratory pathway and photosynthesis which are the vital processes taking place inside the plant leading to wide fluctuations in sugars (14, 15, 16). High sugar levels inhibit the induction of cell wall degrading enzymes in some host-parasite interactions (17). Lower levels of sugars in resistant plant in present results might permit increased concentration of cell wall degrading enzymes after pathogen infection.

Protein content : The average protein content of healthy and infected plants (Figure-1) were found to be 28.70 mg/g and 30.10 mg/g fresh leaf weight respectively (Table-2). The decrease in protein content in the susceptible genotypes was recorded as compared to the resistant genotypes. The average percent increase in protein content of resistant genotypes over healthy was found to be 14.43 % whereas, the average percent decrease in the susceptible genotypes over healthy was recorded as 6.74 %. The protein content was found to be increased by 1.23 fold in resistant genotypes when compared to susceptible genotypes. Among all the genotypes, maximum increase in percentage protein content was recorded in the wilt resistant genotype BDN-2 with 22.01 % over healthy and maximum decrease was observed in wilt susceptible genotype BAHAR with 18.21 % over healthy (Figure-3).

Similar findings were observed in *Fusarium* wilt resistant genotype ICPL-87119 and susceptible genotype T 1515, the recorded protein content was 40.667 mg/g fresh wt. and 25.782 mg/g fresh wt. respectively, after the infection by Mary and Subramanian (2014). Changes in protein occur when pathogen penetrates the host resulting in disturbances in protein and related metabolisms (19). The significant increase in the protein content as a result of pathogen infection may be due to some activities related to a hypersensitive response (14).

Total phenol content : The average total phenol content of healthy and infected pigeonpea genotypes were found to be 6.02 mg GAE/g and 6.87 mg GAE/g fresh leaf weight respectively (Table-3). The average percent increase in total phenol content of the wilt resistant and the susceptible genotypes was found to be 22.02 % and 4.79 % respectively. There was an increase of 1.16 fold in total

Table-1 : Total soluble sugar content (mg g⁻¹ fresh wt.) in healthy and *Fusarium* wilt infected pigeonpea genotypes.

Sr. No.	Genotype	Control	Infected
Resistant			
1.	ICP-8863	3.82± 0.21 ^a	3.52 ± 0.14 ^a
2.	BDN-1	3.47 ± 0.21 ^b	2.87 ± 0.03 ^b
3.	BDN-2	3.67 ± 0.04 ^{ab}	3.46 ± 0.04 ^a
Susceptible			
4.	ICP-2376	3.10 ± 0.12 ^b	2.50 ± 0.12 ^c
5.	BAHAR	2.07± 0.10 ^c	1.33 ± 0.04 ^d
	Average	3.23	2.70
	S.Em	0.13	0.03
	CD	0.3	0.08
	CV%	7.23	3.16

*Mean values followed by different letters within the same column are significantly different (p<0.05) (n=3).

Table-2 : Protein content (mg g⁻¹ fresh wt.) in healthy and *Fusarium* wilt infected pigeonpea genotypes.

Sr. No.	Genotype	Control	Infected
Resistant			
1.	ICP-8863	31.37 ± 0.50 ^a	35.91 ± 3.21 ^a
2.	BDN-1	33.63 ± 0.68 ^a	35.92 ± 3.53 ^a
3.	BDN-2	21.72 ± 0.85 ^b	26.50b ± 1.57 ^b
Susceptible			
4.	ICP-2376	25.09 ± 5.55 ^b	26.28 ± 0.56 ^b
5.	BAHAR	31.68 ± 0.59 ^a	25.91 ± 0.62 ^b
	Average	28.70	30.10
	S.Em	2.08	1.71
	CD	4.64	3.80
	CV%	8.89	6.98

*Mean values followed by different letters within the same column are significantly different (p<0.05) (n=3)

phenol content in resistant genotypes as compared to susceptible genotypes. The resistant genotype BDN-1 had recorded highest increase in percentage total phenol content with 35.86 % over healthy and highest decrease in total phenol content was observed in wilt susceptible genotype ICP-2376 with 5.43 % over healthy (Figure-4). It was observed that total phenol content increased more in resistant genotypes as compared to susceptible genotypes.

The marked increased in phenol might be due to accumulation of phenolic from surrounding healthy tissue (14, 20). Rathi *et al.*(1986) also reported higher total phenol content in leaves of resistant varieties than leaves of susceptible varieties. The accumulation of phenolic compounds in infected host tissues may be related to their release from glycosidic esters by the enzymatic activity of host or pathogen (22). Enhanced synthesis by host through the shikimic acid pathway or due to migration of phenolics from non-infected tissue (23).

Flavonoid content : Average flavonoid content in healthy and infected genotypes were recorded as 3.35 mg QE/g and 3.91 mg QE/g respectively (Table-4). The flavonoids content showed a decrease in the susceptible genotypes compared to the resistant genotypes. The average

percent increase in flavonoids content of resistant genotypes over healthy was found to be 29.89 % whereas, the average percent decrease in the susceptible genotypes over healthy was recorded as 2.27 %. The fold increase in flavonoid content of resistant genotypes over susceptible genotypes was 1.33. Among all the genotypes, maximum increase in percentage flavonoid content was recorded in the wilt resistant genotype ICP-8863 with 54.18 % over healthy and maximum decrease was observed in wilt susceptible genotype ICP-2376 with 6.09 % (Figure-5).

Marley and Hillocks (1994) showed that the underlying mechanism of resistance *Fusarium* wilt in pigeonpea cultivar ICP 9145 was the ability for rapid accumulation of the isoflavonoid, phytoalexin, of which cajanol is the main antifungal compound and phytoalexins indicates the possible role in wilt resistance. Isoflavonoids can be toxic to fungal pathogens, *i.e.*, reduce the development of fungi by inhibiting the growth of their mycelia, spore germination, while they also limit fungal pathogenicity (25, 26). Thus, it can be concluded that results of present investigation are in consistent with the findings of previous researchers.

Table-3 : Total phenol content (mg GAE/gfresh wt.) in healthy and *Fusarium* wilt infected pigeonpea genotypes.

Sr. No.	Genotype	Control	Infected
Resistant			
1.	ICP-8863	5.54 ± 0.28 ^c	6.68 ± 0.13 ^b
2.	BDN-1	6.72 ± 0.03 ^a	9.13 ± 0.10 ^a
3.	BDN-2	5.30 ± 0.30 ^c	5.81 ± 0.06 ^c
Susceptible			
4.	ICP-2376	6.44 ± 0.07 ^{ab}	6.09 ± 0.29 ^c
5.	BAHAR	5.92 ± 0.19 ^b	6.81 ± 0.01 ^b
	Average	6.02	6.87
	S.Em	0.19	0.12
	CD	0.42	0.27
	CV%	2.90	2.22

*Mean values followed by different letters within the same column are significantly different ($p < 0.05$) ($n=3$)

Table-4 : Total flavonoid content (mg QE/gfresh wt.) in healthy and *Fusarium* wilt infected pigeonpea genotypes.

Sr. No.	Genotype	Control	Infected
Resistant			
1.	ICP-8863	3.23 ± 0.03 ^c	4.98 ± 0.66 ^a
2.	BDN-1	3.82 ± 0.06 ^a	4.51 ± 0.20 ^a
3.	BDN-2	3.04 ± 0.11 ^d	3.57 ± 0.06 ^b
Susceptible			
4.	ICP-2376	3.45 ± 0.12 ^b	3.24 ± 0.10 ^b
5.	BAHAR	3.23 ± 0.10 ^c	3.28 ± 0.09 ^b
	Average	3.35	3.91
	S.Em	0.08	0.25
	CD	0.18	0.56
	CV%	2.74	8.04

*Mean values followed by different letters within the same column are significantly different ($p < 0.05$) ($n=3$)



Figure-2 : Effect of *Fusarium* wilt disease on pigeonpea resistant and susceptible genotypes plants (C) control and (T) Treated.

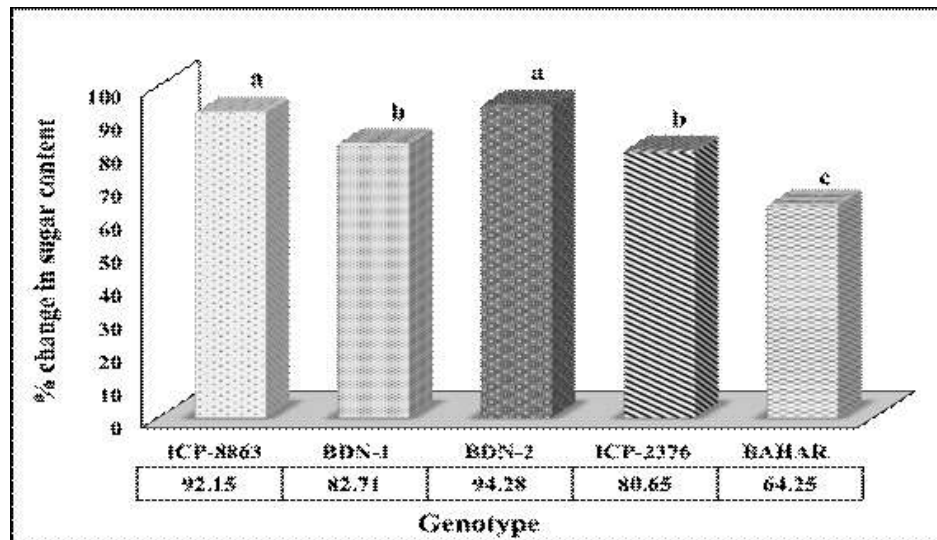


Figure-3 : Percentage change in total soluble sugar content of infected pigeonpea genotypes.

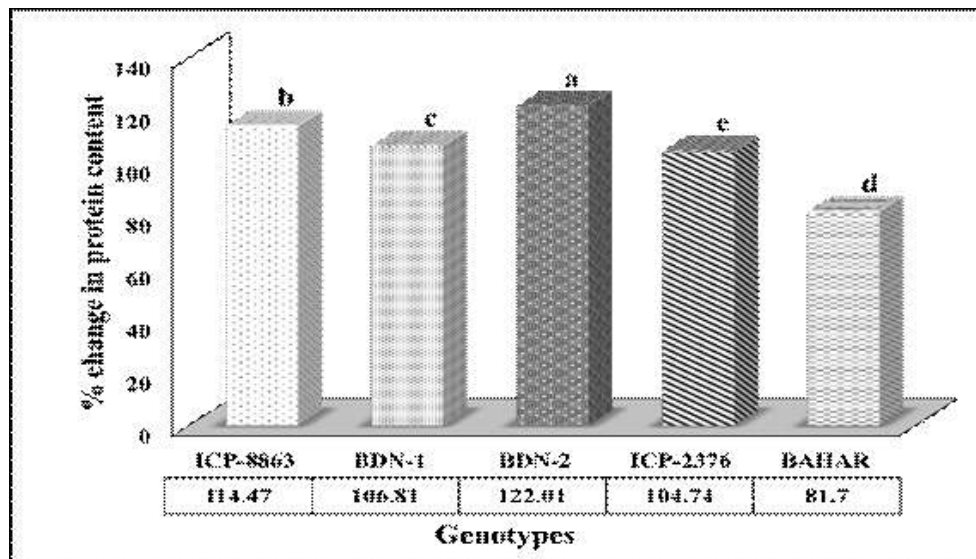


Figure-4 : Percentage change in protein content of infected pigeonpea genotypes.

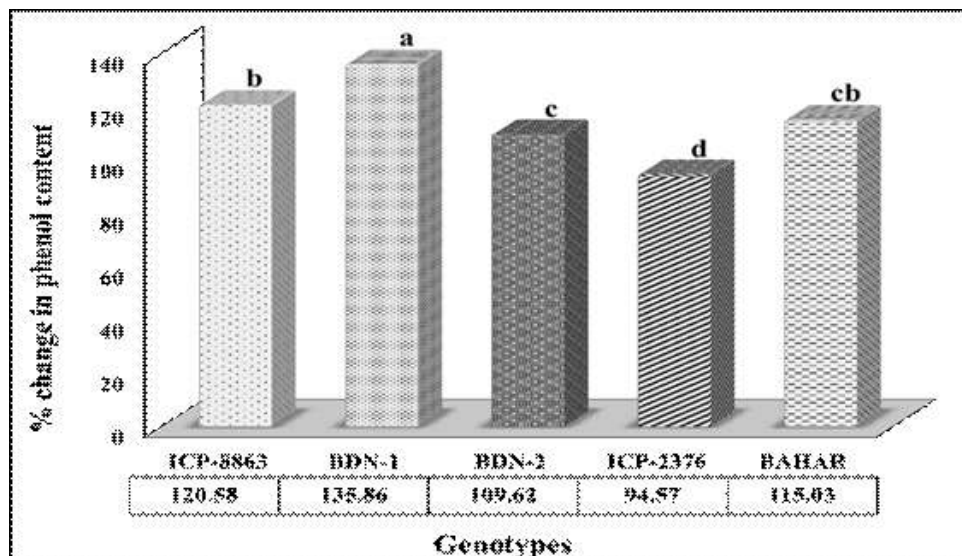


Figure-5 : Percentage change in total phenol content of infected pigeonpea genotypes.

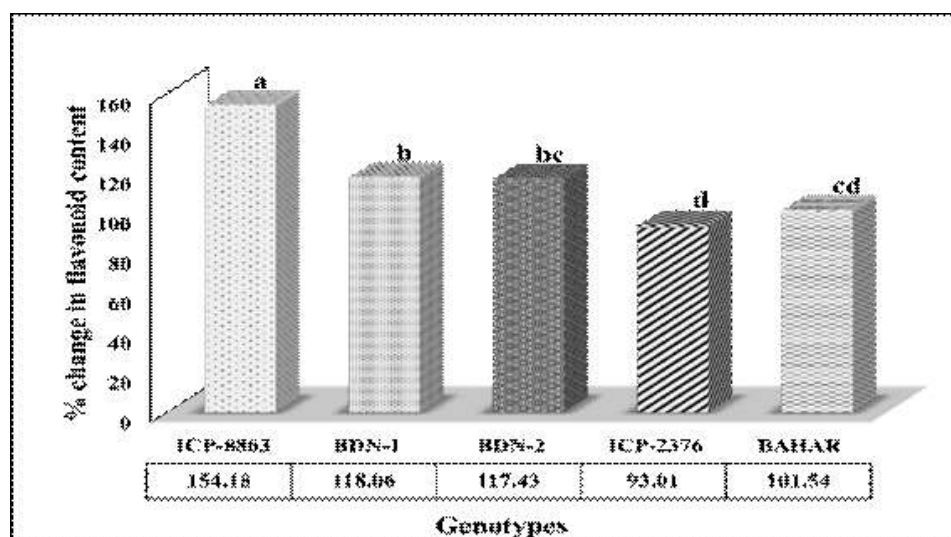


Figure-6 : Percentage change in total flavonoid content of infected pigeonpea genotypes.

Conclusions

Overall, it could be concluded that the wilt resistant genotypes of pigeonpea exerted higher defence mechanism by producing higher amount of biochemicals *i.e.*, total soluble sugar, total protein, total phenols, flavonoids, than wilt susceptible genotypes. Among all the resistant genotype, BDN-1 shows highest resistance against *Fusarium* wilt disease. ICP-2376 and BAHAR shows similar susceptibility towards the *fusarium udum*. The results clearly indicate that the natural resistance of plants to diseases is based not only on the preformed biochemicals, but also on induced mechanisms as evidenced from present study. The higher level of metabolites in wilt resistant genotypes is clearly revealing their direct or indirect function in plant defence response to *fusarium udum*. Therefore, it is important to study molecular mechanisms of resistance in relation to the current study which further, provide information for better understanding of *fusarium udum* and their reaction to crop and therefore may help in management of wilt disease.

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Studies on the Most Remunerative Method and Weed Control in Kharif

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Abstract

An Experiment was laidout during *Kharif* season of 2014, to evaluate most remunerative method of weed control with an objective to improve farm productivity and efficiency. This paper discusses the Comparative study of weed management practices at Kanpur, Central Uttar Pradesh. To fulfilling all requirements related this field experiment, on paddy crop was observed during season's *skharif*, 2014-2015. The treatment effects were evaluated in terms of growth, yield attributes and yield. This study revealed that highest plant population (159.45 ha^{-1}) was found under unweeded or control and the lowest (153.66 ha^{-1}) was found bispyribac 25 g ha^{-1} treated plots. The maximum plant population obtained under Sesbania + Bispyribac 25g ai ha^{-1} ($360.69/\text{m}^2$) but lower in unweeded Control ($299.09/\text{m}^2$). The no. of shoot/ m^2 in the weed management practices was found significantly higher under Sesbania + Bispyribac 25g ai ha^{-1} (341.25 cm) and lower under unweeded Control (280.28 cm). Minimum number of weed population/ m^2 was recorded under the treatment Sesbania + Bispyribac 25g ai/ha after sowing at all stage *i.e.* 29.41, 19.85 & 11.03. The panicle length (cm) was observed maximum in Sesbania + Bispyribac 25g ai/ha (19.93 cm) while, panicle weight (g) was obtained higher in Sesbania + Bispyribac 25g ai/ha (1.14) followed by hand weeding twice (1.13) which was statistically at par with each other. The maximum number of grain/panicle (73.42) was recorded under the Sesbania + Bispyribac 25g ai/ha. This maximum test weight of grains was found in the treatment of hand weeding twice (20.48g). The dry matter production was recorded maximum with Sesbania + Bispyribac 25g ai/ha (499.3g). Grain yield obtained maximum (25.20) from Sesbania + Bispyribac 25g ai/ha and minimum in unweeded control (19.67 q/ha), while stover yield was recorded maximum in Handweeding Twice (20 & 40 DAS) (49.98q/ha). In case of biological yield Sesbania + Bispyribac 25g obtained maximum yield (76.76q/ha). However, harvest index was found higher under in Sesbania + Bispyribac 25g ai/ha (35.18%).

Key words : Weed management, treatment, paddy, sesbania, bispyribac 25g, plant population, handweeding, test weight, biological yield, grain yield, harvest index and panicle.

Introduction

Paddy (*Oryza sativa* L.) is cultivated on about 150 mha area in the world (9% of total cultivated area) and provides the staple food of about half of the world population. In India, rice is cultivated round the year in one or other part of the country in diverse ecologies spread over 44.6 mha producing 132 million tonnes of rice with a productivity of 2.96 t/ha. Increasing yields achieved during green revolution through increase in cultivated areas, high yielding varieties, intensive use of fertilizers, better agronomical practices and expansion of irrigation facilities are showing sign of stagnation across Indo-Gangetic Plains (IGP) and factor productivity is declining (Ladha *et al.*, 2003a).

The demand of cereals to meet the food requirements of the burgeoning population is increasing. The productivity and sustainability of rice-based systems are threatened because of the inefficient use of inputs; increasing scarcity of resources, especially water and labour; changing climate; the emerging energy crisis and rising fuel prices; the rising cost of cultivation and emerging socio-economic changes such as urbanization,

migration of labour, preferences of non-agricultural work, concerns about farm-related pollution (Kumar and Ladha, 2011). Conventional tillage and crop establishment by transplanting is the most input intensive process in an agro-system and, therefore, more efficient alternatives are urgently needed. Potential solutions includes a shift from intensive tillage to no or reduced tillage and/or from manual transplanting to direct seeded rice (DSR). Direct seeding of rice and wheat after no tillage performed as well as the conventional practice but with significant savings in water and labour use (Bhusan *et al.*, 2007). Direct-seeding is cost-effective, can save water through earlier rice crop establishment, and allows early sowing of wheat (Ladha *et al.*, 2003a; Singh *et al.*, 2003). With alternate wetting and drying cycles in DSR, the crop is subjected to greater weed competition than transplanted rice because weeds emerge before or at the same time as the rice. Therefore, heavy weed infestation is a major problem in direct seeded rice and its success lies in effective weed control measures (Singh *et al.*, 2003; Rao *et al.*, 2007), as failure to eliminate weeds may result in low or no yield (Estorninos and Moody, 1988). Keeping in view, present study was conducted at the Kanpur (U.P.)

India, a major food and pulses basket of India, during Rabi season 2014-15. To evaluate most remunerative method of weed control in Direct Seeded Rice for crop productivity, profitability, water requirement and energy use with a goal for finding most suitable ones with a potential to cover large area with similar agro ecological conditions in the IGP.

Materials and Methods

To find out the most remunerative method of weed control the study was conducted at Students Instruction Farm of Chandra Shekhar Azad University of Agriculture and Technology Kanpur-208 002 (U.P.) India during *Kharif*, 2014-15.

Cropping history of experimental field : Cropping pattern followed on a particular field will affect the production potential of that field. The detail of cropping history of the experimental field, preceding the period of experimentation is given in rice-Wheat rotation was followed in the experimental field 2010-11 to 2014-2015.

Field experiment was laid out in Split Plot Design with 12 treatments with each treatment replicated three times during course of investigation. The treatments were randomly allocated to the plots by using random number. NDR-359 (Rice Variety) was sown in the experimental plot with spacing 25 cm row to row. NDR-359. It is a Medium Late duration variety of about 130-135 days and plant height about 90-95 cm. Rice seed at the rate of 45 kg ha⁻¹ and sesbania 20kg ha⁻¹ was sown manually by laborers. The field was well leveled having assured irrigation and drainage facilities. Thus almost double cropping is done on most of the farm field.

The treatments and their symbols used are as under : Treatment main plot and Particulars W₁ - Bisbyribac 25g ai/ha, W₂ Sesbania+ Bisbyribac 25g ai/ha, W₃ - Hand weeding twice (20 & 40 DAS) and W₄ - Unweeded Control.

Details of field operation :

Sr. No.	Field operations	Date
1.	Field preparation	3.07.2014
2.	Layout	3.07.2014
3.	Sowing	
	D ₁ 04.07.2014	04.07.2014
	D ₂ 07.07.2014	07.07.2014
	D ₃ 09.07.2014	09.07.2014
5.	Fertilizer application	
	(a) Basal (50%N+ Full 60 kg ha ⁻¹ P ₂ O ₅ +Full 60 kg ha ⁻¹ K ₂ O	30.07.2014
	(b) First Top Dressing (25% nitrogen)	24.08.2014
	(c) Second top dressing (25% nitrogen)	27.09.2014
6.	Harvesting	16.11.2014
7.	Threshing and winnowing	26.11.2014

After sowing the seed, the first irrigation was given to help in germination of seed further irrigations were given stages when lack of moisture was observed in the field.

Sampling procedure and observations : An appropriate sample is one that provides an estimates or a sample value that is as close as possible to the value that would have been obtained, had all plants in the plot been measured. The difference between the sample and plot value constitutes the sampling error. Thus, a good sampling technique is one that gives a small sampling error. Therefore, the choice of an appropriate sampling technique is of prime concern to maintain proper balance between the size of sampling unit, sampling size and sampling design to achieve the maximum precision with the minimum cost. Single plot as a sampling unit, five plants per experimental plot as a sample size and a random sampling technique (Gomez and Gomez, 1984) were adopted for recording growth and development of the test crop at various stages of observations. The observations were made at 30 days interval depending upon crop indices only to receive a precise observation of growth analysis.

Weed studies

Weed density (No.m⁻²) : Species wise weed counts were recorded at 60 DAS. A weed count, for estimating weed density, was recorded with the help of a quadrat of 0.25 m² placed randomly at two spots in each plot. Individual species wise counts were grouped into grasses, sedges and broad-leaf weeds and expressed as number m⁻².

Weed biomass (g m⁻²) : Weed enclosed in a quadrat of 0.25 m² (0.50m 0.50 m) were cut at ground level and separated at grasses, sedges and BLW at 60 DAS, washed with tap water, sun dried, dried at 70 C for 48 hours, and then weighed. The total weed dry weight was obtained by adding the weight of these three groups. The dry weight was expressed in gm².

Weed Control efficiency (%) : Weed control efficiency (WCE) can be calculated on the basis of weed density as suggested by Mani *et al.* (1973).

$$WCE = \frac{WDC - WDT}{WDC} \times 100$$

Where,

WCE = Weed control efficiency

WDC = Weed density (number/m²) in control plot

WDT = Weed density (number/m²) in treated plot

$$WCE = \frac{WDMc - WDMt}{WDMc} \times 100$$

Growth attributes [Plant height (cm)] : Five plants from each experimental plot were selected randomly and tagged. Plant height in cm of rice plant was recorded with

Table-1: Effect of method of weed management practices on Plant stand/m², number of grassy weed and No of shoot/m².

Treatment	Plant Population/m ²		Weed population/m ²			No. of shoot/m ²
	Initial	Final	30	60	At harvest	
Weed Control						
Bisbyribac 25g ai/ha	155.66	344.73	57.65	45.28	23.18	330.26
Sesbania + Bisbyribac 25g ai/ha	156.12	360.69	29.41	19.85	11.03	341.25
Handweeding Twice (20 & 40 DAS)	158.07	357.58	36.60	26.38	14.43	337.13
Unweeded Control	159.45	299.09	131.06	112.66	62.04	280.28
SE (m)	1.90	2.49	2.20	1.84	1.17	2.05
CD (P= 0.05)	NS	7.32	6.47	2.60	3.44	6.01

Table-2 : Effect of weed management practices on panicle length (cm), panicle weight (g), No. of grain/Panicle, Test weight (g) and Dry mater production (g).

Treatment	Panicle length (cm)	Panicle weight (g)	No. of grain/Panicle	Test weight (g)	Dry mater production (g)
Weed Control					
Bisbyribac 25g ai/ha	19.28	1.10	70.99	19.30	466.2
Sesbania + Bisbyribac 25g ai/ha	19.93	1.14	73.42	20.39	499.3
Handweeding Twice (20 & 40 DAS)	19.76	1.13	72.63	20.48	494.7
Unweeded Control	16.37	0.93	60.20	16.95	363.9
SE (m)	0.37	0.03	0.71	0.33	6.22
CD (P= 0.05)	1.09	0.10	2.09	0.97	16.25

Table-3 : Effect of method of establishment & on yield (biological, grain and Stover) q/ha and harvest index (%).

Treatment	Biological yield (q/ha)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest Index (%)
Weed Control				
Bisbyribac 25g ai/ha	73.00	25.20	47.11	34.44
Sesbania + Bisbyribac 25g ai/ha	76.76	26.99	49.76	35.18
Handweeding Twice (20 & 40 DAS)	76.72	26.74	49.98	34.88
Unweeded Control	59.68	19.67	40.00	32.99
SE (m)	1.07	0.38	0.56	0.26
CD (P= 0.05)	3.14	1.12	1.67	0.78

the help of meter scale from base of the plant to tip of upper most leaf of the plant before panicle emergence and up to the tip of panicle after heading, then averaged and expressed in cm.

Tillers (No. m⁻¹) row length : Number of tillers was recorded by using a meter scale in each plot at different stages of observation, and counted into number of tillers row m⁻¹.

Dry matter accumulation (g m⁻¹) row length : Dry matter accumulation (g) m⁻¹ row length was measured from two randomly selected places in plot and then cut two plant rows near ground level of 50 cm row length from each plot at different stages of crop growth. Samples were first dried in sun and then oven dried at 65°C till the constant weight was achieved. After drying, the samples were weighed for recording dry weight and expressed in g m⁻¹ row length.

Harvesting : The crop was harvested when most of the panicles turned golden yellow. Harvesting was done manually by using sickle. Individual plot was harvested separately and carefully bundled and tagged. It was then brought to the threshing floor separately and allowed to

dry in the sun in order to attain the optimum moisture for threshing.

Threshing : After sun drying, the bundles were weighed with the help of spring balance and total biomass was recorded. The bundles were then threshed separately by laborers with the help of sticks. The grain of each plot was collected, cleaned and weighed to get grain yield kg plot⁻¹. The difference of grain yield and total biomass was recorded as the straw yield of each plot in kg. The yield, thus obtained, was converted in kg ha⁻¹.

Yield and yield attributes

Effective tillers (No. m⁻¹) row length : Number of effective tillers was counted for 50 cm three row length from each plot in the field investigations and then expressed in terms of m⁻¹ row length.

Panicle length (cm) : Five panicles were sampled from the tagged plants in each plot. The length was measured from the base of the panicle to the tip of the top most spikelet. The mean panicle length was computed and expressed in cm.

Biological yield (kg ha⁻¹) : All above ground plant parts harvested from net plot area were carefully bundled, tagged and taken to the threshing floor separately. The individual bundle was weighed after complete drying in the sun and the biological yield per plot was then converted into kg ha⁻¹.

Grain yield (kg ha⁻¹) : Produce of each net plot was threshed separately, and grains thus obtained were winnowed, cleaned and weighed. The moisture content of harvested grain was measured by using moisture meter. The yield recorded in kg plot⁻¹ was standardized to 14 per cent moisture and then weight was converted into kg ha⁻¹.

Harvest index (%) : Harvest index was calculated as per the following formula :

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

Method of Data Collection : Data collection was started after fifteen days of sowing and subsequent at weekly intervals. Observations were taken on hill basis. Five plants (hill) were randomly selected from plot plants sown with NDR-359. The observations continued till harvest of the crop. The observations were recorded at morning hours.

Results and Discussion

The data on plant population (Initial and Final) are presented in Table-1. The initial plant population was not influenced by method weed management practices but numerically the the maximum weed population was recede under unweededcontrol (159.45 ha) and minimum plant populated was recorded inthe 25 ga.i./ha (155.66ha) treated plots. The final plant population was influenced significantly under the weed management practices. The maximum plant population obtained under Sesbania + Bispyribac 25g ai/ha (360.69/m²) but lower in unweeded Control (299.09/m²) The initial population of rice variety NDR-359 did not vary significantly due to use of different method of establishment and but final plant stand influenced significantly under weed management practices. It means the population taken at initial and final stage but has not been affected by method of establishment only initial stage. This result is supported by the finding of Bhurer *et al.*, (2013).

The data on no. of shoot/m² recorded at the time of harvesting are presented in Table-1, showed that the no. of shoot/m² was influenced significantly under the weed management practices. The weed management practices was found significantly higher under Sesbania + Bispyribac 25g ai/ha (341.25 cm) as well as lower under unweeded Control (280.28 cm). Anitha and Mathew (2010) and Bhan *et al.*, (1980) supported neck to neck the present findings. Weed population/m² recorded at 30, 60

and harvest are represented in Table-1, showed that weed population/m² not significantly influenced by at all the stages of crop. The maximum number of weed population/m² was recorded under the treatment unweeded Control (131.06, 112.66 & 62.04) at all stages of the crop after sowing while minimum under Sesbania + Bispyribac 25g ai/ha at all stage i.e. 29.41, 19.85 & 11.03. Similar findings were also reported by Damalas *et al.*, (2008) and Mahajan *et al.*, (2009).

Yield attributes

Panicle length (cm) and Panicle weight (g) : The data on yield attributes (No. of grain per panicle and 1000-grain weight) are presented in Table-2 showed that the panicle length (cm) and panicle weight (g) were influenced significantly under weed management practices. The panicle length (cm) was observed maximum 19.93 cm in Sesbania + Bispyribac 25g ai/ha, while minimum in unweeded Control 16.37 cm. Panicle weight (g) was obtained higher in Sesbania + Bispyribac 25g ai/ha (1.14) followed by hand weeding twice (1.13) which was statistically at par with each other.

Number of grain per panicle and Test weight (g) : The data on yield attributes (No. of grain per panicle and 1000-grain weight) are presented in Table-2. The data showed that the number of grain per panicle significantly influenced by weed management practices. The maximum number of grain/panicle (73.42) was recorded under Sesbania + Bispyribac 25g ai/ha and significantly minimum under unweeded control plot (60.20). The maximum test weight was found in the treatment of hand weeding twice (20.48g) and minimum under in unweeded Control (16.95g).The report of Khaliq *et al.*, (2011) and Hussain *et al.*, (2008) also support the present investigation.

Dry Matter Production : The data on yield attributes (No. of grain per panicle and 1000- grain weight) are presented in Table-2, showed that dry mater production was influenced significantly by weed management practices. The dry matter production was recorded maximum in Sesbania + Bispyribac 25g ai/ha (499.3g) as compared to unweeded control plot (363.9g).

Yield : It is clear from the data Table-3 that Grain Yield were recorded significantly higher in Sesbania + Bispyribac 25g ai/ha (26.99 q/ha) and significant minimum under to unweeded control plot (19.67 q/ha), while Stover Yield was recorded maximum (46.98) in Hand weeding Twice (20 & 40 DAS). In case of Biological Yield maximum yield was obtained in Sesbania + Bispyribac 25g ai/ha (76.76 q/ha) followed byHand weeding Twice (20 & 40 DAS) (76.72 q/ha). The highest Harvest Index was found in Sesbania + Bispyribac 25g ai/ha (35.18%). This may be due to positive effect of weed management practices. The improvement in wheat yield due to combined application

of method of establishment and weed management practiced in direct seeded rice has been corroborated by Ali *et al.*, (1985) and Mahajan *et al.*, (2009).

Statistical analysis : Analysis is drawn between data recorded on Agronomic Practices and Different methods of paddy establishment. Based on this statistical analyzed data, the results of the investigation have been interpreted and conclusions have been drawn.

Conclusions

It is be concluded that, all four treatments of weed management of paddy, which have been discussed in this paper, are important and used in the crop. But, out of four methods, Sesbania + Bisbyribac 25g ai/ha may be treated as most important method in paddy to good crop for gain production.

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Exploring Possibility for Enhancement of Utilisation of Yak in North Eastern Region—A Case Study

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Abstract

CAEPHT Ranipool Centre of AICRP on UAE explored possibility for best utilisation as pack animal involving National Research Centre on Yak, Dirang, West Kamrenge district (Arunachal Pradesh). Feed, work rest cycle and present use of byproducts were reviewed and further saddle development for yak was planned for hills slope to enhance packload capacity. Yak shelters, equipment for feed preparation and milk products were also studied. Test Trials of yaks at different slopes and distances at different packload were conducted. Physiological observations (Pulse rate, respiration rate and body temperature) were recorded at certain interval. A distance of 25 km can be covered by yak in 9 hour at average speed of 2.8 km/h.

Introduction

CAEPHT Ranipool Centre of AICRP on UAE identified work place at National Research Centre on Yak, Dirang, West Kamrenge district (Arunachal Pradesh). The issues related to utilization of Yaks in steep slopes and their by-products utilization were emerged during interaction meeting. The objective of the Project was to collect data on physiological parameters and to study the behavior of yaks for work purpose. The display and demonstrations of byproducts of Yak : Hair and Milk were shown at institute's yak farm situated at 32 km from Dirang. The equipment/laboratories related to Yak investigation were also visited. The by-products of hair was used for making *chanwar* as used in temple/ *gurudwara*, caps, foot-mats, door-mats, blankets, ropes, wool and other items were shown in display. The Milk products of Yak under display were *churpi*, *ghee*, candy, low fat paneer etc. At the farm Feed milling unit (capacity – 400 kg/h) and nutritive feed previously formulated were shown. The method of preparation of feed was demonstrated. In addition to it, functionality of feed block unit (capacity: 70-80 blocks/days, size : 160x160x160 mm and having average. Feed block weight: 2 kg) was shown.

Material and Methods

The breeds of Yak, body wt., size, annual use, daily feed intake per yak, milk production, housing structure, routine farm operations, meat yield, speed of yak, traditional saddle prevailing in steep slope for pack load transport, load transported in traditional system, physical and physiological responses (body temperature, pulse rate and respiration rate) before and after pack-load transport on slope were noted during test trial. A saddle of 19.5 kg (one side size : 420x310 mm) used by army for ponies was shown at Army Camp in Derang which was required to be refined for its use for enhancing packload capacity of

Yaks ensuring safety and comfort. The army used saddle consisting of iron frame, leather and thick cotton pads. The army spoke person demanded modification on the aspects of light weight and durable unit suitable on the steep slope (60-70%). For the Yak, traditional saddle of 6.7 kg (unit price Rs 2000, wooden saddle with yak hair water proof rope). were in use for packload of average 80 kg with average body weight of 350 kg on average 60% slope. The Yak (adult of 3 years age) transported material using traditional saddle for 25 km distance at average speed of 2.8 km/h in 9 hours time. The physiological observations before packload test were pulse rate: 66/min, respiration rate:33/min and body temperature 104.7 degree F and ambient temperature 62.6 degree F. These values after 1 km travel were observed 90/min, 40/min and 104.9 degree F. Improved housing structure



Visit of UAE Centre, Ranipool at feed milling unit



Unit operation for yak hair mattress



Physiological parameters measurements for yak



Milk products of yak.



Pack load study at steep slope



Improved shelter for Yak



Interaction at Yak feed grinding unit at NRC on Yak, Derang.



Improved fodder for Yak.

had 20 adult yaks in shed size of 30x 50 feet. The structure was of GI roof and cement-concrete floor. There were also arrangement of separate feeding and watering trough.

Conclusion

Yak can be used for transport of household commodities at different gradients on slopy land in hills using saddles. These can serve in States especially in Sikkim, Arunachal Pradesh, Uttarakhand, Himachal Pradesh and Jammu Kashmir. Yaks are able to transport 80 - 120 kg in 9 hour at slopes above 30 degree at average speed of 2.8 km per hour.



Genetic Transformation Methods in Plants—A Review

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Abstract

Plant transformation is currently a crucial research tool in plant biology and a useful technique for the growth of transgenic plants. There are numerous tested techniques for introducing novel genes steadily into the nuclear genomes of various plant species. Thus, for many plant species, the development and use of practical transformation methods are no longer constrained by gene transfer and regeneration of transgenic plants. *Agrobacterium tumefaciens*, particle bombardment, and DNA uptake into protoplasts are some of the traditional methods used to modify plant genetics. These techniques produce transgenic events that contain transgenes that are randomly incorporated into the plant genome. Many issues with the current methods of gene transfer are avoided by novel techniques that facilitate the integration of foreign genes at certain pre-determined places. Zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and clustered regularly interspaced short palindrome repeats have all become popular tools for gene targeting in recent years (CRISPR). The current review focuses on the many strategies for plant gene targeting and how well they work, and it makes recommendations for future research in key areas of plant molecular biology.

Key words : *Plant transformation, Agrobacterium tumefaciens, ZFNs, TALENs, CRISPR.*

Introduction

Gene Transfer is the insertion of exogenous DNA into plant cells, organs or tissues employing direct or indirect means developed by molecular and cellular biology. This process is known as transformation. It is a sequential pattern process which involves the selection of plants first, those are capable of giving rise to whole transformed plants. The study of gene functions and connections, protein-protein interactions, developmental processes, applications for crop improvement, and the creation of plant bioreactors to create vaccines are just a few of the many basic research fields where plant transformation is a critical tool. Effective and repeatable transformation technologies are crucial for the creation of transgenic plants as well as for additional uses including gene editing and studies of transient gene expression (Hopp *et al.*, 2022).

There are some other methods also which involves transformation without regeneration and vice versa, but these are of limited value such as *in vitro* regeneration done in meristem culture, pollen culture, organogenesis or embryogenesis using callus phase. The major limitation regarding *in vitro* regeneration in plants is the genome stress, being imposed by, especially when they undergoes regeneration via callus phase that would lead to somaclonal variation among them. Somaclonal variation refers to the genetic abnormalities or chromosomal rearrangement developed due to plant tissue culture methods. Also, genetic manipulation has been done by plant breeders for long years with great

success. These types of variations can be genetic or epigenetic in origin (Bidabadi and Jain., 2020). The process of classical plant breeding is uncertain as well as slow where in order to transmit a gene of interest requires a sexual cross between two lines and then repeated back crossing between the hybrid offspring and one of the parents until a plant with the desired characteristic is obtained. Plant breeding is a lengthy process, taking ten to fifteen years to produce and to release a new variety. This process, however, is limited to those plants which can sexually hybridize, and genes in addition to the desired gene will be transferred. Recombinant DNA technologies circumvent these limitations by enabling plant genetics to identify and clone specific genes for desirable traits. Plants have a number of unique biological features that can be explored with recombinant DNA technologies (Glick and Patten, 2022).

In this review, the basic techniques used to manipulate plants genetically are discussed i.e. from exploitation of the natural gene transfer system of *Agrobacterium* to the chemical treatment of isolated protoplasts by polyethylene glycol. It also includes physical procedures of DNA introduction, including electroporation of protoplasts and tissues, microinjection and silicon carbide fibre-mediated transformation. The methods are classified into the given categories.

Vectors for Genetic Transformation : A DNA molecule used as a vehicle to artificially carry the foreign genetic material into another cell is termed as a vector. It consists of a transgene and a large sequence serving as a backbone of the vector. The vectors used for plant

transformation are plasmids, generally, designed specifically to generate transgenic plants. Binary vectors are most commonly used as it has the ability to replicate in both bacterium, *E.coli* (common lab bacteria) as well as *Agrobacterium tumefaciens* (a vector used to insert recombinant DNA into plants). The common features of a suitable transformation vector as given below (Low *et al.*, 2018) :

- Multiple unique restriction sites (synthetic polylinker)
- Bacterial origin of replication eg. *Col E1*
- Selectable marker gene
- Bacterial antibiotic resistance gene

Mostly, vectors carry these selectable marker genes that allows the recognition of transformed cells. Various types of selectable markers are now known but among all, the most common is nptII (Neomycin phosphotransferase), providing kanamycin resistance.

Agrobacterium Ti plasmids are preferred over all other types as it consists of wide host range of bacterial system and its capacity to transfer genes due to presence of T-DNA border sequences. In 1907, *Agrobacterium tumefaciens* was discovered to be the cause of crown gall disease. In the 1970s, Zaenen *et al.*, 1974 identified the bacterial component that causes tumour induction as a DNA plasmid known as the Ti plasmid (Hopp *et al.*, 2022).

Methods of Gene Transfer in Plants : The uptake of DNA into isolated protoplasts is mediated by chemical processes, electroporation, or the employment of high-velocity particles in a number of gene transformation approaches (particle bombardment). Both steady transformation and momentary gene expression benefit from direct DNA absorption (Narusaka *et al.*, 2012). Finding and introducing novel genes into current elite cultivars is how genetic engineering has transformed the crop development process. The efficiency of the gene transfer into plant cells has been continually improved using a variety of techniques.

Physical Methods of Gene Transfer

Biolistic Gene Gun Method : The concept of transferring DNA-coated particles directly into cells was first conceived by Sanford and co-workers in 1984. This was also known as gene gun technique or microprojectile bombardment, employs high velocity gold or tungsten particles (0.2-0.4 μ m) to deliver DNA into plant cells. The coated particles are loaded into a particle gun and accelerated to high speed either by the electrostatic energy released from a droplet of water exposed to high voltage or using pressurized helium gas; the target could be plant cell suspensions, callus cultures, or tissues. The projectiles penetrate the plant cell walls and membranes. As the microprojectiles enter the cells, transgenes are released from the particle surface for subsequent incorporation into the plant's chromosomal DNA. The method was developed with the aim to transform monocotyledons, that are recalcitrant to transformation with *Agrobacterium* (Narusaka *et al.*, 2012). Compared to the agroinfiltration and protoplast transformation approaches, transient expression experiments in plant tissues by biolistics take a lot less time overall. 24 hours after the vector is prepared, transient expression following biolistic administration can be seen. In addition to the 2 days needed for the transformation of the *Agrobacterium* cells with the DNA construct, the inoculation of *Agrobacterium* requires the establishment of a bacterial culture 24 hours beforehand and the detection of transitory expression 2–4 days following inoculation (Lacroix and Citovsky, 2020).

There are few applications of this method such as its versatility, simplicity as well as efficiency. This method enables to enlighten the concept of gene expression and its regulation. Also, this method of microprojectile bombardment allows more efficient transformation via *Agrobacterium* as it can be used to wound plant tissues. This technique significantly reduces the time required for production of genetically modified plants. With that, it helps in the transformation of several major cereals,

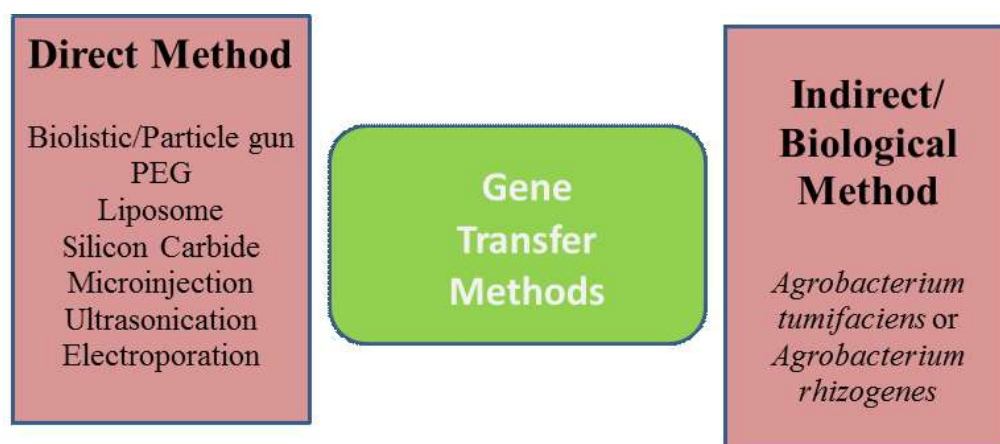


Fig.-1 : Classification of Gene Transfer Methods.

including barley, maize, wheat, rice, pearl millet, together with other monocotyledons such as tulip and orchids.

Due to its simplicity, adaptability, and great efficacy, biolistic DNA transport has been regarded as a universal technique for genetic modification to transfer exotic genes to cells or tissues. In the majority of monocot crops, it has been the method of choice for examining the function of plant genes. In 1993, biolistic DNA delivery led to the successful regeneration of the first transgenic sorghum plants, with a transformation efficiency of only 0.3%. Since then, enormous progress has been made, with the highest transformation efficiency reported in recent years being 46.6% (Liu *et al.*, 2020).

Electroporation : Transient pores are created in the plasma membranes of prokaryotic and eukaryotic cells through the electrical transformation process known as electroporation. The electropores or microscopic pores that are produced by the applied field in the cell membrane enable the entry and/or exit of micro- or macromolecules. Electrical pulses are applied to a suspension of protoplasts with DNA placed between electrodes in an electroporation cuvette. Short high-voltage electrical pulses induce the formation of transient micropores in cell membranes allowing DNA to enter the cell and then the nucleus. The method is used to transport biochemical substrates like lipids, proteins, RNA and DNA to cell interior (Ozyigit *et al.*, 2020). Some of the applications of the method includes the creation of kanamycin-resistant plants from transgenic rice (*Oryza sativa* L.) plants electroporated with plas-mid harbouring the nptII gene revealed the viability of protoplast in genetic engineering investigations (Saunders *et al.*, 1989). The genomes of transgenic rice plants (*O. sativa* L.) were complexly electrotransformed with multiple copies of inserted genes. The study led to the identification and expression of HPT in the developmental history of transformants (Tada *et al.*, 1990).

Microinjection : Dr Marshall A.Barber invented this method initially to clone bacteria and to confirm the germ theory of Koch and Pasteur. Transformation through a microprojectile is a direct and precise delivery of DNA into the plant cell through a glass microcapillary injection pipette. DNA or other material is injected into the cell for later integration and/or expression using very small bore glass needles (outer diameter typically less than 0.2 μm) (Dean, 2013).

Its importance for plant transformation is rather limited due to the characteristics of plant cell walls, which contain a thick layer of lignins and cellulose. The plant cell wall is a barrier for glass micro tools. The method allowed the incorporation not only of DNA plasmids but also of whole chromosomes into plant cells. The transformation efficiency is ten times lower when compared to the

biolistic gene gun method. Also, the injection of inheritable material like immature embryos, meristems, immature pollens, germinating pollen etc using a hypodermic syringe is known as macroinjection. The crops in which microinjection and macroinjection has been done are maize, tobacco, rice, soybean, wheat, cotton, nut, grass, algae, Rye, watermelon and petunia (Parrray *et al.*, 2019).

Silicon-carbide whisker-mediated transformation : Si C mediated transformation (SCMT) method was proposed in 1990 to transform maize and tobacco. Silicon carbide filters are added to a suspension of tissue (cell clusters, immature embryos, callus and plasmid DNA using a vortex, shaker or blender. The fibres are used which are single crystals of silica organic minerals like silicon carbide which possess an elongated shape, having a diameter of 0.6 mm and a length of 10–80 mm. DNA coated fibers will penetrate the cell membrane through small holes created by collisions between the plant cells and fibres. The method is least complicated and allows the stable transformation of different plants but having the disadvantage of low transformation efficiency. Plant material, fiber size, parameters of vortexing, shape of the vessels used, and the characteristics of the plant cells, especially the thickness of the cell wall are the factors on which transformation efficiency depends. The method being done has been reported in case of transformation of cotton (*Gossypium hirsutum* L.) and regeneration of salt tolerant plants (Arshad *et al.*, 2013). The transformation of monocot and dicot plant species embryo and cell suspension cultures has been carried out using silicon carbide and other whiskers from various sources (Asad and Arshad, 2016).

Ultrasound mediated gene transfer : Ultrasound-mediated membrane perforation known as sonoporation has the potential to pierce tough cell walls and plasma membranes on a presumably reversible basis, which is advantageous for gene transfection and plant biotechnology.

The method involves rupturing the cellular membranes by acoustic waves which leads to the possibility to non-invasive introduction of molecules like DNA into the interior of cell. The membrane permeability increases and thereby, the entrance of molecules into the cells is facilitated. This phenomena leads to generate the microscopic channels that favour the exposure of internal plant tissue increasing the transient expression level of transferred DNA even to double. DNA has been introduced to the protoplasts of beetroot and tobacco by 20kHz ultrasound at 0.5 to 1.5 W/cm² (Zolghadrnasab *et al.*, 2021).

Chemical Methods of Plant Transformation

Gene Transfer by Polyethyleneglycol : The method leads to the physicochemical uptake of DNA via

endocytosis. The protoplast are kept in polyethylene glycol (PEG) solution. The concentration of PEG used is 15% having 8000 Dalton molecular weight. After exposure of protoplasts to exogenous DNA in presence of PEG and other chemicals, PEG is removed and intact protoplast are then cultured to form cells with walls and colonies in turn. Due to the simplest transformation protocol, the method is most widely used among all.

Without removing their cell walls, *E. coli* and *Saccharomyces cerevisiae* are both susceptible to the genetic change caused by polyethylene glycol (PEG). The PEG-mediated transformation of *E. coli* is technically straightforward and produces transformants with an efficiency of 10^6 – 10^7 transformants/ μg DNA (Klebe *et al.*, 1983).

Liposome mediated encapsidation : Lipofection, a method developed to protect the foreign DNA using liposomes during the transfer process first described in 1965 as a model of cellular membranes. Liposomes are artificial phospholipid vesicles used for delivery of molecules into the cells, multi-lamellar or unilamellar vesicles with a size range of 0.1-10 μm or 20-25 nm respectively. The method of transformation followed by transgenic plant regeneration has been reported in tobacco and wheat (Zhu *et al.*, 1993).

In terms of vectors for delivering genes to plant cells, liposomes may have the following benefits: Nucleic acids are protected from nuclease activity, nucleic acids are targeted to specific cells, nucleic acids are delivered into a range of cell types other than protoplasts through entry through plasmodesmata, and nucleic acids are delivered with intact tiny organelles (Gad *et al.*, 1990).

DEAE-Dextran (Diethylaminoethyl dextran) : DEAE-dextran is a soluble polycationic carbohydrate that promotes interactions between DNA and endocytotic machinery of the cell. Negatively charged DNA and positively charged DEAE-dextran form aggregates through electrostatic interaction and forms a polyplex. The osmotic shock using DMSO or glycerol improves the complex DNA delivery with DEAE-dextran. The method is simple and inexpensive but sometimes toxic when used at high concentrations. The method is initially reported by Vaheri and Pagano in 1965 for enhancing viral infectivity of cell but later adapted as a method for plasmid DNA transfer (Kujawa *et al.*, 2021).

Indirect or Biological Method of Gene Transfer

Agrobacterium mediated plant transformation : The ability of the bacterial pathogen *Agrobacterium tumefaciens* to introduce foreign genes into a variety of host plants is a key component of *agrobacterium*-mediated transformation (AMT). It is the most commonly used method for plant genetic engineering. The

pathogenic soil bacteria *Agrobacterium tumefaciens* that causes crown gall disease has the ability to introduce part of its plasmid DNA into the nuclear genome of infected plant cells. The genetic material that is introduced is known as T-DNA located on a Ti-plasmid. A Ti-plasmid is a circular piece of DNA found in almost all bacteria (Fig.-2). Due to its high efficiency, it is the most efficient method of transformation. During transformation, several components of Ti-plasmid enables the effective transfer of genes of interest into the plant cells such as T-DNA border sequences, vir genes; for transferring T-DNA region to the plant genome but are not transferred themselves. The advantage of using this method over other methods are reduction in transgene copy number; intact and stable integration of transgene into the plant genome (Bartlett *et al.*, 2008).

Seven steps make up the protocol, which can be summed up as follows: Stage (I) involves the preparation of sterilised seed or samples and inoculum; Stage (II) entails explant preparation, infection, and cocultivation with *A. tumefaciens*; Stages (III) and IV involve selection; Stage (V) involves acclimatisation and molecular identification of T_0 ; Stage (VI) involves cultivation and self-crossing of T_0 ; and Stage (VII) involves T_1 plant analysis (Pratiwi and Surya, 2020).

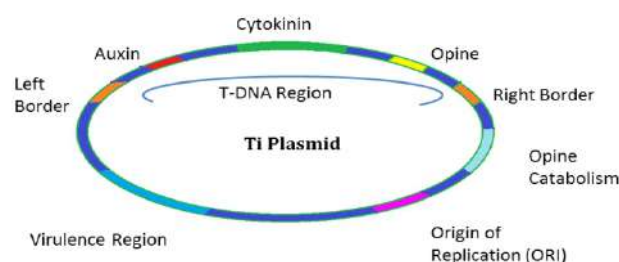


Fig-2 : Schemetic representation of a Ti plasmid.

Also, to cause crown gall formation, T-DNA encodes genes for the production of auxin or indole-3-acetic acid via the IAM pathway. This biosynthetic pathway is not used in many plants for the production of auxin, so it means the plant has no molecular means of regulating it and auxin will be produced constitutively. Genes for the production of cytokinin are also expressed. This stimulates cell proliferation and gall formation.

Example of T-DNA genes in Ti plasmids

Gene	Product	Function
ocs	octopine synthase	opine synthesis
nos	nopaline synthase	opine synthesis
tms1	tryptophan-2-mono-oxygenase	auxin synthesis
tmr	isopentyl transferase	cytokinin synthesis
ags	agropine sunthase	opine synthesis

T-DNA transfer and integration into the genome is mediated by various vir genes such as vir A and vir G both expresses constitutively. Vir A codes for kinase spans the bacterial membrane and for phenolic molecules (acetosyringone) it acts as receptor, released by wounded plant cells. This binding of acetosyringone causes vir A to get autophosphorylated on histidine residue. This phosphate group transferred to aspartate residue in vir G. Both vir A and vir G genes acts as activator for other vir genes. T-DNA transfer occurs through a conjugative pilus formed as a result of vir gene expression, initiated by the products of vir D1 gene (helicase) and vir D2 gene (act as endonuclease). The representation of *Agrobacterium* T-DNA transfer is given below:

In planta transformation : Since the first time *Agrobacterium* was used to transform plant explants, there has been a lot of interest in creating transformation techniques that do not rely on tissue culture regeneration, can provide high throughput transformation, require little to no labour, money, or expertise, and lower the rate of unintended mutagenesis and somaclonal variations induced by in vitro culture. Feldman first created an *in planta* transformation procedure in the *A. thaliana* model plant (Ziemienowicz, 2014).

Role of gene transfer methods in crop improvement

Genetic engineered wheat has led to increase the grain yield and minimize the crop loss due to unfavourable weather conditions and has developed resistance in crop against various pathogen and pests. The first transgenic wheat plants were produced by microprojectile bombardment as a method of DNA delivery. Genetic transformation with a single target gene has been used for the production of transgenic wheat expressing tolerance to herbicide, resistance to fungal and viral diseases.

A coat protein-mediated resistance to viruses, introduced into rice via protoplast transformation, was transferred then to maize and barley via particle gun bombardment. The resistance to sulfonylurea (herbicide) conferred by the *als* gene of *Arabidopsis thaliana* was also transferred to maize by particle gun technology. Maize has been reported to get transformed by Silicon carbide fiber-mediated DNA delivery system. Whiskers-mediated maize transformation has also been reported.

Transformation in rice leads to double the food supply and improved the quality as well as quantity. Biolistic was successfully used for transformation of immature embryos of rice. Reports were also maderegarding the transformation of indica and javanica rice in addition to other japonica rice. Fujimoto et al. were the first to engineer japonica rice

through electroporation with modified d-endotoxin gene (*cry*) from *Bacillus thuringiensis* (Khan, 2009).

Conclusions

One of the most difficult elements of plant science is arguably the development of gene transfer systems in plants. *Agrobacterium*-mediated and biolistic-mediated DNA delivery technologies are now the two best options. Two decades ago, the primary goal of the development of transformation technology was the creation of transgenic crops with enhanced agronomic properties for increased crop productivity.

The challenge of applying transformation strategies to higher plants with a higher frequency to produce GT events has not yet been solved. The transgene-carrying *Agrobacterium* strains can easily transform *Arabidopsis* plants by dipping the plants in the solution. It takes a lot of work to alter and screen higher plants for GT events. By using gene knocking, the creation of the GT technique represents a significant advance in furthering our understanding of how a single gene functions in the context of its genome. It also has the potential to boost public acceptability of molecularly-based plant gene manipulation.

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Assessment of Available Macro and Micronutrient Status of Soils of Waghodiya in Vadodara District of Gujarat

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Abstract

Physical and chemical properties of the soils were characterized, classify and evaluate in the soils of Patiyapura, Tawara, and Waghodiya taluka, Vadodara district, Gujarat. A total of 05 pedons, were studied and carried out with soil series. The soils were very deep, moderate to strongly alkaline in reaction in nature (pH 6.80 to 8.4) with very low to high in organic carbon content (0.09 to 0.80 %), low to high in calcium carbonate (07.03 to 13.3 %) respectively. As a part of the investigation, representative 60 surface soil samples were collected and 05 pedons were selected under the Instructional farm, College of Agriculture, Parul University, and Vadodara Gujarat. The soil texture ranged from sandy loam to sandy clay loam in upland pedons while sandy clay loam to clay in pedons cultivated plains. In general, relatively low bulk density was recorded at surface horizons compared to sub-surface layers. Maximum water holding capacity, pore space, and volume expansion increased with soil depth. The soils were found to be low in nitrogen, low to medium in phosphorus, and medium to high in available potassium status. Manganese and Copper were sufficient but Zinc and Iron were deficient in soils.

Key words : *Physio-Chemical characteristics, macronutrient and micronutrient status.*

Introduction

Land and water are the most vital natural resources of the country and these are under tremendous stress due to ever-increasing biotic pressure. Characterization of soils is fundamental to all soil studies, as it is an important tool for soil classification, which is done based on soil properties. It also provides information for the understanding of the physical, chemical, and mineralogical properties of the soils and an insight into the potentials and limitations of the soils for management.

Worldwide, the demand for food commodities is expected to increase by 75-100 percent between 2010-2050 (Hosain *et al.* 2016). At the same time, modern intensive agriculture accounted a quantum increase in crop production and ensures food security, but has also resulted in the over-exploitation and degradation of natural resources such as soil, air, and water in India. The declining scenario in agricultural land and the growing food demand need attention to optimized use of soil resources. Intensive and formidable land use needs a good level of knowledge of soil resources to design suitable soil management practices (Akpan-Idiok *et al.* 2016).

Evaluation of the fertility status of the soils of an area or region is an important aspect in context of sustainable agricultural production. Nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) are important soil nutrient elements that controls its fertility and yields of the crops (Singh and Mishra 2012). Because of imbalanced and inadequate fertilizer use coupled with low efficiency of

other inputs, the response (production) efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years. The variation in major and micronutrient supply in soil is natural phenomenon and some of them may be sufficient where others deficient. The stagnation in crop productivity cannot be boosted without judicious use of macro and micronutrients of the study area. Therefore, the present study was undertaken to assess the status of available major and micronutrients in Waghodiya tehsil of Vadodara district in of Gujarat.

Materials and Methods

Study area Waghodia Taluka is located in Vadodara district. Geographically the area lies between 73°17' to 73°33'E longitude and 22°12'to 22°21'N latitude. The total geographical area of the Taluka is 585.12 km.

The mean annual temperature is 27.9°C with mean summer temperature of 31.1°C and mean winter temperature 23.3°C. May is the hottest month with 39.5°C mean daily maximum temperature and January is the coldest month with 12.7°C mean daily minimum temperature. The mean annual rainfall of the area is around 869 mm, received mainly during the southwest monsoon from June to September. Major crops grown in this area are pigeon pea (*Cajanus cajan*), maize (*Zea mays*), cotton (*Gossypium hirsutum*), sugarcane (*Saccharum officinarum*), wheat (*Triticum aestivum*) and green gram (*Vigna radiata*) with 90 to 120 days of length of growing period (LGP). The natural vegetation of the area comprised of *Azadirachta indica*, *Prosopis juliflora*,

Prosopis cineraria, Doob (*Cynodon dactylon*), Babool (*Acacia arabica*), Peepal (*Ficus religiosa*).

The site and morphological characteristics of these soils were recorded and horizon wise soil samples were collected (Soil Survey Division Staff 1995). The mechanical composition of soils was estimated by following international pipette method (Piper 1966). For estimation of saturated hydraulic conductivity, 200 g of air dry sample « 2 mm) dumped in one motion in the permeameter that was fitted with a screen and filter paper. The permeameter was then tapped 100 times to attain a uniform bulk density. After saturating the soil with distilled water, the saturated hydraulic conductivity was measured using the constant head method of Richards (1954). Calcium carbonate (Piper 1966), soil organic carbon (Walkley and Black 1934), pH, electrical conductivity Jackson (1973), Available Nitrogen was determined by Subbaiah and Asija (1956). Available phosphorus was estimated calorimetrically as per the method given by Jackson (1973).while Available potassium by Jackson (1973). Micronutrient content with physicochemical properties of the soils as suggested n (Lindsay and Norvell, 1978) and analyzed with the help of Atomic Absorption Spectrophotometer.

Results and Discussion

Soil site characteristics of Waghodiya of Vadodara :
The characteristic of the five soil sites are presented in excavated the representative soil profile. The details about location of soil profile, name of soil series latitude and longitude, Mean Annual Rainfall (MAR), Mean Annual Temperature (MAT) (OC) and topography etc. are given in Table-1.

The soils of patiyapura P1 and P2 are observed Plateau and uneven slope lands in topography to be slightly undulating, that of Tawara pedon P3, P4 and Limda P5 were Plateau. The slop and drainage were recorded to be 1-2 per cent except pedon P3 and P4, medium and Imperfect of all pedon. The Erosion are nil to all pedons of receptivity variation in morphological characteristic of five profiles indicated that the soil vary in depth and colour considerably depending upon the topographic situation. The morphological characteristics showed considerable variation in the nature and degree of horizon development reported by Raina (2008).The morphology of the Vertisols indicated that the soils were deep to very deep (more than 90 cm) Abhishek Jangir (2018). The cracks were 2 to 10 cm wide at the surface and extended up to a depth of 50 cm. The pressure faces were observed in all the profiles. Slicker sides were well developed and were tilted to an angle 45-60 degree from horizontal. In pedons 1, 2, 3 and 4 the effervescence (with 10% HCl) was slight where as in pedons 5, it was strong to violent to which attributed process of diffuse powdery

Table-1 : Soil site characteristics of Waghodiya, of Vadodara.

Location	Latitude	Longitude	MAR (mm)	MAT (°C)	Topography	Drainage	Slope percentage	Erosion	Natural vegetation
Patiyapura	22° 16' 32.2 "	73° 25' 29" 8	869	30°C	Plateau and uneven slope land	well	1-2 %	Nil	Mango (<i>Mangifera indica</i>), Doob (<i>Cynodon dactylon</i>), Babool (<i>Acacia Arabica</i>), Neem (<i>Melia aradirachata</i>), Gumma (<i>Leucas aspera</i>), Peepal (<i>Ficus religiosa</i>)
Tawara	22° 16' 44.0 "	73° 25' 01" 7	869	35°C	Plateau	well	1-3 %	Nil	Mango (<i>Mangifera indica</i>), Gumma (<i>Leucas aspera</i>), Palm (<i>Borassus flabellifer</i>), Gorkhul (<i>Tribulus terrestr</i>)
Limda	22° 29' 24.6 "	73° 36' 34" 5	750	36°C	Plateau	M. well	1-2 %	Nil	Doob (<i>cynodon dactylon</i>), Babool (<i>Acacia Arabica</i>),

(* MAR- Marginal annual rainfall, MAT- Marginal annual temperature)

Table-2 : Physico-Chemical properties of soils of waghodiya of Vadodara.

Location	Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	sHC (cm hr ⁻¹)	BD (M gm ⁻³)	pH	EC (d Sm ⁻³)	OC (%)	CaCO ₃ (%)
Patiyapura-1 Fine, Semectitic, hyperthermic vertic Haplustepts											
Patiyapura P 1	AP	0-15	24.9	22.4	52.7	0.14	1.42	6.90	0.48	0.40	11.33
	A	15-27	23.1	20.8	56.1	0.09	1.36	7.52	0.46	0.34	10.01
	Bw	27-40	21.2	19.3	59.4	0.08	1.34	7.60	0.42	0.21	09.23
	Bssk	40-70	19.3	18.2	62.5	0.06	1.32	7.57	0.41	0.01	07.03
Patiyapura-2 Fine, Semectitic, hyperthermic Vertic Haplustepts											
Patiyapura P2	AP	0-15	23.9	22.1	53.9	0.16	1.40	7.30	0.44	0.40	11.97
	A	15-25	22.2	21.2	56.6	0.10	1.39	7.87	0.42	0.31	11.07
	Bw	25-65	19.1	19.3	61.6	0.08	1.39	7.88	0.41	0.21	09.73
Tawara-1 Fine-loamy, mixed hyperthermic Typic Haplustepts											
Tawra P3	AP	0-15	24.1	22.1	53.8	1.42	1.40	7.00	0.49	0.80	09.41
	A	15-30	22.8	20.2	56.8	0.92	1.39	7.48	0.55	0.62	09.21
	Bw	30-65	21.2	19.1	59.6	0.21	1.37	7.5	0.47	0.41	08.43
Tawara-2 Fine-loamy, mixed hyperthermic Typic Haplustepts											
Tawra P4	AP	0-15	21.9	20.8	57.3	1.10	1.42	6.80	0.44	0.50	09.92
	A	15-30	19.3	19.1	61.6	0.91	1.39	7.22	0.41	0.51	07.73
	Bw	30-77	18.6	17.5	63.9	0.22	1.36	7.63	0.40	0.32	07.10
Limda-1 Very Fine Smectitic hyperthermic Typic Haplustepts											
Limda P5	AP	0-15	17.8	26.2	63.9	0.10	1.38	8.02	0.85	0.54	13.3
	A	15-30	16.3	21.9	61.8	0.08	1.36	8.21	0.60	0.30	11.2
	Bw	30-49	14.4	19.7	65.9	0.06	1.35	8.36	0.42	0.19	07.91
	Bssk	49-75	13.1	17.2	69.1	0.05	1.35	8.40	0.42	0.09	07.10

from of CaCO₃. Calcium carbonate was observed throughout the depth of all soils. Malode and Patil (2014).

Physico-Chemical properties of soils of Waghodiya of Vadodara : The Soil texture is an inherent property of soil that determines the makeup of primary particles and it controls mainly air, water and nutrient availability to the plant. It could be judged considering sand (%), silt (%) and clay (%). The data indicated that all the soils were sandy Lome to clayey in texture. Per cent clay ranged from 69.1 per cent (pedon 5) to 52.7 per cent (pedon 1), whereas the sand per cent ranged from 24.9 (pedon 1) to 13.1 (pedon 5) of Limda and that of silt per cent ranged from 26.2 (pedon 5) to 17.2 (pedon 5). It is also observed that the clay distribution below the profile for all soils was almost uniform, suggesting of their development from their same kind of parent material under same climatic condition. Macro topography must have been played key role in the profile development (Pal *et al.*, 2000). The uniformity in clay distribution is attributed to the movement of finer soil particles along with runoff water from higher topographic position to lower situation and pedoturbation in vertisol (Sharma and Raychoudhari, 1988). The hydraulic conductivity ranged from 0.05 cm hr⁻¹ (P5) to 1.42 cm hr⁻¹ (P3). P5 was found to be the poorly drained depth of soil which showed the low hydraulic conductivity which might be due to presence of Mg²⁺ in the subsurface origin. In general the low hydraulic conductivity decreased with

depth (Table 2). The mass of soil unit-1 of volume including pore space is the bulk density (Hillel, 1980). Bulk density of pedon ranged from 1.42 mg m⁻³ (pedon 1) to 1.32 mg m⁻³ (pedon 1). The increase in dry bulk density is indicative of the compactness of the soil, which is highly correlated with fine clay content of the soil table-2. (Malode and Patil 2014).

The pH data indicated that the soil were generally moderate to strongly alkaline in reaction with pH varying between 6.80 (P2) to 8.4 (P5). The increase in soil pH below the slop and at lower depth may be attributed to the accumulation of the alkaline earth salts. It may be further stated that calcareousness of soil might be due to its formation from basalt rich in calcium (Ca⁺⁺) and high or moderately alkaline earth, which leads to neutral to alkaline conditional as reported by Kaushal *et al.* (1986). Slight variation in electric conductivity (1:2.5 soil: water suspension) was observed with increase in depth i.e. the subsurface horizon. This might be due to leaching of salts from surface to down below through the percolating water, followed by evapotranspiration resulting in the salt accumulation at the subsurface horizon. Similar to this observation Rajankar (1990), Malode and Patil (2014) and Anonymous (1994) also reported that increase in depth i.e. the surface horizon is associated with variation in electric conductivity. The organic carbon data indicated that, organic carbon content decreased with depth in all

Table-3 : Available nutrient status of soils of waghodiya of Vadodara.

Location	Horizon	Depth (cm)	Available Macro Nutrient status (Kg ha ⁻¹)			Available Micro Nutrient status (mg kg ⁻¹)			
			N	P	K	Cu	Fe	Mn	Zn
Patiyapura P1			Patiyapura-1 Fine, Semectitic, hyperthermic vertic Haplustepts						
	AP	0-15	123.69	1.37	70.63	0.32	8.53	48.40	0.16
	A	15-27	111.02	1.12	77.61	0.30	7.22	41.20	0.09
	Bw	27-40	091.02	0.90	67.37	0.25	6.01	33.3	0.02
	Bssk	40-70	071.06	0.71	56.97	0.20	4.21	21.01	0.02
Patiyapura P2			Patiyapura-2 Fine, Semectitic, hyperthermic vertic Haplustepts						
	AP	0-15	119.17	35.50	99.59	0.44	23.89	48.40	0.16
	A	15-25	97.02	21.81	80.01	0.40	19.27	41.01	0.09
	Bw	25-65	73.02	16.03	72.65	0.24	17.22	32.2	0.01
Tawra P3			Tawara-1 Fine-loamy, mixed hyperthermic Typic Haplustepts						
	AP	0-15	185.65	15.95	125.55	0.41	17.82	7.45	0.20
	A	15-30	142.50	12.80	122.21	0.33	14.81	5.02	0.19
	Bw	30-65	92.3	09.20	101.10	0.21	11.32	2.90	0.11
Tawra P4			Tawara-2 Fine-loamy, mixed hyperthermic Typic Haplustepts						
	AP	0-15	136.73	03.10	68.52	0.39	15.44	53.36	0.27
	A	15-30	123.00	02.00	61.00	0.31	11.00	41.50	0.20
	Bw	30-77	090.00	01.07	39.90	0.20	06.02	30.30	0.17
Limda P5			Limda-1 Very Fine Smectitic hyperthermic Typic Haplustepts						
	AP	0-15	162.00	11.00	296.0	2.10	03.94	07.24	0.21
	A	15-30	149.52	09.01	272.5	1.72	02.63	06.10	0.13
	Bw	30-49	97.3	03.00	249.8	1.42	01.92	02.91	0.07
	Bssk	49-75	72.2	01.50	200.0	0.94	0.97	02.97	0.01

studied soils. This content ranged from 0.09 per cent (P5) to 0.8 per cent (P3). This might be due to sieving effect and adsorption of fine organic particles and water soluble organic matter respectively by soil particles. The calcium carbonate content varied from 07.03 per cent (P1) to 13.3 per cent (P5). The high calcium carbonate in soil affect the water holding capacity of soil which has great bearing on crop production under rainfed condition. Calcium carbonate affects the physical and chemical characteristics of soil and may prevent root penetration (Sys, 1985).

Available nutrients of soils of Waghodiya of Vadodara

: The available N, P and K ranged from 71.06 to 185, 0.71 to 32.5 and 39.90 to 296.0 kg ha⁻¹, respectively in different pedons and in general, their content decreased with the increase in soil depth (Table 3). The variation in available N content in soil could be attributed to the differences in their physiographic, differential cultivation and management practices of the soil. Removal of N by the crop, losses through leaching, denitrification, fixation and volatilization take place. Some nitrogen was immobilized by soil microbes. These results are in agreement with Malewar *et al.* (1998). Whereas, available soil K were inadequate range in both the cultivars.

The diethylenetriamine penta acetic acid (DTPA)

extractable micronutrient data indicated that available Zn value showed more or less decreasing trend with the soil depth for all the soils. The surface horizons were deficient in Zn content as the value was below the critical level set at 0.6 ppm which was also reported by Sharma *et al.*

(1996). These soils are usually calcareous accompanied by high pH which may aggravate the deficiency of available Zn due to deleterious effect of CaCO₃ on one hand and formation of insoluble Zn OH₂ or ZnO on the other. Mn deficiency usually do not occur because of sizable portion of Mn is bound as manganese oxide which may be readily available. Cu was not deficient in any of these soils. The content of available Fe was also found to be lower than the critical value of 4.5 ppm as per the criteria given by Lindsay and Norvell (1978).

Conclusions

Based on findings of present study, it is concluded that the soils of Waghodiya of Vadodara districts are neutral to alkaline in reaction and low in organic carbon. Majority of the soils of waghodiya of Vadodara district were low in available Nitrogen and Phosphorus. While about one third of these soils were low in available K. Among the micronutrients, content of available Mn, and Cu were high, whereas the available Fe and Zn was low respective

samples. The application of organic manures and green manuring may be a sustainable management option to enhance the soil quality and productivity of these soils.

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Antimicrobial Peptides : An Emerging Class of Therapeutics

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Abstract

The increased prevalence of disease caused on by bacteria that are resistant to antibiotics urgently demands for alternatives. Consideration should be given to using antimicrobial peptides made by certain bacteria, as an alternative to conventional antibiotics. These compounds are durable, have variable activity spectra, and show notable efficacy against various bacteria, including ones that are resistant to antibiotics. Probiotic bacteria can potentially create antimicrobial compounds in the gut itself to treat intestinal illnesses. Although the emergence of resistance may limit the use of particular antimicrobials, knowledge of the mechanisms by which such resistance may occur will allow researchers to create solutions to mitigate this possible issue.

Introduction

Antimicrobial peptides (AMPs) are oligopeptides peptides found virtually in all life forms. AMPs have a wide spectrum of targeted organisms ranging from viruses to parasites. Historically AMPs have been referred to as cationic host defense peptides (Brown and Hancock, 2006), cationic amphipathic peptides (Groenink *et al.* 1999), anionic antimicrobial peptides/proteins (Harris *et al.* 2009), cationic AMPs, host defense peptides (Riedl *et al.* 2011), and -helical antimicrobial peptides (Huang *et al.* 2010). AMPs are ribosomally synthesized and also called as bacteriocins. Gram negative bacteria generally produces larger AMPs (mostly larger than 20 kDa) whereas, Gram positive AMPs are quite smaller (less than 6kDa). These are membrane permeable and efficient even in very low concentrations (Papagianni and Anastasiadou, 2009; Papagianni, 2003). AMPs produces by LAB are classified into four main groups: (Class I) modified AMPs known as lantibiotic, (Class II) the nonlantibiotics which can withstand high temperature, (Class III) heat labile AMPs and another group is Class IV which consists of complex molecule with carbohydrate and lipid moieties (Table 1). Mostly studies and identification of such AMPs are done during last 20 years. AMPs having antilisterial activity and capable of inhibiting the growth of food born and food spoilage bacteria have attracted the interest of food sector for application in preservation of food.

A number of AMPs have been discovered and their modified structures, mechanisms, mode of actions, genes biosynthesis and regulation have been reported (Ibrahim, 2019). AMPs produces by LAB are considered to be Generally Recognized As Safe (GRAS) with potential applications in food preservation and safety against spoilage microorganisms. These peptides are also having potential applications in cosmetics, pharmaceuticals and agriculture industries. Nisin the most

well known AMP produced by *Lactococcus lactis* has wide spectrum of inhibition against food spoilage bacteria such as *Listeria monocytogenes*, *Staphylococcus aureus*, *Bacillus cereus* and *Clostridium botulinum*. It is only one AMP which awarded as GRAS status in 1988 and being used worldwide in major food producer countries (Ibrahim, 2019). It is water soluble, highly effective at pH range from 3.5 to 8.0 and even at low concentration (1 to 25 ppm). Recently it is used in processed foods, dairy products, canned foods, beer, juices, cured meat and fermented products without altering their flavour, colour, aroma, and taste (Irkin and Esmer, 2015). In addition to food processing Nisin is also used in food packaging as its illuminates the presence of Gram-negative bacteria, molds and yeast. Studies have shown that Nisin can used as therapeutic drug as it prevents the growth of drug-resistant bacteria such as methicillin-resistant *Staphylococcus aureus*, *Enterococci*, *Streptococcus pneumoniae* and *Clostridium difficile* (Shin *et al.* 2016; Mataraci and Dosler, 2012). These studies have proven that when AMPs are used alone or with other peptides can provide lot of beneficial applications in bio-pharmaceutical industries.

The potential applications of AMPs from LAB have gained strong interest of food and health care sector which results in increased studies of AMPs production, purification, biosynthesis and applications. Chemical preservatives are enquired continuously with regard of safety while, the use of AMP were accepted as they are natural and health promoting. This awakens the non-reducing interest of food scientist in this particular area and its expanding trend of applications in food industry (Papagianni and Anastasiadou, 2009).

Mode of action : The main target of antimicrobial peptides for inhibiting the growth of Gram-positive bacteria is their cytoplasmic membrane (Papagianni,

2003). Research studies have revealed that AMPs form a pore in cytoplasmic membrane and make it permeable by inserting its C-terminal regions (Drider *et al.* 2006). Mostly all AMPs belongs to class II uses this method to inhibit bacteria. Though, the exact role of N terminal (YGNGV motif) of AMPs has not clarified yet. This proves that AMPs show bactericidal activity to sensitive Gram-positive bacteria (Ray, 1995). C terminal of AMP is hydrophobic thus, they easily destabilize the cytoplasmic membrane during association. This results in cell lysis initially in which loss of the permeability and membrane potential effected followed by autolytic system of bacteria. Scientist has studied the mode of action of pediocin Ach/PA-1 (Motlagh *et al.* 1991; Ray, 1992).

AMPs destabilises the membrane functions by making the membrane porous so that intercellular potassium molecule escapes and lactose present in medium enters into cell which results in cell lysis. It was found that AMP Ach/PA-1 bind to the receptors present on the cell surface of both resistant and sensitive cells to it (Bhunia *et al.* 1991). Destabilization of the membrane by AMPs mostly takes place in sensitive cells. In these cells conformation alterations took place which impaired the permeability of the membrane. AMPs producing strain has specific immunity gene, encodes for immunity protein which provide resistance to the producer strain (Ray, 1995). The inhibition effect of AMP is observed very less in Gram negative bacteria as they refuse the attachment of AMP to their cell surface. To achieve this prior sublethal stress injury should be given to Gram-negative bacteria which make them sensitive to AMPs. It was predicted that AMP Ach/PA-1 invade the cell through incapacitated outer membrane, reaches to inner membrane and diminish its functions and destroy the cells (Ray, 1995).

The mode of action of AMP PD-1 produced by *P. damnosus* (Green *et al.* 1997; Bauer *et al.* 2005), SA-1 from *P. acidilactici* and SM-1 from *P. pentosaceus* was studied (Anastasiadou *et al.* 2008). To understand the action mechanism of AMP PD-1, *Oenococcus oeni* bacterium is used as indicator strain. It was concluded that the antimicrobial activity of AMP is due to the formation of pores in the cell membrane of bacteria. AMPs initiate the loss of potassium molecule by altering extracellular pH from 7.0 to 5.0. This clearly proves that the action of AMP was due to DpH driving force. A synergistic effect was studied between the PD-1 and pH of the cell. Similar results were also observed the lantibiotic nisin from *L. Lactis* (Moll *et al.* 1999). Cell lysis of bacteria results of membrane disruption and loss of metabolites. It was observed that AMP SA-1 and SM-1 shows bactericidal activity against the indicator strain *Micrococcus luteus* at mid-logarithmic phase of its growth. This led to the postulate that AMPs may also capable of inhibiting biosynthesis of cell wall (Anastasiadou *et al.*

2008) as colony forming units were decreased without any change in turbidity at OD 600 nm (no cell lysis). Similar were the findings with pediocin PD-1 and *O. oeni* cells, as reported by Green *et al.* (1997).

In most recent work, studies were done to understand the activity of class IIa AMPs. The researcher results revealed that the activity of AMPs were dependent on its entire sequence and 3D structure of its membranes (Derksen *et al.* 2008). Some studies also presented that the activity of AMP PD-1 is also dependent on the growth conditions of indicator bacterium *O. Oeni* (Bauer *et al.* 2005). This was recognized by change in membrane fluidity and alteration of its protein and lipid contents that affect the resistance of the membrane to pore formation. Further studies should be done to understand the efficacy of AMP, under a range of growth phases and conditions before making generalized conclusions. When food is in concern, it is essential to differentiate among the various growth phases of the target-cells in order to assure effective control and preservation

Antioxidant activity : Recently, interest in studies of natural antioxidant has increased. Literature and research evidence proves that AMPs can help in reducing oxidative stresses related with several degenerative diseases (e.g., arteriosclerosis and cancer) (Tan *et al.*, 2020). Antioxidants are commonly used in food industries for preservation and preventing food from oxidation because oxidation of food products leads to their deterioration and discoloration. During the storage and processing of food items, the lipid and oil present in food gets oxidized that stimulate the adulteration. Prior to the use of antioxidants in food, they are extensively tested for their toxicity and efficacy at low concentration (Sanchez *et al.*, 2018). Regulatory laws of their use in food are constituted by individual countries or by internal standards. Toxicological studies need to be essentially carried out to find out the safety and acceptability in daily intake. Amongst the several synthetic antioxidant compounds accepted as GRAS by FAO/WHO Expert Committee on Food Additives. Synthetic antioxidants are 1,1- diphenyl-2 picrylhydrazyl (DPPH), propyl gallate, butyl hydroquinone, butylated hydroxyanisole and butylated hydroxyl toluene.

Peptides produced by LAB might be efficient biopreservatives because LAB are also capable of producing organic acids, AMPs, hydrogen peroxide, fatty acids and diacetyl. These peptides are able to scavenge free radicals or may act as inhibitors of lipid oxidation (Wang *et al.*, 2018). These are generally low molecular weight peptides having 2 to 20 residues of amino acids (Karami and Adergani, 2019). The activity of such peptides is associated with their amino acid composition, hydrophobicity and conformation (Perumal and Pandey, 2013). Mostly, antioxidant are used in fermented

Table-1 : Classification of AMPs (bacteriocins) produced by Gram-positive bacteria.

Class	Subclass	Representative AMPs	Producing bacteria
I Lantibiotic	I A	Nisin	<i>Lactococcus lactis</i>
I Lantibiotic	I B	Mersacidin	<i>Bacillus spp.</i>
II Non Lantibiotic	IIa	Leucocin A	<i>Leuconostoc gelidum</i>
II Non Lantibiotic	IIb	Lactococcin G	<i>L. lactis</i>
II NonLantibiotic	IIc	AS-48 enterocin	<i>Enterococcus faecalis</i>
II Non Lantibiotic	IId	Lactococcin A	<i>L. lactis</i>
III Proteins	IIIa	Lysostaphin	<i>Staphylococcus simulans</i>
III Proteins	IIIb	Helveticin J	<i>L. helveticus</i>
IV		Sublancin	<i>Bacillus subtilis</i> 168

products. The demand of fermented products is also increasing, attention of food industry is drawn towards enriching nutrients, enhancing food safety, improving organoleptic aspects and enhancing health benefits (Liu *et al.*, 2011). Natural antioxidants are more desirable than chemical antioxidants because natural antioxidants have no reported side effects (Osuntoki and Korie, 2010). Several LAB have antioxidant activity and are capable of decreasing the accumulation of reactive oxygen species during the ingestion of food (Nakagawa and Miyazaki, 2017).

LAB are mainly used as probiotic because it has safe food-grade status. LAB strains improve gut microflora and enhance immunity that help in acquiring resistance against certain diseases (Khan and Kang, 2016). LAB also exhibit antioxidant activity (Li *et al.* 2016). Metabolic reactions of cells results in formation of free radicals that can cause harm to proteins, lipids and nucleic acids thereby resulting in onset of degenerative diseases viz. atherosclerosis, cancer and cirrhosis (Pieniz *et al.*, 2015). LAB showed great scavenging capacity for free radicals viz. DPPH, superoxide ion (O_2^-) and hydroxyl radical (OH) (Chen *et al.*, 2015; Ji *et al.*, 2015). Some LAB strains were studied for nitrite depletion in fermented sausages i.e. *L. sakei*, *L. plantarum* and *L. brevis* (Paik and Lee 2014), but their antioxidant properties are still not known. *L. bulgaricus* F17 demonstrated the probiotic potential due to its high survival rate (58%) within a simulated gastrointestinal tract and high free radical scavenging activity (59%) (Ding *et al.*, 2017). *L. curvatus* SR6 also had preferable DPPH scavenging activity (59.67%) and *L. paracasei* SR10-1 had better activity against lipid peroxidation capacity (63.89%) and OH scavenging activity (285.67%) (Zhang *et al.* 2017). *L. gasseri* 4M13 (4M13) and *L. rhamnosus*, 4B15 (4B15) also exhibited significantly high antioxidant activity (Oh *et al.* 2018).

Studies have suggested that antioxidant potential of such strains might be due to antioxidant enzymes (catalase, superoxide dismutase and glutathione peroxidase) and their activities (Kullisaar *et al.*, 2002). To understand the effect of LAB anti-oxidase activity, in vivo and in vitro

evaluation of various LAB isolates was studied. *Lactobacillus paracasei* showed DPPH scavenging activity and enhanced glutathione peroxidase and superoxide dismutase activities in kidney, liver and serum of mice (Wang *et al.*, 2016). Finding revealed that cell free supernatant and bacterial lysate of *S. thermophilus* BLM 58 and *P. acidilactici* ATCC 8042 possessed tremendous antioxidant capacity (Shehata *et al.*, 2019). Such findings provide potential evidence for further use of LAB strains as antioxidant agents and probioceutical drugs.

Anti-inflammatory activity : When infectious microorganisms (bacteria, fungi and viruses) invade the body or lie in specific tissue and/or circulate in blood, they cause inflammation. Inflammation also results in activation of host defense mechanism against cell injury (Belkaid and Hand, 2014). Predominantly, both innate and adaptive immune response may be involved in it. The innate immune system is first response of body which acts against invading microbes and induces dendritic, macrophages and mast cells (Chaplin, 2010). Whereas, the adaptive immune systems stimulate the activity of more specialized cells such as B and T cells which play an important role in eradicating invading pathogens by producing antibodies and specific receptors.

LAB also exhibited anti-inflammatory activities. Some studies revealed that anti-inflammatory activity of LAB were dependent on culture conditions of biomass such as pH, temperature and growth phase. *L. rhamnosus* GG excites the production of immunomodulatory cytokines (IL-10) in children and might control in vivo pro-inflammatory response (Pessi *et al.*, 2000). It also initiated the production of dendritic cells, macrophages and neutrophils which are the principal drivers of inflammatory response (Janeway and Medzhitov, 2002). *L. fermentum* SNR1 and *L. mucosae* AN1 are effective antioxidant probiotic strains that showed excellent anti-inflammatory activity in wistar albino rats (Ayyanna *et al.* 2018). *L. gasseri* 4M13 and *L. rhamnosus* 4B15 strains also exhibit significant effect on health by altering pro-inflammatory cytokines. (Oh *et al.*, 2018). LAB are capable of regulating immune response

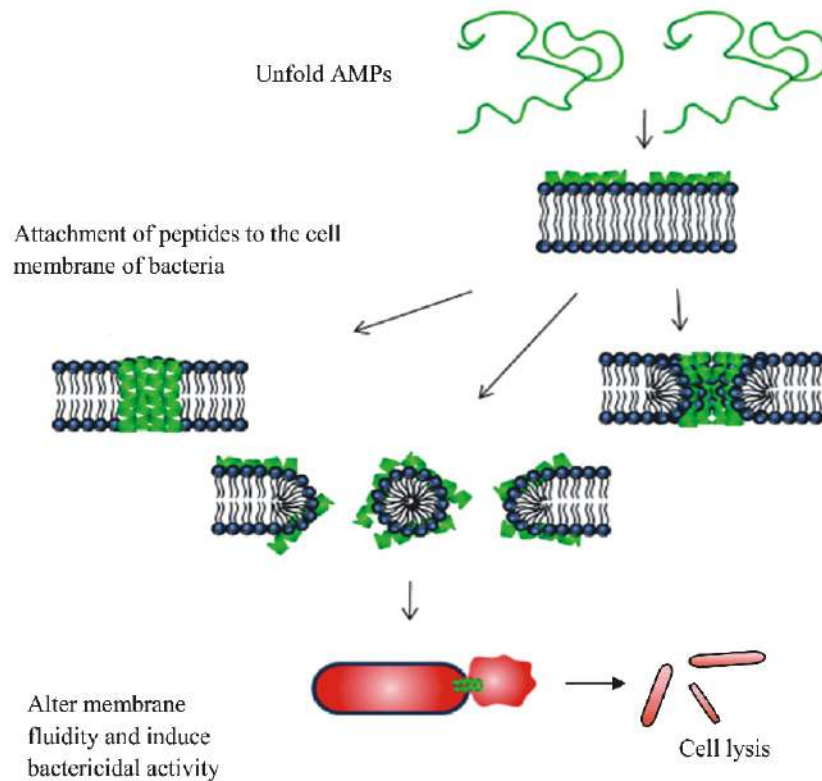


Figure-1 : Mode of action of AMPs on cell membrane of indicator strain.

by altering the production and secretion of cytokines by the host. Generation of free radicals in body are associated with inflammatory processes that may lead to impairment of GIT of humans and pathologies such as inflammatory bowel diseases (IBD), LAB could also halt inflammation by eradicating reactive oxygen species (ROS) through antioxidant enzymes activities. Studies have shown that genetically engineered LAB strains have effectively been utilized to cure IBD in animal models and could be assessed in human clinical assessment (LeBlanc *et al.* 2008).

Antihyperglycemic activity : Recently, the functionality of probiotic LAB have received a grand attention worldwide. Hyperglycemic is a state in which high level of glucose circulates in blood plasma. Chronic high glucose level in blood can damage the organs over time. Nowadays, use of natural antidiabetic drugs instead of synthetic drugs have attracted the interest of therapeutic industries. Probiotic strains were studied to attain this purpose as they are safe and able to survive in gut. Current studies suggested that LAB had anti-diabetic and anti-obesity susceptibilities on their hosts and thus they provide a vital role in human health care. Studies revealed anti-diabetic effect of *Lactobacillus casei* on diabetic mice (Chen *et al.*, 2014). *Lactobacillus* GG cells potentially reduce blood glucose level by down regulation of gluconeogenesis gene expression in diabetic rats (Farida *et al.*, 2020). Studies have shown that three commercial

strains viz. *Lactobacillus plantarum* 152, *Pediococcus acidilactici* 004 and *Lactobacillus rhamnosus* GG have potential antidiabetic properties (Cai *et al.*, 2019). In vitro experiments with *Pediococcus pentosaceus* QU 19 revealed its significant ability to suppress blood glucose level (Fujiwara *et al.*, 2020). *L. paracasei* NTU101 and fermented soy milk supernatant reportedly controlled the obesity in rats (Lee *et al.*, 2013).

Conclusions

These outcomes showed that AMPs produced from LAB are helpful in ensuring human health as they improve immunity. Against a wide range of bacteria, they demonstrated excellent antimicrobial action. The therapeutic class of AMPs is expanded by the discovery of their antioxidant, anti-inflammatory, and anti-hyperglycaemic potential. To identify powerful AMPs and understand about the main mechanisms, more research is required. AMPs need to be researched for their probioceuticals because they have a variety of advantageous effects.

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Nutritional Value of Lathyrus Grain for Animal Feed

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Abstract

Livestock is a key component of farming systems in South Asia and in Africa, and most particularly with small and marginal farmers, estimated about 678 million, and indicates importance of livestock to their livelihoods (ILRI, 2000). *Lathyrus* (*Lathyrus sativus* L.) is an important legume crop with low cost and easy cultivation grown in India, Bangladesh, China, Ethiopia, Nepal, and Pakistan for human food and animal feed. Inherently *Lathyrus* possesses resistance to drought, excess moisture, salinity, diseases, and insect pests. As *Lathyrus* has an ambivalent reputation due to ODAP content in its plant parts, efforts are on to develop low or ODAP free *Lathyrus* varieties with high biomass for dual purpose for human food and animal feed. Older published animal feeding studies are of limited use, since the presence and role of ODAP was unknown until the 1960s. More recent feeding studies indicate that low ODAP lines of *L. sativus* can be safely incorporated at inclusion rates up to 40, 30 and 70% of the diet of poultry, pigs and sheep, respectively, without growth reductions (Hanbury, et.al, 2000). *Lathyrus* is known as excellent feed and fodder crop for centuries as a main concentrate for horses (Anonymous, 1894). *Lathyrus* is increasingly recognized as an important feed and fodder crop by resource poor farmers of semi-arid and dry areas. Acceptability of low ODAP varieties by the farmers of non-traditional *Lathyrus* growing areas and high nutritional composition makes the *Lathyrus* a perfect dual purpose for crop securing food, feed and fodder security in the region. (Sarkar, et.al., 2010). As world demand for legume feed protein is likely to increase, due to increasing demand for animal food products, *L. sativus* are crops that should be considered in regions with suitable environments (Hanbury, et.al, 2016).

Key words : *Lathyrus*, ODAP content, protein, antinutritional factors, lathyrism

Introduction

Lathyrus sativus is a valuable plant of culture, both using it and as a precursor. The *Lathyrus sativus* L belongs to the Fabaceae family. *Lathyrus sativus* L. not only has potential as an agriculturally important crop for animal feed and human food, it also can be useful for studies of plant drought resistance (Choudhary *et al.*, 2016). The people known it under various names: dinner, dental peas, cicericula, dentisor. It is a precious annual plant, which has a long history of culture. The species *sativus* is widely cultivated. *Lathyrus sativus* is cultivated on about 500 thousand ha the globe. The areas large occupy it crop in India, Spain, Portugal, Near East, North Africa. It is used in human nutrition and animal feeding. Flour from the *Lathyrus sativus* is used (10%) for tasty bread. The berries are used up to mature, green and mature in the form of garner. It is use in animal feed as a green fodder, a fan, alone or mixed with cereals, and the grains are given as concentrated fodder. The *Lathyrus sativus* are also used to obtain high-quality glues used in aviation, textile, veneering, etc. The stem is in the muscle, branched, but non-resistant to fall. The leaves par pinnate with two narrow, lance late leaves, end with branched circle. The flowers are of violet color, rarely pink, blue, placed in raceme 2-3.

***Lathyrus sativus* L. :** Livestock plays an important role in Indian agriculture and rural economy. Rural population has major livelihood sources and income from livestock and poultry by selling milk, meat and egg. Livestock contrives 9% and 25% to National GDP and agricultural GDP respectively and contribution from livestock is about 15-20% to the farmers household income. At present, the country faces a net deficit of 45.1% green fodder, 21.9% dry crop residues and 64% in terms of concentrated feeds (Hegde N.G, 2006). In India the available natural fodders are poor in quality with regards to energy, protein and minerals and vitamins which leads to reduces production which directly effects farmer's income. The farmers investing about 70% of total cost of milk production on feed, fodder and concentrates only, thus good quality of green fodder having sufficient nutritive value are the demand of the day due to more demand of milk. Although, green fodder, hay and silage contains good nutritional values, but there maintenance, ways of consumption and presence of some toxic material also alarm us. Among the different quality controlling aspects anti quality materials/substances are also of prime importance (Wadhwan V.M, 2014).

The genus *Lathyrus* is a large one, comprising 189 species and sub-species according to Allkinet *al.* (1985),



and approximately 150 species according to Kupicha (1983). Of these only a small number are cultivated. Erskine *et al.* (1994) suggest that *L. sativus* was originally domesticated as a secondary crop as a result of being a weed of lentil (*Lens culinaris*) crops. It has been demonstrated in recent studies that the *Lathyrus* spp. (*L. sativus* L.) have considerable potential as grain legume crops on fine textured, neutral to alkaline, soil types in southern Australian Mediterranean-type environments (Hanbury *et al.*, 1995; Siddique *et al.*, 1996; Siddique and Hanbury, 1998). This species being evaluated as low input, multi-purpose crops for green manuring, animal feed and fodder. In Australia, animal feed is seen as the primary use of the grain of these species, both on and off farm. Animal feeding with this species has a long history and is still practised in some parts of the world. However, published studies are scattered and frequently difficult to access. This review aims to summarise the animal feeding literature and demonstrate the potential for this species as animal feed.

Soybean (*Glycine max*) meal is used widely as a source of protein for animal feeds, and the price of most other protein meals and grain legumes are set relative to this commodity. In Europe there has been increasing emphasis on local production of legumes for animal feed in order to supply some of this protein demand (Gatel, 1994), rather than relying on imported soybean meal. Subsidies have resulted in increasing production of, particularly, Field peas (*Pisum sativum*) and faba beans (*Vicia faba*). This expansion has been partly at the expense of previously grown legume crops, such as *Lathyrus* spp., which do not have subsidies (Franco Jubete, 1991).

The use of legumes as sources of protein for the animal feed industry is expected to increase further in the near future. Rising incomes in the Asian region are increasing the demand for meat products, and hence the requirement for animal feeds. There have been changes in public perception and some unfortunate developments, such as the consequences of 'mad cow' disease (i.e. bovine spongiform encephalopathy or BSE) in UK. This

has resulted in many feed compounders either choosing to, or being banned from, using animal by-products as a source of protein (Farrell, 1997).

***Lathyrus sativus* L. seeds dried** : The amino acid requirement of animals often differ with species and bodyweight, hence no single source of plant protein will provide the exact amino acids required for all animals. It is, therefore, preferable to include a range of protein sources in diet formulations, each complementing the other. For these reasons, the demand for grain legumes, such as *Lathyrus* spp., by the feed industry is expected to increase. Any feedstuff is likely to be used in diets for animals if it supplies the required nutrients, if it is cost competitive with other available ingredients, and if the user is confident it will produce the desired result.

Lathyrism : *Lathyrus* species, particularly *L. sativus*, have been known since classical times to be implicated in a paralysis of humans and animals (Hugon *et al.*, 2000) known as "lathyrism" or more specifically "neurolathyrism". Both ruminants and monogastric species can be affected, some literature indicates that monogastrics can be more affected. It was only in the later half of the 20th century that the compound responsible was identified (Murti *et al.*, 1964; Rao *et al.*, 1964). Neurolathyrism is the term used to describe the symptoms shown after heavy consumption of several different *Lathyrus* species and some *Vicia* species. The symptoms are weakness of the hind limbs and paralysis or rigidity of the muscles. The form of neurolathyrism most pertinent to this discussion is that caused by the non-protein amino acid 3-(N-oxalyl)-L-2,3-diamino propionic acid (ODAP, also referred to as b-N-oxalylamino-L-alanine or BOAA; Fig.-1): which has been recorded in humans and animals following consumption of *L. sativus*, *L. cicera*, *L. ochrus* and *L. clymenum* (Barrow *et al.*, 1974; Padmanaban, 1980; Franco Jubete, 1991). The seed of a number of other uncultivated *Lathyrus* species have been found to contain ODAP (Bell, 1962, 1964). Historically the consumption of *L. sativus* has been most often linked with lathyrism in humans and animals, primarily because of all *Lathyrus* species it is the most widely utilised as grain and

Table-1 : Anti-Nutritional factor in forage crops.

S. No.	Antinutritional/Toxic substances	Fodder crops
1.	Nitrate	Sudan Grass Pearl millet
2.	Oxalates	Paddy straw, Guinea Grass, Bajra and Hybrid Napier, Setaria Grass, Kikyu & Buffel grass
3.	Saponins	Lucerne
4.	Tannins	Fodder tree/Shrubs
5.	Cynogens	Sorghum, Sudan grass, Jhonson grass
6.	Glucosinolates (Goitrogens)	Cabbage, Turnips, Rapeseed and Mustard green
7.	Mimosine	Subabul
8.	-N-oxalyl-L- , -diamino propionic acid (-ODAP or BOAA)	Lathyrus

Table-2 : ODAP content (% as received) mean and range of a number of lines of *L. sativus* grown at various locations.

<i>L. sativus</i>	No.	Location	Source
Mean (Range)	No.		
0.20 (0.16±0.25)	10	Spain	Franco Jubete (1991)
0.49 (0.07±0.75)	70	Syria	Abd El-Moneim (1994)
0.49 (0.33±0.59)	36	Syria	Aletor et al. (1994)
0.39 (0.04±0.76)	407	Australia	Hanbury et al. (1999)
0.88 (0.45±1.40)	172	Bangladesh	Kaul et al. (1982)
0.72 (0.37±1.04)	10	Ethiopia	TekleHaimanot et al. (1993)
0.44 (0.28±1.50)	1187	India	Pandey et al. (1995)
0.32 (0.18±0.52)	76	Chile	Tay et al. (2000)
NA (0.08±0.99)	73	China	Chen cited by Campbell (1997)
0.46			Grand mean

fodder. Lathyrism is the term mostly used to refer to neurolathyrism caused by ODAP.

There are two forms of lathyrism, neurolathyrism and osteolathyrism. Osteolathyrism is characterized by skeletal deformities and can be caused by consumption of the species *L. odoratus* (sweet pea), *L. hirsutus*, *L. pusillus* and *L. roseus* (Roy, 1981). Osteolathyrism has been recorded experimentally in a wide range of animals (Barrow et al., 1974). The principal compound responsible was found to be b-aminopropionitrile (BAPN; Fig.-1), although the related nitriles aminoacetoneitrile (AAN) and methylene aminoacetoneitrile (MAAN) also have some osteolathyrism activity (Barrow et al., 1974). Although BAPN is not found in either *L. sativus* or *L. cicera* (Bell, 1962, 1964), there is evidence that a BAPN precursor (2-cyanoethyl-isoxazolin-5-one) is present in *L. sativus* seedlings but not in seed (Lambein et al., 1993). Consumption of *L. sativus* seedlings and shoots as vegetables has been blamed as the cause of osteolathyrism symptoms found in a small proportion of people with chronic neurolathyrism (Haque et al., 1997). Incidents of osteolathyrism from feeding of *L. sativus* have not been reported in animal studies, either under natural grazing or experimental conditions.

Lathyrism in humans has received more attention than that in animals, due to the social cost. Symptoms in

humans are most often initial painful spasms in the muscles of the lower limbs with accompanying weakness, followed by chronic spastic paraplegia of various degrees (Spencer et al., 1986), and can lead to total loss of use of the legs (Attal et al., 1978). The paralysis is rarely reversible (and then only in early stages of the symptoms; Hugon et al., 2000) and the consequences for poor communities who depend upon *L. sativus* as a primary food source at times of food scarcity can be devastating. Lathyrism still occurs, with a 1997 outbreak during food shortages in Ethiopia crippling 2000 people (Getahun et al., 1999). Lathyrism is endemic to the areas of the world which have significant areas of *L. sativus* cultivation; India, Bangladesh, Ethiopia and Nepal. However, in the 20th century outbreaks were also reported in Afghanistan, Algeria, China, France, Germany, Italy, Pakistan, Romania, Russia, Spain and Syria (Trabaud and MouhaËrram, 1932; Barrow et al., 1974; Roy and Spencer, 1989; Hugon et al., 2000). Boiling has been found to reduce ODAP levels in several cases, however, there are mixed reports on other forms of cooking (TekleHaimanot et al., 1993; Akalu et al., 1998). Padmajaprasad et al. (1997) reported that boiling grain and discarding the water reduced ODAP levels by up to 90%.

ODAP toxicity : Following its isolation and identification (Murti et al., 1964; Rao et al., 1964) the neurolathyrism

Table-3 : Protein concentrations (as received) reported in *L. sativus* L.

Mean protein (%)	No. lines	Location	Source
24	114	Bangladesh	Kaul <i>et al.</i> (1982)
28	76	Chile	Tay <i>et al.</i> (2000)
29	41	-	Petterson <i>et al.</i> (1997)
26	40	Australia	Laurence (1979)
31	36	Syria	Aletor <i>et al.</i> (1994)
25	25	Ethiopia	Urga <i>et al.</i> (1995)
30	15	India	Ramanujam <i>et al.</i> (1980)
25	12	Australia	Hanbury (unpublished)
25	10	Spain	Franco Jubete (1991)
27	3	Canada	Rotter <i>et al.</i> (1991)
29	3	India	Shobhana <i>et al.</i> (1976)

action of ODAP was soon demonstrated in adult monkeys (Rao et al., 1967). Cheema et al. (1969) administered ODAP intraperitoneally to rats. Young rats showed lathyrism symptoms and had 0.11 mmol g⁻¹ ODAP in the brain, adult rats showing trace or nil ODAP and no symptoms. Olney et al. (1976) found some indication of exclusion of ODAP by the blood-brain barrier in mice. Padmanaban (1980) suggested that the hypothesis of less ODAP exclusion by the blood-brain barrier in young animals should be re-examined, as greater excretion of ODAP by older animals may be an important factor. Spencer et al. (1986) showed unequivocally that ODAP, either naturally present in *L. sativus* or when added to other food sources, was the cause of corticospinal dysfunction in monkeys (*Macaca fascicularis*), with symptoms of hind limb motor difficulties. ODAP acts as a glutamate (Fig.-1) analogue in the nervous system and probably acts by binding strongly to α -amino-3- hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA)- type glutamate receptors. Permanent damage probably occurs with excitotoxic degeneration of neurons, although there are other possible neurotoxic effects. The ultimate fate of ODAP and the distribution in the brain and spinal cord is not known (Hugon et al., 2000). ODAP was not detected in pig loin tissue following feeding for an extended period (Castell et al., 1994).

In human populations young men are widely reported as the most susceptible to lathyrism (McCarrison, 1926; Shourie, 1945; Attal et al., 1978; Hamid et al., 1986; Getahun and TekleHaimanot, 1997), although the reasons for this are not understood (Hugon et al., 2000). The production and susceptibility to ODAP may be linked to Zn deficiency in plants and humans, respectively (Lambein et al., 1994; Lambein and Kuo, 1997). ODAP has also been found to inhibit growth of some insects and yeasts (Rao et al., 1964; Mehta et al., 1972), and so may have a plant protective role.

Anti-nutritional factors : Chemical substances present in the diet which by themselves or their metabolic products arising in the system interfere with the feed utilization, reduce production or affects the health of the animal. They are also called as toxic factors or incriminating factors. Anti-nutritional factors present in various feed/fodder are given in Table-1. Toxic substances of natural origin can be classified based on their chemical properties and on the basis of their effect on utilization of nutrients.

In common with all grain legumes there are a range of antinutritional factors (ANFs) found in *L. sativus* grain. The ANFs commonly found in grain legumes include: tannins, phytic acid, oligosaccharides, protease inhibitors (trypsin and chymotrypsin inhibitors), amylase inhibitors and lectins (Liener, 1989). ODAP is also an ANF and is almost unique to the *Lathyrus* genus. There are only a small number of published studies of levels and activities of ANFs, other than ODAP, in *L. sativus* (Latif et al., 1975; Deshpande and Campbell, 1992; Aletor et al., 1994; Urga et al., 1995; Srivastava and Khokhar, 1996; Wang et al., 1998).

Proteinaceous ANFs : The proteinaceous ANFs are (i) trypsin and chymotrypsin inhibitors (both protease inhibitors), respectively measured as trypsin inhibitor activity (TIA) and chymotrypsin inhibitor activity (CTIA), (ii) amylase inhibitors and (iii) lectins. ODAP will also be included under this heading, although ODAP is a non-protein amino acid and not strictly a proteinaceous ANF.

ODAP : Until recent times animal feeding studies with *L. sativus* have been performed with no knowledge of the role of ODAP in lathyrism. Therefore, in all older studies of animal feeding (i.e. pre 1960s) the concentration of ODAP is unknown. Recent studies have shown that ODAP concentrations can vary widely both within and between the these species, however, environmental conditions are not as important as genotype (Hanbury et al., 1999).

Nonetheless, stresses such as salinity and drought (Hussain et al., 1997) have been found to increase ODAP concentrations but are little understood. Concentrations of ODAP in the seed can be particularly high in *L. sativus* land races, up to 1.50% (Table-2).

Amylase inhibitor activity : Amylase is the enzyme primarily involved in starch digestion in mammals. Amylase inhibitors are thought to reduce amylase activity, but the extent to which they are important is debated (Deshpande and Damodaran, 1990). Deshpande and Campbell (1992) found in 100 lines of *L. sativus* that the range of amylase inhibitor activity (AIA) was 3.6 ± 91.4 units g⁻¹ DM, substantially lower than the 330 ± 675 units g⁻¹ DM found in *P. vulgaris* cultivars (Deshpande et al., 1982).

Tannins : Tannins are polyphenolic compounds of two classes: low molecular weight hydrolysable and higher molecular weight non-hydrolysable (or condensed). It is postulated that condensed tannins bind to proteins in the digestive tract and form complexes which are frequently indigestible (Marquardt, 1989). The hydrolysable tannins are often found to have little effect on digestibility. Tannins in faba beans and field peas are frequently localised in the seed coat (Marquardt, 1989; Gatel and Grosjean, 1990), with high tannin levels in darker seed coats than lighter ones. Similarly, Deshpande and Campbell (1992) found that white or cream coloured seeds of *L. sativus* were associated with low tannin levels (both condensed and total), whereas seed with darker seed coats generally had high tannin levels. Similar observations regarding *L. sativus* were made by Urga et al. (1995) and Wang et al. (1998). In *L. sativus* lighter seeds are associated with white flower colour (Jackson and Yunus, 1984), consequently the selection of white flower colour could be used to reduce tannin contents. There is considerable scope for improvement of varieties with negligible condensed tannin levels. In the case of *L. sativus*, much suitable germplasm is already identified.

Protein content and quality : The mean protein content in *L. cicera* and *L. sativus* is 25 and 27%, respectively, from samples across a wide range of locations (Table-4). These are higher than protein contents in old pea (23%) or faba bean (24%), but lower than in lupin (32%) (Pettersen et al., 1997) or soybean (42%; Ravindran and Blair, 1992). Chandna and Matta (1994) found the composition of seed protein in *L. sativus* to be: albumins (14%), globulins (66%), glutelins (15%) and prolamins (5%); similarly; Duke (1981) also quotes values of 26, 53, 15 and 6%, respectively.

Animal feeding studies : As for human food there are many historical references to the use of *Lathyrus* spp. as animal feed or fodder, principally *L. sativus*, *L. cicera*, *L. ochrus* and *L. clymenum*. Use of *L. sativus* is referred to by

Columella in the first century A.D. (PenãChocarro and Zapata Penã, 1999). Because of concerns of human lathyrism there has been an emphasis in many countries to develop *L. sativus* cultivars with lower ODAP levels (Roy et al., 1993; Campbell et al., 1994) with some success. Consequently, recent animal feeding studies have been able to both quantify the amount of ODAP in the diet and provide a low ODAP intake at higher inclusion rates of *L. sativus*. Due to the possible high variability in ODAP content in the lines used in older studies their results should be interpreted cautiously. Lathyrism can occur in both monogastrics and ruminants. Whether this can be avoided in low ODAP *Lathyrus* spp. lines and what constitutes a safe dose of ODAP in any species of animal is not certain. Observations on the effects on different animal species when fed on *Lathyrus* spp. of unknown ODAP content differ. There is some evidence that rumen micro-organisms may be able to degrade ODAP. Horses are noted as being very susceptible to lathyrism with symptoms of paralysis of the hind limbs and sometimes dying, following heavy grazing or feeding on *Lathyrus* spp. seed (Stockman, 1932; Steyn, 1933; LoãpezBellido, 1994). There is anecdotal evidence of pigs, sheep and cattle having died due to lathyrism after being turned into *Lathyrus* spp. fields (Stockman, 1932). He also claims that pigs may thrive on a pure diet of *Lathyrus* spp. seed, despite developing weakness in the hind legs. Monkeys can be affected similarly to humans by consumption of *L. sativus* and death sometimes results (Rao et al., 1967). It is reported that many species of birds are readily affected by lathyrism when consuming *Lathyrus* spp. seed (Stockman, 1932), although Franco Jubete (1991) reported that in Spain doves fed avidly on *L. cicera* with no obvious ill-effects. Lewis et al. (1948) fed *L. sativus* to young rats at 50% of food intake for 7 ± 21 weeks and did not induce any lathyrism symptoms, growth rates were similar to those fed a diet based on field peas. Basu et al. (1937) found no lathyrism symptoms in rats fed 15% *L. sativus* for 8 weeks, growth rates were lower than those fed field peas.

Although levels of ODAP were not reported in the above mentioned studies, evidence exists indicating that rumen microflora adapt to ODAP and break it down. Bacteria have been isolated from soil sludge which can use ODAP as their sole carbon and nitrogen source (Yadav et al., 1992). In sheep, tolerance to *L. sylvestris* in their diet seems due to changes in the rumen contents (Rasmussen et al., 1992), presumably increasing breakdown of DABA, a neurotoxin chemically similar to ODAP (Fig.-1). Fermenting *L. sativus* seeds with *Aspergillus oryzae* and *Rhizopus oligosporus* for 48 h each has been shown to reduce ODAP concentration by >90% (Kuo et al., 1995). Farhangi (1996) incubated *L. sativus* and *L. cicera* grain in sheep rumen fluid and

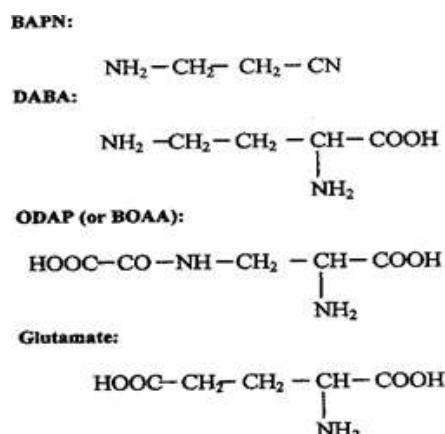


Fig.-1 : Chemical diagrams of b-aminopropionitrile (BAPN), L-2,4-diaminobutyric acid (DABA), 3-(N-oxaly) L-2,3-diamino propionic acid (ODAP or BOAA) and glutamate.

reported a rapid disappearance of ODAP (>90% in 4 h), supporting the idea that certain rumen microorganisms can destroy the toxin. Using *L. sativus* lines of seed with a ODAP content of 0.08%, no symptoms of lathyrism were observed in donkeys, pigs or sheep when fed as 50±80% of daily intake for 180±250 days (Chen referred by Campbell, 1997); details are not available.

Low et al. (1990) found that inclusion of low ODAP *L. sativus* grain at 82% of the diet for up to 4 weeks (commenced at age 7 days) did not induce any symptoms of lathyrism in chickens. Control chickens fed a wheat/soybean based diet grew more rapidly. The ODAP concentration in the seed used was not measured, although the line was known to have low levels (mean 0.13%), low variation within a line is consistent in this *L. sativus* (30%; Hanbury et al., 1999). Rotter et al. (1991) fed high (0.27%), medium (0.22%) and low (0.13%) ODAP lines of *L. sativus* to chickens at 20±80% of the diet. They found that an increased proportion of *L. sativus* seed in the diet of young chickens decreased weight gain, feed intake and efficiencies of feed conversion (feeding commenced at age 7 days). At 20 and 40% proportions there were minor or no differences to a wheat/soybean diet. However, using 0.27% ODAP seed generally resulted in decreased weight gain, feed intake and efficiencies of feed conversion, compared to lower ODAP seed. Since increasing the proportion of *L. sativus* above 40% (irrespective of ODAP concentration) also affected the chickens it can be concluded that there were ANFs in the seed (other than ODAP) which were not characterized.

Castell et al., 1994 indicated that the pig feeding with ODAP concentration (0.09%) reduced growth rates using *L. sativus*. Poultry seem able to tolerate up to 40% of their diet of *L. sativus* of moderate ODAP concentrations (0.27%) with minor reductions in growth. Above 40%

there appears to be significant effects of ANFs other than ODAP. (C.D. Hanbury et al., 2000).

Both pigs and poultry showed depressed performance when high ODAP (0.27%) *L. sativus* line were fed. Whether this was due to ODAP or other ANFs in the Canadian varieties used is unclear. Further characterization of the ANFs in both *L. sativus* and *L. cicera* is necessary to separate the effects of ODAP from those of other ANFs. Until this is performed higher ODAP lines (0.15% or higher) should be avoided. Both pigs and poultry showed depressed performance when high ODAP (0.27%) *L. sativus* line were fed. Whether this was due to ODAP or other ANFs in the Canadian varieties used is unclear. Further characterization of the ANFs in both *L. sativus* and *L. cicera* is necessary to separate the effects of ODAP from those of other ANFs. Until this is performed higher ODAP lines (0.15% or higher) should be avoided (Hanbury, et al, 2000).

The serious consequences of lathyrism for animals means that caution must be exercised in feeding recommendations. There is sufficient evidence to justify the conclusion that safe feeding levels over extended periods are possible with the reduced ODAP levels of cultivars and germplasm now available. However, reduction in animal growth rates due to both ODAP and other ANFs have been recorded. Similarly to other commonly used grain legumes, the heating *L. sativus* will reduce the level and activities of the proteinaceous ANFs, which are particularly important for the monogastric species, also with possible reductions in ODAP content (Hanbury et al., 2000). Little improvement in ANFs (other than ODAP) has been attempted in breeding of *L. sativus*. The improvement of cultivars is possible in a short time frame, given the variation already recorded and available to breeding programs, particularly in *L. sativus*. Experience with other species of grain legumes indicates that variation in the known ANFs will be present in the germplasm. The germplasm for *Lathyrus* species is large, to date relatively unutilized and this *L. sativus*, are highly variable. Compositions of *L. sativus* are generally similar to field pea; apart from the presence of ODAP, and their generally higher protein and ANF levels. Feeding data already shows that current cultivars can perform as well as industry standard ingredients. This indicates that rapid exploitation of these species in the feed industry is possible given experimentally established feeding recommendations. Since *L. sativus* are well adapted to large areas of southern Australia and other Mediterranean-type environments, the effectiveness of a rapidly developed market for grain would be one incentive for growers in these areas to adopt these crop options, particularly for those attempting to replace pasture legume rotations with low input grain legume crops.

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Methodologies for the Analysis of Repeated Measures : A Review

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Abstract

The term repeated measurements refer broadly to the data in which the response of each experimental unit is observed on multiple occasions. In agricultural experiments repeated measurements design is of great importance like in dairy cattle experiments sometimes repeated measurements are inevitable. The main feature of repeated measurements is that observations are taken on the same experimental unit over the time and thus these are correlated and hence conventional methodologies are not applicable for the analysis of repeated measures. In this paper, we have discussed the methodologies available in the literature for the analysis of repeated measurements i.e. univariate analysis of variance (ANOVA), summary statistic, multivariate analysis of variance (MANOVA), growth curve, mixed model, generalized estimating equations (GEE) and weighted least square with their advantages and disadvantages.

Introduction

Repeated measurements are the multiple observations from each experimental unit which is obtained by exposing all the experimental units to all the treatment conditions. It is also known as within subject design. Repeated measurements designs are more widely used in clinical trials, nutrition experiment with dairy cattle, long term agricultural field experiments. The key strength of repeated measurements is that it economizes on experimental units. This is the only type of design in which an experimental unit acts as its own control and does help to obtain information regarding the pattern of change in that particular experimental unit. Repeated measurements design often provide most efficient estimator of the population parameter than other types of design with the same number of measurements because in repeated measurements design variation between experimental units can be excluded from the overall experimental error (Davis, 2002 & Ma *et al.*, 2012). Repeated measures are extensively used in clinical trials (Ye and Bekele, 2018), nutrition experiments with animals (ZoBell *et al.*, 2003, Ammu *et al.*, 2018 and Zhao *et al.*, 2019), long-term agricultural field experiments and behavioral research.

Repeated measures and longitudinal data are often used interchangeably. But, some authors have differentiated them. According to them longitudinal data is referred to data collected over a prolonged period of time i.e. time series data whereas repeated measurements are made over short period of time under controlled experimental conditions (Davis, 2002). The sole independent factor in time series data is time whereas in repeated measures independent factors could be different treatment conditions and time often gets confounded with treatment effects.

The peculiarity of repeated measures is that they tend to be correlated as measurements are repeatedly made on the same experimental unit (Park and Woolson, 1992, Bakdash *et al.*, 2017). So, the existing statistical techniques for independent data cannot be used on repeated measures directly. Most of the statistical techniques available for the independent observations have been modified by various researchers to adjust for the related observations in the repeated measurements. The best method shall account for the correlation among repeated measurements.

The missing observations are prevalent in repeated measurements. Before selecting an approach for the analysis of repeated measures with missing data, mechanism of the missing data should be taken into consideration to avoid bias in the estimation of parameters. Three types of mechanisms for missing data have been defined by Little and Rubin (2019): missing completely at random (MCAR), missing at random (MAR), missing not at random (MNAR). Missing data mechanism is MCAR type when the missing values depend neither on observed data nor on unobserved data. It is MAR when the missing values depend on the observed data but not on the unobserved data and MNAR when the missing value rely on both observed data and unobserved data. MCAR and MAR mechanisms do not cause much of an issue in the analysis of data and can be considered ignorable as no information is required on the missing values. MNAR mechanism on the other hand is quite difficult to deal with.

Before applying any statistical approach, data should be checked for linearity of data, homogeneity of variances, missing observations, whether response variable is continuous or discrete. After data at hand

satisfies all the assumptions of an approach then only that particular approach should be implemented.

In this paper an attempt has been made to systematically review available techniques from conventional to modern for the analysis of repeated measurements along with their respective assumptions, advantages and limitations.

Research Methodologies

Univariate analysis of variance : The most common method for the analysis of repeated measurements data is the conventional univariate analysis of variance (ANOVA) (Lix & Keselman, 2019). The univariate analysis of variance is old, but is still often used. When its assumptions are satisfied, it is a very powerful test in terms of detecting an effect when one is present (Keselman *et al.*, 2001). Repeated measurements for a particular experimental unit are correlated as they experience the common influence from the experimental unit, it violates basic assumption of analysis of variance (ANOVA) of independence of observations (Park *et al.*, 2009 & Wallenstein *et al.*, 1982). Therefore, in order to employ univariate analysis of variance (ANOVA), condition of sphericity has to be satisfied. Sphericity condition means that the variance of difference among all the pairs of treatments is same irrespective of the difference between measurements (Keselman *et al.*, 2001). According to Keselman and Rogan (1980) and Vasey and Thayer (1987), the F-values will be inflated if the assumption of sphericity is not satisfied, there will be increase in Type I error rate, which will result in the false rejection of null hypothesis. Sphericity is a more general criterion for the validity of F test for repeated measures. It is the necessary and sufficient condition for F test to be valid. Mauchly's test is used to check for the significance of sphericity (Mauchly, 1940). Compound symmetry is a related condition of sphericity. Condition of compound symmetry is satisfied when variance and covariance of all pairs of treatments remains constant (Huynh and Feldt, 1970). Compound symmetry is a sufficient condition for F test to be valid it is not a necessary condition. If the condition of sphericity is satisfied by a covariance matrix then it also satisfies the condition of compound symmetry (Huynh, 1978). In order to minimize the misuse of repeated measures ANOVA Park *et al.* (2009) gave the correct use of it along with several follow up comparison tests. When the assumption of is not satisfied then various corrections are made to the degrees of freedom of F test and methods like Greenhouse-Geisser and Huynh-Feldt can be used (keselman *et al.*, 2001) keselman. In case of violation of sphericity, small sample size and large number of measurement occasions, Haverkamp and Beauducel (2017) recommended use of repeated of measures analysis of variance with Huynh-Feldt-correction.

Also, in some cases, repeated measurements obtained are non-linear which cannot be dealt by univariate analysis of variance (Kristensen and Hansen 2004) and also analysis of variance (ANOVA) cannot deal with treatment effects that do not remain constant over time (Ballinger, 2004) Univariate analysis of variance cannot handle missing data, if there is missing data corresponding to a subject then that subject is required to be discarded completely from the analysis (Graham, 2009). In most of the situations, repeated measures fail to fulfill the basic assumptions of univariate analysis of variance (ANOVA) like homogeneity of variances, independence and normality of data and, therefore, in those situations it is wise to consider more robust methodologies available for the analysis of repeated measures data.

In order to minimize the misuse of repeated measures ANOVA Park *et al.* (2009) gave the correct use of it along with several follow up comparison tests.

Summary statistics approach : The summary statistics approach transforms the correlated repeated measurements data into a set of independent summary statistic (Mathews *et al.*, 1990 & Ghosh *et al.*, 2006), which is the main advantage of this approach over conventional univariate analysis of variance approach. Standard methods available for independent data can be used on repeated measurements once they have been transformed into summary statistic (Albert, 1999). The first use of summary statistic was documented by Wishart in 1938. A great care should be taken while choosing summary statistic. Arithmetic mean could be proper choice for summary statistic when treatment effects do not vary much over time and regression coefficient, $\hat{\alpha}$ could be an appropriate choice when treatment effect is not steady over time (Senn *et al.*, 2000), or correlation coefficient, r . It is most appropriate to use summary statistic approach when a large, equal and complete data is obtained from each experimental unit. Ordinary Summary statistic approach cannot be used when each experimental unit do not contribute the same number of measurements. In such cases weighted analysis of summary statistic is used (Matthews, 1993). Univariate summary statistic approach can be extended to multivariate summary statistic approach, where multiple statistics are required to summarize the data (Ghosh *et al.*, 1973). Summary statistic approach can also be extended to ordered categorical variables (Carr *et al.*, 1989). When used for the analysis of linear trend repeated measures, summary statistic approach seemed to out done other approaches (Vossoughi *et al.*, 2012). Main disadvantage of this approach is that misleading results can be obtained if the summary statistic selected does not describe each subject's data adequately. There is loss in the information

as the data is not analyzed in its original form. Moreover, obtained estimates are not random variables.

Multivariate approach : Considering the problem of loss of information faced in summary statistic approach, it is wise to analyze the data in its original multivariate form. Unstructured multivariate approach can be used for analysis of repeated measures. This approach assumes normality of observations. This approach is flexible in the respect that it does not require data to satisfy assumptions regarding the covariance matrix of the multivariate normal distribution (Davis, 2002). So, Multivariate analysis of variance (MANOVA) which was first used for repeated measurements by Cole and Grizzle in 1966 can be preferred when assumption of sphericity is violated in univariate analysis of data (Everitt, 1998). Repeated measures MANOVA almost has same limitations as that of repeated measures ANOVA i.e. like ANOVA, MANOVA cannot handle repeated measures when the data is missing, treatment effects change considerably over time, time intervals are not equally spaced (Schober, 2018). The main advantage of unstructured multivariate repeated measures approach over conventional univariate approach is that it makes fewer assumptions regarding the data, but conventional approach is more powerful in the situations where all its assumptions are met (Kumar *et al.*, 2013). When the number of time points at each observations are taken is large, unstructured multivariate approach is not appropriate as too many parameters will have to be estimated which could result in low power (Wolfinger, 1996). The biggest disadvantage of repeated MANOVA is that it fails to apply post hoc test on the factor. Multivariate approach should be preferred in the situations where there is no missing data and the condition of sphericity is violated (Armstrong, 2017).

Repeated measurements are ordered naturally, so it may be of interest to characterize trend over time using low order polynomials. When number of repeated measurements is large, reduction to a lower order polynomial is very useful. So, we can estimate substantive model for the response. This approach is called growth curve analysis and was proposed by Potthoff and Roy (1964). This is the extension of standard MANOVA model. An alternative approach for this was developed by Rao (1965) and Khatri (1966). Growth curve analysis approach has been extended to accommodate missing data (Kleinbaum, 1973). A comprehensive explanation of this topic has been given by Pan and Fang in 2002. Growth curve analysis is comparatively unused approach because people are not yet familiar with its methodology but there has been increase in the consideration of growth curve modeling in the analysis of repeated measurements. In growth curve model approach, time is treated as continuous variable. Growth

curve models are more appropriate to use when data is unbalanced (Liu, 2012).

Mixed model approach : This approach so far is the most reliable and modern approach for the analysis of repeated measures data as it overcomes the most important drawbacks of the previously discussed approaches. Linear mixed model for repeated measurements was proposed by Laird & Ware in 1982. The linear mixed model is written as

$$Y = X\beta + Z\gamma + \epsilon$$

Where, Y is a vector of order $n \times 1$, X is a $n \times p$ matrix, β is a $p \times 1$ vector of fixed effects, Z is a given $n \times q$ matrix and γ is unobservable vector of order $q \times 1$. ϵ is the vector of random effects and γ is the vector of random effects, hence the name mixed model (Schober *et al.*, 2018).

γ and ϵ are the random components of the model and are assumed to be uncorrelated and following assumptions are made concerning these

$$E(\gamma) = 0$$

$$\text{Var}(\gamma) = B$$

$$E(\epsilon) = 0$$

$$\text{Var}(\epsilon) = W$$

In this model, the error terms, are not necessarily assumed to be independent and can have arbitrary covariance matrix.

$$E(Y) = X\beta$$

$$\text{Var}(Y) = ZBZ' + W$$

As repeated measurements are tend be correlated and are likely to not have homogeneous variance and therefore have complex covariance structure. In this case, the traditional approaches, univariate ANOVA and multivariate ANOVA do not perform well as the basic assumptions of homoscedasticity for analysis of variance and independence of observations are violated. Therefore, for repeated measures it is best to employ mixed model approach as it does not assume independence of error terms and also describes the complex covariance structure of repeated measures which is not taken into account by fixed and random model approaches. In linear mixed model, fixed effects are used to model the means and random effects are used to model residuals as they vary from one individual to another (Edwards 2000 & Liu *et al.*, 2012). Mixed model approach is preferable in the situations when observations are missing (Edwards, 2000 & Livera *et al.*, 2014) and the repeated measures are not spaced regularly. Also this approach has potential to treat time as categorical or continuous variable or both because of which analysis repeated measures data with unequal

entry is possible (Krueger and Tian, 2004). The estimates obtained by mixed models are unbiased and efficient under missing completely at random (MCAR) and missing at random (MAR) mechanisms.

An appropriate covariance structure that fits the data at hand can be selected from the following covariance structures with the help of Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) (Shukla and Kumar, 2012)

Variance Components : The VC structure is the standard variance components and is the default

$$\begin{matrix} & 2 & & & \\ & A & & & \\ 0 & & 2 & & 0 \\ & & B & & \\ 0 & 0 & & 2 & 0 \\ & & & AB & \\ 0 & 0 & 0 & & 2 \\ & & & & AB \end{matrix}$$

Autoregressive(1) : In AR(1) structure, the variances are homogeneous and the correlations decline exponentially with the distance.

$$\begin{matrix} & & 2 & & 3 \\ & & & & 2 \\ 2 & & & & \\ & 2 & & & 1 \\ & & 3 & 2 & \end{matrix}$$

Compound Symmetry : In CS structure, the variances are homogeneous and covariances are homogeneous.

$$\begin{matrix} 2 & 2 & 2 & 2 & 2 \\ & 1 & & & \\ 2 & & 2 & 2 & 2 \\ & & 1 & & \\ 2 & & 2 & 2 & 2 \\ & 1 & & 1 & \\ 2 & & 2 & 2 & 2 \\ & 1 & & 1 & 2 \\ 1 & & 1 & & 1 \end{matrix}$$

Unstructured : It is the most liberal structure of covariance in which neither the variances nor the covariances are equal.

$$\begin{matrix} 2 & & & & \\ 1 & 12 & 13 & 14 & \\ & 2 & & & \\ 12 & & 23 & 24 & \\ & & 2 & & \\ 13 & 23 & 3 & 34 & \\ & & & 2 & \\ 14 & 24 & 34 & 4 & \end{matrix}$$

Toeplitz : The TOEP structure is similar to the AR(1) in that all measurements next to each other have the same correlation.

$$\begin{matrix} 2 & & & & \\ & 1 & 2 & 3 & \\ & & 2 & & \\ 1 & & & 1 & 2 \\ & & & 2 & \\ 2 & 1 & & & 1 \\ & & & & 2 \\ 3 & 2 & 1 & & \end{matrix}$$

The mixed model approach works better compared to the conventional univariate ANOVA and multivariate ANOVA approaches (Wang and Goonewardene, 2004). Multivariate analysis of variance, MANOVA is highly

resistant to the violation of any assumption during the analysis of repeated measures data but mixed model modeling is more flexible approach as it enables users to define a covariance structure of their choice. It can also model non-linearity of the data (Krueger and Tian, 2004). Thus, this approach is more efficient and has high statistical power for both small size and incomplete data (Ma *et al.*, 2012 & Maurissen and Vidmar, 2017).

However, linear mixed models can give inaccurate results and are not robust any longer if the covariance structure for error terms specified is not appropriate (Vossoughi *et al.*, 2012, Detry & Ma, 2016). Therefore, great care should be taken by user while specifying the covariance structure for error terms.

Generalized estimating equations : None of the methodologies discussed above can be recommended for a general settings i.e. they cannot be applied when the response variable is not continuous. Generalized estimating equation is an extension of general linear model to the situations where data is not normally distributed and measurements are correlated. Therefore, this approach can be applied to analysis repeated measures data in the situations when response variable is continuous or categorical (Lipsitz *et al.*, 2000), when the measurements are correlated and when data is missing (Bell *et al.* 2018). The generalized estimating equations (GEE) method for the analysis of repeated measures was proposed by Liang Zeger (1986). It is an extension of quasilielihood to longitudinal data.

Generalized estimating equations can also deal with the data missing at random (MAR) (Robin *et al.*, 1995 & Paik, 1997). Two methods have been proposed by Beunckensa *et al.* in 2008 for the analysis of incomplete binary longitudinal data with missing at random mechanism (MAR). First method is weighted generalized estimating equations (WGEE) and second is multiple imputation generalized estimating equations (MI-GEE), in which first the missing is estimated using multiple imputations and then generalized estimating equations is applied. For small to moderate sample size MI-GEE method is more appropriate than WGEE method.

The misspecification of covariance structure in generalized estimating equations still results in unbiased and consistent estimators but may cause loss of efficiency of the estimators of the mean parameters. Ye and Pan (2006) proposed an approach for joint modelling of the mean and covariance structures of longitudinal data in context to framework of generalized estimating equations which yields consistent, asymptotically normally distributed and efficient estimators for both mean and covariance parameters. A statistical criteria for choosing correlation matrix for generalized estimating equations (GEE) was given by Ziegler and Vens in 2010.

Generalized estimating equations (GEE) with a stabilized working correlation matrix via linear shrinkage method was proposed by Kwon *et al.* in 2017. There are two criteria given by Fu and Wang in 2017 for selecting an appropriate correlation structure in the generalized estimating equations, even for irregularly timed measurements. Liu *et al.* (2014) gave 'weighted estimating equations (WEE)' for the estimation of correlation parameters to make up for the loss of efficiency of solutions due to misspecification of correlation matrix and suggested that this method works well for finite samples.

Generalized estimating equations (GEE) could be more efficient than linear mixed effects models for small and unbalanced longitudinal data (Chelsea *et al.* 2016) and is better for handling discounting data (Friedel *et al.*, 2019).

Weighted Least Square Method For Repeated Categorical Data : The first general approach used for the analysis of repeated categorical variable was weighted least square (WLS) methodology which was given by Grizzle *et al.* (1969). Weighted least square is the generalization of ordinary least square that allows for observations to be correlated and to have heterogeneous variance. WLS approach is free from the assumption of time dependency among repeated measurements. It is a useful approach that can be applied to the situations where response variable has small number of measurements and sample size is large.

Weighted least square approach can easily handle data missing completely at random (MCAR) (Stanish *et al.* 1978 & Woolson and Clarke, 1984). Taesung Park and Charles S. Davis (1993) used a test criterion by Wald to deal with the analysis of longitudinal categorical data when occurrence of missing observations depends on the unobserved outcome value (MAR) F. Lipsitz *et al.* (1994) described a two-step weighted least square method for analyzing repeated categorical outcomes that gives consistent results when the data is missing at random.

The estimates obtained by weighted least square method are unbiased and consistent. But confidence intervals for the parameters cannot be estimated as they are based on assumption of normality (Lanani, 2015).

Conclusion and Future Recommendations

If the assumptions of sphericity and compound symmetry are being satisfied and sample size is moderate then the conventional univariate analysis of repeated measurements should be preferred as it has more power. Summary statistics approach is useful when the data is large. When the covariance matrix associated is not spherical then multivariate analysis of repeated measurements is more applicable but post hoc test is not

available for the multivariate analysis of variance (MANOVA) so an attempt can be made to develop that. The linear mixed model (LLM) approach is so far the most preferred and successful as it is very flexible but gives biased results when the covariance structure is misspecified. Generalized estimating equation (GEE) is for both continuous and categorical response variable but GEE only models fixed effect and not random effect. Weighted least square methodology is the most commonly used method for the analysis of categorical data and gives unbiased and consistent estimates of parameters but this method fails when the sample size is small. Therefore, some modifications can be made in the present weighted least square method to make it applicable for small sample size data as well.

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Crafting a weed into a wonder—(*Lantana camara*)

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Lantana Introduction in India

Today it is one of the worst weeds in the world and acts as a major threat to native plants and animals. It belongs to the family Verbenaceae. It was initially brought to India in 1807 as an ornamental plant at the National Botanical Garden (Kohli et al., 2006), and as an ornamental hedge plant in Calcutta in the early 19th century (Hakimuddin, 1929). But later this plant spread out across all open areas along roadsides, railway tracks, edges of crop fields, and open forests all over the country.

Its leaves and flowers contain the toxins lantadene A and B, making them inedible to herbivores.

It releases chemicals that inhibit/slow down the growth of other plants (allelopathic effect), outperforming all other plants. Each plant can produce up to 12,000 seeds.

Each seed also remains dormant for up to 11 years, and exposure to smoke (perhaps wildfires) accelerates germination.

When cut down, new shoots (shrubs) emerge that grow much faster than the mother plant and form dense, impenetrable thickets.

Digging up the roots will allow many dormant seeds to germinate when exposed to disturbed soil, increasing the density of lantana in the area.

Biomass and Productivity

Now, it has become completely naturalized and is found throughout India. In the North West Himalayan region, lantana was introduced in 1905 in Kathgodam, district Nainital (Hakimuddin, 1929; Hiremath & Sundaram, 2005). It has invaded about 13.2 million ha in Indian pasture lands beside the forest and fallow areas. It is widely distributed in the tropical and sub-tropical zones including the protected forest areas of India. In some places, it has also entered temperate zones (Kimothi et al., 2010). In the Garhwal Himalaya (north India) also, two species viz., *Lantana camara* and *L. indica* have been found growing profusely in all habitats of the submontane and montane zone up to 2000 m altitude (Dobhal et al. 2010; Bisht et al., 2012). It is widely distributed in tropical and sub-tropical forests. *L. Camara* var. *aculeata* Moldenke known as *Lantana* wild sage is a low, erect, or sub-scandent woody perennial

shrub. In India around seven or eight species viz *L. camara*, *L. indica*, *L. veronicifolia*, and *L. trifolia* have been reported, besides species of horticultural value (Rajendran & Daniel, 2002). Three varieties of *L. camara* have been reported from India. These are *L. camara* var. *Aculeata moldenke*, *L. camara* var. *Mista bailey* and *L. camara* var. *Nivea bailey*. Amongst these *L. camara* var., *aculeata* is the most common. Numerous varieties and types of *L. camara* are found; some of them are polyploids. *L. camara* is of hybrid origin and is a polyploid complex. In India it is composed of polyploids ranging from $2x$ to $7x$ ($x=?11$) (Kumar & Subramaniam, 1986). There is marked variability in morphological features such as habit, thorniness, characteristics of leaf, flower, and inflorescence, and size of fruits among different populations of *L. camara*. The varieties and types are very difficult to differentiate on the basis of morphological features.

Litterfall and Nutrients

Total annual litter fall (leaf + wood + reproductive parts) in *L. camara* is reported 3.82 T/ha / year. 80% of it occurs during November to February in the Himalayan foothills in north India (Bhatt, 1990). Lantana leaves decompose completely in about 13-14 months (Negi & Kandpal, 2003) and contain high concentration of nutrients in leaves ($N=?1.71\%$ and $P=?0.09\%$). The total quantity of nitrogen contained in *L. camara* biomass was recorded 289.7 Kg ha⁻¹, and phosphorus (16 kg ha⁻¹), and the total N and P returned via litterfall was 57.3 and 3.1 kg ha⁻¹ yr.⁻¹, respectively, which is comparable to the mature climax forests of the sub-tropical and temperate climate of India (Singh, 1992). *L. camara* has greater influence on the functioning of the shrub community in terms of nutrient cycling with high quantity of N retranslocation from senescing leaves (73 kg ha⁻¹ yr.⁻¹) and high N concentration in leaf litter that may help it in outcompeting other species. High productivity of *L. camara* on degraded land with poor soil fertility may be related to high nutrient extraction efficiency, which is the extraction of nutrients in net primary productivity relative to nutrients in soil and higher retranslocation of nutrients from the foliage (Singh, 1992). Sharma and Raghubanshi (<http://www.designsystems.in/currentconservation>) observed that high N and low lignin content of *Lantana* litter and the favorable microclimate beneath *Lantana* canopies favour faster decomposition

and release of N leading to increase in soil N availability, N mineralization, and total soil N, leading to a positive feedback, and this, in turn, favours the growth of *Lantana*.

Lantana and Fire

Lantana has several characters that invites fire (Hiremath & Sundaram, 2005). It re-sprouts readily on being burnt (Pereira, 1919; Hakimuddin, 1929). The fire has favourable effect on the growth of *Lantana*. This not only increases coppicing potential of the species but also breaks the dormancy of the seeds and helps in massive new growth. *Lantana* affected with fire regenerate more vigorously than control (Joshi, 2002). Similarly, seeds exposed to surface fire have shown early sprouting than the seeds not exposed. Studies from other parts of the tropics confirm that *Lantana* may be favoured by disturbances such as fire and grazing (Duggin and Gentle, 1998; Gentle & Duggin, 1997). Climbing stems of *Lantana* can reach up to >20 m, getting into the forest canopy and resulting in crown fires when they burn (Tireman, 1916). *Lantana* has thus many adverse effects on forest ecosystems which include (i) loss of native biodiversity (Sharma et al., 2005; Day et al., 2003); (ii) replacing native plant communities in forests by forming dense impenetrable thickets, (iii) contributing to soil erosion (Day et al., 2003, FAO: <http://www.fao.org/forestry/media>), (iv) hampering regeneration of forests (Sharma et al., 2005; Day et al., 2003), (v) harbouring vectors that carry infectious diseases (Syed & Guerin, 2004) and (vi) promoting fire hazard (Hiremath & Sundaram, 2005).

Impact on Cattle

The leaves of *Lantana* are toxic to most animals. *Lantana* has been major contributors to poisoning of cattle, buffalo, sheep and goats. The plant is not relished by cattle but is reported to be browsed when pasturage is scarce. Cattle fed leaves (12-16 oz.) develop symptoms of severe jaundice, exfoliation of skin near muzzle, profuse salivation, severe dermatitis and appear dull (CSIR, 1962). The leaves and seeds of this species supposedly contain "Triterpenoids" which cause poisoning and photosensitivity. *L.camara* contains pentacyclic triterpenoids that cause hepatotoxicity and photosensitivity when ingested by grazing animals such as sheep, goats, bovines and horses. Palatability of *Lantana* leaves as fodder is least because of presence of toxic material lantadenes in its leaves, which is not reduced even after several weeks of anaerobic microbial reaction under silage making (Sastry & Mahadevan, 1963; Sharma, 1988; Sharma et al., 1980). In tropical countries, the ripe blue/black berries of *Lantana* are eaten, but ingestion of the green berry leads to human fatalities (Ross, 1999; Morton, 1994).

Economics of managing lantana

Eradicating lantana has been practiced religiously in several protected areas in tropical India, where on an annual basis, hectares of lantana invaded patches are either burnt, or are uprooted. Most of the time, the frontline forest staff works across the summer months in these forests manually uprooting this thorny plant one after the other. But, the impact of dealing with this plant on human health is little known, nor are the wages for these labours promising. The study also mentions that controlling lantana in one sq.km costs 14 lakh rupees and with the current expanse it would need 10 billion dollars more than the total funds allocated to the Ministry of Environment, Forest and Climate Change (MoEFCC), in the year 2019!

Allelopathic Effect

Allelopathy is a phenomenon in which chemicals released by the invasive plant discourage growth of native plants (Heirro & Callaway, 2003). It represents the plant-plant interactions, a part of chemical ecology. The success of *Lantana* in different environmental conditions could also be due to its allelopathic effect on other plants. *Lantana* disrupts succession, decreases biodiversity, and can reduce vigour of native plants due to allelopathy. The effect of *L. camara* aqueous leaf extracts of different concentrations shows significant inhibitory effect on germination, root and shoot elongation and development of lateral roots of food crops such as *Brassica juncea*, *Cicer arietinum*, *Cucumis sativus*, *Phaseolus mungo*, *Raphanus sativus* and *Vigna unguiculata*. The allelopathic effects of dried *Lantana* shoot residues on growth (shoot and root length and dry weight) over a 30-day period of wheat, corn, soybean, Virginia pepper weed and velvet leaf showed that corn was the most sensitive and wheat was least affected by *Lantana* residues (Mersie & Singh, 1987).

Positive Impacts of Lantana

Mulching for Soil Fertility : In spite of the invasive and allelopathic effects, *L. camara* provides a good covering to the ground with fine leaf mulch (Munir, 1996) that improves the fertility of rocky, grave, or hard laterite soils, and serves to retain humus in deforested areas and checks soil erosion (https://en.wikipedia.org/wiki/Lantana_camara). Leaves are rich in nitrogen (0.94%) and poor in lignin and decompose fast; thus leaves are good source of nutrients and can be utilized for biomass production in barren and infertile soils. The leaves and the twigs are occasionally used as green manure in forest areas and for paddy crops in Mysore; they can also be composted along with other materials. Analysis of green materials revealed N=?0.88%; P=?0.15%; K=?0.90%; and Ca=?0.61%. *Lantana* ash (ash content=?10.29%) is

rich in soluble potassium salts and useful for manuring coconut trees (Munir, 1996). It is also rich in manganese (0.3-0.4%), potassium (1.1–1.8%) and phosphorus (1.6–2.2%). The ash (10.9% of plant wt.) is rich in soluble potassium salts (Vasudevan & Jain, 1991) and enriches the soil (CSIR, 1962). In the Western Himalayan mountains in India several workers have found *Lantana* (leaf) mulch improving soil fertility and moisture retention (Acharya & Bhagat, 1984; Sharma & Acharya, 2000), enhance root growth, nutrient uptake and grain yield of maize and wheat (Acharya & Sharma, 1994). Sharma and Parmar (1998) found that mulching with Pine and *Lantana* increased the phosphorus-use efficiency and yield of wheat. *Lantana* mulching has been found to improve soil hydraulic properties to the benefit of the wheat crop in a rice-wheat cropping sequence (Sharma & Verma, 2000; Bhushan & Sharma, 2005).

Herbal Medicine : Presence of toxic compounds in certain *Lantana* spp. makes it an important species to study its phytochemistry. First systematic study on the chemical constituents of *L. camara* was undertaken in 1943 by P. G. J. Louw. The early work on *Lantana* spp. was concerned with studies on the essential oils; the maximum yield obtained by hydro distillation from the leaves reached 0.2% and, from the flowers, up to 0.6% (Ahmed et al., 1972, Gildermeister & Hoffmann, 1961). The chemical composition of essential oils obtained from *Lantana* depends on season, geographical location, and developmental stage of the plant (Randrianalijaona et al., 2005). *Lantana* has 31% hot water soluble fiber, 26% cellulose, 21% hemi-cellulose and 16.2% lignin of dry weight. Throughout the world studies on antibacterial properties of *L. camara* has been carried out extensively (Singh et al., 1990; Siddiqui et al., 1995; Deena & Thoppil, 2000; Mello et al., 2005; Verma & Verma, 2006). It is used as a sudorific, intestinal antiseptic, diaphoretic, and in treatment of tetanus and rheumatism and malaria in Indian medicine (Ojha & Dayal, 1992). Extracts from the leaves exhibit antimicrobial, fungicidal, insecticidal and nematocidal activity (Begum et al., 2000; Day et al., 2003; Girish, 2017). It is useful for fistulae, pustule and tumours. A decoction of the plant is given in tetanus, rheumatism, malaria and atoxy of abdominal viscera (CSIR, 1962). Pounded leaves are applied to cuts, ulcers and swellings. A decoction of leaves and fruits is used as a lotion for wounds. An infusion of leaves is taken internally for bilious fever and catarrhal affections, externally it is used in the form of lotion or fomentation against eczema eruptions and rheumatism. An infusion of flowers is given as pectoral for children (CSIR, 1962; Singh et al., 1984). Stems are used as tooth brush and leaves for polishing wood. While this plant has often described as ‘weed’, research community is exploring various uses of the plant, particularly potential of chemical constituents, such

as *Lantana* oil (Sharma & Sharma, 1989; da Silva et al., 1999). Plants in the Western Himalayan foothill zone of India yield 200 mg of essential oil (market price US\$ 91/kg) from hydro-distillation of 5 quintal of *Lantana* biomass. In addition to perfume ingredient, essential oil from the leaves possess adulticidal activity against the different mosquito species. Thus this species can be utilized for oil-based insecticides as supplementary to synthetic insecticides (Dua et al., 2010; Kumar & Maneemegalai, 2008). The leaves yield (0.2%) yellow and greenish yellow oil with a pleasant and lasting odour reminiscent of sage (*Salvia officinalis* Linn.) on steam distillation. On standing, the oil becomes viscous and insoluble in alcohol. The leaf oil is used in the treatment of itches of skin and also useful as an antiseptic for wounds. The bark of the stem and roots contain a quinine-like alkaloid, lantanine, with strong antipyretic and antispasmodic properties. Acid extracts of the shoots show antibacterial activity against *Escherichia coli*. Uses of *Lantana* extract as herbal medicine are known in the folk medicine (Sastri, 1962; Kirtikar & Basu, 2000; Ghisalberti, 2000) for the treatment of chicken pox, measles, asthma, skin itches, antiseptic for wounds, and externally in leprosy. Extracts of *L. camara* may be used for protection of members of brassicaceae family (e.g., mustard) against the aphid *Lipaphis erysimi* (Srivastava & Guleria, 2003). *Lantana* biomass could be utilized as fertilizer, energy, fuel wood, pulp, paper fiber and developing roofing material (NAS, 1981). It could be a good raw material for paper and pulp industry. The stalks have been tried as raw materials for paper pulp and contain furfuroids (21.6%), lignin (14.0%), cellulose (30.6%) and ash (3.50%).

Uses of *Lantana camara* in Ayurveda : *Lantana camara*, which belongs to the Verbenaceae family has been an important coniferous plant in ayurvedic and indigenous medicinal systems. The different parts of plant extract have been used for various illnesses.

Here are a few more *Lantana camara* uses : *Lantana camara* can be used as an eco-friendly and durable wood polymer composite for making baskets, foot mats and pen cases.

Success story

It was Ashoka Trust for Research in Ecology and the Environment, ATREE that envisioned the utility of *lantana* after taking a cue from one such effort in Mahadeshwara Hills (MM Hills) Uttarakhand. Soligas are the indigenous people of this region who traditionally depended on non-timber forest products (NTFPs) and subsistence farming to eke out a living. Their access to forest resources got restricted over time due to various reasons such as poor rainfall and government regulations. Hence they were forced to work as daily wage

labourers. Realising the need for developing sustainable alternatives for these forest-dependent people, a team of researchers at ATREE, who were studying the ecology of MM Hills, perceived lantana as a substitute for bamboo and cane, and stressed on skill development and capacity building to create different products from the plant.

The trust not only facilitated the training of a team of Soliga people but also helped them develop market linkages. Every month, the artisans spend a week in the forests collecting the stems of matured lantana (over six-years-old). The sticks are then boiled and the bark is peeled off. This raw material is sufficient for a month's work. One big armchair requires one bundle of the stem, weighing around 30 kg. This product costs around Rs 1,500. The artisans earn around Rs 300 per day from this activity and the monthly income is around Rs 6,000. Gradually, they began making different types of furniture which caught the imagination of people. Apart from its aesthetic appeal, the tag of being an eco-friendly alternative to wooden furniture has made lantana products sought after in offices and resorts.

Lantana furniture comes with the label of being low-cost, durable, resistant to termite and bedbugs. All these factors, coupled with the advantages of easy maintenance (a coat of varnish paint once a year) and aesthetic appeal, have increased the demand for this type of furniture. The artisans are proud that they have not got any complaints regarding the quality of the products so far. The artisans make customised products, over 30 types, and the orders are generally placed directly with the artisans. The craftspeople also participate in different exhibitions to popularise the concept and create awareness about its significance. A recent development is the use of lantana statues in public spaces like parks. Right now, Soliga artisans are making elephant statues on a bulk order. They also make customised toys and home decor items from lantana. The artisans have noticed the change locally. While the plants were available in abundance on the fringes of the forest earlier, now they have to go more than three kilometres inside the forest to collect the 'resource'.

The success of this experiment has made the concept spread among the forest-dependent communities in parts of Karnataka, Tamil Nadu and Kerala. ATREE and the Soligas train those who are interested in the craft. One such collaborative effort was coordinated by Junglescapes, a non-profit organisation, working in the Bandipur region.

Conclusion

Though it is not possible to destroy the species completely, but here's a way we can contain its spread and manage it in a better way, hopes that once a patch of forest is cleared of lantana, friendly species will reclaim the space before lantana sprouts again.

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Structural Changes in Input, Output and Prices of Soybean Across the Major Soybean Producing States in India

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Abstract

In India, soybean is predominantly grown as a kharif crop covering the states of Madhya Pradesh, Maharashtra, Rajasthan, Chhattisgarh, Telangana and Andhra Pradesh; on vertisols and associated soils. Madhya Pradesh, Maharashtra and Rajasthan are predominant states growing soybean. The specific objectives of this project are to find out the trends in the costs and returns from soybean to throw light on the impact on the profitability of soybean farming of India. The total cost of cultivation has increased with highest annual rate of 6.35 in Maharashtra, followed by 5.3 per cent & 5.2 per cent in Madhya Pradesh and Rajasthan. The rate of growth in gross returns from soybean cultivation in Madhya Pradesh, Maharashtra and Rajasthan was 4.83, 4.88 and 3.96 per cent per annum, respectively. The rate of return over cost C2 in Madhya Pradesh, Maharashtra and Rajasthan indicated the negative returns from soybean cultivation in recent years. The decline in price realised was faster than the cost of production, and moved in a narrow range. The elasticity of yield increase was found to be higher on the cost of production in three major soybean growing states, where about 9 per cent of the cost of production can be reduced by increasing 5 and 10 per cent yield of soybean in Madhya Pradesh and Rajasthan while in Maharashtra the reduction of cost of production to the tune of 6 per cent is possible with increase in yield by 5 per cent.

Key words : Soybean, costs, rate of return, profitability, elasticity of yield.

Introduction

Soybean (*Glycine max*) plays an important role in edible oil economy and is the fastest growing oilseed crop globally. Soybean is a high value nutritive crop, hence plays a significant role in overcoming problems of food and nutritional insecurity, especially in developing countries. In India, soybean has emerged as a leading oilseed crop within about four decades of its introduction for commercial cultivation. In India, soybean is predominantly grown as a kharif crop covering the states of Madhya Pradesh, Maharashtra, Rajasthan, Chhattisgarh, Telangana and Andhra Pradesh; on vertisols and associated soils. Madhya Pradesh, Maharashtra and Rajasthan are predominant states growing soybean. Extreme variation in rainfall both in time and space acts as a major impediment in successful cultivation of soybean and realizing higher productivity coupled with level of technology adoption and other factors.

Sustained growth in crop production can be achieved provided the sustainable growth in profitability, fuelled with higher yield increase, outpaces the growth in cost of production. Sufficient returns from the crop encourage farmers to continue with the crop over the years in the cropping system and also affect changes in crop mix in the non-traditional areas. The question arises that whether cost of cultivation of soybean is rising or

profitability shrinking from crop? Against this backdrop, it is pertinent to understand the changes in cost of cultivation and profitability from soybean cultivation over time. The specific objectives of this project are to find out the trends in the costs and returns from soybean to throw light on the impact on the profitability of soybean farming of India.

Materials and Methods

The study was based on the time series data on cost of cultivation and input-output prices of soybean in three major soybean growing states viz; Madhya Pradesh, Maharashtra and Rajasthan. The data published by the Directorate of Economics and statistics, Government of India for the period of 1996 to 2019 was used for the analytical purpose. All the cost of cultivation of soybean and income related data have been converted into constant prices by deflating data using wholesale price index (with base year 2004-05).

Simple statistical tools were used for analysing the data. Cost structure was analysed by working out the share of input cost in the total cost of cultivation. The comparative analysis for cost of cultivation and profitability was done on the basis of the input use and output received in various states. The input use change, hike in input prices, increase in cost and profitability of soybean were estimated for different years.

The compound annual growth rates : (CAGR) of area,

production and yield of soybean for each decade were estimated by fitting a semi-log trend equation of the form

$$\ln Y = a + bt$$

Where,

y is the time series data (response variable) of inputs,

t is the trend term (explanatory variable)

The compound growth rate :

$$r = [(\text{Anti } \ln \text{ of } b) - 1] \times 100$$

Cost and productivity relationship : The inverse relationship between cost of production of soybean and the yield levels is expected. This hypothesis was tested by fitting the following regression model: $\log \text{CoP} = a + e \cdot \log y$

Where, a = constant, e = elasticity, CoP = real Cost of Production; and y = yield levels.

Results and Discussion

Changes in input and output levels : The changes in input use levels and output of soybean in three major soybean producing states is presented in Table 1 and Table 2. The important inputs used in cultivation of soybean are seed, fertilizers, manures, human labour and bullock labour. Table 1, shows that in Madhya Pradesh and Maharashtra the seed usage was found to be declined to 8.02 and 4.33 per cent over the reference year, while in Rajasthan, the seed usage found to be increased by 21.33 per cent over the reference triennium average in the year 1996-1999. The seed rate used in Maharashtra was about 74-78 kg ha⁻¹ while that in Madhya Pradesh and Rajasthan was 87-99 kg ha⁻¹ and 89 -112 kg ha⁻¹, respectively, which indicated the fact that the farmers in Rajasthan are using higher seed rate. The higher seed use may be on account of low germination of farm saved seed and farmers practice of narrow row spacing to keep dense population to suppress weeds. The higher seed rate not only adds to the cost of production but also affects yield realisation. Considering the fertilizer use across the three referred states, it was observed that over the base triennium average (year 1996-1999) the fertilizer use was increased to 15.43 per cent and 69.17 per cent in Madhya Pradesh and Maharashtra while it was declined to 64.57 per cent in Rajasthan. The application of plant nutrients was found to be less in MP and Rajasthan than the recommended dose of nutrients (20:60:40:20 NPKS), and is declining continuously in Rajasthan.

Although, the use of FYM was found to be very low as against the recommended dose of FYM i.e. 5 ton/ha in major soybean growing states, the manure use in soybean cultivation showed the increasing trend in all the three states to the tune of 59.31 per cent, 257.04 per cent

and 104.58 per cent, over the reference period. This indicated the positive inclination of farmers to use manures in Madhya Pradesh, Maharashtra and Rajasthan. The decline was observed in use of human labour which was 41.92 per cent, 9.20 per cent and 39.21 per cent over the reference year in all the three states under study so also the use of animal labour also showed the declining trend, the animal labour use was decreased to 92.77 per cent, 54.14 per cent and 88.29 per cent respectively in Madhya Pradesh, Maharashtra and Rajasthan. This decline in both the labour usage in three states may be attributed to increasing use of machine power for farm operations.

The triennium averages of yield (Qtls/ha) of soybean in three states under study are presented in Table 2. The table reveals that during 1999-2002 and 2002-2005, the per hectare yield of soybean was declined by 10.61 per cent and 13.92 per cent in Madhya Pradesh, while that in Rajasthan also it was 26.53 per cent and 11.97 per cent over the period of 1996-99. The lowest decline was in Maharashtra (8.08 per cent), while the highest decline in yield was seen in Rajasthan (22.76 per cent). From year 2002 onwards, the yield per hectare increased continuously up to 2014-2017. Maharashtra witnessed increase in average yield throughout the study period over the year 1996-1999.

Cost structure of soybean cultivation : The cost incurred on different cost components of soybean cultivation and their share in operational cost is presented in Tables-3 and 4. It is evident from the The operational cost of soybean cultivation (at 2004-05 constant prices) in Madhya Pradesh has increased from Rs. 6133.18 ha⁻¹ in TE 1996-99 to Rs. 18380.39 ha⁻¹ in TE 2017-20. Similarly, it has increased from Rs. 6115.54 ha⁻¹ in TE 1996-99 to Rs. 25413.51 ha⁻¹ in TE 2017-20, recently in Maharashtra, and from Rs. 5870.84 ha⁻¹ in TE 1996-99 to Rs. 18445.10 ha⁻¹ in TE 2017-20 in Rajasthan. The operational cost has increased fast in Maharashtra (6.91 per cent per annum) as compared to Madhya Pradesh (5.65 per cent per annum) and Rajasthan (5.35 per cent per annum).

Seed is an important item accounting for more than one-fifth of the operational cost of soybean cultivation in Rajasthan and Madhya Pradesh and about 13 per cent in Maharashtra..

The faster growth was observed in the cost of plant protection chemicals during the reference period in all the three states. The cost of plant protection chemicals was the highest and increased by more than by 41 per cent per annum in Rajasthan and it was around 16 per cent and 27 per cent in Madhya Pradesh and Maharashtra. The increase in expenditure on and proportion of cost for plant protection chemicals may be mainly on account of mono cropping of soybean. The continuous mono-cropping of

Year	Input Utilization														
	Madhya Pradesh						Maharashtra						Rajasthan		
	Seed (Kg.)	Fertilizer (Kg Nutrient)	Manure (Qtl.)	Human Labour (man Hrs.)	Animal Labour (Pair Hrs.)	Seed (Kg.)	Fertilizer (Kg Nutrient)	Manure (Qtl.)	Human Labour (man Hrs.)	Animal Labour (Pair Hrs.)	Seed (Kg.)	Fertilizer (Kg Nutrient)	Manure (Qtl.)	Human Labour (man Hrs.)	Animal Labour (Pair Hrs.)
1996-99	98.54 (100.00)	49.94 (100.00)	5.29 (100.00)	414.99 (100.00)	57.29 (100.00)	78.27 (100.00)	51.59 (100.00)	2.79 (100.00)	443.99 (100.00)	90.72 (100.00)	92.65 (100.00)	17.77 (100.00)	2.76 (100.00)	407.52 (100.00)	36.30 (100.00)
1999-02	95.98 (-2.60)	39.64 (-20.62)	4.14 (-21.79)	347.33 (-16.30)	48.12 (-16.02)	77.52 (-0.95)	78.30 (51.76)	6.94 (148.33)	612.99 (38.06)	81.17 (-10.53)	89.44 (-3.47)	16.58 (-6.70)	0.67 (-75.63)	323.70 (-20.57)	36.05 (-0.70)
2002-05	91.76 (-6.88)	41.53 (-16.83)	5.80 (9.57)	335.94 (-19.05)	49.10 (-14.30)	77.54 (-0.94)	64.00 (24.05)	5.32 (90.33)	489.93 (10.35)	82.91 (-8.61)	96.43 (4.07)	14.81 (-16.64)	2.22 (-19.54)	386.45 (-5.17)	18.88 (-48.00)
2005-08	88.73 (-9.96)	39.40 (-21.11)	5.39 (1.89)	337.18 (-18.750)	45.12 (-21.25)	78.17 (-0.13)	65.65 (27.24)	6.62 (137.11)	485.41 (9.33)	82.73 (-8.81)	99.33 (7.21)	3.84 (-78.37)	5.38 (94.81)	303.33 (-25.57)	18.29 (-49.62)
2008-11	87.08 (-11.63)	42.43 (-15.03)	6.45 (21.85)	312.45 (-24.71)	33.63 (-41.30)	77.18 (-1.39)	80.84 (56.69)	7.32 (161.93)	473.82 (6.72)	77.08 (-15.04)	88.98 (-3.96)	6.96 (-60.81)	5.48 (98.31)	232.64 (-42.91)	7.90 (-78.25)
2011-14	87.46 (-11.24)	44.40 (-11.09)	5.57 (5.23)	258.89 (-37.62)	15.91 (-72.23)	76.17 (-2.69)	92.60 (79.49)	7.99 (186.16)	447.12 (0.70)	49.83 (-45.07)	105.70 (14.08)	4.61 (-74.08)	5.87 (112.42)	257.05 (-36.92)	3.90 (-89.27)
2014-17	88.05 (-10.65)	50.64 (1.40)	8.40 (58.75)	252.69 (-39.11)	8.18 (-85.73)	74.86 (-4.36)	55.89 (8.33)	8.85 (216.83)	443.73 (-0.06)	31.53 (-85.24)	106.43 (14.87)	4.25 (-76.06)	5.81 (110.13)	184.37 (-54.76)	7.47 (-79.43)
2017-20	90.64 (-8.02)	57.65 (15.43)	8.43 (59.31)	241.02 (-41.92)	4.14 (-92.77)	74.88 (-4.33)	87.28 (69.17)	9.97 (257.04)	403.14 (-9.20)	41.61 (-54.14)	112.40 (21.31)	6.30 (-64.57)	5.65 (104.58)	247.72 (-39.21)	4.25 (-88.29)

soybean-wheat or soybean-gram in major soybean growing areas leading to fast depletion of soil health as well as providing opportunity as host for fast spread

The growth was observed in cost of machine labour used in Maharashtra (12.61 per annum) followed by Madhya Pradesh (9.61 per annum) and Rajasthan (6.98 per annum) indicating the replacement of human and animal labour in all the states. The replacement of animal labour was more rather than the human labour (Table-1) in all the three states signifying that the gradual shift towards mechanisation of soybean cultivation. Since, the mechanisation of agriculture is increasing and it is obvious that the animal labour has been replaced by machine power in this process. Fast growth in cost of plant protection chemicals, cost of machine power used, cost of seed and human labour was observed in cultivation of soybean in major producing states implying thereby that crop cultivation now requires more capital. The growth in operational cost of soybean cultivation was about 5.65 and 5.35 per cent per annum in Madhya Pradesh and Rajasthan, and 6.91 per cent per annum in Maharashtra.

The continuously increasing operational cost of soybean cultivation signifies that its cultivation is gradually turning out to be capital intensive and needs to be subsidised by similar yield increase. The operational cost of cultivation of soybean was almost identical in Madhya Pradesh and Rajasthan, whereas it was found to be on the higher side in Maharashtra mainly on account of higher use of both productive and protective inputs. The higher proportion of labour inputs and lower share of productive and protective inputs in operational cost of soybean cultivation in major soybean growing states was observed. This signifies that there was an increase in operational inputs due to an increase in wage rate, hiring charges of tractor and hike in diesel prices leading to curtailment in expenditure on productive or protective inputs or higher dependency on farm-saved inputs (especially seeds) due to a poor resource base. This phenomenon may also be adding to slow growth in soybean productivity.

Soybean Profitability : The total cost and returns (at constant 2004-05 prices) from cultivation of soybean for major growing states were worked out and presented on Table 4. The results indicated that growth in cost of cultivation

Table-2 : State-wise changes in output per hectare of soybean.

Year	State		
	Madhya Pradesh	Maharashtra	Rajasthan
1996-99	11.50 (100.00)	11.04 (100.00)	11.22 (100.00)
1999-02	10.28 (-10.61)	15.40 (39.53)	8.24 (-26.53)
2002-05	9.90 (-13.92)	13.39 (21.29)	9.88 (-11.97)
2005-08	11.71 (1.86)	14.10 (27.76)	12.98 (15.66)
2008-11	13.87 (20.64)	12.45 (12.78)	8.34 (-25.67)
2011-14	11.81 (2.70)	15.23 (38.02)	11.36 (1.28)
2014-17	10.40 (-9.57)	12.13 (9.88)	7.14 (-36.39)
2017-20	12.13 (5.48)	14.51 (31.44)	10.43 (-7.05)

* Figures in parenthesis are per cent of 1996-99.

of soybean outpaced the growth in returns from soybean in all major states.

The paid out cost (cost A2) in cultivation of soybean in Madhya Pradesh has increased from Rs 5091.50 per ha in TE 1996-99 to Rs. 15739.94 per ha in TE 2017-20, grown at the annual rate of 5.73 per cent. The total cost of cultivation has increased from Rs. 9520.93 per ha to Rs. 26317.60/ha, with an annual rate of 5.3 per cent. Whereas, the gross returns from soybean cultivation in Madhya Pradesh has grown at the rate of 4.83 per cent per annum.

In Maharashtra, The total cost cultivation was Rs. 8575.51/ha in TE 1996-99 which has increased to Rs. 35357.49/ha in the corresponding period with the annual growth rate of 6.35 per cent. The gross returns from soybean has increased from 10226.80/ha to 31061.17/ha, with an annual rate of 4.88 per cent, resulting in declining net returns over the period. The total cost of cultivation has increased from Rs. 8318.95 per ha to Rs. 21477.41 per ha. The paid out and total cost of cultivation of soybean in Rajasthan has increased by 5.07 and 5.23 per cent per annum, respectively from TE 1996-99 to TE 2017-10. Whereas, the gross returns from soybean cultivation in Madhya Pradesh has grown at the rate of 3.96 per cent per annum. From the results, it is observed that rate of returns over cost C2 from soybean cultivation in Madhya Pradesh and Maharashtra started declining steeply in recent years showing negative returns, while Rajasthan has rescued from the negative returns to positive returns in recent years.

When the increase in cost of cultivation is more than the rate of growth in value of output from crop, farmers may not be inclined to adopt recommended inputs mix for crop cultivation. Lower than recommended use of fertilizers and manures, main productive inputs, in soybean (Table 2) signifies this phenomenon. Reduction in use of increasing inputs leads to decline in crop productivity.

Cost of production and soybean productivity relationship :

It was hypothesised that the increase in yield would reduce the cost of production, thus expected an inverse relationship between cost of production of soybean and its yield. This hypothesis was tested using regression analysis and results are presented in Table 5. The results of the analysis revealed that there was inverse relationship in cost of production and productivity of soybean in major growing states. The cost of production of soybean can be reduced by about 8.6, 6.2 and 9.4 per cent with the 5 per cent increase in the yield level of soybean in Madhya Pradesh, Maharashtra and Rajasthan, respectively.

The analysis revealed that the elasticity of yield increase was found to be higher on the cost of production in three major soybean growing states, where about 9 per cent of the cost of production can be reduced by increasing 5 and 10 per cent yield of soybean in Madhya Pradesh and Rajasthan while in Maharashtra the reduction of cost of production to the tune of 6 per cent is possible with increase in yield by 5 per cent.

Conclusions

The total cost of soybean cultivation has increased with the annual rate of 5 to 6 per cent due to increase in cost incurred for plant protection chemicals, cost of seed and human labour. With 4 to 5 per cent per annum growth in gross returns from soybean cultivation in Madhya Pradesh, Maharashtra and Rajasthan, 5 per cent increase in yield of soybean in Madhya Pradesh and Maharashtra and 10 per cent in Rajasthan, cost of production of soybean can be reduced to 6 to 9 per cent. Therefore, as the productivity of soybean is the major factor in reducing the relative cost of production, it is recommended that the soybean producing farmers shall adopt the recommended package of practices, integrated pest

Table-3 : Changes in operational cost of soybean cultivation.

Inputs	1996-99	1999-02	2002-05	2005-08	2008-11	2011-14	2014-17	2017-20	CGR
Madhya Pradesh									
Seed	1286.83	1101.03	1515.98	1704.03	1717.22	2058.50	3057.60	3112.56	4.86 ***
Fertilizer	653.08	555.10	647.59	748.77	479.56	834.63	1223.06	1454.94	3.44 ***
Manure	192.26	176.35	261.90	382.47	422.31	390.31	949.81	1089.25	9.03 ***
Human Labour	2286.08	2260.54	2436.92	3364.45	3396.29	3700.22	5182.38	6136.63	4.97 ***
Animal Labour	670.29	821.82	1037.74	1283.74	835.13	459.38	419.51	343.37	-3.63 ***
Machine labour	759.31	713.49	941.92	1739.29	1926.44	2196.56	3385.57	4348.39	9.61 ***
Insecticides	123.25	112.48	189.59	318.42	556.45	987.41	1148.56	1428.32	15.64 ***
Irrigation charges	13.21	40.83	103.00	23.68	0.61	0.00	19.09	4.42	-11.2 *
Int. on WC	148.88	141.61	179.17	241.06	231.34	265.37	389.64	462.53	5.72 ***
Operational cost	6133.18	5923.25	7313.81	9805.91	9565.35	10892.38	15775.21	18380.39	5.65***
Maharashtra									
Seed	1386.80	1274.75	1621.41	1870.17	1944.30	2085.05	3494.69	3205.88	4.84 ***
Fertilizer	729.27	1131.27	937.83	1175.78	1031.41	1457.90	1899.49	2153.33	4.7 ***
Manure	59.84	223.20	277.26	491.26	502.21	992.90	1139.26	873.90	14.11 ***
Human Labour	2226.97	3380.23	2754.82	4082.01	4331.93	5980.46	8230.50	8992.08	6.96 ***
Animal Labour	1168.99	1995.20	3136.31	4583.82	3148.80	2137.07	2516.71	3077.42	3.51 **
Machine labour	342.34	1097.39	1440.88	2026.78	1996.58	3398.81	3883.70	4931.26	12.6 ***
Insecticides	34.15	34.15	34.15	34.15	34.15	34.15	34.15	34.15	26.96 ***
Irrigation charges	1.22	107.48	49.42	23.87	46.03	124.76	247.09	210.89	18.42 ***
Int on WC	165.96	256.33	300.79	412.90	372.35	453.49	602.82	693.97	6.63 ***
Operational cost	6115.54	9513.45	10644.97	14907.78	13778.87	17082.06	22863.29	25413.51	6.91 ***
Rajasthan									
Seed	1373.88	1061.25	1673.56	1914.02	2136.01	2511.02	3730.14	3319.29	5.84 ***
Fertilizer	281.33	223.33	222.51	71.49	74.45	257.78	353.44	287.95	0.8 NS
Manure	65.06	18.58	0.05	233.06	95.50	158.81	0.00	0.00	1.83 NS
Human Labour	2548.20	2229.53	2956.65	4126.76	4398.37	3942.78	6801.12	6900.93	5.35 ***
Animal Labour	579.18	799.97	1863.21	4583.82	3148.80	2137.07	2516.71	3077.42	9.09 ***
Machine labour	881.54	903.15	1159.73	2443.17	1658.44	2010.56	2581.17	3793.07	6.98 ***
Insecticides	3.16	5.89	47.94	229.20	524.60	585.74	956.48	677.39	40.96 ***
Irrigation charges	14.63	56.54	268.12	76.50	64.73	35.77	83.91	66.42	7.64 NS
Int. on WC	123.86	114.98	156.64	221.99	207.70	222.82	318.18	322.63	5.48 ***
Operational cost	5870.84	5413.21	8348.40	13900.02	12308.61	11862.35	17341.14	18445.10	5.35 ***

Table-4 : Soybean profitability.

Inputs	1996-99	1999-02	2002-05	2005-08	2008-11	2011-14	2014-17	2017-20	CGR
Madhya Pradesh									
Cost A2	5091.50	4965.20	6205.03	8365.26	7909.93	8929.75	13192.47	15739.94	5.73 ***
Cost B2	8300.82	8061.92	10249.07	13675.25	13638.31	14579.47	19175.20	22942.43	5.26 ***
Cost C2	9520.93	9312.05	11668.37	15534.27	15581.19	16727.30	22354.87	26317.60	5.3 ***
Gross Returns	11333.93	9646.20	12983.15	18272.67	20456.78	20108.90	21538.40	25383.59	4.83 ***
Returns over Cost A2	6242.43	4681.00	6778.12	9907.41	12546.85	11179.15	8345.93	9643.65	3.42 ***
Returns over Cost B2	3033.11	1584.28	2734.08	4597.42	6818.47	5529.43	2363.20	2441.16	
Returns over Cost C2	1813.00	334.15	1314.78	2738.39	4875.59	3381.61	-816.46	-934.00	
Rate of returns over cost A2	2.23	1.94	2.09	2.18	2.59	2.25	1.63	1.61	
Rate of returns over cost B2	1.37	1.20	1.27	1.34	1.50	1.38	1.12	1.11	
Rate of returns over cost C2	1.19	1.04	1.11	1.18	1.31	1.20	0.96	0.96	
Maharashtra									
Cost A2	5696.35	8682.88	10296.90	14053.45	12784.81	15291.32	20342.82	23388.22	6.19 ***
Cost B2	7936.77	11749.67	14169.88	19051.99	17247.62	21093.17	28593.45	32306.59	6.2 ***
Cost C2	8575.51	12804.22	14889.52	20333.91	18743.13	23214.60	31613.03	35357.49	6.35 ***
Gross Returns	10226.80	13892.12	15842.65	23010.58	18742.03	26551.80	25375.50	31061.17	4.88 ***
Returns over Cost A2	4530.44	5209.24	5545.75	8957.13	5957.22	11260.49	5032.68	7672.95	1.98 *
Returns over Cost B2	2290.03	2142.45	1672.76	3958.59	1494.41	5458.63	-3217.95	-1245.42	
Returns over Cost C2	1651.28	1087.90	953.13	2676.66	-1.10	3337.21	-6237.53	-4296.32	
Rate of returns over cost A2	1.80	1.60	1.54	1.64	1.47	1.74	1.25	1.33	
Rate of returns over cost B2	1.29	1.18	1.12	1.21	1.09	1.26	0.89	0.96	
Rate of returns over cost C2	1.19	1.08	1.06	1.13	1.00	1.14	0.80	0.88	
Rajasthan									
Cost A2	4535.82	4288.16	5516.07	8399.56	7052.85	7511.15	10792.48	10993.95	5.07 ***
Cost B2	6536.68	6040.07	8283.46	12418.88	10795.90	11913.51	15108.48	16258.73	5.2 ***
Cost C2	8318.95	7666.61	10186.34	15046.66	13059.15	14471.41	19717.47	21477.41	5.23 ***
Gross Returns	12409.62	8732.58	12393.99	20977.70	14506.46	19830.33	17202.41	23823.40	3.96 ***
Returns over Cost A2	7873.81	4444.42	6877.92	12578.13	7453.60	12319.19	6409.92	12829.45	2.89 **
Returns over Cost B2	5872.94	2692.51	4110.54	8558.81	3710.56	7916.82	2093.93	7564.66	
Returns over Cost C2	4090.67	1065.98	2207.65	5931.04	1447.31	5358.92	-2515.06	2345.99	
Rate of returns over cost A2	2.74	2.04	2.25	2.50	2.06	2.64	1.59	2.17	
Rate of returns over cost B2	1.90	1.45	1.50	1.69	1.34	1.66	1.14	1.47	
Rate of returns over cost C2	1.49	1.14	1.22	1.39	1.11	1.37	0.87	1.11	

Table-5 : Impact of change in yield on cost of production.

Period	Madhya Pradesh	Maharashtra	Rajasthan
1996-2019	-0.86**	-0.62**	-0.94***

*, ** and *** indicates that coefficients are statistically significant at 1, 5 and 10 per cent respectively.

and disease management techniques and farm mechanization.

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Impact of Front Line Demonstration on Practice Wise Adoption Level of Pulse Production Technology

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Abstract

The study was conducted in Jurisdiction of RVSKVV, Gwalior (M.P.). Two KVKs from Malwa and two KVKs from Gird agro climatic zones were selected randomly. Thus the total numbers of four KVKs were selected for the study. During investigation reveal that the 'Z' values were comparing improved variety (9.21), seed treatment (9.05), sowing time (8.74), fertilizer application (9.88), irrigation (9.18), weed control (10.37), plant protection (8.53) and harvesting and storage (8.07) indicating significant difference in between beneficiary and non-beneficiary farmers.

Key words : Beneficiaries, non-beneficiaries pulse growers and adoption level.

Introduction

Front Line demonstrations (FLDs) is a unique approach to provide an direct interface between researcher and farmers as the scientists are directly involved in planning, execution and monitoring of the demonstrations for the technologies developed by them and get direct feedback from the farmers' field about the crops like wheat, rice and pulses production in general and technology being demonstrated in particular. This enables the scientists to improvise upon the research programme accordingly. In FLDs, the subject matter scientists provide technological inputs to extension scientists to organize the demonstrations. Thus, FLDs provide an opportunity to researchers and extension personnel for understanding the farmer's resources and requirement to fine tune and/or modify the technologies for easy adaptability at farmers' fields. Frontline Demonstration is a form of applied research through ICAR/SAUs system on latest notified/released varieties along with full package of practices on selected farmers' fields with a view to demonstrate the potentiality of the technologies to (a) participating farmers (b) neighboring farmers and other agencies; (c) to analyze the production (d) performance of the technologies for scientific feedback.

Madhya Pradesh is the largest producer of pulses followed by Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh and Karnataka. These six states together contribute 79 per cent of pulses area and 80 per cent of pulses production. There are four states viz., Jharkhand, Orissa, Bihar and Chhattisgarh where ample scope exists to increase coverage and enhance

productivity of pulses as plenty of water is available to raise crops in different seasons and niche areas.

The knowledge farmers possessed and the adoption they attain has a bearing on the future progress of front line demonstration. Understanding of these behavioral aspects may help to predict the success and failure of this innovative program aimed at agricultural development in particular and strategy for transfer of technology in general. The constraints faced by the farmers in adoption of improved pulse production technology and their suggestions to overcome the same may help in developing appropriate extension and research strategy. Further, all the technologies demonstrated on farmers' field might have not been continued by the farmers. Some technologies might have been rejected by them. Therefore, it is necessary to know technologies rejected by them and the reasons for their rejection. This will help in understanding the lacunae in technology. Such lacunae can be communicated to the researcher for technology modification. Keeping in view the low productivity of pulses, it was considered worthwhile to find out how much this program had helped the pulses growers to bring about changes in terms of knowledge and adoption of improved pulse production technology and thereby increasing farm productivity the following objective was undertaken. To study the impact of Frontline demonstration on practice wise adoption level of pulse production technology.

Research Methodology

The study was conducted in Jurisdiction of RVSKVV, Gwalior (M.P.). RVSKVV Jurisdiction comprises of 24

KVKs of which 9 KVKs are in Malwa, 7 KVKs in Gird and remaining 4,2,1,1 KVKs in Nimad valley, Vindhaynchal plateau, Jhabua, Bundelkhand agro Climatic Zones respectively. FLD on chickpea is conducted in all the 24 KVKs. For the purpose of study, Malwa and Gird Agro-climatic zones were selected purposively because more than half of KVKs (16) are situated in both the Agro-climatic zones. The KVKs conducted a number of FLDs on pulse production technology. For judging the impact of FLDs on Pulse Growing Farmers, the chickpea crop was selected because it is one of the important pulse crops grown in all the agro-climatic zones of RVSKVV. Among the 9 KVKs in Malwa and 7 KVKs in Gird agro climatic zones, 2 KVKs from each zone were selected randomly. KVKs wise separate list of beneficiaries' farmers was prepared from the two selected agro-climatic zones. KVKs wise two separate lists of beneficiaries and non- beneficiary farmers were prepared from the two selected agro-climatic zones. Thirty beneficiary and thirty non-beneficiary farmers were selected randomly from each KVK with the help simple random sampling. Thus, a total of 120 beneficiary and 120 non beneficiary farmers were selected from four selected KVKs.

Results and Discussion

Adoption of improved pulse production technology by the beneficiary and non-beneficiary farmers : In presented Table-1 various farm practices of improved pulse cultivation were recommended to the farmers under front line demonstration includes improved variety, seed treatment, sowing time, fertilizer application, irrigation, weed control, plant protection, harvesting and storage. With a view to find out impact of front line demonstrations of adoption of improved pulse production technology, extent of adoption of each practice by the beneficiary farmers was compared with the adoption of such practices by non beneficiary farmers.

Practices wise adoption level of beneficiary according to their pulse production technology : As observed improved variety majority of the respondents (75%) had partial adoption, whereas 23.33 per cent had complete adoption and 1.67 per cent of the respondents had no adoption about improved variety.

In case of seed treatment, 71.67 per cent of the respondents had partial adoption, while 24.17 per cent respondents had complete adoption and 4.16 per cent had no adoption about seed treatment.

In relation to sowing of time majority of the respondents (78.33%) had partial adoption whereas, 18.33 per cent of the respondents had complete adoption and few percentage of the respondent had no adoption about sowing of time in pulse production technology.

Regarding recommended dose of fertilizers, majority

of the respondents (73.33%) had partial adoption followed by complete adoption (23.33%) and no adoption (3.33%) respectively.

In case of irrigation, 70.83 per cent of the respondents had partial adoption, while 27.5 per cent respondents had complete adoption and only 1.67 per cent had no adoption about irrigation.

In subsequently of kin to weed control more than half of the respondents (55%) had partial adoption and 44.17 per cent of the respondent had complete adoption and few percentages of the respondents had no adoption about weed control in pulse production technology.

In relation to plant protection majority of the respondents (69.17%) had partial adoption whereas, 28.33 per cent of the respondents had complete adoption and only 2.5 per cent of the respondent had no adoption about plant protection in pulse production technology.

As regards harvesting and storage, majority of the respondents (66.67%) had partial adoption, whereas 30.83 per cent had complete adoption and 2.5 per cent of the respondents had no adoption about harvesting and storage.

Practices wise adoption level of non-beneficiary according to their pulse production technology : As sensible improved variety more than half of the respondents (55%) had partial adoption, whereas 41.67 per cent had no adoption and 3.33 per cent of the respondents had complete adoption about improved variety.

In case of rate of seed treatment, 51.67 per cent of the respondents had partial adoption, while 45 per cent respondents had no adoption and 3.33 per cent had complete adoption about seed treatment.

In relation to sowing of time more than half of the respondents (54.17%) had partial adoption whereas, 43.33 per cent of the respondents had no adoption and 2.5 per cent of the respondent had complete adoption about sowing of time in pulse production technology.

Regarding recommended dose of fertilizers, majority of the respondents (50%) had no adoption followed by partial adoption (46.67%) and complete adoption (3.33%) respectively.

In case of irrigation, 55.83 per cent of the respondents had partial adoption, while 40 per cent respondents had no adoption and 4.16 per cent had complete level of adoption about irrigation.

In subsequently of kin to weed control more than half of the respondents (55.83%) had partial adoption and 37.5 per cent of the respondent had no adoption and 6.67

Table-1 : Practices wise adoption level of beneficiary and non-beneficiary according to their pulse production technology.

S. No.	Practices	Beneficiaries level of adoption						MN	S.D	Non-beneficiaries level of adoption						MN	S.D.	'Z' Value		
		Complete			Partial					Complete			Partial							
		F	%	F	%	F	%			F	%	F	%	F	%				F	%
		No				No						No							No	
1.	Improved variety	28	23.33	90	75.00	02	1.67	2.22	0.45	04	3.33	66	55.00	50	41.67	1.62	0.55	9.21**		
2.	Seed treatment	29	24.17	86	71.67	05	4.16	2.20	0.49	04	3.33	62	51.67	54	45.00	1.58	0.56	9.05**		
3.	Sowing of time	22	18.33	94	78.33	04	3.33	2.15	0.44	03	2.50	65	54.17	52	43.33	1.59	0.54	8.74**		
4.	Fertilizer	28	23.33	88	73.33	04	3.33	2.20	0.48	04	3.33	56	46.67	60	50.00	1.53	0.56	9.88**		
5.	Irrigation	33	27.50	85	70.83	02	1.67	2.26	0.47	05	4.16	67	55.83	48	40.00	1.64	0.56	9.18**		
6.	Weed control	53	44.17	66	55.00	01	0.83	2.43	0.51	08	6.67	67	55.83	45	37.50	1.69	0.59	10.37**		
7.	Plant protection	34	28.33	83	69.17	03	2.50	2.26	0.49	05	4.16	72	60.00	43	35.83	1.68	0.55	8.53**		
8.	Harvesting and storage	37	30.83	80	66.67	03	2.50	2.28	0.51	07	5.83	73	60.83	40	33.33	1.73	0.56	8.07**		

**Significant at 0.01 level of probability

S.D.= Standard Deviation

F= Frequency,

MN= Mean,

TS= Total Score,

per cent had complete adoption about weed control in pulse production technology.

In relation to plant protection majority of the respondents (60%) had partial adoption whereas, 35.83 per cent of the respondents had no adoption and only 4.16 per cent of the respondent had complete adoption about plant protection in pulse production technology.

As regards harvesting and storage, majority of the respondents (60.83%) had partial adoption, whereas 33.33 per cent had no adoption and 5.83 per cent of the respondents had complete adoption about harvesting and storage.

Impact of frontline demonstrations of the respondents according to their pulse production technology : With a view to find out impact of front line demonstrations of various practice wise knowledge level were compared with the beneficiaries and non-beneficiary farmers.

For comparison of practice-wise knowledge of improved pulse production technology, "Standard Normal Deviate Test" (Z test) was applied and results are presented in Table-1.

The data presented in Table 1 reveal that the 'Z' values were comparing improved variety (9.21), seed treatment (9.05), sowing time (8.74), fertilizer application (9.88), irrigation (9.18), weed control (10.37), plant protection (8.53) and harvesting and storage (8.07) indicating significant difference in between beneficiary and non-beneficiary farmers.

Overall practices wise distribution of the adoption level of farmers according to their pulse production technology : Practice wise level of adoption of recommended pulse production technology was ascertained in the respect of recommended practices and the data thus obtained have been reported in Table-2.

As regards improved variety majority of the respondents (65%) had partial adoption, whereas 21.67 per cent had low adoption and 13.33 per cent of the respondents had complete level of adoption about improved variety.

In case of seed treatment, 61.67 per cent of the respondents had partial adoption, while 24.58 per cent respondents had low adoption and 13.75 per cent had complete level of adoption about seed treatment.

In relation to sowing of time majority of the respondents (66.25%) had partial adoption whereas, 23.33 per cent of the respondents had complete adoption and 10.42 per cent of the respondent had low level of adoption about sowing of time in pulse production technology.

Table-2 : Overall practices wise distribution of the adoption level of farmers according to their pulse production technology.

S. No.	Practices	Level of Adoption						Total Score	Mean	Rank
		Complete		Partial		Low				
		f	%	f	%	f	%			
1.	Improved variety	32	13.33	156	65.00	52	21.67	460	1.92	V
2.	Seed treatment	33	13.75	148	61.67	59	24.58	454	1.89	VI
3.	Sowing of time	25	10.42	159	66.25	56	23.33	449	1.87	VII
4.	Fertilizer	32	13.33	144	60.00	64	26.67	448	1.87	VII
5.	Irrigation	38	15.83	152	63.33	50	20.83	468	1.95	IV
6.	Weed control	61	25.42	133	55.41	46	19.17	495	2.06	I
7.	Plant protection	39	16.25	155	64.58	46	19.17	473	1.97	III
8.	Harvesting & storage	44	18.33	153	63.75	43	17.92	481	2.00	II

Table-3 : Distribution of the farmers according to their extent of adoption of improved pulse production technology.

Level of adoption	Beneficiaries (n=120)	Non-beneficiaries (n=120)	Total (n=240)
Low (<25.62 score)	03 (2.50)	49 (40.83)	52 (21.67)
Medium (25.80-62.44 score)	84 (70.00)	66 (55.00)	150 (62.50)
High (>62.44 score)	33 (27.50)	05 (4.17)	38 (15.83)

(Figures in parenthesis indicate percentage)

Regarding recommended dose of fertilizers, majority of the respondents (60%) had partial adoption followed by low (26.67%) and complete (13.33%) respectively.

In case of irrigation, 63.33 per cent of the respondents had partial adoption, while 20.83 per cent respondents had complete adoption and 15.83 per cent had low level of adoption about irrigation.

In relation to weed control, majority of the respondents (55.41%) had partial adoption and 25.42 per cent of the respondent had complete and 19.17 per cent of the respondents had low level of adoption about weed control in pulse production technology.

In relation to plant protection majority of the respondents (64.58%) had partial adoption whereas, 19.17 per cent of the respondents had low adoption and 16.25 per cent of the respondent had complete adoption about plant protection in pulse production technology.

As regards harvesting and storage, majority of the respondents (63.75%) had partial adoption, whereas 18.33 per cent had complete adoption and 17.92 per cent of the respondents had low adoption about harvesting and storage.

Extent of level of adoption : The data indicated in Table-3 brings to glow about percentage distribution of the beneficiaries which reveals that out of total respondents, majority of the respondents (62.5%) had medium level of

adoption of improved pulse production technology, while 21.67 per cent had low level of adoption and only 15.83 per cent had high level of adoption of improved pulse production technology.

The data presented in Table-3 stated that only 2.5 per cent beneficiary farmers had low adoption of improved pulse production technology. Contrary to this, 40.83 per cent non-beneficiary farmers had low extent of adoption. On the other hand, only 4.17 per cent non-beneficiary farmers had high adoption against 27.5 per cent in case beneficiary farmers. Medium adoption was observed among 70 per cent and 55 per cent beneficiary and non-beneficiary farmers respectively. It can be thus concluded that majority beneficiary of FLD had medium to high adoption of improved pulse production technology.

Conclusion

The findings of the study pointed out that the reveal that the 'Z' values were comparing improved variety (9.21), seed treatment (9.05), sowing time (8.74), fertilizer application (9.88), irrigation (9.18), weed control (10.37), plant protection (8.53) and harvesting and storage (8.07) indicating significant difference in between beneficiary and non-beneficiary farmers. In the case of knowledge level reported that the medium level of adoption was observed among 70 per cent and 55 per cent beneficiary and non-beneficiary farmers respectively

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Analytical study of knowledge and adoption of Pulse Production Technology

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Abstract

Knowledge is a familiarity awareness or understanding of someone or something such as facts, information, description or skills which is acquired through experience or education by perceiving, discovering or learning. The study was conducted in Jurisdiction of RVSKVV, Gwalior (M.P.). Two KVKs from Malwa and two KVKs from Gird agro climatic zones were selected randomly. Thus the total numbers of four KVKs were selected for the study. During investigation reveal that the independent variables viz., education (0.54), land holding (0.23), gross annual income (0.32), sources of information (0.25), extension participation (0.24), economic motivation (0.28), risk preference (0.27), scientific orientation (0.37) and innovative proneness (0.38) were positively and significantly related with knowledge level of improved pulse production technology by the beneficiary farmers at 0.01 level of significance.

Key words : *Beneficiaries, non-beneficiaries pulse growers and adoption level.*

Introduction

Krishi Vigyan Kendra an innovative science based institution plays an important role in bringing the research scientist face to face with farmers. The main aim of Krishi Vigyan Kendra is to reduce the time lag between generations of technology at the research institution and its transfer to the farmers for increasing productivity and income from the agriculture and allied sectors on sustained basis. KVKs are grass root level organizations meant for application of technology through assessment, refinement and demonstration of proven produce technologies under different micro farming situations in a district. Front line demonstration is a long term educational activity conducted in a systematic manner at farmer's fields to prove the worth of a new practice/technology. Farmers in India are still producing crops based on the knowledge transmitted to them by their forefathers leading to a grossly unscientific agronomic, nutrient management and pest management practices. As a result of these, they often fail to achieve the desired potential yield of various crops and new varieties. The knowledge farmers possessed and the adoption they attain has a bearing on the future progress of front line demonstration. Understanding of these behavioral aspects may help to predict the success and failure of this innovative program aimed at agricultural development in particular and strategy for transfer of technology in general. The constraints faced by the farmers in adoption of improved pulse production technology and their suggestions to overcome the same may help in developing appropriate

extension and research strategy. Further, all the technologies demonstrated on farmers' field might have not been continued by the farmers. Some technologies might have been rejected by them. Therefore, it is necessary to know technologies rejected by them and the reasons for their rejection. This will help in understanding the lacunae in technology. Such lacunae can be communicated to the researcher for technology modification.

Keeping in view the low productivity of pulses, it was considered worthwhile to find out how much this program had helped the pulses growers to bring about changes in terms of knowledge and adoption of improved pulse production technology and thereby increasing farm productivity the following objective was undertaken. To find out the relationship between profile of beneficiary and non- beneficiary farmers with their knowledge and adoption towards improved pulse production technology.

Research Methodology

The study was conducted in Jurisdiction of RVSKVV, Gwalior (M.P.). Jurisdiction of RVSKVV is comprises of six agro-climatic zones viz; Gird, Malwa, Nimaad valley, Bundelkhand, Jhabua hill, Vindhyaachal plateau. RVSKVV Jurisdiction comprises of 24 KVKs of which 9 KVKs are in Malwa, 7 KVKs in Gird and remaining 4,2,1,1 KVKs in Nimad valley, Vindhaynchal plateau, Jhabua, Bundelkhand agro Climatic Zones respectively. FLD on chickpea is conducted in all the 24 KVKs. For the purpose of study, Malwa and Gird Agro-climatic zones were selected purposively because more than half of KVKs (16)

Table-1 : Relationship between characteristics of the respondents with their level of Knowledge towards improved pulse production technology.

S. No.	Characteristics	Beneficiaries		Non-beneficiaries	
		“r” value	“t” value	“r” value	“t” value
1.	Age	0.07	0.76NS	-0.14	1.55 NS
2.	Education	0.54	6.96**	0.39	4.60**
3.	Social political participation	0.04	0.43NS	0.04	0.43 NS
4.	Land holding	0.23	2.57**	0.08	0.87 NS
5.	Gross annual income	0.32	3.67**	0.27	3.05**
6.	Material possession	0.12	1.31 NS	0.04	0.43 NS
7.	Source of information	0.25	2.80**	0.30	3.42**
8.	Extension participation	0.24	2.69**	0.21	2.33*
9.	Mass media exposure	0.17	1.87*	0.35	4.06**
10.	Economic motivation	0.28	3.16**	0.15	1.65*
11.	Risk preference	0.27	3.05**	0.12	1.31NS
12.	Scientific orientation	0.37	4.33**	0.12	1.31 NS
13.	Innovative proneness	0.38	4.46**	0.20	2.22*

NS Non significant

**Significant at 0.01 level of probability

*Significant at 0.05 level of probability

Table-2 : Relationship between selected characteristics of the respondents with their level of extent of adoption.

S. No.	Characteristics	Beneficiaries		Non-beneficiaries	
		“r” value	“t” value	“r” value	“t” value
1.	Age	0.06	0.65 NS	-0.12	1.31 NS
2.	Education	0.57	7.53**	0.35	4.05**
3.	Social political participation	0.08	0.87 NS	0.07	0.76 NS
4.	Land holding	0.22	2.44**	0.14	1.53 NS
5.	Gross annual income	0.29	3.29**	0.26	2.92**
6.	Material possession	0.11	1.20 NS	0.04	0.43 NS
7.	Source of information	0.24	2.68**	0.28	3.16**
8.	Extension participation	0.29	3.29**	0.23	2.56**
9.	Mass media exposure	0.26	2.92**	0.21	2.33*
10.	Economic motivation	0.25	2.80**	0.22	2.44**
11.	Risk preference	0.20	2.21*	0.18	1.98*
12.	Scientific orientation	0.32	3.66**	0.21	2.33*
13.	Innovative proneness	0.33	3.79**	0.22	2.44**

NS Non significant

**Significant at 0.01 level of probability

*Significant at 0.05 level of probability

are situated in both the Agro-climatic zones. The KVKs conducted a number of FLDs on pulse production technology. For judging the impact of FLDs on Pulse Growing Farmers, the chickpea crop was selected because it is one of the important pulse crops grown in all the agro-climatic zones of RVSKVV. Among the 9 KVKs in Malwa and 7 KVKs in Gird agro climatic zones, 2 KVKs from each zone were selected randomly. KVKs wise separate list of beneficiaries' farmers was prepared from the two selected agro-climatic zones. Thirty beneficiary farmers were selected randomly from each KVK with the help simple random sampling. Thus, a total of 120 beneficiary farmers were selected from four selected KVKs.

Results and Discussion

Relationships between characteristics of the respondents with their level of Knowledge towards improved pulse production technology :

Correlation coefficient : The result with regard to relationship between independent and dependent variable is presented in Table-1.

The data presented in Table-1 show that the independent variables viz., education (0.54), land holding (0.23), gross annual income (0.32), sources of information (0.25), extension participation (0.24), economic motivation (0.28), risk preference (0.27), scientific

orientation (0.37) and innovative proneness (0.38) were positively and significantly related with knowledge level of improved pulse production technology by the beneficiary farmers at 0.01 level of significance while, mass media exposure (0.17) was positively and significantly related with knowledge level of improved pulse production technology by the beneficiary farmers at 0.05 level of significance whereas, age (0.07), socio political participation (0.04) and material possession (0.12) were found to be not significant.

Among non-beneficiary farmers, the calculated correlation coefficient value in case of education (0.39), gross annual income (0.27), sources of information (0.30), mass media exposure (0.35) were positively and significantly related with knowledge level of improved pulse production technology by the non-beneficiary farmers at 0.01 level of significance while, extension participation (0.21), economic motivation (0.15) and innovative proneness (0.20) were positively and significantly related with knowledge level of improved pulse production technology by the non-beneficiary farmers at 0.05 level of significance whereas, age (-0.14), socio political participation (0.04), material possession (0.04), risk preference (0.12) and scientific orientation (0.12) were found to be not significant.

The probable reason for having significant difference may be that beneficiary farmers were having better participation in the programme. In depth training was also provided to participating farmers covering full package of practice. The beneficiary farmers were found having close contact with KVK scientists and were using more number of sources of information hence, they had more knowledge about improved pulse production technology.

Relationships between profiles of the respondents with their level of extent of adoption:

Correlation coefficient : The result with regard to relationship between independent and dependent variable is presented in Table-2.

The data accessible in Table-2 illustrate that the independent variables viz., education (0.65), land holding (0.22), gross annual income (0.29), sources of information (0.24), extension participation (0.29), mass media exposure (0.26), economic motivation (0.25), scientific orientation (0.32) and innovative proneness (0.33) were positively and significantly related with adoption level of improved pulse production technology by the beneficiary farmers at 0.01 level of significance while, risk preference (0.20) was positively and significantly related with adoption level of improved pulse production technology by the beneficiary farmers at 0.05 level of significance whereas, age (0.06), socio political participation (0.08),

and material possession (0.11) were found to be not significant.

Among non-beneficiary farmers, the calculated correlation coefficient value in case of education (0.35), gross annual income (0.26), sources of information (0.28), extension participation (0.29), economic motivation (0.25) and innovative proneness (0.33) were positively and significantly related with adoption level of improved pulse production technology by the non-beneficiary farmers at 0.01 level of significance while, mass media exposure (0.21), risk preference (0.18) and scientific orientation (0.21) were positively and significantly related with adoption level of improved pulse production technology by the non-beneficiary farmers at 0.05 level of significance whereas, age (-0.12), socio political participation (0.07), land holding (0.14) and material possession (0.04) were found to be not significant.

The probable reasons might be due to sincere efforts put forth by implementing agencies i.e. Krishi Vigyan Kendras to communicate the improved pulse production technology to beneficiary farmers in Madhya Pradesh.

Conclusion

The findings of the study pointed out that the reveal that the education (0.65), land holding (0.22), gross annual income (0.29), sources of information (0.24), extension participation (0.29), mass media exposure (0.26), economic motivation (0.25), scientific orientation (0.32) and innovative proneness (0.33) were positively and significantly related with adoption level of improved pulse production technology by the beneficiary farmers at 0.01 level of significance while, non-beneficiary farmers, the calculated correlation coefficient value in case of education (0.35), gross annual income (0.26), sources of information (0.28), extension participation (0.29), economic motivation (0.25) and innovative proneness (0.33) were positively and significantly related with adoption level of improved pulse production technology by the non-beneficiary farmers at 0.01 level of significance.

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Personal Socio-Economic Profile of the K.C.C. Holders in Chittorgarh and Pratapgarh Districts of Rajasthan

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Abstract

Kisan Credit Card Scheme (KCC) was introduced to ensure that the credit requirements for farmers in the agriculture, fisheries, and animal husbandry sectors were met. This was done by helping them avail of short-term loans and providing them with a credit limit to purchase equipment and for their other expenses as well. With the help of this scheme, farmers can repay their loans depending on the harvesting period of the crop for which the loan was given. Since there is no literature available about the personal Socio-Economic profile of KCC holders in Chittorgarh districts of Rajasthan. The present study was designed to evaluate the socio-economic profile of KCC holders. For the purpose study total 120 KCC holders were selected. Data were collected through personal interview method. The findings of the study revealed that majority of respondents belonged to age group 37 to 63 years. 85.00 per cent respondents were earning annual income i.e., Rs.14,613 to Rs.1,83,486 per annum. 52.50 per cent respondents belonged to joint family category. 88.33 per cent of respondents engaged in agriculture. majority of (41.67 %) of respondents educated up to Primary. Majority of 37.50 per cent respondents were small farmers having land size (1.00 to 2.00 ha). 59.17 per cent of respondents of the study area were have Pukka house. 74.16 per cent respondents reported to have medium level of extension participation and 71.66 per cent respondents reported to have medium level of extension contacts.

Key words : *Socio-economic, profile, K.C.C.*

Introduction

Nearly 67% of the population of India still relies directly or indirectly on agriculture for their livelihood, making it the foundation of the nation's economy. The Reserve Bank of India (RBI) has devised a multi-agency approach to ensure credit flow to the industry in light of the sector's leading role and the significance of credit as an input. Making institutional finance accessible to many farmers, especially small and marginal farmers, remains a difficulty for the banking sector despite the advances in the delivery mechanisms that have been made throughout time. One of the main obstacles for Indian banks in providing agricultural and rural loans to farmers has been the supply of timely and enough financing. To accomplish the goal, continuous innovation is necessary.

The Kisan Credit Card (KCC) scheme is a Government of India scheme which provides farmers with timely access to credit. The Kisan Credit Card (KCC) scheme was launched in 1998 to provide short-term formal credit to farmers and was created by NABARD (National Bank for Agriculture and Rural Development). The Government of India has introduced the Kisan Credit Card (KCC) an appropriate and distinguished program to help farmers avoid fraud and many other obstacles. To eliminate intermediaries, bribery, and other issues, the government is also stepping forward to provide ATM cards to the farmers.

The current study evaluates the KCC's process. The beneficiaries who are receiving the benefits of KCC have been identified by this research. The current study was designed with the specific purpose of examining the socio personal and socio-economic profile of KCC Holders of Chittorgarh districts of Rajasthan.

Research Methodology

The study was focused in Chittorgarh and Pratapgarh districts of Rajasthan because maximum number of K.C.C. holders are present in Chittorgarh district of MPUAT service area and Some branches of Chittorgarh District Central Cooperative Bank (DCCB) are working in Pratapgarh district till now because Pratapgarh District is constituted from Chittorgarh. Therefore, the operational area of both the districts are included in the study. It was decided to select total three branches of Chittorgarh District Central Cooperative Bank on the basis of maximum K.C.C. holders. Out of Total PACS of selected Bank Branches, Two PACS having maximum K.C.C. holders were selected from each branch and from each selected PACS 20 K.C.C. holders were randomly selected. Thus total 120 K.C.C. holders were included in the study sample. The Ex-post-facto research design was used for the present study. Personal interview technique was used to collect data from the selected respondents thereafter; the data were then tabulated and analyzed with

Table-1 : Distribution of respondents as per their age.

S. No.	Age Groups	Chhoti Sadri* (n ₁ =40)		Nimbahera* (n ₂ =40)		Pratapgarh* (n ₃ =40)		Total (n=120)	
		f	%	f	%	f	%	f	%
1.	Young (<37 years)	11	27.50	9	22.50	5	12.50	25	20.83
2.	Middle (37-63 years)	23	57.50	25	62.50	27	67.50	75	62.50
3.	Old (>63 years)	6	15.00	6	15.00	8	20.00	20	16.66
	Total	40	100.00	40	100.00	40	100.00	120	100.00

f = frequency, % = per cent, Mean = 49.67, S.D. = 13.12, * (District Central Cooperative Bank) Branch.

Table-2 : Distribution of respondents according to their annual income.

S. No.	Annual income (Rs.)	Chhoti Sadri* (n ₁ =40)		Nimbahera* (n ₂ =40)		Pratapgarh* (n ₃ =40)		Total (n=120)	
		f	%	f	%	f	%	f	%
1.	Low income (<Rs.14,613)	2	05.00	1	02.50	2	05.00	5	4.16
2.	Medium income (Rs.14,613 to 1,83,486)	36	90.00	32	80.00	34	85.00	102	85.00
3.	High income (> Rs. 1,83,486)	2	05.00	7	17.50	4	10.00	13	10.83
	Total	40	100.00	40	100.00	40	100.00	120	100.00

f = frequency, % = per cent, Mean = 99050, S.D. = 84436.72, * (District Central Cooperative Bank) Branch

Table-3 : Distribution of respondents as per their family type.

S. No.	Family Type	Chhoti Sadri* (n ₁ =40)		Nimbahera* (n ₂ =40)		Pratapgarh* (n ₃ =40)		Total (n=120)	
		f	%	f	%	f	%	f	%
1.	Nuclear	18	45.00	25	62.50	14	35.00	57	47.50
2.	Joint	22	55.00	15	37.50	26	65.00	63	52.50
	Total	40	100.00	40	100.00	40	100.00	120	100.00

f = frequency, % = per cent, * (District Central Cooperative Bank) Branch

Table-4 : Distribution of respondents as per their occupation.

S. No.	Occupation	Chhoti Sadri* (n ₁ =40)		Nimbahera* (n ₂ =40)		Pratapgarh* (n ₃ =40)		Total (n=120)	
		f	%	f	%	f	%	f	%
1.	Agriculture	40	100.00	27	67.50	39	97.50	106	88.33
2.	Agriculture and Business	0	0.00	13	32.50	1	2.50	14	11.67
	Total	40	100.00	40	100.00	40	100.00	120	100.00

f = frequency, % = per cent, * (District Central Cooperative Bank) Branch

mean, standard deviation, were worked out for interpretation of results.

Results and Discussion

The findings on distribution of respondents according to their selected personal and socio-economic characteristics is presented in respective tables:

Table-1 shows that majority of respondents belonged to age group 37 to 63 years. This age group alone constituted 62.50 per cent respondents. While 20.83 per cent respondents were of less than 37 years and remaining 16.66 per cent respondents reported of age above 63 years. This information was consistent with the findings of Prajapati V.V., *et.al.* (2016) ^[1].

The details indicated in table-2 shows that maximum 85.00 per cent respondents were earning annual income *i.e.*, Rs.14,613 to Rs.1,83,486 per annum. Table also reveals that 90.00, 80.00 and 85.00 per cent respondents of Chhoti Sadri, Nimbahera and Pratapgarh branch respectively, were earning annual income *i.e.*, Rs. 14,613 to 1,83,486 per annum, whereas, 5.00, 17.50, and 10.00 per cent respondents of Chhoti Sadri, Nimbahera and Pratapgarh branch respectively, were earning annual income of above *i.e.*, Rs. 1,83,486 per annum.

By closely examining data of table-3 which shows that 47.50 per cent respondents belonged to nuclear family category and 52.50 per cent respondents belonged

Table-5 : Distribution of respondents according to their education level.

S. No.	Education Level	Chhoti sadri* (n ₁ =40)		Nimbahera* (n ₂ =40)		Pratapgarh* (n ₃ =40)		Total (n=120)	
		f	%	f	%	f	%	f	%
1.	Illiterate	11	27.50	9	22.50	9	22.50	29	24.17
2.	Primary	13	32.50	14	35.00	23	57.50	50	41.67
3.	Secondary	9	22.50	10	25.00	7	17.50	26	21.67
4.	Senior secondary	5	12.50	4	10.00	1	2.50	10	8.33
5.	Graduation and above	2	05.00	3	7.50	0	0.00	5	4.17
	Total	40	100.00	40	100.00	40	100.00	120	100.00

f = frequency, % = per cent, * (District Central Cooperative Bank) Branch

Table-6 : Distribution of respondents according to their land holding.

S. No.	Land Holding	Chhoti sadri* (n ₁ =40)		Nimbahera* (n ₂ =40)		Pratapgarh* (n ₃ =40)		Total (n=120)	
		f	%	f	%	f	%	f	%
1.	Marginal (below 1.00 ha)	18	45.00	6	15.00	16	40.00	40	33.33
2.	Small (1.00-2.00 ha)	12	30.00	19	47.50	14	35.00	45	37.50
3.	Medium (2.01-4.00 ha)	10	25.00	10	25.00	5	12.50	25	20.83
4.	Semi-medium (4.01-10.00 ha)	0	0.00	5	12.50	5	12.50	10	8.33
5.	Large (10.00 ha and above)	0	0.00	0	0.00	0	0.00	0	0.00
	Total	40	100.00	40	100.00	40	100.00	120	100.00

f = frequency, % = per cent, * (District Central Cooperative Bank) Branch

Table-7 : Distribution of respondents according to their type of house.

S. No.	House Type	Chhoti sadri* (n ₁ =40)		Nimbahera* (n ₂ =40)		Pratapgarh* (n ₃ =40)		Total (n=120)	
		f	%	f	%	f	%	f	%
1.	Kaccha	7	17.50	14	35.00	28	70.00	49	40.83
2.	Pakka	33	82.50	26	65.00	12	30.00	71	59.17
	Total	40	100.00	40	100.00	40	100.00	120	100.00

f = frequency, % = per cent, * (District Central Cooperative Bank) Branch

to joint family category. The findings are in concurrence with the findings of Shekhawat (2021) ^[3].

The data presented in Table-4 indicates that out of 120 respondents, 88.33 per cent of respondents engaged in agriculture. While, 11.67 per cent of respondents were also engaged in both Agriculture and business. Table 4 also reveals that 100.00, 67.50 and 97.50 per cent respondents of Chhoti Sadri, Nimbahera and Pratapgarh branch respectively, were engaged in agriculture, while not a single respondent of Chhoti Sadri branch was engaged in both agriculture and business.

The data presented in Table-5 indicates that majority of (41.67 %) of respondents educated up to Primary. On the other hand, 24.17 per cent respondents were Illiterate, 21.67 per cent respondents educated up to Secondary, 08.33 per cent of respondents educated up to Senior Secondary and rest only 04.17 per cent of respondents educated up to graduation and above level.

The data depicted in table-6 revealed that 37.50 per

cent respondents were small farmers having land size (1.00 to 2.00 ha). 33.33 per cent of respondents were marginal farmers having land size (below 1.00 ha), 20.83 per cent respondents were medium farmers having land size (2.01 to 4.00 ha), 8.33 per cent respondents were semi-medium having land size (4.01-10.00 ha) and none of the respondents were large farmers having land size (10.00 ha and above). The findings are in agreement with the findings of Sabapara *et al.* (2014) ^[2].

The data presented in the Table-7 indicates that out of 120 respondents, 59.17 per cent of respondents of the study area were have Pakka house. While, 40.83 per cent respondents had Kaccha house.

Data given in Table-8 indicates that out of 120 respondents, 74.16 per cent respondents reported to have medium level of extension participation, whereas, 15.00 per cent of total respondents reported to have low extension participation and remaining 10.83 per cent of respondents were observed in high extension participation.

Table-8 : Distribution of respondents according to their extension participation.

S. No.	Extension Participation (score)	Chhoti sadri* (n ₁ =40)		Nimbahera* (n ₂ =40)		Pratapgarh* (n ₃ =40)		Total (n=120)	
		f	%	f	%	f	%	f	%
1.	Low (<4.34)	2	05.00	7	17.50	9	22.50	18	15.00
2.	Medium (4.34 to 7.16)	29	72.50	30	75.00	30	75.00	89	74.16
3.	High (>7.16)	9	22.50	3	07.50	1	02.50	13	10.83
	Total	40	100.00	40	100.00	40	100.00	120	100.00

f = frequency, % = per cent, Mean = 5.75, S.D. = 1.40, * (District Central Cooperative Bank) Branch

Table-9 : Distribution of respondents according to their extension contacts.

S. No.	Extension Contacts	Chhoti sadri* (n ₁ =40)		Nimbahera* (n ₂ =40)		Pratapgarh* (n ₃ =40)		Total (n=120)	
		f	%	f	%	f	%	f	%
1.	Low (<4.62)	1	2.50	5	12.50	5	12.50	11	9.16
2.	Medium (4.62 to 6.95)	20	50.00	32	80.00	34	85.00	86	71.66
3.	High (>6.95)	19	47.50	3	7.50	1	2.50	23	19.16
	Total	40	100.00	40	100.00	40	100.00	120	100.00

f = frequency, % = per cent, Mean = 5.79, S.D. = 1.16, * (District Central Cooperative Bank) Branch

Close analysis of data of Table 11 reveals that out of 120 respondents, 71.66 per cent respondents reported to have medium level of extension contacts, whereas, 19.16 per cent respondents reported to have high level of extension contacts and remaining 9.16 per cent respondents were observed low level of extension contacts. The similar findings are supported by findings of Vashishtha (2011) ^[4].

Conclusions

It was revealed that K.C.C. holders have good socio-economic condition. The present study has been conducted under limited characteristics, so that, it will be better if more characteristics of K.C.C. holders are taken for further research in this area. As socio-economic status of the K.C.C. holders is a complex phenomenon and includes so many things as stated earlier, it may be possible that some important components might have

skipped out which may be considered by other research workers in future.

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Personal Socio-Economic Profile of the Beneficiaries of Pradhan Mantri Kisan Samman Nidhi scheme in Udaipur Districts of Rajasthan

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Abstract

Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) scheme was first implemented as the Rythu Bandhu scheme by the Government of Telangana where a certain amount was provided directly to the eligible farmers. Hon'ble Prime Minister Narendra Modi officially launches the PM-KISAN scheme on 24th February, 2019 in Gorakhpur, Uttar Pradesh. The scheme is 100% funded from Central Government and provides 6000rs./year as minimum income support to complement farmer's monetary requirements related to cultivation and allied activities as well as domestic needs. This scheme provide benefits to all landholding farmers who have cultivable land. Since there is no literature available about the personal socio-economic profile of PM-KISAN beneficiaries in Udaipur district of Rajasthan. The present study was designed to evaluate the personal profile of PM-KISAN beneficiaries. For this purpose, total 120 beneficiary farmers were selected. Data was collected through personal interview method. The findings of the study revealed that majority (62.50 %) of respondents belonged to age group 35 to 60 years. 85.00 per cent respondents were belong to medium income level i.e., Rs.17,570 to Rs.1,56,872 per annum. 65.00 per cent respondents belonged to joint family category. 47.50 per cent of respondents were engaged in agriculture. Majority (28.33 %) of respondents belonged to OBC category. Most (40.00 %) of respondents were illiterate. 47.50 per cent respondents were marginal farmers having land size of below 1.00 ha. 60.00 per cent of respondents of the study area were have Pakka house. 61.67 per cent respondents reported to have medium level of extension participation. Majority (75.00 %) of respondents have medium level of extension contacts. 72.50 per cent respondents had medium level mass media utilization. Majority (70.00 %) of respondents have medium level of access to source of information.

Key words : Socio-economic, profile, PM-KISAN

Introduction

About 58.00 per cent of Indian depends on agriculture for their livelihood and the Indian population continues to increase exponentially. It would not be inaccurate to state that 'Indian farmers' are the backbone of the economy. Mostly, Indian farmers borrow money or invest their personal saving for inputs such as seeds, fertilizers, chemicals, etc. and waits for the harvest to fulfill their needs and demand. However, mostly after harvest, farmers were not able to get a full return as they were not able to sell their produce even at their cost of cultivation. This is due to a rapid increase in the supply of produce at the end of the cropping season. It results in getting a cash crunch situation for small and marginal farmers.

In view of this, Indian government implemented a central sector scheme called "Pradhan Mantri Kisan Samman Nidhi (PM-KISAN)" for helping farmers and their families to meet their agriculture related needs and requirement. PM-KISAN scheme was first implemented as the Rythu Bandhu scheme by the government of Telangana where a certain amount was handed directly to the eligible farmers. Hon'ble Prime Minister Narendra Modi officially launches the PM-KISAN scheme on 24th

February, 2019 in Gorakhpur, Uttar Pradesh. Scheme was operational from 1st December, 2018, while it was officially launched on 24th February, 2019.

It provides 100% funding from the central government and initially provided benefits to only small and marginal landholding farmers and their families with up to 2 hectares cultivable land, but it's area has been extended by including all landholding farmers from June, 2019. Under the Scheme, Rs. 6000 per annum is provided to all eligible farmer families across the country in three equal installments of Rs. 2000 each every four months. This support is directly transferred into the bank accounts of beneficiary farmers/farmer's family through Direct Benefit Transfer (DBT) mode.

The present investigation evaluate the process and requirement of PM-KISAN scheme for getting its benefits. The beneficiaries who are receiving the benefits of PM-KISAN scheme has been identified by this research. The current study was designed with the specific purpose of examining the socio personal and socio-economic profile of PM-KISAN beneficiary farmers in Udaipur district of Rajasthan.

Table-1 : Distribution of respondents according to their age.

S. No.	Age Groups	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Young (<35 years)	09	15.00	12	20.00	21	17.50
2.	Middle (35-60 years)	35	58.33	40	66.67	75	62.50
3.	Old (>60 years)	16	26.67	08	13.33	24	20.00
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, Mean =47.59, S.D. =13.01, * (Tehsil)

Table-2 : Distribution of respondents according to their annual income.

S. No.	Annual income (Rs.)	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Low income (< Rs.17,570)	01	01.66	02	03.33	03	02.50
2.	Medium income (Rs.17,570 to 1,56,872)	55	91.66	47	78.33	102	85.00
3.	High income (>Rs.1,56,872)	04	06.66	11	18.33	15	12.50
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, Mean =87221, S.D. =69651, * (Tehsil)

Table-3 : Distribution of respondents according to their family type.

S. No.	Family type	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Nuclear	20	33.33	22	36.67	42	35.00
2.	Joint	40	66.67	38	63.33	78	65.00
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, * (Tehsil)

Table-4 : Distribution of respondents according to their occupation.

S. No.	Occupation	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Labour	12	20.00	08	13.33	20	16.67
2.	Traditional occupation	10	16.67	06	10.00	16	13.33
3.	Agriculture	28	46.67	29	48.33	57	47.50
4.	Agriculture + Dairy	04	06.67	06	10.00	10	08.33
5.	Agriculture + Business	04	06.67	08	13.33	12	10.00
6.	Agriculture + Service	02	03.33	03	05.00	05	04.16
	Total	60	100.00	60	100.00	120	100.00

lphaf = frequency, % = per cent, * (Tehsil)

Research Methodology

The study was conducted in Udaipur districts of southern Rajasthan because it is located MPUAT service area and until now, sporadic efforts has been made by previous studies to carry out research. The purpose was to know the Personal Socio-economic profile of Farmers towards PM-KISAN Scheme. The diagnostic study was confined to two tehsils namely; Mavli and Salumber were selected on the basis of maximum number of beneficiaries. Therefore, the operational area of both the tehsil are included in the study. Two villages from each selected tehsil were selected on the basis of highest number of beneficiaries and from each selected village 30 beneficiaries were randomly selected. Thus total 120

beneficiaries of PM-KISAN were included in the study sample. The Ex-post-facto research design was used for the present study. Personal interview technique was used to collect data from the selected respondents thereafter; the data were then tabulated and analyzed with mean, standard deviation, were worked out for interpretation of results.

Results and Discussion

The findings on distribution of respondents according to their selected personal and socio-economic characteristics is presented in respective tables:

Table-1 indicates that out of 120 respondents, majority of respondents belonged to age group 35 to 60 years. This age group alone constituted 62.50 per cent

Table-5 : Distribution of respondents according to their caste.

S. No.	Caste	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	SC	19	31.67	12	20.00	31	25.83
2.	ST	08	13.33	20	33.33	28	23.33
3.	OBC	29	48.33	05	08.33	34	28.33
4.	General	04	06.67	23	38.33	27	22.50
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, * (Tehsil)

Table-6 : Distribution of respondents according to their education level.

S. No.	Education	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Illiterate	30	50.00	18	30.00	48	40.00
2.	Primary	24	40.00	23	38.33	47	39.16
3.	Secondary	04	06.67	12	20.00	16	13.33
4.	Senior Secondary	01	01.67	06	10.00	07	05.83
5.	Graduation and above	01	01.67	01	01.66	02	01.67
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, * (Tehsil)

Table-7 : Distribution of respondents according to their land holding.

S. No.	Land Holding	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Marginal (below 1.00 hectare)	35	58.33	22	36.66	57	47.50
2.	Small (1.00-2.00 hectares)	17	28.33	20	33.33	37	30.83
3.	Medium (2.01-4.00 hectares)	08	13.33	18	30.00	26	21.67
4.	Semi-medium (4.01-10.00 hectares)	0	0	0	0	0	0
5.	Large (10.01 hectares and above)	0	0	0	0	0	0
	Total	60	100.00	60	100.00	120	100.00

af = frequency, % = per cent, * (Tehsil)

Table-8 : Distribution of respondents according to their type of house.

S. No.	Type of house	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Kaccha	22	36.66	26	43.33	48	40.00
2.	Pakka	38	63.33	34	56.66	72	60.00
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, * (Tehsil)

respondents, while 20.00 per cent respondents were of age above 60 years and remaining 17.50 per cent respondents reported of less than 35 years in age. This following information was consistent with the findings of Kumar (2012) ^[3].

The data from table-2 shows that maximum 85.00 per cent respondents belonged to medium income level *i.e.*, Rs.17,570 to Rs.1,56,872 per annum. Table-2 also reveals that 1.66 and 3.33 per cent respondents of Mavli and Salumber respectively, were earning annual income of less than *i.e.*, Rs. 17,570 per annum and 91.66 and 78.33 per cent respondents of Mavli and Salumber, were earning annual income *i.e.*, Rs. 17,570 to 1,56,872 per annum, whereas, 6.66 and 18.33 per cent respondents of

Mavli and Salumber respectively, were earning annual income of above *i.e.*, Rs. 1,56,872 per annum. Similar findings were reported by Prajapati V.V. *et al.* (2016) ^[5].

The data concluded in table-3 indicates that out of 120 respondents, 65.00 per cent respondents belonged to joint family category and 35.00 per cent respondents belonged to nuclear family category. Table-3 also reveals that 33.33 and 66.67 per cent respondents of Mavli and Salumber respectively, belonged to nuclear family, while 66.67 and 63.33 per cent respondents of Mavli and Salumber respectively, belonged to joint family category.

The data presented in the table-4 shows that out of 120 respondents, 47.50 per cent of respondents were engaged in agriculture. It also depicts that 20.00 and

Table-9 : Distribution of respondents according to their extension participation.

S. No.	Extension Participation	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Low (<4.90)	13	21.67	08	13.33	21	17.50
2.	Medium (4.90 to 9.99)	38	63.33	36	60.00	74	61.67
3.	High (>9.99)	09	15.00	16	26.67	25	20.83
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, Mean = 7.45, S.D. = 2.54, * (Tehsil)

Table-10 : Distribution of respondents according to their extension contact.

S. No.	Extension Contact	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Low (<3.90)	05	08.33	10	16.67	15	12.50
2.	Medium (3.90 to 8.31)	44	73.33	46	76.67	90	75.00
3.	High (>8.31)	11	18.33	04	06.67	15	12.50
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, Mean = 6.10, S.D. = 2.20, * (Tehsil)

Table-11 : Distribution of respondents according to their mass media utilization.

S. No.	Mass Media Utilization	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	F	%	f	%
1.	Low (<1.81)	10	16.67	03	05.00	13	10.83
2.	Medium (1.81 to 5.57)	42	70.00	45	75.00	87	72.50
3.	High (>5.57)	08	13.33	12	20.00	20	16.67
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, Mean = 3.69, S.D. = 1.88, * (Tehsil)

Table-12 : Distribution of respondents according to their source of information.

S. No.	Source of information	Mavli* (n ₁ =60)		Salumber* (n ₂ =60)		Total (n=120)	
		f	%	F	%	f	%
1.	Low (<7.32)	07	11.67	11	18.33	18	15.00
2.	Medium (7.32 to 11.11)	41	68.33	43	71.67	84	70.00
3.	High (>11.11)	12	20.00	06	10.00	18	15.00
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent, Mean = 9.21, S.D. = 1.89, * (Tehsil)

13.33 per cent respondents of Mavli and Salumber respectively, were engaged in labour occupation. 16.67 and 10.00 per cent respondents of Mavli and Salumber respectively, were engaged in traditional occupation. 46.67 and 48.33 per cent respondents of Mavli and Salumber respectively, were engaged in agriculture. 6.67 and 10.00 per cent respondents of Mavli and Salumber respectively, were engaged in agriculture along with dairy occupation. 6.67 and 13.33 per cent respondents of Mavli and Salumber respectively, were engaged in agriculture along with business occupation, whereas, 3.33 and 5.00 respondents of Mavli and Salumber respectively, were engaged in agriculture along with service. The result was supported by the findings of Ghosly A. K. (2016) [2].

From table-5 it can be observed that majority (28.33 %) of respondents belonged to OBC category. On the other hand, 25.83 per cent respondents were of SC category, 23.33 per cent respondents were of ST

category and remaining 22.50 per cent of respondents belonged to General category. Further examination of data as presented in table-5 indicates that 31.67 and 20.00 per cent respondents of Mavli and Salumber respectively, were from SC category. 13.33 and 33.33 per cent respondents from ST caste observed in Mavli and Salumber tehsils, respectively. About 48.33 and 8.33 per cent respondents of OBC category were from Mavli and Salumber tehsil, respectively, while 6.67 and 38.33 per cent respondents of Mavli and Salumber respectively, belonged to General caste.

The data shown in table-6 says that majority (40.00 %) of respondents were illiterate. Table-6 also reveals that 50.00 and 30.00 per cent respondents were illiterate from Mavli and Salumber tehsil, respectively. About 40.00 and 38.33 per cent studied up to Primary level in Mavli and Salumber tehsil, respectively. 6.67 and 20.00 per cent respondents were educated up to Secondary level in

Mavli and Salumber tehsil, respectively. About 1.67 and 10.00 per cent respondent were educated up to Senior Secondary level in Mavli and Salumber, respectively. Only 1.67 and 1.66 per cent respondent were Graduate and above in Mavli and Salumber, respectively. This result are supported by the findings of Bharathi (2005)^[1].

The table-7 indicates that out of 120 respondents, majority (47.50 %) respondents were marginal farmers having land size of below 1.00 ha. 30.83 per cent of respondents were small farmers having land size of 1.00 – 2.00 ha, while 21.67 per cent respondents were medium farmers having land size of 2.01 to 4.00 ha. None of the respondents were semi-medium farmers having land size of 4.01-10.00 ha and large farmers having land size of 10.01 ha and above. Same data when examined closely shows that maximum 58.33 and 36.66 per cent respondents of Mavli and Salumber were marginal size land holders, respectively. 28.33 and 33.33 per cent respondents of Mavli and Salumber respectively, were small size land holders, 13.33 and 30.00 per cent respondents of Mavli and Salumber respectively, were medium size land holders. None of the respondents of Mavli and Salumber, was semi-medium size land holders and large size land holders. Findings are in confirmations with Rathod *et al.* (2011)^[6].

The data presented in the table-8 indicates that out of 120 respondents, 60.00 per cent of respondents of the study area were having Pakka house, while, 40.00 per cent respondents were having Kaccha house.

Data given in table-9 shows that out of 120 respondents, 61.67 per cent respondents reported to have medium level of extension participation. Further, it shows that 21.67 and 13.33 per cent respondents of Mavli and Salumber respectively, had low level of extension participation. 63.33 and 60.00 per cent respondents of Mavli and Salumber respectively, had medium level of extension participation. Whereas, 15.00 and 26.67 per cent respondents of Mavli and Salumber respectively, had high level of extension participation.

Table-10 concluded that 75.00 per cent respondents have medium level of extension contacts. Close analysis of data of table-10 reveals that 8.33 and 16.67 per cent respondents of Mavli and Salumber respectively, had low level of extension contact. 73.33 and 76.67 per cent respondents of Mavli and Salumber respectively, had low medium of extension contact, whereas, 18.33 and 06.67 per cent respondents of Mavli and Salumber respectively, had high level of extension contact.

Data presented in table-11 reveals that out of 120

respondents, majority (72.50 %) of respondents had medium level mass media utilization. 16.67 per cent respondents had high level mass media utilization, whereas, 10.83 per cent respondents observed to have low level mass media utilization.

It is apparent from the data present in table-12 that out of 120 respondents, majority (70.00 %) of them have medium level of access to source of information. Few (15.00 %) of them have low level access to source of information and rest (15.00 %) of them have high level access to source of information. Findings are in agreement with Lohakare *et al.* (2013)^[4].

Conclusions

It was concluded that PM-KISAN beneficiaries have medium level of personal socio-economic condition. The present study has been conducted under limited characteristics, so that, it will be better if more characteristics of PM-KISAN beneficiaries are taken for further research in this area. As socio-economic status of the PM-KISAN beneficiaries is a complex phenomenon and includes so many things as stated earlier, it may be possible that some important components might have skipped out which may be considered by other research workers in future.

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Personal Profile of Beneficiary Farmers of Kisan Farm Pond Scheme in Bhilwara District

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Abstract

The productivity and intensity of cropping are significantly impacted by the farm pond. It also enhance in farmers economic circumstances. Farming has always been the main industry in India. Kisan Farm Pond Scheme is the process of growing of crop. The main aim of Kisan Farm Pond Scheme cultivation technique is to get high value yield and productivity throughout year. The personal socio- economic profile of Kisan Farm Pond Scheme in Bhilwara and Shahpura tehsils of Rajasthan. The present study was designed to evaluate the socio-economic profile of farm pond farmers. For the proportionate study total 120 farm pond farmers were selected. The findings indicate that majority (64.17 %) of the farm pond farmers had middle age (from 34-55 years), majority (78.34 %) of the farm pond farmers had medium level of income, majority (83.33 %) of the respondents belonged to nuclear family, majority of farm pond farmers i.e. 75.00 per cent were occupied in agriculture for earning income, majority 75.00 per cent of farm pond farmers were from other backward caste (OBC) category, majority 34.17 per cent of farm pond farmers with secondary education, majority 40.00 per cent of the total respondents were small farmers having land holding, majority (59.17 %) of the farmers had pakka house and showed that 8.33, 78.33 and 13.34 per cent of total farmers possessed low, medium and high level of extension participation, respectively. From the results, it may be concluded that majority of the farmers had medium level of extension participation, majority (66.67 %) of farmers had medium level of extension contact and that majority (59.17 %) of the farmers had medium level of source of information.

Key words : Socio- economic, profile, Kisan farm pond Scheme.

Introduction

India has traditionally been an agricultural nation. Therefore, it is accurate to say that India's progress depends heavily on the growth of agriculture. Increased agricultural output depends on a number of factors, with water playing a significant role. Farm Pond Programme was introduced by the Maharashtra government in 2016. In the semi-arid tropics of India, rainfall provides a fundamental supply of all types of water. Despite the nation's 1200 mm yearly average rainfall, there are variations in space and time, which have an impact on the amount of water available for various industries. About 80 per cent of the water is used in agriculture and remaining 20 per cent is used in India's beverage, industry and energy sectors.

The government of India has introduced several schemes to improve the surface water availability in irrigated and rainfed areas for enhancing the productivity and groundwater recharge. With the primary goal of stabilizing crop output by limiting soil erosion in both arable and non-arable lands, the Integrated Watershed Management Program (IWMP) has been successfully implemented across the majority of the country's rainfed zones. The integrated water shed management programs farm pond technology, which also has other environmental advantages, is the most significant and

promising intervention out of several others. Both the central government and the state governments have launched campaigns to promote farm ponds. Different methods have been used by the state governments to implement their watershed development program in their respective state. On agricultural land, watershed area development involves practices like drainage line treatment and water resource management that save both water and soil. In the recent years farmers in some parts of Maharashtra tended to choose farm ponds as one of these methods. Through MNREGA, NHM and RKVY, the state agriculture department offers financial support to farmers for the development of farm ponds.

Research Methodology

The present study was conducted in Bhilwara district of Rajasthan. The Bhilwara district has been selected proportionate on the basis of maximum farm ponds in this district. Bhilwara district consists of twelve tehsils, out of which Bhilwara tehsil and Shahpura tehsil were selected on the basis of maximum farm pond under the Kisan Farm Pond Scheme. Thus four villages selected in Bhilwara tehsil and eight villages selected in Shahpura tehsil were identifying proportionate based on study area. Thus total 120 respondents were selected for the present study. Like this total sample of 120 farm pond farmers were selected for this study. The Ex-post-facto research design was used for the present study. Data were collected personal

Table-1 : Distribution of farmers based on the age.

S. No.	Category	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Young (<34 years)	10	22.22	10	13.33	20	16.67
2.	Middle (34-55 years)	31	68.89	46	61.33	77	64.17
3.	Old (>55 years)	4	8.89	19	25.34	23	19.17
	Total	45	100.00	75	100.00	120	100

f = frequency, % = per cent

Table-2 : Distribution of the farmers based on the annual income.

S.No.	Annual income Category	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Low income (<Rs. 21,035)	2	4.44	4	5.34	6	5.00
2.	Medium income (Rs. 21,035 to 1,76,065)	33	73.33	61	81.33	94	78.34
3.	High income (Above Rs. 1,76,065)	10	22.23	10	13.33	20	16.66
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

Table-3 : Distribution of the farmers based on the family type.

S. No.	Family type	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Nuclear	40	88.89	60	80.00	100	83.33
2.	Joint	5	11.11	15	20.00	20	16.67
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

interview technique was used to collect data from the selected respondents thereafter; the data were then tabulated and analyzed with mean, standard deviation, were worked out for interpretation of results.

Results and Discussion

The findings on distribution of respondents according to their selected personal and socio-economic characteristics are presented in respective tables.

Table-1 shows that out of 120 respondents majority (64.17 %) of the farm pond farmers had middle age (from 34-55 years), followed by 19.17 and 16.67 per cent were from old age (above 56 years) and young (less than 34 years) age, respectively. While shows that 68.89 and 61.33 per cent of the farm pond farmers were from middle age group (34 to 55 years) in Bhilwara and Shahpura tehsil, respectively. This was followed by 8.89 and 25.34 per cent respondents of Bhilwara and Shahpura tehsils respectively who belonged to old age group (above 55 years). While, 22.22 and 13.33 per cent farmers of Bhilwara and Shahpura tehsils were from respectively young age group (below 34 years). This information was consistent with the findings of Niangti *et al.* (2020).

Table-2 reveals that 4.44 and 5.34 per cent of the respondents belonged to low level income group (less than Rs. 21,035) in Bhilwara and Shahpura tehsil, respectively. About 73.33 and 81.33 per cent of the

farmers have medium level income (from 21,035 to Rs. 1,76,065) in Bhilwara and Shahpura tehsil, respectively. Similarly 22.23 and 13.33 per cent of the respondents have high level of income (above Rs. 1,76,065) in Bhilwara and Shahpura tehsil, respectively. Regarding overall distribution of income level, it was found that majority (78.34 %) of the farm pond farmers had medium level of income followed by high (16.66 %) and low (5.00 %) level of income. Results are in agreement with the findings Thombre *et al.* (2010).

The details indicated in table-3 shows that majority (83.33 %) of the respondents belonged to nuclear family and remaining 16.67 per cent respondents belonged to joint family. While, shows that 88.89 per cent and 80.00 per cent of the respondents of Bhilwara and Shahpura tehsil, respectively were reported from nuclear family group, whereas rest 11.11 per cent respondents from Bhilwara tehsil and 20.00 per cent respondents from Shahpura tehsil were reported from joint family. It may be calculated from the results that majority of farmers resided in nuclear families. The findings are in agreement with the finding of Chandawat and Singh (2013).

The overall data shows that majority of farm pond farmers i.e. 75.00 per cent were occupied in agriculture for earning income, while 25.00 per cent of the farmers were earning income from business and service. The data in Table 4 also revealed that 73.33 per cent farmers of

Table-4 : Distribution of the farmers based on the occupation.

S. No.	Occupation	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Agriculture	33	73.33	57	76.00	90	75.00
2.	Business/Service	12	26.67	18	24.00	30	25.00
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

Table-5 : Distribution of the farmers based on the caste.

S. No.	Caste	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	SC	4	8.89	1	1.33	5	4.17
2.	ST	1	2.22	7	9.34	8	6.67
3.	OBC	33	73.33	57	76.00	90	75.00
4.	GEN	7	15.56	10	13.33	17	14.17
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

Table-6 : Distribution of the farmers based on the education.

S. No.	Education	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Illiterate	4	8.88	6	8.00	10	8.33
2.	Primary	11	24.44	20	26.67	31	25.83
3.	Secondary	17	37.78	24	32.00	41	34.17
4.	Senior secondary	10	22.22	15	20.00	25	20.83
5.	Graduation and above	3	6.67	10	13.33	13	10.83
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

Table-7 : Distribution of the farmers based on the land holding.

S. No.	Land holding	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Marginal (below 1.00 hectare)	13	28.89	20	26.67	33	27.50
2.	Small (1.00-2.00 hectares)	15	33.33	33	44.00	48	40.00
3.	Medium (2.01-4.00 hectares)	5	11.11	6	8.00	11	9.17
4.	Semi-medium(4.01-10.00 hectares)	10	22.22	15	20.00	25	20.83
5.	Large (10.00 hectares and above)	2	4.44	1	1.33	3	2.50
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

Bhilwara tehsil and 76.00 per cent farmers of Shahpura tehsils were involved in agriculture as their main occupation. On the other hand, 26.67 per cent farmers of Bhilwara tehsil and 24.00 per cent farmers of Shahpura tehsil were involved in business and service, as their main occupation.

A perusal of data incorporated in Table-5 revealed that out of selected respondents, 8.89, 2.22, 73.33 and 15.56 per cent farmers from Bhilwara tehsil were observed from SC, ST, OBC and General caste group respectively, whereas, 1.33, 9.34, 76.00 and 13.33 per cent respondents of Shahpura tehsil were from SC, ST OBC and General caste group, respectively.

Further analysis of Table 5 shows that out of selected respondents, 14.17 per cent farmers were from general caste, while, 75.00 per cent farmers were from other backward caste (OBC) category and 6.67 per cent farmers were from schedule tribe (ST), Only 4.17 per cent respondents were from the schedule caste (SC) group. Findings are in agreement with Chaturvedi (2014).

The data presented in Table 6 reveals that 8.33 per cent of the farmers were illiterate, followed by 25.83 per cent farmers with primary education, 34.17 per cent farmers with secondary education, 20.83 per cent farmers with senior secondary education and 10.83 per cent farmers with graduation and above education. A further

Table-8 : Distribution of the farmers based on the type of house.

S.No.	Type of house	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Kaccha	19	42.22	30	40.00	49	40.83
2.	Pakka	26	57.78	45	60.00	71	59.17
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

Table -9: Distribution of the farmers based on the extension participation.

S.No.	Extension participation	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Low (<4.30)	11	24.44	12	16.00	10	8.33
2.	Medium (4.30-8.19)	26	57.78	55	73.33	94	78.33
3.	High (>8.19)	8	17.78	8	10.67	16	13.34
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

Table-10 : Distribution of the farmers based on the extension contact.

S.No.	Extension contact	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Low (<3.99)	6	13.33	7	9.33	13	10.83
2.	Medium (3.99-7.76)	31	68.89	49	65.34	80	66.67
3.	High (>7.76)	8	17.78	19	25.33	27	22.50
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

Table-11 : Distribution of the farmers based on the source of information.

S. No.	Source of information	Bhilwara (n ₁ =45)		Shahpura (n ₂ =75)		Total (n=120)	
		f	%	f	%	f	%
1.	Low (<7.14)	9	20.00	18	24.00	27	22.50
2.	Medium(7.14-12.52)	21	46.67	50	66.67	71	59.17
3.	High (>12.52)	15	33.33	7	9.33	22	18.33
	Total	45	100.00	75	100.00	120	100.00

f = frequency, % = per cent

glance at the data in the table revealed that 8.88 per cent farmers of Bhilwara tehsil and 8.00 per cent farmers of Shahpura tehsil were illiterate. About 24.44 per cent and 26.67 per cent farmers of Bhilwara tehsil and Shahpura tehsil were educated up to primary level respectively, while 37.78 per cent farmers of Bhilwara tehsil and 32.00 per cent farmers of Shahpura tehsil were educated up to secondary level. Similarly, 22.22 per cent and 20.00 per cent farmers of Bhilwara and Shahpura tehsil were educated up to senior secondary level respectively, whereas, 6.67 per cent farmers of Bhilwara tehsil and 13.33 per cent farmers of Shahpura tehsil were graduate and above. These findings support the finding of Kadam Prakash (2016).

It is evident from the Table 7 that 27.50 per cent of the respondents were observed as marginal. Whereas, 40.00 per cent of the total respondents were small farmers having land holding. While, 9.17 per cent of the total respondents belonged to medium land holding.

About 20.83 per cent of the total respondents were semi medium having a land holding and only 2.50 per cent respondents belonged to large farmers group and above land holding.

A close observation of the Table further shows that 28.89 per cent farmers from Bhilwara tehsil and 26.67 per cent farmers from Shahpura tehsil were having marginal land holding. Whereas, 33.33 and 44.00 per cent farmers from Bhilwara tehsil and Shahpura tehsil, respectively were having small land holding. Similarly 11.11 per cent farmers of Bhilwara tehsil and 8.00 per cent farmers of Shahpura tehsil were having medium land holding. While, 22.22 and 20.00 per cent farmers from Bhilwara tehsil and Shahpura tehsil were semi- medium, respectively. Only 4.44 per cent Bhilwara tehsil farmers and 1.33 per cent Shahpura tehsil farmers were large farmers.

The data in Table- 8 showed that 40.83 per cent farmers had kaccha house and majority of farmers (59.17 %) of the farmers had pakka house. Table- 8 further

showed that 42.22 per cent of the farm pond farmers in Bhilwara and 40.00 per cent farm pond farmers from Shahpura tehsil had kaccha house respectively, whereas 57.78 per cent and 60.00 per cent farm pond farmers in Bhilwara tehsil and Shahpura tehsil were having pakka house, respectively. It may be concluded from the results that majority of farmers resided in pakka house. This information was consistent with the findings of Patel *et al.* (2016).

The overall data presented in Table- 9 showed that 8.33, 78.33 and 13.34 per cent of total farmers possessed low, medium and high level of extension participation, respectively. From the results, it may be concluded that majority of the farmers had medium level of extension participation. While, Table-9 revealed that 57.78 per cent respondents from Bhilwara and 73.33 per cent respondents from Shahpura tehsil were having medium level of extension participation. About 17.78 per cent farmers of Bhilwara tehsil and 10.67 per cent respondents of Shahpura tehsil were having high level of extension participation, remaining 24.44 per cent farmers of Bhilwara tehsil and 16.00 per cent farmers of Shahpura tehsil were found to have low level of extension participation. The similar findings are supported by findings of Diptesh and Chauhan (2016).

The data given in Table-10 revealed that out of 120 farmers, 66.67 per cent of farmers had medium level of extension contact. Whereas, 22.5 per cent of total farmers reported to have high level of extension contacts and remaining 10.83 per cent of farmers were observed in low level of extension contacts. From results it can be concluded that majority of the farmers had medium to high level of extension contact. A close study of data given in the Table-10 revealed that 68.89 per cent farmers of Bhilwara and 65.34 per cent farmers of Shahpura were having medium level of extension contact, while 17.78 per cent farmers of Bhilwara and 25.33 per cent farmers of Shahpura were having high level of extension contact, remaining 13.33 per cent farmers of Bhilwara and 9.33 per cent farmers of Shahpura tehsil had low level of extension contact.

The data presented in Table-11 showed that majority of the farmers (59.17 %) had medium level of source of information, whereas, 18.33 per cent of total farmers reported to have high level of source of information and remaining 22.50 per cent of farmers were observed in low level of source of information. The data presented in Table 11 further revealed that 46.67 per cent farmers of

Bhilwara and 66.67 per cent farmers of Shahpura were having medium level of source of information. About 33.33 per cent of respondents Bhilwara tehsil and 9.33 per cent respondents of Shahpura tehsil were having high level of source of information. Remaining 20.00 per cent farmers of Bhilwara tehsil and 24.00 per cent farmers of Shahpura tehsil were found to have low level of source of information. The results are in concurrent with Diptesh and Chauhan (2016).

Conclusions

It was revealed that Kisan Farm Pond Scheme has good socio-economic condition. The present study has been conducted under limited characteristics, so that, it will be better if more characteristics of farm pond are taken for further research in this area. As socio-economic status of the farm pond farmers is a complex phenomenon and includes so many things as stated earlier, it may be possible that some important components might have skipped out which may be considered by other research workers in future.

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Personal Socio-Economic Profile of Custom Hiring Centres respondents in Chittorgarh District of Rajasthan

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Abstract

Agriculture is the backbone of Indian economy. Agriculture is an extremely labour-intensive occupation, which is now facing a challenge of labour shortage. The main objective of CHCs is to supply farm implements to small, marginal and poor farmers at subsidized rates on hire. This enables the small and marginal farmers to take up farm operation in time. Agricultural mechanization is required to provide engineering inputs to agriculture. The results of this study will be useful to the personnel of the State Agriculture Department, KVKs and NGOs involved in upliftment activities of farmers. The present study was designed to evaluate the socio-economic profile CHCs respondents. For the purpose study total 120 respondents were selected. Data were collected through personal interview method. The findings of the study revealed that majority of respondents belonged to age group 34 to 55 years. 80.00 per cent respondents were earning medium annual income *i.e.*, Rs. 23,135 to 1,64,198 per annum. 75.83 per cent respondents belonged to nuclear family. 86.67 per cent farmers in the study area were doing agriculture. Farmers categorized based on caste then OBC category farmers found to be 72.50 per cent. 35.00 per cent respondents educated up to secondary. 60.00 per cent of the study area have Pakka house. 77.50 per cent respondents reported to had medium level of extension participation. 75.83 per cent respondents reported to had medium level of extension contacts.

Key words : Socio-economic, profile, custom hiring centres.

Introduction

The Indian economy is based primarily on agriculture. Agriculture is a very labour intensive industry and a labour shortage is currently a problem. Agriculture in India was the first to use farm equipment that was hired on a custom basis in the 19th century (Srinivasa Rao *et al.* 2013)^[8].

A new strategy called "Custom Hiring Centres" (CHCs) has been devised to fulfill the demand for this digitization. A Custom Hiring Centres (CHCs) is essentially a group of farm implements, machinery, and other items that farmers can rent on a case-by-case basis. The traction units like tractors, power tillers etc. and self-propelled machinery like combine harvesters etc. are used in commonly used for tillage operations for all crops, multi crop equipment and a minimum of crop specific machinery even though some implements and equipment are crop specific.

The primary goal of CHCs is to provide small, marginal and disadvantaged farmers with farm equipment at discounted rates for short-term rental. As Indian farming community is dominated by small and marginal farmers, they may not afford all the equipment and implements necessary for various agricultural operations.

Research Methodology

The study was focused in a Chittorgarh district because

the maximum number of Custom Hiring Centres are present in district. It was decided to select total two tehsils from Chittorgarh district. From each selected tehsil three active CHCs having maximum number of users were selected. Like this three CHCs from Nimbahera tehsil and next three CHCs from Kapasan tehsil were selected. Hence, total six CHCs were selected for this study. From the list so prepared, twenty farmers were selected randomly from each CHCs. Hence, sixty CHCs respondents from each tehsils *i.e.*, Chittorgarh was selected for the present investigation. Like this total sample of 120 CHCs respondents were selected for this study. The Ex-post-facto research design was used for the present study. Data were collected personal interview technique was used to collect data from the selected respondents thereafter; the data were then tabulated and analyzed with mean, standard deviation, were worked out for interpretation of results.

Results and Discussion

The findings on distribution of respondents according to their selected personal and socio-economic characteristics is presented in respective tables.

Table-1 shows that out of 120 respondents, majority of respondents belonged to age group 34 to 55 years. This age group alone constituted 64.16 per cent of respondents. While 17.50 per cent respondent were having age below 34 years and remaining 18.33 per cent

Table-1 : Categorization of respondents based on their age.

S. No.	Category	Nimbahera (n ₁ =60)		Kapasan (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Young (<34 years)	13	21.67	8	13.33	21	17.50
2.	Middle (34-55 years)	41	68.33	36	60.00	77	64.16
3.	Old (>55 years)	6	10.00	16	26.67	22	18.33
	Total	60	100.00	60	100.00	120	100.00

f = frequency, % = per cent Mean = 44.78 S.D. = 10.48

Table-2 : Categorization of respondents based on their annual income.

S.No.	Annual income	Nimbahera (n ₁ =60)		Kapasan (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Low income (<Rs.23,135)	3	5.00	2	3.33	5	4.16
2.	Medium income (Rs.23,135-1,64,198)	48	80.00	48	80.00	96	80.00
3.	High income (>1,64,198)	9	15.00	10	16.67	19	15.83
	Total	60	100.00	60	100.0	120	100.0

f=frequency % =per cent Mean=93,667 S.D.=70531.4

Table-3 : Categorization of farmers based on their family type.

S. No.	Type of family	Nimbahera (n ₁ =60)		Kapasan (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Nuclear	41	68.33	50	83.33	91	75.83
2.	Joint	19	31.67	10	16.67	29	24.17
	Total	60	100.00	60	100.00	120	100.00

f=frequency % =per cent

Table-4 : Categorization of farmers based on their occupation.

S.No.	Occupation	Nimbahera (n ₁ =60)		Kapasan (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Agriculture	53	88.33	51	85.00	104	86.67
2.	Business/service	7	11.67	9	15.00	16	13.33
	Total	60	100.00	60	100.00	120	100.00

f=frequency % =per cent

respondents reported from above 55 years of age. This information was consistent with the findings of Prajapati, V.V., *et al.* (2016) ^[4].

The details indicated in table-2 reveals that maximum 80.00 per cent respondents were earning medium annual income *i.e.*, Rs. 23,135 to 1,64,198 per annum. 15.83 per cent respondents were earning high 100.00 income *i.e.*, Rs. >1,64,198 per annum. Rest 4.16 per cent respondents were gaining low annual income *i.e.*, Rs. < 23,135 per annum. The same table when further examined at tehsils level which shows that majority 80.00 per cent respondents of Nimbahera and Kapasan tehsils were earning *i.e.*, Rs. 23,135 to 1,64,198 per annum. Similar findings reported by Prajapati V.V., (2016) ^[4].

The details indicated in table-3 shows that majority of (75.83 %) respondents belonged to nuclear family. Whereas, 24.17 per cent respondents belonged to joint family. The table also shows that majority of (68.33 % and 83.33 %) respondents of Nimbahera and Kapasan tehsils

belonged to nuclear family. Whereas, 31.67 per cent and 16.67 per cent respondents of Nimbahera and Kapasan tehsils belonged to joint family, respectively. The findings are in concurrence with the findings of Shekhawat (2021) ^[7].

Data presented in table-4 indicates that out of total number of respondents 86.67 per cent farmers in the study area were doing agriculture. While, 13.33 per cent respondents were also engaged in business and service. Majority of 88.33 per cent respondents of Nimbahera tehsil and 85.00 per cent respondents of Kapasan tehsil which are higher per cent engaged purely in agriculture. Only 11.67 per cent respondents of Nimbahera tehsil and 15.00 per cent respondents of Kapasan tehsil were engaged in business and service along with agriculture. This conclusion is in accordance with Rathod *et al.* (2011) ^[5].

Data presented in table-5 shows that when farmers categorized based on caste then OBC category farmers found to be 72.50 per cent followed by General categories

Table-5 : Categorization of farmers based on their caste.

S.No.	Caste	Nimbahera (n ₁ =60)		Kapasan (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	SC	5	8.33	4	6.67	9	7.50
2.	ST	7	11.67	5	8.33	12	10.00
3.	OBC	47	78.33	40	66.67	87	72.50
4.	GEN	1	1.67	11	18.33	12	10.00
	Total	60	100.00	60	100.00	120	100.00

f=frequency %=per cent

Table-6 : Categorization of farmers based on their education.

S.No.	Education	Nimbahera (n ₁ =60)		Kapasan (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Illiterate	3	5.00	7	11.67	10	8.33
2.	Primary	14	23.33	17	28.33	31	25.84
3.	Secondary	23	38.34	19	31.67	42	35.00
4.	Senior secondary	14	23.33	11	18.33	25	20.83
5.	Graduation and above	6	10.00	6	10.00	12	10.00
	Total	60	100.00	60	100.00	120	100.00

f=frequency %=per cent

Table-7 : Categorization of farmers based on the land holding.

S.No.	Land holding	Nimbahera (n ₁ =60)		Kapasan (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Marginal (< 1.00 ha)	17	28.33	16	28.33	33	27.50
2.	Small (1.01-2.00 ha)	25	41.67	24	41.67	49	40.84
3.	Medium (2.01-4.0 ha)	5	8.33	5	8.33	10	8.33
4.	Semi-medium (4.01-10.00 ha)	13	21.67	14	21.67	27	22.50
5.	Large (>10.00 ha)	0	0	1	0	1	0.83
	Total	60	100.00	60	100.00	120	100.00

f=frequency %=per cent

which was 10.00 per cent while SC and ST category farmers was 7.50 per cent and 10.00 per cent, respectively. OBC caste was a dominant farming caste of both Nimbahera and Kapasan tehsils with 78.33 per cent and 66.67 per cent respondents. Similar findings of Kirad, M. S.,(2020) ^[2].

Examination of data in table-6 shows that majority of 35.00 per cent respondents educated up to secondary. On the other hand, only 8.33 per cent respondents were illiterate, 10.00 per cent respondents educated up to graduation and above graduation. 20.83 per cent respondents educated up to senior secondary level and 25.84 per cent respondents educated up to primary level. Similar findings of Prajapati V.V., *et al.* (2016)^[4].

The table-7 indicates that out of 120 respondents, 40.84 per cent respondents were small farmers (from 1.01 to 2.00 ha land). 27.50 per cent of respondents were marginal farmers having land size (<1.00 ha). 22.50 per cent respondents had semi medium land size (4.01 to 10.00 ha). 8.33 per cent of respondents had land size

(2.01-4.00 ha) and remaining 0.83 per cent respondents were large farmers having land size (>10.00 ha). Similar findings of Sabapara *et al.* (2014)^[6].

From the table-8 it shows that majority of the respondents 60.00 per cent of the study area have Pakka house, while 40.00 per cent respondents have Kaccha house. Similar findings of Patel *et al.* (2016)^[3].

Close analysis of data of table- 9 reveals that out of 120 respondents, 77.50 per cent respondents reported to had medium level of extension participation. Whereas, 12.50 per cent of total respondents reported to had high level of extension participation and remaining 10.00 per cent respondents were observed in low level of extension participation. 75.00 per cent respondents of Nimbahera tehsil and 80.00 per cent respondents of Kapasan tehsil had medium level of extension participation. Similar findings of Mistry (2016)^[2].

Data given in table-10 indicates that out of 120 respondents, 75.83 per cent respondents reported to had

Table-8 : Categorization of farmers based on type of house they possessed.

S.No.	Type of house	Nimbahera (n ₁ =60)		Kapasan (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Kaccha	25	41.67	23	38.33	48	40.00
2.	Pakka	35	58.33	37	61.67	72	60.00
	Total	60	100	60	100	120	100

f=frequency %=per cent

Table-9 : Categorization of farmers based on their extension participation.

S.No.	Extension participation	Nimbahera (n ₁ =60)		Kapasan(n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Low (<38.28)	6	10.00	6	10.00	12	10.00
2.	Medium (38.28-69.21)	45	75.00	48	80.00	93	77.50
3.	High (>69.21)	9	15.00	6	10.00	15	12.50
	Total	60	100.00	60	100.00	60	100.00

f=frequency %=per cent Mean=53.11 S.D.=15.46

Table-10 : Categorization of farmers based on their extension contacts.

S.No.	Extension contacts	Nimbahera (n ₁ =60)		Kapasan (n ₂ =60)		Total (n=120)	
		f	%	f	%	f	%
1.	Low (<23.16)	4	6.67	12	20.00	6	5.00
2.	Medium (23.16-51.41)	44	73.33	37	61.67	91	75.83
3.	High (>51.41)	12	20.00	11	18.33	23	19.16
	Total	60	100.00	60	100.00	60	100.00

f=frequency %=per cent Mean=40.56 S.D.=13.36

medium level of extension contacts. Whereas, 19.16 per cent of total respondents reported to had high level of extension contacts and remaining 5.00 per cent respondents were observed in low level of extension contacts. 73.33 per cent respondents of Nimbahera and 61.67 per cent respondents of Kapasan tehsils had medium level of extension contacts.

Conclusions

It was revealed that CHCs respondents have good socio-economic condition. The present study has been conducted under limited characteristics, so that, it will be better if more characteristics of CHCs respondents are taken for further research in this area. As socio-economic status of the CHCs respondents is a complex phenomenon and includes so many things as stated earlier, it may be possible that some important components might have skipped out which may be considered by other research workers in future.

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Distant Hybridization for a Crop Improvement : A Review

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Abstract

Mating between individuals of various species or genera those results in the merging of divergent genomes into a single nucleus is known as distant or wide hybridization. The species barrier to gene transfer is broken by this procedure. It allows the entire genome of one species to be transferred to another, causing changes in the progenies' genotypes and phenotypes. Natural remote hybridization and speciation have produced many of today's crop plants. Many allopolyploid species are the result of broad hybrids doubling their chromosomes. Backcrossing broad hybrids to their parents on a regular basis is another method of gene introgression. This occurs when chromosomes or chromosomal fragments from one species infiltrate into another.

Introduction

Green revolution has transformed India into a food grain surplus country from a deficit one. No other activity has such an immense impact on the agricultural development as the green revolution has done. It also has reflected its impact on breeding and production of vegetable crops. Side effects of green revolution were witnessed largely in the form of reduced varietal diversity in major cultivated crop species and increased uniformity in appearance and harvestable products. This predisposed improved agriculture to natural calamities. Emergence of new pathogen races lead to outbreak of diseases and pest attack caused yield loss up has caused abiotic stresses like drought, flood, salinity and high temperature, which in turn results in reduction of yield and quality. Most of the horticultural crops are perennial in nature, they stand for long time in field, hence they prone to several biotic and abiotic stress during their growth and development. We can achieve resistance or tolerance through many methods of breeding such as introduction, hybridization is a only reliable method of crop improvement for biotic and abiotic stress tolerance or resistance. Wild species are the treasure of valuable genes .Exploration of these genes could be possible through distant hybridization..

Distant or wide hybridization : Distant hybridization occurs when two distinct species of the same genus or genera of the same family cross, and such crosses are referred to as distant crosses or broad crosses. In the genetic enhancement of various agricultural plants, wide crossing or remote hybridization has been utilized. It's an efficient way to get desired genes from related species and genera into cultivated plants. In more closely related species or genera, distant crosses are more effective than in less closely related species or genera.

Classification of Distant hybridization : It is broadly classified into two main types :

1. Interspecific hybridization

Fully fertile

Partially fertile

Fully sterile

2. Intergeneric hybridization

Interspecific Hybridization

Interspecific hybridization, also known as Intergeneric hybridization, occurs when two distinct species of the same genus cross. Interspecific crossings are the offspring of such crosses, while interspecific hybrids are the offspring of such crosses. Thomas fair child created the first interspecific hybrid between sweet William and Dianthus carnation species in 1717. (*Dianthus barbatus* x *Dianthus caryophyllus*). When a desirable trait is not found within a crop species, interspecific hybridization is utilized .Karpachenko created the first Intergeneric hybrid between radish and cabbage in Russia in 1928. Raphanobrassica has radish (*Raphanus sativus*) and cabbage as parents(*Brassica oleracea*).

Fully Fertile : Crosses of this type are made between animals that have full chromosomal homology. Interspecific crosses between individuals with perfect chromosomal similarity are completely viable. Because the chromosomes in such hybrids couple normally during meiosis, the F1 Plants are totally fertile.

Example : Cotton comes in four varieties: *Gossypium hirsutum*, *G. barbadense*, *G. arboreum*, and *G. herbaceum*. The first two New World species are diploid ($2n = 26$), while the latter two Old World species are tetraploid ($2n = 52$). Fully viable crosses exist between the tetraploid species *G. hirsutum* and *G. barbadense*, as well

Differences between Interspecific and Intergeneric hybridization

S. No.	Particulars	Interspecific	Intergeneric
1.	Parents involved	Involve two different species of same genes	Involve two different genera of the same family
2.	Fertility	Such hybrid vary from completely fertile to completely sterile	Hybrids are always sterile
3.	Seed setting	More than Intergeneric crosses	Low
4.	Use in crop improvement	More than Intergeneric crosses	Less then interspecific crosses
5.	Release of hybrid variety	Possible in some crops	Not possible
6.	Evolution of new crop	Not possible but evolution of new species is sometimes possible	sometimes possible

as between the diploid species *G. arboreum* and *G. herbaceum*.

G. hirsutum (2n = 52) x *G. barbadense* (ln = 52) F₁ plants are fully fertile.

G. arboreum (2n = 26) x *G. herbaceum* (2n = 26) F₁ plants are fully fertile.

Partially Fertile : These crosses are made between animals that have different ploidy levels yet share certain chromosomes. Interspecific crosses between individuals with different chromosomal numbers but some chromosomes in common are partly viable. The F₁ plants are partly fertile and partially sterile in such conditions.

Example : Wheat: Diploid (2n = 14), tetraploid (2n = 28), and hexaploid (2n = 42) are the three kinds of wheat species. Partially viable cross between common wheat (*Triticum aestivum*, 2n = 42) and durum wheat (*T. durum*, 2n = 28). Because A and B genome chromosomes are prevalent in both of these animals, F₁ hybrids are only partly viable. During meiosis, F₁ has 14 bivalents and 7 univalents. In this cross, there is some seed set.

Triticum aestivum (AA BB DD) x *Triticum durum* (AA BB)
(2n = 42) (2n = 28)

F₁ (AABBD) (2n = 35) partially fertile

Fully Sterile : These crosses are made between individuals with different chromosomes. Interspecific crosses that do not have chromosomal homology are completely infertile. The chromosomal number in these individuals may or may not be the same. During meiosis, the absence of chromosomal similarity prevents chromosome pairing between two species. As a result, the F₁ plants are self-sterile to the fullest extent possible. Colchicine therapy cans double the number of chromosomes in such hybrids, making them self-fertile. Tobacco, wheat, cotton, Brassica, Vigna, and a variety of other crops have all been documented to have fully sterile F₁ hybrids.

Example : Tobacco

Clausen and Good speed (1928) crossed two wild diploid tobacco species, *Nicotiana sylvestris* (2n = 24) and *Nicotiana tomentosa* (2n = 24), to produce a hybrid. The

F₁ hybrid proved to be infertile. When the F₁ plants were given colchicine, they produced a completely viable tetraploid (2n = 48) that looked like farmed species (*N. tabacum*).

Another hybrid was created between two wild diploid tobacco species, *N. paniculata* (2n = 24) and *N. undulata* (2n = 24). The F₁ was sterile once more. Colchicine treatment of F₁ resulted in the generation of viable amphidiploid (2n = 48) seeds that were comparable to those found in farmed *N. rustica*.

Main features of Interspecific Hybridization:

It's utilized when a desirable characteristic isn't found in a crop species.

It is a successful way of transplanting beneficial genes from farmed or wild species into cultivated plants.

In vegetatively propagated species like sugarcane, and potato, interspecific hybridization is more effective than in seed propagated species.

Introgression occurs when certain genes from one species are transferred to the genome of another species as a result of interspecific hybridization.

Intergeneric hybridization

Intergeneric hybridization occurs when two genera from the same family cross. Intergeneric crosses produced Triticale and Raphnobrassica.

Example : *Radish-Cabbage*: Karpechenko created an intergeneric hybrid between radish (*Raphanus sativus*) and cabbage (*Brassica oleracea*) of the Cruciferae family in Russia in 1928. The major goal was to mix radish roots with cabbage leaves. The F₁ was found to be infertile. The creation of a viable amphidiploid, called Raphanobrassica by Karpechenko came from the doubling of chromosomal number by colchicine therapy. However, the new species that resulted had roots similar to cabbage and leaves similar to radish, which was an ineffective combination.

Main features of Intergeneric Hybridization

When the desired genes are not found in various species of the same genus, intergeneric hybridization is utilized

This approach is infrequently employed in crop development programs, and only for the transfer of particular characteristics from related taxa into cultivated species.

In asexually propagated species, Intergeneric hybridization is commonly utilized.

Sterility is usually present in F₁ hybrids between two genera. The fertility must be restored by colchicine therapy, which involves doubling the chromosomes.

Some researchers utilized Intergeneric hybridization to create new crop species.

Barriers associated with wide hybridization

Spatial isolation : It is associated with geographical distance, physical separations of time and environment. Sensitivity to photoperiod, introduction to different latitudes and separation by geographical and political barriers can isolate two species reproductively. Development of different maturity groups in knoll khol, radish and cauliflower are consequences of spatial isolation.

Pre-fertilization barriers : These barriers are operative between the parental species. They prevent crossability by hindering the fertilization process. Such disturbance of fertilization in interspecific crosses is also termed as interspecific incompatibility or incongruity. Lack of pollen-stigma recognition is mainly responsible for incongruity. The reaction is sporophytic in nature and reported to be associated with pollen wall substances.

Failure of Pollen germination : Interspecific hybrid in *Cucumis* species through conventional breeding procedures was unsuccessful because of the existence of a pre-fertilization barrier. The barrier was characterized by non-germination of pollen even up to 72 hours after pollination.

Swollen pollen tube growth : This has been widely reported in case of failure of wide crosses. Incompatibility in *Cucumis* spp. is characterized by delayed growth of pollen, or arrested pollen tube growth in the stigma or inability of pollen tubes to reach the ovules. Based on pollen tube growth, behavior, crosses between African groups, namely bilateral congruity, bilateral incognity and unilateral incognity.

Lack of Fertilization : In such cases, pollen tube effectively delivered the two sperm nuclei to embryo sac. In one case, zygote was formed but no endosperm development while in second case 10 percent crosses developed endosperm but no embryo.

Post fertilization barriers : These barriers are operative in the distant hybrids and their progenies. These are also known as post syngamic barriers and include embryonic breakdown, failure of zygote development, abnormal

fertilization, inhibition of endosperm and embryo development.

Hybrid embryo abortion : Arrest of embryo development or its abortion has been noticed in several interspecific hybrids. The major barriers to interspecific hybridization in *Phaseolus* sp. i.e. *P. vulgaris*, abnormal embryo development is observed.

Hybrid in viability : It results from various factors and manifests from zygote development to seed formation. It operates in F₁ seedlings causing high mortality, hybrid plants are characterized by poor growth, chlorotic leaves and die before maturity. The reason may be disharmony between nucleus of one species and cytoplasm of other or between nucleus of both the species or due to action of specific genes known to cause lethality, chlorosis and weakness in F₁ hybrids. eg. Cross between *Cucumis sativus* x *C. Melo* and *Abelmoschus esculentus* x *A. tetraphyllus*.

Hybrid sterility : F₁ hybrids are characterized by lack of seed set. Hybrid sterility is due to manifestation of lethal genes, genetic imbalance due to chromosomal non-homology, chromosomal elimination and endosperm abortion. Several interspecific hybrids of *Abelmoschus esculentus* x *A. ficulneus* and *Abelmoschus esculentus* x *A. tuberculanthus* show very poor seed set.

Failure of flowering in the progenies

Either hybrid is devoid of reproductive structure or highly deformed non-functional structures are formed. It is due to failure of physiological differentiation while non-functional reproductive systems are attributed to failure of meiosis in either one or both the sexes.

Hybrid breaks down : It is manifested in the form of inviable and weak F₂ plant progenies show normal development and good fertility but in F₂ generation performance of hybrids fall below satisfaction and sometimes may be complete sterility. Afful *et al.*, (2018) observed failure in fruit set, when the wild accessions were used as female parents in the crossability study of cultivated brinjal with *Solanum torvum*, *S. anguivi* and *S. aethiopicum*

Techniques to overcome pre-fertilization barriers

Taxonomic position of parental species : An ease in hybridization is expected when the species more resemble phenotypically. Taxonomic classification is based on morphological features but by and large is the outcome of genetic factors in association with environment.

Doubling of chromosome number : When the failure of hybridization is due to different ploidy level then this technique is followed. In many Polyploid level then this technique is followed. In many polyploid cultivated

species, their wild progenitors are diploid and crossing attempts are difficult. One may increase ploidy level of wild type by colchicine treatment. This enhances the success rate in crops like Potato, Cucumis and Brassica spp.

Bridging species technique : In many crops, two species which are otherwise incompatible may be hybridized with the help of third species. The third species acts as bridge in recommending the two incompatible species so known as bridging species. This technique has been used in making wide crosses in potato, lettuce and sugar beet. Hayes et al., (2005) were successful in using *S. verrucosum* as a female bridging parent to access 2x (IEBN) *S. pinnatisectum*. *Solanum simplicifolium* was used as bridging species in crossing *Seakale* and *S. tuberosum*.

Shortening of the cycle : In some species, the incompatible reaction can be overcome by reducing the length of style. Incompatible reaction in radish can also be overcome by reduction of stylar tissues.

Mentor pollination : Pollen grains of distant species do not germinate on the stigma of cultivated species. However, when these pollen grains are mixed with killed maternal pollen grains, germination of the incompatible pollen grains takes place as in case of Cucumis (Beharav and Cohen, 1994). It happens because cell wall proteins of pollen play a pivotal role in pollen-pistil interaction. Pollen killed in ethanol and mixed with incompatible pollens; release the proteinaceous recognition factors, thereby masking rejection reaction of the recipient stigma. The killed maternal pollen is known as mentor pollen.

Use of growth regulators and immunosuppressants : Growth regulators (GRs) enhance the zygotic formation in distant hybrids of many cucurbits, okra and tomato. Commonly used GRs are IAA, IBA, GA3. GA3 75ppm application to maternal plant 1 or 2 days before and after pollination improved zygote formation, faster pollen tube growth, more embryo survival and more seed set in wide crosses. Application of auxin in *Solanum* prevented flower abscission and enhanced fruit set.

In vitro fertilization : It is effective when stigma and style inhibit pollen tube growth and embryo abortion occurs at early stages of development. The whole gynoecium is excised and placed on MS medium followed by dusting of pollens on the stigma and fertilized ovule is reared to maturity (Ondrej et al., 2002).

Protoplast fusion : It involves the fusion of protoplasts of two incompatible species or genera and the fused heterokaryon is placed on artificial nutrient medium and regenerated into hybrid plant. This approach has particularly more potential to generate new genotypes in vegetatively propagated species. Some examples are tomato + potato, *solanum nigrum* + *S. tuberosum*. Chandel

et al 2015 studied interspecific potato somatic hybrids between cultivated *S. tuberosum* dihaploid C-13 and wild species *S. cardiophyllum* via protoplast fusion. The use of somatic fusion for improving valuable agronomic traits in cultivated potatoes is done for traits like atrazine resistance, frost tolerance, quality improvement and pest and disease resistance.

Techniques to overcome Post-fertilization barriers.

Embryo rescue : Embryo abortion is the major barrier in distant hybridization. It can occur at any stage of development depending on the genomic relationship of two parental species. *Solanum sitiens* is a rare endemic plant of the Atacama Desert of Chile having tolerance to drought, salinity and low temperatures, resistance to certain pathogens and modified fruit ripening. To overcome sterility and unilateral incompatibility of *solanum lycopersicum* x *S. sitiens* hybrids embryo rescue.

Capsicum chinense, *C. annuum* and *C. frutescens* were crossed with each other and embryo rescue was done between 27-33 days after pollination by Debbarma et al., 2013. Hybrid plants were obtained and their hybridity was confirmed using both morphological and RAPD markers.

Ovary culture : In some wide crosses, embryo abortion occurs at early stages of development when it is difficult to excise and culture embryos. To overcome this problem, ovaries are cultured. Depending on cross combination, ovaries 2-15 days after pollination are excised and cultured on nutrient medium. Flower is pruned by removing calyx, corolla and stamen. Distal part of the pedicel is cut and ovary planted on simple semi-solid MS nutrient medium. When the embryos become visible, they are aseptically taken out and cultured in a manner of embryo rescue technique.

Ovule culture : Ovule culture is an elegant experimental system by which ovules are aseptically isolated from the ovary and are grown aseptically on chemically defined nutrient medium under controlled conditions. It is used when barrier impedes growth of zygote at earlier stages of development.

Backcrossing : Wide crosses showing poor fertility can be backcrossed to cultivated species to improve the fertility of hybrids. Backcrossing can be applied to balance cytoplasmic interaction by producing cybrids or alloplasmic lines.

Chamola et al., 2015 used cytoplasmic male sterile (CMS) lines of *Brassica juncea* and *B. napus* with the mitochondrial genome of *Morinda arvensis* and *Erucastrum canariense*, respectively, were used to transfer CMS to cauliflower (*B. oleracea*). Embryo rescue was also done in BC1 and BC2 to obtain progenies. Recovery of the recurrent parent phenotype was faster in

B. napus x *B. oleracea* than *B. juncea* x *B. oleracea*. BC3 generation plants of *B. napus* x *B. oleracea* showed good curd formation and complete male sterility and nine bivalents at meiosis whereas those of *B. juncea* x *B. oleracea* were male sterile but still had genetic elements of *B. juncea*.

Chromosome doubling : Distant hybrids exhibit high degree of sterility, which is mainly due to genic or chromosomal difference between parental species. This problem in many cases has been overcome by doubling the chromosome number of F₁ hybrid. Bharathi *et al.*, (2014) crossed natural tetraploid *Momordica subangulata* subsp. *renigera* (2n = 56) with induced tetraploid *Momordica dioica* (2n = 4x = 56) to produce new species *Momordica* x *suboica*. This hybrid maintains its morphological characteristics, superior agronomic traits making it a good choice as a new vegetable crop.

In conclusion, wild species are the store house of novel genes, which can be utilized for wide hybridization. So, wild species forms the heart of wide hybridization programme. Wide hybridization is an effective tool for genetic improvement in vegetables crops. It is a highly technical and knowledge intensive process. Even though, wide hybridization has so many barriers, it can be overcome through the conventional and biotechnological approach. To broaden the genetic base, wide hybridization following in vitro and biotechnological approach is being used. It can be used for disease and insect resistance breeding and quality improvement in the cultivars, which is need of the hour.

Applications of Distant Hybridization in crop Improvement

Improvement of fruit quality : Custard apple: Jalikop and Kumar have studied effect of different annona species (*Annona squamosa*, *A. reticulata*, *A. atemoya* and *A. cherimoya*) pollen on var. Arka Sahan and to know the best pollen source in both quality and yield wise. They found *Annona squamosa* followed by *A. reticulata* were best pollen source for Arka Sahan. *Annona squamosa* pollens resulted in increased taste, fruit shape and size.

Fruits with less seeds : Citrus: Smith *et al.*, have produced first intergeneric hybrid between Citrus and Citropsis. Citropsis is producing less number of seeds per fruit (4/fruit) and showing resistance to many diseases. They successfully produced viable intergeneric hybrid between citrus and citropsis and confirmed through molecular marker.

Abiotic stress tolerance Mango : Vasugi *et al.*, have found interspecific crossability in mango by using both fresh and cryopreserved pollens. Among different varieties of *Mangifera indica* (Arka Anmol and Arka Neelkiran) and species *M. zeylanica* (salt tolerant) and *M.*

odorata (good fruit quality) used in the experiment, species *M. odorata* recorded high fruit set when Arka Anmol is used as a female parent. But due to heavy fruit drop, matured fruit could not be recovered. However, this drop was not due to embryo abortion, but due to environmental factors as this was confirmed by dissecting the fallen fruits. This generated hybrid seeds can be used for further breeding programme for screening against salt tolerance.

Limitations of Distant Hybridization

Though remote hybridization offers a number of important uses in crop development, it has certain drawbacks that have limited its widespread adoption.

Cross incompatibility, hybrid in viability, hybrid sterility, and hybrid breakdown are all difficulties connected with distant crossings. Interspecific or Intergeneric gene transfer is complicated by these issues.

To make distant hybrids effective in some situations, specific procedures like as ploidy modification, pistil manipulation, chemical (growth regulator) therapy, bridge crossing, grafting, embryo culture, and so on must be used. As a result, this is a difficult task

Desirable traits are frequently associated with unfavorable characters, making remote hybridization of desirable genes from wild species problematic. Several wheat chromosomal addition and replacement lines have been created, however because to the presence of some undesired genes, none of them could be employed for commercial production.

Distant hybrids can exhibit a number of negative characteristics, including as non-flowering, late maturity, seed dormancy, and ineffective combinations, such as *Raphanobrassica*.

Interspecific crossings make it harder to transfer recessive gene-controlled traits.

Character transmission is not as straightforward in remote hybridization as it is in intervarietal crosses.

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A Study on Constraints Faced by Farmers in Prevailing Farming Systems in Jaipur District of Rajasthan

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Abstract

The present investigation was conducted in Jaipur district of Rajasthan with aimed to "identify major constraints faced by farmers in different farming systems". The study revealed that four farming systems were existed in both rainfed and irrigated situations of Jaipur district viz: FS-I: Crop + Dairy (C+D), FS-II: Crop + Dairy + Vegetable (C+D+V), FS-III: Crop + Dairy + Goat (C+D+G) and FS-IV Crop + Poultry (C+P). The major constraints reported by household in rainfed situation for crops and dairy enterprises were inadequate irrigation facilities (61.24 mean score) and high cost of concentrates feed (64.41 mean score), respectively. While, under irrigated situation, major constraints observed in crop enterprise were lower price of farm produce (59.41 mean score) and low milk productivity of cattle (59.47 mean score) in dairy enterprise. Under poultry enterprise, high cost of feed (75.48 mean score) was observed as prime constraint under both the situations.

Key word : Crop, vegetable, dairy, enterprises, constraints.

Introduction

Agriculture is the backbone of the Indian economy. Despite concerted industrialisation in the last five decades, agriculture occupied a pride of place in the Indian economy. The improved technology, progressiveness, innovative nature and entrepreneurial ability of the farmers could result in increased production in seventies and eighties. But, the same tempo could not be maintained now. Since, continuous input use resulted only in disproportionate returns to individual crops or cropping systems. A vast majority of available land is under dry land agriculture whose potential is not yet fully exploited. For a sustained agricultural development, the minimisation of risk in agricultural production is essential. Diversification of agriculture is the best alternative to realise this end objective.

The adoption of various farming system approaches fits well into the funnel of diversified agriculture. Farming system enterprise includes crops, livestock, poultry, fish, sericulture, vermicompost, piggery, dairy, goat, horticulture etc. A combination of one or more enterprises with cropping, when carefully chosen, planned, and executed, gives greater dividends than single enterprise. Farming system approach in analyzing the problems of agriculture is gaining lot of importance in recent years. Such a study, it is believed to throw light on the problems associated with different farming systems and enable the academicians and policy makers to formulate and implement appropriate policies for a balanced, integrated and overall agricultural development.

The study will also be useful for research scientists

who are engaged in farming system research to observe the major constraints in farming system and to suggest the farmers for improvement on the basis of research and evaluate them critically.

Research Methodology

The present study was conducted purposively in Jaipur district of Rajasthan, Out of sixteen tehsils of Jaipur district, two tehsils namely, Chomu and Phulera were purposively selected for the study. In both tehsils, Chomu having more proportion of irrigated area and Phulera tehsils also having more proportion of rainfed area to the total operational holding. The complete list of all the villages from each selected tehsil was prepared separately, with the help of tehsil officials of the concerned tehsil. From each list of the villages, two villages from each selected tehsil were randomly selected. Thus, constituting four villages for the detailed investigation. Then, 15 farmers from each selected village were randomly selected. In all, 60 farmers (thirty each from rainfed and irrigated farming situations) were selected for detailed study.

Primary data were collected from the selected farmers by using personal interview method with the help of pre-structured schedules. Information regarding the constraints being faced by the farmers in different enterprises were also collected. Garrets ranking technique was used to analyze the constraints perceived by the respondents in farming systems. The respondents were asked to rank the factors that limit in adoption of integrated farming systems. These orders of merit were transformed into units of scores by using the following formula:

Table-1 : Constraints faced by households for crop enterprises.

S. No.	Constraints	Rainfed situation		Irrigated situation	
		Garrett Score	Rank	Garrett Score	Rank
1.	Higher price of Inputs	61.24	IV	56.71	II
2.	Inadequate irrigation Facilities	61.24	I	31.21	X
3.	Lack of technical Knowledge	4.17	XII	35.87	IX
4.	Lower price of farm Produce	47.28	II	59.41	I
5.	Shortage of agriculture labour during peak hours of cultivation	10.71	X	38.27	VII
6.	Lack of market Information	16.46	VII	39.24	VI
7.	Lack of desired Variety	37.84	III	42.27	V
8.	High cost of labour	8.12	XI	17.24	XII
9.	Lack of credit Availability	1.18	XIII	9.23	XIII
10.	Lack of knowledge about improved production practices	15.47	VIII	36.77	VIII
11.	Lack of good storage facilities	12.25	IX	25.14	XI
12.	High incidence of disease and pest	19.87	VI	46.63	IV
13.	Grazing by stray Animals	23.21	V	49.47	III

Table-2 : Constraints faced by households for dairy enterprises.

S. No.	Constraints	Rainfed situation		Irrigated situation	
		Garrett Score	Rank	Garrett Score	Rank
1.	Low milk productivity of Cattles	51.24	IV	59.47	I
2.	Long dry period in cattles	47.44	V	56.27	II
3.	Late maturity of animals	43.17	VII	39.74	VIII
4.	High cost of concentrates	64.41	I	46.82	V
5.	Lack of development programme for livestock rearing	29.41	XI	21.74	XII
6.	Lack of AI and veterinary Facilities	34.78	X	42.64	VII
7.	Non- availability of dry fodder	39.00	VIII	51.24	III
8.	Low price for milk	44.29	VI	49.62	IV
9.	Lack of cold storage facilities	26.44	XII	27.44	XI
10.	Improper housing facilities	36.47	IX	36.22	IX
11.	Non- availability of green fodder round the year	58.17	II	33.44	X
12.	High cost of feeds and Fodder	56.14	III	43.58	VI

$$\text{Per cent position} = \frac{100(R_{ij} - 0.50)}{N_j}$$

Where,

R_{ij}- rank given for the ith factor by the jth individual.

N_j- number of factor ranked by the jth individual.

The per cent position was converted into scores by referring to the table given by Garrett and Woodworth (1969). Then for each factor the scores of the individual respondents were added together and divided by the total number of respondents for whom score were added. These mean scores for all the factors were arranged in descending order and the most influencing factors were identified through the rank assigned.

Results and Discussion

The constraints faced by the households for different enterprises have been discussed under three sub-heads:

Constraints faced by households for crop enterprises

An attempt was made to assess the constraints in crop enterprises in the study area. The major occurred

constraints were enlisted and the respondents were asked to rank the constraints related to production, technology and marketing aspects of field crops and vegetable crops. The constraints faced by households for crop enterprises (field crops +vegetable crops) in rainfed and irrigated situations are shown in table-1.

In rainfed situations : Table-1 reveals that, among thirteen constraints considered, the inadequate irrigation facilities was the major problem reported by households with a mean score of 61.24. So, this problem got first rank, followed by lower price of farm produce (mean score of 47.28), lack of desired variety (mean score of 37.84), high price of inputs (mean score of 25.94), grazing by stray animals (mean score of 23.21), disease and pest problems (mean score of 19.87), lack of market information (mean score of 16.46), lack of knowledge about improved production practices (mean score of 15.47), lack of good storage facilities (mean score of 12.25), shortage of agricultural labour during peak hours of cultivation(mean score of 10.71), high cost of labour (mean score of 8.12), lack of technical knowledge (mean score of 4.17) and lack of credit availability (mean score of 1.18).

Table-3 : Constraints faced by households for poultry enterprises.

S. No.	Constraints	Garrett Score	Rank
1.	High charge of electricity	68.65	IV
2.	Non availability of grading equipments	67.50	V
3.	Lack of credit facilities	64.69	VI
4.	Low egg price during summer	70.00	III
5.	Lack of training on poultry health Management	61.98	VII
6.	High cost of feed	75.48	I
7.	Death rate of birds is high	71.22	II

In irrigated situation : Table-1 shows that, out of thirteen constraints, lower price of farm produce was the major problem expressed by the households with mean score of 59.41 and hence the problem assigned first rank followed by higher price of inputs (mean score of 56.71), grazing by stray animals (mean score of 49.47 score), disease and pest problems (mean score of 46.63 score), lack of desired variety (mean score of 42.27 score), lack of market information (mean score of 39.24 score), shortage of agricultural labour during peak hours of cultivation (mean score of 38.27), lack of knowledge about improved production practices (mean score of 36.77), lack of technical knowledge (mean score of 35.87), inadequate irrigation facilities (mean score of 31.21), lack of good storage facilities (mean score of 25.14), high cost of labour (mean score of 17.24) and lack of credit availability (mean score of 9.23). Similar, results were observed by Wadear (2003) and Singh and Burark (2016).

Thus, it can be concluded that in rainfed situation, inadequate irrigation facilities were found to be first rank (i.e. mean score of 61.24) among constraints reported by households. While, in irrigated situation, households opinion on lower price of farm produce was highest (i.e. mean score of 59.41) that got first rank.

Constraints faced by households for dairy enterprise

An attempt was made to assess the constraints under dairy enterprises in the study area. The major occurred constraints were enlisted and the respondents were asked to rank the constraints related to feeding, breeding, health management, milk marketing, infrastructure and technical aspects of dairy farming. The constraints faced by households for dairy enterprises in the rainfed and irrigated situations are presented in table-2.

In rainfed situation : Table-2 shows that, in rainfed situation, total twelve constraints reported by households towards dairy enterprise. Among constraints, high cost of concentrates was the prime problem with a mean score of 64.41, which got first rank followed by non-availability of green fodder round the year (mean score of 58.17), high cost of feed and fodder (mean score of 56.14), low milk productivity of cattle (mean score of 51.24), long dry periods in cattle (mean score of 47.44), low price of milk

(mean score of 44.29), late maturity of animals (mean score of 43.17), non-availability of dry fodder (mean score of 39.00), improper housing facilities (mean score of 36.47), lack of veterinary facilities (mean score of 34.78), lack of development programme for livestock rearing (mean score of 29.41) and lack of cold storage facilities (mean score of 26.44).

In irrigated situation : Table-2 reveals that, in irrigated situation, total twelve constraints observed by households. Out of twelve constraints, low milk productivity of cattle was the major problem with highest mean score 59.47, so this problem assigned first rank, followed by long dry periods in cattle (mean score of 56.27), non-availability of dry fodder (mean score of 51.24), low price of milk (mean score of 49.62), high cost of concentrates (mean score of 46.82), late maturity of animals (mean score of 39.74), improper housing facilities (mean score of 36.22), high cost of feed and fodder (mean score of 43.58), lack of veterinary facilities (mean score of 42.64), non-availability of green fodder around the year (mean score of 33.44), lack of cold storage facilities (mean score of 27.44) and lack of development programme for livestock rearing (mean score of 21.74). Similar findings were reported by Nagaraju and Sankhala (2003), Nirmala and Muthuraman (2009) and Bhutia et al. (2017).

Constraints faced by households for poultry enterprises

An attempt was made to assess the constraints in poultry enterprises in the study area. The major prevailed constraints were enlisted and the poultry - respondents were asked to rank the constraints related to feeding, breeding, health management, electricity and equipment etc. The Constraints faced by farmers in poultry enterprises are shown in table-3.

Table-3 depicts that, seven constraints were faced by households for poultry enterprises. Among seven constraints, high cost of poultry feed (mean score of 75.48) was the major constraints faced by the majority of farmers and hence it was assigned first rank followed by death rate of birds (mean score of 71.22), low egg price during summer (mean score of 70.00), high charge of electricity (mean score of 68.65), non-availability of grading equipments (mean score of 67.50), lack of credit

facilities (mean score of 64.69) and lack of training on poultry health management (mean score of 61.98).

Conclusions

The major constraints under rainfed situation in crop production was inadequate irrigation facilities (with 61.24 mean score), whereas, lack of credit availability was minor problem (with 1.18 mean score).

Among constraints under irrigated situation in crop production, lower price of farm produce got first rank (with 59.41 mean score) and lack of credit availability got least rank (with 9.23 mean score) in the study area.

The major problem under rainfed situation in dairy enterprise was reported the high cost of concentrate (with 64.41 mean score) and minor problem was observed towards the lack of cold storage facilities (with 26.44 mean score) in the study area.

Among the constraints under irrigated situation in dairy enterprise, low milk productivity of cattle was assigned first rank (with 59.47 mean score) and lack of cold storage facilities was reported least in rank (with 21.74 mean score).

The prime constraint under rainfed and irrigated situations in poultry enterprise was the high cost of poultry feed (with 75.48 mean score) whereas minor constraint was lack of training on poultry health management (with 61.98 mean score).

Recommendations

Based on the conclusions drawn from the results of the study following policy recommendations may be suggested :

The study indicated that, under rainfed situation, major constraint faced by farmers in crop production was inadequate irrigation facilities. So, there is need for creating the awareness about the storage of rain water among the farmers through construction of farm ponds with the help of the programme and schemes run by the State Government, other agencies and NGOs.

In the study area, it was observed that, under irrigated situation, most of the farmers faced the problem of lower price of farm produce. Hence, there is a need to strengthen institutional support for procurement of farm produce at MSP and formulate appropriate produce price policies for safe guarding the interest of the farmers.

The majority of households faced with problems of high cost of concentrates and low milk productivity of cattle in rainfed and irrigated situations of the study area, respectively. Therefore, Government along with private agencies should organize efforts for improvement programmes for milk productivity of cattle and also should develop buffer stock for concentrate feed and fodder to avoid adverse farming conditions at village levels as well as block levels.

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Productivity, Quality and Nutrient Uptake of Garlic (*Allium sativum* L.) as Influenced by Integrated Nutrient Management

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Abstract

A field experiment was carried out at the Krishi Vigyan Kendra situated in Sewania village, Jchhawar block of Sehore district (M.P.) during winter seasons of 2020-21 and 2021-22. The study was on the productivity, quality and nutrient uptake of garlic as influenced by integrated nutrients management. The experiment comprising six treatments on organic sources of nutrients and four levels of inorganic sources of nutrients were laid out in a factorial randomised block design with three replications. The garlic var. G-282 was grown as per recommended package of procedures. The results revealed that the application of vermicompost @ 8 t/ha produced maximum 103.64 q/ha garlic bulb, recorded highest N, P and K contents in bulbs (0.192, 0.071 and 0.149 %, respectively) and consequently maximum uptake of N, P and K by bulbs (20.17, 7.50 and 15.61 kg/ha, respectively) along with 41.12 °Brix, TSS 0.199 mg/g, ascorbic acid and 38.71 % dry matter. The second, third and fourth best organics were 10 t poultry manure/ha, 15 t FYM/ha and 15 t goat manure/ha, respectively, with respect to all these parameters. The highest level of 100 % RDF (N₁₀₀ P₅₀ K₅₀) recorded maximum bulb yield (110.84 q/ha), its nutritional quality, N, P and K contents and their uptake by garlic. This was followed by the application of 75 % and then 50 % RDF.

Key words : Integrated nutrient management, garlic.

Introduction

Garlic (*Allium sativum* L.) is one of the most important spices and condiments used in daily cooking in India. It is an important crop among all the spice crops due to its medicinal as well as flavour and taste imparting characters. Garlic belongs to the family Alliaceae with genus *Allium* and spices.

Garlic (*Allium sativum* L.) having 2n=16 chromosome numbers. Thus is a hardly bulbous rooted perennial herb. Garlic has higher nutritive value as compared to other bulbous crops. It is a rich source of carbohydrates (29.0%), proteins (6.3%), essential oils (0.1-0.4%) and also contains appreciable quantities of fats, vitamin C and sulphur (Memane *et al.*, 2008). Despite its importance and increased production, garlic productivity is generally low due to genetic and environmental factors affecting its yield and yield related traits.

The multi-nutrient efficiencies are increasing and soil properties are decreasing day by day due to imbalanced and insufficient use of manures and fertilizers. The continuous application of inorganic fertilizers has deteriorated the soil. The general tendency is that the total crop removal of nutrients is never replenished. The organic sources of nutrients are gaining global importance in vegetable crop production and are required to be integrated with chemical fertilizers.

Serious attention is now being paid towards the

organic farming having integrated nutrient supply system because it is economically viable, eco-friendly and ecologically sound practice. The combined use of organic manures (FYM, vermicompost, poultry manure etc.) with NPK and biofertilizers helps to maintain soil productivity on sustainable basis (Vikas Kumar *et al.*, 2019). Organic manures are well known to improve physico-chemical and biological soil properties to enhance its fertility and productivity (Ali *et al.*, 2018). Incorporation of organic and inorganic sources of nutrients holds great promise in garlic production (Badal *et al.*, 2019). The information on the conjunctive use of organic manures and inorganic fertilizers on the productivity of garlic is limited for this region. Therefore, the present research work taken up.

Materials and Methods

The field experiment was carried out at the Krishi Vigyan Kendra situated in Sewania village, Jchhawar block of Sehore district (M.P.) during winter seasons of 2020-21 and 2021-22. The soil of the experimental field was clay-loam (medium black) having pH 7.2, electrical conductivity 0.32 dS/m, organic carbon 0.44 %, available N, P₂O₅ and K₂O 240, 12.8 and 425 kg/ha, respectively. The treatments comprised 6 organic sources of nutrients (control, 15 t FYM/ha, 8 t vermicompost/ha, 10 t PM/ha, 15 t goat manure/ha and *Azotobacter* + PSB) and 4 levels of inorganic sources (control, 50, 75 and 100 % RDF (N₁₀₀ P₅₀ K₅₀)). The 24 treatment combinations were laid out in factorial randomised-block design keeping three

Table-1 : Yield quality nutrient contents and their uptake of garlic bulb as influenced by integrated nutrient management.

Treatments	Bulb yield (q/ha)	Nutrient contents (%)			Total uptake of nutrients (kg/ha)			Nutritional qualities		
		N	P	K	N	P	K	TSS (°Brix)	Ascorbic acid (mg/g)	Dry mater (%)
Organic sources of nutrients										
Control	84.01	0.167	0.054	0.123	14.26	4.21	9.16	32.79	0.176	32.11
FYM (15 t/ha)	96.66	0.187	0.65	0.139	18.12	6.27	13.52	37.73	0.191	34.68
Vermicompost (8 t/ha)	103.64	0.192	0.071	0.149	20.17	7.50	15.61	41.12	0.199	38.71
Poultry manure 10 t/ha)	98.26	0.187	0.067	0.144	18.65	6.69	14.28	39.24	0.193	36.71
Goat manure (15 t/ha)	94.32	0.183	0.063	0.136	17.53	6.00	12.92	36.46	0.191	34.23
Biof. (Azotobactor + PSB)	90.52	0.177	0.059	0.129	16.35	5.42	11.80	33.75	0.184	33.29
S.Em±	0.22	0.002	0.007	0.002	0.161	0.086	0.127	0.21		0.18
C.D. (P=0.05)	0.62	0.006	0.0020	0.007	0.457	0.243	0.359	0.58		0.51
Inorganic sources of nutrients										
Control	78.09	0.154	0.054	0.120	11.97	3.94	9.43	34.18	0.180	32.58
50% RDF (N ₅₀ P ₂₅ K ₂₅)	91.63	0.171	0.058	0.132	15.66	5.28	12.09	35.95	0.185	34.19
75% RDF (N ₇₅ P ₅₀ K ₅₀)	97.72	0.188	0.067	0.139	18.51	6.59	13.71	37.69	0.191	35.73
100 % RDF (N ₁₀₀ P ₅₀ K ₅₀)	110.84	0.215	0.074	0.54	23.91	8.25	16.29	39.58	0.200	37.31
S.Em±	0.18	0.002	0.0006	0.002	0.132	0.071	0.104	0.17		0.15
C.D. (P=0.05)	0.50	0.005	0.0016	0.006	0.373	0.200	0.293	0.47		0.42
Interaction	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig		NS

NS= Non-significant

Sig. = significant

replications. The garlic var. G-282 was sown in November using 500 kg seed /ha and keeping 15x15 cm spacing between plants. The crop was grown as per recommended package of practices. The quality parameters were determined as per recommended procedures.

Results and Discussion

Productivity : The data (Table-1) indicated that the maximum bulb yield (103.64 q/ha) was secured from vermicompost applied @ 8 t/ha. This was followed by 10 t poultry manure/ha, 15 t FYM/ha and then 15 t goat manure/ha according to the yield attributes under these organics. The increased bulb yield from these organics have also been observed by Badal *et al.* (2019), Sanjay Kumar *et al.* (2019) and Sharma *et al.* (2021.). Similarly the highest level of 100 % applied NPK also resulted in maximum bulb (110.84 q/ha). This was followed by the lower doses of 50 and 75 % NPK applied to garlic. The findings concluded that the application of vermicompost @ 8t/ha along with 100 % RDF (N₁₀₀ P₅₀ K₅₀) gave the maximum garlic yield (120.97 q/ha) for this region. The results agree with those of Hore *et al.* (2014), Nainwal *et al.* (2015) and Shukla *et al.* (2018).

Nutrient contents in garlic bulb : The vermicompost applied @ 8 t/ha recorded almost significantly higher N, P and K contents (0.192, 0.071 and 0.149 %, respectively).

This was followed by 10 t poultry manure /ha, 15 t FYM/ha and then 15 t goat manure /ha and dual biofertilizers. Such variations in N, P and K contents in bulb may be owing to the fact that the organic sources of nutrients due to their constitutional variations maintained differential harmony between photosynthesis and translocation of absorbed nutrients towards the sink (bulb). The present results conform with those of Rai *et al.* (2016), Sanjay Kumar *et al.* (2019) and Vikas Kumar *et al.* (2019).

Application of 100 % RDF (N₁₀₀ P₅₀ K₅₀) recorded the maximum N, P and K contents in bulb (0.215, 0.074 and 0.154 %, respectively). This may be due to the fact that the plants absorbed such nutrients proportionately in higher amounts because the pool for available N, P and K nutrients was already increased in the soil by supplementing increased doses of applied N P K fertilizers. These findings corroborate with those of Rai *et al.* (2016), Shukla *et al.* (2018) and Yadav *et al.* (2022).

Uptake of nutrients by garlic bulb : The data further indicated that the total removal of N, P and K from soil by garlic bulbs yielding up to 103.64 q/ha was found significantly highest due to vermicompost applied @ 8t/ha. Consequently the uptake of N, P and K was up to 20.17, 7.50 and 15.61 kg/ha, respectively. The second and third best organics were 10 t PM/ha and 15 t FYM/ha, respectively. The fourth best organic manure was goat

manure @ 15 t/ha. Biofertilizers recorded the lowest performance. The increased uptake of N, P and K nutrients per due hectare due to applied organics was exactly in accordance with the similar increases in the NPK contents in bulbs as well as the bulb yield per hectare. The significant variation in growth yield and uptake of NPK nutrients under different organic sources was exactly in accordance to the variation in their nutrients contents, sources, rates and times of availability as well as differences in their decomposition and nutrient release pattern under the existing agro-climatic conditions. (Sanwal *et al.*, 2007). These results are in close conformity with those of Rai *et al.* (2016), Sitaula *et al.* (2020) and Vikas Kumar *et al.* (2019).

Application of 100 % RDF (N₁₀₀ P₅₀ K₅₀) enhanced the N, P and K uptake by garlic bulbs significantly up to 110.84 q/ha which removed 23.91 kg N, 8.25 kg P and 16.29 kg K/ha. This may be due to increased supply of NPK which increased root-shoot growth, multi-role activities in plant and soil which in turn resulted in greater accumulation of carbohydrates, protein and their translocation to the reproductive organs, consequently bulb yield and uptake of NPK nutrients. These results find credence with those reported by Shukla *et al.* (2018) and Badal *et al.* (2019).

Nutritional qualities of bulb : The TSS, ascorbic acid and dry matter contents in garlic bulbs were found to increase up to maximum extent due to 8 t vermicompost/ha, followed by 10 t poultry manure/ha and then 15 t FYM/ha. Similarly 100 % RDF also encouraged these parameters significantly over the preceding NPK levels. The response of organic and inorganic sources of nutrients in improving bulb quality may be attributed to their combined significant role in regulating the root enlargement chemical activities, photosynthesis and better microbial activities (Sharma *et al.*, 2021). According to Pachauri *et al.* (2005), the increased trend of vitamin C under nitrogen, potash and FYM application to onion might be due to increased activity of ascorbic acid oxidase enzyme. Sanjay Kumar *et al.* (2019) found that TSS content of garlic bulb (40.30 °Brix) was recorded with the treatment 75 % RDF + PSB (5 kg/ha) + *Azotobacter* (3 kg/ha) + FYM (20 t/ha). The improvement in TSS might be due to the supplying adequate macro and micro plant nutrients which play major role in improvement of quality through desirable enzymatic changes during growth. The TSS and dry matter in onion was recorded highest when grown with vermicompost (Dhotre and Allolli, 2012); and with 50 % NPK + 50 % FYM (Jamir *et al.*, 2013).

The present results concluded that the application of 8 t vermicompost /ha as well as 100 % RDF (N₁₀₀ P₅₀ K₅₀) brought about maximum bulb yield of garlic var. G-282 its quality as well as highest NPK uptake /ha.

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Effect of Integrated Nutrient Management on Growth, Yield and Economics of Garlic (*Allium sativum* L.) Cv. G-282

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Abstract

A field experiment was carried out at the Krish Vigyan Kendra situated in Sewania village, Jchhawar block of Sehore district (M.P.) during winter seasons of 2020-21 and 2021-22. The effect of INM on growth, yield, quality and economics of garlic was evaluated. The treatments comprised six treatments of organic sources of nutrients and four treatments of inorganic sources of nutrients. The 24 treatments combinations were replicated thrice in factorial randomised-block design. Results revealed the application of vermicompost @ 8t/ha recorded maximum growth, yield and yield attributes and quality parameters of garlic var. G-282. The bulb yield was 103.64 q/ha, net income Rs. 203310/ha, TSS 41.12° Brix, ascorbic acid 0.199 mg/g and dry matter 38.71 %. The second, third and fourth best organics were 10 t poultry manure /ha and 15 t FYM/ha and goat manure 15 t/ha, respectively. Amongst the inorganic sources, 100 % RDF (N₁₀₀ P₅₀ K₅₀) recorded maximum growth, yield and quality parameters of garlic. Thus the best treatment combination was 8 t vermicompost/ha with along 100 % RDF to obtain the maximum monetary gain under the existing agro-climatic conditions of this region.

Key words : Integrated nutrient management, garlic.

Introduction

Garlic (*Allium sativum* L.) is the most widely used cultivated *Allium* species after onion belongs to the family Amaryllidaceae. Garlic is one of the main *Allium* vegetable crops known world wide with respect to its production and economic value. Garlic is cultivated all over India. The crop is highly nutrient responsive. The productivity of garlic is lower than the potential productivity because of imbalanced used of inorganic fertilizers and limited use of organic manures.

There is a need to seek alternative nutrient sources which could be cheap and eco-friendly so that farmers may be able to reduce the cost of fertilizers along with maintaining good soil environmental conditions leading to ecological sustainable farming.

Organic sources of nutrients like farmyard manure, vermicompost, farm compost, poultry, pig and goat manures are very popular among the farmers and easily produced or obtained. The balanced fertilization from different sources is referred as the integrated nutrient management. It ensures higher productivity minimizes expenditure, improves physical properties of soil, efficiency of added nutrients and ensures good soil health and in also an environment friendly approach (Tyagi and Singh, 2019). The beneficial effect of vermicompost on growth and yield attributes might be due to the fact that worm casts contain five times more nitrogen, seven times more phosphorus and eleven times more potassium than

ordinary soil in addition to a lot of beneficial soil microorganisms (Sharma and Agrawal, 2004). Verma *et al.* (2014) reported that poultry manure has been recognized as a valuable source of plant nutrients for crops and is a potential source of plant nutrients like nitrogen (0.84 to 1.21 %) phosphorus (0.91 to 1.07 %) and potassium (1.35 to 2.35 %) The appropriate information on the integrated nutrient management on garlic was lacking in this region, hence the present research work was taken up.

Materials and Methods

The field experiment was carried out at the Krishi Vigyan Kendra situated in Sewania village, Jchhawar block of Sehore district (M.P.) during winter seasons of 2020-21 and 2021-22. The soil of the experimental field was clay-loam (medium black) having pH 7.2, electrical conductivity 0.32 dS/m, organic carbon 0.44 %, available N, P₂O₅ and K₂O 240, 12.8 and 425 kg/ha, respectively. The treatments comprised 6 organic sources of nutrients (control, 15 t FYM/ha, 8 t VC/ha, 10 t PM/ha, 15 t GM /ha and *Azotobacter* + PSB) and 4 levels of inorganic sources (control, 50, 75 and 100 % NPK (N₁₀₀ P₅₀ K₅₀)). The 24 treatment combinations were laid out in factorial randomised-block design keeping three replications. The garlic var. G-282 was sown in November using 500 kg seed /ha and keeping 15x15 cm spacing between plants. The crop was grown as per recommended package of practices and harvested in April month. The TSS (°Brix) of garlic was recorded under each treatment with the help of

Table-1 : Growth and yield attributes of garlic as influenced by integrated nutrient management.

Treatments	Plant height (cm)	Leaves /plant	Length of leaf (cm)	Width of leaf (cm)	Neck thickness (cm)	Fresh weight of bulb (g)	Vertical diameter of bulb (cm)	Horizontal diameter of bulb (cm)
Organic sources of nutrients								
Control	69.70	13.70	46.43	1.89	0.89	27.91	3.95	4.17
FYM (15 t/ha)	74.97	14.15	53.18	2.01	0.96	31.44	4.59	4.95
Vermicompost (8 t/ha)	76.73	14.33	54.40	2.05	0.97	33.47	4.78	5.45
Poultry manure 10 t/ha)	75.29	14.24	52.36	2.02	0.96	32.30	4.65	5.00
Goat manure (15 t/ha)	74.20	14.06	51.80	2.00	0.94	30.95	4.46	4.83
Biof. (<i>Azotobacter</i> + PSB)	72.75	13.86	49.31	1.95	0.91	28.92	4.17	4.54
S.Em±	0.32	0.105	0.12	0.135	0.009	0.22	0.004	0.05
C.D. (P=0.05)	0.91	0.300	0.34	0.0382	0.027	0.62	0.012	0.14
Inorganic sources of nutrients								
Control	66.66	12.95	46.98	1.84	0.89	27.81	4.20	4.46
50 % RDF (N ₅₀ P ₂₅ K ₂₅)	71.72	13.70	49.90	1.94	0.93	29.86	4.36	4.71
75 % RDF (N ₇₅ P ₅₀ K ₅₀)	76.64	14.51	52.68	2.04	0.96	31.86	4.51	4.95
100 % RDF (N ₁₀₀ P ₅₀ K ₅₀)	80.74	15.06	55.43	2.13	0.97	33.80	4.66	5.19
S.Em±	0.26	0.086	0.10	0.011	0.008	0.18	0.0035	0.04
C.D. (P=0.05)	0.74	0.243	0.28	0.031	0.022	0.51	0.010	0.114
Interaction	Sig.	NS	Sig.	NS	NS	NS	Sig.	NS

NS= Non-significant

Sig. = significant

Pocket Refractometer. The plant growth, yield and yield attributing parameters were recorded in each treatment. The data obtained were statistically analysed before presenting the results.

Results and Discussion

Growth parameters : The data (Table-1) reveal that the application of 8 t/ha vermicompost resulted in maximum growth parameters viz. plant height 76.23 cm, leaves 14.33 /plant, leaf length 54.40 cm, leaf width 2.05 cm and neck thickness 0.97 cm. The second, third and fourth best organic sources were 10 t poultry manure/ha, 15 t FYM/ha and 15 t goat manure/ha, respectively. This was followed by dual biofertilizers treatment. The significant variation in growth parameters of garlic towards different contents, decomposition of organic residues, C:N ratio and nutrient release pattern under the existing agro-climatic conditions (Sanwal *et al.* 2007). Such type of variations in the soil processes of organics and in the availability of nutrients brought about the photosynthetics production according to that extent. Among the growth parameters leave are the important vegetative part of the plant and these are these are the principal sites of plant metabolism, photosynthate production and the changes in the nutrients supply under varied organics are reflected in the composition and growth of plant. The present results corroborate with those of Acharya *et al.* (2018), Vikas Kumar *et al.* (2019), Badal *et al.* (2019) and Sharma *et al.* (2021).

The increasing levels of inorganic fertilizers up to N₁₀₀ P₅₀ K₅₀ brought about maximum increase in all the

growth parameters. The immediate increased supply of NPK from fertilizers promoted plant growth by ensuring higher number of greener leaves with increased photosynthesis as a result of increased metabolism of the absorbed multi-nutrients. The similar results have also been reported by. Das *et al.* (2014), Hore *et al.* (2014), Nainwal *et al.* (2015) and Yadav *et al.* (2022).

Yield attributes : The vermicompost applied @ 8t/ha enhanced the yield attributes up to maximum extent. The fresh bulb weight was 33.47 g, vertical bulb diameter 4.78 cm, horizontal bulb diameter 5.45 cm, cloves 18.34 /bulb, weight of clove 1.57 g, length of clove 2.42 cm and width of clove 1.16 cm. The second, third and fourth best organics were 10 t PM/ha, 15 t FYM/ha and 15 t GM/ha, respectively. The best performance of vermicompost may be owing to the fact that worm casts contains five times more nitrogen, seven times more phosphorus and eleven times more potassium than ordinary soil. It also contains a lot of beneficial soil microorganisms (Sharma and Agarwal, 2004). The higher yield attributes was exactly in accordance with the growth parameters recorded under the different organics. the increased photosynthates produced might have translocated towards the sink (bulb). The results are also in congruence with the findings of Sachin *et al.* (2017), Acharya *et al.* (2018) and Sanjay Kumar *et al.* (2019). The application of 100 % NPK registered maximum increment in the yield attributes which was in accordance with the increased growth parameters under their increased availability to the actively growing plants.

Table-2 : Yield attributes yield of garlic and economics of garlic as influenced by integrated nutrient management.

Treatments	Clovers /bulb	Weight of clove (g)	Length of clove (cm)	Width of clove (cm)	Bulb yield (q/ha)	Net income (Rs. /ha)	B : C ratio
Organic sources of nutrients							
Control	16.20	1.40	1.99	1.00	84.01	160412	2.74
FYM (15 t/ha)	17.63	1.52	2.24	1.06	96.66	182237	2.71
Vermicompost (8 t/ha)	18.34	1.57	2.42	1.16	103.64	203310	2.89
Poultry manure 10 t/ha)	17.88	1.53	2.31	1.11	98.26	183170	2.64
Goat manure (15 t/ha)	17.56	1.49	2.19	1.05	94.32	171357	2.53
Biof. (<i>Azotobacter</i> + PSB)	16.86	1.46	2.05	1.03	90.52	176442	2.85
S.Em±	0.06	0.006	0.008	0.006	0.22	-	-
C.D. (P=0.05)	0.18	0.016	0.022	0.016	0.62	-	-
Inorganic sources of nutrients							
Control	15.15	1.35	1.96	0.92	78.09	132848	2.31
50% RDF (N ₅₀ P ₂₅ K ₂₅)	16.64	1.44	2.12	1.02	91.63	170438	2.65
75% RDF (N ₇₅ P ₅₀ K ₅₀)	18.14	1.55	2.28	1.11	97.72	188258	2.80
100% RDF (N ₁₀₀ P ₅₀ K ₅₀)	19.71	1.65	2.44	1.21	110.84	226408	3.14
S.Em±	0.05	0.005	0.006	0.005	0.18	-	-
C.D. (P=0.05)	0.15	0.013	0.018	0.013	0.50	-	-
Interaction	Sig.	NS	NS	NS	Sig.	-	-

NS= Non-significant

Sig. = significant

Yield and economics : The data (Table-2) indicated that the maximum bulb yield (103.64 q/ha) and consequently net income (Rs. 203310/ha) was secured from vermicompost applied @ 8 t/ha. This was followed by 10 t PM/ha, 15 t FYM/ha and then 15 t GM/ha according to the yield attributes under these organics. The increased economical gain under vermicompost and other organics was exactly in accordance with the bulb yield obtained and there by gross income /ha achieved as per market sale of garlic bulbs. The increased bulb yield and economical gain from these organics have also been observed by Badal *et al.* (2019), Sanjay Kumar *et al.* (2019) and Sharma *et al.* (2021.). Similarly the highest level of 100 % applied NPK also resulted in maximum bulb (110.84 q/ha) and consequently net income (Rs. 226408/ha). This was followed by the lower doses of 50 and 75 % NPK applied to garlic. The findings concluded that the application of vermicompost @ 8t/ha along with 100 % RDF (N₁₀₀ P₅₀ K₅₀) gave the maximum garlic yield (120.97 q/ha) and net income (Rs. 253210/ha) with 3.31 B:C ratio for this region.

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Effects of Intercrop, Border and Strip Crop on Diversity of Predator, Natural Enemies and Birds in Cotton Agro-ecosystem—A review

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Abstract

Cotton is a worldwide important fiber crop often damaged by many pests. Now a day's pest management in cotton is totally dependent on chemical pesticides. Although, pesticides applications are usually effective but long-term application of these often leads to increased insecticide resistance, reduced natural control and a degraded environment. Due to sustainable cotton production, the control of cotton pests using cultural modification like intercropping is increasingly receiving attention. Appropriate intercropping of cotton with many other crops often boost the yield and quality of cotton, increases the number of natural enemies, kill or repel pests, attract natural enemies, reduce pesticide usage, possess antibacterial effects between the rows of economic crops, provide refuge for natural enemies and reduces the occurrence of cotton pests by altering the ecological structure and environmental conditions in the fields. Because, sole cropping is the exception while mixture is rule of nature. However, unfortunate intercropping can also increase labor requirements and even result in inadequate control of pests. Cotton intercropping can involve a variety of patterns such as Cotton-food crop intercropping, cotton-melon intercropping and cotton-vegetable intercropping are all important multiple cropping methods for cotton fields around the world. Thus, this review indicates the effects of appropriate combination (intercropping, strip cropping, border cropping etc.) of crop with the cotton on natural enemies population and reduce pest incidence etc. This study aids researchers and cotton growers in designing economically viable and ecologically friendly pest management tactics that will reduce the use of chemicals and the cost of cotton production.

Key words : Cotton based intercropping, natural enemies, predators and pest management.

Introduction

Conservation of biological control is a tactic of habitat modification to support and sustain the natural enemies and predator's population for successful biological control of crop pest. Agricultural habitats modification is the need of the hour in the recent years of crop intensification. Riparian environments that border the fields such as grassy bank, beetle banks, hedge rows, intercrops, border crops and strip crops are some examples of habitat modification and crop diversification that can provide shelter to natural enemies/predators for overwintering sites, alternate non-prey foods such as pollen, nectar and honey dew and protects during adverse weather and use of insecticidal sprays long-term resources for beneficial arthropods (Pollard and Holland 2006; Bone et al. 2009; Landis et al. 2000). Habitat manipulation approaches are the coolest way to enhance the performance and local abundance and diversity of the natural enemies and predators (Corbett and Rosenheim 1996). Natural enemies are organisms that kill, decrease the reproductive potential of, or otherwise reduce the numbers of another organism and reduce pests as a key component of integrated pest management programs. Spiders, coccinellids, larvae of green lacewings, pirate bugs, parasitic wasps (*Bracon* spp. and *Encarsia* spp,

beetles and birds are important regulators and the first line of defense against cotton pest particularly in early and mid season. Use of natural enemies reduces the indiscriminate use of pesticides in cotton which induces many problems such as pest resurgence, secondary pest outbreak, phyto-toxicity, bioaccumulation, environmental pollution and toxic residue in food. Some insecticides are more toxic to parasites and predators; consequently, they should be used to kill the target insects only when necessary and at minimum doses. So, there is a need to text the effect of habitat manipulation by using cover crops/intercrops along with main crop to support the diversity of predators of crop pests. This review indicated the diversity and abundance of parasitoids and predators in the sole cropped and intercropped and border cropped in cotton fields.

Intercropping or mixed cropping system is one of the important cultural practices in pest management based on the principle of reducing the insect pests and reducing the population of natural enemies (Smith and Van den Bosch, 1970). A lack of synchrony or poor ratio between the number of natural enemies and pest or their host, (often occurring in crop monoculture) could be improved by providing intercropping conditions (Ananthakrishnan, 1992). A large number of natural enemies are associated

Table-1 : Major predators of cotton pests identified from alternative winter crops in Narrabri, New South Wales, Australia.

Order	Family	Species	Group
Coleoptera	Coccinellidae	<i>Coccinella transversalis</i>	Predatory beetles
	Melyridae	<i>Dicranolaius bellulus</i>	
Hemiptera	Nabidae	<i>Nabis kinbergii</i>	Predatory bugs
	Lygaeidae	<i>Geocoris lubra</i>	
	Pentatomidae	<i>Cermatulus nasalis</i> and <i>Ochalia schellenberg</i>	
	Reduviidae	<i>Coranus triabeatus</i>	
Neuroptera	Chrysopidae	<i>Chrysopa</i> spp.	Predatory lacewings
	Hemerobiidae	<i>Micromus tasmaniae</i>	
Araneida	Lycosidae	<i>Lycosa</i> spp.	Spiders
	Oxyopidae	<i>Oxyopes</i> spp.	
	Araneidae	<i>Araneus</i> spp.	

Source : After Mensah (1999)

Table-2 : Spider species from multiple families and its effects.

Spider species from multiple families	References	Effects
<i>Hylyphantes graminicola</i>	(Sundevall 1830)	Showed no population differences in untreated Bt and non-Bt fields.
<i>Linyphiidae</i>	(Cui & Xia 1999)	
<i>Emblyna reticulata</i>	(Gertsch & Ivie 1936)	Decreased in abundance in Bt cotton
<i>Dictynidae</i> and <i>Mecaphesa celer</i>	(Hentz 1847)	
<i>Thomisidae</i> and <i>Salticidae</i>	(Naranjo 2005),	
<i>Clubionidae</i>	(Sisterson et al. 2004)	
Other <i>Araneae</i>	(Naranjo 2005).	

with insect pests of cotton and these are more in diverse crops as compared to sole crop. Intercropping in cotton with other crops is of great significance as it provides higher profit and stabilized yield, especially under adverse weather conditions because sole cultivation of cotton usually found to be risky and less remunerative. Although, some intercrops may act as barrier crops which may either deter or attract insect pests of cotton while others attract natural enemies of insect pests. Intercropping system in crops may be due to increasing awareness about the adverse effects of pesticide, particularly in terms of pest resurgence, and other ailments.

Intercropping and spider population : Patel (2001) and Kadam *et al.*, (2014) concluded that cotton intercropping with sesame and cotton intercropped with pigeonpea (Venugopala *et al.*, (1995) and Mote *et al.*, (2001) Devi (2018) enhanced arthropod natural enemies i.e. spiders population was found induced in cotton field against cotton pests when it compared with sole grown cotton. Spiders population was reported higher when cotton intercropped with sorghum as border crop followed with bajra, cotton-pigeonpea 3:1, cotton-pigeonpea 2:1 and cotton-sesame 3:1 (Devi (2018) and intercropped with sorghum and maize (Rajput and Daware 2002) as compare to sole cotton crop. Schader *et al.* (2005) reported that intercropping cotton *G. barbadense* with basil *Ocimum basilicum* (repellent plant) reduced pest infestation and increased the abundance of the epigeic

fauna in intercropped plots. Interplanting cotton with lucerne (refuge crops) (Mensah 1999, 2002), chickpea, pigeon pea and others (Sequeira 2001; Annells and Strickland 2002) leads to development of a natural enemy based IPM program for the cotton-cropping systems in Australia. Balasubramanian *et al.* (1998) observed that more population of spiders in cotton intercropped with cluster bean or green gram than in cotton as monocrop. Rao and Rao (2011) recorded abundance of spiders in cotton + soybean followed by cotton + red gram intercropping system. In cotton ecosystem, 21 species of spiders were reported and the predatory potential of the spider *Paradosa viridianum* was maximum on sucking pests (Rajeswaran *et al.* 2005). Owens and Mensah (2000); Gurr *et al.* (2004) evaluated the utility of crops such as lucerne, saltbush, faba beans, wheat, canola, chickpeas, vetch and lablab for intercropping in cotton to conserve natural enemies indicated in table-1.

Border crop and spider population : In province of Eastern China, Lin *et al.* (2003) reported that when alfalfa (*Medicago sativa*) intercropped with cotton field as a nursery crop, increment in aphids population was significantly slower in cotton grown in plots bordered while the rate of increasing ladybirds *Coccinella septempunctata*, *Propylea quatuordecimpunctata* and *Hypodamia variagata*, spiders and lacewings were significantly faster in cotton grown in plots bordered. Sharma *et al.* (2009) conducted a field trial to revealed maize in cowpea as intercrops/border crops act as source

Table-3 : Effects of strip cropping system in cotton with other crops.

Cropping system	Other crop	Main crop	Result	Reference
Conservation tillage and strip cropping systems	Clover	Cotton	bird and arthropod activity	Cederbaum et al. (2004)
Strip cropping systems	Maize	Cotton	Reduced sucking pest incidence and enhanced natural enemy activity	Fabiao and De Souza (2007)
Strip cropping systems	Sorghum red gram, <i>Crotalaria orchroleuca</i>	Cotton	Syrphids, green lacewings and spiders and fewer <i>H. armigera</i> and <i>A.gossypii</i> infested plants	Chamuene et al. (2007)
Intercropped and barrier crops	Okra and red gram or pearl millet	Cotton	No effect on insect pests of cotton	Dhaliwal et al. (1997)
Strip cropping systems	<i>Brassica rapa</i> , <i>Vicia villosa</i> , <i>Triticum aestivum</i>	Cotton	Enhanced predator numbers and reduces aphid bollworm population	Parajulee and Slosser (1999)
Strip cropping systems	Sunflower and safflower, Lucerne, tomato	Cotton	Refugia for predators Abundance per meter row length was high of predatory beetles, bugs, lacewings and spiders	Mensah (1999)
Strip intercropping rotation in vertisols	pigeon pea	Cotton	Increased natural enemy activity.	Potdar et al. (1994)
Intercropped	vegetables like radish, cluster bean and beet root.	Cotton	No change in sucking pest populations	Sankaranarayanan et al (2012)
Weedy area	Weeds	Cotton	Prey and predator increased	Showler and Greenberg (2003)

Table-4 : Recommended references that shows the impact on the occurrence of cotton pests and natural enemies under different intercropping conditions.

Sr. No.	Main crop	Intercropped with	References
1.	Cotton	Peas and cantaloupes	Marcovitch (1935)
2.	Cotton	Cowpea, sorghum and maize strip cropping of alfalfa	Gao et al. (2008)
3.	Cotton	Short maturing pulses like black gram, green gram and cluster bean	Muruganadam (1984)
4.	Cotton	Maize and Cowpea	Amoako et al. (1983)
5.	Cotton	Soybean	Natarajan and Seshadri (1988)
6.	Cotton	Groundnut, Soybean, Cowpea and Greengram or cluster bean	Venugopal Rao et al., 1995
7.	Cotton	Pigeonpea, crotalaria and orchroluca	Chamune et al. (2007)
8.	Cotton	Onion, black gram, green gram and Lucerne	Jayakumar et al. (2008)
9.	Cotton	Maize/cowpea and setaria	Sharma et al. (2009)

of predator in cotton ecosystem due to diverse microhabitats, greater availability of food sources such as prey, nectar and pollen, all of which encouraged colonization and build up of natural enemies, compared with cotton monoculture having lesser biodiversity. Peterson *et al* (2011) and many other worker indicated the spider populations difference between Bt and non-Bt cotton fields given in the table-2.

Intercropping and coccinellids population : Burleigh *et al.* (1973); Kavitha *et al.*, (2003) and Scholz and Parker (2004) reported that lady bird beetles (*Hippodamia* sp.) were one of the main predators in cotton growing area immediately adjacent to sorghum than cotton grown distal to strip crop while Venugopal *et al.*, (1995); Mote *et al.*, (2001) reported that maximum coccinellids were found in pigeonpea and lowest in sole cotton. Study of Lester and Furr (1972); Patel (2001); Kadam *et al.* (2014); Devi (2018) registered that the inter-planting cotton-sesame buildup of ladybird beetles population over the sole cotton.

Cotton-cowpea cropping system recorded significantly higher population of coccinellids (*M. sexmaculatus* and *Coccinella* sp.) than in sole cotton (Natarajan and Seshadri, 1988). Balasubramanian *et al.* (1998) observed more coccinellid in cotton when intercropped with cowpea than in mono crop of cotton. Lady beetles and lacewings as important predators in cotton intercropped with different pulse crops Kranthi and Russell (2009). Pesticide Post (2009) reported that intercropping of cotton with black gram, green gram and cowpea helped colonization of coccinellids in central and southern India. Intercropping modules of cotton + soybean, cotton + red gram and cotton + black gram showed higher number of *Cheilomenes sexmaculata* as compare to sole grown cotton reported by (Rao and Rao 2011).

Ma *et al.* (2006) observed benefits of Cotton-wheat relay intercropping practice in northern China and reported that natural enemies are maintained in the field because they feed on prey (aphid) in wheat and then

easily disperse to emerging cotton seedlings where they can prevent population increase by *A. gossypii*. Mensah (1999) evaluated the utility of intercropping alternative crops such as sunflower, lucerne, safflower, sorghum and tomato for management of insect pests in cotton and found that higher densities of predators on lucerne followed by sunflower, safflower, sorghum, cotton and tomato. Wells (2001) and Rathod and Bapodra (2004) reported that Coccinellid predators showed density dependent fluctuations with aphid in cotton. Scholz and Parker (2004) found that intercropping cotton+sorghum encouraged the establishment and growth of *Trichogramma* and predatory beetles in cotton. In Brazil, Viera *et al.* (1983) found that when the crop was intercropped with maize and cowpea, *Aphis gossypii* infestation was about 14 times lower due to increased coccinellids than grown as monoculture. Ramalho *et al.* (2012) reported that maximum number of *Cycloneda sanguinea* and *Chrysoperla* spp. were found in cotton intercropped with fennel.

Intercropping and *chrysoperla* population

Venugopal *et al.* (1995) and Kranthi and Russell (2009) reported that maximum number of *Chrysoperla* spp. were found in cotton+ pigeonpea agroecosystem and lowest in sole cotton. Li (1987) reported that cotton+safflower intercropped system attracted *Chrysoperla* sp. and *C. septempunctata* resulting in the effective control of Aphid. Interplanting of cotton with maize and cabbage (Wu *et al.*, 1991) and alfalfa (Godfrey and Fleigh, 1994) influenced the natural enemies like spiders, coccinellids and chrysopids. Cotton intercropped with sunflower and cowpeas in paired row system were favorable for the conservation of *C. carnea* than on sole Cotton (Swaminathan *et al.*, 1999). Rajput and Daware (2002) and Hegde *et al.*, (2004) also reported that cotton-sorghum intercropping and cotton with legumes (Lin *et al.*, 2003) enhanced the abundance and activity of *Chrysoperla* spp. over sole cotton. Intercropping sorghum in cotton help in the conservation of *C. carnea* and *Trichogramma* Hegde (2003). Increased predation and parasitization rates of these two bioagents brought *Helicoverpa armigera* to below ET levels. Devi (2018) recorded maximum population of *Chrysoperla* spp. in cotton-sesame 1:1 and 2:1 ratio found 0.5 and 0.54 grubs and adults/plant, respectively while minimum *Chrysoperla* spp. was recorded in sole cotton (0.28). The egg, larval and adult population of *Chrysopa* species were significantly high in cotton intercropped either with soybean or red gram (Rao and Rao 2011) and they also observed that between black gram and green gram as intercrops with cotton, lacewings preferred green gram better than black gram. Wu (1991) reported that maize+cotton intercropping increased the population of

Araneae, Coccinellidae and Chrysopidae by 62.8-115.7% compared with control fields. Hedge *et al* (2003) noticed that average population of *C. carnea* and spiders were significantly high on cotton intercropped with lucerne, cowpea and groundnut.

There are many examples of predators achieving higher densities or equally high in monoculture than polyculture (Corbett and Plant 1993; Rao and Rao 2011). For instance, Schultz (1988) found significantly fewer lacewing (Chrysopidae) eggs on cotton intercropped with corn or weeds than on monocropped cotton. Schuster (1980) found that a rich complex of predators on alfalfa did not disperse substantially into cotton when the two crops were interplanted.

Intercropping and bugs population : Plantings of Sorghum beside cotton crops effectively preferential the abundance of heteropteran predators (Prasifka *et al.* 1999). Van Den Berg and Cock (1995) observed irreplaceable mortality of *H. armigera* due to presence of natural enemies in cotton in Western Kenya and Anthocorids and Geocorid. Study of (Loya-Ramirez *et al.* 2003) showed that when cotton interplanted with canola, alfalfa, hairy vetch and sainfoin favoured high populations of heteropteran predators toward the intercropped cotton. Although, Abro *et al.* (2004) who reported that cotton as sole crop received maximum fluctuation in comparison to mixed cropping of cotton and okra. In texas cotton, Sansone and Smith (2001) observed that *Orius insidiosus* was leading predator which consumes 84-71% eggs of *H.zea*. Vaiapuri *et al.* (2007) revealed that intercropped cotton-maize remained highly beneficial for bug's population followed by cow peas, sesame and sunhemp. *A. graveolens*, *C. officinalis*, *C. cyanus*, *F. vulgare* and *F. esculentum* were most effective crop to attract beneficial insects i.e. hoverflies and ladybeetles followed by predatory bugs and ichneumon wasps (Kopta *et al.* 2012). If cotton intercropped with either soybean or red gram, activity of predatory geocorid bug checked superior to sole cotton (Rao and Rao, 2011). Siddiqui *et al.* (2018) indicated in their study that when maize intercropped with cotton as trap crop represented higher population of predators, *G. ochropterus*, *Orius* spp. and *Zanchius* sp. per plant and lowest density of cotton pests. Study report was almost similar of (Greenberg *et al.* 2009) and (Solangi *et al* 2008).

Strip cropping and predators

There are various workers who observed new cropping approaches, such as use of conservation tillage, strip cover cropping and weedy area in hope for improving the ecological value of cotton fields given in table 3.

Intercropping and natural enemies

Marigold, cowpeas, sun hemp and sesamum are some of

the trap crops used in cotton (Vaiyapuri et al., 2007). Olson and Wackers, 2007 reported that increased field border diversity and remnant vegetation, increased abundance and diversity of natural enemies on many crops. There are various study done by worker as cotton intercropping with other main crop reduced the pressure of pests on cotton crop and increased the population of natural enemies indicated in table 4.

Intercropping and soil dwelling insects

Liu et al. (2010) observed that ground dwelling carabids (Coleoptera : Carabidae) were play important role in regulating the soil inhabiting life stages of foliar insects of cotton. Cotton, maize and wheat are considered as promoters of ground beetle diversity because of diverse habitats and diversity of agricultural cropping system. Torres and Ruberson (2005) reported that abundance of ground dwelling predators was not affected by cotton type, where as abundance of canopy predators varied across seasons with no population trend for either cotton type. Cotton intercropped with soybean or red gram increase the carabid beetle population (Rao and Rao 2011)

Intercropping with flowering plants and birds

Intercropping with insectary plants, also called companion plants can be used to augment the activity of predators and parasitoids by providing them with habitat and food sources. The attraction of flower and floral resources can result in higher enemy efficiency in biological control agent for pest (Bianchi and Wackers 2008). Chakravathy et al. (1997) reported that increased parasitism and natural enemies (Coccinellids and Chrysopids) population due to the availability of nectar, pollen by flowering plants, and existence of favorable microclimate and conservation facilities. The increased crop diversity can provide vast and favorable habitats and shelters to natural enemy and predators like birds to get rid of adverse condition like excessive wind and extreme temperature (Rodriguez-Saona et al., 2012). (Bhosle et al. 2007) registered that growing of maize + cowpea as border crop and one row of sateria in between each 9th and 10th rows of cotton attracts predatory birds for gobbling cotton bollworm. Jones and Gillett (2005) observed higher occurrence of beneficial insects on sunflowers were big-eyed bugs (*Geocoris* spp.), honeybees (*Apis mellifera*), green lynx spiders (*Peucetia viridans*), ants (Formicidae), and *sphecids* wasps (Sphecidae), lady beetles (Coccinellidae) predatory stink bugs (Pentatomidae), and assassin bugs (Reduviidae) than on crop vegetation in control blocks and results are similar with the study of Jones and Sieving (2006) reported that intercropping sunflowers effectively increase avian number and forager time in organic vegetables. A total of insectivorous 68 bird species were observed by (Jones et al. 2005) in cropped area adjacent to hedge/ or tree. Many insects such as cabbages worms, blue flea

beetles, seed bugs, and grasshopper etc. were identified from body parts and regurgitated gut sample confirming that economically important pests were consumed at some level (Jones and Gillet 2005). Bird perches play important role for the predatory bird to look for their prey in the field where they have places to rest; such as insect pests of cotton (Lalita et al., 2022).

Conclusion

This review conclude that that the activity of *natural enemies such as coccinellids, chrysopids* and spiders spp. were found to be greater in intercropped cotton as compare to the sole cotton. This would help the farmers to reduce costs associated with pests management in cotton. Provisioning the parasitoids with intercrops/border crops will help in supporting their population in the agricultural habitats to enhance biological control of insect pests. Habitat manipulation strategies using intercrops/ strip and refugia should be integrated with the farm landscape in a spatial and temporal way to benefit natural enemies for natural biological control of cotton pests.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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Performance of Isabgol (*Plantago ovata* Forsk.) Varieties under Varying Fertility Levels on Nutrient Uptake and Total Uptake

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Abstract

A field experiment entitled "Performance of isabgol (*Plantago ovata* Forsk.) varieties under varying fertility levels" was conducted at Instructional Farm of Agronomy, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur during the *rabi* season of 2019-20 to study the effect different of isabgol varieties under varying fertility levels. The experiment was conducted in factorial randomized block design keeping seven varieties and two fertility levels. The treatment consisted of seven varieties viz., UI-2-1, UI-3, UI-89, UI-124, Niharika, GI-2, VI-1 and two fertility levels viz., 30 kg N ha⁻¹, 15 kg P₂O₅ ha⁻¹, 15 kg K₂O ha⁻¹, 45 kg N ha⁻¹, 30 kg P₂O₅ ha⁻¹, 20 kg K₂O ha⁻¹ thereby making 14 treatments combinations replicated three times. The results revealed that isabgol crop variety UI-124 and 45 kg N ha⁻¹, 30 kg P₂O₅ ha⁻¹, 20 kg K₂O ha⁻¹ RDF produced significantly increased nutrient uptake and total uptake. The isabgol crop variety UI-124 accumulated highest quantum of nutrient in seed, straw thereby total accumulation which was found at par with UI-89. Application of 45 kg N ha⁻¹, 30 kg P₂O₅ ha⁻¹, 20 kg K₂O ha⁻¹ RDF significantly increased nitrogen, phosphorus and potassium uptake by seed and straw thereby total accumulation over application of 30 kg N ha⁻¹, 15 kg P₂O₅ ha⁻¹, 15 kg K₂O ha⁻¹ RDF.

Key words : Variety, isabgol, NPK, nutrient uptake and total.

Introduction

Isabgol (*Plantago ovata* Forsk) is a winter season medicinal crop. It belongs to the family Plantaginaceae and genus *Plantago* which comprise of about 50 species. It is a highly cross pollinated crop. Isabgol derives its name from two Persian words, 'asp' and 'ghol' which means horse-ear, referring to its characteristic boat-shaped seeds. The term "Psyllium" is used for the crust, seed and the whole plant. It is considered as a good source for soluble and insoluble fibres. At present, blond psyllium has acquired the name "Dollar earner" in North Gujarat and South Western Rajasthan. In India, major isabgol growing states are Rajasthan, Gujarat, Madhya Pradesh and Haryana. It is grown on 1.38 lakh ha area with 2.27 lakh tonnes production at an average productivity status of 670 kg ha⁻¹ (Anonymous, 2018-19). Its cultivation is mainly centralized in northern Gujarat and districts of South-west of Rajasthan namely Jalore, Barmer, Pali, Jaisalmer, Jhalawar and Sirohi. Isabgol is cultivated in about 3.36 lakh ha area in Rajasthan with a production of 1.93 lakh tonnes at an average productivity status of 576 kg ha⁻¹ (Anonymous, 2018-19). Isabgol (*Plantago ovata*) is known as Psyllium, Isabgol, Ispaghula, Spogel seed. Isabgol is a 30-35 cm tall short-stemmed annual herb. Leaves are opposite, narrow and liner in shape. A large number of flowering shoot arises from the

base of the plant. Flower is numerous, small and white in colour which occurs after 50-60 days of plantation. Seeds are boat-shaped, smooth, rosy-white, concave on one side and convex on the other. The concave side of the seed is covered with a thin white membrane, forming the seed coat (Sahu *et al.*, 2016). The seeds also contain fixed oil (2.5%) consisting mainly linoleic, oleic, palmitic acid with aliphatic hydrocarbons and oxygenated fatty acids, iridoids and protein. In addition, the secondary metabolites in the seeds include sterols, triterpenes and aucubin glycosides (Killedar *et al.*, 2016). Nitrogen is an essential nutrient for plant growth and development. Nitrogen is a major component of chlorophyll, thereby plants use sunlight energy to produce sugars from water and carbon dioxide (*i.e.* photosynthesis). It is also a major component of amino acids, the building blocks of protein (Cheng *et al.* 2014). Phosphorus plays a vital role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement and several other processes in plants. A plant must have phosphorus to complete its normal production cycle. Phosphorus plays a vital role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement and several other processes in plants. A plant must have phosphorus to complete its normal production cycle. Potassium is also an essential plant nutrient and is required in large amounts for proper growth and reproduction of plants. Potassium is

considered as the “quality nutrient.” It affects the plant shape, size, colour, taste and other measurements attributed to a healthy produce. (Hasanuzzaman *et al.*, 2018).

Keeping these facts in view, the present study entitled “Performance of isabgol (*Plantago ovata* Forsk.) varieties under varying fertility levels” was conducted during *rabi* 2019-20 at Instructional farm of Rajasthan Collage of Agriculture, MPUAT, Udaipur.

Materials and Methods

A field experiment was conducted during *rabi* seasons of 2019-20 to study the effect different of isabgol varieties under varying fertility levels on nutrient uptake and total uptake of isabgol (*Plantago ovata* Forsk.) at the Instructional Farm, Rajasthan College of Agriculture, Udaipur. The soil of experimental field was clay loam in texture, slightly alkaline in reaction (pH 7.9), low in available nitrogen (271.30 kg ha⁻¹), medium in available phosphorus (18.90 kg ha⁻¹) and high in available potassium status (315.40 kg ha⁻¹). The experiment was conducted in factorial randomized block design keeping seven varieties and two fertility levels. The treatment consisted of seven varieties viz., UI-2-1, UI-3, UI-89, UI-124, Niharika, GI-2, VI-1 and two fertility levels viz., 30 kg N ha⁻¹, 15 kg P₂O₅ ha⁻¹, 15 kg K₂O ha⁻¹, 45 kg N ha⁻¹, 30 kg P₂O₅ ha⁻¹, 20 kg K₂O ha⁻¹ thereby making 14 treatments combinations replicated three times. The crop was sown on 20th Nov, 2019 with recommended seed rate of 6 kg ha⁻¹. The treatments were allotted randomly in each replication. The plot size was 5.0 x 3.0 m. The seed of isabgol @ 6.0 kg ha⁻¹ was sown in furrow manually by dropping the seed in the furrow row to row distance of 30 cm. The crop of isabgol was fertilized through Urea, SSP and MOP, respectively were applied into the already opened furrows before sowing. The half dose of nitrogen and full dose of phosphorus and potash was applied at the time of sowing, remaining half dose of nitrogen was top dressed after 1st irrigation. The crop harvested from net plot at physiological maturity. The seed and straw samples collected from each plot at harvest were dried in oven at 65°C till a constant weight. These samples were grounded in laboratory mill, passed through 40 mm mesh sieve. Uptake of N, P and K by seed and straw was estimated by using following formula :

$$\begin{aligned} &\text{Nutrient uptake by seed (kg ha}^{-1}\text{)} \\ &= \frac{\text{Nutrient content in seed} \times \text{seed yield (kg ha}^{-1}\text{)}}{100} \end{aligned}$$

$$\begin{aligned} &\text{Nutrient uptake by straw (kg ha}^{-1}\text{)} \\ &= \frac{\text{Nutrient content in straw} \times \text{straw yield (kg ha}^{-1}\text{)}}{100} \end{aligned}$$

Result and Discussion

1. Nitrogen uptake

Seed

Varieties : Data (Table 1) indicate that the variety UI-124 application had significant effect on nitrogen uptake in seed. Maximum nitrogen uptake of 17.36 kg ha⁻¹ in seed variety of UI-124 which was significantly higher over the variety. Minimum nitrogen uptake in seed was recorded with VI-1 (10.96 kg ha⁻¹).

Fertility levels : Perusal of data indicate that maximum nitrogen uptake in seed (14.89 kg ha⁻¹) was registered with application of 45 N kg ha⁻¹ + 30 P₂O₅ kg ha⁻¹ + 20 K₂O kg ha⁻¹ RDF but proved superior over 30 N kg ha⁻¹ + 15 P₂O₅ kg ha⁻¹ + 15 K₂O kg ha⁻¹ RDF (12.25 kg ha⁻¹).

Straw

Varieties : Data indicate that the variety UI-124 application had significant effect on nitrogen uptake in straw. Maximum phosphorus uptake of 12.35 kg ha⁻¹ in straw variety of UI-124 which was significantly higher over the variety, but it was found at par with UI-89. Minimum nitrogen uptake in straw was recorded with VI-1 (7.41 kg ha⁻¹).

Fertility levels : Perusal of data indicate that maximum nitrogen uptake in straw (10.73 kg ha⁻¹) was registered with application of 45 N kg ha⁻¹ + 30 P₂O₅ kg ha⁻¹ + 20 K₂O kg ha⁻¹ RDF but proved superior over 30 N kg ha⁻¹ + 15 P₂O₅ kg ha⁻¹ + 15 K₂O kg ha⁻¹ RDF (7.95 kg ha⁻¹).

Total

Varieties : Data indicate that the variety UI-124 application had significant effect on total nitrogen uptake by crop. Maximum total nitrogen uptake of 29.71 kg ha⁻¹ by variety of UI-124 which was significantly higher over the variety. Minimum total nitrogen uptake was recorded with VI-1 (18.37 kg ha⁻¹).

Fertility levels : Perusal of data indicate that maximum total nitrogen uptake by crop (25.62 kg ha⁻¹) was registered with application of 45 N kg ha⁻¹ + 30 P₂O₅ kg ha⁻¹ + 20 K₂O kg ha⁻¹ RDF but proved superior over 30 N kg ha⁻¹ + 15 P₂O₅ kg ha⁻¹ + 15 K₂O kg ha⁻¹ RDF (20.19 kg ha⁻¹).

2. Phosphorus

Seed

Varieties : Data indicate that the variety UI-124 application had significant effect on phosphorus uptake in seed. Maximum phosphorus uptake of 3.43 kg ha⁻¹ in seed variety of UI-124 which was significantly higher over the variety. Minimum phosphorus uptake in seed was recorded with VI-1 (2.12 kg ha⁻¹).

Table-1 : Performance of isabgol varieties under varying fertility levels on nutrients uptake.

Treatments	Nitrogen uptake (kg ha ⁻¹)			Phosphorus uptake (kg ha ⁻¹)			Potassium uptake (kg ha ⁻¹)		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
Varieties									
UI-2-1	14.73	10.25	27.98	2.95	3.25	6.20	8.53	23.81	32.33
UI-3	12.19	7.95	20.14	2.52	2.79	5.31	7.34	25.40	32.74
UI-89	15.33	11.25	26.58	2.97	3.44	6.41	8.64	27.83	36.47
UI-124	17.36	12.35	29.71	3.43	4.55	7.98	9.88	27.08	36.96
Niharika	12.82	8.33	21.15	2.53	2.86	5.39	7.52	22.35	29.87
GI-2	11.59	7.83	19.41	2.29	2.65	4.94	6.91	20.78	27.69
VI-1	10.96	7.41	18.37	2.12	2.34	4.46	6.52	11.54	18.06
SEm±	0.49	0.37	0.69	0.10	0.013	0.19	0.28	0.77	0.87
CD (P=0.05)	1.41	1.08	2.02	0.29	0.38	0.56	0.81	2.25	2.25
Fertility levels (N + P ₂ O ₅ + K ₂ O kg ha ⁻¹)									
30 + 15 + 15	12.25	7.95	20.19	1.95	2.06	4.01	6.89	19.32	28.24
45+ 30+ 20	14.89	10.73	25.62	3.43	4.19	7.62	8.92	26.05	32.94
SEm±	0.26	0.20	0.37	0.05	0.07	1.10	0.15	0.41	0.46
CD (P=0.05)	0.75	0.57	1.08	0.16	0.20	0.30	0.43	1.20	1.34

Fertility levels : Perusal of data indicated that maximum phosphorus uptake in seed (3.43 kg ha⁻¹) was registered with application of 45 N kg ha⁻¹ + 30 P₂O₅ kg ha⁻¹ + 20 K₂O kg ha⁻¹ RDF but proved superior over 30 N kg ha⁻¹ + 15 P₂O₅ kg ha⁻¹ + 15 K₂O kg ha⁻¹ RDF (1.95 kg ha⁻¹).

Straw

Varieties : Data indicate that the variety UI-124 application had significant effect on phosphorus uptake in straw. Maximum phosphorus uptake of 4.55 kg ha⁻¹ in straw variety of UI-124 which was significantly higher over the variety. Minimum phosphorus uptake in straw was recorded with VI-1 (2.34 kg ha⁻¹).

Fertility levels : Perusal of data indicate that maximum phosphorus uptake in straw (4.19 kg ha⁻¹) was registered with application of 45 N kg ha⁻¹ + 30 P₂O₅ kg ha⁻¹ + 20 K₂O kg ha⁻¹ RDF but proved superior over 30 N kg ha⁻¹ + 15 P₂O₅ kg ha⁻¹ + 15 K₂O kg ha⁻¹ RDF (2.06 kg ha⁻¹).

Total

Varieties : Data indicate that the variety UI-124 application had significant effect on total phosphorus uptake by crop. Maximum total phosphorus uptake of 7.98 kg ha⁻¹ by variety of UI-124 which was significantly higher over the variety. Minimum total nitrogen uptake was recorded with VI-1 (4.46 kg ha⁻¹).

Fertility levels : Perusal of data indicate that maximum total phosphorus uptake by crop (7.62 kg ha⁻¹) was registered with application of 45 N kg ha⁻¹ + 30 P₂O₅ kg ha⁻¹ + 20 K₂O kg ha⁻¹ RDF but proved superior over 30 N kg ha⁻¹ + 15 P₂O₅ kg ha⁻¹ + 15 K₂O kg ha⁻¹ RDF (4.01 kg ha⁻¹).

3. Potassium uptake

Seed

Varieties : Data indicate that the variety UI-124 application had significant effect on potassium uptake in seed. Maximum potassium uptake of 9.88 kg ha⁻¹ in seed variety of UI-124 which was significantly higher over the variety. Minimum potassium uptake in seed was recorded with VI-1 (6.52 kg ha⁻¹).

Fertility levels : Perusal of data indicated that maximum potassium uptake in seed (8.92 kg ha⁻¹) was registered with application of 45 N kg ha⁻¹ + 30 P₂O₅ kg ha⁻¹ + 20 K₂O kg ha⁻¹ RDF but proved superior over 30 N kg ha⁻¹ + 15 P₂O₅ kg ha⁻¹ + 15 K₂O kg ha⁻¹ RDF (6.89 kg ha⁻¹).

Straw

Varieties : Data indicate that the variety UI-124 application had significant effect on potassium uptake in straw. Maximum potassium uptake of 27.08 kg ha⁻¹ in straw variety of UI-124 which was significantly higher over the variety, but it was found at par with UI-89. Minimum potassium uptake in straw was recorded with VI-1 (11.54 kg ha⁻¹).

Fertility levels : Perusal of data indicate that maximum potassium uptake in straw (26.05 kg ha⁻¹) was registered with application of 45 N kg ha⁻¹ + 30 P₂O₅ kg ha⁻¹ + 20 K₂O kg ha⁻¹ RDF but proved superior over 30 N kg ha⁻¹ + 15 P₂O₅ kg ha⁻¹ + 15 K₂O kg ha⁻¹ RDF (19.32 kg ha⁻¹).

Total

Varieties : Data indicate that the variety UI-124 application had significant effect on total potassium

uptake by crop. Maximum total potassium uptake of 36.96 kg ha⁻¹ by variety of UI-124 which was significantly higher over the variety, but it was found at par with UI-89. Minimum total potassium uptake was recorded with VI-1 (18.06 kg ha⁻¹).

Fertility levels : Perusal of data indicate that maximum total potassium uptake by crop (32.94 kg ha⁻¹) was registered with application of 45 N kg ha⁻¹ + 30 P₂O₅ kg ha⁻¹ + 20 K₂O kg ha⁻¹ RDF but proved superior over 30 N kg ha⁻¹ + 15 P₂O₅ kg ha⁻¹ + 15 K₂O kg ha⁻¹ RDF (28.24 kg ha⁻¹).

The plant analysis indicates that genotype UI-124 recorded highest concentration of N, P and K content and uptake in seed and straw. The improvement in nutrient status of plant parts under variety UI-124 might be due to their genetic makeup. It is generally believed that nutrients extracted by plants are used for maintaining their critical concentration that can be used for plant growth and development. The significant increase in N, P and K content of fodder seems to be on account of potential of the genotypes for efficient absorption, translocation and utilization of mineral nutrients. Moreover, the increased dry matter accumulation, opined that adequate supply of metabolites from root to shoot decides proliferation and facilitate higher nutrients extraction from soil environment. Further higher availability of nutrients with the variety UI-124 seems to be because of critical concentration at cellular level and fulfilling requirement for profuse plant growth and their efficient translocation towards sink. Similar findings were also reported by (Charak, 2002). These results are close agreement with the finding of Kumar et al. (2019) and Charak, 2002. The total nutrient uptake by isabgol crop significantly increased with increased fertility levels. It is well established fact that total uptake of nitrogen, phosphorus and potassium by the crop is primarily governed by total dry matter production and secondarily on nutrient status at cellular level. Thus, impact of N, P and K fertilizer ultimately led to higher accumulation of nutrients by plant parts along with total uptake by the crop. These results are close conformity with the finding of Singh *et al.* (2001), Saraswathi *et al.* (2014), Shivran (2016), Patel *et al.* (2016), Kumar et al. (2020) and Eragegowda *et al.* (2021).

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Effect of Biochar and its Split Application on Nutrient Content and Uptake by Fenugreek (*Trigonella foenum-graecum* L.) Grown under Organic Farming

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Abstract

To study the effect of biochar and its split application on the nutrient content and uptake by fenugreek, a field research experiment was laid out in split plot design at the Organic Farming Unit, Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan). The experiment comprised of five levels of biochar doses *i.e.*, biochar @ 0, 1, 2, 3 and 4 t ha⁻¹ in main plots and three levels of split application of biochar *i.e.*, Basal application, 50 % as Basal application+ 50 % with first irrigation, 50 % as basal application + 25 % with first irrigation + 25 % with second irrigation in sub plots which were replicated thrice. The significantly higher nitrogen and phosphorus content and uptake by seed and straw of fenugreek were recorded under biochar @ 4 t ha⁻¹ over control and biochar @ 1 t ha⁻¹; however effect of it found at par with the application of biochar @ 2 and 3 t ha⁻¹. Nutrient content and uptake significantly increases with three split application of biochar over basal application but the increase was found at par with two split application of biochar.

Key words : Biochar, fenugreek, doses, split application, nutrient content, nutrient uptake.

Introduction

Fenugreek is India's third most popular seed spice, after coriander and cumin. Fenugreek contains 23–26 per cent protein, 6–7 per cent fat and 58 per cent carbohydrates of which about 25 per cent is dietary fiber (US Department of Agriculture, 2012). Fenugreek plant also used to treat diabetes, chronic dysentery, diarrhea and its seed have anti-inflammatory, anti-cancerous and anti-microbial properties (Kausar *et al.*, 2017). Fenugreek is also a rich source of iron (33 mg/100 g dry weight) (US Department of Agriculture, 2001). It contains phytochemicals like phytic acid, tannin and total polyphenols are found to be 152.91, 1.32 and 452.12 mg /100 g, respectively.

The average productivity of fenugreek in India is very low (1215 kg/ha) which required to be increased (Malav *et al.*, 2018). The main factor responsible for low productivity is poor soil fertility due to low soil organic carbon status, low level of nitrogen, low level of micro nutrients and poor crop management practices (Sharma *et al.*, 2017). In this context, biochar is one of the good options for improving the soil quality and enhancing the yield of crops. Biochar is a carbon rich stable solid substance, made by pyrolysis of biomass. Biochar have condensed aromatic structure highly stable and porous with high surface area and responsible for its resistance against decomposition and make carbon stable in soils for long time and can be a suitable approach to add carbon in the soil. Biochar contains more than 50 per cent carbon with neutral or alkaline pH (Maliska, 2012). It increases potassium,

phosphorus, nitrogen and magnesium levels in soil (Laird, 2008) has a high water-holding capacity (Liu *et al.*, 2016) and provides a favorite growing medium for micro-organisms due to its porous structure and nutrient- rich particles as well as organic carbon molecules; as a result, it improves soil fertility (Cayuela *et al.*, 2014).

Materials and Methods

The experimental trial was set up at Organic Farming Unit, Rajasthan College of Agriculture, MPUAT, Udaipur, which is located in the Southern-Eastern region of Rajasthan at 24° 35' N latitude, 73° 42' E longitude and an altitude of 582.17 meter above mean sea level. The area falls under agro-climatic zone IVa (Sub-Humid Southern Plain and Aravali Hills) of Rajasthan. The soil of the experimental site was clay loam in texture having 0.67 % soil organic carbon, 281.54 kg ha⁻¹ available nitrogen, 20.96 kg ha⁻¹ available phosphorus and 314.54 kg ha⁻¹ available potassium with soil pH 7.8. The experiment laid out in split plot design with three replications and 15 treatments. The treatment consists of five levels of doses of biochar (Control, 1, 2, 3 and 4 t ha⁻¹) in main plot and three levels of split application of biochar (Basal application, 50 % as basal + 50% with percent first irrigation and 50 % as basal + 25 % with percent first irrigation + 25 % with second irrigation) in subplots. Variety PRM-45 of fenugreek was sown on 17 November, 2021 at 30 cm row to row spacing by using recommended seed rate of 25 kg ha⁻¹. Basal application of biochar was broadcasted manually before the sowing of fenugreek crop and was mixed into the soil with the help of hand hoes. Further application of biochar

was done in narrow bands between the crop rows (47 and 95 days after sowing), after which irrigation was applied. As per recommendation, about 40 kg of nitrogen was applied. 20 kg nitrogen supplied through NADEP compost (1825 kg NADEP compost) remaining through vermicompost (1450 kg vermicompost) and these were applied before sowing through broadcasting during last ploughing.

Nutrient content and uptake estimation : Five plants were selected at random after harvest and seeds were collected from these plants. The collected samples were oven dried at 65 °C till constant weight is obtained. Then, samples were grounded to produce fine powder and passed through 60 mesh sieves to obtain final sample for the nutrient analysis. Nutrient content in seed and straw were estimated as per the following method.

S.No.	Parameters	Method of analysis	References
1.	Nitrogen content	N was estimated by using spectrophotometer after developing colour with Nessler's reagent	Snell and Snell, 1959
2.	Phosphorus content	P was estimated by using spectrophotometer after developing colour with vanado-molybdo phosphoric yellow colour method	Richards, 1968
3.	Potassium content	Flame photometer	Jackson, 1959

Uptake of N, P, K, in seed and straw samples were calculated by multiplying per cent nutrient content and their respective dry matter accumulation as per the formula given below :

$$\text{Nutrient uptake by seed (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in seed} \times \text{seed yield (kg ha}^{-1}\text{)}}{100}$$

Results and Discussion

Effect of Biochar doses : Data elucidated in Table-1 clearly demonstrate that there was significant improvement in the nitrogen (3.086 and 1.125 %) and phosphorus (0.427 and 0.238 %) content in seed and haulm of fenugreek under the application of biochar @ 4 t ha⁻¹ over control and this was statistically at par to the effect of application of biochar @ 2 and 3 t ha⁻¹. Furthermore, application of biochar @ 4 t ha⁻¹ recorded an increase of 16.45 and 14.79 per cent in nitrogen content, 14.17 and 13.33 per cent in phosphorus content over control in seed and haulm of fenugreek, respectively.

Similarly, the uptake of N, P and K by seed and haulm also showed the similar kind of trend as shown by the nutrient content (Table-2). There was appreciably utmost amount of nutrient uptake of these nutrient *i. e.*, N, P and K by seed (56.82, 7.85 and 18.47 Kg ha⁻¹), haulm (51.92, 10.98, 64.04 Kg ha⁻¹) and total (108.75, 18.83,

82.51 Kg ha⁻¹) noticed under the application of biochar @ 4 t ha⁻¹. Total nutrient uptake of N, P and K increased by means of 74.67, 72.27 and 51.89 per cent over the control.

Nutrient content and uptake were significantly improved under the different doses of biochar application. Application of biochar increased nutrient availability in soil by improving the physico-chemical properties of soil and this result into increased content and uptake of nutrients by the plants. High efficiency of biochar in adsorption of NH₄⁺ and NO₃⁻ might inhibit their leaching from soils and this improved its absorption by plants (Guerena *et al.*, 2015). Biochar also acts as source of soluble phosphorus salts and exchangeable phosphorus forms, avoids phosphorus precipitation by altering soil pH (bonding or sorbing elements which precipitate P) or boost microbial activity leading to changes in phosphorus which can enhance availability and plant uptake of phosphorus (Atkinson *et al.* 2010).

The pH, total exchangeable bases and electrical conductivity of soil increased with the application of biochar and this increase might have increased the availability of nutrients to the plants (Atkinson *et al.*, 2010; Laird *et al.*, 2010; Major *et al.*, 2010).

Effect of split application of biochar : Data presented in the table-1 showed that there was significant increase in the nitrogen (2.928 and 1.089 %) and phosphorus (0.410 and 0.231%) content in seed and haulm of fenugreek respectively under the three split application of biochar and this was statistically analogous to effect of application of biochar in two splits. Furthermore, three split application of biochar recorded an increase of 2.19 and 4.01 per cent in nitrogen content, 2.24 and 4.52 per cent in phosphorus content in seed and haulm of fenugreek, respectively over basal application.

Similarly, the uptake of N, P and K by seed, haulm and total also showed the similar kind of trend as shown by the nutrient content (Table-2). There was appreciably utmost amount of nutrient uptake of these nutrient *i. e.*, N, P and K by seed (49.89, 6.96 and 16.76Kg ha⁻¹), haulm (45.80, 9.70, 58.48Kg ha⁻¹) and total (95.69, 16.67, 75.24 Kg ha⁻¹) noticed under the three split application of biochar. Total nutrient uptake of N, P and K increased by means of 15.51, 15.20 and 10.72 per cent over the basal application by the three split application of biochar. These results corroborate the findings of Banerjee *et al.*, (2013) who observed higher availability of nitrogen (N) in soil with split applications with higher nitrogen use efficiency and thus, split application of manures reduced nitrogen losses.

Table-1 : Effect of doses of biochar and split application of biochar on nutrient content in seed and haulm of organic fenugreek.

Treatments	Nutrient content (%)					
	N		P		K	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Doses of biochar						
Control	2.650	0.980	0.374	0.210	0.975	1.398
1 t ha ⁻¹	2.740	1.043	0.389	0.221	0.984	1.401
2 t ha ⁻¹	3.021	1.102	0.420	0.232	0.994	1.403
3 t ha ⁻¹	3.037	1.120	0.423	0.235	0.995	1.405
4 t ha ⁻¹	3.086	1.125	0.427	0.238	1.005	1.390
SEm ±	0.027	0.017	0.004	0.003	0.012	0.013
CD (P=0.05)	0.089	0.055	0.015	0.010	NS	NS
Split application of biochar						
Basal application	2.865	1.047	0.401	0.221	0.987	1.396
50% as Basal + 50% with 1 st irrigation	2.927	1.086	0.409	0.229	0.991	1.399
50% as Basal + 25% with 1 st irrigation + 25% with 2 nd irrigation	2.928	1.089	0.410	0.231	0.994	1.403
SEm ±	0.017	0.010	0.002	0.002	0.007	0.009
CD (P=0.05)	0.051	0.028	0.006	0.007	NS	NS

Table-2 : Effect of doses of biochar and split application of biochar on nutrient uptake by organic fenugreek.

Treatments	Nutrient uptake (Kg ha ⁻¹)								
	N			P			K		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Doses of biochar									
Control	32.63	29.62	62.26	4.58	6.35	10.93	11.99	42.33	54.32
1 t ha ⁻¹	39.95	38.75	78.70	5.69	8.22	13.90	14.36	51.98	66.34
2 t ha ⁻¹	52.33	47.68	100.01	7.27	10.04	17.31	17.24	60.58	77.82
3 t ha ⁻¹	54.42	50.10	104.52	7.58	10.51	18.09	17.81	62.78	80.59
4 t ha ⁻¹	56.82	51.92	108.75	7.85	10.98	18.83	18.47	64.04	82.51
SEm ±	1.51	1.49	2.76	0.19	0.37	0.52	0.59	1.92	2.35
CD (P=0.05)	4.92	4.86	8.99	0.61	1.21	1.69	1.92	6.27	7.68
Split application of biochar									
Basal application	42.84	40.00	82.84	5.99	8.47	14.47	14.69	53.26	67.95
50% as Basal + 50% with 1 st irrigation	48.96	45.05	94.01	6.82	9.48	16.30	16.48	57.29	73.76
50% as Basal + 25% with 1 st irrigation + 25% with 2 nd irrigation	49.89	45.80	95.69	6.96	9.70	16.67	16.76	58.48	75.24
SEm ±	0.75	0.93	1.29	0.09	0.19	0.22	0.26	1.22	1.28
CD (P=0.05)	2.21	2.75	3.80	0.27	0.56	0.65	0.77	3.59	3.76

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Fodder Quality, Fibre Fractionation and Energy Balances of Oats (*Avena sativa* L.) as Influenced by Nano Urea Application

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Abstract

An experiment was carried out during *rabi* season of 2020 at Research farm of Agronomy Section, ICAR-National Dairy Research Institute, Karnal in Randomized Block Design with six treatments and four replications. The treatments comprised of T₁: Absolute control; T₂: 100% Recommended dose of nitrogen (RDN) through Urea; T₃: 75% Recommended dose of nitrogen (RDN) + 25% N through Nano-N; T₄: 50% RDN + 50% N through Nano-N; T₅: 25% RDN + 75% N through Nano-N and T₆: 100% Recommended dose of nitrogen (RDN) through Nano-N. Application of 100% RDN through urea recorded the maximum content and yields of dry matter, crude protein, ether extract and total ash which was at par with 75% RDN + 25% N through Nano-N. The result reveals that significantly higher nutritive values and energy balances were recorded with application of 100% RDN through urea which remained at par with 75% RDN + 25% N through Nano-N especially at first cut. Similarly, remarkably lower fibre fractionations were reported under 75% RDN + 25% N through Nano-N as well as 100% RDN through urea during both cuts. The experimental results indicates that application of either 100% RDN through urea or 75% RDN + 25% N through Nano-N are equally important and helps in enhancing the quality of fodder oats.

Key words : Fodder quality, livestock, nano-N, urea, yield.

Introduction

India has 157.35 million hectares of agricultural land, which sustains about 15% of the world's cattle and 17.8% of the world's human population (Shanmathy *et al.*, 2018). Livestock is a main complementary component of Indian agriculture. India is the home to around 536 million animals (Anonymous, 2020) and is the world's highest milk producer, but the productivity is still lower than the worldwide average (Anonymous, 2018). As such genetic variables contribute to only 30% of productivity gains in cattle, while feed and fodder management contribute to around 70%; hence, feeding and care are of crucial importance. India confronts a net shortfall of 35.6, 10.95, and 44% of green fodder, dry crop residue, and concentrate feed, respectively (Anonymous, 2018). The only solution to solve the problem of feeding livestock is to increase fodder productivity. Among the different fodder crops, oats (*Avena sativa* L.) is an important *rabi* season fodder crop which can be cultivated under a wide range of climatic conditions in the north, central and western zones of the country and provides succulent and very delicious fodder to animals during winter (Kumar *et al.*, 2022a). On average, it contains 10-11.5% crude protein, 55-63%

neutral detergent fibre, 30-32% acid detergent fibre, 22-23.5% cellulose and 17-20% hemicelluloses (Kumar *et al.*, 2019).

Adequate supply of nitrogen to plants increases photosynthetic activity leading to increased growth, development, and quality of fodder (Kumar *et al.*, 2021). Urea is a major source of nitrogen fertilizer in agricultural production. Furthermore, the nitrogen efficacy of traditional urea is very poor, resulting in either a nitrogen deficit in the crop or a greater cost of extra urea spray to compensate for the deficiency to increase production. Around 50-70% of the nitrogen supplied by the traditional source is lost via leaching and volatilization rendering it inaccessible to plants. Nano fertilizers are a synthetic or modified form of conventional fertilizers that are encased with nonporous material and covered with a thin polymer layer, and supply nutrients in the form of nano scale particles or emulsions (Kumar *et al.*, 2022b). These nano scale dimensions (1-100 nm) polymers enable low and target specific release for delivering nutrients to plants in a sustainable manner throughout their whole growth period leading to increase nutrient use efficiency due to lower losses (Rai *et al.*, 2012; Mahil and Kumar, 2019). At present, very scanty work has been reported on nitrogen

management using nano nitrogen fertilizers, especially in fodder crops. Considering the above facts in view the present study was proposed to find out a suitable combination and source of nitrogen fertilizer to enhance the fodder quality of oats.

Materials and Methods

The experiment was conducted during *rabi* season of 2020 at the Research farm, Agronomy Section, ICAR-National Dairy Research Institute, Karnal (Haryana). Karnal is located at 29°45' North latitude and 76°58' East longitude and an altitude of 245m above mean sea level. Climate of this area is semi-arid with a mean annual rainfall is 707mm, 70-80% of rainfall is received during the months of July-September and the rest during the winter and spring seasons. The highest (100%) and lowest (41.4%) relative humidity were recorded in the 3rd and 43rd standard week, respectively. The maximum temperature (34.5°C) was recorded in the 40th and 41st standard weeks and the minimum (5.9°C) in 2nd standard week. The soil properties of the experimental site were clay loam in texture with pH 7.70, electrical conductivity 0.25 dS/m, organic carbon 0.67%, available nitrogen, phosphorus and potassium 172.60, 25.70 and 185.40 kg/ha, respectively.

The experiment was laid out in randomized block design with six treatments viz., T₁: Absolute control; T₂: 100% RDN through urea; T₃: 75% RDN + 25% N through Nano-N; T₄: 50% RDN + 50% N through Nano-N; T₅: 25% RDN + 75% N through Nano-N and T₆: 100% RDN through Nano-N with four replications. The land preparation involved one deep ploughing with disc plough followed by one disc harrow and planking. As per treatments, the recommended dose of nitrogen (120 kg/ha) was applied through traditional and nano urea. The 1/3rd dose of nitrogen (Urea) and full doses of P₂O₅ (40 kg/ha) and K₂O (40 kg/ha) were applied to the soil at the time of sowing. The remaining dose of nitrogen (Urea and Nano-N) was applied in two split doses at 30 DAS (Urea as top dressing and Nano-N as a foliar spray) and after 1st cutting (Urea and Nano-N in soil) as per treatment. Remaining package of practices was followed as per the standard procedure for oats cultivation. Oats cv. Kent was sown using 100 kg seed per hectare with maintaining spacing 25 and 10 cm from row to row and plant to plant, respectively.

First cutting was taken at 60 DAS (50% flowering stage) from 8-10 cm above the ground level and the second cutting was taken at 45 days after the first cutting. During both cuttings, net plot area was harvested separately from each plot and total fresh biomass was recorded. Thereafter, fresh chopped plant samples were collected and analyzed for different quality parameters.

The oven-dried fodder samples were ground to pass through 40 mesh sieves by Macro-Wiley Mill and used for chemical analysis. All quality/proximate analysis was done as per the standard process followed by AOAC (2005). Crude protein (CP) content was determined by multiplying the N % by 6.25 factors. Fiber fractions (neutral detergent fiber-NDF, acid detergent fiber-ADF, and acid detergent lignin-ADL) were analyzed using Van Soest *et al.*, (1991) method. Similarly, Horrocks and Vallentine (1999) method was used to estimate total digestible nutrients (TDN), dry matter digestibility (DMD) and dry matter intake (DMI). Net energy for lactation (NE₁), relative feed quality (RFQ) and digestible energy (DE) were determined using Horrocks and Vallentine (1999), Undersander *et al.*, (2002) and Fonnesbeck *et al.*, (1984) methods, respectively. All data recorded were analyzed with the help of analysis of variance (Gomez and Gomez, 1984) at 5% level of significance (P<0.05).

Results and Discussion

Fodder quality parameters and their yield : On dry weight basis, the maximum contents of dry matter (16.20 and 16.03%), crude protein (10.78 and 10.48%) and ether extract (2.66 and 2.46%) were observed under T₂ treatment at first and second cuts, respectively, which was found statistically at par with T₃ and T₄ treatments at first cut, while, statistically at par with T₃ treatment at second cutting (Table-1). Significantly higher total ash content (10.35 and 9.93%) was observed with T₂ treatment at first and second cut, respectively, which was found statistically at par with T₃ treatment. Significantly higher value of these quality parameters during both cuts with 100% RDN through urea and 75% RDN + 25% N through Nano-N could be due to sufficient supply of N. Aside from essential nutrient, N is an indispensable content of amino acids which is a basic unit of proteins. Sufficient N supply through urea and foliar spray through nano-N would have kept the oats free from N stress and also sufficient N supply accelerated the protein synthesis from carbohydrates and reduced the rate of lignifications, thereby maintaining the fodder quality (Kumar *et al.*, 2021, 2022c). In case of yields (Fig.-1), significantly higher crude protein (5.76 and 4.11 q/ha), ether extract (1.42 and 0.96 q/ha) and total ash yield (5.53 and 3.89 q/ha) were recorded with T₂ treatment at first and second cutting, respectively, which was found statistically at par with T₃ treatment at both cuts. In case of total yields, the maximum total crude protein (9.87 q/ha), ether extract (2.38 q ha⁻¹), and total ash yield (9.42 q/ha) were also recorded with T₂ treatment. The higher dry matter yield and content of these quality parameters (CP, EE and total ash) could be the probable reason for higher yields of CP, EE and total ash.

Fiber fractionations : The chemical analysis of oats

Table-1 : Effect of different combinations of doses and sources of nitrogen on quality parameters of fodder oats.

Treatments	Dry matter		Crude protein		Ether extract		Total ash		Cellulose		Hemi-cellulose	
	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut
T ₁	15.08	14.95	9.63	9.46	2.33	2.19	9.11	8.63	29.83	30.53	23.93	24.28
T ₂	16.28	16.03	10.78	10.48	2.66	2.46	10.35	9.93	27.30	27.59	20.78	23.28
T ₃	16.08	15.65	10.65	10.38	2.61	2.42	9.95	9.43	27.88	29.10	21.10	22.35
T ₄	15.90	15.28	10.40	10.01	2.54	2.38	9.65	9.20	28.00	28.78	21.95	22.28
T ₅	15.48	15.25	10.36	9.97	2.51	2.33	9.43	9.13	28.83	29.78	21.80	21.98
T ₆	15.25	15.28	10.26	9.94	2.48	2.32	9.35	9.11	28.93	29.70	23.56	23.42
SEm±	0.24	0.23	0.13	0.12	0.05	0.05	0.21	0.19	0.43	0.33	0.54	0.66
CD (P=0.05)	0.72	0.70	0.40	0.36	0.14	0.14	0.63	0.56	1.30	1.01	1.62	1.99

Note: T₁: Absolute control; T₂: 100% RDN through urea; T₃: 75% RDN + 25% N through Nano-N; T₄: 50% RDN + 50% N through Nano-N; T₅: 25% RDN + 75% N through Nano-N; T₆: 100% RDN through Nano-N.

Table-2 : Effect of different combinations of doses and sources of nitrogen on organic matter, nutritive values and fiber fraction of fodder oats.

Treatments	NDF		ADF		ADL		OM		TDN		DMI		DMD	
	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut
T ₁	58.68	60.13	34.75	35.85	4.93	5.33	90.89	91.38	56.49	55.07	2.05	2.00	61.83	60.97
T ₂	52.30	55.40	31.53	32.13	4.23	4.54	89.65	90.08	60.65	59.88	2.29	2.17	64.34	63.87
T ₃	53.18	55.95	32.08	33.60	4.20	4.50	90.05	90.58	59.94	57.97	2.26	2.14	63.91	62.73
T ₄	54.38	56.00	32.43	33.73	4.43	4.95	90.35	90.80	59.49	57.81	2.21	2.14	63.64	62.63
T ₅	55.18	56.75	33.38	34.78	4.55	5.00	90.58	90.88	58.26	56.46	2.18	2.11	62.90	61.81
T ₆	57.06	58.17	33.50	34.75	4.58	5.05	90.65	90.90	58.10	56.48	2.10	2.07	62.80	61.83
SEm±	0.53	0.60	0.41	0.31	0.13	0.18	0.21	0.19	0.52	0.40	0.02	0.02	0.32	0.24
CD (P=0.05)	1.60	1.80	1.23	0.94	0.38	0.54	0.63	0.56	1.58	1.21	0.06	0.07	0.95	0.73

Note: OM: Organic matter; TDN: Total digestible nutrients; DMI: Dry matter intake; DMD: Dry matter digestibility; NDF: neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin; T₁: Absolute control; T₂: 100% RDN through urea; T₃: 75% RDN + 25% N through Nano-N; T₄: 50% RDN + 50% N through Nano-N; T₅: 25% RDN + 75% N through Nano-N; T₆: 100% RDN through Nano-N.

showed that fiber fraction was significantly influenced by different combinations of doses and sources of nitrogen (Table-1 and 2). Significantly lowest organic matter (89.65 and 90.08%), NDF (52.30 and 55.40%), ADF (31.53 and 32.13%) and cellulose contents (27.30 and 27.59%) were recorded with T₂ treatment at first and second cut, respectively. Though, NDF was found statistically at par with T₃ treatment at the first cut and T₃, T₄ and T₅ treatments at second cut; ADF and cellulose were found at par with T₃ and T₄ treatment at first cut; and organic matter found at par with T₃ treatment during both cuts. Significantly lowest ADL content (4.20 and 4.50%) was recorded with T₃ treatment. Whereas, lowest hemicelluloses content (20.78 and 21.98%) was obtained with T₂ and T₅ at the first and second cut, respectively. Remarkably lower fiber content in oats under the application of 100% RDN through urea and 75% RDN + 25% N through Nano-N are ascribed to higher quality enhancing parameters (CP, EE and TA content) and also less stress condition prevailed under these treatments. Rai *et al.*, (2012) also reported that nano urea releases N in slow manner through crop growth which might be responsible for adequate N supply to oats.

Nutritional values and energy fractionations : The chemical analysis of oats showed that nutritional value and digestibility were significantly influenced by different combinations of doses and sources of nitrogen (Table-2). Significantly highest total digestible nutrients (60.65 and 59.88%), dry matter digestibility (64.34 and 63.87%), dry matter intake (2.29 and 2.17%) and relative forage quality (113.10 and 105.50) were recorded with T₂ treatment at the first and second cut, respectively, where TDN and DDM content found at par with T₃ and T₄ treatments at first cut; RFQ found at par with T₃ treatment at first cut and DMI found at par with T₃ treatment at the first cut and T₄ and T₅ treatments at the second cut. With respect to energy fractionations, significantly highest digestible energy (12.65 and 12.57 MJ/kg) and net energy for lactation (6.17 and 6.10 MJ/kg) was recorded with T₂ treatment at the first and second cut, respectively, which was found statistically at par with T₃ followed by T₄ treatment at first cut. The higher nutritional values and energy fractionations (TDN, DMD, RFQ and DE) under 100% RDN through urea and 75% RDN + 25% N through Nano-N might be due to their positive relationship with quality enhancing parameters (CP, EE and TA) and negative relationship with fibers

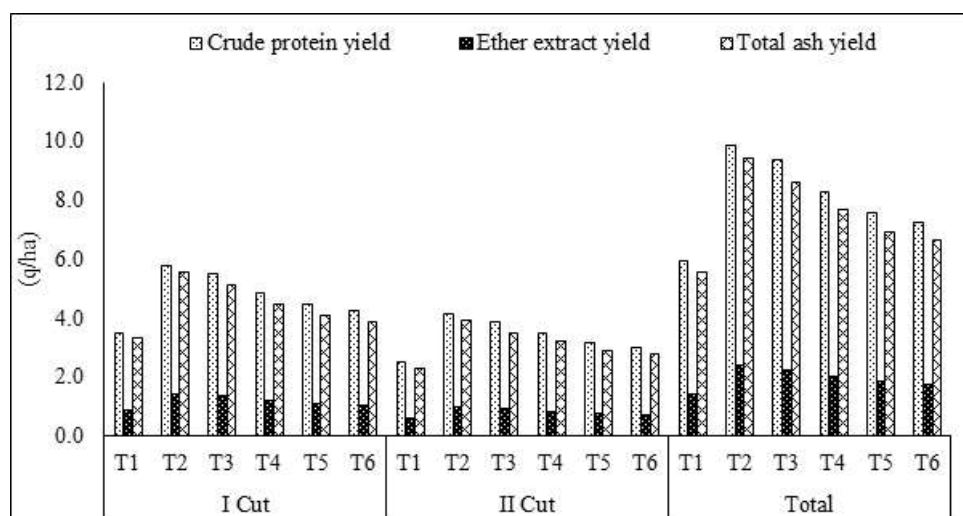


Fig.-1 : Effect of different combinations of doses and sources of nitrogen on crude protein, ether extract and total ash yields of fodder oats.

Note: T₁: Absolute control; T₂: 100% RDN through urea; T₃: 75% RDN + 25% N through Nano-N; T₄: 50% RDN + 50% N through Nano-N; T₅: 25% RDN + 75% N through Nano-N; T₆: 100% RDN through Nano-N.

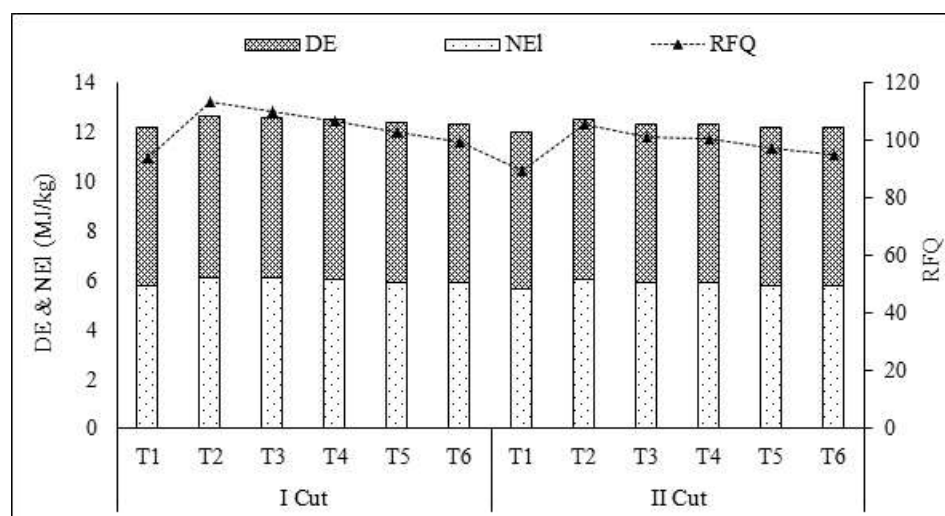


Fig.-2 : Effect of different combinations of doses and sources of nitrogen on energy balances and relative fodder quality of fodder oats.

Note: DE: Digestible energy; NEI: Net energy for lactation; RFQ: Relative feed quality; T₁: Absolute control; T₂: 100% RDN through urea; T₃: 75% RDN + 25% N through Nano-N; T₄: 50% RDN + 50% N through Nano-N; T₅: 25% RDN + 75% N through Nano-N; T₆: 100% RDN through Nano-N.

(NDF and ADF). Similar results were also reported by Kumar *et al.*, (2022c).

Based on the present experimentation, it may be concluded that the application of either 100% RDN through urea (T₂) or 75% RDN + 25% N through Nano-N to fodder oats gave the maximum yield with better quality fodder which resulted into maximum energy to animals for sustainable livestock production.

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Effect of Spacing and Training Method on Yield, Quality and there Economics of Off-Season Ridge Gourd (*Luffa acutangula* L.) Cultivation under Insect Proof Net-House Conditions

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Abstract

Spacing and training method on yield, quality and there economics of off-season cultivation of ridge gourd (*Luffa acutangula* L.) under insect proof net-house conditions. The experiment was laid out following factorial randomized block design (FRBD) with three replications. The experiment was comprising of total nine treatment combinations viz. three levels of spacing 45 cm × 45 cm (S₁), 45 cm × 60 cm (S₂) and 45 cm × 75 cm (S₃) with three levels of training methods viz. Single stem (T₁), Double stem (T₂) and Triple stem (T₃). The plant spacing S₃ (45 cm × 75 cm) was found to be the best with regard to yield and economics attributing traits. Highest number of fruits per vine (62.44), and fruit weight (33.22g), TSS (2.34° B) and yield per vine were recorded in S₃. Amongst the training methods highest total yield per vine, total yield per plot obtained in T₃ training method. The treatment S₃ T₃ recorded maximum number of fruits produced per vine while the treatment S₁ T₃ had the highest net returns (RS. 86,142.0) as well as B: C ration (2.78).

Key words : Ridge gourd, spacing, training method, insect proof net-house, B: C ratio.

Introduction

One of the most important cucurbitaceous vegetable crops is the ridge gourd (*Luffa acutangula* L.), which is a member of the *Luffa* genus. The term "Loofah" refers to a variety of products include bathing sponges, scrubbing pads, doormats, cushions, mattresses, and cleaning supplies. According to Kandlakunta *et al.* (2008), ridge gourd is commonly grown in India for basically picked immature fruits, which are eaten as cooked vegetables. Its therapeutic benefits and role in the diet make it important to increase its production and productivity with the use of high-quality seed and sensible management techniques. It's also crucial to standardise agricultural practises, such as training vines, because a good training system will not only enable better management but also will permit closer planting, higher yield per unit area, larger sized fruits and good quality seed (Lal *et al.*, 2014).

Luffa (satputia), is characterized by smooth skin, tender fruits in clusters, bearing bisexual flowers and generally the cultivars bear seven fruits in each inflorescence and this appears to be a constant feature. Based on this trait, it is locally called "Satputria" or "Satputiya" meaning seven children (Ali and Pandey, 2006).

Satputia is commonly grown vegetable in the north-eastern part of Uttar Pradesh and adjoining regions (Sirohi *et al.* 2005). The fruits of Satputia can be consumed without removal of the skin as it is soft and gets

cooked homogeneously. The fruit is diuretic, expectorant, and is used in curing biliousness, bronchitis, diseases of spleen and ulcers while the seed is emetic and cathartic.

Protected vegetable cultivation technology can be utilized for year round and off-season production of high value-low volume vegetables, production of virus free quality seedlings, quality hybrid seed production and disease resistance breeding programs (Wani *et al.*, 2011). Greenhouse technology for commercial vegetable cultivation is getting momentum in India. India being a vast country with diverse and extreme agro-climatic conditions, the protected cultivation technologies are suitable for water scarce and harsh climatic conditions of western Rajasthan for commercial vegetable cultivation for increasing the socio-economic status of small farmers through high profitability. Besides, protected cultivation also offers distinct advantages of earliness, higher productivity and better quality, particularly pesticide residue-free produce.

Ridge gourd is an important vegetable crop of India and it's being cultivated in various part of the country on commercial scale by using monoecious varieties or hybrids. Ridge gourd can be grown under protected conditions, but monoecious varieties or hybrids are not preferred for such cultivation system due to the main problem of pollination and fertilization. However, with the introduction of hermaphrodite and parthenocarpic varieties like Satputia of ridge gourd, these issues can be

Table-1 : ffect of spacing and training method on fruit yield (kg vine⁻¹) and fruit yield (kg plot⁻¹).

Treatment	Number of fruits produced per vine	Fruit yield (kg vine ⁻¹)	Fruit yield (kg plot ⁻¹)
Spacing (S)			
S ₁ (45 × 45 cm)	57.37	1.74	19.14
S ₂ (45 × 60 cm)	59.81	1.89	17.03
S ₃ (45 × 75 cm)	62.44	2.06	14.48
SEm±	0.88	0.04	0.34
CD (0.05)	2.66	0.12	0.09
Training (T)			
T ₁ (Single stem)	52.79	1.79	15.77
T ₂ (Double stem)	59.95	1.91	17.03
T ₃ (Triple stem)	66.88	2.00	17.86
SEm ±	0.88	0.04	0.344
CD (0.05)	2.66	0.12	0.09
Interaction (S × T)			
SEm±	1.53	0.06	0.58
CD (0.05)	4.61	NS	NS

Table-2 : ffect of spacing and training method on fruit pH, TSS (°B) and shelf life.

Treatment	Fruit pH	TSS (°B)	Shelf life
Spacing (S)			
S ₁ (45 × 45 cm)	8.52	1.99	3.70
S ₂ (45 × 60 cm)	8.61	2.25	3.71
S ₃ (45 × 75 cm)	8.63	2.34	3.79
SEm±	0.11	0.03	0.06
CD (0.05)	NS	0.10	NS
Training (T)			
T ₁ (Single stem)	8.67	2.23	3.99
T ₂ (Double stem)	8.58	2.19	3.72
T ₃ (Triple stem)	8.52	2.15	3.49
SEm±	0.11	0.03	0.06
NS	2.66	NS	0.20
Interaction (S × T)			
SEm±	0.19	0.06	0.11
CD (0.05)	NS	NS	NS

resolved and it can be a lucrative crop for protected cultivation to capture the off-season market.

Materials and Methods

The experiment was conducted under insect proof net-house covered with 50% white nylon UV stabilized insect proof 40 mesh mononet, at college of Agriculture, Jodhpur. The experiment comprised total nine treatment combinations viz three levels of spacing 45 cm × 45 cm (S₁), 45 cm × 60 cm (S₂) and 45 cm × 75 cm (S₃) with three levels of training methods viz. Single stem (T₁), Double stem (T₂) and Triple stem (T₃). The experiment was laid out following factorial randomized design with three replications. The yield, quality and economics traits viz. fruit weight (g), yield per vine (kg) and yield per plot (kg), TSS (° B), pH and shelf life. The economic feasibility of different treatments was determined on the basis of prevailing market prices of inputs and output.

Results and Discussion

Yield and yield attributing characters : Yield and yield attributing characters like number of fruits per vine, fruit Weight and fruit yield per vine were influenced significantly by plant spacing and training methods. Widest spacing (S₃) was recorded superior for the characters such as number of fruits per vine (62.44), fruit weight (33.22 g) and yield per vine (2.06 kg). The maximum fruit yield per plot (19.14kg) was recorded in treatment S₁. It could be due to increased availability of nutrients and moisture at wider spacing. The results are also supported by the findings of Rodriguez *et al.* (2007), Lacob *et al.* (2009) and Sharma *et al.* (2018).

Amongst the various training methods T₃ was significantly better for number of fruits per vine (66.88), yield per vine (2.00 kg) and yield per plot (17.85 kg). The more number of fruit per vine recorded in wider spacing of

Table-3 : conomics of different treatment for ridge gourd cultivation under insect proof net house (area 500 m²).

Treatment	Yield (kg/500m ²)	Gross (Rs./500m ²)	Cost of cultivation (kg/500m ²)	Net returns (kg/500m ²)	B : C Ratio
S ₁ T ₁	1912.2	95610	30,048	65,562	2.18
S ₁ T ₂	2234.1	111705	30,528	81,177	2.66
S ₁ T ₃	2344.0	117150	31,008	86,142	2.78
S ₂ T ₁	1802.2	90110	29,904	60,206	2.01
S ₂ T ₂	1952.8	97640	30,384	67,256	2.21
S ₂ T ₃	2028.2	101910	30,864	71,046	2.30
S ₃ T ₁	1509.6	75480	29,759	45,721	1.54
S ₃ T ₂	1584.9	79245	30,239	49,006	1.62
S ₃ T ₃	1693.0	84650	30,719	53,931	1.76

T₃ could be attributed to availability of more number of fruit producing stems which resulted into higher number of fruits per vine. The findings are in agreement with Khairul Mazed *et al.* (2015), Singh *et al.* (2017) and Dhillon *et al.* (2017). The interactions between spacing and training methods had significant effect on number of fruits per vine. The maximum number of fruits per vine (67.67) was recorded in treatment S₃T₃. This could be attributed to the availability of more higher photosynthetic to individual plant due ample light availability under wider spacing and more number of fruit producing stems which resulted into higher number of fruits per vine. The results are in close conformity with earlier findings of Mamnoi *et al.* (2014) and Sharma *et al.* (2018).

Quality characters : Non-significantly difference in the value of qualitative traits (pH, shelf life) due to various levels of spacing, training methods and their interactions except TSS (°Brix). TSS was significantly affected by various levels of spacing. The maximum TSS (2.34 °Brix) found in treatment S₃, whereas the minimum TSS (1.99 °Brix) found in treatment S₁. Increase in TSS (°Brix) could be due to effective utilization of sunlight at wider spacing. These results are supported by the work of Nerson (1998). Training methods could not influence the TSS (°Brix) significantly. The maximum shelf life produced treatment T₁ results confirms the observation of our previous study Klieber *et al.* (1993).

Economics : The highest net returns of Rs. 86143.0 were found in S₁ T₃ followed by S₁ T₂ (Rs. 81176.0) and the lowest net returns were found in S₃ T₁ (Rs. 45719.3). The highest B:C ratio (2.7) was recorded in S₁ T₃ amongst all the treatments studied, whereas the lowest B:C ratio (1.5) was recorded in S₃ T₁.

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Effect of Bio-Fertilizer and Kitchen Waste Manure on Growth of Chilli cv. Pusa Jwala

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Abstract

An experiment was carried out at the Horticulture Research Farm, Department of Applied Plant Science (Horticulture) Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow to Effect of bio-fertilizer and kitchen waste manure on vegetative growth of chilli cv. PusaJwala, The results revealed that the that application of treatment T₁₀ [RDF 50% + kitchen waste manure (25 and 50 days after transplanting)] was found to be the best treatment in respect of betterment of vegetative growth except treatment T₇ (RDF 50% + kitchen waste manure) showed the early flowering to harvesting (23.67 days).

Key words : Bio-fertilizer, growth, chilli, pusa jwala.

Introduction

Pepper (*Capsicum* sp.) is an economically important vegetable crop belonging to the family solanaceae having chromosome number $n = 12$ (Thambhuraraj and Singh, 2015). It originated from South and Central America where it is still under cultivation (Pickersgill, 1997). Pepper was introduced into Europe by Columbus and other early new explorers in the sixteenth century and cultivation spread throughout the world (Greenleaf, 1986). Chilli (*Capsicum annum* var. *frutescence*) is one of the most important vegetable crops grown throughout India. It is grown for export as well as for domestic market. Chilli is a heavy feeder crop so, it needs higher amount of nutrient according to recommended that 150 kg/ha Nitrogen, 75 kg/ha Phosphorus, 75 kg/ha Potassium. It is used for good growth and yield for production of chilli proper supply sufficient amount of nutrient by inorganic source.

But now a days, inorganic or chemical fertilizer can be reduce the soil fertility, plant growth, flowering and yield as well as it affect the quality of chilli. thus I have used to bio-fertilizer like *Azospirillum* in chilli crop because it help to convert the atmospheric nitrogen in available nitrogen form and increases the growth, no of leaves, flowering, fruiting, yield and biochemical property in fruit as well as in kitchen waste manure good amount of nutrient because it is made by plant origin like leaves, flower, peel, seed etc. kitchen waste manure is not only good amount in nutrient as well as clean area and provide fresh air because disposed the kitchen garbage and it increase the microbial activity, soil porosity, water retention and reducing the pH level. It is used for increase the growth yield and quality of chilli.

Materials and Methods

The experiment was carried out at the Horticulture

Research Farm, Department of Applied Plant Science (Horticulture) BabasahebBhimraoAmbedkar University (A Central University), VidyaVihar, Rae Barely Road, Lucknow during October 2016 - May 2017. Geographically, experimental field is situated at an elevation of 123 meter above Mean Sea Level (MSL) in the Sub-tropical Climate of Central Uttar Pradesh at 26° 55' North latitude and 80° 59' East longitude. The experiment was laid out in Randomized Block Design (RBD) with three replications. Total plot size 2.16 m², total number of plot 36 along with 30 x 30 cm. The seeds of chilli (*Capsicum annum* var. *frutescence*) cv. PusaJwala were obtained from the Indian Agricultural Research Institute, Pusa, New Delhi.

Before the seed sowing, the nursery field was ploughed, harrowed and the soil was brought to a fine tilth. Raised nursery beds were prepared at a height of 15cm with 1m width and 2m length. Well-decomposed compost at 2 kg per meter cube and NPK complex fertilizer was applied 15 days before sowing. Seeds of chilli variety PusaJwala sown after treating the seeds with 0.2 percent captan. Seeds of chilli were sown in rows and after sowing the lines were covered with fine FYM. Healthy seedling of 35 days old with 4-6 true leaves were transplanted in main field.

Well-rotted Farmyard manure applied as per the treatments one month prior to transplanting. The other inorganic sources of nitrogen, phosphorous and potassium were applied in the form of urea, di ammonium phosphate and muriate of potash respectively at recommended dose. Full dose of phosphorous and potassium and half dose of nitrogen was applied to the treatments receiving Farmyard manure and *Azospirillum* inoculation, while the remaining treatments received full dose of recommended dose of nitrogen (RDN) 150 kg N/ha in two splits doses and 50 % RDN (in two splits) as

per treatment specifications at the time of transplanting. The roots of chilli seedlings were dipped in solution containing *Azospirillum* inoculation and left for 15 minutes before transplanting as per the treatment specifications. The solution was made by adding jaggery in sterile distilled water.

Results and Discussion

It revealed (Table-1) that application of 50% Recommended dose of fertilizers (RDF) and kitchen waste manure applied at 25 and 50 days after transplanting (T_{10} treatment) increased the plant height at maximum rate i.e. 66.83 cm at 120 days after transplanting, respectively followed by T_4 (50% RDF + *Azospirillum* application at the time of transplanting) and T_9 (50% RDF + Kitchen waste manure at 25 days of transplanting while, the minimum height was recorded under control plant (T_0). Similarly, Natarajan (1990) also observed that chilli cultivars Local and CA- 42 when inoculated with *Azospirillum* in combination with 75% of recommended nitrogen produced higher plant height (56.13 cm and 57.86 cm, respectively)

It was also observed that T_{10} i.e. treatment with 50% RDF and kitchen waste manure applied at showed the maximum number of branches per plant at 120 days after transplanting (27.81, respectively) followed by T_4 (50% RDF + *Azospirillum* at the time transplanting) as similar trend observed in case of plant height. Seedling treatment with *Azospirillum* and 50% RDF application (T_3) also had a better result to increase the number of branches. The maximum number of leaves were counted under treatment T_{10} (50% RDF and kitchen waste manure 186.50 but, there was a negligible statistical difference among most of the treatments (Table 1). In general, all the treatments increase the number of leaves as compared to the control plants and some of the treatment effect (except T_7) were better than the 100% RDF treatment (T_1). To find out T_{10} treatment (50% RDF and kitchen waste manure showed the maximum average spreading of plant (39.20cm, respectively) at 120 days after transplanting followed by T_4 (50% RDF + *Azospirillum* at the time transplanting) while the minimum average spreading of per plant was recorded under control plant (T_0). Siddesh (2006) also observed that application of *Azospirillum* to chilli plants with 70 kg N per ha produced the higher branches (11.2/plant) respectively .

The observation on flowering revealed that early flowering was initiated by the application of 50% RDF and kitchen waste manure showed (79.30 days from transplanting) followed by 82.30 days in T_4 i.e. 50% RDF + *Azospirillum* at the time transplanting and 84.3 days at T_9 (50% RDF + *Azospirillum*; soil application at transplanting) while the late flowering was recorded under

control plant (T_0). Deshpande *et al.* (2010) also examined and found that the treatment N 125 kg / ha + FYM @ 10 t/ha + *Azospirillum* reported more plant height, number of braches per plant, days to first 50 % flowering, days to first harvest, number of fruits per plant, weight of individual fruit, fruit length, fruit diameter, yield of fresh red fruits, while least values for all above characters were recorded in control (N 150 kg/ha + FYM @ 10 t/ha).

The early flowering also caused early harvesting of green chilli fruits. Plants under T_{10} showed the early harvesting from transplanting (107.67 days) followed by 109.00 days from transplanting date under T_4 (RDF 50% + *Azospirillum* at the time transplanting). Late flowering in control plants lead to late harvesting from transplanting. However, Jeevansab (2000) reported that *Azospirillum* + RDF (150:75:50) took more number of days (37.81 days) to 50 per cent flowering as compared to RDF (36.6) alone in capsicum. But, Sutagundi (2000) reported early flowering (43.66 days) in plants when treated with FYM (10 t/ha) as compared to 100:50:50 kg NPK per ha (43.75 days) in chilli.

Maximum fruit set (96.07%) was recorded under treatment T_{10} followed by T_4 . The significant fruit set increase was observed in all the treated plants a compared to control plants. This increase also reflected in case of number of fruits per plants after 10 harvesting. Control plants showed minimum fruit numbers than the other treatments, Sajan *et al.* (2002) studied the effect of bio-fertilizers combined with different N, P and K fertilizer rates on the growth and yield of chilli cv. Byadagi Dabba. They showed that plants inoculated with *Azotobacter*, *Azospirillum*, PSB and VAM in combination with 75% NPK+100% K recorded 36% more fruits per plant (111.38) and 45% more dry fruit yield (2.27 t/ha) compared to the control (81.68 and 1.56 t/ha, respectively). Similarly, a significant increase on average fruit weight was also observed of physico-chemical qualities of fruits. The application of RDF 50% and kitchen waste manure at 25 and 50 days after transplanting produced fruits with the highest average fruit weight of 3.35g followed by application of RDF 50% and *Azospirillum* as soil application during transplanting (T_4) as well as seedling transplanting (T_3). Mishra and Singh (2005) also noticed that NPK and *Azotobacter* significantly increase in okra, number of fruits, fruit length, fruit width, fruit size, average fruit weight and finally the yield was noted maximum under the treatment (Sewage Sludge @ 2.5 t + $\frac{3}{4}$ NPK + *Azotobacter*).

Maximum fruit thickness of pericarp (1.37 mm) was recorded under treatment T_{10} followed by T_4 . The significant fruit thickness of pericarp increase was observed in all the treated plants a compared to control

Table-1 : Five different Vegetative growth parameters in chilli.

Treatment	Vegetative growth parameters				
	Plant height (cm)	Number of branches	Number of leaves	Average Spreading of plant (cm)	Days required for first flowering after transplanting
T ₀ -Control	51.91	16.67	129.39	27.17	94.7
T ₁ -100% RDF (NPK)	56.02	23.42	167.00	34.77	90.0
T ₂ -RDF50% + <i>Azospirillum</i> (soil application before transplanting)	62.75	24.83	171.67	35.43	86.3
T ₃ -RDF50% + <i>Azospirillum</i> (Seedling treatment)	64.33	26.16	176.92	35.90	86.0
T ₄ -RDF50% + <i>Azospirillum</i> (soil application at transplanting treatment)	64.92	26.79	178.83	38.20	82.3
T ₅ -RDF 50% + <i>Azospirillum</i> (at 25 days after transplanting)	58.75	23.63	153.67	34.93	87.3
T ₆ -RDF50% + <i>Azospirillum</i> (at 25 and 50 days after transplanting)	61.25	24.70	158.25	34.00	88.3
T ₇ -RDF50% + Kitchen waste manure (soil application before transplanting)	59.08	23.80	153.50	34.83	89.0
T ₈ -RDF50% + Kitchen waste manure(at the time of transplanting)	63.00	25.90	174.50	34.40	85.7
T ₉ -RDF50% + Kitchen waste manure (25 days after transplanting)	64.00	26.38	174.58	35.60	84.3
T ₁₀ -RDF50% + Kitchen waste manure (25 and 50 days after transplanting)	66.83	27.81	186.50	39.20	79.3
T ₁₁ -100% Kitchen waste manure (at the time of transplanting)	59.42	23.50	156.08	35.30	86.7
SEm (±)	0.986	0.491	5.417	0.324	1.486
CD (P=0.05)	2.709	1.449	15.990	15.990	4.388

Table-2 : Five different Vegetative growth parameters in chilli.

Treatment	Vegetative growth parameters				
	Days to first harvesting after transplanting in chilli	Fruit set (%)	Individual average fruit weight (g)	Thickness of pericarp (mm)	Days from flowering to harvesting
T ₀ -Control	120.67	80.67	2.11	0.75	26.00
T ₁ -100% RDF (NPK)	118.00	84.12	2.58	0.82	28.00
T ₂ -RDF50% + <i>Azospirillum</i> (soil application before transplanting)	115.33	85.42	2.85	0.93	29.00
T ₃ -RDF50% + <i>Azospirillum</i> (Seedling treatment)	113.33	91.83	2.93	1.17	27.33
T ₄ -RDF50% + <i>Azospirillum</i> (soil application at transplanting treatment)	109.00	92.92	3.18	1.20	26.67
T ₅ -RDF 50% + <i>Azospirillum</i> (at 25 days after transplanting)	116.33	84.92	2.81	0.96	29.00
T ₆ -RDF50% + <i>Azospirillum</i> (at 25 and 50 days after transplanting)	114.67	87.49	2.77	1.02	26.33
T ₇ -RDF50% + kitchen waste manure (soil application before transplanting)	112.67	86.16	2.77	1.05	23.67
T ₈ -RDF50% + kitchen waste manure (at the time of transplanting)	115.00	86.69	2.94	1.05	29.33
T ₉ -RDF50% + kitchen waste manure (25 days after transplanting)	112.00	89.92	2.88	1.06	27.67
T ₁₀ -RDF50% + kitchen waste manure (25 and 50 days after transplanting)	107.67	96.07	3.35	1.37	28.33
T ₁₁ -100% kitchen waste manure (at the time of transplanting)	112.33	88.46	2.79	0.88	25.67
SEm (±)	1.038	0.738	0.036	0.020	1.572
CD (P=0.05)	3.065	2.179	0.107	0.060	NS

plants. According to the study by Gosavi *et al.* (2010) fruit quality parameter of tomato such as pericarp thickness found to be better in the treatment with organic fertilizers in combination bio-fertilizer. The days from flowering to harvesting of green chilli fruits under T₇ (RDF 50% + kitchen waste manure) showed the early from flowering to harvesting (23.67 days) followed by 25.67 days from flowering to harvesting and maximum days from flowering to harvesting of green chilli fruits 29.33 days under T₈ (RDF 50% + kitchen waste manure at the time of transplanting).

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Effect of Silica Enriched Nutrient Management on Growth of Okra

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Abstract

An investigation conducted at open field of Horticulture farm, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur. Rajasthan (India) during two consecutive seasons of 2019 and 2020. The factorial experiment was laid out in split plot design with three replications, assigning Seven levels of silica enriched nutrient management (Control, 25 tonnes FYM/ha + Silica Diatomaceous 2%, RDF + Silica diatomaceous 2%, RDF + 25 tonnes FYM/ha + Silica diatomaceous 2%, RDF + 25 tonnes FYM/ha + Silica diatomaceous 4%, RDF + 25 tonnes FYM/ha + Silica diatomaceous 6% and RDF + 25 tonnes FYM/ha + Silica diatomaceous 8%) and four levels of spray scheduling (Three weeks after sowing, Five weeks after sowing, Seven weeks after sowing and Nine weeks after sowing). The whole field was divided into three blocks each representing a replication and each replication consists of 28 treatments combination. The results showed that silica enriched nutrient management levels significantly improved growth attributes (plant height, number of branches at different growth stages and flower initiation) of okra crop during both the years of investigation. The maximum growth attributes was recorded with RDF + 25 t FYM/ha + silica diatomaceous 8% (F₇) being at par with RDF + 25 t FYM/ha + silica diatomaceous 6% (F₆) and RDF + 25 t FYM/ha + silica diatomaceous 4% (F₅) during first and second year of investigation. Spray scheduling also significantly enhanced growth, yield attributes and yield of okra crop and recorded maximum values with S₁ (three weeks after sowing) being at par with S₂ (five weeks after sowing) during both the years of investigation.

Introduction

Vegetables provide all the nutrient components like carbohydrate, protein, fat, vitamins, minerals and water along with roughages in good quantities which are the essential constituents of a balanced diet. Calorific value of the vegetables is not much in comparison to the cereals and animal products. Vegetables abounding in vitamins and minerals are rightly called as protective foods. Raw vegetables are particularly useful because of many vitamins are water soluble such as vitamin C and compounds of vitamin B complex are not stable at cooking temperatures. Mineral complexes of the products of animal origin create on excess of acid inside the body, which disrupts protective mechanisms and metabolic processes. Vegetables neutralize these substances and provide alkaline medium to neutralize reactions for normal metabolism. Consumption of sufficient quantities of vegetables very much reduces the possibility of cancerous growth in the intestine and colon.

In India, vegetables are grown over an area of 10316 thousand hectares with production of 189.46 million tonnes (Anonymous, 2019-20)^[2]. Among the vegetables, okra (*Abelmoschus esculents* (L.) Moench) is an important vegetable crop of India. It is the most popular vegetable around the world in respect of area, production and availability.

Okra or lady's finger (*Abelmoschus esculentus* L.

Moench), commonly known as bhendi and belongs to the family *Malvaceae*, is a warm season fruit vegetable grown in the tropical and subtropical countries of the world. In India, it is grown over an area of 534 thousand hectare with an annual production of 6371 thousand metric tonnes and least in productivity of 11.93 tonnes per hectare. It shares about 6.1 percent of area and 4.2 percent of total vegetable production under vegetable crops in our country (Anonymous, 2019-20)^[2]. In Rajasthan, it is grown over an area of 173.70 thousand hectare with production of 1877 thousand tonnes and productivity of 10805 kg per hectare. (Anonymous 2019-20)^[2].

Material and Methods

Considering the nature of factors under study and the convenience of agricultural operations, factorial experiment was laid out in split plot design with three replications, assigning Seven levels of silica enriched nutrient management (Control, 25 tonnes FYM/ha + Silica Diatomaceous 2%, RDF + Silica diatomaceous 2%, RDF + 25 tonnes FYM/ha + Silica diatomaceous 2%, RDF + 25 tonnes FYM/ha + Silica diatomaceous 4%, RDF + 25 tonnes FYM/ha + Silica diatomaceous 6% and RDF + 25 tonnes FYM/ha + Silica diatomaceous 8%) and four levels of spray scheduling (Three weeks after sowing, Five weeks after sowing, Seven weeks after sowing and Nine weeks after sowing). The whole field was divided into three blocks each representing a replication and each

Table-1 : Effect of silica enriched nutrient management and spray schedule on plant height of okra at different growth stages.

Treatment	Plant height (cm)								
	30 DAS			60 DAS			90 DAS		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Silica enriched nutrient management									
F ₁	25.59	26.17	25.88	56.40	57.15	56.78	91.20	93.28	92.24
F ₂	26.87	27.11	26.99	58.54	59.07	58.81	94.97	97.50	96.24
F ₃	27.91	27.81	27.86	61.39	61.26	61.32	98.60	100.09	99.34
F ₄	29.21	28.77	28.99	63.33	63.29	63.31	101.99	104.40	103.20
F ₅	30.29	30.06	30.17	66.94	66.48	66.71	107.41	110.27	108.84
F ₆	31.15	31.05	31.10	68.68	68.96	68.82	109.58	112.30	110.94
F ₇	31.88	31.25	31.56	71.21	69.95	70.58	111.28	113.92	112.60
SE m±	1.14	1.04	0.84	1.33	1.03	1.10	2.60	3.22	2.51
CD (P=0.05)	3.50	3.20	2.60	4.09	3.18	3.40	8.01	9.92	7.74
Spray Scheduling									
S ₁	30.58	31.33	30.95	67.68	67.50	67.59	106.40	108.56	107.48
S ₂	29.45	28.99	29.22	66.55	65.96	66.26	106.45	108.83	107.64
S ₃	28.66	28.16	28.41	65.00	65.04	65.02	105.39	108.44	106.91
S ₄	27.26	27.07	27.17	55.91	56.44	56.18	90.35	92.32	91.34
SE m±	0.84	1.10	0.90	0.81	0.70	0.71	1.76	1.54	1.32
CD (P=0.05)	NS	NS	2.57	2.32	1.99	2.01	5.02	4.38	3.76
F x S	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table-2 : Effect of silica enriched nutrient management and spray schedule on number of branches/plant of okra at different growth stages.

Treatment	Number of branches/plant								
	30 DAS			60 DAS			90 DAS		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Silica enriched nutrient management									
F ₁	1.56	1.52	1.54	3.88	3.90	3.89	4.24	4.25	4.24
F ₂	1.59	1.61	1.60	4.04	4.08	4.06	4.39	4.43	4.41
F ₃	1.75	1.76	1.76	4.21	4.25	4.23	4.57	4.61	4.59
F ₄	1.90	1.93	1.92	4.39	4.43	4.41	4.75	4.79	4.77
F ₅	2.10	2.12	2.11	4.61	4.65	4.63	5.00	5.04	5.02
F ₆	2.22	2.22	2.22	4.74	4.78	4.76	5.13	5.17	5.15
F ₇	2.32	2.34	2.33	4.85	4.89	4.87	5.24	5.29	5.26
SE m±	0.19	0.30	0.19	0.08	0.07	0.07	0.08	0.07	0.07
CD (P=0.05)	NS	NS	NS	0.25	0.22	0.21	0.24	0.23	0.22
Spray Scheduling									
S ₁	2.18	2.11	2.15	4.70	4.69	4.69	5.03	5.04	5.04
S ₂	2.09	1.97	2.03	4.59	4.62	4.61	4.96	5.02	4.99
S ₃	1.98	1.86	1.92	4.47	4.57	4.52	4.90	4.94	4.92
S ₄	1.43	1.78	1.60	3.79	3.83	3.81	4.15	4.18	4.16
SE m±	0.21	0.19	0.15	0.03	0.03	0.03	0.04	0.03	0.02
CD (P=0.05)	NS	NS	NS	0.09	0.08	0.07	0.11	0.07	0.07
F x S	NS	NS	NS	NS	NS	NS	NS	NS	NS

replication consists of 28 treatments combination. All the treatment combinations were allotted to each replication randomly by following the principles of randomization and the whole set-up was repeated during the 2nd year to confirm the results.

Results and Discussion

Growth is the irreversible process occurs by cell division and cell elongation which led to increases in plant

biomass, weight and size of leaves and stems. Various growths attributes like plant height, number of branches per plant, flower initiation, number of flower per plant and dry matter accumulation which in turn, collectively determine the productivity of the crop.

The effect of silica enriched nutrient management on plant height, number of branches per plant at all growth stages, flower initiation and number of flowers per plant was significant during both the year of investigation and in

Table-3 : Effect of silica enriched nutrient management and spray schedule on flower initiation and number of flower/plant of okra.

Treatment	Flower initiation (DAS)			Number of flower/plant		
	2019	2020	Pooled	2019	2020	Pooled
Silica enriched nutrient management						
F ₁	43.48	40.25	41.87	26.69	31.01	28.85
F ₂	43.54	40.45	42.00	27.34	31.89	29.62
F ₃	42.40	38.94	40.67	28.10	32.81	30.46
F ₄	41.90	39.17	40.54	28.87	33.74	31.30
F ₅	42.42	38.66	40.54	29.93	35.03	32.48
F ₆	42.05	38.77	40.41	30.50	35.71	33.10
F ₇	42.17	38.88	40.52	30.99	36.32	33.66
SE m±	0.55	0.93	0.55	0.93	0.54	0.68
CD (P=0.05)	NS	NS	NS	2.86	1.68	2.08
Spray Scheduling						
S ₁	43.19	39.52	41.36	29.81	34.88	32.34
S ₂	42.77	39.11	40.94	29.89	34.92	32.40
S ₃	42.48	39.26	40.87	29.66	34.75	32.20
S ₄	41.83	39.32	40.58	26.32	30.61	28.46
SE m±	0.57	0.76	0.56	0.53	0.32	0.31
CD (P=0.05)	NS	NS	NS	1.53	0.91	0.89
F x S	NS	NS	NS	NS	NS	NS

pooled analysis (Table 4.1 and 4.2) The tallest plant and maximum number of branches per plant were recorded at 30, 60 and 90 DAS during first and second year with the application of RDF + 25 tonnes FYM/ha + Silica Diatomaceous 8% (F₇). However, similar trend in plant height and number of branches per plant of okra at all growth stages was also noted with the application of RDF + 25 tonnes FYM/ha + Silica Diatomaceous 8% in pooled analysis. This might be due to integrated nutrient management by use of fertilizers, farm yard manures and spray of silica diatomaceous earth improved the chemical, physical and biological properties of soil which lead to higher growth of roots which might have resulted in increased absorption and efficient translocation of nutrients towards plant system during vegetative growth. Nitrogen, phosphorus and potassium contained in the inorganic fertilizer have great effects in plant growth and development. It would be relevant to recall here that increased nutrient fixation by recommended use of fertilizers, farm yard manures and spray of silica diatomaceous earth have the ability of enhancing available nutrient content in soil thereby increased nutrient supply to plant and resulted in higher growth, improved morphological development of plant and more dry matter partitioning. This result is confirmed by Gowda *et al.* (2015)^[5], Pozo *et al.* (2015)^[8], Pati *et al.* (2016)^[9], Cuong *et al.* (2017)^[4], Alam *et al.* (2019)^[1], Vashi *et al.* (2019a)^[10] and Mahendran *et al.* (2021)^[7].

Early flower initiation in okra was started with the application of recommended dose of fertilizer (RDF) + 25 tonnes FYM/ha + Silica Diatomaceous 8% (F₇) during

both the year of investigation and in pooled analysis. Maximum number of flowers per plant in okra was recorded with the application of application of recommended dose of fertilizer (RDF) + 25 tonnes FYM/ha + Silica Diatomaceous 8% (F₇) during both the year of investigation and in pooled analysis (Table 4.3). This might be due to rapid growth and development of plant cells due to adequate availability of nutrients to growing plants and favourable environmental condition. The increased availability of photosynthetes might have increased the number of flower and better fertilization resulted in higher number of fruits per plant. Due to adequate supply of nutrients, it also increased various metabolic processes that improve better mobilization of synthesized carbohydrates in to amino acid and protein, rapid cell division and cell elongation and rapid phenological development. The similar finding was also reported by Mahendran *et al.* (2021)^[7].

Spray scheduling showed favourable effect on growth parameters viz. plant height, number of branches per plant, flower initiation and number of flower per plant at different growth stages during both years of experimentation. Scrutiny of the data (Table 4.1 to 4.3) revealed that spray scheduling significantly influenced plant height at 30, 60 and 90 DAS and number of branches per plant at 60-90 DAS but each spray scheduling treatments were at par with each other during both year of investigation except spray scheduling at nine week after sowing. However, plant height and number of branches continued to increase with advancement in age but rapid increase was recorded between 60-90 DAS.

Spray scheduling of S_1 (three week after sowing), S_2 (five week after sowing) and S_3 (seven week after sowing) was at par to each other but significant over S_4 (nine week after sowing) during both the years and in pooled analysis in respect to plant height and number of flower per plant. The improvement in growth characters might be due to fast and adequate availability of nutrients in plant systems. The fast growth of plant height and more number of branches between 60-90 DAS might be due to favourable nutrient, water and environmental balance at vegetative growth stages that resulted enhanced the photosynthetic rate, more cell division, enlargement and rapid cell elongation, which ultimately results in better crop growth and development (Mandal *et al.*, 2009)^[6]. Silicon nutrition increased the source and sink strength and might have possible to provide resistant against disease and insects, through which leaf become healthier and increased the number of branches (Chen *et al.*, 2011)^[3].

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Effect of Drip Irrigation and Standardization of Fertilizer Dose on Yield and Nutrient Uptake of Mentha (*Mentha arvensis*) Crop

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Abstract

The field experiment was conducted at the Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), India during the spring season, to assess the impact of scheduling of drip irrigation and NPK levels on mentha crop of Nutrient content and Nutrient uptake and Dry matter. The experiment was laid out in RBD (Factorial) with one control treatment having three replications. The treatments consisted of three levels of drip irrigation scheduling based on cumulative pan evaporation (CPE) loss and three levels of fertilizer doses with one control as a conventional flood. Maximum N content in Irrigation was recorded at 100% CPE (1.79%), the NPK levels, 125% dose showed (1.97) significantly higher. Maximum P content in mint plant did not differ significantly in irrigation. Maximum P (0.46) content in NPK dose was recorded at 125 % CEP level. K content in plant at harvesting stage it was non- significant for the drip irrigation and NPK dose. Drip irrigation (Drip irrigation level (CPE) with 125% recorded maximum N uptake 85.80 kg/ ha and NPK recorded the maximum N uptake (97.1 N kg/ha). Drip irrigation with 125% recorded maximum P uptake 22.30 kg/ ha and NPK recorded the maximum P uptake (24.80 N kg/ha). K uptake increased significantly with increase in the depth of irrigation and it was found (65.50 kg/ ha), the maximum at 125% CPE level. Mentha fertilized with 125% NPK level produced the maximum K uptake 70.40 kg/ha. All the drip irrigation levels and NPK dose on accumulated higher dry matter of mint crop.

Key words : Drip irrigation, fertilizer dose, dry matter, nutrient content and uptake.

Introduction

Mentha, an aromatic perennial herb, belongs to the family Lamiaceae. Among the 40 mint species, *Japanese* mint (*Mentha arvensis* L.), peppermint (*Mentha piperita* L.), bergamot mint (*Mentha citrata* E.), and spearmint (*Mentha spicata* L.) are commercially cultivated in India. *Japanese* mint (*Mentha arvensis* L.) accounts for more than 80 per cent of total area. It is one of the most extensively cultivated mint species all over the world due to its high menthol content. It is a rich source of natural menthol as well as other ingredients such as mint terpenes, menthone, isomenthone and menthyl acetate, which are extensively used in pharmaceutical, cosmetic, food, and flavor industries.

Herbage is the harvestable product of mint thus irrigation and fertilization are the key inputs for securing optimum productivity and quality. Mint requires 10-12 irrigations depending on soil texture and weather conditions during the crop growing period. It is a shallow rooted crop and its active growth period coincides with pre- monsoon hot summer months, higher soil and air temperatures are high leading to high ET. Mint being a leafy herb, responds to frequent irrigations during dry season months (Shormin *et al.*, 2009). The favourable effects of irrigation in enhancing herb and essential oil

yield of various mint species have also been reported by (Ram *et al.* (1995). Conventionally, mint is irrigated through surface flood method having low water use efficiency (30-40 per cent). Both excess as well as suboptimal soil moisture conditions decrease the growth, herb and oil yield of mint crop (Shormin *et al.*, 2009). Stress reduces plant biomass including plant height and leaf area, its lateral spread and dry matter accumulation. Water stress impairs numerous metabolic and physiological processes in plants such as nutrient uptake and their transport (Mengel and Kirkby, 1996). Hence, maintaining adequate soil moisture is essential to minimize the adverse effect of moisture stress, which can be achieved through proper monitoring and scheduling of irrigation. Water has been and would be the most precious input for sustainable yields and higher efficiency of other inputs

Mint is a heavy feeder of nutrients and removes substantial quantities of N, P and K (Patra *et al.*, 2002). Adequate supply of nutrients increased herbage and oil yields due to production of taller plants, more branches and leaves, superior leaf- stem ratio and increased dry matter (Li and Zhang, 2003). Among various nutrients, nitrogen is the most effective and important nutrient, which regulates vegetative growth, herbage and oil yields. It is the essential component of cell molecules including

chlorophyll, nucleic acids, amino acids, ATP and a number of plant hormones. Behera *et al.* (2015) observed significant increase in herbage and oil yields due to N application in *Japanese mint*.

Phosphorus is a nutrient largely used in energy transfer processes in cells, mainly as a component of ATP. Adequate P fertilization in mint helps in ramification of the root system which increased the number of suckers in plants (Rehman *et al.*, 2003) and finally enhanced the herbage and oil yields. Behera *et al.* (2014) observed the maximum herbage (35,798 kg ha⁻¹) and oil yields (260 kg ha⁻¹) of mint with 100% NPK application. Mint also has a constant growing demand for potassium during the growing season (Brown *et al.*, 2003). Potassium is known to play an essential role in enzyme activation, protein synthesis, photosynthesis, osmo-regulation, stomatal opening, energy transfer, cation-anion balance and stress resistance (Marshner, 2012).

Materials and Methods

The field experiment was conducted at the Norman E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, district U.S. Nagar (Uttarakhand) during spring season of 2017. Geographically, Pantnagar is situated at the foot hills of Himalayas at 29° North latitude and 79.5° East longitude and at an altitude of 243.83 m above mean sea level.

Cultural Operations

Land preparation : The field was prepared by two cross harrowings and one planking with the tractor mounted disc harrow. Thereafter, the field was leveled with leveler and layout was done.

Seed treatment and planting : Disease free healthy suckers were used for mint planting. Furrows were opened manually 40 cm apart. The suckers (4-5 cm length) @ 2 q/ha were placed in end to end fashion at a depth of 4 to 5 cm in furrows and covered immediately with fine loose soil. For seed treatment, suckers were treated with the mixture of Copper oxychloride and Thiram (2 g + 1 g/ kg of suckers) before planting.

Drip installation : Drip laterals were installed in the field immediately after planting along the mint rows. Laterals were spaced at 40 cm row spacing.

Treatment execution

Weed control : Pendimethaline @ 3.33 l/ha was applied as pre emergence to control the weeds. One manual weeding was also done at 26 days after planting to remove the left over weeds.

Insect pest control : The mint crop experienced a minor attack of shoot borer which was controlled by the

application of Nuvan 76 SC @ 0.5 litre/ ha (380 g a.i./ ha) at 40 DAP.

Harvesting : The crop was harvested manually with a sickle by cutting at 5 cm above the ground level on 25th May, 2017 when lower leaves of the plant turned yellow and started shedding. After removing the border area, the individual net plot area (4.6 m²) area was harvested.

Observation

Nutrient content

Nutrient uptake

Dry matter accumulation

Variety : For mint cultivation, CIM Kranti, a high oil yielding variety was used. This variety has been developed through intensive selection at CIMAP. It has potential to produce 2.74 t/ha of herb with 0.84-1.0 % oil and the average oil yield is 265-290 kg/ha (CSIR Annual Report, 2009-10). Its oil contains 79-80% menthol.

Results and Discussion

Nitrogen content in plant : Maximum N content was recorded at 100% CPE (1.79%) and the respective values at 75% CPE level and 125% CPE level were 1.59 and 1.67 per cent, respectively. Drip irrigation showed numerically higher N content as compared to flood irrigation. Plots fertilized with 75, 100 and 125% recommended dose of fertilizer showed significant differences for content of N in plant at harvest stage. Higher dose of fertilizer (125% NPK level) had significantly higher nitrogen content than 75% and 100% NPK dose.

Phosphorus content in plant : Maximum P content in mint plant did not differ significantly due to irrigation levels at harvest stage. At this stage, drip irrigation regime had significantly higher P content than conventional flood irrigated mint. Among the drip regime 125% CPE (0.44) level has numerically higher than the 75% (0.39) CPE level.

Fertilizer dose had significant variation in P content at harvest stage. Across the NPK levels, 125% dose showed significantly higher value of P than 75% but remained statistically with 100% NPK.

Potassium content in plant : K content in plant at harvesting stage it was non-significant for the drip irrigation regimes. The 125 and 100% CPE possessed numerically higher K content than the irrigation level of 75% CPE, whereas, 125% CPE and 100% CPE had equal K content. Drip irrigated mint treatments had numerically higher values than the control (Flood, IW:CPE 1.2). Fertilizer levels did not show significant variation in content.

Nitrogen uptake by mint : Irrigation scheduling exerted significant effect on N uptake by menthol mint. Nitrogen

Table-1 : Effect of drip irrigation levels and NPK dose on NPK content in mint at harvest stage.

Treatment	Nutrient content		
	Nitrogen	Phosphorus	Potassium
Drip irrigation level (CPE)			
75% CPE	1.59	0.39	1.23
100% CPE	1.79	0.44	1.29
125% CPE	1.67	0.44	1.29
SEm ±	0.011	0.014	0.027
CD (5%)	0.03	NS	NS
N:P₂O₅:K₂O dose (100:60:40 kg/ha)			
75% NPK	1.63	0.37	1.26
100% NPK	1.62	0.43	1.32
125% NPK	1.79	0.46	1.29
SEm ±	0.011	0.014	0.027
CD (5%)	0.03	0.04	NS
Control			
Flood (1.0 IW:CPE ratios)	1.54	0.32	1.19

Table-2 : Mint NPK uptake under different drip irrigation and NPK levels.

Treatment	NPK uptake (kg/ha)		
	Nitrogen	Phosphorus	Potassium
Drip irrigation level (CPE)			
75%	63.3	16.1	49.4
100%	84.5	20.8	61.1
125%	85.8	22.3	65.5
SEm ±	2.6	0.8	2.6
CD at 5%	7.9	2.4	7.8
N:P₂O₅:K₂O dose (100:60:40 kg/ha)			
75%	63.3	14.7	47.5
100%	73.2	19.7	58.1
125%	97.1	24.8	70.4
SEm ±	2.6	0.8	2.6
CD at 5%	7.9	2.4	7.8
Control			
Flood (1.2 IW:CPE)	45.5	9.7	35.5

uptake showed an increasing trend with increase level of irrigation being the maximum at 125% CPE drip irrigation level. Flood irrigated mint crop recorded the lowest N uptake (45 kg/ha). The lowest N uptake was due to lower irrigation schedule resulted in lower fresh herb yield, which ultimately led to a decrease in uptake of nitrogen. Drip irrigation at 125% level recorded the maximum N uptake but it was comparable with 100% CPE level. Former treatment recorded significantly higher N uptake than 75% CPE level.

The N uptake is the function of fresh herbage yield and its N content. Higher moisture in the soil resulted in increase uptake due to better plant growth in terms of plant height, more stool count, fresh herbage yield at higher irrigation level ultimately resulted in higher N uptake. Behera *et al.* (2015) also reported significantly higher uptake of nitrogen at 100% PE than at 80% and 60% PE.

Increase in fertilizer dose from 75% to 125% NPK resulted in significant improvement in N uptake. Drip irrigation with 125% NPK recorded the maximum N uptake (97.1 N kg/ha). Its N uptake was significantly higher than 75% and 100% NPK levels with a difference of 34.8 and 24.6%, respectively. Mint fertigated with 100% NPK levels recorded 9.9% higher N uptake than 75% NPK levels. Higher mint N uptake with higher doses of NPK was due to its higher herbage yield as well as its higher N content. Ram *et al.* (2006) also reported significantly higher uptake of nitrogen with 200 kg N/ha than 0 & 100 kg N/ha.

Phosphorus uptake by mint crop : Mint grown with the drip irrigation produced higher K uptake than flood irrigated mint crop irrespective of its levels. Among the drip irrigation levels, P uptake increased significantly with increase in the depth of irrigation and it was found the maximum at 125% CPE level. Drip irrigation in mentha at

Table-3 : Dry matter accumulation in mint under different drip irrigation and NPK levels.

Treatment	Dry matter (g/m ²)		
	60 DAP	80 DAP	At harvest
Drip irrigation level (CPE)			
75%	179.6	399.8	894.7
100%	205.7	471.3	1221.9
125%	226.8	508.9	1720.8
SEm ±	7.5	16.4	10.7
CD at 5%	22.8	49.7	32.4
N:P₂O₅:K₂O dose (100:60:40 kg/ha)			
75%	178.2	178.2	961.9
100%	200.3	200.3	1309.1
125%	233.6	233.6	1566.4
SEm ±	7.5	16.4	10.7
CD at 5%	22.8	49.7	32.4
Control			
Flood (1.2 IW:CPE)	155.8	298.0	983.8

125% CPE level recorded 27.8% higher P uptake than 75% CPE level of irrigation and at par with 100% CPE level. Irrigation schedule of 100% also produced 22.6% higher P uptake than 75% CPE level with a significant difference. Actually the crop subjected to lower moisture regimes was incapable of fully exploiting the nutrient applied in the top soil. Further, under better moisture regime, more mass flow and diffusion movement may be the cause of its better P uptake. Phosphorus uptake also exhibited increasing trend with the increasing NPK dose. Mentha fertilized with 125% NPK level produced the maximum P uptake 24.8 kg/ha. It was significantly superior to 75 and 100% NPK levels.

Potassium uptake by mint crop : The highest K uptake was received from the 125% CPE drip irrigation level. It extract 45.8% higher K than flood irrigated mint crop because of higher mint fresh herbage yield. Among the drip irrigation levels, at 125% CPE drip level K uptake was 24.6% more than 75% CPE level and at par with the 100% CPE level. Among the nutrient schedules, 125% of NPK dose provided the maximum K uptake (70.4 kg K /ha) and it declined significantly with reduction in the NPK dose. Higher potassium uptake at higher drip irrigation and NPK levels was because of higher fresh herbage yield, under this treatment.

Dry matter : Among the drip irrigation levels, mint irrigated with 125% CPE accumulated the maximum dry matter at all the crop growth stages. At harvest, it was significantly higher than 75 and 100% CPE levels with a difference of 48.0 and 28.9%, respectively. Higher dry matter accumulation at 125% CPE level was due to better plant growth in terms of plant height and number of leaves. Lower dry matter under more water stressed environment i.e. at 75% CPE level might be due to higher leaf temperature (due to low soil moisture and high ET) which

enhanced respiration and decreased net assimilation rate resulting in low accumulation of dry matter.

All the drip irrigation levels accumulated higher dry matter than mint crop irrigated with flood method except at harvest, when dry matter at 75% CPE level was lower as compared to conventional method. Saxena and Singh (1998) at Pantnagar observed that irrigation scheduled at CPE 50 mm produced 5.5 and 9.9% higher dry matter than CPE 100 and 150 mm, respectively.

Different NPK levels significantly influenced the dry matter at harvest only. Crop fertilized with 125% NPK dose recorded significantly higher value of dry matter than the 75 and 100% NPK levels. More dry matter accumulation under high dose of fertilizer was the result of better plant growth under these treatments owing to more availability of nutrient as evident by better plant height and leaf area under these treatments. This increase in the LAI in turn resulted in higher dry matter accumulation in leaves. Ram *et al.* (2006) at CIMAP, Lucknow observed that dry matter accumulation were significantly influenced by application of N and produced significantly higher dry matter at 200 Kg N/ha compared to control (0 kg N/ha).

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Health Benefits of Lutein

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Abstract

Lutein is a yellow pigment of carotenoid family. Lutein is synthesized only by plants and is found in high quantities in green leafy vegetables such as spinach, kale and yellow carrots. In green plants, xanthophylls act to modulate light energy and serve as non-photochemical quenching agents to deal with triplet chlorophyll. The human body cannot synthesize lutein or another vision boosting antioxidant, zeaxanthin, on its own, so these nutrients must be obtained through diet. Of the 600 carotenoids found in nature, lutein and zeaxanthin are the only two that the body sends to the macular portion of the eyes, where they fight free radical damage that can lead to macular degeneration and cataracts.

Key words : Lutein, health, benefits.

Introduction

The word Lutein derived from Latin word *luteus* meaning “yellow”. Lutein is a yellow pigment of carotenoid family. Lutein is synthesized only by plants and is found in high quantities in green leafy vegetables such as spinach, kale and yellow carrots. In green plants, xanthophylls act to modulate light energy and serve as non-photochemical quenching agents to deal with triplet chlorophyll (an excited form of chlorophyll), which is overproduced at very high light levels, during photosynthesis. Egg yolk and maize (corn) contained the highest mole percentage (% of total) of lutein and zeaxanthin (more than 85% of the total carotenoids). Maize was the vegetable with the highest quantity of lutein (60% of total) and orange pepper was the vegetable with the highest amount of zeaxanthin (37% of total). Substantial amounts of lutein and zeaxanthin (30-50%) were also present in kiwi fruit, grapes, spinach, orange juice, zucchini (or vegetable marrow), and different kinds of squash (Sommerburg *et al.*, 1998). The flower Marigold (*Tagetes Erecta* L.) also represents a rich source of lutein. Dried Marigold flowers contain 0.1 -0.2 % dry matter (DM) of carotenoids, out of which 80% are lutein diesters (Miroslav *et al.* 2014). The human body cannot synthesize lutein or zeaxanthin on its own, which means we must obtain these important nutrients from our diet (or in some cases, supplements). In plants, Lutein is present either in the form of free lutein or in the form of esters with fatty acids (Khachik *et al.* 1986; Breithaupt & Bamedi 2001 and Calvo 2005). Where lutein is present in plants as fatty-acid esters, with one or two fatty acids bound to the two hydroxyl-groups, saponification (de-esterification) of lutein esters to yield free lutein may yield lutein in any ratio from 1:1 to 1:2 molar ratio with the saponifying fatty acid.

Absorption and Metabolism : Mammalians are not able to synthesize carotenoids which therefore need to be introduced with food (Eroglu *et al.*, 2013). Once consumed, lutein is absorbed by the mucosa of the small bowel and bound to chylomicrons, then, it is secreted into lymph and reaches the liver (Parker 1996). In hepatocytes, lutein is incorporated into lipoproteins that are distributed to peripheral tissues (Clevidence 1993), particularly the retina, where the highest concentrations have been demonstrated. Lutein being fat soluble the dietary content of lipids mediates lutein absorption through its incorporation into micelles (Unlu *et al.* 2005), and several dietary factors may compete.

Dietary fat is important for the absorption of xanthophyll carotenoids like lutein and zeaxanthin. Fat stimulates bile flow from the gall bladder to emulsify fat-soluble vitamins into lipid micelles – microscopic fat droplets – so they can be absorbed in the small intestine. Inadequate fat intake can result in reduced absorption of carotenoids, even if the diet is carotenoid rich. On the other hand, some competition for absorption is observed when similar structured carotenoids like beta-carotene and lutein are consumed together. (Loane E, *et al.* 2008). A diet rich in fiber has been reported to reduce carotenoid serum levels (Rock and Swendseid 1992, Riedl *et al.* 1999), also affecting lutein absorption. The content of iron and zinc as well as protein deficiency may affect lutein absorption (Williams *et al.* 1998).

Mechanisms of Action : The macular region of the primate retina is yellow in color due to the presence of the macular pigment, composed of two dietary xanthophylls,

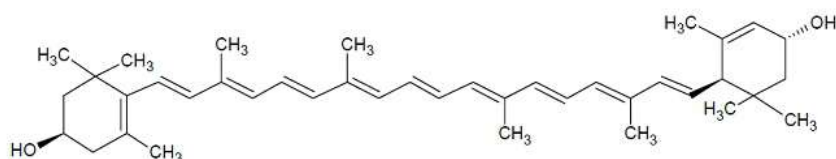


Figure 1. Structural formula of lutein

Some foods are considered good sources of the nutrients: (SanGiovanni et al., Niizu et al., USDA Database)

Product	Lutein/zeaxanthin (mg/100g)
Nasturtium (Yellow flowers, Lutein levels only)	45,000 [28]
Kale (Raw)	39,550
Kale (Cooked)	18,246
Dandelion Leaves (Raw)	13,610
Nasturtium (Leaves, Lutein Levels Only)	13,600 [28]
Turnip Greens (Raw)	12,825
Spinach (Raw)	12,198
Spinach (Cooked)	11,308
Swiss Chard (Raw Or Cooked)	11,000
pararsid11038589 Turnip Greens (Cooked)	8440
Collard Greens (Cooked)	7694
Watercress (Raw)	5767
Garden Peas (Raw)	2593
Romaine Lettuce	2312
Zucchini	2125
Brussels Sprouts	1590
Pistachio Nuts	1205
Broccoli	1121
Carrot (Cooked)	687
Maize/Corn	642
Egg (Hard Boiled)	353
Avocado (Raw)	271
Carrot (Raw)	256
Kiwifruit	122

lutein and zeaxanthin, and another xanthophyll, meso-zeaxanthin. The latter is presumably formed from either lutein or zeaxanthin in the retina. By absorbing blue-light, the macular pigment protects the underlying photoreceptor cell layer from light damage, possibly initiated by the formation of reactive oxygen species during a photosensitized reaction. There is ample epidemiological evidence that the amount of macular pigment is inversely associated with the incidence of age-related macular degeneration, an irreversible process that is the major cause of blindness in the elderly. The macular pigment can be increased in primates by either increasing the intake of foods that are rich in lutein and zeaxanthin, such as dark-green leafy vegetables, or by supplementation with lutein or zeaxanthin. Although increasing the intake of lutein or zeaxanthin might prove to be protective against the development of age-related macular degeneration, a causative relationship has yet to be experimentally demonstrated. (Norman 2003)

Both animal and in vitro studies demonstrated that some carotenoids are compounds with antioxidant activity (Fiedor and Burda 2014, Young and Lowe 2001). Lutein

has been demonstrated to exert an extremely potent antioxidant action by quenching singlet oxygen and scavenging free radicals (Kim *et al.*, 2006). Another protective effect of lutein consists in the ability of filtering blue light, thus reducing phototoxic damage to photoreceptor cells (Junghans *et al.* 2001). Notably, several studies have observed that lutein inhibits both the pro-inflammatory cytokine cascade (Chung *et al.* 2017). Through all these mechanism(s), it is quite conceivable that lutein may exert a key role in regulating immune pathways, modulating inflammatory responses, and reducing oxidative damage.

Lutein Intake : Lutein is naturally abundant and available in fruit, cereals, and vegetables, and it is also present in egg yolk (Perry *et al.*, 2009), where its bioavailability is higher than in any other food (Chung *et al.*, 2004). Interestingly, the highest lutein intake was reported in Pacific countries, where individuals consume a diet extremely rich in fruit and vegetables, reaching the peak of about 25 mg/d in the Fiji Islands (Augood *et al.*, 2006). Currently, there are no established upper limits for lutein and zeaxanthin intake neither for adults nor for pregnant

women. A systematic risk assessment of lutein supplements in placebo-controlled intervention trials indicate that lutein is safe up to 20 mg/day; however these levels are not sufficient to draw confident conclusions on long-term safety (Omenn *et al.*, 1996). Some positive health effects have been seen at dietary intake levels of 6–10 mg/day (Moukarzel *et al.*, 2009). The only definitive side effect of excess lutein consumption is bronzing of the skin (carotenodermia).

Benefits of Lutein

Protects Against Eye Disorders Like Macular Degeneration : Lutein is considered a natural treatment for macular degeneration (AMD), which is considered the most common cause of blindness among older adults. Estimates show that more than 25 million people worldwide are affected by age-related macular degeneration or cataracts, especially people aged 55 and older living in industrialized Western nations. Several studies show that an increase in macula pigmentation decreases the risk for eye diseases such as age-related macular degeneration (AMD). (Richer, 1999., Richer *et al.*, 2004., Age-Related Eye Disease Study Research Group (2001).

Lutein protects the eyes by filtering out a percentage of damaging short-wavelength UV light that negatively affects delicate parts of the eyes such as the retina (the macula). Researchers at Harvard University have found that supplementing with 6 milligrams daily of lutein can lower the risk for macular degeneration by an average of 43 percent.

Lowers the risk of cataract development : There is also epidemiological evidence that increasing lutein and zeaxanthin intake lowers the risk of cataract development (San Giovanni *et al.* 2007.). Consumption of more than 2.4 mg of lutein/zeaxanthin daily from foods and supplements was significantly correlated with reduced incidence of nuclear lens opacities, as revealed from data collected during a 13- to 15-year period in the Nutrition and Vision Project (NVP) (Barke, 2010)

Two meta-analyses confirm a correlation between high diet content or high serum concentrations of lutein and zeaxanthin and a decrease in the risk of nuclear cataract, but not cortical or subcapsular cataract (Liu *et al.* 2014., Ma *et al.* 2014). While the research is still in its early stages, taking lutein three times weekly for up to two years has been shown to improve vision in older people who already have cataracts.

Helps Protect Skin Health : In addition to being found within the pigments of our eyes, carotenoids including lutein and zeaxanthin are also present within the skin. To preserve skin health and fight skin cancer, lutein helps

filter high-energy wavelengths of visible light, which slows down the rate of oxidative stress. Some animal studies show evidence that lutein offers significant protection against light-induced skin damage, such as signs of aging and potentially skin cancer.

Can Help Lower Diabetes Risk : According to some animal studies, higher levels of lutein and other carotenoids within the blood are linked with fewer problems controlling blood sugar and a lower risk for diabetes or related complications. A 2000 study conducted on diabetic rats found that supplementing with lutein and DHA (a crucial type of omega-3 fatty acid) helped normalize all diabetes-induced biochemical modifications.

Might Help Lower Risk of Cancer : Some evidence shows that people who obtain more lutein from their diet experience lower rates of breast, colon, cervical and lung cancers. While we don't know exactly how lutein and cancer formation is tied just yet, correlational studies have shown that adults with higher levels of lutein in the blood experience a reduced risk of developing several forms of common cancers.

Lutein may act as a natural cancer treatment because of the fact that foods rich in lutein (like leafy greens and citrus fruits) also provide other beneficial antioxidants and nutrients that lower disease-causing inflammation and oxidative stress. However, at this time, more research is still needed to help us fully understand the effects of lutein and other carotenoids on cancer, immune, hormonal and cardiovascular health, independent of other nutrients that are found in fruits and vegetables.

Can Help Maintain Heart Health : Some observational studies show that xanthophyll carotenoids including lutein can help reduce the risk of developing heart disease and stroke. Just like with the previously mentioned studies that show potential cancer-protective effects of lutein, we aren't exactly sure yet how lutein improves heart health. Because lutein has anti-inflammatory and antioxidant properties, it seems that it would benefit heart health by lowering inflammation, which is an underlying cause of coronary heart disease.

Mammalian development : Evidence has recently supported the role of lutein and zeaxanthin also in mammalian development, specifically in relationship to their potential protective activity on infant retinal and brain development and functions. It remains to be established whether or not these are the only body sites where accumulation of xanthophylls may be beneficial to the developing fetus and rapidly growing infant. Most of the human data derive from observational studies that are generally complicated by a number of variables, which

have an impact on carotenoid and metabolites in serum and tissues (Elena and Loredana, 2018). Higher maternal lutein and zeaxanthin intake during pregnancy was associated with better offspring verbal intelligence and behavior regulation ability in mid-childhood, suggesting a potential benefit during prenatal development. (Hiya , 2021)

Industrial uses of lutein

Food, beverage and Pharmaceuticals : The natural pigment is widely used in food as feed additives, cosmetic and pharmaceutical industry.

Cosmetics : The oil may be added to perfumes to infuse an apple scent into them. It is also used in washing the skin.

Coloring agent : It is used as a yellow dyeing agent.

Culinary : In salads and other foods to add colour and flavour in them.

Animal Feed : Finds application as poultry feed to ensure a good colouration of egg yolks and broiler skin.

Conclusions

The most recent data available from the WHO estimate that 285 million people in the world are visually-impaired while 39 million are legally blind (Pascolini and Mariotti, 2012). Several studies have suggested that lutein and zeaxanthin play critical roles in delaying the onset and reducing the risk of cataract and age-related macular degeneration (AMD), both of which are responsible for 56% of all cases of blindness globally (Bone *et al.*, 2007, Bone and Landrum, 2010, Ma *et al.*, 2012b, Murray *et al.*, 2013, Pascolini and Mariotti, 2012).

Since 80% of all visual impairments are avoidable or curable, it has become pertinent to undertake a comprehensive review of the contributions of dietary lutein and zeaxanthin to visual health with a view to highlighting the position of these xanthophylls as critical players in reducing the incidence of ocular abnormalities. It is found in brightly colored foods like fruits and vegetables. The human body cannot synthesize lutein or another vision boosting antioxidant, zeaxanthin, on its own, so these nutrients must be obtained through diet. Of the 600 carotenoids found in nature, lutein and zeaxanthin are the only two that the body sends to the macular portion of the eyes, where they fight free radical damage that can lead to macular degeneration and cataracts.

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Optimizing Different Cow Urine Rates at Various Fertility and Zinc Levels on Growth, Yield and Economics of Wheat (*Triticum aestivum* L.) under Dairy Based Integrated Farming System in Varanasi Tract

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Abstract

The field investigation was carried out at the Agricultural Research Farm, Banaras Hindu University, Varanasi (U. P.) in two consecutive years of 2016-17 and 2017-18 to assess the effect of cow urine application at varying fertility and zinc levels on growth, yield and economics of wheat (*Triticum aestivum* L.) under dairy based integrated farming system in Varanasi. Results revealed that application of the fertilizer at 100% RDF (F₁) recorded significantly higher shoot dry weight, no. of green leaves, leaf area index, number of spikes m⁻¹ row length, SPAD value (chlorophyll content), days to 50% spike emergence, grain yield, straw yield, gross return, net return and B: C ratio than 75% RDF (F₂) during both the years. Among the zinc levels, zinc applied at 10 kg ha⁻¹ though remained comparable to 5 kg Zn ha⁻¹ but both recorded significantly higher values of above parameters over control except B:C ratio, days to 50% spike emergence and days to physiological maturity. Application of cow urine @ 12000 l ha⁻¹ equally distributed at sowing, CRI and spike emergence stages (U₂) recorded significantly higher grain yield, straw yield, shoot dry weight, no. of green leaves, leaf area index, number of spikes m⁻¹ row length, SPAD value (chlorophyll content), gross return and net return which being at par with 8000 l ha⁻¹ cow urine equally distributed at sowing and CRI (U₁), both proved significantly superior over control. With respect to B: C ratio highest value was obtained with U₀ which being at par with U₁ significantly higher than U₂ during first year. However, in the second year all the treatments differ significantly with each other.

Key words : Cow urine, zinc, yield, spike length and test weight.

Introduction

Worldwide, wheat (*Triticum aestivum* L) is the widely grown staple food crop and a high-priority food in more than 40 countries. It leads in area (220.06 m ha) in the world, stands second in production (763.2 m t) after maize and third in the productivity (3.49 t ha⁻¹) after maize and rice. Wheat contributes nearly 35 per cent to the world's food grain production and supplementing about 55% carbohydrates and 20% food calories. It's nutritional profile is better than the other cereals i.e. 12.1% protein, 1.8% lipids, 1.8% ash, 2.0% reducing sugars, 6.7% pentose's, 59.2% starch, 70 % total carbohydrates, 314 Cal/100 g of food and minerals and vitamins viz., calcium (37 mg/100g), iron (4.1 mg/100g), thiamine (0.45 mg/100g), riboflavin (0.13 mg/100g), and nicotinic acid (5.4 mg/100g) (Vaughan *et al.*, 2003). Among the countries, India occupies the highest wheat growing area (30.79 m ha) and ranks second in production (98.51 m t) after china (USDA, 2019), contributes 15.36% to the world wheat production. In India, it is the second major staple cereal crop after rice, contributes significantly to food and nutrition security by meeting 20 % of proteins and 19 % calorie intake. Uttar Pradesh, among the states, occupied highest wheat growing area (9.66 m ha, 31.56 % to all India) and production (30.06 m t, 30.55 % to all India) despite its low productivity (3113 kg ha⁻¹) than Punjab

(4704 kg ha⁻¹) and Haryana (4514 kg ha⁻¹) (Agri. statistics at a glance, 2017). India has also lower wheat productivity (3216 kg ha⁻¹) than the world average (3470 kg ha⁻¹).

As the growing area of wheat will be predicted to reduce by 5-6 m ha by 2050 resulting from non-agricultural activities as well as alternate crops, the wheat demand by 2030 and 2050 will be around 115 m t (Kumar *et al.*, 2016) and 140 m t, require 46% more production over the present production level (Vision 2050, IIWBR, 2015). Most studies on climate change also shows a 20-30% yield loss in various wheat cultivated areas resulting from a projected temperature increase of 2-3°C by 2050 (Vision 2050, IIWBR, 2015). Declining soil fertility, inadequate, unbalanced and inefficient use of fertilizers are the major factors contributing low productivity of wheat (Yadav *et al.*, 2000; Dwivedi *et al.*, 2001). The entire exhaustive rice-wheat system in Indo-Gangetic alluvial belt is practiced with continuous application of inadequate and imbalanced nutrients which leads to the deterioration of soil fertility and soil health (Bohra *et al.*, 2007). Thus, as a renewable source of plant nutrients, the organic sources of plant nutrients is getting importance in wheat cultivation because the combination of organic sources with inorganic fertilizer increases productivity as well as sustain soil health (Pullicino *et al.*, 2009).

Now-a-days, individual animal products and their formulations are widely popularized in agriculture. Cow urine is the waste of livestock production and adequately found at farm household under integrated farming system. One cattle produced 2187 liters of cow urine annually and approximate quantity of plant nutrient excreted is 21.87 kg N, 29.52 kg K₂O and traces of phosphorus (Yawalkar *et al.*, 1996). Due to its special characteristics, it had been used from *vedic* period in India as a low cost agriculture practices for various purposes viz. medicinal, agricultural etc. Cow urine is the major component of *Panchagavya* which is prepared and sprayed by Indian farmers as an organic crop booster from *vedic* period (Tharmaraj *et al.*, 2011). Its use in crop production is eco friendly without any adverse effect on crop, human health and ecosystem as its constituents mainly 95% water, 2.5% urea and remaining 2.5% is a mixture of hormones, minerals, enzymes and salts thus, it can be concluded that cow's urine is not a toxic effluent (Kishore *et al.*, 2015). Also, like other organic sources, it does not have the problem of the slow release nutrients which affects crop growth and it can be sprayed at critical growth stage of crop. Cow urine has the concentration of total nitrogen vary from 6.8-21.1 g N/litre which constitutes 69% urea, 5.8% hippuric acid, 7.3% allantoin, 2.5% creatine, 3.7% creatinine, 1.3% uric acid, 0.5% xanthin plus hypoxanthin, 2.8% ammonia and 1.3% free amino acid nitrogen (Bristow *et al.*, 1992). It also has the good amount of other nutrients such as phosphate, potassium, sulphur, sodium, manganese, iron, silicon, chlorine, carbolic acid, salts, enzymes and hormones, besides nitrogen (Saunders, 1982). It is observed that cow urine contains different inorganic compounds including silver, Na-K ratio of 4:1 (36%:9% in dried urine), besides this, about 50-100 mg oestrogens; 20-200 µg of cortico-steroids and 0.05-0.15 mg of 17-keto-steroids are found in 100 ml of cow urine (Vasanthi and Venkatalakshmi, 2015). The beneficial effect of cow urine was observed by various researchers on different crops such as Abraham and Lal, 2004 in wheat, Devakumar *et al.*, 2014 in maize, Pradhan and Bohra, 2015 and Pradhan *et al.*, 2016 in mustard and Sahare and Mahapatra, 2015 in rice. Hence, it seems that cow urine in crop production has great potential as a organic fertilizer source as soil and foliar application both and it requires to be studied more under existing climatic condition particularly under integrated farming system involving livestock.

Balanced NPK application has major impact on quality and yield improvement of the crops. It is well known that high yielding varieties of wheat is highly responsive to nitrogen fertilization and when nitrogen and phosphorus applied together gives synergetic efficiency (Stoeva and Tonev, 2003). Currently, deficiency of

micronutrient, zinc has become normalized in Indian soils and it is major deficiency after N and P. Nearly, 50% north Indian soils are deficient in Zn and likely to respond to its application (Sharma *et al.*, 2016). The macro nutrients, N and P deficiency, that limits root growth also limits Zn uptake. On the other hand, when Zn availability is marginal and N and P are sufficient, nutrient dilution causes its deficiency (Loneragan and Webb, 1993). Thus, Zn deficiency in soil also impact uptake of other nutrients and finally crop growth in wheat. Zinc is an essential micronutrient needed in completing basic functions of plant life viz. chlorophyll synthesis, photosynthesis, carbohydrate translocation, nitrogen uptake and metabolism etc. (Potarzycki and Grzebisz, 2009). It is the constituent of many enzymes viz. carbonic anhydrase as well as proteins. Therefore, the current investigation was executed to evaluate the impact of cow urine as a potential organic fertilizer source in crop production under integrated farming system involving livestock along with fertility and zinc levels.

Materials and Methods

The field study was carried out at the Agricultural Research Farm, Banaras Hindu University, Varanasi (U.P.) in two successive years of 2016-17 and 2017-18. The experiment was performed in split plot design with combinations of 2 fertility levels (100% RDF and 75% RDF) and three zinc levels (0 kg ha⁻¹ Zn, 5 and 10 kg Zn ha⁻¹) in main plots and 3 cow urine levels (U₂ - 12000 l ha⁻¹ equally distributed at sowing, CRI, and spike emergence, U₁ - 8000 l ha⁻¹ equally applied at sowing and CRI and U₀ - 0 l ha⁻¹) in sub-plots and all the 18 treatment combinations replicated thrice. The soil of the experimental site was sandy clay loam in texture having slightly alkaline soil pH (7.35), low in organic carbon (0.35%) and available nitrogen (203.49 kg ha⁻¹) and medium in available phosphorus (17.77 kg ha⁻¹) and potassium (192.21 kg ha⁻¹). The DTPA-Extractable soil available Zn was 1.03 mg kg⁻¹ of soil. The nutrient sources, Urea, DAP, MOP and ZnSO₄.H₂O were utilized for application of the nutrients, N, P, K and Zn as per treatment, respectively. Full recommended doses of P, K, Zn and half of nitrogen were applied as basal and remaining half dose of nitrogen was top dressed through urea in two equal splits at CRI and spike emergence stages. The cow urine without any mixture was collected from cattle shed of IFS model of the Institute of Agricultural Sciences, BHU, Varanasi and stored in plastic cans. The cow urine was applied as per treatment with watering can in the furrow at the time of sowing as basal application and towards the root zone between two rows at CRI and spike emergence stages. Variety "HD 2967" of wheat was sown at the seed rate of 100 kg ha⁻¹ during the first week of December at 22.5 cm row spacing with the help of *Kudal*. The crop was irrigated

Table-1 : Effect of cow urine application at varying fertility and zinc levels on shoot dry weight of wheat at different growth stages.

Treatments	Shoot dry weight (g) m ⁻¹ row length							
	40 DAS		70 DAS		100 DAS		At harvest	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Main plot								
Fertility level								
F ₁ -100% RDF	13.78	14.52	108.49	110.87	285.67	288.96	334.50	339.09
F ₂ -75% RDF	12.59	13.67	99.33	103.24	260.67	265.67	306.28	310.04
SEm±	0.19	0.18	1.95	1.81	5.34	4.42	5.13	4.25
CD 5%	0.59	0.56	6.14	5.69	16.84	13.94	16.15	13.40
Zinc level (kg Zn ha⁻¹)								
Zn ₀ -0	12.55	13.57	97.75	99.59	256.67	262.06	303.81	305.28
Zn ₁ -5	13.44	14.27	105.69	109.87	277.72	280.94	324.08	329.25
Zn ₂ -10	13.57	14.44	108.29	111.71	285.11	288.94	333.28	339.17
SEm±	0.23	0.22	2.39	2.21	6.55	5.42	6.28	5.21
CD 5%	0.73	0.68	7.52	6.97	20.63	17.07	19.78	16.41
Sub plot (Cow urine application at 4000 l ha⁻¹)								
U ₀ - Control (4000 l ha ⁻¹ water)	12.40	13.72	99.28	102.90	260.00	265.89	307.33	314.83
U ₁ -4000 + 4000 (Basal + CRI)	13.29	14.14	105.04	107.71	273.44	277.67	325.00	327.22
U ₂ -4000 + 4000 + 4000 (Basal + CRI + Spike emergence)	13.86	14.42	107.41	110.56	286.06	288.39	328.83	331.64
SEm±	0.22	0.10	1.88	1.48	3.82	3.65	3.85	2.42
CD 5%	0.65	0.31	5.50	4.33	11.15	10.65	11.23	7.07

Table-2 : Effect of cow urine application at varying fertility and zinc levels on no. of green leaves of wheat at different growth stages.

Treatments	No. of green leaves m ⁻¹ row length					
	40 DAS		70 DAS		100 DAS	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Main plot						
Fertility level						
F ₁ -100% RDF	41.02	42.56	71.55	73.57	103.57	105.71
F ₂ -75% RDF	38.48	40.33	68.81	70.16	98.71	100.22
SEm±	0.41	0.39	0.79	0.64	1.27	1.04
CD 5%	1.29	1.24	2.49	2.02	4.02	3.29
Zinc level (kg ha⁻¹ Zn)						
Zn ₀ -0	38.76	40.29	67.47	69.90	97.44	99.83
Zn ₁ -5	39.68	41.54	70.67	72.63	102.38	103.98
Zn ₂ -10	40.81	42.51	72.39	73.07	103.60	105.07
SEm±	0.50	0.48	0.97	0.79	1.56	1.28
CD 5%	1.59	1.52	3.05	2.48	4.92	4.03
Sub plot (Cow urine application at 4000 l ha⁻¹)						
U ₀ -Control (4000 l ha ⁻¹ water)	38.60	40.16	68.17	69.94	98.33	100.33
U ₁ -4000 + 4000 (Basal + CRI)	39.96	41.71	70.65	72.32	101.53	103.33
U ₂ -4000 + 4000 + 4000 (Basal + CRI + Spike emergence)	40.70	42.46	71.72	73.34	103.56	105.23
SEm±	0.27	0.27	0.78	0.54	0.95	0.98
CD 5%	0.80	0.78	2.29	1.58	2.78	2.85

according to the crop need mainly at the critical stages and the required plant protection measures were adopted. Similarly, all other recommended package of practices was followed. The number of green leaf m⁻¹ row length were counted at 40, 70 and 100 DAS at five places in the net plot on the randomly marked area of 0.20 m in crop rows. Plants were taken from randomly marked area of 0.2 m from the border rows in each plot from five places at 40,

70, 100 DAS and at harvest for estimation of the shoot dry weight m⁻¹ row length. Similarly, leaf area m⁻¹ row length at 70 and 100 DAS was measured with the help of leaf area meter and calculated as leaf area index using following formula :

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

Table-3 : Effect of cow urine application at varying fertility and zinc levels on leaf area index of wheat at different growth stages.

Treatments	Leaf area index m ⁻¹ row length			
	70 DAS		100 DAS	
	2016-17	2017-18	2016-17	2017-18
Main plot				
Fertility level				
F ₁ -100% RDF	3.58	3.68	4.66	4.91
F ₂ -75% RDF	3.09	3.19	4.09	4.49
SEm±	0.06	0.06	0.09	0.06
CD 5%	0.18	0.18	0.27	0.20
Zinc level (kg ha⁻¹ Zn)				
Zn ₀ -0	3.07	3.21	3.97	4.32
Zn ₁ -5	3.46	3.52	4.50	4.78
Zn ₂ -10	3.48	3.59	4.65	5.00
SEm±	0.07	0.07	0.10	0.08
CD 5%	0.23	0.22	0.33	0.25
Sub plot (Cow urine application at 4000 l ha⁻¹)				
U ₀ -Control (4000 l ha ⁻¹ water)	3.16	3.27	4.15	4.51
U ₁ -4000 + 4000 (Basal + CRI)	3.36	3.47	4.47	4.74
U ₂ -4000 + 4000 + 4000 (Basal + CRI + Spike emergence)	3.49	3.58	4.50	4.85
SEm±	0.06	0.05	0.07	0.06
CD 5%	0.16	0.16	0.20	0.17

Table-4 : Effect of cow urine application at varying fertility and zinc levels on SPAD value (chlorophyll content) of wheat.

Treatments	SPAD value (chlorophyll content)					
	40 DAS		70 DAS		100 DAS	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Main plot						
Fertility level						
F ₁ -100% RDF	41.13	41.80	42.61	43.23	44.93	45.72
F ₂ -75% RDF	39.74	39.85	40.18	40.91	43.00	43.65
SEm±	0.42	0.41	0.44	0.38	0.43	0.40
CD 5%	1.32	1.28	1.37	1.21	1.36	1.27
Zinc level (kg ha⁻¹ Zn)						
Zn ₀ -0	39.28	39.59	40.01	40.53	42.72	43.28
Zn ₁ -5	40.46	40.98	41.72	42.62	44.44	45.26
Zn ₂ -10	41.57	41.90	42.46	43.06	44.74	45.53
SEm±	0.51	0.50	0.53	0.47	0.53	0.49
CD 5%	1.62	1.57	1.68	1.48	1.67	1.55
Sub plot (Cow urine application at 4000 l ha⁻¹)						
U ₀ -Control (4000 l ha ⁻¹ water)	39.38	39.63	40.02	40.67	43.00	43.27
U ₁ -4000 + 4000 (Basal + CRI)	40.69	41.08	41.89	42.37	44.00	45.11
U ₂ -4000 + 4000 + 4000 (Basal + CRI + Spike emergence)	41.23	41.76	42.28	43.17	44.90	45.68
SEm±	0.28	0.24	0.45	0.32	0.32	0.30
CD 5%	0.83	0.69	1.32	0.93	0.92	0.88

The number of days taken from the date of planting to the date when ears emerged in 50% of the plants and ears attain physiological maturity in each experimental plot is expressed as days to 50% spike emergence and days to physiological maturity, respectively. The number of spikes m⁻¹ row length was counted from the randomly marked area of 0.2 m at five places in crop rows at harvesting from net plot. The topmost fully expanded leaf

from five randomly selected plants in net plot area were selected for recording SPAD reading with hand held SPAD (soil plant analysis development)-502 meter at 40, 70 and 100 DAS for non-destructive and quick estimation of extractable chlorophyll in leaves. The economics of different treatments were calculated separately by taking into account the existing price of inputs and produce for both the years.

Table-5 : Effect of cow urine application at varying fertility and zinc levels on number of spikes m⁻¹ row length, days taken to 50% spike emergence and physiological maturity of wheat.

Treatments	Number of spikes m ⁻¹ row length		Days to 50% spike emergence		Days to physiological maturity	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Main plot						
Fertility level						
F ₁ -100% RDF	117.70	119.33	73.85	73.59	124.37	123.33
F ₂ -75% RDF	105.93	107.28	73.11	73.07	123.96	123.04
SEm±	1.50	1.36	0.23	0.12	0.41	0.26
CD 5%	4.72	4.29	0.73	0.39	NS	NS
Zinc level (kg ha⁻¹ Zn)						
Zn ₀ -0	99.00	100.46	73.39	73.22	124.11	123.11
Zn ₁ -5	115.72	118.06	73.39	73.28	124.00	123.11
Zn ₂ -10	120.72	121.39	73.67	73.50	124.39	123.33
SEm±	1.83	1.67	0.28	0.15	0.50	0.31
CD 5%	5.78	5.26	NS	NS	NS	NS
Sub plot (Cow urine application at 4000 l ha⁻¹)						
U ₀ -Control (4000 l ha ⁻¹ water)	107.50	108.75	73.17	73.00	123.61	122.83
U ₁ -4000 + 4000 (Basal + CRI)	112.56	113.78	73.67	73.39	124.06	123.11
U ₂ -4000 + 4000 + 4000 (Basal + CRI + Spike emergence)	115.39	117.38	73.61	73.61	124.83	123.61
SEm±	1.49	1.38	0.22	0.18	0.34	0.23
CD 5%	4.36	4.03	NS	NS	NS	NS

Table-6 : Effect of cow urine application at varying fertility and zinc levels on yield of wheat.

Treatments	Grain yield (kg ha ⁻¹)		Straw yield (kg ha ⁻¹)		Harvest index (%)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Main plot						
Fertility level						
F ₁ -100% RDF	4813	4916	7142	7244	40.30	40.47
F ₂ -75% RDF	4382	4476	6520	6645	40.15	40.22
SEm±	62	49	113	112	0.54	0.50
CD 5%	194	154	355	354	NS	NS
Zinc level (kg ha⁻¹ Zn)						
Zn ₀ -0	4353	4456	6501	6607	40.03	40.23
Zn ₁ -5	4662	4744	6958	7041	40.17	40.30
Zn ₂ -10	4777	4888	7033	7185	40.47	40.51
SEm±	75	60	138	138	0.66	0.62
CD 5%	237	189	435	433	NS	NS
Sub plot (Cow urine application at 4000 l ha⁻¹)						
U ₀ -Control (4000 l ha ⁻¹ water)	4292	4409	6494	6601	39.79	40.06
U ₁ -4000 + 4000 (Basal + CRI)	4730	4815	6979	7098	40.40	40.43
U ₂ -4000 + 4000 + 4000 (Basal + CRI + Spike emergence)	4770	4864	7020	7133	40.49	40.54
SEm±	56	48	66	65	0.40	0.33
CD 5%	162	141	192	189	NS	NS

Results and Discussion

Effect of varying levels of fertility, zinc and cow urine on yield : Various fertility levels distinctly improved grain and straw yield of wheat during both the years of investigation. The 100% RDF increased 9.84 and 9.83% grain yield and 9.54% and 9.01% straw yield of wheat over 75% RDF during 2016-17 and 2017-18, respectively. Adequate and balanced fertilization at higher fertility levels might have improved grain and straw yields of wheat due

to increased availability and assimilation of major nutrients that assist in higher dry matter production resulting into improved source and sink relationship and production of favorable growth and yield components which finally increased yield. These findings are similar to the findings of Samimi and Thomas (2016) and Rahman *et al.* (2016).

Zinc fertilization in wheat was markedly improved the grain and straw yield during both the years. Zinc application at the rate of 10 kg Zn ha⁻¹ being at par with 5 kg Zn ha⁻¹ gave significantly higher grain as well as straw

Table-7 : Effect of cow urine application at varying fertility and zinc levels on economics of wheat.

Treatments	Cost of cultivation (₹ ha ⁻¹)		Gross return (₹ ha ⁻¹)		Net return (₹ ha ⁻¹)		B:C	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Main plot								
Fertility level								
F ₁ -100% RDF	47760	47760	122342	124195	74582	76435	1.56	1.60
F ₂ -75% RDF	45779	45779	111469	113170	65689	67391	1.44	1.48
SEm±	-	-	1199	978	1199	978	0.03	0.02
CD 5%	-	-	3777	3081	3777	3081	0.08	0.07
Zinc level (kg ha⁻¹ Zn)								
Zn ₀ -0	45324	45324	110863	112711	65539	67387	1.45	1.49
Zn ₁ -5	46770	46770	118708	120180	71938	73410	1.54	1.58
Zn ₂ -10	48215	48215	121145	123156	72930	74941	1.51	1.56
SEm±	-	-	1468	1197	1468	1197	0.03	0.03
CD 5%	-	-	4625	3773	4625	3773	NS	NS
Sub plot (Cow urine application at 4000 l ha⁻¹)								
U ₀ -Control (4000 l ha ⁻¹ water)	42706	42706	109718	111822	67012	69116	1.57	1.62
U ₁ -4000 + 4000 (Basal + CRI)	47582	47582	119448	120988	71865	73406	1.51	1.54
U ₂ -4000 + 4000 + 4000 (Basal + CRI + Spike emergence)	50020	50020	121550	123237	71530	73217	1.43	1.46
SEm±	-	-	1034	938	1034	938	0.02	0.02
CD 5%	-	-	3017	2737	3017	2737	0.07	0.06

yield over control. This yield increment might be due to the beneficial effect of zinc on the growth parameters of wheat which also promoted yield attributes, finally contributed to yield. These results are in line to those of Singh *et al.* (2004a and 2004b) and Ahmadi and David (2016).

Each successive increase in cow urine level from 0-12000 l ha⁻¹ statistically improved grain and straw yield during both the years of investigation. An increment of 13.05 and 8.25% in the first year and 11.45% and 8.07% in the second year was obtained with application of 12000 and 8000 l ha⁻¹ cow urine, respectively, as compared to control. This could be due to increased growth parameters at higher cow urine doses which resulted into higher yield attributes viz. number of spikes, spike length and number of grain spike⁻¹, finally contributed to increased grain and straw yield. The results are matching the findings of Devakumar *et al.* (2014) and Veeresha *et al.* (2014) in maize and Sadhukhan *et al.* (2018a) in wheat.

Effect of varying levels of fertility, zinc and cow urine on growth parameters : Fertilizer application at 100% RDF significantly enhanced the shoot dry weight, number of green leaf, leaf area index m⁻¹ row length and SPAD value (chlorophyll content) at all the growth stages and days to 50% spike emergence than 75% RDF during both the years of investigation. The fast and increased availability of inorganic nutrients at higher fertility levels improved growth parameters thus the synthesis of protein and nucleic acid from photosynthates transferred to active

vegetative growth sites ultimately leads to increased growth of the plants. Adequate availability of fertilizer elements might have caused prolonged vegetative growth period resulting from better nutrition thus the nutritional stresses to the crop was minimized which leads to delay in attainment of physiological stages. These results are in accordance to the findings of Srivastava and Singh (2014), Singh *et al.* (2018), and Maruti (2016).

The application of zinc in wheat significantly improved the above growth parameters. The values of shoot dry weight, number of green leaf and leaf area index m⁻¹ row length and SPAD value (chlorophyll content) at all the growth stages were found maximum with application of 10 kg Zn ha⁻¹. However, it remained at par application of 5 kg Zn ha⁻¹ but both were significantly higher than control during both the years. Higher plant growth at higher zinc levels might be due to its active role in enzymatic systems such as carbonic anhydrase which is principally known for transportation of CO₂ in photosynthesis (Srivastava and Gupta, 1996).

As concluded from the data, application of cow urine at different growth stages markedly improved the growth parameters of wheat during both the years. Cow urine application at 12000 l ha⁻¹ equally applied at sowing, CRI and spike emergence stages (U₂) gave significantly maximum values of shoot dry weight, number of green leaf, leaf area index m⁻¹ row length and SPAD value (chlorophyll content) at all the growth stages but remained at par with 8000 l cow urine ha⁻¹ equally applied at sowing and CRI (U₁) except shoot dry weight accumulation at 100

DAS which was significantly higher with U_2 over the remaining treatments during both the years of study. The improvement in plant growth at higher cow urine doses might be due to various kinds of minerals, hormones and enzymes present in cow urine which might have favored physiological reaction in plant system resulting into higher growth and development. The above results are matching the results of Sadhukhan *et al.* (2018a) in wheat, Sadhukhan and Bohra, 2017 in rice and Sadhukhan *et al.* (2019) in rice.

Effect of varying levels of fertility, zinc and cow urine on yield attributes : During both the years, yield attributes of wheat viz. number of spike m^{-1} row length was distinctly improved due to fertility levels. Maximum number of spike m^{-1} row length was recorded with application of 100% RDF which was significant over 75% RDF. This might be due to adequate assimilation of fertilizer elements at higher fertility levels which improved growth parameters for exploiting productive tillering potential of crop plants and their effectiveness to attain ear. These findings are in accordance to the results of Srivastava and Singh (2014), Akhtar *et al.* (2018) and Chaudhry *et al.* (2014).

Zinc application in wheat distinctly impacted yield attributes viz. number of spike m^{-1} row length during both the years. Study of the data indicated that zinc levels increased from 0-10 kg Zn ha^{-1} correspondingly improved the spike number m^{-1} row length. Nevertheless, the 5 and 10 kg Zn ha^{-1} did not vary significantly. This could be attributed to favorable effect of zinc on growth parameters which enhance the photosynthetic activity of plant and helps to produce fertile tillers. These findings are in line to those of Jan *et al.* (2013) and Zeidan *et al.* (2010).

The number of spike m^{-1} row length increased distinctly with increasing the cow urine levels upto 8000 l cow urine ha^{-1} equally applied at sowing and CRI. However, further increase in cow urine level up to 12000 l cow urine ha^{-1} equally applied at sowing, CRI and SE, though, enhanced the number of spike m^{-1} row length but remained at par with 8000 l cow urine ha^{-1} . Availability of higher nutrient elements and favourable growth conditions provided by growth contributing constituents of cow urine might have improved the growth parameters resulted into increase in number of spike m^{-1} row length. Share and Mahapatra (2015) and Sadhukhan *et al.* (2019) working on rice and Ayalew (2015) on maize were also obtained the similar findings in their study.

Effect of varying levels of fertility, zinc and cow urine on economics : Fertility levels increasing from 75% to 100% RDF significantly increased the net returns and benefit cost ratio which indicated that application of 100% RDF in wheat was more beneficial over 75% RDF.

Study of data further indicated that significantly maximum gross and net returns in wheat was obtained with 10 kg Zn ha^{-1} which remained at par with 5 kg Zn ha^{-1} . However, the benefit cost ratio was not significantly differed. Hence, it is concluded that, however, the differences among zinc application at 5 and 10 kg ha^{-1} were not significant but the maximum net returns was obtained at 10 kg Zn ha^{-1} during both the years. This denoted that zinc application was profitable at 10 kg ha^{-1} .

The data regarding cow urine application revealed that 12000 l cow urine ha^{-1} gave the gross returns but the 8000 l ha^{-1} cow urine gave the maximum net returns during both the years. Nonetheless, the differences were not at the level of significance. Thus, it is concluded that cow urine application at 8000 l ha^{-1} was more remunerative. The benefit cost ratio was decreasing with increasing cow urine levels, the maximum with control followed by 8000 l cow urine ha^{-1} , both being at par but significantly higher than 12000 l cow urine ha^{-1} . This might be due to increasing cost of application of cow urine with higher doses of cow urine.

Recommendations

Based on the care full study of data, it is concluded from the two years field experiment that application of 100% RDF (150-60-60 kg ha^{-1} N P K) and application of 10 kg Zn ha^{-1} and cow urine at the rate of 12000 l ha^{-1} (4000 l ha^{-1} each at sowing, CRI and spike emergence stages) may be followed for higher yield and net profit in wheat under dairy based integrated farming system in Varanasi tract.

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Capturing of Runoff Water through Vegetative Barriers to Reduce Soil Erosion—A Research Review

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Abstract

Soil degradation is a very critical environmental problem throughout the world's terrestrial ecosystems. Erosion inflicts the serious damage of natural ecosystem, nutrient, biodiversity, and forest as well as plough soil layer. Erosion reduces the water holding capacity of soil because of rapid water runoff, and reduces soil organic matter. As a result, many of plant nutrients and valuable soil biota are transported from one place to another. At the same time, species diversity of microbes, animals and plants is significantly reduced. One of the most effective measures for soil erosion control is the establishment of vegetation on the field. Vegetation cover is an important natural resource of the terrestrial ecosystem, and it has significant role in preserving the ecological balance in an area. Cover crops reduced erosion rates by four- to six-times compared to tillage. Indeed, achieving future of safe environment depends on conserving soil, water, energy, and biodiversity. Soil erosion can also be controlled through plant cover, restoration of water, and development of erosion control structure. Napier and Broom grasses are more effective in reference to soil binding capacity and forage production simultaneously. Thus, conservation of these vital resources needs to receive high priority to ensure the effective protection of managed and natural ecosystems.

Key word : Crop residue, productivity, soil conservation, soil loss, vegetation.

Introduction

Land degradation, and soil and nutrient loss, are significant environmental problems in semi-arid agricultural environments. Soil is a dynamic body on the upper surface of the earth. It is a natural resource for supporting plant growth. Soil is mainly composed of mineral matter i.e. sand, silt, clay, organic matter and living entities that provide the necessary nutrient and support to the growing plants. Water act as a nutrient carrier as well as agent for soil transporter also. Soil erosion by water is a worldwide environmental problem which degrades soil productivity and water quality day by day and causes sedimentation and increases the probability of flood (Zhou *et al*, 2008). Mismanagement and indiscriminate use of natural resources i.e. soil and water, resulted soil and environmental degradation and may prove dangerous for natural ecosystem. Every year, about 75 billion tons of soil is eroded from the world's terrestrial ecosystems, most from agricultural land ranging from 13-40 Mg ha⁻¹ yr⁻¹ (Pimentel and Kounang, 1998). Hence judicious management and conservation of soil and water are essential for sustainable production and environmental benefits. Soil conservation is a techniques in which manage or reduce the soil erosion. The conservation of soil implies utilization of natural resources without wastage, so as to make possible a continuous high level of crop production, higher water table as well as improving environmental quality. Some of the methods

that used to maintain soil fertility includes shifting cultivation, land rotation, crop rotation, mixed cropping, planting of cover crops and use of organic manure. The nature of vegetation cover on soil surface is a major factor influencing soil erosion. The dynamics of vegetation, productivity, and its inter-annual changes play a major role to recognize the strong relationship between rainfall and vegetative growth from a regional to global scale (Hilker *et al*. 2014; Hawinkel *et al*. 2015). According to Naylor *et al*. (2002) the effects of vegetation on soil can be divided into two major related categories: bio protection and bio construction. Plant cover protects soil against erosion by reducing water runoff (Duran *et al.*, 2007) and by increasing water infiltration into the soil matrix (Wainwright *et al.*, 2002). The importance of vegetation in controlling water erosion is widely accepted throughout the world. A thick layer of plants reduces erosivity of rainfall and most of the water either quickly percolates through the soils or flow over the surface with non-erosive velocity. Moreover, the rooting system of grasses also improves the binding capacity of soil particles as well as soil infiltration. Mulches being directly in touch with land surface are most efficient in reducing runoff and soil loss followed by grasses and cover crops. Many of these conservation practices have been shown to consistently reduce soil erosion (Ghidey and Alberts 1998). In this review paper, we summarize the factors that responsible for erosion and management strategies to check soil erosion through vegetative barriers.

Materials and Methods

Soil erosion estimation by RUSLE (Revised Universal Soil Loss Equation) : Soil and water conservation is a combination of all management and land use practices which protect the soil against depletion or deterioration by natural and anthropogenic factors. Attempts have been made for many years to quantify the soil erosion effect in various purposes like cropping practices in numerical form which would allow erosion to be predicted for given circumstances (Wischmeier and Smith, 1965). Data for derivation and field use equations were obtained from the runoff plots. Zingg (1940) proposed a relationship of soil loss to slope length raised to a power. In 1947, a committee chaired by Musgrave proposed a soil loss equation having some similarity to the present day Universal Soil Loss Equation (USLE). This equation was later refined with more recent data from same runoff plots and rainfall simulations from field experience (Wischmeier and Smith, 1978).

The soil loss equation is : $A = RKLSCP$

Where,

A is the average annual soil loss per unit of area,

R is the rainfall-runoff erosivity factor,

K is the soil erodibility factor,

L is the Slope length factor,

S is the slope gradient factor,

C is the cropping management factor, and

P is the erosion control practice factor.

Results and Discussion

Now a days, Soil erosion is a very serious problem all over the world and deteriorate air and water day by day. It may cause million of nutrient and carbon loss from the soil surface. The formation of gully by huge runoff through water erosion is depicted in Fig-1. To overcome of these problems, some important management techniques are given below:

Soil erosion controlled by vegetation cover

Soil vegetative cover : It can help to reduce soil erosion as it reduce the impact of rainwater droplets hitting the soil, increasing water infiltration and slow down the speed at which runoff flows through the field. Use of perennial grasses as well as growing of trees along with agricultural crops as vegetative barriers to reduce soil erosion from farm land and non-farm lands is increasing world-over. A number of perennial grasses have been identified for their soil conserving properties, but their effectiveness varies with location and method of planting. Installing vegetative barriers in combination with suitable mechanical measures, like bunds or trenches or both, on the appropriately spaced contours may enhance their conservation potential.

Water erosion, especially Rill and gully erosion is a critical environmental problem in India, where plant cover plays a vital role in the runoff and soil loss reduction and stabilization of disturbed systems. Shit, *et.al* (2012) concluded one of experiment that the impact of vegetal cover on runoff and soil erosion in lateritic soil was assessed through experimental observation on five plots



Fig.-1 : Formation of gully through water erosion.

Table-1 : Effect of vegetative barriers on runoff.

Treatment	Runoff (%)			
	2002	2003	2004	Average
<i>Sambuta</i> + bund	7.83	8.26	8.10	8.06
<i>Sambuta</i> + berm	10.50	11.42	11.22	11.04
Vetiver + bund	8.96	10.44	9.90	9.77
Vetiver + berm	12.50	13.26	13.14	12.95
Lemongrass + bund	10.78	12.35	12.23	11.78
Lemongrass + berm	13.67	15.54	14.80	14.67
LSD (0.05)	1.10	2.10	1.75	1.68

(Source : Dass *et al.* 2010)

Table-2 : Effect of vegetative barriers on soil loss.

Treatment	Runoff (%)			
	2002	2003	2004	Average
<i>Sambuta</i> + bund	3.69	4.30	4.10	4.03
<i>Sambuta</i> + berm	4.95	5.32	5.23	5.16
Vetiver + bund	3.9	4.87	4.74	4.49
Vetiver + berm	6.8	7.52	7.42	7.24
Lemongrass + bund	5.18	6.01	6.21	5.80
Lemongrass + berm	7.5	8.58	8.70	8.26
LSD (0.05)	0.42	0.55	0.52	0.65

(Source : Dass *et al.* 2010)

(<5 m² area), containing varied vegetal cover at successive time period. Runoff and rate of soil loss were measured in each plot under seven natural rain storm conditions and compared them. The observed data showed bare plot experienced larger sediment yield than they are with vegetal cover.

Ranade (1997) observed the mechanical and vegetative barriers are effective in reducing seasonal runoff and soil loss by about 20 to 25 per cent over control under moderate slope category (up to 2 %). At the same time, it was observed that vegetative barriers are also effective as mechanical measure and they can be considered suitable alternative to mechanical measures in the region.

Kundu *et al.*, 2017 conducted an experiment in Bundelkhand region which is one of the most drought area. They analyzed 16 year of datasets to detect temporal trend of vegetation in this area. In order to estimate the NDVI trend, significant correlation was observed between climatic impact on increasing or decreasing the vegetation over there.

Crop residues cover : Farm yard with minimum of 30% surface crop residue cover is considered beneficial for minimizing soil erosion mulching crop residue which helps to slow down surface runoff velocities, improve water infiltration, increase soil organic matter levels and improve water holding capacity.

Nalatwadmath (2004) studied the length of the slope increased runoff percentage as well as soil loss per unit

area decreased due to trap efficiency. Runoff and soil loss increases with increase in percentage of slope. These results confirmed with those of Wischemeir and Smith (1978) studies.

Dasset *et al.* 2010 resulted that the Lowest average runoff (8.1%) and soil loss (4.0 Mg ha⁻¹) were observed in the sambuta + trench-cum-bund followed by vetiver + trench-cum-bund treatment (runoff 9.77%, soil loss 12.95 Mg ha⁻¹). The lemongrass barrier, owing to its significantly lower survival and poor growth, allowed significantly higher runoff than sambuta and vetiver grasses. Whereas, significantly higher values of aboveground growth parameters coupled with better root proliferations in sambuta and vetiver resulted in significantly lower runoff and soil loss (Table 1 & 2).

The cropping pattern and management factors influences the intensity of runoff resulted impact on soil degradation. If the land is left undisturbed under a natural cover, the runoff and soil loss are the least, which increase steeply when the vegetation is removed from the land surface and land is cultivated. Along with the loss of runoff water and soil, considerable amounts of plant nutrient are also lost (Sharma, *et al* 2012). The effect of land use pattern on runoff and soil erosion is expressed in Table-3.

For preventing soil erosion from cultivated soil, the proper selection of crops and cropping system should be necessary, particularly hilly and slopy lands. The protection through vegetation covers, forest cover,

Table-3 : Effect of land use system on runoff and soil erosion.

Treatments	Runoff (mm)	Soil loss (tonnes/ha)
Alluvial soils: 8% slope (Uttarakhand)		
Bare fallow	339	42.4
Cultivated fallow	889	156.0
Natural Grasses	265	1.0
Maize-Wheat cropping system	870	28.5
Black soils: 0.5% slope (Rajasthan)		
Natural cover	33	0.3
Cultivated fallow	111	3.5
Sorghum (<i>Khari</i>)	79	2.9
Red soils: 2% slope (Bihar)		
Natural fallow	105	0.6
Overgrazed fallow	222	3.3
Maize (Contour cultivation)	64	3.3

(Source : Sharma, et. al., 2012)

Table-4 : Runoff and soil losses under different grass species at 9% and 11% slopes at Dehradun.

Land Slope	Treatments	Runoff (%)	Soil Loss (tonnes/ha)	Reduction (%)		Biomass (Kg/ha)
				Runoff	Soil loss	
9%	Bare and ploughed	59.6	155.95	-	-	-
	Bare fallow	71.1	92.42	19.3	40.7	-
	<i>Cynadondactylon</i>	27.1	2.10	54.5	98.7	-
	Natural grass	21.2	1.02	64.4	99.3	4355
11%	Cultivated fallow	16.2	18.45	-	-	-
	<i>Pueraria hirsute</i>	1.8	0.11	88.2	99.4	14962
	<i>Dicanthiumannulatum</i>	1.9	0.23	88.1	98.7	6805
	<i>Chrysopogonfalvus</i>	2.5	0.30	84.2	98.4	19170
	<i>Eulaliopsisbinata</i>	5.2	0.29	67.1	98.4	16290

(Source : Tejawani et al. 1975)

Table-5 : Effectiveness of different grasses on soil conservation and forage production.

S.N.	Name of Grasses	Rooting depth	Root lateral spread	Infiltration	Soil Binding function	Forage production function
1.	Napier	14-54 cm	19-73 cm	Excellent	Good	Excellent
2.	Stylo	24-103 cm	25-115 cm	Moderate	Very good	Very good
3.	Molasses	15-27 cm	11-30 cm	Very Good	Moderate	Good
4.	Broom Grass	70-95 cm	103-132 cm	Moderate	Excellent	Moderate

(Source : Kafle and Balla, 2008)

grasses, trees, crops and mulches are some important measure to prevent soil erosion.

Among these, grasses are the best conservator of soil as well as water. Small and well distributed canopy and fibrous rooting pattern with more soil binding capacity make grasses highly effectively in preventing soil erosion. The selection of grasses should be on their adoptability, local edaphic conditions. The performance of various grasses with different land slope in controlling runoff and soil erosion are presented in Table-4.

Rooting Pattern of Grasses : Soil conservation is an important requirement in sustainable farming. Basics of soil erosion control are to reduce detachment and transportation capacity of the eroding agents (water and

wind) through different agronomic, vegetative measures generally known as conservative measures (Amatya and Shrestha, 2002). Grasses are generally used to reduce soil erosion due to their rooting pattern. The rooting depth and lateral spread of roots affect the extent of soil erosion control.

Broom Grass and Napier grass are most effective in reinforcing the soil by providing a network of strong roots that increases the soil's resistance to shear are presented in Table 5. Broom Grass can moderately support the soil mass by its strong and long fibrous roots. Broom Grass can bind average 3.8 cubic m. soil, and that for napier, stylo, and molasses are 0.37 cubic m., 0.45 cubic m. and 0.04 cubic m. soil respectively. The farmers can plant the

improved and selected varieties of grasses primarily for forage due to high foliage content and Soil conservation is second priority. A combination of improved varieties of grasses and natural grasses helps to conserve soil and moisture more effectively than single-use of grass species on marginal land.

Conclusions

The vegetative barriers in combination with small trench-cum-bund can be used for reducing the runoff, soil and nutrient losses, building up soil fertility and enhancing soil moisture retention and crop yield. The obvious yield loss in the short distances from the barrier can be overcome by the yield grains from the remaining area of the plot. Among the three grass barriers under study, *Sambuta* (a local grass) barrier proved more effective than vetiver and lemongrass in the sub-humid region having predominance of red lateritic soils. This barrier in combination with a trench-cum-bund resulted in significantly less runoff, soil and nutrient losses and produced higher crop yield compared to other two barriers. Napier, Broom grasses, *Puerara hirsute* and *Dicanthiummannulatum* are the best grasses among different vegetation to reduce the velocity of runoff and protection against soil loss from sloppy land.

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Effect of Crop Residue and Potassium Management Practices on Residual Soil Fertility, Potassium use Efficiency and Monetary Efficiency of Wheat (*Triticum aestivum* L.) Crop

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Abstract

The investigation was carried out at the Research Farm of the ICAR-Indian Agricultural Research Institute (IARI), New Delhi during *Rabi* seasons of 2020-21, with the objective to determine better crop residue and potassium management practices for nutrient uptake and their impact on nutrient use efficiency of wheat. The experiment was laid out in split-plot design with three replications having three residue management treatments in main plot and five potassium management practices [Control (no application of fertilizer, K1), 50% of RDK (K2), 100% of RDK (K3), 50% of RDK ($\frac{1}{2}$ basal + $\frac{1}{2}$ top dress at 25 DAS, K4) and 100% RDK ($\frac{1}{2}$ basal + $\frac{1}{2}$ top dress at 25 DAS, K5)] in sub-plot. Results indicated that the higher values of all major nutrients uptake by wheat was recorded with the crop residue incorporation @ 3t/ha with the split application of 100 % recommended dose of potassium ($\frac{1}{2}$ at basal + $\frac{1}{2}$ top dress at 25 DAS) and economic and potassium use efficiencies was higher with the crop residue retention @ 3t/ha Overall, it was concluded that the combined application of crop residue retention with the split application of 100 % of recommended dose of potassium ($\frac{1}{2}$ at basal + $\frac{1}{2}$ top dress at 25 DAS) is significant.

Introduction

Wheat (*Triticum aestivum* L.) is the principal cereal crop of the world and stands next to rice in India. In India, It occupies 31.61 Million Hectares acreage and production of 109.52 million tonnes with an productivity of 3464 kg/ha (MoA & FW, 2021). Though the country is producing sufficient wheat to meet its current demand but has to increase annual wheat production with a significant pace to achieve the ever-increasing future demands for burgeoning population (Prasad, 2010). That's why, the assured supply of wheat is essential for food security of the country.

Crop residues are key natural and eco-friendly resource for the stability of diverse agricultural systems. It is estimated that 686.2 mt of crop residues are generated by India annually (Singh and Sidhu 2014). Out of this, 234.4 mt crop residues is surplus (Hiloidhari *et al.*, 2014). The organic matter or crop residue helps to recycle the nutrients to correct their deficiency. The addition of crop residues enhances soil quality and increase soil nutrients, especially N and K. Furthermore, crop residues are the primary energy resource for soil microorganisms and an important source of plant nutrients (Choudhary *et al.*, 2017).

On the other hand, the use of blanket nutrient management recommendations in India has led to low nutrient use efficiencies, lowered profits and increased environmental problems. Globally, K is applied to replenish only 35 per cent of the K removed by crops that is much lower rate than replenishment, hence in major

production regions of the world widespread K deficiency is observed (Singh *et al.*, 2021). Long term fertilizer experiments have shown a comparatively better yield of crops when balanced NPK fertilizers are used in comparisons to NP use only (Dutta *et al.*, 2015). So, Balanced application of fertilizers is needed for sustainable crop production and maintenance of soil health. Therefore, present study is proposed.

Materials and Methods

The experiment was performed at ICAR-IARI Research Farm, New Delhi in the field no. Mid-Block 3A of ICAR-IARI Research Farm, which is situated at 28°35'N latitude, 77°12'E longitude and at an altitude of about 228.6 m above mean sea level (MSL). The climate of New Delhi is a semi-arid and sub-tropical with hot dry summer and cold winter. The soil of research Farm was alluvial, sandy loam in texture nearly level to gently sloping topography with pH 8.18, low in organic carbon, available N, medium in available P, and available K. The field experiment was carried out in split plot design having three replications. The plot size was 5 m x 3.30 m (16.5m²) with 15 treatment combinations. The treatments comprised of three levels of crop residue in main plot viz., no residue, Maize residue incorporation @ 3t/ha and Maize residue retention @ 3t/ha and four levels of potassium management viz., control ((no application of potassium), 50% of RDK (recommended dose of potassium), 100% of RDK, 50% of RDK ($\frac{1}{2}$ basal + $\frac{1}{2}$ top dress at 25 DAS) and 100% of RDK ($\frac{1}{2}$ basal + $\frac{1}{2}$ top dress at 25 DAS). The Wheat variety HD 3086 was sown in lines with row to row spacing of 22.5 cm.

Soil organic carbon, available N, P and K were determined from the processed samples for each treatment (in triplicate) as per the standard method. The soil samples (0-5 cm depth) were collected in small polythene bags from each plot of the experimental field at the end of the crop season. The samples were air dried and organic carbon content in soil samples were determined by Walkley and Black (1934). Available N, P and K from a depth of 0-15 cm were analyzed by alkaline permanganate (KMnO_4) (Subbiah and Asija, 1956), Olsen's method (Olsen *et al.*, 1954) and by flame photometer (Jackson, 1973) respectively.

Apparent potassium recovery : Apparent potassium recovery denotes the proportion of applied potassium taken up by the crop usually expressed as a percentage. AKR (%) is calculated by the help of the formula :

$$\text{AKR} = \frac{\text{Potassium uptake F (kg / ha)} - \text{Potassium uptake C (kg / ha)}}{\text{Quantity of potassium applied}} \times 100$$

Potassium harvest index

$$\text{KHI (\%)} = \frac{\text{K uptake in grain (kg / ha)}}{\text{K uptake in straw (kg / ha)}} \times 100$$

Production efficiency : The production efficiency was computed separately for all the treatments by dividing the grain yield by total crop duration.

Monetary efficiency

$$\text{Monetary efficiency (\text{₹}/\text{ha}/\text{day})} = \frac{\text{Net returns}}{\text{Total crop duration}}$$

Statistical analysis : The experimental data was subjected to statistical analysis by using the standard technique of analysis of variance (ANOVA). The significance of treatment means was tested using F-test (Gomez and Gomez, 1984).

Result and Discussion

Residual soil fertility : The data in Table-1 revealed that the soil fertility status after the harvest of wheat crop was significantly affected by both the residue and potassium management practices. Among the different residue management practices, Soil Organic carbon, available nitrogen, phosphorus and potassium (0.47 %, 173.2, 16.9 and 276.3 kg/ha) respectively were recorded maximum under crop residue incorporation treatment followed by crop residue retention and control. Many researchers have observed a significant increase in SOC owing to integrated use of organic manures and synthetic fertilizers. (Bhandari *et al.*, 2002) However, returning higher quantity of crop residues were associated with increased SOC concentration (Dolan *et al.*, 2006). Returning crop residues into soil increases the soil organic

carbon and nitrogen Malhi and Lemke (2007). Similarly, Nyborg *et al.* (1995) also reported a rise in total soil carbon concentration owing to straw input as compared to straw removal. Meena (2015), also witnessed that status of SOC and availability of macro and micro nutrients in soil got improved by incorporation of paddy straw and Leucaena mulching Crop residue, soil and fertilizer management strategies were found to have an additive interaction on carbon sequestration (Malhi *et al.* 2011). Das *et al.* (2013) found that 13% higher total SOC was observed in top 5 cm soil layer under cotton/maize + wheat residue (C/M+ W Res) as compared with plots without any residues.

Soil organic carbon and the availability of Primary nutrients in soil were increased significantly with different potassium management practices than compare to control (Table-1). In different potassium management practices, the split application of 100 % RDK ($\frac{1}{2}$ at basal + $\frac{1}{2}$ top dress at 25 DAS) recorded the maximum N, P and K content (172.2, 15.7 and 279.1 kg/ha) respectively followed by 100 % RDK and the values with the split application of 50 % of RDK ($\frac{1}{2}$ at basal + $\frac{1}{2}$ top dress at 25 DAS) was at par with 100 % RDK followed by 50 % RDK. The control treatment recorded lowest contents. Ghosh *et al.* (2016) revealed the higher soil carbon sequestration under maize-cowpea based crop rotation by increasing the potassium application rate. Similar results were also reported by Xiaobin *et al.* (2001); Meena *et al.* (2018).

Potassium use efficiencies

Potassium harvest index : The potassium harvest index of wheat was not influenced with different residue and potassium management treatments (figure-1).

Apparent potassium recovery : The data presented in figure-1 showed that apparent recovery of potassium by wheat crop was not significantly influenced with different residue management treatments. Potassium management practices significantly influenced the apparent recovery of potassium by wheat crop (figure-1). In different potassium management practices, the split application of 50 % of RDK ($\frac{1}{2}$ at basal + $\frac{1}{2}$ top dress at 25 DAS) recorded the highest apparent recovery of potassium (43.63 %) followed by the split application of 100 % RDK ($\frac{1}{2}$ at basal + $\frac{1}{2}$ top dress at 25 DAS) (38.92 %), 50 % RDK (33.82 %) and 100 % RDK (28.78 %).

Production and Monetary efficiency : Production and monetary efficiency of wheat crop was significantly influenced with different residue and potassium management practices (Table 2). Among the different residue management practices maximum efficiency was reported under crop residue retention treatment followed by crop residue incorporation than compare to no residue.

Different potassium management practices also showed a significant impact on production and monetary

Table-1 : Effect of residue and potassium management on residual soil fertility after harvest of wheat crop.

Treatment	Nutrient status after harvest			
	Organic carbon (%)	Available Nitrogen (kg N/ha)	Available Phosphorus (kg P/ha)	Available Potassium (kg K/ha)
Residue management				
No residue	0.47	162.5	13.5	262.9
Maize residue incorporation @ 3t/ha	0.51	173.2	16.9	276.3
Maize residue retention @ 3t/ha	0.50	170.1	15.8	269.9
SEm±	0.008	1.00	0.05	1.57
CD (P=0.05)	0.033	4.05	0.20	6.32
Potassium management				
Control	0.47	163.9	15.1	253.6
50% RDK	0.48	167.1	15.3	265.3
100% RDK	0.50	170.1	15.6	276.0
50% RDK (½ at basal + ½ top dress at 25 DAS)	0.49	169.1	15.6	274.6
100% RDK (½ at basal + ½ top dress at 25 DAS)	0.51	172.2	15.7	279.1
SEm±	0.006	0.78	0.06	2.21
CD (P=0.05)	0.017	2.29	0.18	6.50

*RDK= Recommended dose of K

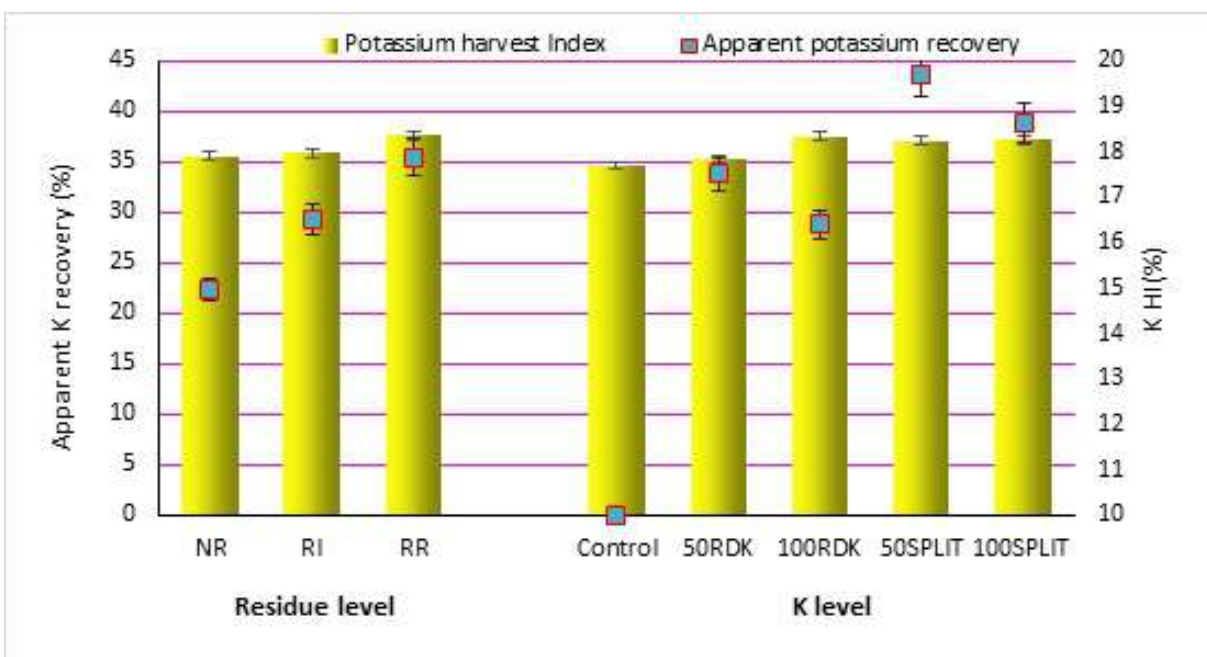


Figure-1 : Effect of crop residue and potassium management on KHI (%) and apparent potassium recovery (%) of wheat.

efficiency of wheat (Table-2). Among the different potassium management treatments the split application of 100 % RDK (½ at basal + ½ top dress at 25 DAS) recorded the maximum efficiency followed by 100 % RDK and the efficiency with the split application of 50 % of RDK (½ at basal + ½ top dress at 25 DAS) was at par with 100 % RDK followed by 50 % RDK and the control treatment recorded minimum efficiency.

Conclusions

The residue and potassium management practices significantly influenced the nutrient uptake by wheat crop. Additionally, potassium recovery, Production and monetary efficiency were also significantly affected by respective management practices. Based on the research findings of experiment, it can be concluded that residue retention treatment with the split application of 100 %

Table-2 : Effect of crop residue and potassium management on production efficiency and monetary efficiency of wheat.

Treatments	Production efficiency (kg / ha/ day)	Monetary efficiency (₹ / ha/ day)
Residue management		
No residue	36	705
Maize residue incorporation @ 3t/ha	40	740
Maize residue retention @ 3t/ha	41	769
SEm±	0.38	5.44
CD (P= 0.05)	1.54	21.94
Potassium management		
Control	33	606
50% RDK	38	707
100% RDK	42	790
50 % RDK (½ at basal + ½ top dress at 25 DAS)	41	768
100 % RDK (½ at basal + ½ top dress at 25 DAS)	43	819
SEm±	0.577	13.03
CD (P= 0.05)	1.69	38.28

*RDK= Recommended dose of K

RDK(½ at basal + ½ top dress at 25 DAS) was found optimum in terms of crop performance, economics, use efficiency of applied potassium and residual fertility status of soil.

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Effect of Foliar Application of Plant Growth Regulators and Nutrients on Flowering, Matutity and Grain Yield of Pearl Millet under Rainfed Condition

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Abstract

A field experiment was conducted to study the effect of plant growth regulators and nutrients on yield attributes and yield of pearl millet for three years during *Kharif* 2014, 2015 and 2016 at three locations with four replications in Randomized Block Design. Seven treatments of plant growth regulators and nutrients were comprised of untreated control, distilled water, thiourea 1000 ppm, benzyl adenine 25 ppm, benzyl adenine 50 ppm and potassium chloride 0.75 % & 1.50%. The results revealed that foliar application of bio regulators and nutrients had significant impact on number of effective tillers, chlorophyll content and plant height. Foliar application of potassium chloride 1.50% at 25-30 tillering stage (DAS) and 40-45 post-anthesis stage (DAS) was found effective for enhanced vegetative growth and higher grain yield.

Key words : Plant growth regulators, nutrients, benzyl adenine, potassium chloride, pearl millet, rainfed condition

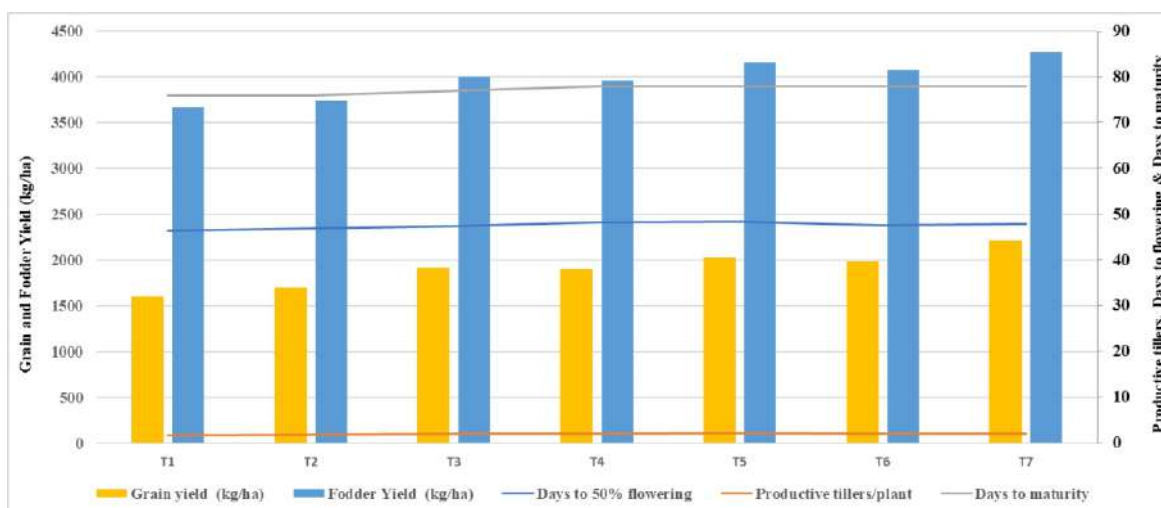
Introduction

Pearl millet is the most important millet crop for human as well as animal feeding. It is grown in arid and semi-arid region occupying fourth position among the cereals next to rice, wheat and sorghum, both in term of area (7.41 mha) and in production (10.30 mt) with an average productivity of 1391 kg/ha (1). Drought is the most severe abiotic stresses that affects growth and development of crop plants. Although, pearl millet is drought resistant and tolerant crop, the potential yield is reduced when it is grown under rainfed condition. There is limitation of nutrients application by soil under rainfed condition. Growth regulators are bio- chemical substances which can modify the growth and developmental processes leading to enhanced yield, improved grain quality or aided harvesting (2). Pearl millet responds to plant growth regulators application to increase yields. Foliar application of PGRs with associations of nutrients can be effective to mitigate the drought effect, and also enhance the productivity of pearl millet under rainfed condition. Prabha (3) reported that the foliar application of PGRs and nutrients twice at 50 and 70 days after sowing gave better yield and economic returns. Foliar application of potassium enhanced the drought tolerance, growth and yield components in wheat (4). Chang *et al.* (5) described that the exogenous application of cytokinin postponed leaf wilting under drought stress. Thiourea is effective in improving plant growth and development under drought, salinity, heat stress and heavy metal toxicity. At physiological level, it improves the leaf gas exchange,

nutrient acquisition by the root and assimilation thereafter. At biochemical level, exogenously applied thiourea improves the sugar metabolism and enhances the proteins biosynthesis (6). Hence, the present field trial was planned and conducted to enhance the productivity of direct sown pearl millet by using plant growth regulators and nutrients under rainfed condition.

Materials and Methods

The experiment was conducted at three locations i.e. RARI Dugapura (Jaipur), Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar and AICRP on Pearl Millet, PC unit farm, Mandor (Jodhpur) India during rainy season 2014 to 2016 with GHB 558 pearl millet hybrid. The experiment was laid out in randomized block design with four replications and seven treatments viz., untreated control (T1), distilled water (T2), Thiourea 1000 ppm (T3), Benzyl adenine 25 ppm (T4), Benzyl adenine 50 ppm (T5), Potassium chloride 0.75% (T6) and Potassium chloride 1.50% (T7) which were applied as foliar spray at tillering and pre-anthesis stage. The gross plot size was 5.0 m x 2.4 m (four row of five meters length) and net plot size was 4.0 m x 1.2 m (two row of four meters length). All the recommended practices of the locations were followed for raising the crop. The observations viz., grain yield, fodder yield, dry ear head weight and total dry matter yield were observed on net plot basis and converted in to kg/ha, while plant height and number of effective tillers were taken on five randomly selected plants from in each net plot.



Graph-1: Effect of foliar spray of bio regulators and nutrients on number of productive tillers, days to 50% flowering and days to maturity.

Results and Discussion

Application of Benzyl adenine 50 ppm (T5) produced maximum productive tillers and it was on par with the application of Potassium chloride 0.75% (T6) and Potassium chloride 1.50% (T7) (Graph-1). The work of Emam and Moaied (7) winter barley and Shekoofa and Emam (8) on winter wheat confirmed that the increased grain yield was the result of higher grain number and significant inhibition on the growth of unproductive tillers with NAA application and the elimination of unproductive tillers promoted the growth of productive tillers at an appropriate concentration whereas days to 50% flowering did not differ significantly among different treatments. Improvements in morph-physiological parameter contributed to grain yield and its attributing characters. Foliar application of growth-regulating substances improved the vegetative growth at the latter phase of the pearl millet crop under rainfed conditions. Grain yield, fodder and ear head weight and total dry matter were found significantly highest with foliar application of potassium chloride 1.50% (2212 kg/ha, 4266 kg/ha and 6882 kg /ha) in comparison to other treatments and control. Shivkumar and Krishna (9) described that foliar spray of potassium chloride 1% + benzyl amino purine 50 ppm registered highest root length (17.2 cm), leaf area (425.3 cm²), leaf area index (1.82) and leaf area duration (55.7 days) as compared to other treatments in finger millet. Parihar et al. (10) reported that foliar spray of 1000 ppm thiourea at pre-flowering stage of pearl millet significantly enhanced the crop growth and dry matter as compared to water sprayed control plants. Jagetiya and Kaur (11) also stated that foliar spray with 2000 ppm of thiourea increased chlorophyll content, shoot dry weight and final weight per 100 seeds by delaying senescence and improving photosynthetic capacity in soybean. Abou Aziz et al. (12) found that application of benzyl adenine

significantly increased the Shoot & Leaf Weight (SLW) as compared to the control. The increase in the SLW by benzyl adenine could be due to stimulating dry mass production through enhancement of cell division and chlorophyll accumulation which leads to higher photosynthetic activity and accumulation of dry matter.

Conclusions

From the present investigation it is evident that foliar spray of plant growth regulators and nutrients at tillering and post-anthesis stage influenced growth and yield attributing traits. Foliar application of potassium chloride 1.5% (7.5 kg/ha in 500-liter water) at 25-35 and 45-50 DAS was found to enhance vegetative growth and higher grain yield of pearl millet. The findings can be used to improve productivity of pearl millet under rainfed condition.

Acknowledgement

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The Effectiveness of Plant Product's Against *Rhyzopertha dominica* Fab. (Lesser Grain Borer)

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Abstract

The Present study entitled The effect of Plant products in their management and the most effective plant products against lesser grain borer, *R. dominica* Fab. The study was carried out at the experimental laboratory of Department of Entomology, College of Agriculture, and Gwalior The lesser grain borer, *Rhyzopertha dominica* is one of the important storage pests of wheat. 10 different wheat varieties were collected from Department of Genetics and Plant Breeding, RVSKVV, Gwalior, were evaluate resistance/susceptibility against lesser grain borers. The wheat grains are treated with three types of Plant products namely Custard apple seed powder, jamun seed powder, neem seed kernel powder Maximum (22.30) population was observed in grains treated with jamun seed powder 0.5 per cent, maximum grain damage was recorded in grains treated with jamun seed powder at 0.5 per cent (12.73%) apart control (39%) and per cent weight loss. While, maximum weight loss was recorded in grains treated with jamun seed powder at 0.5 per cent (13.51%) followed by jamun seed powder at 1.0 per cent (11.55%). The grains treated with neem seed kernel powder 0.5 per cent and 1 per cent and custard apple seed powder 1 per cent showed complete mortality. While, least mortality was recorded in grains treated with jamun seed powder at 0.5 per cent (79.67%).. While, lowest population was recorded in grains treated with jamun seed powder at 0.5 per cent (20.33) when compared to control (53.33).

Key words : plant products, resistance, susceptibility, against.

Introduction

Wheat is the second most important cereal crop after rice and it contributes nearly 25 per cent to the national food basket (Wheat.org). Wheat comprises of higher protein content than maize or rice and other cereal grains (Anonymous, 1976). In India It is staple food for many humans and is of prime importance on that basis when compared to other Cereals Wheat occupies the highest cropping area compared to any other commercial crop (Arya M and Tiwari R. 2013). Based on the duration of storage of wheat, its quality is affected the most in due to infestation by a number of insect pests. Due to its destructive nature in both larval as well as in adult stages Lesser grain borer, *R. dominica* incidence is seen in both field and storage, Their indiscriminate in the storage, however, has led to a number of problems including insect resistance, toxic residues in food grains (Fishwick, 1988), the poor storage facilities of traditional farmers in the developing countries are unsuitable for effective conventional chemical control, as most of the storage types are open to re-infestation by insect pests (Tapondjou *et al.*, 2002) environment pollution and increasing cost of application. Plant material based insecticides are target specific, non-toxic to human being and beneficial organisms, less prone to insect resistance and resurgence, biodegradable and less expensive and are promising grain protectants. Plant materials constitute

a rich source of bio-active chemicals (Wink, 1993). Hence, they could lead to the development of new classes of safer insect control agents. There are some reports that invigorate that the usage of certain indigenous plant products as grain protectants were found to be quite effective (Sundria *et al.*, 2001).

Research Methodology

The experimental study for the management of lesser grain borer in wheat was conducted in the laboratory of the Department of Entomology, College of Agriculture, Gwalior, Madhya Pradesh, during the year 2019-2020. Seed material of 10 different seed varieties was acquired from RVSKVV, Gwalior and stored efficiently in a sterilized container. The study was done by taking 100 grams of grains of each wheat variety in plastic containers of 250 grams capacity for each replication to evaluate resistance/susceptibility against lesser grain borer. Five days old adults collected from stock culture are taken into pairs and ten pairs are released in each plastic jar and they are covered with muslin cloth and tightly fixed with rubber band to avoid escape of insects and are conditioned in laboratory. The observations were recorded at 30, 60, 90 and 120 days after storage to evaluate the per cent weight loss, per cent grain damage and progeny development (no. of adults emerged).

The wheat grains are treated with plant products.

Three plant products with two concentrations were used viz., Custard apple seed powder (0.5% and 1.0%), Neem seed powder (0.5% and 1.0%) and Jamun seed powder (0.5% and 1.0%) and the observations are recorded at 30, 60, 90 and 120 days after storage (Singh RK, Singh AK and Singh HK.2012). The parameters of per cent grain damage, per cent weight loss, percent adult mortality and population build up were recorded to assess the efficacy of the plant products against lesser grain borer (Shivanna S. 1988).

Results and Discussion

The parameters of per cent grain damage, per cent weight loss, percent adult mortality and population build up were recorded to assess the efficacy of the plant products against lesser grain borer.

Per cent grain damage

30 DAS : The grain damage ranged from 0.00% to 13.93% per cent in different plant products. neem seed powder 0.5 per cent and 1 per cent did not observe any grain damage. While, maximum grain damage was recorded in grains treated with jamun seed powder at 0.5 per cent.

60 DAS : The grain damage ranged from 0.00 to 19.07% in different plant products. neem seed powder 0.5 per cent and 1 per cent did not observe any grain damage. While, maximum grain damage was recorded in grains treated with jamun seed powder at 0.5 per cent (6.03%).

90 DAS : The grain damage ranged from 0.00 to 27.33% in different plant products. neem seed powder 0.5 per cent and 1 per cent did not observe any grain damage. While, maximum grain damage was recorded in grains treated with jamun seed powder at 0.5 per cent (10.53%).

120 DAS : The grain damage ranged from 0.00 to 39% in different plant products, The grains treated with custard apple seed powder at 1 percent, neem seed powder 0.5 per cent and 1 per cent did not observe any grain damage. While, maximum grain damage was recorded in grains treated with jamun seed powder at 0.5 per cent (12.73%) apart control (39%).

Overall mean per cent grain damage : The grain damage ranged from 0.00 to 28.60% in different plant products. The grains treated with custard apple seed powder at 1 percent, neem seed powder 0.5 per cent and 1 per cent did not observe any grain damage. While, all other treatments were at par with each other.

Per cent weight loss

The data collected with respect to effect of plant products on per cent weight loss in grains due to lesser grain borer damage at 30, 60, 90 and 120 days after storage.

30 DAS : The weight loss ranged from 0.00% to 5.16% per cent in different plant products. The grains treated with neem seed powder 0.5 per cent and 1 per cent and custard apple seed powder at 1 per cent did not observe any weight loss. While, maximum weight loss was recorded in grains treated with jamun seed powder at 0.5 per cent (5.16%) followed by jamun seed powder at 1.0 percent (4.05%).

60 DAS : The weight loss ranged from 0.00% to 6.08% per cent in different plant products. The grains treated with neem seed powder 0.5 per cent and 1 per cent and custard apple seed powder at 1 per cent did not observe any weight loss. While, maximum weight loss was recorded in grains treated with jamun seed powder at 0.5 per cent (6.08%) which is at par with jamun seed powder at 1.0 percent (5.05%).

90 DAS : The weight loss ranged from 0.00% to 9.53% per cent in different plant products. The grains treated with neem seed powder 0.5 per cent and 1 per cent and custard apple seed powder at 1 per cent did not observe any weight loss. While, maximum weight loss was recorded in grains treated with jamun seed powder at 0.5 per cent (9.53%) which was at par with jamun seed powder at 1.0 percent (8.47%).

120 DAS : The percent weight loss ranged from 0.00% to 13.51% per cent in different plant products. The grains treated with neem seed powder 0.5 per cent and 1 per cent and custard apple seed powder at 1 per cent did not observe any weight loss. While, maximum weight loss was recorded in grains treated with jamun seed powder at 0.5 per cent (13.51%) followed by jamun seed powder at 1.0 percent (11.55%).

Overall mean per cent weight loss : The per cent weight loss ranged from 0.00% to 9.71% per cent in different plant products. The grains treated with neem seed powder 0.5 per cent and 1 per cent and custard apple seed powder at 1 per cent did not observe any weight loss. While, all other treatments are at par with each other

Per cent adult mortality

The data collected with respect to per cent adult mortality due to plant products at 30, 60, 90 and 120 days after storage

30 DAS : The per cent adult mortality ranged from 100% to 92.67% per cent in different plant products. The grains treated with neem seed kernel powder 0.5 per cent and 1 per cent and custard apple seed powder 1 per cent showed complete mortality. While, least mortality was recorded in grains treated with jamun seed powder at 0.5 per cent (92.67%).

60 DAS : The per cent adult mortality ranged from 100% to 90.33% per cent in different plant products. The grains

Table-1 : Effect of plant products on per cent grain damage by *R. dominica*.

Plant products	Per cent grain damage (%)				Mean
	30 DAS	60 DAS	90 DAS	120 DAS	
Custard apple seed powder (0.5%)	0.87 (5.33)*	4.07 (11.59)*	7.73 (16.12)*	10.53 (18.92)*	7.44 (15.54)*
Custard apple seed powder (1%)	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*
Neem seed kernel powder (0.5%)	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*
Neem seed kernel powder (1%)	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*
Jamun seed powder (0.5%)	4.53 (12.24)*	6.03 (14.17)*	10.53 (18.92)*	12.73 (20.89)*	9.77 (18.00)*
Jamun seed powder (1%)	3.07 (9.98)*	5.07 (12.94)*	9.53 (17.96)*	11.53 (19.84)*	8.71 (16.91)*
Control	13.93 (21.91)*	19.07 (25.88)*	27.73 (31.77)*	39.00 (38.64)*	28.60 (32.10)
SeM±	0.599	0.596	0.477	0.418	2.113
CD@5%	1.711	1.824	1.460	1.280	6.257

(*) Figures in parenthesis are angular transformed and DAS – days after storage.

Table-2 : Effect of plant products on per cent weight loss in grains caused by *R. dominica*.

Plant products	Per cent weight loss (%)				Mean
	30 DAS	60 DAS	90 DAS	120 DAS	
Custard apple seed powder (0.5%)	0.83 (5.18)*	4.00 (11.45)*	6.78 (15.06)*	9.64 (18.07)*	6.81 (14.86)*
Custard apple seed powder (1%)	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*
Neem seed kernel powder (0.5%)	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*
Neem seed kernel powder (1%)	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*
Jamun seed powder (0.5%)	5.16 (13.08)*	6.08 (14.24)*	9.53 (17.96)*	13.51 (21.56)*	9.71 (17.92)*
Jamun seed powder (1%)	4.05 (11.53)*	5.05 (12.93)*	8.47 (16.89)*	11.55 (19.86)*	8.36 (16.56)*
Control	8.89 (17.33)*	11.89 (20.16)*	17.86 (24.99)*	22.82 (28.53)*	17.53 (24.56)*
SeM±	0.612	0.645	0.510	0.436	3.253
CD@ 5%	1.875	1.976	1.562	1.335	9.962

(*) Figures in parenthesis are angular transformed and DAS – days after storage.

treated with neem seed kernel powder 0.5 per cent and 1 per cent and custard apple seed powder 1 per cent showed complete mortality. While, least mortality was recorded in grains treated with jamun seed powder at 0.5 per cent (90.33%).

90 DAS : The percent adult mortality ranged from 100% to 87.67% per cent in different plant products. The grains treated with neem seed kernel powder 0.5 per cent and 1 per cent and custard apple seed powder 1 per cent showed complete mortality. While, least mortality was recorded in grains treated with jamun seed powder at 0.5 per cent (87.67%).

120 DAS : The per cent adult mortality ranged from 100% to 79.67% per cent in different plant products. The grains

treated with neem seed kernel powder 0.5 per cent and 1 per cent and custard apple seed powder 1 per cent showed complete mortality. While, least mortality was recorded in grains treated with jamun seed powder at 0.5 per cent (79.67%).

Overall mean per cent adult mortality: The per cent adult mortality ranged from 100% to 85.89% per cent in different plant products. The grains treated with neem seed kernel powder 0.5 per cent and 1 per cent and custard apple seed powder 1 per cent showed complete mortality. While, least mortality was recorded in grains treated with jamun seed powder at 0.5 per cent (85.89%) which was at par with jamun seed powder 1.0 per cent (89%).

Table-3 : Effect of plant products on per cent adult mortality in grains caused by *R. dominica*.

Plant products	Adult mortality (%)				Mean
	30DAS	60DAS	90DAS	120DAS	
Custard apple seed powder (0.5%)	96.33 (78.98)*	94.67 (76.66)*	93.00 (74.66)*	90.33 (71.89)*	92.67 (74.40)*
Custard apple seed powder (1%)	100.00 (90.00)*	100.00 (90.00)*	100.00 (90.00)*	100.00 (90.00)*	100.00 (90.00)*
Neem seed kernel powder (0.5%)	100.00 (90.00)*	100.00 (90.00)*	100.00 (90.00)*	100.00 (90.00)*	100.00 (90.00)*
Neem seed kernel powder (1%)	100.00 (90.00)*	100.00 (90.00)*	100.00 (90.00)*	100.00 (90.00)*	100.00 (90.00)*
Jamun seed powder (0.5%)	92.67 (74.30)*	90.33 (71.89)*	87.67 (69.44)*	79.67 (63.20)*	85.89 (68.18)*
Jamun seed powder (1%)	94.33 (76.27)*	92.00 (73.59)*	89.67 (71.25)*	85.33 (67.50)*	89.00 (70.78)*
Control	5.33 (13.30)*	7.67 (16.07)*	13.33 (21.40)*	17.67 (24.85)*	12.89 (20.77)*
SeM±	0.511	0.335	0.268	0.326	1.611
CD@5%	1.566	1.027	0.820	0.998	4.769

Table-4 : Effect of plant products on population build up of *R. dominica*.

Plant products	Population build up (Mean)				Mean
	30DAS	60DAS	90DAS	120DAS	
Custard apple seed powder (0.5%)	3.67 (2.04)*	5.33 (2.41)*	7.00 (2.74)*	9.67 (3.19)*	7.33 (2.78)*
Custard apple seed powder (1%)	0.00 (0.71)*	0.00 (0.71)*	0.00 (0.71)*	0.00 (0.71)*	0.00 (0.71)*
Neem seed kernel powder (0.5%)	0.00 (0.71)*	0.00 (0.71)*	0.00 (0.71)*	0.00 (0.71)*	0.00 (0.71)*
Neem seed kernel powder (1%)	0.00 (0.71)*	0.00 (0.71)*	0.00 (0.71)*	0.00 (0.71)*	0.00 (0.71)*
Jamun seed powder (0.5%)	7.33 (2.80)*	9.67 (3.19)*	12.33 (3.58)*	20.33 (4.56)*	14.11 (3.78)*
Jamun seed powder (1%)	5.67 (2.48)*	8.00 (2.91)*	10.33 (3.29)*	14.67 (3.89)*	11.00 (3.36)*
Control	34.67 (5.93)*	36.67 (6.09)*	45.33 (6.77)*	53.33 (7.33)*	45.11 (6.73)*
SeM±	0.069	0.064	0.031	0.079	0.238
CD@5%	0.210	0.197	0.096	0.242	0.704

Population build-up:

The data collected with respect to effect of plant products on population build up of lesser grain borer in different wheat varieties at 30, 60, 90 and 120 days after storage

30 DAS : All the plant products were found effective in disrupting population build up as compared to control. The population build up ranged from 0.00 to 34.67. The grains treated with neem seed kernel powder 0.5 per cent and 1 per cent, custard apple seed powder 1 per cent did not show any population build up. While, lowest population was recorded in grains treated with jamun seed powder at 0.5 per cent (7.33) when compared to control (34.67).

60 DAS : The population build up ranged from 0.00 to 36.67. The grains treated with neem seed kernel powder 0.5 per cent and 1 per cent, custard apple seed powder 1 per cent did not show any population build up. While,

lowest population was recorded in grains treated with jamun seed powder at 0.5 per cent (9.67) when compared to control (36.67).

90 DAS : The population build up ranged from 0.00 to 45.33. The grains treated with neem seed kernel powder 0.5 per cent and 1 per cent and custard apple seed powder 0.5 per cent did not show any population build up. While, lowest population was recorded in grains treated with jamun seed powder at 0.5 per cent (12.33) when compared to control (45.33).

120 DAS : The population build up ranged from 0.00 to 53.33. The grains treated with neem seed kernel powder 0.5 per cent and 1 per cent per cent and custard apple seed powder 1 per cent did not show any population build up. While, lowest population was recorded in grains treated with jamun seed powder at 0.5 per cent (20.33) .

Overall mean population build up : The population build up ranged from 0.00 to 45.11. The grains treated with neem seed kernel powder 0.5 per cent and 1 per cent per cent, and custard apple seed powder 1 per cent did not show any population build up. While, lowest population was recorded in grains treated with jamun seed powder at 0.5 per cent (14.11).

Conclusions

Neem seed kernel powder at 1% and 0.5% and custard apple seed powder at 1% were the best effective among all the plant products which resulted in complete mortality, zero population build up resulting in no grain damage and no weight loss. Jamun seed powder at 0.5% dose recorded high grain damage, high weight loss, high population build up and lesser mortality when compared to other treatments. But all the plant products were effective on lesser grain borer.

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Chemical Management and Damage Potential of Sorghum Stem Borer *Chilopartellus* (Rondani)

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Abstract

Seven insecticides were tested against sorghum stem borer on sorghum variety csv 13 for plant infestation, internodes infestation, peduncle infestation, stem tunnelling, peduncle tunnelling and grain yield. The result found that Flubendiamide 480 SC showed 5 % internode infestation, 5.40% peduncle infestation, 7% stem tunnelling, 6.43% peduncle tunnelling followed by Chlorantraniliprole 18.5 SC. The highest infestation was seen next to untreated control is in NSKE 5% with 21.33% internode infestation, 14.17% peduncle infestation, 20.67% stem tunnelling, 20.23% peduncle tunnelling. The larval population or pupal population recorded showed lowest in Flubendiamide 480 SC followed by Chlorantraniliprole 18.5 SC. The highest grain yield was recorded in Flubendiamide 480 SC 2,296kg per hectare which was followed by Chlorantraniliprole 18.5 SC 1,913kg per hectare. The newer insecticides evaluated against stem borer showed that Flubendiamide 480 SC and Chlorantraniliprole 18.5 SC were the best effective insecticides in management of stem borer.

Key word : Chlorantraniliprole, flubendiamide, internode infestation, NSKE, peduncle infestation, stem tunnelling.

Introduction

It is an important food crop for a large section of people in Africa and Asia and also the main source of fodder and industrial raw material. It ranks third in area and production after rice and wheat. Some researchers believe that global warming will make sorghum a more valuable product in the forthcoming years because of its less need for water (millermagazine.com). The area under the grain sorghum is gradually declining due to its low demand for food and low producer price. In India the annual production for the year 2018 was 3.76 mmt under 4mha with productivity of 383t/ha (Santosh, 2019). Sorghum is well known for its drought tolerance and its water use efficiency is more than other cereals. It is mainly grown in rainfed conditions and preferred by majority of the marginal farmers in Madhya Pradesh during *kharif* season, despite all the adaptable benefits of the crop its average productivity is still low because the grain yield is influenced by various biotic and abiotic factors. More than 150 species of insects have been reported attacking sorghum crops during different stages of its growth. Among them the most damaging species are *Chilo partellus*, (Songa *et al.*, 2001). High damage is seen in maize stalk and nearly 80% yield loss is seen in sorghum by *Chilo partellus* was reported in young crop, where as, similar infestations induced no significant loss when plants were infested soon (6 days) after emergence (Van den berg, 2009). To minimize damage caused by stem borer explore new techniques for the management of insect pests with minimum use of pesticides at the appropriate time or vulnerable stage of insect biology. Keeping in view,

the present studies were carried out on newer insecticides on sorghum in Gwalior (M.P.)

Materials and Methods

An experiment was laid out in the Randomized Block Design in three replications at the experimental field at college research farm, RVSKVV, Gwalior, Madhya Pradesh during the *kharif* season of 2019-2020. with a plot size of 3.00 x 1.8 m. The sorghum cultivar, CSV-13 with a spacing of 45 x 15 cm was sown. The Treatment details including insecticides doses/ha was Chlorantraniliprole 18.5SC 150 ml, Emamectin benzoate 5 SG 150gm, Thiacloprid 21.7 SC 300ml, Spinosad 45 EC 180ml, Flubendiamide 480 SC 100ml, Fipronil 80 WG 100gm, NSKE 5% 25kg and Control (untreated). Observation was recorded on plant infestation, internodes infestation, peduncle infestation, stem tunnelling, peduncle, tunnelling and larval/pupal population of stem borer at harvest. Grain yield per plot was also recorded. The incidence data was subjected to square root and arc sine transformation before ANOVA. The treatment was separated by LSD at (p=0.05).

Results and Discussion

At the time of harvesting the crop, the percent internodes infestation observed was the lowest with Flubendiamide 480 SC with 5% internode infestation which was followed by Chlorantraniliprole 18.5 SC with 8.67% infestation. The highest percent internode infestation apart from untreated control (23.67%), was in NSKE 5% with 21.33%, Spinosad 45SC with 19.53% and Thiacloprid 21.7 SC with 17.20% internode infestation which were all at par with

Table-1 : Effect of different insecticides on sorghum at the time of harvesting during Kharif 2019.

Treatments	Percent internode infestation	Percent peduncle infestation	Percent peduncle tunneling	Percent stem tunneling	Larval/Pupal population/10 plant
T ₁ (Chlorantraniliprole 18.5SC)	8.67 (17.05)*	7.00 (15.32)*	10.80 (19.18)*	8.67 (17.12)*	5.47 (2.34)**
T ₂ (Emamectin benzoate 5SG)	11.63 (19.93)*	7.57 (15.96)*	12.23 (20.47)*	10.33 (18.73)*	7.00 (2.65)**
T ₃ (Thiacloprid 21.7SC)	17.20 (24.50)*	10.33 (18.75)*	16.83 (24.22)*	14.27 (22.16)*	12.33 (3.51)**
T ₄ (Spinosad 45SC)	19.53 (26.22)*	12.50 (20.70)*	19.30 (26.06)*	16.33 (23.83)*	13.00 (3.60)**
T ₅ (Flubendiamide 480SC)	5.00 (12.88)*	5.40 (13.42)*	6.43 (14.69)*	7.00 (15.32)*	3.57 (1.89)**
T ₆ (Fipronil 80WG)	14.40 (22.30)*	9.63 (18.08)*	14.83 (22.65)*	11.70 (20.00)*	10.67 (3.27)**
T ₇ (NSKE 5%)	21.33 (27.51)*	14.17 (22.11)*	20.23 (26.73)*	20.67 (27.02)*	16.33 (4.04)**
T ₈ (Control)	23.67 (29.11)*	20.67 (27.03)*	25.07 (30.04)*	23.67 (29.10)*	19.33 (4.39)**
SE(m)±	0.540	0.374	0.154	0.526	0.096
C.D @ 5%	1.655	1.145	0.472	1.610	0.294

Figures in parenthesis (*) -arc-sinetrans formed and (**) -square-root transformed.

Table-2 : Grain yield due to effect of newer insecticides on stem borer infestation.

Treatments	Grain Yield (t/ha)
T ₁ (Chlorantraniliprole 18.5SC)	19.13(2.19)*
T ₂ (Emamectin benzoate 5 SG)	18.53(2.15)*
T ₃ (Thiacloprid 21.7 SC)	17.15(2.07)*
T ₄ (Spinosad 45 SC)	16.05(2.00)*
T ₅ (Flubendiamide 480 SC)	22.99(2.40)*
T ₄ (Spinosad 45 SC)	18.49(2.15)*
T ₅ (Flubendiamide 480 SC)	15.11(1.94)*
T ₄ (Spinosad 45 SC)	15.09(1.94)*
SE(m)±	0.008
C.D @ 5%	0.026

Figure in parenthesis (*) are square root transformed.

each other. The percent peduncle infestation recorded showed that the lowest percent peduncle infestation was observed with Flubendiamide 480 SC with 5.40% infestation which was followed by Chlorantraniliprole 18.5 SC with 7% infestation. Lowest level of infestation was seen with Flubendiamide 480 SC (7%) which was followed by Chlorantraniliprole 18.5 SC (8.67%) which is at par with Emamectin Benzoate 5SG (10.33%) stem tunnelling.

The percent peduncle tunnelling the lowest peduncle tunnelling was observed in Flubendiamide 480SC (6.43%) which was followed by Chlorantraniliprole 18.5 SC (10.8%). Highest peduncle tunnelling was seen in NSKE 5% with 20.23% followed by Spinosad 45SC with 19.30% except control.

Larval population recorded showed that lowest

population was recorded in Flubendiamide 480 SC (3.57) followed by Chlorantraniliprole 18.5 SC (5.47), Emamectin Benzoate 5SG (7) and Fipronil 80WG (10.67). Thiacloprid 21.7SC (12.33) was at par with Spinosad 45SC (13.00). Highest population was seen in NSKE 5% 16.33 larvae/pupae per 10 plants in that treatment when compared to untreated control (20) (Table-1).

The highest grain yield was recorded in Flubendiamide 480 SC 2,296kg per hectare which was followed by Chlorantraniliprole 18.5 SC 1,913kg per hectare. Lowest grain yield was recorded in NSKE 5% (1511 kg/ha) which was at par with untreated control (1509 kg/ha) (Table-2).

The present findings are in conformity with the findings of Ravinder Kumar and Jawala Jindal (2015),

Jindal *et al.*, (2016), The mean leaf injury incidence was on par at respective doses in Flubendiamide (1.39-2.58%), Novaluron (2.01-2.94%) and fipronil (2.36-3.67%) but significantly less than untreated control (9.58%). Kumar and Alam (2017), Ram Kumar and Tanweer Alam (2017), Jindal Jawala *et al.*, (2018), Reddy *et al.* (2018) and Sudha Rani *et al.*, (2018).

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Author Contribution Statement

R.S.* and K.B conceived designed research. R.S.* and N. conducted experiments. S.S. and K.B. contributed to analytical tools and analysed data. S.S.*, N., K.B. wrote the manuscript. All authors read and approved the manuscript.

Conflicts of Interest / Competing Interests

There are no conflicts of interest among the parties involved in the investigation and among authors. All the authors undergo mutual interests in this investigation.

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Impact of Anthropogenic Activities on Water Quality of Shaliganga River at Doodhpathri of Kashmir Valley

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Abstract

Present study was conducted to find out the impact of touristic and other anthropogenic activities on the water quality of Shaliganga river at Doodhpathri Budgam in spring and summer season. Some selected physico-chemical, nutrient, heavy metal and microbial parameters viz. temperature, pH, EC, Ca, Mg, K, Nitrate N, Na, Fe, Mn, Cu, Zn, Cd, Ni, DO, COD, BOD, Total viable bacteria monitored during study period. Two study sites viz. Inlet and Outlet site were selected for the sampling. It was found that significant change in water quality of Shaliganga river at two sites due to different touristic and anthropogenic activities. Moreover, tourism influx in the Doodhpathri shows a drastic increase in the summer months from June to September, which is responsible for deteriorating the water quality of Shaliganga River. The widespread use of pesticides and fertilizers in horticulture and agriculture during the growth season (June to August), also wastes from hotels and houses is another factor contributing to the Shaliganga River's declining water quality.

Introduction

Our environment has witnessed a continuous and rapid deterioration which cause pollution in all its abiotic and biotic components. Now-a-days water pollution is burning issue all over the world. Like other developing countries water pollution in India also reach in alarming situation due to lack of proper management policies. Hence the quality and quantity of utilizable surface water decreases which ultimately results in water crisis. So there is need for continuous evaluation of water quality and pollution level in order to promote better living condition around the reservoirs and to save the reservoirs before their extreme worst condition of eutrophication (Anu and Bajpai 2011). The physico-chemical parameters of water and the dependence of all life process of these factors make it desirable to take as an environ (Manjare *et al.*, 2010). Surface waters may be contaminated by substances originating from anthropogenic or human sources and due to biogenic processes occurring in the environment. Natural sources may include various pollutant substances, such as clay and silt particles of soils or rocks, plant remnants and humus substances, compounds of iron and manganese, etc. However, pollution caused by various human activities is far more dangerous to the environment (Policht-Latawiec *et al.*, 2015). Increase in tourist flows and the rapid development of tourism infrastructure further increases the quantum of waste generates that accelerates the magnitude of problem in tourist destinations with adverse impact on the environment and problem of sustainable waste management is becoming increasingly relevant in many tourist destinations (Murava and Korobeinykova, 2016).

The quality of freshwater sources has been continuously deteriorated by means of development, pollution, un-planned settlements, industrialization, urbanization, population pressure, agricultural activities, discharge of untreated domestic sewage into fresh water streams, dumping of solid wastes in and around fresh water streams and over exploitation of natural resources by human beings.

Materials and Methods

The present study was carried out in Doodhpathri area of Kashmir. Doodhpathri lies within the geo-coordinates of 33° 54' 23 N latitude and 74° 36' 15 E at an elevation of 2544 meters above sea level, in the Budgam district of Kashmir. Two seasons (Spring and Summer) and two sites were selected viz. inlet site and outlet site (5 km away from inlet site) in Shaliganga river in order to study the physico-chemical properties of water. The study sites were selected on the basis of anthropogenic activities for the purpose of comparison each site, 6 water samples were collected in plastic bottles randomly and used for further analysis. Physico chemical and nutrient analysis of water samples was done by following the standard methods (Trivedy and Goel, 1984 and APHA, 2005).

Results

Assessment of biotic stress on physicochemical parameters of water : The data on the impact of biotic stress on physicochemical parameters of water viz., pH, temperature and electrical conductivity at inlet and outlet site is presented in Table-1. From the mean data it is clear that values of all these parameters showed a significant increase at outlet site as compared to inlet site. The mean

value of pH, temperature, EC observed was 7.15, 5.35 °C and 0.056 dS/m at inlet site while at outlet site, the value recorded was 7.44, 8.88 °C and 0.065 dS/m respectively. Furthermore, all the physicochemical parameters showed an increasing trend in summer season while minimum values were observed in spring season.

Assessment of biotic stress on nutrient status of water : From the data presented in Table-2, it is evident that content of different nutrients showed a significant increase at outlet site as compared to inlet site ($p=0.05$). The water calcium, magnesium, potassium, nitrate nitrogen and sodium content with highest mean values recorded at outlet site viz., 61.29, 9.108, 8.116, 0.390 and 3.21 mg/l as compared to inlet site 46.66, 6.516, 5.509, 0.264 and 2.36 mg/l respectively. Moreover, the nutrient content of water was significantly higher in summer as compared to spring season.

Assessment of biotic stress on heavy metal status of water : In the present investigation, as evident from Table-3, it was observed that the heavy metals viz., iron (Fe), manganese (Mn), copper (Cu), and zinc (Zn) content increased significantly at outlet site as compared to inlet site ($p= 0.05$). However, the cadmium (Cd) content was non-detectable at both inlet and outlet site, while as nickel (Ni) content was also non detectable at inlet site only. The highest mean value for iron, manganese, copper and zinc content in water was observed at outlet site (3.101, 0.06, 0.035, 0.080 mg/l) while as the lowest value was recorded at inlet site (1.824, 0.03, 0.015, 0.042) respectively. Nickel content was only detectable at outlet site with mean value observed as 0.05 mg/l. Moreover, the heavy metal accumulation was significantly higher in summer as compared to spring season.

Total dissolved content (DO, COD and BOD) estimation : From the data in Table-4, it is evident that the observed mean value of DO content was significantly higher (13.591 mg/l) at inlet site when compared to outlet site with observed mean value as 11.391 mg/l. In contrast, the COD and BOD content depicted a significant increase at the outlet site compared to inlet site. The maximum mean values of COD (4.800 mg/l) and BOD (4.000 mg/l) was observed at outlet site while the minimum mean values 2.080 and 1.735 mg/l respectively were witnessed at the inlet site.

Total bacterial count in water : The observed values in Table-5 for total viable bacteria at outlet site were 32 ± 0.31 and 24 ± 0.22 CFU $\times 10^6$ ml⁻¹ which was comparatively higher as that of inlet site with observed values as 25 ± 0.24 and 19 ± 0.18 CFU $\times 10^6$ ml⁻¹ in summer and spring season respectively. Moreover, it is clear from data that the total bacterial count was significantly higher in summer as compared to spring season.

Discussion

Assessment of biotic stress on physicochemical parameters of water : Measurement of pH gives the intensity of acidic or basic nature of water. It gets changed drastically due to pollution, biological activities and temperature fluctuations. Changes in the pH of water may be the result of various biological activities (Gupta *et al.*, 2009). The pH changes in water are governed by the amount of free CO₂, carbonates and bicarbonates. Slightly alkaline condition displays water as hard due to dissolution of Ca and Mg containing limestone and other minerals. Similarly, high nutrient load, pollution, agricultural run-off, domestic and industrial effluents greatly alters the pH of water. The municipal and domestic wastes can also change the pH of the receiving freshwater ecosystems (Sithik *et al.*, 2009). The pH of water ranged between 6.81 and 7.58 seasonally during the entire study period (Table 1). Slightly acidic pH was recorded in summer and slightly alkaline in spring season. This may be attributed due to high temperature which enhances the rate of decomposition of organic matter, releases CO₂ which favours the formation of acidic factors i.e., carbonates in summer conditions. Khalique and Afser (1995), Islam and Islam (1996) and Sithik *et al.* (2009) also reported acidic pH values during summer in different water bodies. A slight rise in pH values was observed during spring. This may be due to rate of decomposition of organic matter in spring was very low due to low temperature conditions which governed the alkaline pH of the water. Seasons have crude impact on water pH concentrations reported by Ruth *et al.* (2013). Similar observations were made by Gupta *et al.* (2009). pH values were recorded slightly acidic at inlet site compared to outlet site, which might be due to domestic, agricultural and commercial runoff (Bansal and Khare, 1990).

Temperature is one of the most essential attribute for functioning and maintaining equilibria positions of chemical reactions in aquatic ecosystems. The temperature of water stream at Doodhpathri ranged between 5.26 °C and 11.86 °C in two different seasons due to changes in air temperature (Table-1). The highest mean value of water temperature was observed in summer (11.00 °C) and lowest (5.58 °C) in spring. Clear sky and solar radiations thereby enhances the air temperature and directly influenced the water temperature during summer. The fluctuation in water temperature has been found maximum at outlet site and minimum at inlet site. This might be due to the direct discharge of domestic wastewater by households and commercial establishments (hotels) could have slight increasing impact on water temperature. The findings were in accordance with many researchers (Bath, 1996; Kaur *et al.*, 2003; Wong *et al.*, 2012).

Electrical conductivity (EC) is an index to represent total quantity of dissolved ions and an estimate which indicates degree of mineralization in a water body. EC reflects the nutrient status of water (Sankpal and Naikwade 2012). Increase in EC values indicates the presence of higher concentration of ions (Deepali *et al.*, 2009; Noortheen *et al.*, 2016). The EC of water showed increasing trend from spring to summer and ranged between 0.053 and 0.067 dS/m in two seasons. Seasons influence greatly to the fluctuations of EC as reported by (Umerfaruq and Solanki 2015). The highest mean value of EC was observed in summer (0.064 dS/m) and lowest (0.058 dS/m) in spring, this may be attributed with high discharge of effluents from agricultural and domestic waste water into the stream. Similar findings were reported by Alam *et al.* (2007), Umerfaruq and Solanki (2015). Low volume of inlet water sources and declining agricultural activities in and around water source might be the reasons of low EC in spring. The EC values were highest at outlet site and lowest at inlet site as the dumping of household discharge and solid waste could have moderately added concentrations of dissolved solids.

Assessment of biotic stress on nutrient status of water : In the present study, Ca was found highest at outlet site and lowest at inlet site and these results are in concordance with results reported by Verma *et al.* (2011). Moreover, the maximum concentration of Ca was detected in summer which might be due to discharge of domestic and agricultural waste water into the water sources and minimum concentration was observed in spring season. The present observations are in accordance with the observations of Sinha and Srivastava (1995), Sirsath *et al.* (2006) and Verma *et al.* (2011). Reducing volume of source water and least agricultural activities could be the reasons of minimum concentration of Ca in spring which is in accordance with findings reported by Ramesh and Selvanayagam (2013). The maximum concentration Ca was observed at outlet compared to inlet site and this may be attributed to the discharge of domestic sewage, agricultural run-off and dumping of solid wastes, which is an agreement with the results reported by Khan *et al.* (2004), Toma *et al.* (2011), Khan *et al.* (2012).

Magnesium (Mg) is an essential cation detected in all kinds of natural waters. Venkatasubramani and Meenambal (2007) reported that magnesium is often associated with calcium in all kinds of waters, but its concentration remains generally lower than the calcium. Mg concentration depends upon sewage discharges, industrial wastes, agricultural run-off and weathering of rocks. Verma *et al.* (2011) reported interrelated results while studying the physiochemical characteristics of Kankaria Lake. Similar findings have been reported by

Toma *et al.* (2011), Khan *et al.* (2012). In summer the concentration of magnesium is much higher than spring due to plenty of mineral rocks such as dolomite and gypsum in water because of flooding and also optimum temperature for the growth and development of macrophytes which result in more Mg is present in water stream.

The highest Mg concentration was found at outlet site followed by inlet site and this results are in conformity with findings reported by Goldman (1960), Bhuiyan and Gupta (2007).

Potassium is naturally present in water from weathering and erosion of silicate, mica, feldspars, clay minerals (Krishnamurthi and Bharati, 1994) and leaching of plant and animal residues. Potassium pollution in water can occur from the application of potassium permanganate as an oxidant in water treatment process and application of potassium salts as water softeners. The results are concordance with finding reported by Siraj *et al.* (2010). Furthermore, the maximum K concentration was found in summer and minimum in spring which may be attributed to the large quantity of synthetic fertilizers used in agricultural fields, and discharge of untreated sewage and dumping of solid wastes in and around the water stream. In spring, the reduced agricultural activities and reduced rate of weathering of bedrocks due low water volume could lead to the decline in concentration of K. The findings coincide with the observations reported by Ramesh and Selvanayagam (2013). Furthermore, the highest concentration of K was found at outlet compared to inlet site. This may be attributed that high input of discharged organic wastes, agricultural run-off and domestic sewage into the water. These observations coincide with the findings of Krishnamurthy and Bharati (1994).

The higher concentration of nitrates in water bodies is an indication of higher pollution load in water bodies. In fresh water, nitrogen content is naturally produced from mineralization of organic matter (detritus), nitrification and denitrification processes. Nitrate nitrogen pollution of surface waters is mainly due to discharge of municipal/domestic wastewaters and agricultural runoff including animal feedlots. Nitrogen pollution by high nitrate can cause eutrophication in surface waters (Fried, 1991; Mlitan *et al.*, 2015). Very high levels of NO_2^- in waters indicate unsatisfactory microbial activity (Das and Acharya, 2003). It is known for its toxicity effects on aquatic plants, biota as well as on human beings. Nitrate-nitrogen ($\text{NO}_3\text{-N}$) in water was varied between in two seasons. The findings are in conformity with the findings of Zimba *et al.* (2001), Parveen *et al.* (2013) and Singh and Choudhary (2013). Furthermore, highest

Table-1 : Assessment of biotic stress on physicochemical parameters of water at different sites.

Parameters	Site	Season		Mean	C.D (P=0.05)
		Spring	Summer		
pH	Inlet	7.50±0.20	6.81±0.172	7.15	Sites (S): 0.155
	Outlet	7.58±0.30	7.30±0.30	7.44	Season (S): 0.155
	Mean	7.54	7.05		Sites × Season (S × S): 0.310
Temperature (°C)	Inlet	5.26±0.09	10.15±0.16	5.35	Sites (S): 0.088
	Outlet	5.91±0.05	11.86±0.05	8.88	Season (S): 0.088
	Mean	5.58	11.00		Sites × Season (S × S): 0.176
Electrical conductivity (dS/m)	Inlet	0.053±0.001	0.060±0.002	0.056	Sites (S): 0.002
	Outlet	0.063±0.001	0.067±0.004	0.065	Season (S): 0.002
	Mean	0.058	0.064		Sites × Season (S × S): 0.004

The data are given in Mean±Standard Error of 6 replicates.

Table-2 : Assessment of biotic stress on different nutrients (mg/L) in water at different sites.

Parameters	Site	Season		Mean	C.D (P=0.05)
		Spring	Summer		
Calcium (Ca)	Inlet	34.140±2.608	59.195±2.625	46.66	Sites (S): 2.595
	Outlet	47.160±3.046	75.425±4.250	61.29	Season (S): 2.595
	Mean	40.650	67.310		Sites × Season (S × S): 5.19
Magnesium (Mg)	Inlet	5.466±0.771	7.566±0.771	6.516	Sites (S): 0.481
	Outlet	8.066±0.750	10.150±0.763	9.108	Season (S): 0.481
	Mean	6.766	8.858		Sites × Season (S × S): 0.962
Potassium (K)	Inlet	4.566±0.271	5.356±0.541	5.509	Sites (S): 0.371
	Outlet	7.050±0.363	8.107±0.640	8.116	Season (S): 0.371
	Mean	5.798	7.876		Sites × Season (S × S): 0.742
Nitrate nitrogen (NN)	Inlet	0.244±0.003	0.283±0.003	0.264	Sites (S): 0.002
	Outlet	0.371±0.002	0.410±0.003	0.390	Season (S): 0.002
	Mean	0.308	0.346		Sites × Season (S × S): 0.004
Sodium (Na)	Inlet	1.71±0.63	3.01±0.45	2.36	Sites (S): 0.312
	Outlet	2.47±0.37	3.95±0.40	3.21	Season (S): 0.312
	Mean	2.09	3.48		Sites × Season (S × S): 0.624

The data are given in Mean±Standard Error of 6 replicates.

concentration of NO₃-N was detected in summer followed by spring. High volume agricultural, domestic run-off and organic load in summer and spring could be the main reasons of high concentration of NO₃-N. Similar findings have been reported by Abdar (2013), Shilpa *et al.* (2011). The highest NO₃-N was recorded in outlet site compared to inlet site.

This might be due to high discharges of sewage, agricultural run-off which drastically triggers the NO₃-N concentration at these sites. Similar results was also reported by Jaji *et al.* (2007), Zimba *et al.* (2001), Umerfaruq and Solanki (2015).

In natural waters, sodium (Na) occurs as halide salt (NaCl), Sodium tetraborate and sodium sulphate. The weathering of various rocks is the major source of Na. The harmful effects of high concentration of Na⁺ on water could be related to structure, infiltration and permeability rates. During natural softening of water, Na is exchanged by Ca and Mg and thus gets increased in concentration in

surface waters. In the present study the highest value of Na was found in summer and lowest in spring. The high pollution rate in the form of untreated domestic sewage, agricultural run-off, dumping of solid wastes could be the main reasons of high concentration of Na in summer, and reduced agricultural activities in spring. The present observations are in conformity with the findings of Mitra (1997). Furthermore, the highest concentration of Na was observed at outlet site and lowest at inlet site (Table 7).

The high concentration of Na is associated with discharge of domestic sewage, agricultural run-off, wastes from commercial units, weathering of bedrocks and erosion in the catchment area which is mainly mountainous in nature. The results are agreement with the findings of Mishra and Saxena (1991) and Soalnki (2001).

Assessment of biotic stress on heavy metal status of water : The pollution of the waters with heavy metals has become a worldwide problem during recent years,

Table-3 : Assessment of biotic stress on heavy metals status (mg/L) in water at different sites.

Parameters	Site	Season		Mean	C.D (P=0.05)
		Spring	Summer		
Iron (Fe)	Inlet	1.203±0.005	2.445±0.016	1.824	Sites (S): 0.009
	Outlet	2.786±0.012	3.416±0.012	3.101	Season (S): 0.009
	Mean	1.995	2.930		Sites × Season (S × S): 0.018
Manganese (Mn)	Inlet	0.02±0.002	0.04±0.001	0.03	Sites (S): 0.001
	Outlet	0.05±0.001	0.07±0.0002	0.06	Season (S): 0.002
	Mean	0.035	0.055		Sites × Season (S × S): 0.04
Copper (Cu)	Inlet	0.01±0.001	0.02±0.002	0.015	Sites (S): 0.001
	Outlet	0.03±0.002	0.04±0.002	0.035	Season (S): 0.001
	Mean	0.02	0.03		Sites × Season (S × S): 0.01
Zinc (Zn)	Inlet	0.032±0.01	0.052±0.03	0.042	Sites (S): 0.021
	Outlet	0.069±0.03	0.091±0.04	0.080	Season (S): 0.021
	Mean	0.050	0.071		Sites × Season (S × S): 0.033
Cadmium (Cd)	Inlet	ND	ND		Sites (S): ND
					Season (S): ND
	Outlet	ND	ND		Sites × Season (S × S): ND
Nickel (Ni)	Inlet	ND	ND		Sites (S): ND
					Season (S): ND
	Outlet	0.040±0.03	0.060±0.04	0.05	Sites × Season (S × S): ND

The data are given in Mean±Standard Error of 6 replicates

Table-4 : Assessment of biotic stress on DO, COD and BOD (mg/L) in water at different sites.

Parameters	Site	Season		Mean	C.D (P=0.05)
		Spring	Summer		
DO	Inlet	14.420±0.022	12.763±0.0121	13.591	Sites (S):0.239
	Outlet	11.603±0.020	11.180±0.551	11.391	Season (S): 0.239
	Mean	13.011	11.971		Sites × Season (S × S):0.478
COD	Inlet	1.601±0.087	2.560±0.247	2.080	Sites (S): 0.162
	Outlet	4.360±0.223	5.240±0.210	4.800	Season (S): 0.162
	Mean	2.980	3.900		Sites × Season (S × S): 0.324
BOD	Inlet	1.338±0.072	2.133±0.206	1.735	Sites (S): 0.135
	Outlet	3.633±0.186	4.366±0.175	4.000	Season (S): 0.135
	Mean	2.485	3.250		Sites × Season (S × S): 0.27

The data are given in Mean±Standard Error of 6 replicates

because they are indestructible and most of them have toxic effects on organisms (MacFarlane and Burchett, 2000). Among environmental pollutants, heavy metals are of particular concern, due to their potential toxic effect and ability to bio-accumulate in aquatic ecosystems (Censi *et al.*, 2006). Heavy metals in particular are major toxicants present in surface water (Yasuhiro *et al.*, 2007). Heavy metals are one of the serious pollutants in natural environment due to their toxicity, persistence and bioaccumulation problems (Pekey, 2006; Nouri *et al.*, 2006).

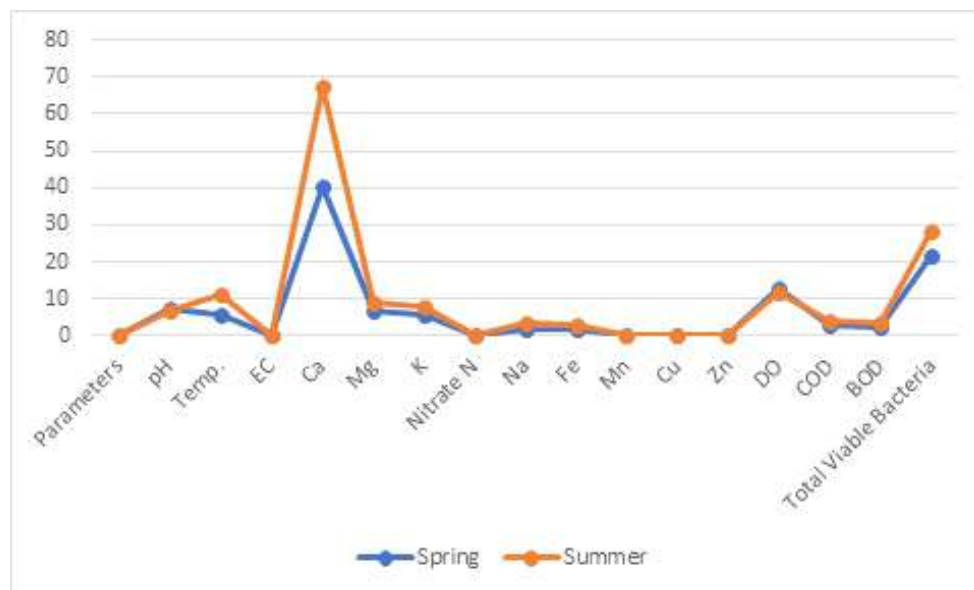
Chemical weathering of geological materials is the major source of Fe in natural waters. Anthropogenic sources of Fe in water include industrial wastewaters from units, such as, iron smelting, textiles, pigments/paints and agriculture (Girija *et al.*, 2007). Many Fe salts are also employed as coagulants in water treatment (Renoldi *et*

al., 1997). Precipitation of Fe (II) salts as insoluble Fe (III) hydroxide produces rust-coloured silt in water supplies (Girija *et al.*, 2007). Surface and ground water show appreciable quantities of Fe²⁺ when acidic. The Fe concentration at inlet and outlet sites significantly varied between 1.995 and 2.930 mg/L in two seasons. Similar findings have been reported by Jirsa *et al.* (2013) while studying the trace element geochemistry in Lake Bogoria and river Nakuru. Moreover, the highest Fe concentration was found in summer and lowest in spring season. This can be associated to cumulative effect of the discharge of untreated wastes from point, non- point, geological, erosion of soil in the steep catchment, agricultural run-off and pedogenic sources. The results are concordance with findings reported by Rocher *et al.* (2004), Reiss *et al.* (2004), Wildi *et al.* (2004), Jirsa *et al.* (2013). The highest value of Fe was found at outlet site while lowest value of

Table-5 : Total viable bacteria CFU $\times 10^6$ ml⁻¹ in water.

Sites	Season		Mean
	Spring	Summer	
Inlet	19 $\pm$ 0.18	25 $\pm$ 0.24	22
Outlet	24 $\pm$ 0.22	32 $\pm$ 0.31	28
Mean	21.5	28.5	

Mn concentration was observed in two seasons during the study period. Kassaye *et al.* (2016) reported similar findings in Lake Ziway and Lake Awassa in the Ethiopia Rift Valley. Moreover, the highest value of Mn was found in summer and least concentration was observed in spring (Table-3). The agricultural run-off, soil erosion,

**Fig.-1 : Graphical representation of mean values of water quality parameters at different seasons.**

Fe was found at inlet site (Table-3). Discharge of wastewater from urban/rural settlements, washing of vehicles and dumping of waste could be possible reasons for high concentration of Fe²⁺. Anthropogenic sources of Fe in local environment are largely attributed to corrosion of Fe and steel structures in buildings, pipe lines, dumpsites and vehicles (Jaji *et al.*, 2007).

Manganese (Mn), one of the most abundant elements in the earth's crust and is an essential nutrient for both humans and animals. Mn is essential for the functioning of many cellular and metabolic activities because it is a functional component of many metalloenzymes such as Mn-superoxide dismutase, pyruvate carboxylase etc. acts as a cofactor for many enzymatic processes (Cook *et al.*, 1974; Deskin *et al.*, 1980). Mn naturally occurs in many water sources. However, human interference is increasingly responsible for causing Mn contamination in natural waters. Production and use of Mn compounds such as fungicides, fertilizers, varnish and as livestock feeding supplements may lead to environmental Mn contamination. Mn²⁺ occurs naturally in many water sources and groundwater sources and in soils that may erode into waters. Human activities are also responsible for much of the Mn²⁺ contamination in water (Davis and Greger, 1992). In the present study significant variation (0.035-0.055 mg/l) of

washing of vehicles around the water stream, domestic sewage, and wastes from automobile workshops could be the main reason of high concentration of Mn in summer and minimum above activities have least impact on Mn concentration during spring. Human activities such as industrialization, agriculture and urbanization together with increasing human population around and near the water streams have also been reported having their influence on water quality through elevated level of contaminants (Zinabu, 1998; Zinabu and Pearce, 2003; Masresha *et al.*, 2011). Furthermore, significant variation of Mn was found among sites. However, the highest concentration of Mn was at outlet site compared to inlet site. The dominated anthropogenic activities viz., agriculture, commercial, rearing of animals and domestic sewage may be attributed to the high Mn at the outlet site. The findings are concordance with findings of Ahmed and Mohamed (2005), Ntakirutimana *et al.* (2013), Goher *et al.* (2014).

Copper (Cu) is one of the essential metals to sustain healthy development of the living organisms because many physiological processes depend on it. However, exposure to higher concentration produces many toxic effects in the biota (Linder and Hazegh-Azam, 1996). Industrial waste, mining and metal plating are common sources of Cu in natural waters. It is employed in

plumbing, roofing and in chemical industry, for examples, as paints and pigments and azo dye manufacture (Lonnerdal, 1996). Cu compounds also found in fungicides, insecticides, algicides and wood preservatives (Novotny and Olem 1994). The concentration of Cu in the water significantly varied between 0.02 and 0.03 mg/L in two seasons. The findings are accordance with results reported by Salem *et al.* (2014), Benila and Sumithra (2015). Furthermore, the high values of Cu were recorded in summer and least in spring (Table 3). This may be attributed that agricultural run-off, domestic waste, washing of copper utensils in and around the water stream, washing of vehicles, weathering of bedrocks, erosion during could enhanced the values of Cu in summer. The variation of site-wise Cu was also found significant. However, the maximum Cu was detected at outlet site compared to inlet site. Huge influx of agriculture, domestic sewage and dumping of solid wastes could be the main reason for increased Cu at outlet site. The current findings are agreement with the findings reported by Prasath and Khan (2008), Lawson (2011), Salem *et al.* (2014), Benila and Sumithra (2015).

Zinc (Zn) is one of the earliest known trace metals and a common environmental pollutant, which is widely distributed in the aquatic environment. The sources of Zn include mining of Zn ores and wastes from industries manufacturing products such as corrosion-resistant alloys and galvanized iron and steel products. Zinc oxide, used as a white pigment in rubber, for example, is the most common industrial Zn compound (Vallee and Falchuk, 1993). Tyre wear is a major source of Zn input in the environment (Eisler 1993). The other two major commercial Zn compounds are zinc chloride used in dry cells and Zn use in electroplating. Other sources of Zn include fertilizers and pesticides (zinc phosphide and zinc sulphide), printing processes, building materials, sewage wastewater, animal wastes, coal combustion and atmospheric depositions. In aquatic ecosystems, Zn is an essential micro-nutrient but at higher concentrations, it can cause toxicity to animals and human through drinking water. In the present study Zn concentration in the water was found fluctuating significantly and varied between 0.050 and 0.071 mg/L in two seasons. Similar findings have been reported by Benila and Sumithra (2015). Moreover, the values of Zn were found highest in summer and lowest in spring (Table 3). This may be attributed due to high anthropogenic activities. The findings are concordance with findings reported by Eisler (1993), USEPA (1987). Significant variation of Zn values were observed among the sites. The highest concentration of Zn was found at outlet site compared to inlet site. The disposal of industrial waste, discharging of agricultural drainage as well as sewage effluent from industries,

settlements around the area could be responsible for the high concentrations of Zn. This opinion was equally shared by Eisler (1993), Adeniyi *et al.* (2008).

At all the two sites of Doodhpathri Kashmir viz, inlet and outlet cadmium (Cd) was not being traced/detected from the water.

Under environmental conditions, the most prevalent oxidation state of Ni is Ni^{2+} . Ni is released in the environment from both natural sources and human-induced activities. Natural sources include weathering of rocks and soils. Ni and its alloys find wide applications, especially as pigments and catalysts, Ni-Cd batteries, electroplating and food processing industries (Sitting, 1976). Ni is mostly utilized for the production of stainless steel and other high temperature and corrosion resistance non-ferrous alloys and super alloys (Flint and Packirisamy, 1995). Ni salts of chloride, sulphate, acetate, carbonate, nitrate, hydroxide and oxide are of greatest commercial importance. Ni enters water bodies due to atmospheric depositions from combustion of coal, fuel oil and diesel oil. Other sources of Ni in water sources include domestic wastewater effluents and non-ferrous metal smelters (Flint and Packirisamy, 1995). Although Ni is essential for some important physiological functions in organisms, at high exposure it may be toxic. Drinking water and food are the most important sources of Ni in the human body. In the present study Ni concentration in the water was only found at outlet site, it significantly varied between 0.040 and 0.060 in two seasons. These findings are concordance with findings reported by Salem *et al.* (2014), Kassaye *et al.* (2016). The highest value of Ni was recorded in summer and lowest was observed in spring at outlet site (Table 3). The discharge of wastes from vehicle workshops, commercial activities and geological inputs could have impact of high values of Ni in the water during summer conditions. The major anthropogenic sources of nickel in the environment are combustion of fossil fuels, electroplating, and smelting industries, batteries, and electronics (Birge and Black 1980; USEPA, 1986). However, the values of Ni were detected highest at outlet site and was not found at the inlet site. Human activities such as industrialization, agriculture and urbanization together increasing human population around and near the water streams and lakes having their influence on water quality through elevated level of contaminants especially trace elements (Zinabu, 1998; Zinabu and Pearce, 2003; Masresha *et al.*, 2011).

Total dissolved contents (DO, COD and BOD) : Dissolved oxygen (DO) concentration is a crucial part of water quality, especially surface water assessment and monitoring programs since oxygen plays essential role in nearly all chemical and biological processes occurring in

aquatic ecosystems (Pandey *et al.*, 1993). Dissolved oxygen reflects the physical and biological process in water, shows the metabolic balance and DO level acts as an indicator of water body (Pradhan *et al.*, 2012). In addition to its requirement in respiration of the most aquatic organisms; it also combines with elements such as carbon, nitrogen, sulphur and phosphorous to form their respective compounds like carbonate, nitrate, sulphate and phosphate required for the aquatic biota to survive (Spasojevic *et al.*, 2005). DO content in water bodies is function of ambient temperature, salinity, turbulence, atmospheric pressure and biological activity. The concentration of DO indicates pollution load, the degradation of organic materials and the intensity of self-purification capacity of the aquatic bodies. In the present study data on DO in the water was found between of 13.011 and 11.971 mg/L in two seasons (Table 4). The findings are in agreement with findings earlier reported by Patel and Datar, 2014; Pandey *et al.*, 1993. The highest DO concentration was found in spring season and minimum was in summer. This may be attributed due to the presence of high load of organic matter and nutrients can cause depletion of DO level because of enhanced rate of decomposition by microbial activities, in the form of respiration. Otieno (2008) observed that the process of organic matter degradation, result in increased consumption of oxygen in water bodies. Moreover, the high temperature in summer, decreases the DO holding capacities of water thus, DO declined whereas at low temperatures in spring supports increased DO holding capacities in the water. High organic load, warm conditions in water ecosystem declines the DO concentration and vice-versa (Pandey *et al.*, 1993; Esmaeili and Johal, 2005; Spasojevic *et al.*, 2005). The data on DO at different sites of the river revealed its concentration lower during summer and higher during spring. At high temperature during summer, oxygen holding capacities of water gets decreased and thus, DO declines whereas at lower temperatures during winter, oxygen remains dissolved in water thus increasing its DO content (Pandey *et al.*, 1993; Esmaeili and Johal, 2005; Spasojevic *et al.*, 2005). The maximum concentration of DO was observed at inlet site and lowest was recorded at outlet site. The low concentration of DO at outlet site might be due high temperature. High temperature decreases the rate of dissolved gases in water bodies (Pandey *et al.*, 1993; Esmaeili and Johal, 2005; Spasojevic *et al.*, 2005).

COD is the amount of dissolved oxygen to oxidize and stabilize a sample when organic or inorganic matter of sample solution is responsive by a strong chemical oxidant. The COD value indicates the mass of oxygen consumed per litre of solution and expressed in milligrams per litre (mg/L). In the present study COD value varied from 2.980 to 3.900 mg/L during two different seasons.

Increase in mean COD value at outlet is by virtue of increased influx of nutrient load. High COD values indicate the presence of non-biodegradable oxygen demanding pollutants were present in the water. The present findings are in accordance with Zutshi and Vass (1978). Moreover, high value of COD was recorded during summer and least during spring (Table 4). Increase in phytoplankton growth during summer months could be the reason of higher COD level in summer season.

BOD is the amount of oxygen used by microorganisms in the aerobic oxidation of organic matter. In the present study mean BOD value varied significantly from 2.485 to 3.250 mg/L during two different seasons. Higher level of BOD at outlet site may be attributed to the presence of organic matter in large quantities. The maximum mean value of BOD value was recorded during summer season and the minimum value was recorded during spring season (Table 4). High BOD level during summer season may be attributed to the presence of large number of microbes which enhance the rate of degradation of organic matter due to high temperature. Similar results were reported by Prasannakumari *et al.* (2003).

Total bacterial count in water : The total viable bacterial count is used to estimate the total amount of bacteria in water and indicates the overall microbial status of the water (Aksu and Vural, 2004). From the bacteriological view, polluted sites showed higher counts of total viable bacterial counts as compared to controlled sites. The data in Table-5 reveals that the total viable bacteria in water samples from outlet site exhibited higher value compared to inlet site which recorded lowest mean value. The observed values for total viable bacteria at outlet site was comparatively higher as that of inlet site in summer and spring season, which may be due to the presence of human or animal wastes, high temperature and faecal pollution source around the outlet sites. Moreover, it is clear from data that the total bacterial count was significantly higher in summer as compared to spring season. These findings are concordance with findings reported by (Rawway *et al.*, 2016).

Conclusions

From the analysis and discussion of the results, it is concluded that the main reasons for the deterioration of the water quality of Shaliganga river are increase in tourist flow, which increases the concentration of nutrients due to sewage disposal, bathing and washing in the vicinity of the stream. This information has been depicted by the physico-chemical characteristics of the stream. The direct disposal of sewage from the nearby areas into the Shaliganga river is also deteriorate the water quality hence increased the nutrient load. Due to higher nutrient

enhancement, reduction in the DO content has been observed. The water of Shaliganga stream serves domestic, agriculture, irrigation and other commercial sectors (including hotels) which have a directly impact on the water quality. According to the current study, the pollutant load caused by tourism and other anthropogenic activities has increased. As a result, waste generated by the tourism industry and disposal of sewage wastes from locals should be managed and disposed of properly. It is advised that an appropriate mechanism for continuous monitoring of the Shaliganga stream be implemented in order to conserve this significant stream.

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Analysis of Variability and Growth Rate of Rice Production in Madhya Pradesh

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Abstract

The present study has been made to work out, relative change, variability, growth rate in area, production and productivity of rice in major producing districts of Madhya Pradesh. The highest relative change in case of acreage was found to be 1495.55 per cent in Raisen but lowest in Shahdol (1.27%) as well as variability in area was also found maximum in Raisen district (94.27%) as compared to Hoshangabad (88.81%), Jabalpur (30.30%) and Satna (24.04%). The relative change and variability in area was 40.14 and 17.49 per cent, respectively although the positive and significant growth rate in area was observed 3.13 per cent in state of Madhya Pradesh. The highest relative change in case of production of rice was noticed in Raisen followed by Hoshangabad and Mandla. The positive and significant growth rate per annum in area of rice was noticed maximum in Raisen (18.99%) followed by Hoshangabad (18.16%), Jabalpur (5.71%), Damoh (3.23%), Seoni (2.95%) and Mandla (1.95%). The all selected districts showed positive and significant growth rate in production of rice. The positive and significant growth rate in case of production was 14.57 per cent in Madhya Pradesh. The relative change, variability and growth rate in productivity were highest in Rewa. The lowest relative change in productivity of rice was noticed in Shahdol but lowest variability was noticed in Balaghat. The highest positive and significant growth rate in productivity of rice was recorded in Rewa, Mandla and Katni during course of study period.

Key words : Growth rate, relative change, variability, area, production and productivity.

Introduction

Rice (*Oryza sativa*) is very important cereal crop in the world and it is one of major food grains and the rich source of calories of more than half of the global population. Globally, China is a leading rice producing country followed by India and Indonesia which is about 27.13 per cent, 22.07 per cent and 10.62 per cent, respectively of the world. The rice production of 116.48 million tones, acreage of 44.16 million hectare with productivity of 2638 kg/hectare in India. In India, the state of West Bengal is a leading first position in production of rice followed by Uttar Pradesh and Punjab. The area of rice is about 2.27 million hectare and production of 4.80 million tons in Madhya Pradesh which is about 4.60 per cent area and 4.07 per cent production of India (2018-19). Looking to the importance of rice, the present study has been formulated with following objectives :

To analyse the change and variation in area, production and productivity of rice in different districts of Madhya Pradesh.

To determine the pace of growth in area, production and productivity of rice in different districts of Madhya Pradesh

Materials and Methods

The study confined to state of Madhya Pradesh in which 13 districts viz. Jabalpur, Katni, Balaghat, Seoni, Mandla,

Rewa, Satna, Shahdol, Anuppur, Raisen, Dindori, Damoh and Hoshangabad were selected on basis of area. To meet the objective of this study, the time series data on different variables such as area, production and productivity of rice were collected for last 15 years from 2004-05 to 2018-19 from website of Department of Farmer Welfare and Agriculture Development, Madhya Pradesh, Bhopal and Directorate of Economics and Statistics, Ministry of Agriculture, New Delhi. The average of first three years was taken as base year and last average of three years were taken as current year for the analysis in view of economics accuracy. The statistical tools were used for estimation of mean, relative change, coefficient of variation and linear growth rate.

Arithmetic mean : The arithmetic mean of area, production and productivity were estimated by using following formula

$$\text{Arithmetic mean} = \frac{x}{N}$$

Where :

x = Total value of area/production/productivity

N = Number of years

The Relative Change : The relative change of area, production and productivity was estimated by using following formula :

$$\text{Relative change (\%)} = \frac{(P_n - P_o/P_o) \times 100}{}$$

Table-1 : Relative change, variability and growth rate in area of Rice in MP.

Districts	RC (%)	SD	CV(%)	LGR (%)
Jabalpur	94.93	25.18	30.30	5.71*
Katni	13.68	21.76	21.31	1.22
Balaghat	9.03	19.36	7.67	0.73
Seoni	36.53	22.29	16.66	2.95*
Mandla	24.53	11.95	9.59	1.95*
Rewa	13.03	28.63	21.30	1.08
Satna	41.78	24.89	24.04	3.34
Shahdol	1.27	10.83	9.54	-0.22
Anupppur	4.77	4.94	4.79	0.45
Raisen	1494.55	56.56	94.27	18.99*
Dindori	12.39	6.62	8.20	1.06
Damoh	45.41	10.21	16.71	3.23*
Hoshangabad	854.12	48.66	88.81	18.16*
Others districts	37.34	94.35	19.82	3.24*
Madhya Pradesh	40.14	329.29	17.49	3.13*

Significant at 5% level

Table-2 : Relative change, variation and growth rate in production of rice.

Districts	RC (%)	SD	CV (%)	LGR (%)
Jabalpur	554.86	140.73	88.64	15.68*
Katni	536.94	179.28	91.00	16.38*
Balaghat	172.76	236.25	46.94	8.95*
Seoni	317.30	167.66	63.71	11.88*
Mandla	639.79	221.96	99.40	17.05*
Rewa	573.04	257.14	94.84	16.86*
Satna	466.01	197.69	83.26	16.40*
Shahdol	128.66	88.23	42.90	7.63*
Anupppur	199.19	107.05	60.25	10.44*
Raisen	8370.59	218.90	122.80	23.65*
Dindori	249.83	70.31	59.38	11.79*
Damoh	438.53	60.66	73.34	13.79*
Hoshangabad	2707.21	193.32	106.29	21.90*
Others Districts	523.58	669.42	76.08	15.72*
Madhya Pradesh	431.15	2603.71	70.78	14.57*

Significant at 5% level of probability.

Whereas :

Pn = Current year

Po = Base year

Base year = Triennium average (2004-05 to 2006-07) of area, production and productivity

Current year = Triennium average (2016-17 to 2018-19) of area, production and productivity.

The Coefficient of Variability : The Coefficient of variation (variability) in area, production and productivity of rice was estimated by using following formula

$$\text{C.V. (\%)} = (\text{S.D./Mean}) \times 100$$

Whereas

C.V. = Coefficient of variation of area, production and productivity

S. D. = Standard deviation of area, production and productivity

Mean = Average of area, production and productivity

Linear Growth Rate : Linear growth rate was computed for examining trends in area, production and productivity of rice by fitting to the time series data in linear model of the following form

$$Y = a + bx$$

Whereas

Y = Area, production and productivity

A = Constant value/intercept value

$$\text{LGR (\%)} = \frac{b}{y} \times 100$$

Table-3 : Relative change, variability and growth rate in productivity of rice.

Districts	RC (%)	SD	CV (%)	LGR (%)
Jabalpur	252.05	1112.69	65.37	10.70*
Katni	469.04	1408.32	77.95	14.70*
Balaghat	148.73	830.12	42.14	8.21*
Seoni	208.50	934.35	50.19	9.37*
Mandla	502.60	1578.84	93.17	15.57*
Rewa	560.50	1924.26	96.19	15.73*
Satna	313.22	1447.96	69.13	13.33*
Shahdol	127.37	829.97	45.21	7.72*
Anuppur	184.71	990.33	58.33	10.14*
Raisen	433.30	1240.57	63.78	13.10*
Dindori	209.20	765.02	53.48	10.65*
Damoh	269.25	702.68	55.99	10.73*
Hoshangabad	198.13	1636.91	62.43	9.64*
Others	359.06	1074.52	63.02	13.13*
Total MP	284.90	1047.35	61.44	12.00*

Significant at 5% level of probability

Whereas

LGR = Linear Growth Rate of area, production and productivity

b = Regression coefficient of area, production and productivity

$\bar{y}$ = Average of area, production, productivity

Results and Discussion

The relative change, variability and growth in area of rice have been discussed of different districts of Madhya Pradesh. The data of relative change, variability and growth rate of rice acreage is presented in table 1 and it reveals that maximum relative change in area of rice was found in Raisen (1494.55%) followed by Hoshangabad (854.12%), Jabalpur (94.93%), Damoh (45.41%), Satna (41.78%), Seoni (36.53%), Mandla (24.53%), Katni (13.68%), Rewa (13.03%), Dindori (12.39%), Balaghat (9.03%), Anuppur (4.77%) and Shahdol.

The variability in area was also found highest in Raisen (94.27%) as compared to Hoshangabad (88.81%), Jabalpur (30.30%), Satna (24.04%), Katni (21.31%), Rewa (21.30%), Damoh (16.71%), Seoni (16.66%), Mandla (9.59%), Shahdol (9.54%), Dindori (8.20%), Balaghat (7.67%) and Anuppur (4.79%). Area under rice increased a significant growth rate of 3.13 per cent per annum in the state of Madhya Pradesh. Raisen showed maximum positive and significant growth rate in area amongst the all districts. The positive and significant growth rate in case of acreage of rice was noticed in Hoshangabad (18.16%), Jabalpur (5.71%), Damoh (3.23%), Seoni (2.95%) and Mandla (1.95%). Only Shahdol showed negative growth rate in rice acreage during the assessment period.

Relative change, variability and growth rate in production :

The relative change, variability and growth rate in case of production of rice in different districts of Madhya Pradesh are presented in Table 2. Data reveals that the maximum relative change in production of rice was found in Raisen (8370.59%) followed by Hoshangabad (2707.21%), Mandla (639.79%), Rewa (573.04%), Jabalpur(554.86%), Katni (536.94%), Satna (466.01%), Damoh (438.53%), Seoni (317.30%), Dindori (249.83%), Anuppur (199.19%), Balaghat (172.76%) and Shahdol (128.66%). The highest variability in production of rice was noticed in Raisen (122.80%) followed by Hoshangabad (106.29%), Mandla (99.40%), Rewa (94.84%), Katni (91.00%), Jabalpur (88.64%), Satna (83.26%), Damoh (73.34%), Seoni (63.71%), Anuppur (60.25%), Dindori (59.38%), Balaghat (46.94%), Shahdol (42.90%). The growth in production of rice was found positive and significant in Jabalpur (15.88%), Katni (16.38%), Balaghat (8.95%), Seoni (11.88%), Mandla (17.05%), Rewa (16.86%), Satna (16.40%), Shahdol (7.63%), Anuppur (10.44%), Raisen (23.65%), Dindori (11.79%), Damoh (13.59%), Hoshangabad (21.90%) districts during entire course of investigation.

Relative change, variability and growth rate in productivity :

The relative change in case of rice productivity is presented in table-3 and data reveals that the highest relative change in productivity was recorded in Rewa (560.50%) as compared to Mandla (502.60%), Katni (469.04%), Raisen (433.30%), Satna (313.22%), Damoh (269.25%), Jabalpur (252.05%), Dindori (209.20%), Seoni (208.50%), Hoshangabad (198.13%), Anuppur (184.71%), Balaghat (148.73%) and Shahdol (127.37%).

The maximum variability in case of productivity of

rice was recorded in Rewa (96.19%), Mandla (93.17%), Katni (77.95%), Satna (69.13%), Jabalpur (65.37%), Raisen (63.78%), Hoshangabad (62.43%), Anuppur (58.33%), Damoh (55.99%), Dindori (53.48%), Seoni (50.19%), Shahdol (45.21%) and Balaghat (42.14%) during entire study period.

Conclusions

On the basis of above results and discussion, it is concluded that the relative change and variability in area, production and productivity of rice were highest in Raisen district among all districts of Madhya Pradesh. The maximum positive and significant growth rate in area and production of rice were also found in Raisen. As regards to productivity of rice, the highest growth rate was found in Rewa showed 15.73 per cent per annum during entire period of study.

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Effect of Sulphur and Zinc on Yield Attributes and Yield of Mustard (*Brassica juncea* L.)

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Abstract

A field experiment was carried out during *rabi* season of the year 2021-22 at Research farm, RCA, Udaipur (Rajasthan) to study the "Effect of Sulphur and Zinc on Yield attributes and Yield of Mustard". The experiment consists of four levels of sulphur (control, 30 kg S ha⁻¹, 40 kg S ha⁻¹ and 50 kg S ha⁻¹) and four application of zinc (0.5 % zinc sulphate) as foliar spray at DAS (control, at 15 DAS, at 30 DAS and at 45 DAS), it was laid out in Factorial Randomized Block Design with sixteen treatment combinations and replicated thrice. A significant increase number of siliqua plant⁻¹, number of seeds siliqua⁻¹, test weight, seed yield, stover yield and biological yield was observed through application of T₁₁ (40 kg S ha⁻¹ + 0.5 % ZnSO₄ at 30 DAS), as compared to control.

Key words : Sulphur, 0.5% zinc sulphate, foliar spray of zinc, days after sowing, mustard.

Introduction

Indian mustard is one of the most important edible oilseed *rabi* crop of North India commonly known as *Sarson*, *Rai* or *Laha*. It belongs to the family Brassicaceae and genus Brassica. Mustard is cultivated for edible oil, condiment, vegetable and animal feed. Mustard contains 35-40% oil which is low in saturated fatty acids and is good source of essential fatty acids (EFA) viz. linolenic acid and linoleic acid. Oil is used for the purpose of cooking, frying preserving pickles and leaves are used as vegetable. Mustard oil cake is used for cattle feed and as an organic manure due to its high protein and nitrogen content, respectively. Mustard and its derivatives are used in manufacturing of medicines. It is used as diuretic, emetic, in treatment of inflammatory infections such as rheumatism and arthritis, it also has anti-cancer properties due to presence of antioxidant (tocopherol) in oil and glucosinolates (e.g., indolyl glucosinolate) in seed meal (Kumar, 2012). Rajasthan is leading state particularly Indian mustard production contributing about 45 per cent of the country. Moreover, Rajasthan ranks first both in area and production of Indian mustard. It is the most important *Rabi* season oilseed crop of Rajasthan which is grown on 2.18 million hectares with annual production of 3.40 million tonnes at an average productivity of 1558 kg ha⁻¹ (Anonymous, 2019-20). In the Udaipur region, it is grown an area 16.3 thousand hectares with a production of 23.64 thousand tonnes and productivity of 1449 kg ha⁻¹ (Anonymous 2020-21). Sulphur is an essential secondary nutrient and an essential constituent of S-containing amino acids like cysteine, cystine, methionine, vitamins, enzymes, chlorophyll in plants. Compared to other crops

mustard is more responsive to sulphur. The oil content in mustard seed is increased after the application of sulphur (Singh *et al.*, 2015). Several studies confirmed that N utilization is improved when the availability of sulphur increased and thus photosynthesis, growth, dry mass accumulation of crop is also improved (Tandon, 1995; Kopriva *et al.*, 2002). The consumption of sulphur fertilizer increases the yield in Indian mustard (Piri *et al.*, 2011). Application of sulphur has a significant effect on oil, fatty acids and glucosinate content in mustard seeds (Ahmad and Abdin, 2000 and Falk *et al.*, 2007). The unbalanced use of fertilizers is the main cause for low productivity of mustard. Zinc is one of the essential micronutrients and plays an important role in various enzymatic and physiological activities of the plant (Alloway, 2008). It is also essential for photosynthesis and nitrogen metabolism and important for the stability of cytoplasmic ribosome's, cell division, as co factor to enzymes like dehydrogenase, proteinase and peptidase in the synthesis of tryptophan, a component of some proteins and a compound needed for production of growth hormones (auxin) such as indole acetic acid. The present study was under taken to evaluate the effect of sulphur and zinc on yield attributes and yield of mustard.

Materials and Methods

The experiment was carried out at the Research farm of Rajasthan College of Agriculture, Udaipur during *rabi* season of 2021-22. The experimental site lies under the agro-climatic zone ?-a of Rajasthan in the South-Eastern part of Rajasthan at 24°34' N latitude and 73°42' E longitude at an altitude of 582.17 m above mean sea level. The maximum and minimum temperatures ranged

Table-1 : Effect of Sulphur and Zinc on Yield and Yield Attributing characters of Mustard.

Treatments	Number of siliqua plant ¹	Number of seed siliqua ¹	Test weight (g)	Yield (kg ha ⁻¹)		
				Seed	Stover	Biological
Sulphur levels (kg ha ⁻¹)						
Control	225.04	13.88	4.55	1241	3760	5001
30 kg S ha ⁻¹	260.06	14.37	4.68	1632	4329	5961
40 kg S ha ⁻¹	270.28	14.90	4.80	1719	4550	6269
50 kg S ha ⁻¹	271.26	15.05	4.82	1723	4668	6391
SEm±	3.49	0.16	0.04	27.35	48.20	57.75
C.D. (P = 0.05)	10.09	0.46	0.11	78.99	139.21	166.80
0.5% Zinc spray (Days after sowing)						
Control	226.13	12.99	4.39	1445	3775	5220
15 DAS	253.50	14.18	4.58	1540	4318	5857
30 DAS	272.30	15.45	4.92	1650	4604	6254
45 DAS	274.72	15.58	4.95	1681	4611	6292
SEm±	3.49	0.16	0.04	27.35	48.20	57.75
C.D. (P = 0.05)	10.09	0.46	0.11	78.99	139.21	166.80

between 30.4°C and 3.2°C. Mean weekly maximum and minimum relative humidity ranged between 96.0% and 51.1% respectively and the total rainfall received during the crop period is 205.6 mm. The experiment consisted of four levels of sulphur viz. control, 30, 40 and 50 kg ha⁻¹ and four foliar application of zinc (0.5 % zinc sulphate) at number of days after sowing viz. control, at 15 DAS, 30 DAS and 45 DAS, thereby making 16 treatment combinations, which were laid out in Factorial Randomized Block Design and replicated three times. The seed was sown manually on 28 October 2021 by placing 2 seeds at a depth of 3–4 cm. Thinning was done at 20-25 DAS maintaining row-to-row and plant-to-plant distance of 30 x 10 cm. In order to minimise weed competition, pre-emergence herbicide pendimethalin was applied and two manual hand weeding was performed. Three irrigations were given to mustard crop viz. after sowing, second irrigation at 35 DAS and third after 75 days (pod filling stage). The recommended dose of NPK viz., 60, 40, 40 kg ha⁻¹ was applied uniformly through urea, DAP and MOP respectively. For calculating number of siliqua plant⁻¹ and number of seeds siliqua⁻¹ the siliqua present on five randomly selected plants were separated and twenty selected siliquae taken from respective plant were threshed, counted and average number of was reported, respectively. For calculating test weight, 1000 grains were counted from individual plot after weighing. These counted grains were weighed on electronic balance and the weight was taken in gram. For calculating seed yield, grain yield of net plot was weighed. In case of stover yield, seed yield is subtracted from biological yield and for

determining biological yield the plants from net plot is weighed after harvesting and sun drying.

The obtained data were statistically analysed with the techniques of analysis of variance as described by Steel and Torrie, 1960. The comparison in the treatment mean was tested by critical difference (CD) at 5% (P=0.05) level of significance.

Results and Discussion

Effect of Sulphur : The significant improvement in yield attributes and yield under 40 kg sulphur ha⁻¹ resulted in 20.10, 7.35, 5.49, 38.52, 21.01 and 23.35 per cent increase in number of siliqua plant⁻¹, number of seeds siliqua⁻¹, test weight, seed, stover and biological yield, over control, respectively. Further increase in sulphur levels failed to bring any significant change thus remained at par with S application of 40 kg ha⁻¹. The increased number of siliqua plant⁻¹ and seeds siliqua⁻¹ might be due to increased total biomass production and its translocation in various plant parts. Sulphur contributes to the synthesis of storage protein for the developing reproductive tissue and helps in enhancing N assimilation to fulfil the requirement of developing sink/seeds (Thompson *et al.*, 1986). The increase in test weight might be due to better seed development with an increasing rate of S application, which enhanced the availability of sulfolipids, amino acids, protein and carbohydrates resulting in increased test weight (Thompson *et al.*, 1986, Singh *et al.*, 2010). The increase in seed yield was primarily due to an enhanced rate of photosynthesis, translocation of photosynthates, chlorophyll formation, protein synthesis

and carbohydrate metabolism. The balanced nutritional environment and adequate sulphur availability enhanced the nutrient assimilation which in turn sped up the crop to put forth the maximum yield attributes and yield. These results are in line with the findings of Verma *et al.*, (2012), Singh and Singh (2013) and Tomar (2012).

Effect of Zinc : The significant increase in yield attributes and yield with 0.5% foliar application of zinc sulphate at 30 DAS has resulted in 20.42, 18.94, 12.07, 14.19, 21.96, 27.79 per cent increase in number of siliqua plant⁻¹, number of seeds siliqua⁻¹, test weight, seed, stover and biological yield, over control, respectively. Further application at 45 DAS failed to bring any significant change thus remained at par with the application at 30 DAS. The increase in number of siliqua plant⁻¹ and number of seeds siliqua⁻¹ might be due to the balanced nutrition with optimum availability of zinc which led to the development of pollen and pollen tubes and ultimately resulted in increased fruit/seed setting and siliqua development (Alloway, 2008). The increase in test weight might be due to the increased carbohydrate production, as it helps in enhancing the activity of enzymes involved in photosynthesis thus increasing the translocation of photosynthates to growing seed and increasing the photosynthetic capacity of the crop (Sinha *et al.*, 2000). Seed and stover yield significantly increased with the enhancement in yield attributes which might be due to the fact that zinc plays a role in biosynthesis of indole acetic acid (IAA) which in turn resulted in the initiation of reproductive parts and partitioning of photosynthesis towards them consequently resulting into better yield, also with better Zn availability which promotes numerous enzymes such as carbonic anhydrase and ribulose biphosphate carboxylase involved in carbohydrate metabolism. A significant increase in biological yield could be due to a relative increase in seed and straw yield. The positive effect of zinc on yield attributing characteristics could be ascribed to its catalytic or stimulatory effect on the metabolic process in plants. Zinc is requisite by meristematic tissues where synthesis of protein and nucleic acid is taking place. The beneficial effect of zinc on mustard yield could be attributed to its role in a variety of enzymatic reactions, growth processes, hormone development, and protein synthesis, as well as the translocation of photosynthates to seed, resulting in increased seed yield (Bhadauria *et al.*, 2012). Similar results are also reported by Dubey *et al.* (2013); Kumar *et al.* (2014) and Tripathi *et al.* (2014).

Conclusions

On the basis of the statistical data, it can be concluded that there was a significant response to application of sulphur and zinc on mustard crop and farmers of Zone IVa can get significantly higher yield and yield attributes with soil

application of 40 kg S ha⁻¹ along with 0.5% foliar spray of zinc sulphate at 30 DAS.

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Effect of Seed Priming with Glutamic Acid on Tomato (*Solanum lycopersicum* L.) Seedling in Pro Tray

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Abstract

The aim of this work was to evaluate the possible biochemical and physiological effect of seed treatment with glutamic acid on tomato seedlings in pro tray. Glutamic acid formulation was prepared by dissolving glutamic acid into DI water and tomato seeds were treated into different concentrations of glutamic acid (100, 200, 300, 400 and 500 ppm) and water (control) for 1 hour. The effect of the treatment was evaluated in 7 parameters at different time points during the experiment to evaluate changes at a biochemical and physiological level. Outcome of the study related to seed treatment with glutamic acid (400 ppm) showing best positive effect in all parameters of tomato seedlings. Based on the aforementioned results and comparative evaluation of different doses of glutamic acid, we concluded that glutamic acid is very effective at less concentration. Therefore, it may claim that glutamic acid amino acid have potential to deliver organic nitrogen and amplify tomato seedling growth.

Key words : Amino acid, glutamic acid, seedling, growth and tomato.

Introduction

Tomato is very important vegetable in the human diet, because tomato has a valuable source of nutrients, including vitamins, proteins, fibers, minerals, essential amino acids, monounsaturated fatty acids, carotenoids and phytosterols which are known to contribute to the health-related properties of plant derived foods. Therefore, growing high-quality vegetables is one of the most significant goals of the current agriculture in order to meet the needs of the growing inhabitants and the increasing demand for healthy food (Salehi *et al.*, 2019). In recent past, many experiments implicate that amino acids can play broad roles in plants including acting as regulatory and signalling molecules. Amino acids take part in plant stress responses acting as osmolytes, regulating the ion transport, the stomatal opening and they are involved in detoxification mechanisms (Rai, 2002). The application of amino acids as bio stimulants is an approach that can be used in horticultural crops for counteracting the negative effects induced by ecological stresses. Amino acids can act as hormone precursors and they can contribute to regulate carbon and nitrogen metabolisms and to promote nitrogen absorption (Miller *et al.*, 2007; Calvo *et al.*, 2014; Colla and Roupael, 2015; Bulgari *et al.*, 2019). Glutamic acid is a central molecule in amino acid metabolism in higher plants. The α -amino

group of glutamic acid is directly involved in both the assimilation and dissimilation of ammonia and is transferred to all other amino acids (Forde and Lea., 2007). Recently, in plants, Glutamic acid is found to appear as a novel signaling role in many physiological processes. These processes include seed germination (Kong *et al.*, 2015), root building (Forde, 2014; Lopez-Bucio *et al.*, 2019), pollen germination and pollen tube growth (Michard *et al.*, 2011; Wudick *et al.*, 2018), wound response and pathogen resistance (Manzoor *et al.*, 2013; Mousavi *et al.*, 2013; Nguyen *et al.*, 2018; Toyota *et al.*, 2018; Jin *et al.*, 2019), and response and adaptation to abiotic stress (Cheng *et al.*, 2018; Zheng *et al.*, 2018; Li H. *et al.*, 2019; Li Z. *et al.*, 2019; Philippe *et al.*, 2019). In addition, glutamic acid can act as a long-distance signaling transducer among cells, tissues, organs, and even the entire plants by the crosstalk with Ca^{2+} , ROS, and electrical signaling (Mousavi *et al.*, 2013; Nguyen *et al.*, 2018; Toyota *et al.*, 2018). Glutamic acid is involved in different organic processes and among them it plays an important role in chlorophyll and proline biosynthesis (Franzoni *et al.*, 2021). Glutamic acid application had a positive effect also under stressful conditions, reducing physiological break by enhancing the activity of antioxidant enzymes, as observed in Kimchi cabbage subjected to low temperature stress (Lee *et al.*, 2017). Glutamic acid is one of the most important amino acids in

plants playing a role in the biosynthesis of proline and other nitrogen-containing compounds (Okumoto *et al.*, 2016). On the basis of above facts, seed treatment with glutamic acid was tested on tomato seedling in pro tray to measure physiological responses under greenhouse condition.

Materials and Methods

Formulation preparation : In present study, glutamic acid formulations (100, 200, 300, 400 and 500 ppm) were prepared by dissolving glutamic acid into DI water.

Experimental details : The seed treatment tested for seedling growth in the pro tray experiment under greenhouse condition on tomato seedling. The experiments were conducted in year 2021-22 at research farm of Rajasthan college of Agriculture, Maharana Pratap University Agriculture and Technology, Udaipur, India, (24.58° latitude, 73.70° longitude). Tomato seeds were treated into different concentrations of glutamic acid (100, 200, 300, 400 and 500 ppm) and water (control) for 1 hour. Treated seeds were sun dried and sown in pro tray (filled with cocopeat, perlite and vermiculite with the ratio of 3:1:1, respectively) under shade net condition. In present study, germination % was recorded on 30 DAS while seedling vigor index, shoot length, root length, membrane stability index, fresh and dry weight were recorded on 40 DAS. Total chlorophyll content in leaf was measured at 40 DAS (Yoshida *et al.*, 1976). The chlorophyll content was calculated as follows and expressed as mg/g fresh weight.

$$\text{Chlorophyll a} = 12.21(A_{663}) - 2.81(A_{646})$$

$$\text{Chlorophyll b} = 20.13(A_{646}) - 5.03(A_{663})$$

$$\text{Total chlorophyll} = \text{Chlorophyll a} + \text{Chlorophyll b}$$

Statistical analysis : The statistical analysis were performed with JMP software version 12 (SAS, 2019) using Kramer HSD test. Seedling experiment was performed in three replications (triplicates) and each replication consisted of minimum ten samples from randomly selected plants.

Results and Discussion

In present investigation, pro tray experiment was conducted to check the effect of seed treatment into different concentration of glutamic acid on seedling growth parameters viz: germination %, shoot length (cm), root length (cm), membrane stability index, fresh and dry weight of seedlings (g), chlorophyll content (mg/g). Germination % was recorded on 30 DAS while various growth parameters were recorded on 40 DAS. Chlorophyll content in leaf was measured at 40 DAS (Yoshida *et al.*, 1976).

The result showed that % germination (86.6 %) was significantly higher in 400 ppm concentration of glutamic

acid as compared with control (75.5%). Similarly, 400 ppm concentration of glutamic acid showed maximum and significant length of shoot (7.5 cm) as compared with control (4.9 cm) and rest of treatments (Table-1). Moreover, 400 ppm concentration of glutamic acid showed significantly higher root length (13.7 cm) as compared with control. Whereas, significantly higher membrane stability index (14.5) was observed in 300 ppm concentration of glutamic acid as compared with rest of all treatments. However, among the all treatments maximum fresh weight (2.3 gm) and dry weight (0.26 gm) was observed in 400 ppm concentration of glutamic acid. The total chlorophyll content (2.87 mg/gm) was significantly higher in 400 ppm as compared with all other treatments (Table 1). Amino acids take part in plant stress responses acting as osmolytes, regulating the ion transport, the stomatal opening and they are implicated in detoxification mechanisms (Rai 2002). In particular, amino acids in the form of foliar spray have proved to be a promising agronomic tool (Abdelhamid *et al.*, 2014; Teixeira *et al.*, 2017). Studies showed that different cultivars respond to amino acids application in a different way. Moreover, the effect depends on the type of amino acids supplied as well as if they are applied in a mixture or individually (Khan *et al.*, 2019). Glutamic acid is a novel signalling molecule, which is involved in many physiological processes. These processes include seed germination, seedling establishment, plant growth, development, senescence, and even response and adaptation to ecological stress, such as salt, heat, drought, and pathogen stress (Qiu *et al.*, 2020). In soyabean crop, foliar or seed application of Glutamic acid in both greenhouse and field could enhance the antioxidant capability by activating antioxidant enzymes catalase, peroxidase, superoxide dismutase, polyphenol oxidase, and phenylalanine ammonia lyase (Teixeira *et al.*, 2017) and improved nitrogen metabolism and productivity (Teixeira *et al.*, 2018). Under drought stress situation, foliar or seed application of glutamic acid, as stress reducer, increased Pro and relative water content, leaf and root dry weight, and plant productivity (Teixeira *et al.*, 2020). Glutamic acid not only a metabolic mediator (storage), which takes part in the biosynthesis of many organic compounds such as amino acids, GABA, proteins, chlorophyll, and so on; but also a novel signaling molecule implicating in all aspects of the life cycle of plants (Brosnan and Brosnan, 2013; Reiner and Levitz, 2018). Recently, the positive effect of Glutamic acid in heat tolerance had been found by Li Z. *et al.*, (2019), who first reported that, in maize (*Zea mays* L.) seedlings treatment with glutamic acid elevated the survival percentage of seedlings under heat stress.

As mentioned above, Glutamic acid plays a very

Table-1 : Effect of seed treatment with glutamic acid on seedling growth parameters of tomato in pro tray.

Treatment (Seed treatment)	Seed germination percent (%)	Shoot length (cm)	Root length (cm)	Membrane stability index	Fresh weight (g)	Dry weight (g)	Chlorophyll content (mg/g)
Control (water)	75.5±0.33 ^f	4.9±0.19 ^f	9.2±0.31 ^e	9.8±0.11 ^f	1.1±0.01 ^f	0.14±0.00 ^{ef}	2.30±0.03 ^f
Glutamic acid							
100 ppm	77.3±0.99 ^e	5.5±0.31 ^e	10.9±0.21 ^d	10.5±0.21 ^e	1.4±0.03 ^e	0.15±0.01 ^{de}	2.45±0.02 ^e
200 ppm	80.6±0.66 ^d	5.9±0.27 ^d	11.1±0.22 ^{cd}	11.3±0.16 ^d	1.7±0.01 ^d	0.16±0.01 ^{cd}	2.54±0.02 ^{cd}
300 ppm	83.4±0.33 ^{bc}	6.6±0.21 ^c	11.9±0.29 ^c	14.5±0.28 ^a	2.0±0.02 ^{bc}	0.17±0.00 ^c	2.65±0.01 ^b
400 ppm	86.6±0.33 ^a	7.5±0.22 ^a	13.7±0.28 ^a	13.2±0.21 ^b	2.3±0.02 ^a	0.26±0.01 ^a	2.87±0.03 ^a
500 ppm	84.4±0.66 ^b	7.1±0.29 ^{ab}	12.8±0.25 ^b	12.3±0.13 ^c	2.1±0.01 ^b	0.19±0.02 ^b	2.59±0.02 ^{bc}

Seedlings growth parameters were recorded at 40 DAS of tomato seedling (Germination % at 30 DAS). Each value is mean of triplicates and each replicate consisted of 10 plants. Error bars represent $\pm$ SE (standard error) with the same letter statistically insignificant ($p=0.05$) as determined by Tukey-Kramer HSD. Water (control) and glutamic acid (0.01%, w/v)

important role in plant growth, development, and response and adaptation to environmental stress. Glutamic acid is one of the most important amino acids in plants playing a role in the biosynthesis of proline and other nitrogen-containing compounds. Overall, the present study showed positive response due to seed treatment of glutamic acid on tomato seedling. Based on the results, present study sum up that seed treatment with glutamic acid could be further explored on tomato seedlings at large scale trials for validation of the growth data obtained in the present study.

Conclusions

The available review of literature and results of the present investigation concluded that seed treatment with glutamic acid has shown significant level of physiological responses on tomato seedling in pro tray. Outcome of the study related to seed treatment with glutamic acid (400 ppm) showing best positive effect in all parameters of tomato seedlings. It has been concluded that glutamic acid has remarkable effect on growth parameters of tomato seedling. Based on the results, present study finally concluded that glutamic acid could be further explored on tomato seedling at large scale trials.

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Screening of Wheat Genotype for Drought Stress under Laboratory Condition

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Abstract

Among several factors known, drought remains the most important factor affecting wheat yield worldwide. Under the present study, the experimental layout was comprised of three drought treatments with three replicates under controlled conditions in completely randomized design at Plant pathology laboratory RLBCAU, Jhansi. Drought stress was induced through polyethylene glycol-6000 solutions by maintaining three osmotic potential (-0.2 MPa, -0.4 MPa) in water culture medium while 1/4th Hoagland's solution with zero osmotic potential was applied as control. Germination rate and seedling's growth were declined with increased levels of water deficiency. Seedling length, fresh and dry biomass of root and shoot executed more reduction at higher water deficit conditions. The percentage of seed germination at control point was highest and started to decrease as the amount of osmotic stress rise with the use of PEG-6000 in all genotypes of wheat. Maximum seed germination of 98.9% was recorded at control point. Similarly, medium seed germination was recorded at moderate osmotic stress level (-0.2MPa). The lowest seed germination of 88.2% was exhibited under high osmotic stress condition of (-0.4MPa). The maximum shoot length exhibited at the control point. Under the higher osmotic stress conditions (-0.4MPa) reported lowest shoot length. The maximum root length observed for) at control conditions. The maximum seedling fresh weight was observed at the control conditions. At high stress genotypes DH-1124 (96.4 mg) followed by DBW-110 (89 mg) and C-306 (85 mg) recorded maximum seedling fresh weight. Under higher and moderate osmotic stress condition (-0.2 MPa and -0.4 MPa) reported low seedling dry weight comparatively at control conditions. Lok-1, MACS-6478, Raj-4079, Hindi-62, MP-3388, IC-611477, Raj-3765, K-1006, NW-5054, HD-2733, DBW-150, WH-1124 and Raj-4238 are the 13 genotypes found with drought tolerance reaction with STI value more than 0.8. Genotypes Raj-3765 and Macs-6478 are highly drought tolerance with high grain yield under irrigated conditions. These genotypes are superior and productive in further breeding programmes for drought stress tolerance.

Key words : Drought, germination, growth, polyethylene-glycol, stress tolerance index.

Introduction

Wheat (*Triticum spp.*) is one of the most important and widely cultivated staple food crops among the cereals and is known as "King of Cereals". It is agronomically and nutritionally most important cereal essential for the food security, poverty alleviation and improved livelihoods. Wheat occupies prominent position in Indian agriculture after rice, consumed by 36 per cent of world population and providing 20 per cent of the total food calories. In world, wheat occupies an area of 217 million ha (M ha) with total production of 765 million tonnes (M t) and productivity of 3530 kg/ha (USDA, 2020). China has maximum productivity followed by India, Russia and USA. In India area, production and productivity of wheat was tremendously increased since green revolution of 1967. During 2019-20, 3rd estimation India occupies an area of 30.55 million ha with total production of 107.17 million tonnes and productivity of 3508 kg/ha. Uttar Pradesh leads in area of 9.35 Mha with a production of 32.09 Mt and productivity of 3432 kg/ha in the country and Madhya Pradesh occupies wheat area of 6.02 Mha with production 18.58 Mt and productivity of 3083 kg/ha (DAC&FW, 2020).

Drought stress can be simply defined as a shortage of water which induces dramatic morphological, biochemical, physiological, and molecular changes. Drought stress is one of the consequences of climate change that has a negative impact on crop growth and yield in many rainfed areas including Bundelkhand. The improvement of wheat crop for drought tolerance is limited for many reasons namely drought may cause dramatic changes in the physiological parameters in the plant which need to be measured and understood, genotypic x environment (GE) interaction, drought is a complex trait controlled by many genes, most of which make a minor genetic contribution, but these are important to genetically improve drought tolerance (Sallam *et al.*, 2019). Polyethylene glycol (PEG-6000) is used to artificially cause osmotic stress (khakwani *et al.*, 2011). Identification of drought tolerant wheat genotypes using different concentrations of PEG-6000 had showed significant different for germination, shoot length, root length and seedling dry weight (Rauf *et al.*, 2006).

Materials and Methods

The investigations were carried out using eighty-two wheat genotypes. The seeds were collected from Indian Institute of Wheat and Barley Research, Karnal (Haryana). These eighty-two genotypes of wheat were raised in growth chamber available in Plant pathology laboratory RLBCAU, Jhansi were surface sterilized by dipping the seeds in 0.1% mercuric chloride solution for 2 minutes and rinsed thoroughly with sterilized water. Required amount of PEG 6000 was dissolved in tap water to develop -0.2 bar and -0.4 bar water potential. Thirty seeds of each genotype were placed for germination in 11cm sterilized petri plates on filter paper irrigated with respective treatments. The petri plates were irrigated daily with required amount (5 ml) of respective solution. Each treatment was replicated thrice. Seedlings were allowed to grow up to 7 days after placement for germination.

Preparation of PEG-6000 solutions : -0.2 MPa and -0.4 MPa polyethylene glycol (PEG-6000) solutions were prepared by 11 g and 19 g polyethylene glycol (PEG 6000), respectively, dissolved in 100 ml distilled water. Stress conditions were created with PEG 6000 (0, -0.2 MPa and -0.4 MPa) which was applied as distilled water. Control use through distilled water. Sample from control and the two stress treatments (-0.2 MPa and -0.4 MPa PEG-6000) were collected at two different stages i.e., 4 DAS & 8 DAS for analysis. Observations were recorded for physiological studies like germination percentage, shoot-root length and seedling fresh and dry weight at 4 and 8 days after the treatment.

Stress tolerance index (Fernandez, 1992) calculated by

$$STI = \frac{(Y_p) (Y_s)}{(\bar{Y}_p)^2}$$

Where,

Y_p = mean value of the genotype under control condition.

Y_s = mean value of the genotype under stress condition.

$\bar{Y}_p$ = mean value of the all genotypes under control condition.

Results and Discussion

The percentage of seed germination at control point was highest and started to decrease as the amount of osmotic stress rise with the use of PEG-6000 in all genotypes of wheat. Maximum seed germination of 98.9% was recorded in HD-2733 and HI-1544 followed by HD-3086 (97.80%), Raj-4079 (96.7%) and C-306 (96.7%) as presented in Table-1, while minimum seed germination was recorded in IC-470828 (61.1%) at the control level. Similarly, maximum seed germination was recorded in HD-2733 (88.9%) followed by HD-3086 (86.7%) and Hindi-62 (85.6%) at moderate osmotic stress level (-0.2 MPa) whereas the minimum seed germination of 21.1% was recorded in IC-296438 at the moderate osmotic

stress level (-0.2MPa), respectively. The maximum seed germination of 88.2% was exhibited in HD-2733 followed by WH-730 (75.6%) and Hindi-62 (70.0%) under high osmotic stress condition of (-0.4 MPa) whereas, minimum seed germination was recorded for IC-296529 (5.6%). Similar results are in agreement with the findings of Chahar *et al.* (2014) and Saha *et al.* (2017).

The maximum shoot length of 5.3 cm was observed in Hindi-62 followed by DBW-150 (4.5 cm) and IC-616573 (4.5 cm) as presented in Table-1 whereas, minimum shoot length reported for WR-544 (1.4 cm) followed by IC-624500 (1.6 cm) and AKAW-3117 (1.7 cm) at the control level. Under the moderate stress (-0.2 MPa), maximum shoot length observed for Hindi-62 (3.9 cm) followed by HI-1544 (3.1 cm), Similarly, IC-595583 (1.2 cm) had the minimum shoot length recorded. Under the higher osmotic stress conditions (-0.4 MPa) maximum shoot length reported for WH-1124 (5.0 cm) followed by DBW-150 (3.5 cm), while minimum for Raj-4037 (0.5 cm). Increasing osmotic stress concentration decreasing shoot and root length of all the genotypes of wheat. The maximum root length observed for HI1544 (9.5 cm) followed by DBW- 110 (9.3 cm) and WR-544 (9.2 cm) at control conditions, while, IC-589934 (2.9 cm) showed the minimum root length at control conditions, respectively. The genotypes NW-5054 (5.0 cm) followed by WH-5042 (4.9 cm) and Kharachia local (4.6 cm) showed maximum root length at high osmotic stress condition, while genotypes WH-1124 (0.5 cm) showed minimum root length at high water stress conditions, respectively. The decreasing trend in shoot and root length reported by (Chahar 2014 a) under water stress. Similar results for both shoot and root length are in agreement with the findings of Datta *et al.* (2011) and Saha *et al.* (2017) and Faisal *et al.* (2019).

The maximum seedling fresh weight was observed for GW-322 (112 mg) followed by HI-1544 (104 mg) and K-0307 (99 mg) at the control conditions, whereas similar the minimum seedling fresh weight observed for TL-1210 (42.8 mg), respectively. The maximum seedling fresh weight at moderate stress level was recorded for DBW-110 (100 mg) followed by HI-1544 (98 mg) and GW-322 (96 mg), whereas, minimum was reported in AKAW-3717 (33.8 mg). At high stress genotypes DH-1124 (96.4 mg) followed by DBW-110 (89 mg) and C-306 (85 mg) recorded maximum seedling fresh weight, whereas minimum seedling fresh weight was recorded in Raj -4037 (43.0 mg).

The maximum value of seedling dry weight was recorded for IC-611477 (53.4 mg) followed by K-1006 (50.8 mg) under control condition, whereas, DBW-150 (20.2 mg) reported minimum value for seedling dry weight at control conditions. Under moderate osmotic stress

Table-1 : List of the promising genotypes of wheat under different level of drought stress.

S. No.	Traits	Promising genotypes		
		Control	0.2MPa	0.4MPa
1.	Seed germination percentage (%)	HD2733(98.9), HD3086(97.8), Raj4079 (96.7)	HD2733(88.9), HD3086(86.7), Hindi 62(85.6)	HD 2733(88.2), WH730(75.6), Hindi 62(70.0)
2.	Shoot length (cm)	Hindi 62(5.3), DBW150(4.5), IC616573(4.5)	Hindi 62(3.9), HI1544(3.1), IC616573(3.1)	WH1124(5.0), DBW150(3.5), GW322(3.5)
3.	Root length (cm)	HI1544(9.5), DBW110(9.3), WR544(9.2)	AKAW3717(7.8), WR544(7.3), Lok1(6.8)	NW5054(5.0), WH542(4.9), Kharchia local (4.6)
4.	Seedling fresh weight (gm)	GW322(112), HI1544(104), K307(99)	DBW110(100), HI1544(98), GW322(96)	WH1124(96.4), DBW110(89), C306(85)
5.	Seedling dry weight (gm)	IC611477(53.4), K1006(50.8), IC296446(50.6)	K1006(48.6), IC611477(48.4), IC594379(47.0)	IC553955(43.6), IC296446(42.6), MP3336(40.6)

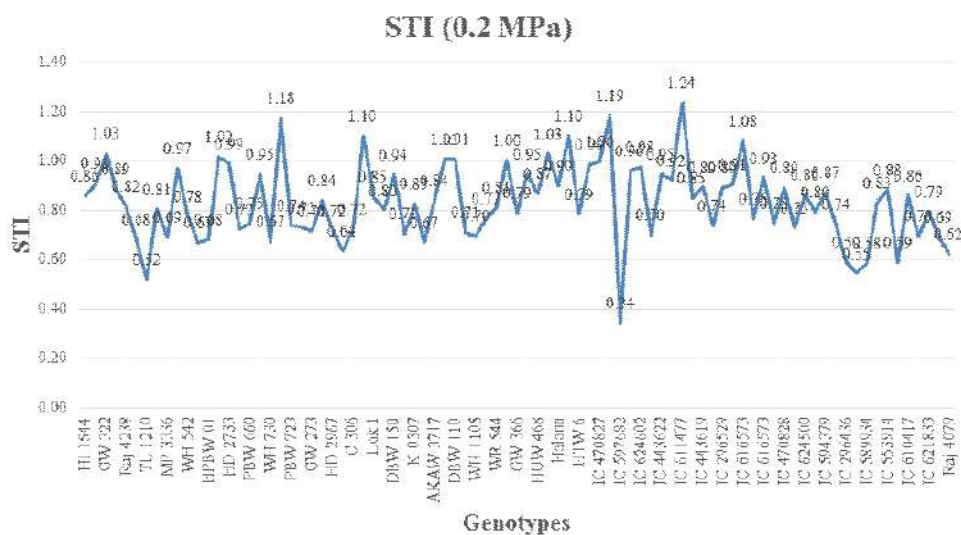


Figure-1 : Graphical representation of stress tolerance index under 0.2MPa stress level for wheat genotypes stress tolerance index.

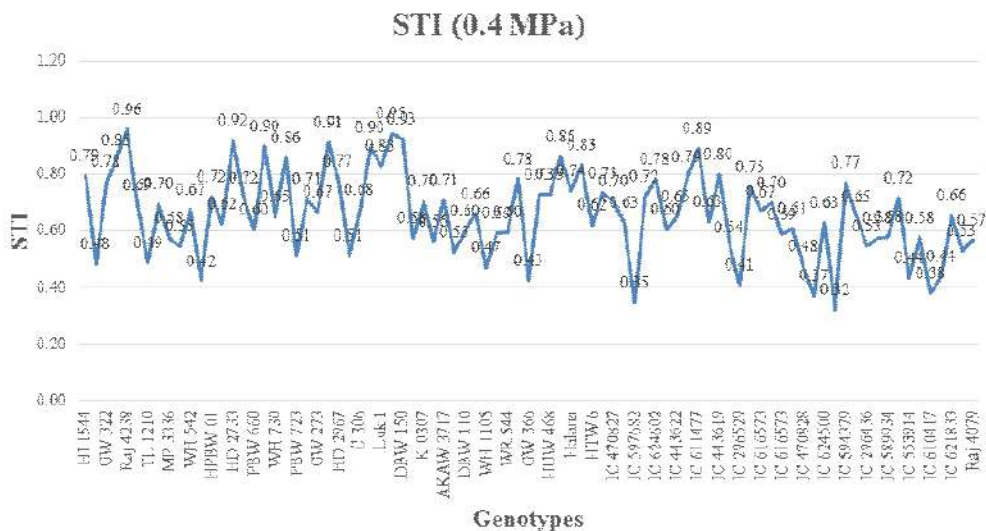


Figure-2 : Graphical representation of stress tolerance index under 0.4MPa stress level for wheat genotypes.

Table-2 : Simple correlation between grain yield and drought tolerance.

Correlation Matrix (R)	STI (0.2 MPa)	STI (0.4 MPa)	GYPP
STI (0.2 MPa)	1.000		
STI (0.4 MPa)	0.488*	1.000	
GYPP	0.159	0.047	1.000
BYPP	0.042	0.001	0.890*

*Significance under 5% level of significance, GYPP-Grain yield per plant, BYPP- Biological yield per plant.

condition (-0.2 MPa) reported low seedling dry weight comparatively at control conditions, whereas under the higher concentration of osmotic stress maximum seedling dry weight showed IC-553915 (43.6 mg) followed by IC-296446 (42.6 mg) and MP-3388 (40.6 mg), whereas minimum seedling dry weight was recorded in K-0307 (17.6 mg). Similar results for both seedling fresh and dry weight are in agreement with the finding of Khakwani *et al.* (2011), Chahar *et al.* (2014) and Faisal *et al.* (2019).

Stress tolerance index indicates a wide difference in water deficit stress tolerance among the wheat genotypes under study. 21 genotypes showed moderately tolerant response under 0.2 MPa drought stress with STI (0.7-0.8), some of the promising genotypes are PBW-550, PBW-343, GW-273 and HD-296 (Figure 1). Whereas, 44 genotypes reported with tolerant drought reaction under 0.2 MPa with STI value of more than 0.8 namely, DHTW-60, WR-544, Raj-4238 and K-0307.

Fifty-two genotypes showed susceptible drought reaction under 0.4 MPa stress whereas, 17 genotypes observed with moderately drought tolerance reaction. Lok-1, MACS-6478, Raj-4079, Hindi-62, MP-3388, IC-611477, Raj-3765, K-1006, NW-5054, HD-2733, DBW-150, WH-1124 and Raj-4238 are the 13 genotypes found with tolerant reaction with STI value more than 0.8. Genotypes Raj-3765 and Macs-6478 are highly drought tolerance with high grain yield under irrigated conditions (Figure 2). These genotypes are superior and productive in further breeding programmes for drought stress tolerance. Similar results for both -0.2 MPa and -0.4 MPa are in agreement with the findings of Mwadingeni *et al.* (2016) and Rana *et al.* (2017).

Conclusions

The traits, germination percentage, root length, shoot length, seedling dry weight and seedling fresh weight for eighty-two wheat genotypes had higher value in control than in both the treatments (0.2 MPa and 0.4 MPa), this suggested that as the osmotic stress increases, there will be simultaneous decrease in these traits. 21 genotypes showed moderately tolerant response under -0.2MPa drought stress with STI (0.7-0.8), some of the promising genotypes are PBW-550, PBW-343, GW-273 and HD-296. Genotypes Raj-3765 and Macs-6478 are highly drought tolerance with high grain yield under irrigated conditions. They showed considerable potential to

improve drought tolerance in wheat through breeding programs.

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Effect of Feeding Azolla Leaf Powder (*Azolla pinnata*) on the Performance of Kadaknath Chicken (*Gallus domesticus*)

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Abstract

The study was conducted to investigate the "Effect of feeding Azolla Leaf Powder (*Azolla pinnata*) on the performance of Kadaknath chicken (*Gallus domesticus*)." One hundred fifty Kadaknath chicks (four weeks old) were used in a completely randomized design in 5 treatments with 3 replications, each consisting of 10 chicks. The treatments were T₁: control, T₂: control group supplemented with Azolla leaf powder @ 2.5%, T₃: control group supplemented with Azolla leaf powder @ 5%, T₄: control group supplemented with Azolla leaf powder @ 7.5% and T₅: control group supplemented with Azolla leaf powder @ 10%. In this experiment, body weight, body weight gain, feed intake, FCR, nutrient utilization, nitrogen balance, carcass traits viz., live weight, dressed weight, eviscerated weight, dressing weight percentage, thigh, drumstick, liver, gizzard, heart weight as per cent of slaughter weight and haemato-biochemical parameters were measured to assess the effect of different treatments in Kadaknath chicken. The overall feed intake was significantly highest in T₃ (3769.95±7.14) followed by T₅ (3721.08±8.64), T₄ (3610.81±6.54), T₂ (3570.33±7.71) and lowest feed intake was found in T₁ (3545.86±3.40). Significantly highest body weight was observed in T₃ (1086.88±1.10) followed by T₅ (1036.88±0.98), T₄ (1035.98±1.73); T₂ (968.62±0.83) and lowest in T₁ (964.87±2.05). Overall body weight gain was significantly highest in T₃ (925.81±1.51 g) followed by T₄ (890.98±0.58 g), T₅ (880.76±3.12 g) and lowest in T₁ (820.64±4.20 g) and T₂ (819.56±4.09 g).

Key words : Feeding azolla leaf powder, kadaknath chicken.

Introduction

The poultry sector majorly maintain the requirements of protein and nutrition. The poultry industry in India has endured an exemplary transformation in structure and operation during the last two decades and modified into a mega-industry with the presence of a huge number of workers from a mere backward poultry farming that appears to be very fast. Kadaknath" meaning a fowl having black flesh and also known as Kalamashi very famous for its black-colored meat. The bird is native of Jhabua and Dhar districts in western parts of Madhya Pradesh. Kadaknath chicken meat is famous for its taste and claimed aphrodisiac and medicinal properties. Kadaknath meat is high in protein and also contains 18 kinds of essential amino acids and vitamins B-1, B-2, B-6, B-12, C and E. Poultry feed cost in developing country are continuing challenge improving feed efficiency and reduce feed cost, make poultry production a remunerative one.

Azolla pinnata has been tried as a feed for broiler chicken and was also used in diet formulations. Azolla contains (on DM basis) 20.4–28.5% crude protein, 2.37–6.70% ether extract, 12.6–17.5% crude fibre, 15.7–19.9% total ash, 30.0–47.0% nitrogen free extract, 48.2–54.8% neutral detergent fibre, 36.5–37.1% acid detergent fibre, 0.80–2.22% calcium and 0.35–1.39% total phosphorous. The protein composition of Azolla varies from 25-35 per cent on dry matter basis which is

easily digested by poultry. The nutrient composition of Azolla is almost identical to that of commercial poultry feed, except that Azolla's high protein content and calcium content is slightly low. The purpose of this study was to evaluate the effect of Azolla leaf powder (ALP) in the Kadaknath chicken diet on their productive performance.

Materials and Methods

The Poultry Farm, Department of Animal Production, Rajasthan College of Agriculture, Udaipur provided 150, four-week-old Kadaknath chicks for this study. The chicks were wing banded and divided into five treatment groups at random. Each treatment group contained 30 chicks, with three replications of 10 each.

Observations to be recorded

Feed intake and feed conversion ratio

Feed intake : Every treatment group had their feed intake measured twice in a row, every week. To determine feed intake, the total amount of feed supplied and its residue were weighed.

Feed intake (g) = Feed offered during the current day (g) – Feed leftover at the next day (g)

Feed conversion ratio (FCR) : Feed conversion ratio was estimated at weekly interval as well as for the entire growth period i.e., from 5th to 16th week of age. Feed

conversion ratio was calculated by Feed consumed in a particular period (g) divided by Body weight gain during same period (g).

Growth performance of birds

Weekly body weight : From the fourth to the sixteenth week, the body weight of each bird in each treatment group was noted at weekly intervals.

Weekly body weight gain : Body weight gain was measured in each treatment group at weekly interval.

Weekly body weight gain (g) = Current week body weight (g) – Previous week body weight (g)

Results and Discussion

Feed Intake : Total feed intake (table-1) from 4th to 16th weeks of age among different groups ranged from 3545.86±3.40 to 3769.95±7.14 g per chick. Feed intake was significantly higher in Azolla fed groups as compared to control. Further, it was observed that the feed intake increases as level in ration increases up to 5 per cent level there after a slight decrease in feed intake was observed.

Paudel *et al.* (2015) reported that feed intake increases upon inclusion of 10% Azolla meal in diet but further increase in the level of AZM decreases the feed intake. Rout *et al.* (2017) also reported highest feed intake in 10% Azolla meal fed broilers compared to 0, 5, 10, 15, 20 and 25% levels. Abdelatty *et al.* (2020) found that Azolla leaf meal inclusion in the diet of broiler chicken increased feed intake during the starter and grower but not the finisher stage regardless of the dose of ALM. Sharma *et al.* (2020) also reported that feed intake increases as the level of Azolla meal supplementation increases from 3.5 to 5.5%.

Feed conversion ratio : The mean feed conversion ratio (table-2) from 5th to 16th week was 4.14±0.03, 4.09±0.03, 3.84±0.02, 3.94±0.06 and 4.01±0.02 in T₁, T₂, T₃, T₄ and T₅, respectively. Birds fed control (T₁) and diet supplemented with 2.5% Azolla leaf powder (T₂) had significantly highest FCR as compared to rest of the treatment groups. The mean FCR was significantly lowest in T₃ (5% Azolla) as compared to rest of the treatment groups.

The result obtained in present study fall in line with the findings of Basek *et al.* (2002) that corroborated with present study who found lowest (Best) FCR in 5% Azolla meal fed group and observed that FCR decreased significantly at 10 and 15% Azolla meal in the diet. These might be due to higher fibre and tannin content in Azolla which may be responsible for decreased nutrient utilization and ultimately decreased FCR. Naghshi *et al.* (2014) observed that chicken fed 5% Azolla powder significantly improved feed conversion ratio (FCR) which

is in close agreement with the result of present study. Acharya *et al.* (2015) and Rana *et al.* (2017) observed that Azolla fed group showed higher feed efficiency than the control which is in agreement with the results of the present study. Similarly, Mishra *et al.* (2016) reported that FCR was significantly lower in Azolla meal fed groups than control with lowest FCR in 5% Azolla meal fed group of Chabro chicken. Kumar *et al.* (2018) who also recorded lowest FCR in 5% sun dried Azolla fed broiler chicks and highest FCR in control group. Swain *et al.* (2018) also reported that feeding of fresh azolla @ 200g/duck/day as replacement of 20 percent of concentrate feed in White Pekin Laying ducks was beneficial in terms of improved feed conversion ratio. Thavasi *et al.* (2020) also reported that the birds fed on 5% Azolla and 3% *U.lactuca* diet showed highest feed conversion efficiency.

On the other hand, Shukla *et al.* (2018), Lakshmi *et al.* (2019), Varadharajan *et al.* (2019), Samad *et al.* (2020) and Shamna *et al.* (2020) found non-significant effect of feeding Azolla on feed conversion ratio (FCR).

Body weight and body weight gain : The body weight of Kadaknath chicken at 4th week of age was 144.23±2.16, 149.07±3.41, 161.06±2.59, 145±2.31 and 155.2±3.96 g in T₁, T₂, T₃, T₄ and T₅, respectively. The initial body weight of Kadaknath chicken was statistically non-significant in all dietary treatments indicating that the treatments were homogenous in nature.

Body weight of chicks in all the treatment increases with the advancement of chicks and differed significantly among different treatment groups from 5th to 16th weeks of age (table 3). At 16th week, the body weight (g) was 964.87±2.05, 968.62±0.83, 1086.88±1.10, 1035.98±1.73, 1036.88±0.98 in T₁, T₂, T₃, T₄ and T₅, respectively. The overall body weight gain (table 4) was (from 5th to 16th week) 820.64±4.20, 819.56±4.09, 925.81±1.51, 890.98±0.58 and 880.76±3.12 in T₁, T₂, T₃, T₄ and T₅, respectively. Significantly highest body weight was observed in T₃ (5% Azolla) followed by T₅ (10% Azolla), T₄ (7.5% Azolla), T₂ (2.5% Azolla) and lowest in T₁ (0% Azolla) The difference between T₄ and T₅ was found non-significant. Overall body weight gain was significantly highest in T₃ (925.81±1.51 g) followed by T₄ (890.98±0.58 g), T₅ (880.76±3.12 g) and lowest in T₁ (820.64±4.20 g) and T₂ (819.56±4.09 g). The difference between T₁ and T₂ was found non-significant.

The results of present study are in close agreement with the findings of Shamna *et al.* (2013) who reported that inclusion level of 5 per cent Azolla in diet was considered optimum in quails, as there was depression in body weight and body weight gain beyond this level. Naghshi *et al.* (2014) observed that chicken fed diet containing 5 per cent Azolla powder significantly improved

Table-1 : Effect of feeding Azolla leaf powder on weekly feed intake (g/bird) in Kadaknath chicken.

Week/ Treatments	T ₁	T ₂	T ₃	T ₄	T ₅	SEm±	CD at 5 %
4	82.40 ^c ±1.39	66.48 ^d ±1.37	94.30 ^a ±0.98	85.60 ^b ±1.27	85.69 ^b ±1.08	0.94	2.98
5	135.47 ^c ±0.88	146.7 ^b ±1.78	182.97 ^a ±1.15	144.28 ^b ±0.99	109.61 ^d ±1.15	0.99	3.12
6	126.88 ^d ±1.12	160.64 ^a ±1.33	147.28 ^c ±1.32	152.54 ^b ±1.15	159.85 ^a ±1.08	1.19	3.73
7	166.61 ^c ±1.03	172.50 ^b ±1.35	155.68 ^d ±1.11	196.48 ^a ±1.29	175.38 ^b ±1.08	1.14	3.59
8	332.28 ^a ±1.51	111.56 ^e ±0.99	126.42 ^d ±1.24	208.80 ^c ±1.15	256.73 ^b ±1.20	3.60	0.76
9	329.43 ^a ±1.23	168.45 ^e ±1.24	288.24 ^b ±1.21	274.66 ^c ±1.24	241.95 ^d ±1.17	0.02	0.08
10	299.10 ^c ±1.13	265.75 ^e ±1.21	403.77 ^a ±1.03	338.43 ^b ±0.91	272.27 ^d ±1.21	0.83	2.61
11	278.65 ^c ±1.04	255.68 ^e ±1.38	398.28 ^a ±1.31	302.48 ^b ±1.41	272.04 ^d ±1.16	0.13	0.41
12	221.65 ^d ±0.98	378.88 ^a ±1.17	349.37 ^b ±1.87	316.77 ^c ±1.41	353.66 ^b ±1.34	1.37	4.31
13	266.57 ^e ±1.15	370.02 ^b ±1.17	373.17 ^a ±1.11	329.92 ^d ±1.17	354.62 ^c ±1.33	0.92	2.99
14	375.76 ^b ±1.20	335.88 ^d ±1.21	365.04 ^c ±1.15	364.61 ^c ±1.25	419.46 ^a ±1.37	0.98	3.07
15	422.40 ^c ±1.04	402.15 ^e ±1.23	461.47 ^b ±1.23	408.30 ^d ±1.33	488.69 ^a ±1.29	0.94	2.97
16	508.66 ^c ±0.96	483.29 ^e ±1.21	564.25 ^a ±1.21	487.94 ^d ±1.13	531.13 ^b ±1.20	0.11	0.35
Overall Feed intake	3545.86 ^e ±3.40	3570.33 ^d ±7.71	3769.95 ^a ±7.14	3610.81 ^c ±6.54	3721.08 ^b ±8.64	1.81	5.70

Means with the same superscript in a particular row do not differ significantly ($P < 0.05$) from each other.

Table-2 : Effect of feeding Azolla leaf powder on weekly FCR of Kadaknath chicken.

Week/ Treatments	T ₁	T ₂	T ₃	T ₄	T ₅	SEm±	CD at 5 %
5	3.90 ^{ab} ±0.02	4.10 ^a ±0.14	3.87 ^{ab} ±0.32	2.45 ^c ±0.03	3.14 ^{bc} ±0.46	0.26	0.82
6	3.57 ^b ±0.19	4.13 ^a ±0.21	2.49 ^c ±0.01	2.54 ^c ±0.05	2.80 ^c ±0.13	0.10	0.34
7	3.40 ^{ab} ±0.06	3.19 ^{bc} ±0.10	2.59 ^d ±0.06	3.50 ^a ±0.12	2.98 ^c ±0.03	0.07	0.24
8	4.90 ^a ±0.19	2.42 ^{cd} ±0.02	2.12 ^d ±0.04	2.68 ^c ±0.06	3.29 ^b ±0.04	0.09	0.30
9	4.63 ^b ±0.17	3.35 ^c ±0.09	4.36 ^b ±0.05	5.64 ^a ±0.22	4.61 ^b ±0.04	0.13	0.42
10	4.49 ^b ±0.02	4.48 ^b ±0.20	4.64 ^b ±0.04	5.05 ^a ±0.16	4.24 ^b ±0.02	0.12	0.38
11	4.14 ^b ±0.03	3.88 ^c ±0.18	4.68 ^a ±0.01	3.55 ^d ±0.01	4.01 ^{bc} ±0.02	0.07	0.22
12	3.27 ^d ±0.01	4.29 ^a ±0.02	3.95 ^b ±0.05	3.74 ^c ±0.11	4.04 ^b ±0.01	0.04	0.14
13	3.42 ^b ±0.06	4.11 ^a ±0.01	4.05 ^a ±0.02	3.52 ^b ±0.09	4.00 ^a ±0.09	0.06	0.20
14	3.90 ^{bc} ±0.05	3.73 ^c ±0.01	4.05 ^b ±0.12	4.36 ^a ±0.21	4.44 ^a ±0.02	0.06	0.20
15	4.49 ^{cd} ±0.04	4.72 ^{ab} ±0.12	4.34 ^d ±0.09	4.64 ^{bc} ±0.08	4.84 ^a ±0.13	0.047	0.15
16	5.55 ^b ±0.04	6.66 ^a ±0.17	4.98 ^c ±0.10	5.65 ^b ±0.05	5.68 ^b ±0.03	0.087	0.27
Mean FCR	4.14 ^a ±0.03	4.09 ^a ±0.03	3.84 ^c ±0.02	3.94 ^b ±0.06	4.01 ^b ±0.02	0.024	0.07

Means with the same superscript in a particular row do not differ significantly ($P < 0.05$) from each other.

daily weight gain compared to other diet. Mishra *et al.* (2016) found that Azolla meal at 5 to 7.5% level in poultry resulted in higher body weight gain. Rout *et al.* (2017) reported that higher body weight gain fed Azolla in the broiler ration up to 15% level. Similarly, Parthasarathy *et al.* (2002), Basek *et al.* (2002) and Ara *et al.* (2015) observed improvement in weight of chicken fed 5% Azolla meal in the diet.

On the contrary, Saikia *et al.* (2014) showed that broilers, which consumed 5 % Azolla meal showed comparable body weight gain to that of control group whereas 15 % Azolla meal inclusion in the broiler diet resulted in significantly lowest body weight gain. Similarly,

Paudel *et al.* (2015) reported that body weight of broiler chicks at 6th week was significantly lower in 10% Azolla fed group compared to control and 5% Azolla fed group.

On the other hand, Parthasarathy *et al.* (2002) reported non-significant difference in body weight gain of broilers on basal and 5 per cent Azolla diets. Balaji *et al.* (2009) did not find any significant difference in body weight gain at 6th week of age among treatments fed with 1.5, 3.0 and 4.5 per cent levels of sun dried and ground Azolla in basal diet. Acharya *et al.* (2015) and Yadav *et al.* (2016) observed non-significant effect on body weight gain of broilers fed Azolla in diet.

Table-3 : Effect of feeding Azolla leaf powder on body weight (g) of Kadaknath chicken.

Week/ Treatments	T ₁	T ₂	T ₃	T ₄	T ₅	SEm±	CD at 5 %
4	144.23±2.16	149.07±3.41	161.06±2.59	145±2.31	155.2±3.96	2.94	NS
5	179.00 ^c ±1.73	185.00 ^{bc} ±1.73	209.00 ^a ±1.73	204.00 ^a ±3.46	191.73 ^b ±1.75	2.19	6.91
6	214.83 ^e ±0.60	224.17 ^d ±0.60	268.23 ^a ±1.18	264.03 ^b ±1.73	249.17 ^c ±1.30	0.46	1.46
7	263.84 ^e ±1.74	278.34 ^d ±1.90	328.27 ^a ±0.64	320.41 ^b ±0.60	308.01 ^c ±1.15	0.91	2.86
8	331.83 ^c ±1.15	324.52 ^d ±1.13	388.02 ^b ±1.15	398.36 ^a ±0.95	386.00 ^b ±1.73	0.99	3.13
9	403.17 ^d ±1.17	374.80 ^e ±2.14	454.10 ^a ±1.68	447.25 ^b ±1.18	438.54 ^c ±1.01	1.14	3.58
10	469.75 ^d ±1.18	434.44 ^e ±0.90	541.14 ^a ±2.22	514.36 ^b ±1.24	502.81 ^c ±1.03	1.02	3.21
11	537.00 ^d ±1.32	500.67 ^e ±1.93	626.22 ^a ±1.73	599.55 ^b ±1.18	570.61 ^c ±1.09	0.34	1.07
12	604.76 ^d ±1.15	589.00 ^e ±1.15	714.57 ^a ±1.15	684.34 ^b ±1.07	658.15 ^c ±1.15	0.89	2.80
13	682.87 ^d ±0.59	679.01 ^d ±1.15	806.64 ^a ±1.93	778.10 ^b ±1.10	746.94 ^c ±1.18	1.17	3.68
14	779.25 ^d ±1.01	769.06 ^e ±1.13	896.95 ^a ±1.16	861.70 ^b ±1.21	841.34 ^c ±1.07	1.09	3.45
15	873.25 ^d ±1.64	866.92 ^e ±3.44	989.68 ^a ±1.18	949.68 ^b ±1.07	942.45 ^c ±1.38	0.87	2.75
16	964.87 ^d ±2.05	968.62 ^c ±0.83	1086.88 ^a ±1.10	1035.98 ^b ±1.73	1036.88 ^b ±0.98	1.12	3.52

Means with the same superscript in a particular row do not differ significantly (P<0.05) from each other.

Table-4 : Effect of feeding Azolla leaf powder on weekly body weight gain (g) of Kadaknath chicken.

Week/ Treatments	T ₁	T ₂	T ₃	T ₄	T ₅	SEm±	CD at 5 %
5	34.77 ^c ±0.43	35.93 ^c ±1.67	47.93 ^b ±4.31	59.00 ^a ±1.15	36.54 ^c ±5.70	3.30	10.41
6	35.83 ^b ±2.31	39.17 ^b ±2.31	59.23 ^a ±0.62	60.03 ^a ±1.73	57.43 ^a ±3.04	1.88	5.91
7	49.01 ^c ±1.15	54.18 ^b ±1.30	60.04 ^a ±0.58	56.37 ^{ab} ±2.32	58.84 ^a ±0.14	1.32	4.15
8	67.98 ^b ±2.89	46.18 ^d ±0.82	59.75 ^c ±0.63	77.95 ^a ±1.54	77.99 ^a ±0.58	1.54	4.86
9	71.34 ^a ±2.31	50.28 ^c ±1.01	66.08 ^b ±0.52	48.89 ^c ±2.12	52.54 ^c ±0.72	1.51	4.76
10	66.58 ^b ±0.17	59.64 ^c ±3.03	87.04 ^a ±0.55	67.11 ^b ±2.41	64.26 ^{bc} ±0.03	1.75	5.51
11	67.25 ^b ±0.28	66.23 ^b ±2.82	85.08 ^a ±0.49	85.20 ^a ±0.06	67.80 ^b ±0.06	1.19	3.75
12	67.76 ^c ±0.29	88.33 ^a ±0.77	88.35 ^a ±0.58	84.79 ^b ±2.25	87.54 ^a ±0.05	0.82	2.57
13	78.11 ^b ±1.73	90.01 ^a ±0.09	92.07 ^a ±0.78	93.76 ^a ±2.16	88.79 ^a ±2.33	1.64	5.17
14	96.38 ^a ±1.60	90.05 ^b ±0.03	90.31 ^b ±3.09	83.59 ^c ±0.12	94.40 ^{ab} ±0.11	1.54	4.83
15	94.00 ^b ±0.63	97.86 ^a ±2.31	92.73 ^b ±2.34	87.98 ^c ±0.15	101.11 ^a ±2.42	1.06	3.35
16	91.62 ^c ±0.53	101.70 ^a ±2.85	97.19 ^b ±2.28	86.30 ^d ±0.66	93.51 ^{bc} ±0.67	1.42	4.46
Overall BWG	820.64 ^d ±4.20	819.56 ^d ±4.09	925.81 ^a ±1.51	890.98 ^b ±0.58	880.76 ^c ±3.12	2.80	8.82

Means with the same superscript in a particular row do not differ significantly (P<0.05) from each other.

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Effect of Plant Growth Substances on Floral, Corm and Cormlet Traits in Gladiolus (*Gladiolus hybrida* L.)

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Abstract

The present investigation aimed to find out the “Effect of plant growth substances on floral, corm and cormlet traits in gladiolus (*Gladiolus hybrida* L.)” was conducted at Horticulture Farm, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur (Raj.) during the year 2021-22. The experiment was laid out in complete randomized design in plastic crates under protected condition on cormlets in replicated thrice with 10 treatment combinations, comprising three plant growth regulators. In this experiment on gladiolus cormlets application of CCC @ 750 ppm for 24 hours dipping was found most effective to improve growth parameters like earliest days to sprouting, highest leaves per plant with the dipping of cormlets in CCC @ 750 ppm, while cormel diameter was improved with the application of CCC @ 500 ppm in plastic crates. An application of GA₃ @ 200 ppm improved the weight of cormels per plant and propagation coefficient when planting material used as cormlet.

Key words : CCC, BAP, GA₃, gladiolus, plant growth substances.

Introduction

Gladiolus, a majestic bulbous ornamental crop grown throughout the world and native from South Africa. It is called the “Queen of bulbous flowers”. It comprises of about 300 species in which 250 are wild and 50 of garden origin. Gladiolus name derived from latin word *Gladius* commonly known as sword lily due to sword shape foliage, botanical name is *Gladiolus hybrida* and belongs to the family Iridaceae and subfamily is crocoidae. Gladiolus have chromosome number 2n=30 and diploid in nature but *Gladiolus grandiflora* is tetraploid in nature with chromosome number 2n=60.

Gladiolus is a mainly popular cut flower crop in international market one of the bulbous flower crops. Area of flowers in India is 304610 ha. and production of cut flowers in India is 762000 MT respectively (NHB, 2019-20). Area and production of gladiolus in India is 11850 ha, 174730 MT (NHB, 2015-16).

The plant growth substances soaking of bulbs in solution of plant growth substances has been used for obtaining good results, Pre-plant dipping of planting material in a plant growth regulator solution is now becoming a popular method among commercial growers by Schnelle *et al.* (2005).

Gibberellins was discovered by Kurosawa (1926). It was extracted from the fungus *Giberella fujikori* (*Fusarium*

moniliforme). First isolated gibberellin by Yabuta (1935). Phinney (1956) discovered GA₃ as a natural product of higher plants. Functions of GA₃ helps in seed germination, dormancy breaking, cell division, flowering, extending shelf life and fruit setting. Gibberellic acid has an important role in different plant processes, including seed germination, stem elongation, leaf expansion and flower development by Olszewski *et al.* (2002).

GA₃ delays senescence of flowers by reducing the senescence-promoting effect of ethylene. Attempts have been made to explore the role of GA₃ in growth and flowering of gladiolus by various workers and the application of GA₃ was found to shorten number of days to flowering, increase spike length, florets per spike, floret diameter, shoot elongation and vegetative growth significantly. GA₃ is used in stem growth, bolting in long day plants and induction of seed germination.

Cytokinin is also called as Phytokinin Haberlandt (1913) provided evidence that the substance from the phloem induces cell division. Miller *et al.* (1955) isolated a substance from heiring sperm DNA and named it kinetin. Hamzi and Skoog (1964) isolated zeatin from maize and thereafter other cytokinin's were isolated. The functions of the cytokinin cell division, cell and organ enlargement, seed germination, root initiation and growth, retention of chlorophyll and delayed senescence in leaves, breaking dormancy.

Table-1 : Effect of plant growth substances for cormel dip on cormel traits in gladiolus cv. GS-2.

Treatment	Vegetative parameter							
	Days to sprout of cormlet	Leaves per plant	Leaf length (cm)	Leaf width (cm)	Number of cormels per plant	Diameter of cormels (mm)	Harvested weight of cormels per plant (gm)	Propagation coefficient (%)
C1-GA ₃ @ 100 ppm	59.20	2.73	12.80	0.85	1.13	11.97	1.05	32.91
C2-GA ₃ @ 200 ppm	66.20	2.40	16.60	0.96	1.20	13.67	1.35	70.88
C3-GA ₃ @ 300 ppm	61.20	2.60	16.50	0.86	1.26	12.63	1.10	38.81
C4-BAP @ 50 ppm	65.80	2.20	10.84	0.78	1.26	12.07	0.96	21.51
C5-BAP @ 100 ppm	59.60	2.20	10.90	0.85	1.33	12.43	1.00	26.58
C6-BAP @ 150 ppm	49.00	2.73	10.00	1.13	1.40	12.44	0.89	12.65
C7-CCC @ 250 ppm	60.00	2.53	19.30	0.78	1.20	13.20	1.09	37.97
C8-CCC @ 500 ppm	60.20	2.73	15.80	1.06	1.20	13.67	1.11	40.50
C9-CCC @ 750 ppm	48.60	2.73	12.40	1.07	1.26	12.47	1.15	45.57
C10 (Control)	70.40	2.00	9.90	0.72	1.06	10.77	0.80	1.26
SEM (±)	0.11	0.23	0.35	0.005	0.08	0.005	0.01	2.40
CD (P = 0.05)	0.34	0.68	1.03	0.01	0.26	0.01	0.05	7.09
CV	0.33	16.21	4.49	1.10	12.56	0.07	3.14	12.67

6-Benzyl Amino Purine (BAP) is the type of cytokinin and mostly used for organ genesis.

The existence of auxin was proposed by Darwin (1880) while working on canary grass. Went (1928) performed "Avena-curvature test" that substance was known as IAA.

Cycocel (Chlormequat chloride, 2-chloroethyl trimethyl ammonium chloride) is a plant growth regulator for ornamentals, including bedding plants and herbaceous crops. Cycocel treated crops are more compact with shorter internodes, stronger stems and green leaves. It contains 11.8% chlormequat (2-chloroethyl) trimethyl ammonium chloride. (1.0 lbs per US gallon). Cycocel is a gibberellin inhibitor. Cycocel produces earlier budded plants with multiple buds per shoot. Cycocel (CCC) is the type of auxin act as growth retardant and stop the vegetative growth and induce the reproductive growth.

Materials and Methods

The investigation entitled "Effect of plant growth substances on floral, corm and cormlet traits in gladiolus (*Gladiolus hybrida* L.)" was conducted during Rabi season 2021-22 at the Horticulture Farm, RCA, MPUAT, Udaipur (Rajasthan) with a height of 562.8 metres above mean sea level. Udaipur city is located at latitude: 24° 34' N and 73° 42' E longitudes with summer and mild winters with annual rainfall 760 and 900 mm. the experiment included the 10 treatments with three replications in CRD design. Cormlets of gladiolus were planted in plastic crates under protected condition during 25 November, 2021. The observation was recorded for growth parameter which are as follow days to sprout of cormlet, leaf per plant, leaf length, leaf width, number of cormels per plant, diameter

of cormels, harvested weight of cormels per plant and propagation coefficient.

The details of used ten treatments respectively Plant growth substances are given under :

Treatments

- C1-GA₃ @ 100 ppm
- C2-GA₃ @ 200 ppm
- C3-GA₃ @ 300 ppm
- C4-BAP @ 50 ppm
- C5-BAP @ 100 ppm
- C6-BAP @ 150 ppm
- C7-CCC @ 250 ppm
- C8-CCC @ 500 ppm
- C9-CCC @ 750 ppm
- C10 (Control)

Figure-1 : Effect of Plant growth substances on growth and yield parameter of gladiolus.

Results and Discussion

Effect on vegetative parameter : It is evident from the data presented in preceding chapter that various characteristics had significant effect on vegetative growth parameter like days to sprout of cormels, leaves per plant, leaf length and leaf width of gladiolus. The critical analysis of the findings of the presents investigation clearly indicates that plant growth substances was significantly enhances vegetative parameters of gladiolus. The minimum days to sprout (48.60 days) and maximum leaves per plant (2.73) was observed with treatment C₉ (CCC @ 750 ppm), while maximum leaf length (19.30 cm) was recorded in treatment C₇ (CCC @ 250 ppm). This might be due to the CCC promoting increased synthesis of auxin and utilization of carbohydrate (Bhattacharjee *et al.* 1974). Similar results were found by Kumar and Singh

(2020) and Swain (2006) in gladiolus. The maximum leaf width (1.13 cm) was observed with treatment C₆ (BAP @ 150 ppm). This might be due to BAP inducing the cell division and responsible for maximum leaf width and shoots per corm (Mahesh and Misra 1993). These results are conformity with the finding of Kumar and Misra (2012) and Kumar *et al.* (2016) in gladiolus. However, the maximum days to sprout (70.40 days), minimum leaves per plant (2.00), leaf length (9.90 cm) and leaf width (0.72 cm) was observed with treatment C₁₀ (control).

Effect on cormels yield parameter : Different treatments of plant growth substances were showed significant effect on maximum number of cormels per plant (1.40) was recorded in C₆-BAP @ 150 ppm, while minimum number of cormels per plant (1.06) was recorded in C₁₀ (control). This might be due to BAP causes more splitting due to cytokinesis phase of mitosis cell division then increasing the number of cormels (Roy *et al.* 2017). Previous studied Khan *et al.* (2013) also found that higher concentration of BAP enhanced multiple shooting and accelerated cormels production in gladiolus. BAP increases the sink activity of developing cormels at the expense of flower spike, this might be the reason for increased in number of corms and cormels and poor-quality flower spikes. These results are in conformity with the finding of Tawar *et al.* (2007), Havale *et al.* (2007), Chopde *et al.* (2015), Aier *et al.* (2015), Baskaran and Abirami, (2016) and Roy *et al.* (2017) in gladiolus.

Application of CCC were significantly affected the maximum diameter of cormels (13.67 mm) was recorded with treatment C₈ (CCC @ 500 ppm), while lowest diameter of cormels (10.77 mm) was recorded in C₁₀ (control). This might be due to influence of growth retardants in delaying floral initiation, which would have enhanced source to sink relationship ratio by reducing the partition of carbohydrates to floral spike which is evident from the reduction in spike length due to CCC application as compared to control (Raaga, 2012) in iris plant and Patel *et al.* (2010) in gladiolus. Similar results were found Sudhakar and Kumar (2012) also reported CCC @ 500 ppm, Patel *et al.* (2010), Sable *et al.* (2015), Tameshwar *et al.* (2017), Khella (2018), Kumar and Singh (2020) and Kumar *et al.* (2021) while working in gladiolus.

Various levels of GA₃ were significantly influenced the maximum weight of cormels per plant (1.35 g) and propagation coefficient (70.88 %) was found in C₂ (GA₃ @ 200 ppm), while minimum weight of cormels per plant (0.80 g) and propagation coefficient (1.26 %) was recorded in C₁₀ (control). Previous studies revealed that the application of gibberellic acid significantly increased weight of cormels per plant due to exhaustion of assimilates towards stem elongation at higher concentrations which are positively correlated to the

propagation coefficient (Mahesh, 1992). Similar results were reported by Baskaran *et al.* (2009), Baskaran and Abirami (2016), Baskaran *et al.* (2017), Rashmi and Deen (2017), Priyanka *et al.* (2018), Rashid (2018) and Dua *et al.* (1984) in gladiolus.

Conclusions

On the basis of present investigation entitled "Effect of plant growth substances on floral, corm and cormlet traits in gladiolus (*Gladiolus hybrida* L.)" it may be concluded that to increase the size of cormlets dip treatment with C₉-CCC @ 750 ppm for 24 hours and planting in gladiolus was recorded earliest days to sprouting, highest leaves per plant, while cormel diameter were recorded in C₈-CCC @ 500 ppm, C₂-GA₃ @ 200 ppm along with weight of cormels per plant, propagation coefficient and C₆-BAP @ 150 ppm cormels per plant in gladiolus over the C₁₀ (control).

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Assessment of Traditional Storage Structures for Pulses in Southern Rajasthan

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Abstract

Efficient post-harvest handling storage contribute extremely to socio-economic enabling in developing nations. Growers utilize cheap, eco-friendly traditional storage containers for storing food grains for their own requirement to impart high shelf life to the stored commodities. These traditional storage systems could be applied in modern storage areas with minor modification, could save food commodities that would be damaged by insects. The present investigation was carried out by conducting a survey for the adoption of various pulse storage structure like *metallic khoti*, *metallic Peta*, plastic drum, HDPE bags (*katta*), jute bags, *metallic pepa* (tin box), earthen pots (*matka*), cloth bags (*jhola*), steel pots (*charu*), *bhukari* and simple polythene were adopted for pulse storage by the farmers along with the pest management practices like dry neem leaves (7.33%); fumigation with Aluminum phosphide (6.67%), sun drying of grain (6.00%), layer of ash or sand on top of grains (2.00%) against pulse beetle (*C. chinensis* L.). The order of adoption by mostly farmers is *metallic khoti* (36%); followed by *metallic peta* (14.66%), plastic drum (12.66%), HDPE bags (*katta*) (8.66%), jute bags (8.00%), *metallic pepa* (tin box) (6.00%), earthen pots (*matka*) (4.00%), cloth bags (*jhola*) and steel pots (*charu*) (3.33%), *bhukari* (2.00%) and simple polythene (1.33%).

Key words : Indigenous container, pulses, storage, pulse beetle.

Introduction

Grain legumes (*Fabaceae*) are excellent, principal and affordable source of protein and minerals in human dietary intake worldwide. Pulses contribute around 7-10 per cent of the total food grains production in the country (Naveen *et al.*, 2022). In India, total pulse area and production during 2020 was 283.4 lakh ha and 23.2 mt, respectively (Anonymous 2020). Rajasthan occupied second position in area and production of pulses. In Rajasthan, total pulses production was 4.49 mt with an area of 48.19 lakh ha during 2019-20 (Anonymous 2020). Black gram, scientifically known as *Vigna mungo* is an annually grown pulse crop and commonly known as *Urad* in India.

Pulses are fairly excellent sources of proteins (20 - 40%), carbohydrates (50 - 60%) and are good sources of thiamin, niacin, calcium and iron (Bhalla *et al.*, 2008). Pulses are damaged by a number of insect pests both in field and storage. Pulses suffer huge post-harvest deterioration due to infestation by *Callosobruchus chinensis* attributed to its prolific and rapid breeding; hence, cause a serious quantitative reduction as well as diminish nutritive value of stored seeds (Parsai *et al.*, 1989). Storage of pulses is one of the important links in the entire pulse production and utilization chain. Post-harvest losses account for 9.5 per cent of total pulses production. Among myriad postharvest operations, storage is responsible for the maximum loss (7.5%) while processing, threshing and transport cause (1%), (0.5%)

and (0.5%) losses, respectively. Among storage losses, pulses are most susceptible for qualitative and quantitative losses caused by storage pest (5%) compared to wheat (2.5%), paddy (2%) and maize (3.5%) (Singh, 2020).

In India about 70 per cent of farm produce is stored at farmers level using different types of storage structures made from locally available materials (Shukla and Pati, 1998). Farmers have been evolving number of traditional practices to avoid huge losses that are occurring in stored pulse seeds due to insect and pest infestation (Pushpamma and Rao, 1980). These indigenous storage structures and storage practices have been evolved in relation to specific environmental conditions and standardized after years of experimentation in the crudest but most practical manner at the farm and household level. Indigenous storage structures are based on the traditional knowledge of any particular area with the environment. These storage structures besides being cost effective are also well suited to varying storage needs of farmers (Parvathi *et al.*, 2003). These practices are considered eco-friendly because these are evolved within the community and carried over generation to generation with improvement at each level. On the other hand, proper packaging materials and storage containers are essential for retaining the seed quality and viability. Before or during marketing the commodity has to be stored in suitable containers/packings. The infestation intensity of different insect-pests is variable with different

storage structures and practices (Meena and Bhargava, 2003). Storage conditions and containers in addition to preservation and maintenance of healthy seed play a significant role in keeping the stored commodity free from the storage pest infestation during post-harvest period. Therefore, a detailed survey was conducted to collect the details of various indigenous storage structures and practices adopted by the farmers in the experimental area.

Materials and Methods

The details about the different storage structure and practices for pulses prevailing in the Udaipur district was carried out during 2021. Three blocks viz., Bhindar, Girwa and Mavli of ten farmers from five villages of each block were selected to collect the quantities data through questionnaires. Thus, data were collected from 150 farmers belonging to 15 villages in the three blocks of Udaipur. From storage structure of each farmer representative samples (approximately 200 gm) of pulses were collected in plastic zip lock pouches to find out the presence of infestation in terms of per cent grain damage.

Udaipur is located at 24°35' N latitude and 73°42' E longitude at an elevation of 582.17 MSL (Mean Sea Level) in the state of Rajasthan. The region comes under agro-climatic Zone IV (a) "Sub-humid southern plains and Aravalli hills" of Rajasthan. The average annual rainfall, humidity, temperature of Udaipur district is 637mm, 53%, is 24.1°C.

Observations

Per cent seed damage : The healthy seeds (un-infested) were sorted out and remaining infested or damaged seeds were counted. The per cent seed damage was calculated by the following formula :

$$\text{Per cent seed damage} = \frac{\text{Number of damage seed}}{\text{Total number of seeds used}} \times 100$$

Results

A detailed survey was conducted to find out prevailing traditional storage structures for pulses storage in Udaipur district of Rajasthan. A total number of 150 farmers were surveyed, belonging to three blocks of Udaipur region viz., Bhindar, Girwa and Mavli comprising of 15 villages (5 villages from each block) during the year 2020-21. The villages surveyed included were: Bhindar- Navaniya, Khokhrwas, Modi, Manjvada, Bhtewar; Mavli- Intali, Badgav, Udakhera, Dudhaliya, Changedi; Girwa- Meetaneem, Karget, Pai, Nichala Fla, Kaladwas. The data of survey presented in Table-1 reveal that *Metallic kothi* was observed as the most common adopted storage structure followed by *metallic peta*, plastic drum, HDPE

bags (*katta*), jute bags, *metallic pepa* (tin box), earthen pots (*matka*), cloth bags (*jhola*), steel pots (*charu*), *bhukari* and simple polythene. (Plate-1) The maximum number of farmers used *metallic kothi* [36%- Bhindar (40% farmers); Mavli (36% farmers); Girwa (32% farmers)] which is a metallic cylindrical structure having the capacity of 1,000 to 50,000 kg. The *Metallic peta* [14.66%- Bhindar and Mavli (16% farmers); Girwa (12% farmers)] was observed as next prevailing structure, used for storing small to medium quantity of grains, having the capacity from 100 kg to 2,000 kg.; followed by cylindrical shaped plastic drum [12.66%- Girwa (18% farmers); Mavli (12% farmers); Bhindar (8% farmers)] of 100 to 15000 kg. storage capacity. The adoption of high-density polyethylene (HDPE) bags commonly known as *katta*, was next commonly adopted storage structure with storage capacity ranged from 50 kg to 100 kg was used by [8.66%- Mavli (14% farmers); Bhindar (8% farmers); Girwa (4% farmers)] farmers, followed by jute bags (8.00%), having the capacity of 25 kg to 100 kg. It was observed that about [6%- Girwa (10% farmers); Bhindar (8% farmers); Mavli (6% farmers)] farmers store pulses in metallic containers (tin box) known as *pepa* usually with storing capacity of 5 kg to 100 kg. Earthen pots (*matka*) with storing capacity of 5 to 50 kg, were observed to be used by [4%- Bhindar (6% farmers); Girwa (4% farmers); Mavli (2% farmers)] farmers each, these both were used for storing small amount of pulses for short duration; while, 3.33 per cent farmers use cotton cloth bags (*jhola*) and Steel pots (*charu*) of capacity 10kg to 100kg. *Bhukari*, one of the ancient storage structures made up of mud, bricks and cement in which small outlet is provided at the base having the capacity of 3500 to 18000 kg; which prevailed only among [2%- Bhindar (4% farmers); Mavli (2% farmers); Girwa (0% farmers)] farmers. The use of simple polythene for storage of pulses observed among [1.33%- Girwa (4% farmers); Bhindar and Mavli (0% farmers)] farmers.

Per cent grain damage : The data recorded on per cent grain damage in different pulse storage structure presented in Table-2 revealed that the per cent grain damage was ranged up to 22.93 per cent. The mean per cent grain damage was highest in earthen pots (*matka*) [22.93%- Girwa (24.30); Mavli (23.00); Bhindar (21.50)] followed by jute bags [20.27%- Girwa (22.25); Mavli (20.00); Bhindar (18.58)], simple polythene [19.33%- Girwa (58); Bhindar and Mavli (0)], cloth bags (*jhola*) [15.83%- Girwa (26.00); Mavli (21.50); Bhindar (0)], HDPE bags (*katta*) [14.26%- Bhindar (16); Girwa (15.53); Mavli (11.23)], plastic drum [12.57%- Mavli (15.22); Girwa (13.50); Bhindar (9.00)], *metallic peta* [10.45%- Girwa (12.11); Bhindar (10.25); Mavli (9.00)], *metallic kothi* [8.45%- Girwa (9.30); Bhindar (8.06); Mavli (8.00)], steel pots (*charu*) [4.55%- Mavli (8.66); Girwa (5.00); Bhindar



Plate 4.1: Different pulses storage structures prevailed among farmers of Udaipur (2020-2021)

A. Metallic Khoti, B. Metallic Peta, C. Steel pot (*charu*), D. Metallic pepa (Tin box), E. Drum F. Earthen pot (*matka*) G. Bhukari, H. HDPE bags (*katta*), I. Jute bag, J. Cloth bag (*johla*), K. Simple polythene

(0)], *bhukari* [4.16%- Girwa (7.50); Bhindar (5.00); Mavli (0)] and in *metallic pepa* (tin box) lowest mean per cent grain damage [4.00%- Bhindar (4.50); Girwa (4.00); Mavli (3.50)] was recorded.

Discussion

The data recorded during the survey showed that farmers used (*metallic khoti*, *metallic peta*, plastic drum, HDPE bags (*katta*), jute bags, *metallic pepa* (tin box), earthen pots (*matka*), cloth bags (*johla*), steel pots (*charu*), *bhukari*

and simple polythene) structures (Fig.1). The result exhibited that farmers preferred *metallic khoti* followed by *metallic peta*, plastic drum, HDPE bags (*katta*), jute bags, *metallic pepa* (tin box), earthen pots (*matka*), cloth bags (*johla*), steel pots (*charu*), *bhukari* and simple polythene. The present findings are in line of agreement with the results of Alam *et al.* (2007), who recorded use of *dole*, *berh*, *motka*, *jala*, steel drum, gunny and plastic bags and *gola* for pulses storage. Similarly, Chattha (2014) recorded use of earthen bin (23%), metallic bin (16%),

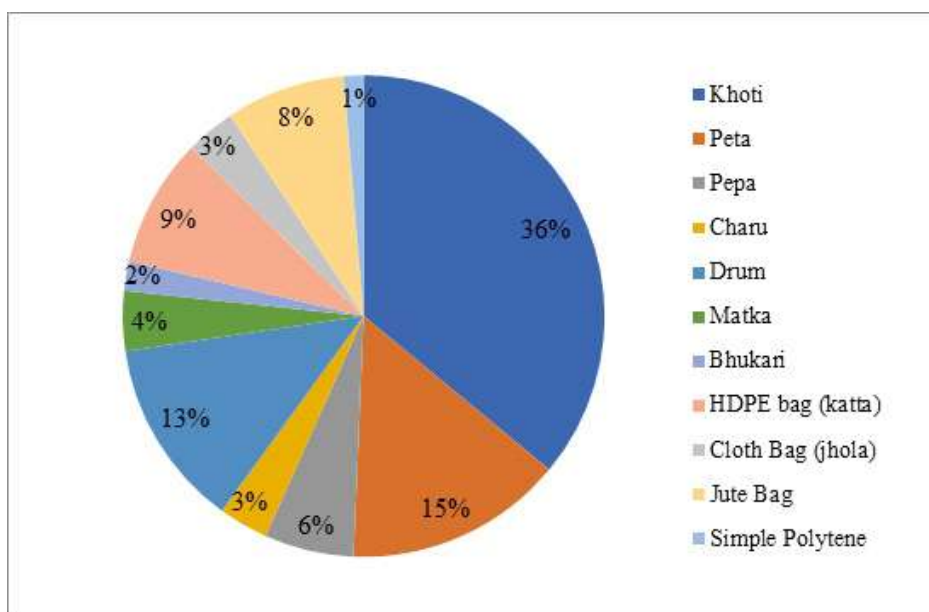


Fig.-1 : Adoption of various storage structures and packaging materials for the storage of pulses in Udaipur region of Rajasthan (2020-21).

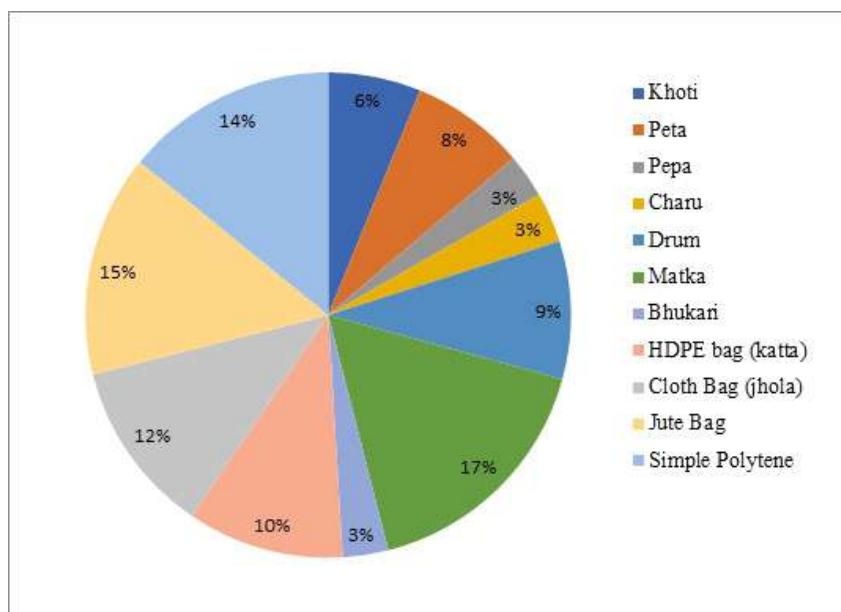


Fig.-2: Grain damage in different pulse storage structures adopted by farmers in Udaipur region of Rajasthan (2020-21).

bamboo/straw bin (20%), bulk covered (17%), bags covered (10%) and room type structures (14%) for pulse. Kumar *et al.* (2018) also recorded use of traditional storage structures like earthen pots and gunny bags for pulses storage. Present study also supported by Dubey and Saxena, 2014, Mobolade *et al.* (2019), Kumar *et al.* (2020).

Conclusions

Pulses are the main source of human protein requirements and animal feed worldwide and more so in developing countries. All the storage practices and methods review in this study are comparatively cheap and

constructed with readily available local materials, eco-friendly, impart considerable high shelf life to stored food grains by effectively reduced or suppressed insect infestation. These traditional storage and preservation practices can be improved upon or modified where necessary for effective pulse storage to ensure the full realization of agricultural potential to meet the world's increasing food and energy needs.

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Table-1 : Block wise prevalence of different pulse storage structures among farmers of Udaipur district (2020-21).

Storage structures		Numbers of farmers adopted different pulse storage structures (No.)				Per cent adoption of different storage structures (%)			
		Bhinder	Girwa	Mavli	Total	Bhinder	Girwa	Mavli	Mean adoption (%)
Metal bins	Metallic Khoti	20.00	16.00	18.00	54.00	40.00	32.00	36.00	36.00
	Metallic Peta	8.00	6.00	8.00	22.00	16.00	12.00	16.00	14.66
	Metallic Pepa (tin box)	3.00	2.00	4.00	9.00	6.00	4.00	8.00	6.00
	Steel Pot (charu)	2.00	3.00	0.00	5.00	4.00	6.00	0.00	3.33
Plastic bins	Plastic Drum	4.00	9.00	6.00	19.00	8.00	18.00	12.00	12.66
Other	Earthen Pot (Matka)	3.00	2.00	1.00	6.00	6.00	4.00	2.00	4.00
	Bhukari	2.00	0.00	1.00	3.00	4.00	0.00	2.00	2.00
	HDPE Bag (katta)	4.00	2.00	7.00	13.00	8.00	4.00	14.00	8.66
	Cloth Bag (jhola)	0.00	3.00	2.00	5.00	0.00	6.00	4.00	3.33
	Jute Bag	4.00	5.00	3.00	12.00	8.00	10.00	6.00	8.00
	Simple Polythene	0.00	2.00	0.00	2.00	0.00	4.00	0.00	1.33

Table-2 : Per cent grain damage in different pulse storage structures adopted by farmers of Udaipur district (2020-21).

Storage structures		Per cent grain damage (%)			
		Girwa	Mavli	Bhinder	Mean grain damage (%)
Metal bins	Metallic Khoti	9.30	8.00	8.06	8.45
	Metallic Peta	12.12	9.00	10.25	10.45
	Metallic Pepa (tin box)	4.00	4.50	3.5	4.00
	Steel Pot (charu)	5.00	8.66	0.00	4.55
Plastic bins	Plastic Drum	13.50	15.22	9.00	12.57
Other	Earthen Pot (Matka)	24.30	23.00	21.50	22.93
	Bhukari	7.50	0.00	5.00	4.16
	HDPE Bag (katta)	11.25	15.53	16.00	14.26
	Cloth Bag (jhola)	0.00	26.00	21.50	15.83
	Jute Bag	22.25	20.00	18.58	20.27
	Simple Polythene	0.00	58.00	0.00	19.33

Table-3 : Block wise different specific pest management practices adopted by farmers of Udaipur district (2020-21).

Pest management practices	Numbers of farmers adopted different specific pest management practices (No.)				Per cent adoption of different specific pest management practices (%)			
	Bhinder	Mavli	Girwa	Total	Bhinder	Mavli	Girwa	Mean adoption (%)
Sun drying of grain (A)	5.00	2.00	2.00	9.00	10.00	4.00	4.00	6.00
Use of neem leaves (B)	4.00	3.00	4.00	11.00	8.00	6.00	8.00	7.33
Use of ash and sand (C)	0.00	1.00	2.00	3.00	0.00	2.00	4.00	2.00
Fumigation of grain with aluminum phosphide (D)	3.00	5.00	2.00	10.00	6.00	10.00	4.00	6.67
Various combination*	2.00	1.00	0.00	3.00	4.00	2.00	0.00	2.00
Total adopted method	14.00	12.00	10.00	37.00	28.00	24.00	20.00	24.00
No method adopted	36.00	38.00	40.00	113.00	72.00	76.00	80.00	76.00

*A to D in Different combination

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Conflict of Interest

The authors declare that they have no conflict of interest.

Authors' Contributions

Conceptualization and designing of the research work (SN, L, HS); Execution of field experiments and data collection (SN, L, HS); Analysis of data and interpretation (SN, GC); Preparation of original draft manuscript (SN, L); Review & editing of manuscript (SN, GC, L, SB).

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Genetic Variability, Heritability and Genetic Advance among Wheat (*Triticum aestivum* L.) Genotypes

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Abstract

Fifty-five germplasm of wheat were evaluated to estimate relationships among yield and some yield components using direct selection parameters like variability, heritability and genetic advance at research farm, School of Agricultural Sciences and Engineering IFTM University, Moradabad (U.P.) during 2017-18 to 2018-19. Analysis of variance revealed highly significant differences for all the characters studied. Sufficient variability was present in the genotype under study. The genotypes showed moderate to high level of genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV). In general, phenotypic coefficient of variance was marginally higher than their genotypic coefficient of variance for the entire trait but the extent was quite small, indicating thereby that there is negligible influence on the characters by the environment. Genotypic coefficient of variation was found to be yield per q/ha (19.69), Number of effective tillers per plant (18.83), grain yield per plant (18.40) Number of spikelet's per spike (14.17). High genetic advance with high heritability estimates were observed for Grain yield per plant, Number of grain per spike, Plant height, Days to blooming, Days to maturity and yield(q/ha), indicating heritability is due to additive gene effects, so selection may be effective and it would be helpful in predicting the gain under selection.

Key Words : wheat, heritability, genetic advance, genotypic variation, phenotypic variation, yield.

Introduction

World wheat production is based almost completely on two modern species: hexaploid bread wheat (*Triticum aestivum* L, $2n = 6X = 42$, AABBDD), belongs to the family Poaceae, is one of the most important staple food amongst major cereals of the world, occupying 17 % of crop acreage worldwide, feeding about 40 % of the world population and provide 20 % of the total food calories and protein in human nutrition. Wheat originated from South West Asia. It is a self-pollinated crop and an annual plant having height about 60 to 150 cm long. Inflorescence of wheat is erect terminal spike of spikelet's called as ear or head of grains, flower grouped into 15-20 spikelet's arranged alternatively on rachis, each spikelet's with 2-6 flowers out of which only 2-3 flowers are fertile and produce grains. Wheat grain contains 2-3 % germ, 13-17 % bran (outer layers of wheat grain) and 80-85 % mealy endosperm on dry matter basis (3) (Globally, wheat (*Triticum spp.*) is grown in about 220.83 million hectares holding the position of highest acreage among all crops with annual production hovering around 769.31 million tones (USDA, 2020). In India, it is grown in area of 30.55 million hectares with a production of 107.18 million tones and productivity of 3508 kg/ha. With a production and productivity of 10.57 million tones and 3501 kg/ha., respectively (1). Grain yield in wheat is a complex character and is depend on its component traits. For genetic manipulation of grain yield, quality and other characters in wheat, there is a need to examine the nature

of genetic variability for the yield related attributes and quality traits. Estimation of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) helps to choose the potential genotype and heritability along with genetic advance would be more useful tool in predicting the resultant effect for selection of best genotypes for yield. The genetic advance (GA) is another important parameter to selection (18). Phenotypic and genotypic coefficients of variations, heritability and genetic advance have been widely used in wheat to assess the magnitude of variance in breeding material, to determine appropriate selection procedures and to predict the breeding advance in improvement of important traits (7,18, 20,). High genetic advancement together with high heritability estimates offers the most suitable condition for selection (12). The presence of variability, heritability and genetic advance in different yield related characters of bread wheat has been reported by different authors (2,8, 11, 16, 21). More importantly changes in genetic variability such as grain yield and related traits of bread wheat were studied not incorporated the recent one including candidates. Therefore, the objective of the present study was accomplished with to estimate genotypic and phenotypic variability in bread wheat genotypes and estimate the heritability and genetic advance under selection. The success of a breeding program depends largely upon the amount of genetic variability present in the population and the extent to which the desired traits are heritable (14). Heritability is an indicator for transfer of traits of interest from parents to its progeny and is widely

Table-1 : Analysis of variance (ANOVA) for the different characters of wheat genotypes.

Source of variation	df	Mean Sum of Square											
		DEE	DB	DM	PH	NETP	SL	SPS	NGPS	GYPP	TGW	DFH	YD
Replication	2	53.90	434	233.89	303	92.79	24.63	23.65	332.64	21367.13	18.23	634.42	152.46
Treatment	54	39.44**	89.30**	88.20**	148.58**	12.63**	6.02**	7.33**	193.76**	16709.93	12.35**	33.21**	58.99**
Error	108	5.98	0.008	1.90	1.53	0.24	0.67	1.41	3.92	12182.16	8.08	5.80	4.76
GM		72.16	78.58	144.67	103.79	18.85	15.10	19.13	76.29	702.52	39.95	111.68	39.01
Sem		1.41	0.05	0.80	0.71	0.28	0.47	0.69	1.14	63.72	1.64	1.39	1.26
CD 5%		3.96	0.14	2.23	1.99	0.79	1.32	1.92	3.20	178.63	4.60	3.90	3.53
CD 1%		5.24	0.19	2.95	2.65	1.04	1.76	2.54	4.24	236.31	6.09	5.12	4.67
CV		3.39	0.11	0.95	1.19	2.58	5.43	6.21	2.59	15.71	7.12	2.16	5.59

** 1 per cent level of significance, * 5 per cent level of significance

DEE: Days to ear head emergence; DB: Days to blooming; DM: Days to maturity; PH: Plant height (cm), NETP: Number of effective tillers per plant, SL: Spike Length (cm), SPS: Number of spikelet's/spike, NGPS: Number of grains per spike; GYPP: Grain yield per plant (gm), TGW: 1000 grain weight (gm), DFH: Days to 50% heading, YD: Yield (q/ha)

Table-2 : Genetic Variability parameters for yield and its contributing traits in wheat genotype.

S.No.	Character	General mean	Vg	Vp	Ve	GCV	PCV	ECV	h ²	GA	GG
1.	Days to ear head emergence	72.16	33.46	39.44	5.98	8.01	8.70	3.40	84.84	10.96	15.21
2.	Days to blooming	78.58	89.29	89.30	0.01	12.03	12.03	0.11	99.99	19.47	24.77
3.	Days to maturity	114.67	86.30	88.20	1.90	8.10	8.19	1.20	97.85	18.93	16.51
4.	Plant height at maturity (cm)	103.76	147.05	148.58	1.53	11.69	11.74	1.20	98.97	24.83	23.93
5.	No. of effective tillers per plant	18.85	12.39	12.63	0.24	18.67	18.83	2.60	98.10	7.173	38.06
6.	Spike length (cm)	15.1	5.35	6.02	0.67	15.30	16.23	5.43	88.87	4.49	29.70
7.	No. of spikelets per spike	19.13	5.92	7.33	1.41	12.70	14.17	6.22	80.76	4.51	23.57
8.	Number of grains per spike	76.29	189.84	193.76	3.92	18.06	18.25	2.60	97.98	28.10	36.83
9.	Grain yield per plant (gm)	702.52	4527.77	16709.93	12182.16	9.58	18.40	15.71	27.10	72.16	10.27
10.	1000 grain weight (gm)	39.95	4.27	12.35	8.08	5.18	8.79	7.11	34.57	2.50	6.26
11.	Days to 50 per cent heading	111.68	27.41	33.21	5.80	4.68	5.16	2.16	82.54	9.79	8.77
12.	yield (q/ha)	39.01	54.23	58.99	4.76	18.87	19.69	5.59	91.93	14.54	37.28

Vg: Genetic variance, Vp: phenotypic variance, Ve: Environmental variance, GCV: Genotypic Coefficient of Variation, PCV: Phenotypic Coefficient of Variation, ECV: Environmental Coefficient of Variation, h²: Heritability in broad sense; GA: Genetic Advance and GG: Genetic gain

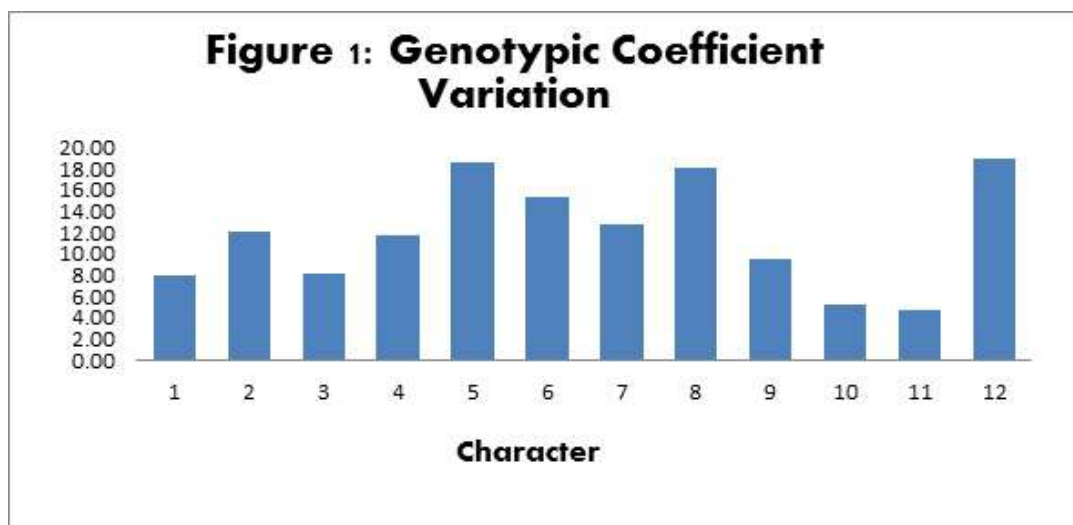


Figure-1 : Representing the genotypic coefficient of variation (GCV) for twelve different characters in wheat genotypes.

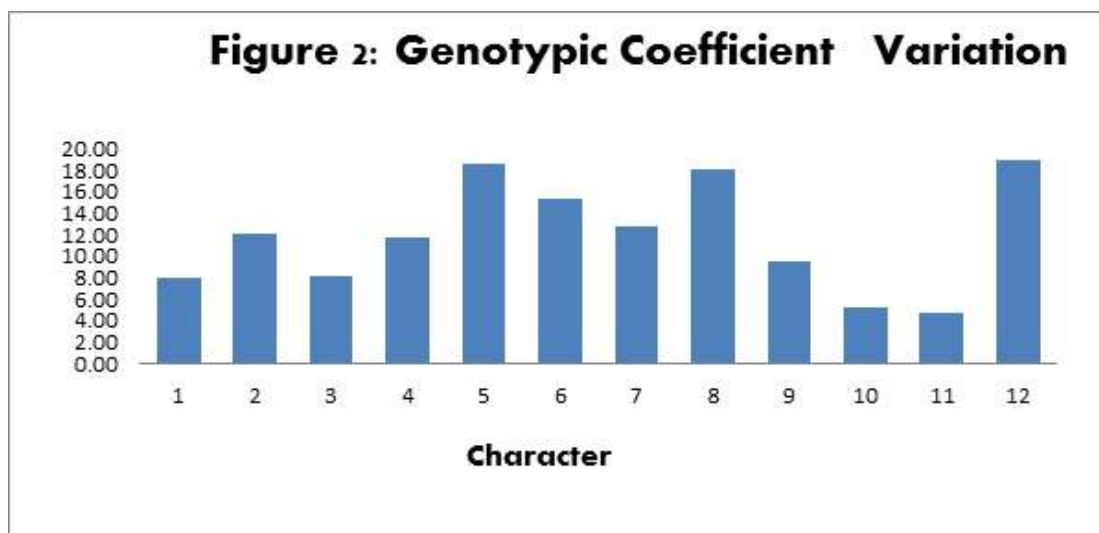


Figure-2 : Representing the genotypic coefficient of variation (PCV) for twelve different characters in wheat genotypes.

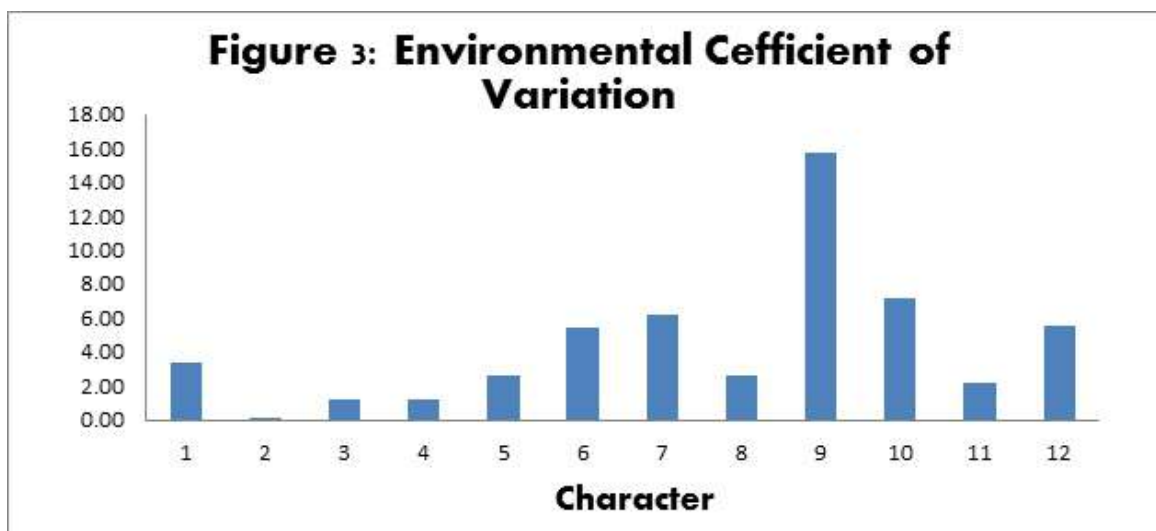


Figure-3 : Representing the environmental coefficient of variation (ECV) for twelve different characters in wheat genotypes.

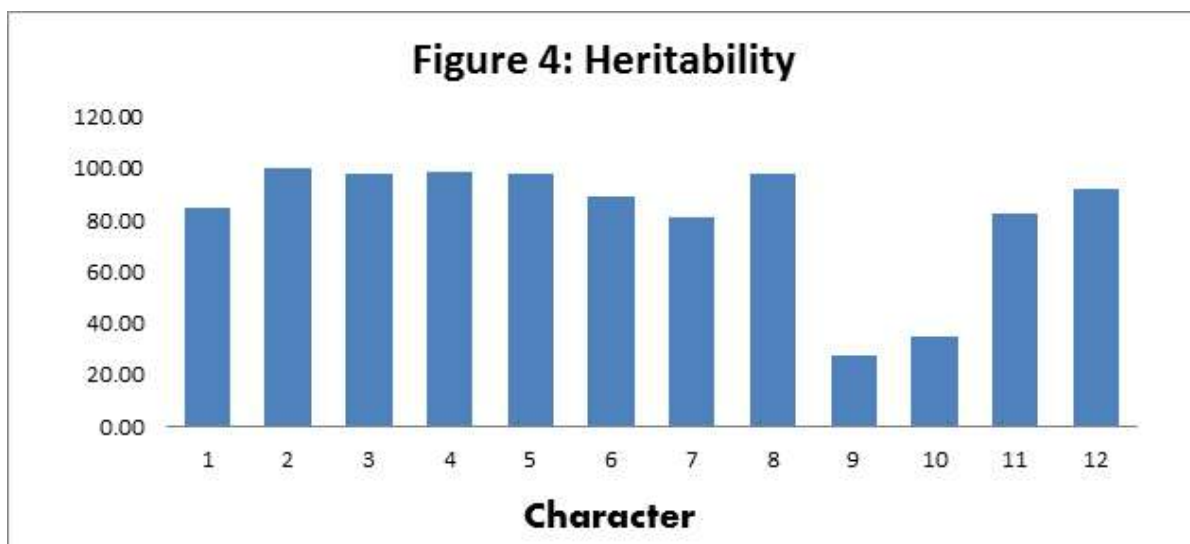


Figure-4 : Representing the heritability (h^2) in broad sense for twelve different characters in wheat genotypes.

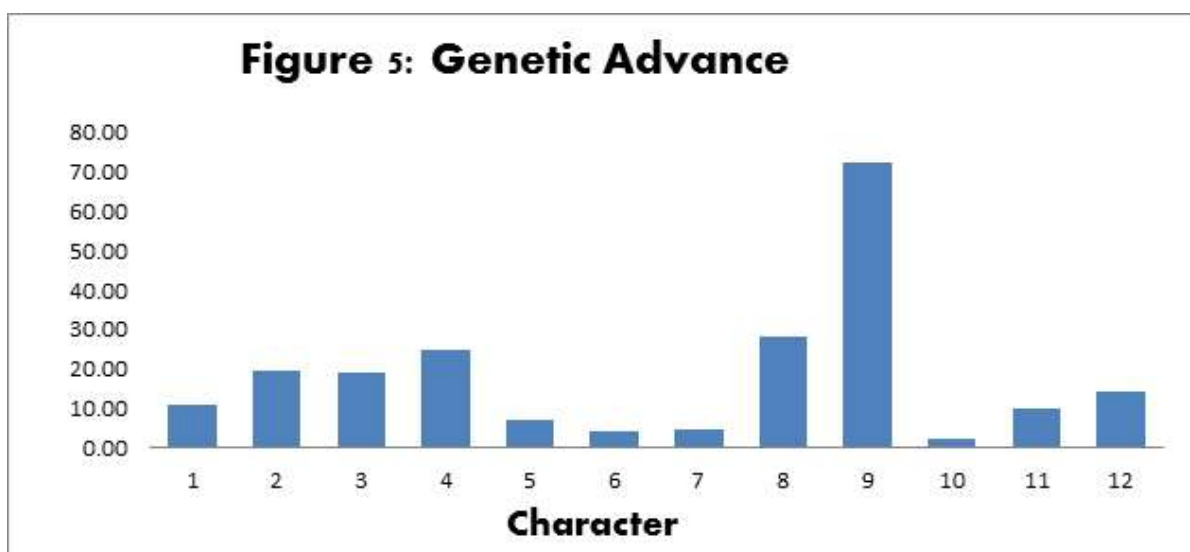


Figure-5 : Representing the genetic advance (GA) for twelve different characters in wheat genotypes.

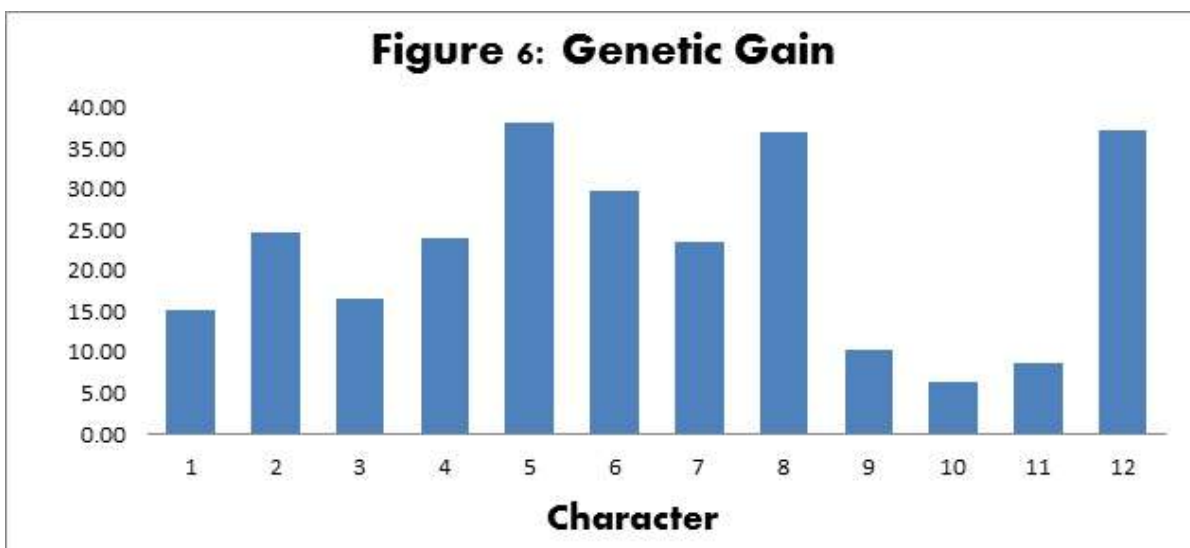


Figure-6 : Representing the genetic gain (GG) broad sense for twelve different characters in wheat genotypes.

used in breeding programs (9). Keeping these things in the view, the present investigation was made to assess genotypes with the objectives, to estimate the variability, heritability and genetic advance for yield and yield components traits in wheat.

Materials and Methods

A field experiment was conducted of 55 genotypes of wheat were sown in Randomized Block Design with three replication at research farm of School of Agricultural Sciences and Engineering, IFTM University, Moradabad (U.P.) and RB (PG) College Agra during 2017-18 to 2018-19. The soil type of experimental site was sandy loam (pH= 8.6) rich in potash and low organic carbon, nitrogen and phosphorus. The recommended package of practices was adopted for raising the healthy crop. Observations for all the traits were recorded on five randomly selected plants of each entry in each replication. Analysis of variance (ANOVA) for randomized block design for all attributes was done using statistical software (Windostat ver.80). Analysis of variance and the genetic parameters were computed by following standard statistical procedure outlined by (17). Genotypic and phenotypic coefficient of variation was calculated as per the standard formula suggested by (5). To test the difference among the genotype, the analysis of variance was worked out separately for each character as per method suggested by (10).

Results and Discussion

The genetic variability was estimated by the analysis of variance (ANOVA) is presenting in Table-1. The result based on the analysis all the treatments showed significant variation for all the characters like days to ear head emergence days to blooming days to maturity plant height number of effective tillers per plant spike length (cm) number of spikelet's/spike number of grains per spike 1000 grain weight (gm) days to 50% heading and yield (q/ha) exposed significant mean sum of squares due to genotypes for all the characters studied indicating presence of sufficient genetic variation among all the genotypes (NS) non significant except grain yield per plant was (gm) non-significant. The mean sum of squares due to replication was found to be non-significant for all the characters studied, Table-2. High magnitude of GCV were observed for yield (q/ha) (18.87%) followed by Number of effective tiller per plant (18.67%), number of grain per spike (18.06%) and spike length (15.30%), rest of traits were showed low magnitude of GCV. High magnitude of PCV were observed for yield (q/ha) (19.69%) followed by Number of effective tiller per plant (18.83%), number of grain per spike (18.25%) and spike length (16.23%), and remaining traits were showed low magnitude of PCV. Heritability in broad sense was high for most of the characters studied except grain yield per plant (27.10%)

and 1000 grain weight (34.57%). The highest heritability were observed for Days to blooming (99.99%), Plant height at maturity (98.97%), No. of effective tillers per plant (98.10%), Number of grain per spike (97.98%), spike length (88.87%), yield q/ha (91.93%). High magnitude of genetic gain were observed for Number of effective tiller per plant (38.06%), yield q/ha (37.28%), number of grain per spike (36.83) and spike length (29.70%) and days to blooming. Low magnitude of genetic gain was observed for 1000 grain weight (6.26%), days to 50% heading (8.77%). In the present investigating the phenotypic coefficient of variation (PCV) was marginally higher than the respective genotypic coefficient of variation (GCV) for all the characters studied indicating that there is negligible influence on the expression of characters by the environment. The grain yield per plant depicted highest genotypic coefficient of variation followed by grain weight per spike, biological yield per plant, number of grains per spike and number of effective tillers per plant, while highest phenotypic coefficient of variation (PCV) observed for grain weight per spike. The magnitude of GCV and PCV were low for days to maturity and protein content, Table-2. Earlier similar finding have been also reported by (4, 13, 19). The heritability estimates in broad sense were quite high for most of the characters indicated that strong genetic nature for all the traits. The higher heritability implied that selection for most of the traits might be effective in this set of genotypes. High estimates of heritability coupled with high genetic advance were observed for number of grains per spike, biological yield per plant, days to 50 % heading and plant height which indicated that above characters was governed by additive gene action and as such expected to exhibit improvement by direct selection. Similar findings were also reported by (4) and (15).

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Comparative Study on External Egg Quality Traits in Indigenous and Improved Chicken

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Abstract

The present experimentation was conducted at Animal farm, Department of Animal Production, Rajasthan College of Agriculture Udaipur. One hundred eighty eggs was collected from four different chicken breeds (40 week old) were used in 4 treatments with 3 replications, each consisting of 45 eggs. The treatments were (T₁) Kadaknath, (T₂) RIR, (T₃) Mewari, (T₄) Pratapdhan. In this experiment external egg quality traits were measured to comparison of indigenous and improved chicken breeds. Results showed that the egg weight at 40 week age was higher ($P<0.05$) in RIR (56.88g) followed by Pratapdhan (51.03g), Kadaknath (44.76g) and the lowest egg weight was found in Mewari (41.89g). Shape index was significantly higher ($P<0.05$) in Mewari (76.64%) as compared to Pratapdhan (74.72%). The egg shell weight was significantly highest ($P<0.05$) in RIR (5.44g) and lowest in Mewari (4.25g) as compared to rest of the treatments groups. The higher egg shell thickness was found in Pratapdhan (0.35mm) followed by RIR (0.34mm), Mewari (0.33mm) and significantly lower egg shell thickness was found in Kadaknath (0.32mm). It may be concluded that the external egg quality traits were significantly higher in improved chicken germplasm namely RIR and Pratapdhan as compared to indigenous chicken.

Key words : External egg quality, improved chicken, indigenous.

Introduction

Poultry farming is one of the fastest growing segments of the agriculture sector. Egg production in India is around 122.11 billion in 2020-21. The hen's egg has been conventionally believed as a good source of nutrients for human beings. Poultry products constitute an important component of human diet. Eggs contain all the essential amino acid, several vitamins and minerals required for human. As far as egg consumption is concerned it has been accepted worldwide as a staple food and included as an important ingredient in a balanced human diet. It is generally agreed that all characteristics of egg quality have a genetic basis. Egg quality has been defined by Stadelman (1977) as the characteristics of an egg that affect its acceptability to the consumers. Egg quality is the more important price contributing factor in table and hatching eggs. Among many quality characteristics, external factors including cleanliness freshness, egg weight and shell weight are important in consumers acceptability of shell eggs (Song *et al* (2000)). Quality of chicken eggs may vary due to several factors like rearing temperature, season, relative humidity and also a breed difference.

Materials and Methods

This research work was carried out with four chicken genotypes Kadaknath, Rhode Island Red, Mewari and Pratapdhan maintained at Poultry farm, Department of Animal Production, Rajasthan College of Agriculture Udaipur. The birds of each breed were reared in different

pens separately on deep litter system under optimum temperature, humidity and other management conditions.

External egg quality traits :

(A) Egg weight (g) : The weight of eggs was recorded in grams using digital balance to the nearest of 0.1g accuracy. In order to identify every egg marked by the pen.

(B) Egg colour : Colour of eggs shell was determined by visual observation.

(C) Shape index (%) : Experimentally this trait is usually defined by an index which is expressed as 100 times the maximum width divided by maximum length. The maximum length and width of eggs were measured by Vernier caliper.

Length: The longest length of each of the eggs was measured (mm) using Vernier caliper to the accuracy of 0.2mm.

Width: The broadest width of each of the egg was measured (mm) using Vernier caliper to the accuracy of 0.2mm.

(D) Egg shell weight (g) : The egg shell weight was measured by analytical balance while the percentage egg shell weight of total egg was calculated by egg shell weight divided by total egg weight

(E) Egg shell thickness (mm) : Shell thickness (mm) of dry egg shell was measured by help of micrometer (screw gauge) after six hours sun drying. The shell thickness was

Table-1 : Egg weight, egg size and shape index in different breeds of chicken.

Observation	T ₁ (Kadaknath)	T ₂ (RIR)	T ₃ (Mewari)	T ₄ (Pratapdhan)
Egg weight (g)	44.76 ^c ±0.25	56.88 ^a ±0.18	41.89 ^d ±0.35	51.03 ^b ±0.64
Egg length (mm)	51.29 ^c ±0.05	57.50 ^a ±0.07	50.10 ^d ±0.04	52.11 ^b ±0.08
Egg width (mm)	39.01 ^b ±0.05	43.21 ^a ±0.04	38.52 ^b ±0.12	38.92 ^b ±0.08
Shape index (%)	76.06 ^{ab} ±0.03	75.27 ^{ab} ±0.04	76.64 ^a ±0.09	74.72 ^b ±0.04

Figures bearing different superscripts in a row differ significantly ($P < 0.05$)

Table-2 : Egg shell quality traits in different breeds of chicken.

Observation	T ₁ (Kadaknath)	T ₂ (RIR)	T ₃ (Mewari)	T ₄ (Pratapdhan)
Egg shell weight (g)	4.66 ^b ±0.03	5.44 ^a ±0.04	4.25 ^c ±0.05	4.58 ^b ±0.02
Egg shell %	10.37 ^a ±0.02	9.59 ^{ab} ±0.06	10.14 ^{ab} ±0.02	9.38 ^b ±0.02
Egg shell thickness (mm)	0.32 ^b ±0.003	0.34 ^{ab} ±0.003	0.33 ^{ab} ±0.003	0.35 ^a ±0.003
Egg colour	light cream	Medium brown	Light cream	Light brown

Figures bearing different superscripts in a row differ significantly ($P < 0.05$)

measured at three points, first at the broad end, second at narrow end point and third at the middle part of the body of the egg shell. The mean of these three measurements was considered as shell thickness of the egg.

Results and Discussion

External egg quality traits

Egg weight : The egg weights in different breeds of chicken ranged from 41.89 to 56.88 g and the values were 44.76±0.25, 56.88±0.18, 41.89±0.35 and 51.03±0.64 g in Kadaknath, RIR, Mewari and Pratapdhan, respectively. Significantly highest egg weight was found in RIR followed by Pratapdhan, Kadaknath and the lowest egg weight was found in Mewari. Results of the present study are in agreement with the findings of Monira *et al.* (2003), they reported egg weight of RIR is 55.95 g. Islam and Dutta (2010) have recorded highest egg weight in RIR at 56.50 g as compared to desi (40.04g), broiler (46.80g), Fayoumi (39.83g) and crossbreed (43.80g). Similarly, Khawaja *et al.* (2012) reported 56.82 g egg weight of RIR which was significantly higher as compared to Desi and Fayoumi. Ali and Anjum (2014) also reported that egg weight (g) of RIR egg was 49.07 g which is lower as compared to the findings of present study.

Egg length and Width : The egg length (mm) in different breeds of chicken ranged from 50.10 to 57.50 mm and the values were 51.29±0.05, 57.50±0.07, 50.10±0.38 and 52.11±0.08 in Kadaknath, RIR, Mewari and Partapdhan, respectively. The egg width (mm) in different chicken breeds ranged from 38.52 to 43.21mm and the mean egg width were 39.01±0.05, 43.21±0.04, 38.52±0.12, and 38.92±0.08mm in Kadaknath, RIR, Mewari and Partapdhan, respectively. Similar observation was reported by Hrncar *et al.* (2016) who observed that egg length of RIR was 57.78 mm and egg width was 43.20 mm and found significant ($P<0.05$) breed differences for egg length however egg width didn't differ significantly.

Shape index : The shape index (%) ranged from 74.72 to 76.64 % among different breeds of chicken studied. The shape index in Kadaknath, RIR, Mewari and Pratapdhan was 76.06±0.03, 75.27±0.03, 76.64±0.09 and 74.72±0.04 % respectively. The results of the present study are in agreement with the findings of Niranjana *et al.* (2008) who reported that shape index (%) of Vanraja birds ranged from 76.18 to 78.13% while Hrncar *et al.* (2016) reported that the shape index of RIR breed was 74.74%.

Egg shell quality traits in different breeds of chicken :

Egg shell weight : The egg shell weight (g) in different breeds of chicken ranged from 4.25 to 5.44 g and the values were 4.66±0.03, 5.44±0.04, 4.25±0.05 and 4.58±0.02g in Kadaknath, RIR, Mewari, and Pratapdhan, respectively. Significantly highest egg shell weight was found in RIR and lowest in Mewari as compared to rest of the treatments groups. Similar egg shell weight in RIR was reported by Hrncar *et al.* (2016) at 5.43 g. Sinha *et al.* (2018) reported that higher egg shell weight (6.21 g) of RIR eggs as compared to present study.

Egg shell percent : The eggshell percent ranged from 9.38 to 10.37 % among different breeds of chicken. The eggshell (%) in Kadaknath, RIR, Mewari and Pratapdhan were 10.37±0.02, 9.59±0.06, 10.14±0.02 and 9.38±0.02% respectively. Results of the present study are in agreement with the findings of Jena *et al.* (2018) who also reported that egg shell percent of Kadaknath egg was 10.18% whereas Haunshi *et al.* (2013) reported that egg shell percent of 9.57 in Kadaknath egg which was lower than present study.

Egg shell thickness : The egg shell thickness (mm) ranged from 0.32 to 0.35 mm among different breeds of chicken studied. The eggshell thickness (mm) in Kadaknath, RIR, Mewari and Pratapdhan were 0.32±0.003, 0.34±0.003, 0.33±0.003 and 0.35±0.003mm respectively. The data observed present study are in

agreement with the findings of Jha and Prasad (2013) who reported the mean shell thickness of Vanraja egg was 0.36mm and Grampriya egg was 0.37mm. While Pathak *et al* (2018) reported that egg shell thickness of Vanraja egg was 0.38 mm which was significantly higher as compared to the values found in the present study for different breeds.

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Probiotics-An Emerging Panacea for Curing Skin Disorders

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Abstract

Skin disorders are one of the major concerns for researchers in the medical field today because these are the foremost indication of many serious diseases like cancer, HIV/ AIDS and the other reason is the never-ending desire of humans for pulchritudinous looks. Topical treatments, retinoids, moisturizers, medications, and light treatments are currently being used to reduce the symptoms of skin disorders but no proper treatment is available. Several studies have shown that gut microbiota could prove to be a hidden skin regulator and the gut-microbial balance could be used as an alternative for curing skin disorders. In this review, we are focusing on the mechanism of occurrence of different skin disorders, the treatments available for them and also the role of gut microbiota in maintaining healthy skin. Also, it details the available evidence that indicates the effectiveness of probiotics in curing skin disorders. Probiotics may prove to be an effective modulator of the skin microbiota which in turn is a hidden regulator of skin health. Therefore, the use of probiotics in curing skin disorders could prove to be an effective approach in the future of the medical field.

Key words : Skin disorders, gut microbiota, probiotics.

Introduction

Advances in medical science and research have transformed global health and reduced mortality, with non-fatal diseases and injuries emerging as risks affecting the quality of life globally. According to the 'Global burden of disease' project, skin disorders are assessed to be the fourth most precarious cause of non-fatal disease burden worldwide. Skin is the largest organ of the human body and plays important role in sensation, heat regulation, protection against mechanical impacts and pressure and also acts as a biological barrier to pathogens. It also acts as a major determinant of appearance and identity. Major skin diseases include atopic dermatitis, acne vulgaris, vaginal infection, psoriasis, etc. Cramped houses, ignorance and lack of proper financial resources are the reasons that these diseases are more prevalent in developing countries. Not only this, the appearance of skin problems is the foremost indication of diseases like HIV/AIDS, leprosy and onchocerciasis and thus exacerbate the situation in case not given due recognition in time. Commonly used skin treatments include the use of topical ointments, antifungal medicines, antibiotics, herbals, etc. But each of them has different consequences like excessive use of antibiotics may result in the development of antibiotic resistance and antifungal medicines can cause an allergic reaction. The topical ointments may also result in irritation, dryness, or unusual hair growth. Herbal treatment does not have any side-effect but one needs to have a lot of patience. The present scenario solemnly demands for operational research and evaluate interventions that can work in a

better way of dealing with the situation (Nankervis *et al.*, 2016).

Several kinds of research and studies have shown that oral and topical use of probiotics can prove to be effective in curing these disorders while avoiding the harmful effects shown by available treatments. According to ISAAP, "Probiotics are live microorganisms that when administered in adequate amounts, confer a health benefit to the host". Many pieces of evidence have shown that gut microbiota also affects the distant sites and organs. They are demonstrated to have a beneficial effect in curing several skin disorders such as atopic dermatitis, psoriasis, rosacea, acne vulgaris, and other skin diseases. The topical use of probiotics results in the inhibition of pathogen growth and also resists their adhesion to skin (Najem *et al.*, 2017). This article reviews the current knowledge on the effectiveness of probiotics in curing skin disorders and also describes the mechanism involved in healing these disorders.

Common Skin-disorders and their mechanism

Atopic Dermatitis : Atopic Dermatitis (AD), commonly known as eczema, is one of the most frequently occurring non-communicable chronic skin diseases characterized by itching, pain, inflammation, etc. (Nankervis *et al.*, 2016). This disease has affected more than 20% of children and about 3% of adults worldwide and is still vaulting up at high rates (Najem *et al.*, 2017). The affected areas include the face, arms, neck, leg, etc. The common symptoms of AD include itching, redness, swelling, vesicle formation, blisters, scaling, and dehydration of the skin.

These patients show higher susceptibility to diseases like asthma, hay fever, seborrheic dermatitis and staphylococcus infections. Several factors like low humidity, exposure to harsh soaps and detergents, cold weather, and seasonal allergies increase the risk of disease development. AD incur as a preliminary indication of several allergies such as food allergy and allergic rhinitis (Guo *et al.*, 2020). This progression is also known as 'Atopic March'. The main components of AD include epidermal barrier disruption, genetic predisposition and dysregulation of the immune system. AD can be of two types – Extrinsic and Intrinsic. More than 70% of the patients are affected by extrinsic AD which occurs in response to environmental allergens and increased IgE serum levels. This form is also known as the allergic form. The second type intrinsic or non-allergic AD, which affects about 20% of the patients, is characterized by low IgE serum levels and the absence of any allergic sensitization (Novak *et al.*, 2003).

The mechanism of development of this disease is unevenness in Th1/ Th2 leukocyte profile which results in mast cell dysfunction. This dysregulation is mainly skewed towards Th2 profile. This imbalance phenotypically leads to conditions like erythema, hemorrhage, itching, etc. (Gerritsen *et al.*, 2011). It is seen that affected patients have higher skin pH when compared with a normal person which adversely affects the epidermal barrier function. The available treatments include rehydration of the skin with moisturizers like petroleum jelly, oral antibiotics, antihistamines, and the use of topical steroids (Parrish, 2012). However, the available therapies have lowered the inflammation, dryness and itchiness caused due to AD, but there is no panacea available that clearly demands the development of better therapies to improve the quality of life.

Psoriasis : Psoriasis is a chronic, non-contagious, recurring, immune-mediated skin disorder that is identified by red, itchy, silver scaly patches on the skin (WHO, 2016). According to the World Psoriasis Day consortium, Psoriasis has affected about 2-3% of the total population worldwide. Increasing prevalence, associated comorbidities and socio-economic burden have highlighted it as a new emerging threat affecting the quality of life at the global level. This disease can affect any age group however is more prevalent among people aged between 50-69 years (WebMd, 1998). Mostly affected areas include the scalp, elbows, knees, nails and lower back. Factors like emotional stress, strep infections, cuts, surgery, and medications such as Beta-blockers, and hydroxychloroquine provoke the chances of its outbreak. About 10-30% of patients affected by this disease develop psoriasis arthritis which results in pain and swelling of joints (Rendon *et al.*, 2019).

Psoriasis can be of mainly four types such as plaque psoriasis, flexural psoriasis, guttate type and pustular type. Among these plaque, type is the most common. Depending on the type it can affect different areas like nails, skin and joints. Associated co-morbidities of this disease include serious diseases such as type-2 diabetes, obesity, coronary artery disease, cardiovascular disease and many more (Cole *et al.*, 2022). The exact etiology of this disease is still unknown. However, it is believed to be immune based disorder in which T-cells lead to hyperproliferation of keratinocytes due to which the formation of new skin cells takes place at a faster rate. Ideally, the cells which should have been replaced within 10-30 days, now get replaced in 3-4 days. This faster action is responsible for the formation of silver scales (Saboo, 2020). At present, there is no cure for Psoriasis. But uses of certain topical treatments, retinoids, moisturizers, light therapies, and medications help in lowering the adverse effect of this disease. The pernicious effect of Psoriasis on quality of life is well-known but it is still either undertreated or under-diagnosed. Various consequences are associated with the currently available treatments. This clearly demands new research and development of new therapies with the least side-effects that can help us to deal with this dreadful disease easily.

Rosacea : Rosacea is a common chronic skin disorder that mainly affects the face and is characterized by persistent redness on the cheeks, neck, nose, chin, or ears. In severe cases, the person may develop broken swelled blood vessels in the eyelids. Other symptoms include inflammatory and dry skin, larger pores and bumps on eyelids (Cynthia *et al.*, 2012). Eye-related co-morbidities are commonly associated with Rosacea like redness, swelling and pain. These patients are more prone to diseases like diabetes, CVD, inflammatory diseases, etc. As per the reports currently available, it has been reported that almost one in every twenty Americans is suffering from this disease, which points out the alarming situation of the current scenario (Mikkelsen *et al.*, 2022). Like many other skin diseases, the cause of Rosacea is also unknown. However, evidence show the involvement of hereditary factors, problems with blood vessels which are intensified by sun damage and mites such as *Demodex folliculorum* among highly sensitized individuals. *H.pylori*, a gut microbiome is also found to raise the amount of a hormone called gastrin which results in the development of this disorder.

Factors like sunlight, stress, spicy food, alcohol, intense exercise and some medications can act as triggers for Rosacea. It is more common among middle-aged women with fair skin. It mainly affects the face and hence physical appearance which results in stress, depression and lack of confidence among

individuals. It is of four types which are erythematotelangiectatic (ETR), papulopustular, phymatous and ocular (Williams *et al.*, 2012). Symptoms of ETR include persistent redness on face and broken blood vessels. Papulopustular type is characterized by redness, swelling and plaque formation while in the case of phymatous type skin becomes thicker. Ocular type results in swelling and irritation on eyelids. Rosacea has no cure. However certain treatments used for other skin diseases such as topical creams, antibiotics, lasers, pulsed light therapies, and antibacterial washes can help to lower the symptoms.

Acne vulgaris : Acne vulgaris is a common inflammatory skin disorder that occurs because of the clogging of hair follicles which is due to excessive oil production and presence of dead cells on the skin surface. It is mainly characterized by scars and pimples on face, shoulders, back, neck, chest etc. Acne can be of several types such as pimples, cysts, whiteheads, blackheads etc. This disease is more prevalent among adolescents. There are several factors responsible for acne development. The primary reason is blockage of the follicle that connects skin pores to sebaceous glands present under the skin. These glands secrete oil called sebum which carries dead skin cells to the surface. Excessive production of this oil which is mainly androgen induced, a hormone specifically produced at a higher level when a person attains puberty, results in blockage of the follicle which ultimately leads to pimple formation. Colonization of bacteria such as *P.acnes* on hair follicles of face and follicular hyper keratinization may also be responsible (Rathi *et al.*, 2011). Use of greasy cosmetics, hormonal changes, emotional stress and disturbed menstrual cycle provokes the situation. The treatment for this disease depends on the severity of the condition. Mild cases can be treated with the use of topical agents which include benzoyl peroxide, antibiotics, and retinoid while severe cases need to be treated with hormonal therapy, photo-therapy or isotretinoin (Ruiz-Lozano *et al.*, 2020). However, isotretinoin is the most commonly used drug but it can't be prescribed to pregnant women or persons with high cholesterol levels due to the adverse effect involved. All the available treatments have different side effects. This is the reason that there is a significantly increasing demand for new therapies with the least possible adverse effects (Salem *et al.*, 2018).

Gut microbiota–The hidden Skin-regulator : The Gut microbiome refers to trillions of microbes including bacteria, fungi, protozoa, viruses and their genetic material that inhabit the gastrointestinal tract of every individual. Many research workers have shown the interrelation between the gut microbiome and the occurrence of several diseases such as cancer, type-2 diabetes, obesity, etc. which has pooled the interest of scientists towards the gut microbiota as a newly emerging

tool in the field of medicine. Not only these diseases but this microbiome balance is also found to affect the health of distant organs including skin, bones and brain. The gut and skin both are neuroendocrine organs and are inhabited by a large number of microbes that have a direct impact on the anatomy of surrounding organs. Evidence has shown the interlinkage between gut microbiome imbalance (dysbiosis) and the development of skin diseases like inflammation, rosacea, acne, etc. (Gewin, 2012). This unique interrelation between the gut and the skin is described with the help of the term gut-skin axis. The gut microbiota regulates the skin-health by reciprocating with the immune system, affecting the growth of certain hormones directly (Kosiewicz *et al.*, 2014). The gut microbiota communicates with the immune system to regulate the level of T-cells which in turn act as an inflammation modulator. Also, the absorbed nutrients from the diet may result in the stimulation of excessive growth of certain hormones like insulin. Increased level of Insulin-like growth factor (IGF-1) results in excessive production of inflammatory mediators and sebum oil which leads to the development of acne flares. Also, studies have shown that a diet with a high glycemic index increases the concentration of IGF-1 which increases the chances of acne development. Moreover, the metabolites produced by microbiota during digestion such as SCFA also regulate the growth of certain microbes and pathogens present on the skin and hence influence inflammation and other skin diseases. A new approach to curing skin disorders with the lipopolysaccharides produced by the gut-microbes is an emerging area of research in the field of medicine (Vaughn *et al.*, 2017).

Different skin disorders are found to be linked with gut microbiome imbalance. A clinical trial conducted to analyze the difference in gut microbiome composition of psoriatic patients and healthy individuals has reported a less diverse microbial population and a reduction in important bacterial enterotypes such as *Coprococcus spp.* in patients with Psoriasis and a reduction of enterotypes like *Akkermansia*, *Ruminococcus* and *Psuedobutyrvibrio*. Evidence has also shown the association of dysbiosis with atopic dermatitis due to the observed reduction in SCFA-producing bacteria like *Bifidobacterium spp.* and the presence of a less diverse population in the gut of a person suffering from AD. Similarly, rosacea is linked with the infection of *H. pylori* (Kalliomäki *et al.*, 2003). The gut microbiome balance helps in maintaining skin allostasis and rejuvenation of homeostasis by modulating the inherent immunity of an individual. According to a controlled study on hairless mice, the oral supplementation of *Lb. johnsonni* has been found to protect mice against UV-induced hypersensitivity by increasing systemic IL-10 levels (Kim, 2020). Hence an intentional modulation of the gut microbiota can help us to

fight against a number of skin diseases. Although a significant amount of research has been done but exploring the modulation of the gut microbiota as a treatment for disorders, is still a neglected area in the field of medicine. And it might prove an important area of future research to deal with the consequences of available treatments such as antibiotic resistance, allergies, etc.

Probiotics in curing Skin-disorders : The interrelation of gut-microbiota balance and different skin disorders has clearly shown that an intentional alteration of the gut microbiome population might show promising results in curing skin disorders. Different factors are responsible for the modification of gut microbiota, but diet is one of the most important factors. Adding probiotics to the diet can effectively help in modulating the immune response by altering the gut microbiota and is currently being used as a newly emerging therapy for several diseases in the era of antibiotic resistance and various other side effects of the available treatments. Recent advances have pooled the interest of scientists toward the use of probiotics as an alternative therapy for skin disorders and many studies have shown positive effects. Evidence has shown a lack of intestinal bacteria, especially *Bifidobacteria*, which are responsible for maintaining the Th1/Th2 balance and shifting the balance towards the Th2 profile in patients with AD. A study conducted on selected pregnant women in the last trimester of pregnancy who were very likely to have children with AD has shown fewer neonates with AD when the mother's diet was supplemented with probiotics (Kalliomäki *et al.*, 2003). A clinical trial was conducted to study the effect of *Lb. acidophilus*, *Bifidobacterium lactis* and fructooligosaccharides in 12-36 months children already suffering from AD, has shown a decrease in the scoring index of AD among the group members who were fed with Probiotics (Jiang, 2013). Probiotics are also found to be effective in the treatment of Acne vulgaris. It has been reported that *S.epidermidis* produce SCFAs which inhibit the growth of *P. acnes* and exclude it from sebaceous glands which are the major causes of acne development. A diet supplemented with *Lb.brevis* is found to secrete a peptide that stimulates the growth of *S.epidermidis* and hence has an indirect effect in controlling Acne vulgaris. (24) *Lb.rhamnosus* when added to the diet for 12 weeks decreased the expression of IGF-1 in the skin which reduced the acne symptoms (Huang *et al.*, 2022). According to a study by Robert H. Silver in 1961, when Probiotics such as *Lb.acidophilus* and *Lb.bulgaricus* were added to the diets of 300 acne patients, they were reported to have an improvement in acne symptoms especially those with inflammatory lesions (Jiang, 2013).

Psoriasis is also found to be associated with gut-dysbiosis. Psoriatic patients have shown a higher *firmicutes* ratio, *Acidobacteria*, *Schlegeliella* which induce

inflammation, and a lower level of *Akkermansia mucinephila*, *Propionibacteria* and *Actinobacteria* which are considered good for health. The ethanol extract of *L.sakei*, when consumed by psoriatic patients in adequate amounts has shown better results in inhibiting inflammation than clobetasol (the most widely used treatment for psoriasis at present (Kim, 2020). Like other skin diseases, rosacea is also associated with disturbed gut-microbiome balance. A study conducted on 12 Korean women has shown an interrelation between gut microbial alteration and rosacea. Patients with rosacea have disturbed concentrations of *Helicobacter pylori*, *S.epidermidis*, *Bacillus oleronorum*, *Demodex mites*, etc. The combination of doxycycline and oral probiotics has shown positive results in the treatment of rosacea, where doxycycline mainly inhibits the growth of pathogenic bacteria and probiotics promote the concentration of desired bacteria. Recent advances have shown a positive effect of topical probiotics in curing several skin disorders such as acne vulgaris, rosacea, and psoriasis. The topical floras compete with pathogens for available nutrients and make them unavailable to them and hence inhibit their growth. Enhanced production of ceramide and mucin by the microbes is also found to trap pathogens. The use of topical probiotics can play an effective role in restoring skin homeostasis by preventing biofilm formation and increasing tissue repair. A study has shown the effectiveness of applying topical *Bifidobacterium longum* lysate in reducing skin dryness, reactivity and aging (Guéniche *et al.*, 2010).

Conclusions

The positive results of several studies have highlighted the importance of gut microbiota in the field of medicine but some cases have shown conflicting results. Moreover, due to the availability of limited and heterogeneous data, it is not possible to suggest a treatment protocol for any disease. Further research is necessary to fruitfully explore this area and validate the conclusions drawn from different studies.

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Effect of Fungicides on Germination, Radicle and Plumule Length and Production of Biomass of Pigeonpea

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Abstracts

Disease survey was conducted in different pigeonpea growing district of Madhya Pradesh to record *Fusarium* wilt incidence. Maximum *Fusarium* wilt incidence was recorded in Betul district whereas Narshingpur district has recorded the minimum wilt incidence. The *Fusarium udum* was identified on the basis of cultural, morphological and pathogenic characteristics. Five fungicides viz., Blue copper, Carbendazim, Carbendazim + Mancozeb, Thiophanate Methyl and Pyraclostrobin were evaluated at different concentration to find out the efficacy on various plant growth parameters of pigeonpea seed. All the concentrations used had stimulating effect on the germination, growth of radicle and plumule and its biomass. The fungicide Carbendazim at 50 ppm concentration has shown best stimulating effect on the germination, radicle and plumule length and its biomass.

Key words : Fungicides, plumule, radicle, seed germination, survey, wilt.

Introduction

Pigeonpea (*Cajanus cajan*), is one of the important pulse crop after chickpea in India. Besides being rich source of protein, vitamin B, carotene, essential amino acids particularly lysine, this crop also help in maintaining the soil fertility through natural biological nitrogen fixation (1, 2). *Fusarium* wilt is the most important soil borne disease and was first reported from Bihar state in India (3). It is prevalent in Andhra Pradesh, Maharashtra, Madhya Pradesh, Uttar Pradesh and Bihar. Pigeonpea is susceptible to wilt pathogen throughout its development stages (4). The disease appears on young seedlings but the highest mortality occurs during flowering and podding stage. Although the disease first appears in patches in a field and can extend to entire field if pigeonpea is repeatedly cultivated in the same field (5). The yield loss of pigeonpea depends on the stage at which the plants wilt and it can approach 100, 67 and 30 per cent when wilt occurs at pre-pod, maturity and pre harvest stages, respectively (6) and sometimes it causing upto 100 per cent loss in grain yield (7). Seeds as a basic unit of propagation carry a wide range of microorganisms externally or internally, become active under favourable conditions resulting extensive damage to seeds and diseases on crops raised from them. Most of the food crops grown are propagated by seed and these crops are infected by many harmful seed borne diseases (8). Seed treatment with fungicides not only controls the seed-borne diseases but also improves seed health, plant stand and crop yield (9). In any seed production programme, storage of seeds from harvest to next planting season is of prime importance respect to seed viability and seed vigour under

normal storage conditions. Fungicide treatments are required to be stored for several months and stability of fungicides effect without affecting the seed health adversely. Present investigation was carried out to assess the effect of seed treatment with some fungicides on the germination, radicle & plumule length and production of biomass of pigeonpea.

Materials and Methods

Disease Survey : An intensive roving survey was conducted in the seven major pigeonpea growing districts of Madhya Pradesh viz., Jabalpur, Narshingpur, Satna, Raisen, Betul, Chhindwara and Sidhi during the period from September to December during the year 2015. The districts were traversed and observations were recorded in fields after every 15-20 km. Stops were less frequent in areas where pigeonpea was sparsely grown. The major soil-borne diseases were *Fusarium* wilt. Their incidence was assessed by counting the number of plants showing symptoms in three representative 100 plants randomly chosen in each field. The percentage incidence at each location in a district was used for calculating the district average. The percent disease incidence was calculated using the formula.

Percent disease incidence

$$= \frac{\text{No. of plants showing wilting symptoms}}{\text{Total no. of plants observed}} \times 100$$

Collection of diseased plants : Diseased plants of pigeonpea showing characteristic symptoms of wilt (*Fusarium udum*) in the field of farmers and research farm, J.N.K.V.V, Jabalpur, during *Kharif* 2015-16 were collected. The infected plants were carefully uprooted

from the soil to get whole root system intact. The roots were washed with tap water and dried with the help of blotter paper to remove traces of water, for isolation of causal organism.

Isolation, purification and identification of *Fusarium udum*

udum : The isolation of *Fusarium udum* was obtained from pigeonpea plants showing characteristic symptoms of wilt. Small pieces of about one cm, from affected plants, were cut by sterilized knife. These were then surface sterilized with 1 per cent sodium hypochloride solution for 30 seconds followed by three changes of sterilized distilled water and dried on sterilized blotter paper before keeping them on Petri plates containing PDA. The inoculated plates were kept for incubation at $28 \pm 1^\circ\text{C}$ and examined for the growth of fungus after seven days. The causal organism was identified and transferred on fresh Petri plate containing PDA. The fungus was identified under the inverted fluorescence microscope according to the identification keys of *F. oxysporum* (Colony character, chlamydospores micro and macroconidia) provided by (10 & 11). Pure culture was maintained on PDA slants by sub culturing it at 30 days intervals. For preservation of cultures the plugged end of the culture tubes were dipped in melted wax and stored in a refrigerator at $5 \pm 1^\circ\text{C}$.

Pathogenicity test : Sorghum seeds were soaked in water overnight and excess water was drained off. About 500g water soaked grains were taken into 2000 ml Erlenmeyer flask, sealed by cotton plug and were sterilized in autoclave at 121.6°C temperature 15 psi for 20 minutes. After cooling the flasks, these were inoculated with 10 mycelial discs (5 mm) of the *Fusarium udum* and incubated at $28 \pm 1^\circ\text{C}$ for 21 days. They were shaken by hand after five days interval for even growth. Inocula of *Fusarium* culture were prepared separately. The completely colonized sorghum seed was air dried on brown paper for two days at laboratory (26 to 28°C) temperature and stored at $5 \pm 1^\circ\text{C}$ until use.

On the sufficient growth of sorghum seed inoculum of *Fusarium* was thoroughly mixed with the soil at the rate of 50g/450g soil (12). The pots were kept for seven days to allow the multiplication, development and spread of the fungus in pot soil. The pathogenicity test of *Fusarium udum* was tested on pigeonpea susceptible cultivar TJT-501 under green house conditions. Control pots were prepared using sterilized soil only. Seeds of TJT-501 were surface sterilized using 1 per cent sodium hypochloride for 2 min. Each pot received two seeds of TJT-501. The pots were irrigated with 50 ml of sterilized tap water. The pots were observed for germination and emergence of seed and mortality of the seedlings.

Effect of some fungicides on the germination and other growth parameters of pigeonpea seeds : Seeds of pigeonpea (TJT-501) were collected from the vendor.

Seeds were carefully selected with no apparent infection/damage and sterilized with 2 per cent sodium hypochloride for 15 minutes. The solution of five fungicides namely Thiophanate Methyl, Pyraclostrobin, Blue copper, Carbendazim and Carbendazim + Mancozeb was prepared at different concentrations (25, 50, 75 and 100 ppm). Then the selected seeds were soaked overnight (24 hours) in different flasks containing the test solution of various concentrations. For germination, the treated seeds were placed uniformly in sterilized Petri-dishes lined with double layer of blotting paper and wetted with 10 ml of different concentration of the fungicide test solution. For each replicate 10 nos. of treated seed were used, so total no. of seeds used for each treatment has been 30 (10x3). One treatment was run as control and treated with distilled water only. Three replicates for each of the treatment including control was maintained. All the Petri-dishes were maintained under room temperature. The seeds were kept under moist condition with the test solutions and equal volume (*i.e.* 10 ml) of distilled water. Water was added when the moisture content of the blotting paper declined. The number of seeds germinated in each treatment was counted and the germination percentage was calculated by using the following formula.

$$\text{Germination (\%)} = \frac{\text{No. of seeds germinated}}{\text{Total no. of seed planted}} \times 100$$

The radicle and plumule growth of the seedlings exposed to various concentration of fungicide solution was measured for each germinating seed. At the end of the experiment, all the radicle and plumule was harvested separately and oven dried at 70°C for 48 hours to get the biomass of the same.

Results and Discussion

Isolation and Identification of the *Fusarium udum*

The pathogen was identified as *Fusarium udum* on the basis of cultural and morphological characters. Observations were recorded on morphological characteristics from five days old culture of the test pathogen grown on Potato dextrose agar (55.0 mm). The mycelium was hyaline, septate and produced three types of spores. It produced extensive and cottony mycelium in culture, often with a purple tinge in the mycelium or medium. The conidia were variable in size and shape. Microconidia were oval, hyaline, mostly non-septate and rarely with single septum and measured about $5.3\text{--}7.2\ \mu\text{m}$ x $2.1\text{--}4.9\ \mu\text{m}$. Macroconidia were fusiform, curved or falcate shaped, mostly 3–5 septate and the measured about $20.9\text{--}40.5\ \mu\text{m}$ x $4.3\text{--}4.8\ \mu\text{m}$. Abundant chlamydospores were formed by the fungus in 20 days old culture. They were hyaline to pale brown in colour, intercalary, either single or in chain (Plate 1: fig A to E).

Table-1 : Incidence of wilt in different districts of Madhya Pradesh.

S. No.	Name of District	Percent wilt incidence
1.	Betul	28.8
2.	Raisen	26.8
3.	Satna	15.0
4.	Chhindwara	14.3
5.	Sidhi	10.6
6.	Jabalpur	9.3
7.	Narshingpur	8.03

The species of fungus under study agrees with the description reported for (13) Saprophytic culture on agar medium showed deep purple pigmentation, aerial mycelium almost absent and usually with the profuse development of pinnate sporodochia. Microconidia were one celled, hyaline, ovoid/fusoid or curved measuring 6-11 x 2-3µm. Macroconidia were hyaline, typically thin walled, 1-3 septate or occasionally with 5 septa, falcate with a distinct foot cell and an apical cell of decreasing diameter towards the tip which may be curved or hooked, measuring 15-30 x 2.5-3.5µm. Chlamydospores were globose, intercalary in the mycelium measuring 8-10µm diameters. (14) observed that the size of macroconidia varied from 13.03 x 3.60µm (Bangalore isolate) to 20.60 x 2.10µm (ICRISAT isolate), while the size of microconidia varied between 5.26 x 1.78µm (ICRISAT isolate) to 9.09 x 1.94µm (Gulbarga isolate). (15) studies sixty nine isolates of *F. udum* showed wide variation in sporulation, mycelial colour, conidial length, conidial septation and growth rate. Based on mycelial mat colour, three major colony types viz., whitish, pinkish and yellowish were noted. Growth rate varied from 0.1 to 1.31cm/day. Length and breadth of macroconidia varied from 14.4 to 61.6µm and 1.6 to 4.6 µm respectively. Based on combining characters like sporulation on PDA, mycelia colour, growth rate (<0.55 or >0.55cm/day), length (<45 or >45mm) and number of septa (<4 or >4) of macroconidia.

Pathogenicity of *F. udum* isolate was established by verifying the Koch's postulates. The experiment was conducted under glass house condition using infested soil. The initial symptoms appeared 30 days after sowing of seeds in the infested soil. The symptoms further developed and plants were wilted within 60 days. The wilt symptoms were identical to those recorded in naturally infested plants. In addition, blackening was sometimes visible through the bark as streaks or bands. The fungus was reisolated from such infected plants and tailored with the original culture of *F. udum*. The results observed were similar to the work done by (16) conducted an experiment where they 50 isolates of *Fusarium udum*. Out of 50 isolates 15 isolates were found to show typical wilting symptoms and these isolates were able to prove Koch's

postulate and proved to be truly pathogenic to pigeonpea cultivar '*Bahar*'. (17) studies twenty two isolates of *Fusarium oxysporum* and subjected them to pathogenicity tests by sick pot method. Ten isolates viz., FOU 2, FOU 3, FOU 6, FOU 12, FOU 13, FOU 16, FOU 17, FOU 19, FOU 22 and FOU 30 were highly pathogenic and these were carried further for studies. (18) studies conduct 104 isolates of *Fusarium* were subjected to pathogenicity test on susceptible ICP 2376 cultivar using artificial root-dip inoculation technique. All the isolates were identified as pathogenic to pigeonpea. The re-isolated cultures were morphologically and microscopically similar to that of original cultures and confirmed as *F. udum*.

Incidence of wilt in different districts of Madhya Pradesh :

Survey was conducted in seven districts viz., Jabalpur, Narshingpur, Satna, Raisen, Betul, Chhindwara and Sidhi of Madhya Pradesh to study the incidence of disease during 2015-16 to find out the distribution of disease and the observed data are presented in Table 1. The disease was prevalent in all the districts surveyed however, incidence of disease varied in different districts. The highest incidence of wilt was recorded in Betul district with an incidence of 28.8 per cent followed by Raisen district with an incidence of 26.8 per cent. Least incidence was noted in Narsinghpur (8.03%) district. The disease incidence recorded in other districts was ranged between 9.3 to 15.0 percent. The present study was in agreement with the report of (19) conducted a survey on the wilt incidence in 27 districts of Madhya Pradesh at the maturity stage of pigeonpea and reported maximum disease from Shajapur and Baster districts and minimum (1.0-5.0%) disease in rest of the districts. (20) Surveyed forty districts of Madhya Pradesh and reported that wilt incidence ranged between 0.0 to 97.0 per cent (average 5.4%). In MP maximum incidence was found in Khargone district (43.2%). Wilt incidence was above 10.0 per cent in the districts of Betul, Chhindwara, Damoh, Khargone, Raisen, Sehore, Shajapur and Ujjain districts. (21) roving survey was conducted during two consecutive *Kharif* seasons from 2013-14 to 2014-15 in pigeonpea growing areas of Madhya Pradesh. Four major pigeonpea growing districts were selected to assess the status of *Fusarium* wilt incidence of pigeonpea under field condition. The maximum incidence was noticed in Seoni district (10.39%) followed by Chhindawada (9.43%), Houshangabad (4.13%) and Narashingpur (7.29). During the second year (2014-15) reported maximum disease incidence from Chhindawada district (9.57%) followed by Seoni (7.72%) Houshangabad (6.47%) and Narashingpur district (5.49%).

Effect of various concentrations of fungicides on the germination, radicle and plumule length and it's of biomass : The present study was carried out in relation to

Table-2 : Effect of various concentrations of fungicides on the germination, radicle and plumule length and production of biomass.

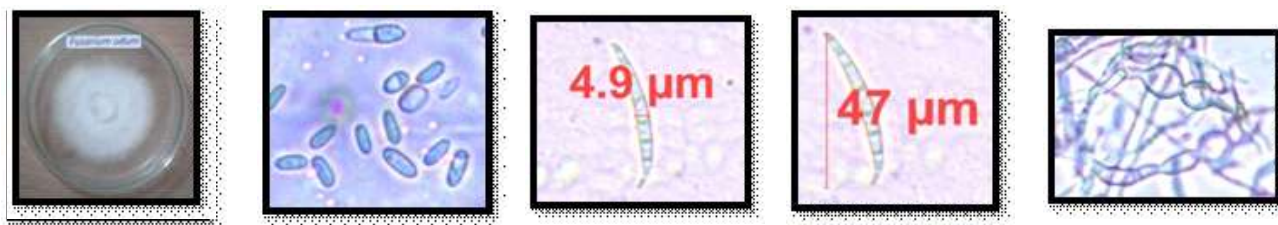
Treatment	Germination (%)				Radicle length (cm)				Plumule length (cm)				Radical weight (g)				Plumule weight (g)			
	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%
Pyraclostrobin	86.66	98.3	93.33	93.33	4.7	5.6	4.9	4.9	7.8	8.2	8.4	8.3	0.13	0.16	0.14	0.13	0.14	0.18	0.20	0.13
Thiophanate Methyl	93.33	83.33	86.66	83.33	4.6	4.8	4.6	5.6	7.5	7.0	7.6	7.1	0.13	0.10	0.14	0.19	0.13	0.10	0.20	0.14
Carbendazim	73.33	100	90.0	90.0	4.8	5.8	5.4	4.1	8.8	10.2	8.9	8.7	0.11	0.21	0.15	0.18	0.12	0.23	0.12	0.11
Carbendazim + Mancozeb	96.60	96.0	86.70	93.33	5.0	5.4	5.6	5.7	8.9	9.7	9.9	10.1	0.14	0.14	0.10	0.20	0.17	0.15	0.11	0.22
Blue copper	91.00	87.70	86.70	85.00	4.8	5.0	5.5	5.6	7.4	7.1	7.6	7.3	0.13	0.14	0.12	0.18	0.12	0.12	0.14	0.12
Control	83.33	83.33	83.33	83.33	4.5	4.5	4.5	4.5	7.2	7.2	7.2	7.2	0.13	0.13	0.13	0.13	0.10	0.10	0.10	0.10
CD (0.05)					N/A	N/A	N/A	N/A	1.045	2.301	1.841	1.348	N/A	N/A	N/A	0.018	N/A	N/A	N/A	N/A

Mean of three replicates, significant at $P < 0.05$

treatment of the seeds of pigeonpea with various 25 ppm, 50 ppm, 75 ppm and 100 ppm concentrations of fungicides (i.e. Pyraclostrobin, Thiophanate methyl, Carbendazim, Carbendazim + Mancozeb and Blue copper) and their effect of on the seed germination, growth and biomass production were observed *in vitro* (Table 2 & Plate 2).

Effect on the Seed germination : All the fungicides tested at different concentrations improve the germination percentage of seed *in vitro* (Table-2). Seed treatment with Thiophanate methyl, Carbendazim + Mancozeb, and Blue copper at 25 ppm concentration were found best as they respectively, produced 93.33, 96.60 and 91.00 percentage germination. Carbendazim and Pyraclostrobin seed treatment at 50 ppm concentration gave best results having 100 and 98.3 per cent germination. The germination percent recorded in control was 83.33 per cent. These results are in support of the findings with (22) who reported that *Cicer arietinum* gave 100 per cent germination in all the concentrations viz., 1 ppm, 10 ppm, 50 ppm and 100 ppm of Captan and Carbendazim fungicide while in case of *Zea mays*, 1 ppm concentration of Carbendazim has shown better stimulating effect on the seed germination (96.66%) followed by Carbendazim 10 ppm and 1 ppm of Captan fungicides respectively having 90.0 per cent germination as compared to control. Mogle and Maske, (2012) studies conducted the seed treatments of cowpea with fungicides 0.2 per cent concentration of Dithane (M-45), Carbendazim and Benomyl. The maximum seed germination were recorded 90.0 (Dithane (M-45), 87.0 (Carbendazim) and 85.0 (Benomyl) per cent and reducing seed borne mycoflora of cowpea seeds.

Effect on the Radicle and Plumule length : Fungicidal seed treatment did influence the radicle and plumule length when compared to control (Table 2). Maximum radicle length viz., 5.6, 5.7 and 5.6 cm were recorded in seed treatment with Thiophanate methyl, Carbendazim + Mancozeb, and Blue copper at 100 ppm concentration. Seed treatment with Carbendazim and Pyraclostrobin recorded maximum radicle length (5.8 and 5.6 cm) at 50 ppm concentration. The radicle length recorded in control was 4.5 cm. Maximum plumule length were recorded in seed treatment with Pyraclostrobin, Thiophanate methyl and Blue copper at 75 ppm concentration as they respectively, produced 8.4, 7.6 and 7.6 cm length. However, in Carbendazim and Carbendazim + Mancozeb maximum plumule length (10.2 and 10.1) was recorded at 50 and 100 ppm concentrations respectively. These results were in confirmation with (22) who reported that Carbendazim at 10 ppm concentration was the best



A-Isolation

B-Micro conidia

C & D-Length and width of macro conidia

E-Chlamydospores

Plate 1. Isolation and identification of *Fusarium udum*.

Plate 2. Effect of 50 ppm concentration of fungicides on the germination, radicle and plumule length and its biomass.

among the treatments of *Cicer arietinum* (gram) while in case of *Zea mays* (maize), 1 ppm concentration of Carbendazim has shown better stimulating effect on the plant growth (radicle and plumule) as compared to control. (23) reported that seed treatments of cowpea with fungicides 0.2 per cent concentration for improvement of radicle and plumule length. Highest radicle and plumule length (21.1cm & 19.2 cm) was observed in the treatment of Dithane (M-45) followed by Carbendazim (20.4cm & 18.6cm) and Benomyl (20.8cm & 18.1cm).

Effect on the Radicle and Plumule biomass : A result in table-2 represents the effect of fungicides on the production of biomass in treated seedlings of pigeonpea seeds. Fungicidal seed treatment did also influence the dry weight of radicle and plumule. Thiophanate Methyl, Carbendazim + Mancozeb and Blue copper at 100 ppm concentration found effective as they respectively, produced maximum radicle biomass of 0.19, 0.20 and 0.18 g. The maximum radicle biomass in Carbendazim and Pyraclostrobin were 0.21 and 0.16 g, respectively. Further seed treatment with Pyraclostrobin, Thiophanate

Methyl and Blue copper at 75 ppm concentration gave maximum (0.20, 0.20 and 0.14 g) plumule biomass. Maximum plumule biomass (0.23 g) recorded in seed treatment with Carbendazim at 50 ppm concentration. The plumule and radicle biomass recorded in control was 0.10 and 0.13g. These results were in confirmation with (22) evaluated the effect of fungicides on the production of biomass in treated seedlings of gram seeds (*Cicer arietinum*) at 10 ppm (Carbendazim) concentration has shown highest biomass production having 0.21 g for radicle and 0.14 g for plumule while in case of Captan at 1 ppm concentration recorded the biomass production having 0.21 g for radicle and 0.17 g for plumule as compared to control, which have the biomass production of 0.14 g and 0.10 g for radicle and plumule, respectively. In case of *Zea mays* (maize), at 10 ppm concentration of Carbendazim seen best production of biomass i.e. (0.57 g) for radicle and (0.33 g) for plumule.

Conclusions

In the present study, maximum *Fusarium* wilt incidence was recorded in Betul district whereas Narshingpur district

has recorded the minimum wilt incidence. The *Fusarium udum* was identified on the basis of cultural, morphological and pathogenic characteristics. All the concentrations of fungicides had stimulating effect on the germination, growth of radicle and plumule and its biomass. The fungicide Carbendazim at 50 ppm concentration has shown best stimulating effect on the germination, radicle and plumule length and its biomass as compared to control.

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Morphological Behaviour of Clusterbean and Mungbean against Fluoride Stress

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Abstract

Fifteen days of climate-dependent seedlings (*Vigna. Radiata* L.) and (*Cyamopsis tetragonoloba* L. Taub.) selected for experimental study with 1-2 leaves stage. Fluoride solution (NaF) was added to the half strength Hoagland nutrient solution for 5 days at the following concentrations: For (*Vigna. Radiata* L.) - 0, 2.5, 5, 7.5, 10, 12.5 and 15 mM and for (*Cyamopsis tetragonoloba* L. Taub.) - 0, 10, 20, 30, 40, 50, and 60 mM. All treatments were statistically analyzed with Student's t-test. In clusterbean initiation of the reduction in growth rates starts from 30 mM NaF in root and leaf samples. An increase growth rate of leaf and roots were recorded in mungbean at 15 mM concentration of NaF.

Key words : Abiotic stress, *Cyamopsis Tetragonoloba* L., fluoride stress (NaF) and *Vigna radiata* (L.).

Introduction

Adverse climatic conditions that create abiotic stresses are among the major limiting factors for declining agricultural productivity (Padgham, 2009). Water deficit (drought), floods (anoxia), salinity, mineral deficiency, acid soils, cold soil degradation and salinity problems (Riadh *et al.*, 2010). Agroecological disturbances due to abiotic stresses has not been made, it is clear that such stresses affect large tracts of land and significantly impact the loss. Qualitative and quantitative in crop production (Cramer *et al.*, 2011). Fluoride stress is one among the majority of significant abiotic stresses. Fluoride is a common environmental pollutant and Fluoride rich soil is a potential source of its contamination in the groundwater, in the food chain and ultimately in the human body. (Meenakshi and Maheshwari 2006). Intake of plants with a high Fluoride concentration can also lead to chronic Fluoride toxicity in human animals and pastures and cause bone damage or tooth wear (Clark and Stewart 1983). Fluoride toxicity affects the most morphological, physiological and biochemical parameters in the plant due to germination and early seedling growth. Fluoride affects a wide variety of physiological processes, such as germination, growth, mineral nutrition, photosynthesis, respiration, carbohydrate metabolism, and protein synthesis and lipid metabolism. Fluoride also interferes with the metabolism of proteins, lipids and carbohydrates. Fluoride usually inhibits enzymes that require cofactors such as Ca^{2+} , Mg^{2+} , and Mn^{2+} ions. Inhibition is partially attributed to the elimination of Ca^{2+} cofactor. Changes in enzyme activity and intermediate metabolism caused by chronic fluoride exposure may cause the organism to grow, develop and multiply (McCune and Weinstein, 1971). This becomes more important when consider agricultural crops because, in many agricultural systems, most crops grow under

sub-optimal environmental conditions that limit the genetic potential of plants for growth and development (Bray *et al.*, 2000). Defense, repair, acclimatization and adaptation are the main components of stress resistance responses. Environmental stimuli and reactions to abiotic stress include interactive metabolism formation within various networks and biosynthetic pathways. The root architecture is believed to be more sensitive if abiotic stimuli are recognized and reacted accordingly in soils (Khan *et al.*, 2016). It is a complex phenomenon where real-time dynamic changes or stress sensitivity are a dynamic event that spans several stages of plant development. Instead of imposing an additive effect on plants, abiotic stress reactions may reduce or enhance the susceptibility of plants to biotic loads due to pests or pathogens (Rizhsky *et al.*, 2004). Environmental changes such as irrigation or circulatory water conditions occur most frequently in changing global climate conditions (Xu *et al.*, 2010). In severe water deficiency conditions, peroxidation can be induced, which has a negative effect on antioxidant metabolism (Bian and Jiang, 2009 and Xu *et al.*, 2014). Disaggregation further reduces the degree of Peroxidation and restores the growth and development of new plant parts and the opening of the stomata in roots, both drought and re- irrigation lead to a high concentration of H_2O_2 (Bian and Jiang, 2009). Drought reactions vary from plant to plant with respect to Superoxide Dismutase (SOD) activity, which plays a central function in antioxidant metabolism (Xu Z. *et al.*, 2015). Increased salinity in the soil is harmful to plant cells, and different cells in a tissue react differently to stress caused by salinity (Voeselek and Pierik, 2008). Elevated temperatures adversely affect the morphoanatomical, physiological, biochemical and genetic changes in plants. Heat affects plants at various stages of development and high temperatures lead to reduced germination of the

seeds, loss of photosynthesis and respiration as well as reduced membrane permeability (Xu *et al.*, 2014). Therefore, regular measurement and control of the fluoride concentration is very important to prevent both biological and environmental damage (Edward 1975). Due to environmental pressures such as fluoride pressure; legume survival and productivity are affected. By understanding the role of SOD and CAT as antioxidants relative to other antioxidant enzymes at the biochemical level and by analyzing SOD and CAT at the genetic level, it will be possible to form future legume plants that can easily survive under various environmental pressures including fluoride stress. Therefore, a large number of fluoride-tolerant plants can be developed to be sustainable and increase productivity in the future.

Material and Methods

Guar (*Cyamopsis tetragonoloba* L.) Var. RGC-1038 and Mung bean (*V. radiata* L.) var. RMG-492 were obtained from Rajasthan Agricultural Research Institute (Sri Karan Narendra Agriculture University Jobner), Rajasthan, India, for experimental purposes developed for the present study. The seeds of Guar were cleaned with 0.5% sodium hypochlorite, used for 15 minutes, and then washed with distilled water. The sterilized seeds are germinated in a Petri dish with filter paper dipped in distilled water after 24 hours in the dark. 3 days after the seedling appeared, ten seedlings were placed in each plastic pot containing a medium-strength Hoagland nutrient solution, production tolerance maintained at $28 \pm 2^\circ\text{C}$ in a thermostatically prohibited indoor culture and 500°C photoperiod at 16 hours photoperiod at $\text{mol}^{-2} \text{h}^{-1}$. Seedlings (*Cyamopsis tetragonoloba* L.) acclimated to the 15 days climate were grown with different concentrations of NaF (0, 10, 20, 30, 40, 50 and 60 for 5 days mM). Control plant maintained in a strong Hoagland environment without fluoride treatment. Seeds of mungbean were surface cleaned by 0.5 per cent sodium hypochlorite used for 15 min, furthermore, washed in the distilled water. After that, sterilized seed germinates into a Petri plate contain filter paper pre-soaked by the distilled water at 24 h in the dark condition. After 3 days, the appearance of the planula, ten seedlings were transferred to each plastic pot contain half-strength Hoagland nutrient solution with tolerable to produce up and about in a thermostatically proscribed room culture maintained by $28 \pm 2^\circ\text{C}$ and at $500 \text{ mol}^{-2} \text{s}^{-1}$ expose to 16 h photo-period. Seedlings of (*V. radiata* L.) 15 days old acclimated were treated by different concentrations of NaF (0, 2.5, 5, 7.5, 10, 12.5, and 15 mM) for 5 days. The control plant was maintained in a half strength Hoagland medium without fluoride treatment.

Fresh weight, root length and dry weight : The plants were collected and cleaned with distilled water. Plant growth, root lengthening, fresh weight, and dry weight

were measured. The root length of the seedlings was calculated and seedlings were scored before adding NaF to the nutrient solution.

Growth Rate : Fresh weight (*Cyamopsis tetragonoloba* L. Taub.) and (*Vigna. Radiata* L.) were recorded and scored previous to fluoride treatment. After measure the fresh mass, the dry weight (DW) of the same seedlings was calculated both were dried in a hot air oven at 70°C for 72 hours. Dry weight was expressed as a percentage reduction in control.

$$\text{Growth rate} = \frac{(\text{FW g day}^{-1})}{\ln W_2 - \ln W_1 T_2 - T_1}$$

(W_1 : initially recorded fresh weight; W_2 : last recorded fresh weight; T_1 : pre-treatment time; T_2 : post-treatment time)

Tolerance index : The tolerance index (Wilkins, 1978 and Baker *et al.*, 1994) for (*Cyamopsis tetragonoloba* L. Taub.) and (*Vigna. Radiata* L.) was designed for fresh biomass as follows :

Tolerance index (%)

$$= \frac{\text{Fresh weight of metal treated seedling}}{\text{Fresh weight of control seedling}} \times 100$$

Results and Discussion

Changes in growth parameters are direct indicators of fluoride stress effect. The extent of root elongation rate increased significantly together with a decrease in increased NaF concentration. 30 mM NaF was found to inhibit increased concentrations of root elongation rates. 60 mM NaF, root elongation was extremely repressed ($0.666 \text{ cm day}^{-1}$) compared to controls ($0.378 \text{ cm day}^{-1}$). The Initiation of the reduction in growth rates starts from 30 mM NaF in root and leaf samples. Increased growth rate at 30 mM NaF in leaf and roots compared to control. An increase was recorded growth rate of leaf or root samples were respectively at 60 mM NaF concentration. The tolerance index (TI) was observed in the leaf and roots sample of *Cyamopsis Tetragonoloba* (L.) Taub. Tolerance index compared to control of high fresh biomass production at initial fluoride concentrations in *Cyamopsis Tetragonoloba* (L.) Taub. but to lethal NaF concentrations, seedlings showed a significant increase. The leaf treatment with 60 mM NaF found 77.35. % TI over control. Root treatment with 60 mM NaF found 62.62 % of TI compared with control. 7.5 mM NaF was found to inhibit increased concentrations of root elongation rates. 15 mM NaF, root elongation was extremely repressed ($0.0582 \text{ cm day}^{-1}$) compared to controls ($0.0184 \text{ cm day}^{-1}$). This is combined with reduced metabolic activity in the presence of fluoride because the latter acts as a metabolic inhibitor. Increased NaF concentration showed phytotoxic effects on physiological parameters of seedling growth imilar results have been reported by Sabal *et al.*, 2006. In *Vigna*.

Table-1 : Changes in physiological parameters of clusterbean cultivated with a nutrient solution containing different concentrations of NaF for 5 days.

NaF (Fluoride) Conc. (mM)	Root elongation rate (cm/day)	Leaves		Roots	
		Growth rate (FW g/day)	Tolerance index (%)	Growth rate (FW g/day)	Tolerance index (%)
Control	0.0666±0.0078	0.060±0.007	77.35±5.32	0.059±0.007	62.62±2.72
10 mM	0.066±0.007*	0.059±0.007*	59.28±2.72*	0.056±0.007*	56.08±2.42*
20 mM	0.066±0.011*	0.065±0.007*	52.28±2.19*	0.040±0.004*	45.39±2.22*
30 mM	0.082±0.019*	0.078±0.014*	47.27±2.62*	0.076±0.008*	48.62±2.46*
40 mM	0.524±0.014*	0.045±0.007*	38.08±2.33*	0.055±0.006*	31.79±2.69*
50 mM	0.0376±0.121*	0.039±0.006*	27.00±1.33*	0.037±0.006*	28.00±1.32*
60 mM	0.004±0.100*	0.028±0.004*	21.28±2.17*	0.025±0.004*	13.98±2.15*

Table-2 : Changes in physiological parameters of Moong bean cultivated with a nutrient solution containing different concentrations of NaF for 5 days.

NaF (Fluoride) Conc. (mM)	Root elongation rate (cm/day)	Leaves		Roots	
		Growth rate (FW g/day)	Tolerance index (%)	Growth rate (FW g/day)	Tolerance index (%)
Control	0.0582±0.0121	0.0516±0.0009	100±0.0	0.0515±0.0004	100±0.0
2.5 mM	0.0524±0.0120*	0.0515±0.0009*	69.71±2.33*	0.0575±0.0004*	68.73±2.34*
5.0 mM	0.0526±0.0203*	0.0498±0.0006*	61.27±2.34*	0.0464±0.0004*	59.28±2.16*
7.5 mM	0.0709±0.0141*	0.0742±0.0002*	48.08±1.46*	0.709±0.00002*	46.09±1.46*
10.0 mM	0.0464±0.0094*	0.0532±0.0005*	38.08±1.45*	0.0531±0.0005*	37.88±2.46*
12.5 mM	0.0394±0.0123*	0.0193±0.0004*	32.28±2.19*	0.0200±0.0030*	30.27±2.34*
15.0 mM	0.0184±0.0041*	0.0175±0.0004*	28.78±2.34*	0.0169±0.0004*	25.78±2.19*

Radiata L increased growth rate at 7.5 mM NaF in leaf and roots compared to controls. An increase was recorded growth rate of leaf or root samples were respectively at 15 mM NaF concentration. The tolerance index (TI) was observed in the leaf and roots of *Vigna. Radiata L*. Tolerance index compared to control of high fresh biomass production at initial fluoride concentrations in *Vigna. Radiata L*. but to lethal NaF concentrations, seedlings showed a significant increase. The leaf treatment with 15 mM NaF found 94.78% TI compared control. Root treatment with 15 mM NaF found 87.78 % of TI compared with control. Increased concentrations of sodium fluoride show phytotoxic effects on parameters that determine morphology, biochemistry and phytotoxicity. Fluoride causes a reduction in root length and shoots length due to unbalanced nutrient uptake by seeds in the presence of fluoride (Sabal et al., 2006). Fresh weight, dry weight and percentage of seedlings decreased monotonically with increasing fluoride concentration due to decreased metabolic activity in the presence of fluoride (because germination is a type of metabolism and fluoride acts as an ametabolic inhibitor (Gulzar and Khan, 2001; Gupta et al., 2009). Plant fluoride tolerance is mainly associated with various morpho-physiological properties. However, increased fluoride tolerance depends on the genetic variability of a plant. From a number of published research reports, it can be determined that the screening and selection of plant germplasm is an economically viable strategy for

identifying fluoride tolerant genotypes or lines that can achieve adequate yields in salt-filled areas (Munns et al., 2006; Munns et al., 2010 ; Munne-Bosch and Penuelas 2003).

Conclusions

The roots are the first plant in the plant that is resistant to the stress of the average fluorine content or transfer of CAT and GR from the roots and leaves due to the increase in the activity of among the species studied *V. radiata L*. It 15 Mm, CAT and GR decreased compared to 7.5 mM NaF. The 7.5 mm of NaF. Reduction in Growth, enhanced levels of MDA and decreased chlorophyll level in seedlings treated with NaF were recorded. The results of this study explain that the basic plant defense response to fluoride stress occurs through SOD and CAT antioxidant enzymes. This study allows us to better understand the complexity of the defense system, including SOD and CAT against stress of NaF, which will determine its use in future research to improve fluoride-resistant strains.

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Design and Development of Microcontroller Based Automatic Pressure Control System for Spray Patternator

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Abstract

The uniformity of the spray pattern of a nozzle is determined with the help of spray patternator. The spray pattern uniformity is mainly affected by the boom pressure. In existing spray patternators, the boom pressure is controlled manually by using pressure control valve. In these manually controlled systems, the fluctuation in boom pressure is more than $\pm 10\%$ which exceed the permissible limit (up to $\pm 2.5\%$) of boom pressure fluctuation. Hence, In order to maintain a constant boom pressure for the nozzle, an automatic pressure control system was developed for a spray patternator. The system consisted of an Arduino Uno microcontroller, RKL 1341 motor driver, pressure sensor, and 12 V DC motor pump to maintain a constant boom pressure for the nozzle. The pressure sensor was calibrated for measuring the nozzle pressure, and the motor pump was calibrated for the desired discharge rate. The system was tested for different input voltages, and the performance of the system was evaluated. The results showed that the system could maintain the desired boom pressure with an accuracy of ± 2 PSI. The system is expected to have potential applications in agriculture and other spray applications. Future work includes improving the accuracy and reliability of the system, and testing the system under different environmental conditions.

Key words : Microcontroller, pressure sensor, automatic pressure control, spray patternator.

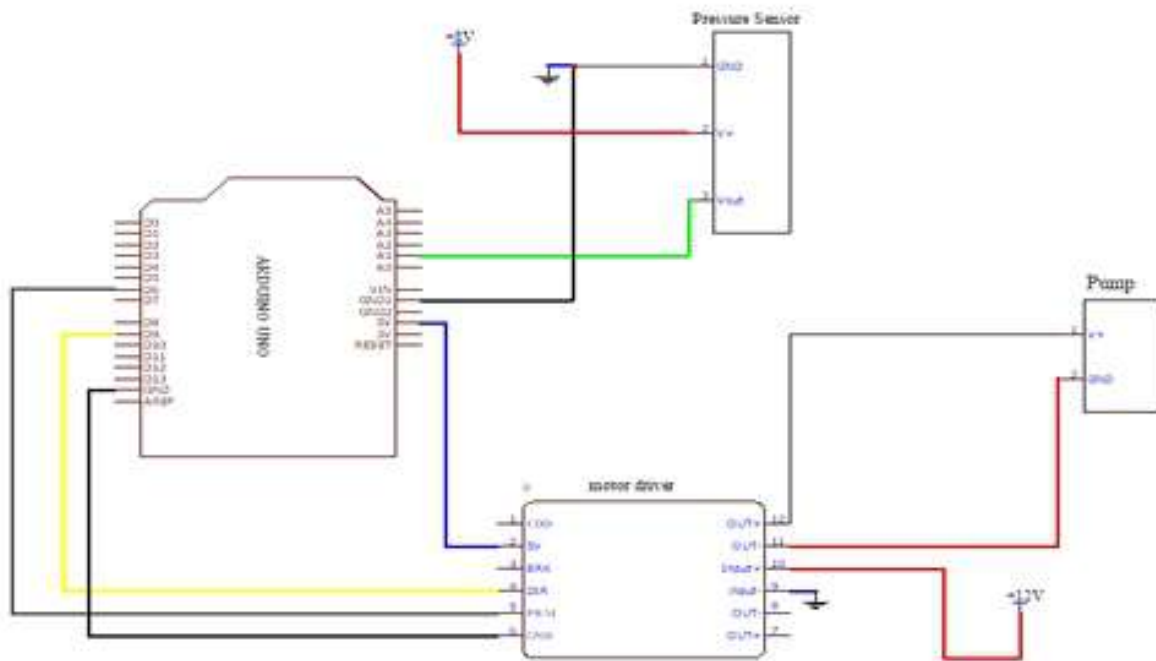
Introduction

Agricultural sprayers are widely used for the application of herbicides, insecticides, and fungicides to crops (Ahmad *et al.*, 2021). The uniformity and effectiveness of the application are highly dependent on the spray pattern and droplet size of the nozzle (Dowlati *et al.*, 2022; Višacki *et al.*, 2017). The spray pattern is determined by the boom pressure, which is often controlled manually using a pressure control valve. However, manual control of boom pressure can result in significant fluctuations, which can impact the accuracy and uniformity of the spray pattern. In these manually controlled systems, the fluctuation in boom pressure is more than $\pm 10\%$ which exceed the permissible limit (up to $\pm 2.5\%$) (IS 10064: 1982) of boom pressure fluctuation. Efforts had been done by various researchers to develop an automatic pressure control system. Sood *et al.*, (2013) designed and developed an automatic water flow meter system. The system consisted of AT89S52 microcontroller, G1/2 Hall effect water flow sensor, relay, optocoupler, a water pump, 5V supply, LCD, keypad and some passive components. The Hall effect water flow sensor was used as a sensing unit with a turbine rotor inside it, the speed of rotation of turbine changes with varying rate of flow of water. Liu *et al.*, (2014) developed a digital flow control system for multi-channel variable rate sprayers. An automatic flow rate control

system activated with microprocessors and pulse width modulation (PWM) controlled by solenoid valves. The system consisted of a data acquisition module, a data processing module, and a flow rate control module. An embedded computer along with a touch screen was used to process control algorithms and allowed communication between the sprayer operator and the control system. The flow rate control module was designed with multichannel driver circuits for activating the solenoid valves and driver protection circuits for avoiding surge voltages due to frequent on/off actions of the solenoid valves. However, these developed system had their own limitation such as high cost, complex system, not suitable for agricultural applications. Therefore, a study was conducted to design and develop an embedded system with low cost and especially for agriculture spraying to reduce the fluctuation in boom pressure. This system consisted of a microcontroller, motor driver, pressure sensor and 12 V DC motor pump to automatically maintain a constant boom pressure for the nozzle. The development of this automatic pressure control system can have several potential benefits for agricultural applications. Firstly, it can improve the accuracy and uniformity of spray applications, that leads to effective application of chemicals and reduction in the risk of crop damage. Secondly, it can reduce the workload and skill requirements for operators,

Table-1 : Technical specification of the pressure sensor.

Types of pressure sensor	Setra 3100 Series Pressure Transducer
Input supply	8-30 V DC
Output of sensor	0.5 V to 4.5 V DC
Pressure range	0-10 kg/cm ²
Pressure port	1/2" BSP M with Adaptor



microcontroller. The RKL 1341 motor driver was used to control the speed of the 12 V DC motor pump. The motor driver was connected to the digital output pins of the Arduino Uno microcontroller. The motor driver receives signals from the microcontroller and adjusts the voltage supplied to the motor accordingly. The 12 V DC motor pump was used to maintain a constant pressure in the spray nozzle. The motor pump was connected to the motor driver (Fig.-1). The pressure sensor provides real-time pressure measurements that are used by the microcontroller to adjust the speed of the motor pump via the motor driver. This ensured that the pressure in the nozzle remains constant, leading to a uniform and consistent spray pattern. The complete setup of the automatic pressure control system is shown in Fig.-2.

Pump : A self-priming diaphragm pump (Fig.-3) was used in the developed system (Specifications in Table-2). The pump was selected based on required discharge capacity and market availability. The diaphragm pump is a type of positive displacement pump that uses a flexible diaphragm to move the water through the pump. The pump consists of an inlet and outlet valve, as well as a diaphragm that moves back and forth due to the change in pressure.



Fig.-3 : Supply pump (12 V DC) with motor.

Table-2 : Technical specification of pump.

Manufacturer and make	ASPEE
Model number	CF 2202A
Voltage	12 V nom. (9-14.4 V)
Current	2.8 A
Liquid flow rate	4.0 LPM
Rated pressure	100 PSI (6.88 bar)

Results and Discussion

The developed automatic pressure control system was tested in a controlled laboratory environment to evaluate its performance. The system was tested at different pressures ranging from 1 to 5 kg/cm². The RKL 1341 motor driver was used to control the motor speed. At first, the pressure sensor was calibrated. Thereafter, relationship between the pressure and discharge v/s with voltage was plotted to study the effectiveness of the developed system.

Calibration of pressure sensor for measurement of pressure : The calibration of the pressure sensor was carried out by plotting the obtained pressure values with the measured pressure values (Fig 4). The plot showed a linear relationship between the output voltage of the pressure sensor and the actual nozzle pressure, with a coefficient of determination (R^2) value of 0.9971. The results of the calibration indicate that the pressure sensor can accurately measure the nozzle pressure with precision.

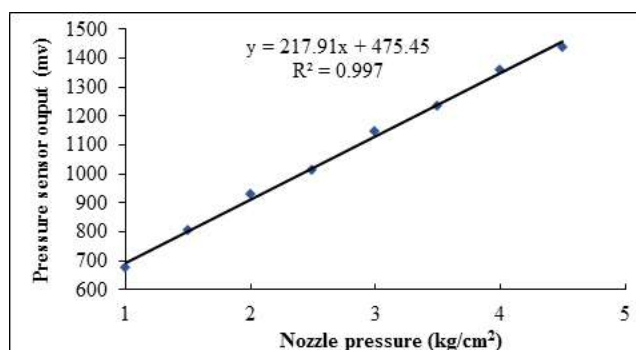


Fig.-4 : Calibration curve of pressure sensor.

Pump vs input supply voltage relationship : The graph between pressure and input voltage showed a linear relationship with a correlation coefficient of $R^2 = 0.996$, indicating a strong positive correlation between the two variables (Fig.-5). The results indicate that as the input voltage increased, the pressure also increased proportionally. This was a desirable outcome as it demonstrates the ability of the system to maintain a consistent boom pressure, as intended. However, there were slight fluctuations in the pressure at certain points in the graph. These fluctuations may be attributed to external factors, such as changes in ambient temperature or variations in the liquid being sprayed. Nevertheless, the overall trend of the graph suggests that the system was able to maintain a relatively stable pressure throughout the range of input voltages tested. The system was able to achieve a boom pressure within the desired range of $\pm 2.5\%$, with a maximum deviation of 2.1%. This demonstrates the effectiveness of the automatic pressure

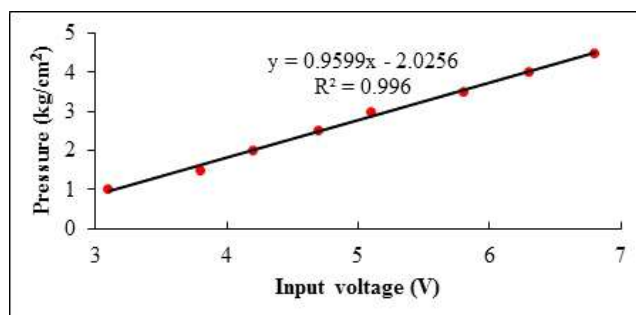


Fig.-5 : Pressure vs input supply voltage relationship.

control system in maintaining a consistent boom pressure for the nozzle, and highlights its potential for use in agricultural spraying applications.

Pump discharge rate at different input voltage supply of pump : The testing of pump was also carried out for its discharge rate at different input voltage. The graph between discharge rate (LPM) of pump and input voltage supply was shown in Fig.-6. The results indicated a linear relationship between the discharge rate of the pump and the input voltage supply. As the voltage increases, the discharge rate of the pump also increases linearly. The R^2 value of the linear regression line was 0.992. It illustrated a strong correlation between the input voltage and the discharge rate of the pump. This relationship was important for the performance of the automatic pressure control system. The results of this experiment showed that the pump used in the system can be accurately controlled by varying the input voltage supply, and that the system can achieve the desired nozzle discharge rate by controlling the voltage supplied to the pump.

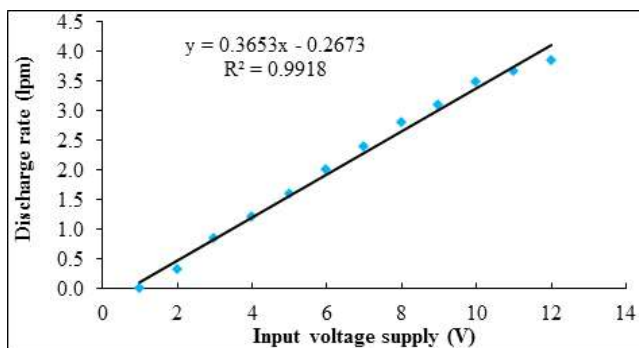


Fig.-6 : Relationship of pump discharge rate with input voltage supply.

Conclusions

The system was found to be effective in maintaining a constant boom pressure for the nozzle adequately. The pressure sensor was able to detect the pressure within the water pipeline, and the microcontroller was able to adjust the speed of motor pump accordingly to maintain the desired pressure. The system was able to maintain the desired pressure within a range of $\pm 0.2 \text{ kg/cm}^2$, which is well within the acceptable range for agricultural sprayers. The system was also able to respond quickly to any changes in the desired pressure, with a response time of less than 0.5 seconds.

Future Scope

Development of a wireless control system for remote monitoring and control of the automatic pressure control system can be done. Additionally, the accuracy and effectiveness of system could be further evaluated under different environmental conditions and for different types of agricultural chemicals.

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Conflict of Interest : The authors declare no conflict of interest

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Effect of Leaf Area Index on the Absorbed Photosynthetically Active Radiation for Barley Crop (*Hordeum vulgare* L.) under Different Growing Environments

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Abstract

Photosynthetically Active Radiation (PAR) is important for physiological development of the crop as it is responsible for photosynthesis in the crop. Present study was conducted in CCS HAU Research Field in Hisar, Haryana in rabi season 2019-20. Barley crop cultivars (V₁-BH 393, V₂-BH 902, V₃-BH-946 and V₄-BH 885) were selected for the study under different growing environments (D₁- 15th November 2019, D₂- 30th November 2019, D₃- 15th December 2019 and D₄- 30th December 2019). Leaf Area Index (LAI) and absorbed PAR were calculated using observations recorded from field experiment. The aim of the study was to understand the effect of LAI on the absorption of PAR fraction from incoming solar radiation for different growing environments and cultivars. From the study it was concluded that timely sown (D₁) crop absorbed more PAR and the absorption of PAR decreased subsequently as sowing days delayed. BH 885 absorbed more PAR than other barley cultivars.

Key words : Barley, leaf area index, photosynthetically active radiation.

Introduction

Barley (*Hordeum vulgare* L.) is a major rabi season crop. Barley cultivars are classified into three distinct species: *H. vulgare* L. (six-rowed barley), *H. distichon* L. (two-rowed barley) and *H. irregular* L. (two-rowed barley) (Singh *et al.*, 2009). It is cultivated in a broad range of soils which varies from saline to poor textured soils under different climatic conditions. Barley crop has the ability to withstand water scarcity in soils when compared with other cereal crops (Ahmed and Hassan, 2019). Barley crop is predominantly cultivated in semi-arid conditions for pasture and cereal production (Oueslati *et al.*, 2005). In year 2021-22, Barley crop was cultivated in 592 thousand ha area, total production of crop remain 1656 thousand tonnes and average yield produced was 2.8 t/ha in India (USDA, 2022). In Haryana (2020-21), Barley crop was grown in 19.4 thousand ha area, total production was 73.9 thousand tonnes and total yield was estimated to be 3803 kg/ha (ICAR-IIWBR, 2021). Barley crop is predominantly produced in Indian states of Rajasthan, Uttar Pradesh, Madhya Pradesh, Jammu and Kashmir, Himachal Pradesh, Haryana and Punjab.

Photosynthesis is an essential process for physiological development of barley crop and it helps in determining the productivity of the plant for the given season. Solar radiation ranging from 400 to 700 nm is essential for photosynthesis which also known as photosynthetically active radiation (PAR) (Peng *et al.*, 2018). The interception of the PAR is directly affected by leaf area index and canopy structure of the plant (Lake *et al.*, 2021). An increase in nitrogen content in soil during anthesis stage can help increase leaf area index (LAI) of the crop which can help increase the absorption of PAR

by 62% and interception of PAR by 20% (Salvagiotti and Miralles, 2008). The present study aims at understanding the relationship between PAR absorption and leaf area index of the barley cultivars grown under different growing environments for rabi season of 2019-20.

Material and Methods

Experimental Site : The study was conducted in Department of Agricultural Meteorology research farm at CCS HAU, Hisar. The site is located at 29°10'N latitude, 75°46'E longitude. The altitude of the location is 215.2 m above msl.

Climate of the site : The climate of Hisar is characterized by continental climate which is located on the periphery of monsoon zone. It is located in the semi-arid and subtropical zone. Monsoon arrives in summer season from first week of July to second week of September by south-westerly winds. In winter season rainfall is received due to Western Disturbance. Climate from October to June remain mostly dry, summer season remain hot while winter season remain cold. The maximum temperature of the region is observed to cross 45 °C during the June month and during winter season minimum temperature can go below 0 °C (freezing point) during the month of January. Extreme temperature fluctuations are observed in the region diurnally. Due to western disturbance two to three light showers are received which is followed by lower temperature. Frost occurrence is common in the region on certain days during winter season. The average rainfall in the region is 450 mm where much of the rainfall amount is contributed by south-west monsoon. The coefficient of variation of annual rainfall can range between 45 to 50 per cent. Seasonal variation for monsoon season can be

around 80 per cent and for winter season the variation can go upto 65 per cent.

Technical details of the experiment : Crop selected for study was barley crop (*Hordeum vulgare* L.) during rabi season of 2019-20. Four cultivars were selected for the study (V₁-BH 393, V₂-BH 902, V₃-BH 946 and V₄-BH 885) under four different growing environments (D₁-15th November 2019, D₂-30th November 2019, D₃-15th December 2019 and D₄-30th December 2019).

Leaf Area Index : The leaves were separated from plant sample taken from individual plots and were used for measuring green leaf area (cm²) which was recorded using LAI meter (LI-3000 Area meter, LI-COR Biosciences, Nebraska, USA). The observations were recorded from tillering to physiological maturity. LAI was computed using the following formula :

$$\text{LAI} = \frac{\text{Leaf Area (cm}^2\text{)}}{\text{Total Land Area Covered by plant (cm}^2\text{)}}$$

Photosynthetically Active Radiation (PAR %) : For PAR observation, the line quantum sensor (Model-L1-191R-BNC-2) was used to measure photosynthetically active radiation in the range of 400-700 nm in micro moles/m²/sec which was converted to W/m² by multiplying the factor by 0.219. The PAR observations were recorded at two levels of the canopy of crop, that was, one meter above the canopy and below the canopy at the ground surface. The observations were recorded during noon hour from 12:00 to 13:00 hrs during tillering, jointing, booting, anthesis, hard dough and physiological maturity. The incident PAR was obtained by keeping the sensor above the canopy facing the sky, reflected PAR was observed by keeping the sensor inversed facing the ground and transmitted PAR was obtained by placing the sensor on ground at random site at a diagonal position. Absorbed radiation was determined using equation :

$$\text{Absorbed PAR} = 1 - \text{Reflected PAR} - \text{Transmitted PAR}$$

Statistical Analysis : Statistical analysis was done using correlation coefficient to study the relationship between LAI and absorbed PAR%. ANOVA was used to statistically analyze the data collected from experimental site. F-test was used to test the significance of the effect of treatment at 5% probability. To test the significant difference between the mean of two treatments the critical difference (C.D.) was used.

Results and Discussion

Leaf Area Index (LAI) : Table-1 depicts the LAI observed in different phenophases of the growing season of the crop for 2019-20. LAI recorded in barley crop increased with the advancement in growth stages until anthesis stage after which LAI of the plant reduces till physiological maturity. The reason for increase in LAI from tillering stage

onwards is that amount of solar radiation absorption increased which increased the rate of photosynthesis in crop. Increase in number of leaves and plant height also played an important role in increase in LAI (Dubey, 2018). After anthesis crop attains senescence which resulted in reduced LAI in the crop till physiological maturity. Maximum LAI was recorded in timely sown crop (D₁ treatment) followed by D₂, D₃ and minimum LAI was recorded in late sown crop (D₄ treatment) a similar result was observed by Pankaj *et al.*, in 2015. During anthesis stage, D₁ treatment recorded LAI of 3.86, followed by D₂ which recorded the LAI of 3.61, D₃ treatment recorded LAI of 3.53 and LAI recorded by D₄ treatment was 3.33 in 2019-20. Zang *et al.* in 2007 also observed the LAI at anthesis stage to be ranging from 3-4 which is consistent with the present study. Among varieties, maximum LAI was recorded by BH 885 followed by BH 946, BH 902 and lowest LAI was recorded by BH 393. BH 885 recorded highest LAI because of profuse tillering and more number of leaves than other cultivars. During anthesis stage, BH 885 recorded LAI of 3.63 followed by BH 946 which recorded LAI of 3.59, BH 902 recorded LAI of 3.56 and BH 393 recorded lowest LAI of 3.54 for 2019-20.

Absorbed Photosynthetically Active Radiation (%) : In table-2 the absorbed PAR to the total incoming PAR increases from tillering to anthesis stage and then it declines thereafter till physiological maturity. Absorption fraction increased because of increase in incoming solar radiation available for absorption to the barley crop (Gomez *et al.*, 1998) and reduces after anthesis stage due to senescence of the crop which resulted in degradation of proteins in chloroplast resulting in reduced absorption of PAR and similar results were observed by Gregersen *et al.* in 2008. Absorbed PAR was observed to be highest in timely sown crop (D₁) followed by D₂, D₃ and lowest absorbed PAR was observed in late sown crop (D₄) in all the phenological stages of the crop. Dutta *et al.* in 2011 observed a similar trend in PAR absorption in rice during tillering and reproductive phase of the crop. Absorbed PAR was observed to be 96.8% for D₁ treatment, 95.8% for D₂, 94.8% for D₃ and least absorbed PAR was 93.9% in D₄ treatment during 2019-20 in anthesis stage. Among varieties, BH 885 absorbed highest amount of PAR for in booting (95.3%), hard dough (89.7%) and physiological maturity (80.2%) in 2019-20. BH 902 observed highest absorption of PAR in anthesis (95.8%) in 2019-20. Lowest PAR absorption was recorded by BH 393 in many phenophases. BH 393 have recorded a low absorption of PAR except in tillering and hard dough stage of crop growth season 2019-20 where BH 393 have recorded highest PAR absorption of 81.5 and 90.4%, respectively.

Correlation between LAI and absorbed PAR% : Table-3 depicts a strong and significant relationship observed between LAI and absorbed PAR in all the

Table-1 : Leaf Area Index (LAI) in different phenophases of the crop for different barley varieties for 2019-20 rabi season.

Treatments	Leaf Area Index (LAI)					
	Tillering	Jointing	Booting	Anthesis	Hard Dough	Physiological Maturity
15th Nov 2019	2.48	3.18	3.53	3.86	1.87	1.03
30th Nov 2019	2.32	3.09	3.19	3.61	1.65	0.98
15th Dec 2019	2.13	3.02	3.07	3.53	1.58	0.91
30th Dec 2019	1.92	2.86	2.96	3.33	1.42	0.89
Mean	2.21	3.04	3.19	3.58	1.63	0.95
SE(m)	0.03	0.03	0.03	0.03	0.01	0.01
CD at 5%	0.01	0.02	0.02	0.01	0.03	0.03
BH 393	2.17	2.99	3.14	3.54	1.58	0.90
BH 902	2.20	3.02	3.17	3.56	1.61	0.93
BH 946	2.23	3.06	3.21	3.59	1.65	0.97
BH 885	2.26	3.09	3.23	3.63	1.68	1.00
Mean	2.21	3.04	3.19	3.58	1.63	0.95
SE(m)	0.03	0.03	0.03	0.03	0.01	0.01
CD at 5%	0.01	0.02	0.02	0.01	0.03	0.03

Table-2 : Absorbed photosynthetically active radiation (Absorbed PAR %) for different barley phenophases and varieties for 2019-20 rabi season.

Treatment	Absorbed PAR%					
	Tillering	Jointing	Booting	Anthesis	Hard Dough	Physiological Maturity
15th Nov 2019	82.3	87.8	96.5	96.8	91.1	82.3
30th Nov 2019	81.1	87.1	95.4	95.8	90.5	80.5
15th Dec 2019	79.8	85.5	94.4	94.8	88.8	79.3
30th Dec 2019	78.3	83.8	93.0	93.9	87.3	75.9
Mean	80.4	86.0	94.8	95.3	89.5	79.5
SE(m)	0.14	0.36	0.30	0.11	0.10	0.09
CD at 5%	0.42	0.12	0.10	0.31	0.29	0.27
BH 393	81.5	85.2	94.5	94.9	90.4	79.6
BH 902	80.7	85.2	94.3	95.8	88.2	78.1
BH 946	79.6	86.9	95.2	94.9	89.5	80.0
BH 885	79.6	86.8	95.3	95.7	89.7	80.2
Mean	80.4	86.0	94.8	95.3	89.5	79.5
SE(m)	0.14	0.36	0.30	0.11	0.10	0.09
CD at 5%	0.42	0.12	0.10	0.31	0.29	0.27

Table-3 : Correlation coefficient to understand the relationship between LAI and absorbed PAR% for 2019-20 rabi season.

Correlation Coefficient between LAI and Absorbed PAR%						
	Tillering	Jointing	Booting	Anthesis	Hard Dough	Physiological Maturity
LAI	0.99**	0.99**	0.94*	0.98*	0.94*	0.92*

selected phenophases *i.e.* tillering, jointing, booting, anthesis, hard dough and physiological maturity. The correlation is performed to observe the effect of LAI on absorption of PAR under different growing environments. In all the phenophases a positive correlation was observed between LAI and absorbed PAR indicating an increase in absorption of PAR with increase in LAI. LAI increases with advancing crop age till anthesis after which it reduces and a similar trend is observed in absorption of PAR which tends to increase and becomes maximum at anthesis stage after which it reduces. Singh *et al.* in 2012 observed that solar radiation absorption decreases with

decrease in LAI due to leaf senescence in barley crop reaching maximum during early anthesis stage. Strongest correlation is observed in tillering stage (0.99) with level of significance of 99% showing the influence of LAI with increased absorption of PAR. Among all the phenophases weakest correlation was observed in physiological maturity showing reduction in influence of LAI on absorption of PAR (0.92) with level of significance of 95%. Anthesis stage showed a strong relationship between LAI and absorbed PAR with a positive correlation of 0.98 with level of significance of 99%.

Conclusions

It was concluded from the study that LAI decreases with delay in sowing as observed from D₁ to D₄ treatment and Absorption of PAR also reduces with the delay in sowing of the crop as observed from D₁ to D₄ treatment. LAI has a strong correlation with the absorption of PAR in all the phenophases of the crop under different growing environments and hence as the leaf area reduces the absorption of PAR for photosynthesis also reduces.

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Assessment of Employment Generated in Per Hectare of Banana Cultivation in Vaishali District of Bihar

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Abstract

The study was designed with the main objective of employment generated in banana cultivation. Primary data were collected from 100 banana growers, located in five randomly selected villages of purposively selected Bidupur block and Hazipur block of Vaishali district. The respondents were grouped into four size categories viz. marginal, small, medium and large farmers based on their size of holding. The secondary data were collected from various published and unpublished sources. On an average cultivation of banana generated 149.64 man days per hectare per year. Out of that 102.23 man days i.e. (68.39 per cent) was claimed by male labours whereas 47.41 man days (31.69 per cent) was share of female labours. Operation wise analysis of the number of man days generated in cultivation of banana indicated that male labours played a dominant role in activities like land preparation, irrigation, earthing-up, spraying of plant protection chemicals, fencing and harvesting. On the other hand female labours had a larger share in employment in weeding of banana (72.78 per cent) and a substantial share (46.98 per cent) in fertilizer application. However, male labours had also a substantial share (32.81 man days per hectare) employment generated in pit digging.

Key words : On an average cultivation of banana generated man days per hectare per year.

Introduction

Banana (*Musa species*) the “queen of tropical fruit” is considered to be one of the oldest fruits known to mankind. It has enjoyed universal popularity in this country from times immemorial. The antiquity of banana can be traced to the mythological time. There are frequent references to bananas in the Ramayana and Mahabharata. It has been the food of sages and hence the name *Musa sapientum*. India is believed to be one of the centers of origin of banana. It is said to have been taken by Arabs from the West Coast of India to Palestine and Egypt. Indian traders took it to Africa from where it spread to the West. Banana is grown within thirty degrees latitude on either side of the equator. It is cultivated in India over an area of about 3.2 million hectares and accounts for 23 per cent of the area under fruits. The estimated production of banana is about 3.3 million tones accounting for about 31.7 per cent of total fruit production. As per F.A.O. report. India was the highest producer of banana in the world and accounted for 27.5 million tones out of world production of 154.5 million tonnes in 2014-15 (F.A.O.2014-15). This fruit occupies second position, next only to mango with regard to area and production. In the state of Bihar area under this fruit is about 1.5 lakh hectares producing roughly 60.4 lakh tones annually.

Research Methodology

Selection of the study area : In order to study

Production and Marketing of Banana “the present study was undertaken in Vaishali district of Bihar. The district was purposively selected because this district had abundant banana production. This district is well known for growing quality banana. Also, this is one of the leading banana producing districts of Bihar.

There are altogether sixteen blocks in vaishali district. A list of banana producing blocks along with quantity of banana produced in respective blocks was prepared and arranged in ascending order. Out of the 16 blocks, Hajipur and three villages from Bidupur blocks were selected randomly. From each selected blocks, a list of banana producing villages was prepared and after arranging them in ascending order, two village namely, Ismailpur and salimabad from Hajipur and Mohanpur, Dharpur and salimpur from Bidupur were selected randomly there by making a total of five sample village. Again, a list of banana growers of every selected village was prepared and from each village 20 banana growers were selected randomly. Thus, total 100 banana growers were selected for detail investigation.

Method of inquiry : At first general information about the village was obtained from the District Statistical Office, vaishali. The information comprised land utilization, crop rotation demographic features, marketing facilities etcetera. The survey method was followed for detailed inquiry of the individual Banana grower.

Table-1 : Employment generation.

Sl. No.	Particular	Marginal			Small			Medium			Large			Overall		
		Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1.	Land preparation	6.98 (100.00)	0.00 (0.00)	6.98 (100.00)	5.90 (100.00)	0.00 (0.00)	5.90 (100.00)	4.98 (100.00)	0.00 (0.00)	4.98 (100.00)	5.59 (100.0)	0.00 (0.00)	5.59 (100.00)	5.86 (100.00)	0.00 (0.00)	5.86 (100.00)
2.	Pit Digging	20.27 (66.46)	10.23 (33.54)	30.50 (100.00)	17.37 (56.00)	13.65 (44.00)	31.02 (100.00)	19.28 (55.75)	15.30 (44.25)	34.58 (100.00)	24.07 (68.54)	11.05 (31.46)	35.12 (100.00)	17.71 (53.98)	15.10 (46.02)	32.81 (100.00)
3.	Transplanting	8.81 (63.89)	4.98 (36.11)	13.79 (100.00)	6.84 (49.49)	6.98 (50.51)	13.82 (100.00)	6.52 (47.49)	7.21 (52.51)	13.73 (100.00)	7.96 (55.78)	6.31 (44.22)	14.27 (100.00)	7.96 (55.78)	6.02 (44.22)	13.90 (100.00)
4.	Fencing	5.55 (100.00)	0.00 (0.00)	5.55 (100.00)	5.50 (100.00)	0.00 (0.00)	5.50 (100.00)	5.10 (100.00)	0.00 (0.00)	5.10 (100.00)	5.12 (100.0)	0.00 (0.00)	5.12 (100.00)	5.32 (100.00)	0.00 (0.00)	5.32 (100.00)
5.	Manure application	6.17 (63.81)	3.50 (36.19)	9.67 (100.00)	6.40 (73.99)	2.25 (26.01)	8.65 (100.00)	3.53 (48.96)	3.68 (51.04)	7.21 (100.00)	4.63 (63.43)	2.67 (36.57)	7.30 (100.00)	4.85 (59.07)	3.36 (40.93)	8.21 (100.00)
6.	Fertilizer application	6.43 (69.82)	2.78 (30.18)	9.21 (100.00)	5.49 (61.20)	3.48 (38.80)	8.97 (100.00)	5.37 (63.25)	3.12 (36.75)	8.49 (100.00)	5.34 (63.64)	3.05 (36.36)	8.39 (100.00)	4.65 (53.02)	4.12 (46.98)	8.77 (100.00)
7.	Irrigation	10.04 (100.00)	0.00 (0.00)	10.04 (100.00)	12.34 (100.00)	0.00 (0.00)	12.34 (100.00)	12.21 (100.00)	0.00 (0.00)	12.21 (100.00)	10.51 (100.0)	0.00 (0.00)	10.51 (100.00)	11.27 (100.00)	0.00 (0.00)	11.27 (100.00)
8.	Weeding	6.20 (24.82)	18.78 (75.18)	24.98 (100.00)	7.92 (30.97)	17.65 (69.03)	25.57 (100.00)	7.39 (27.90)	19.10 (72.10)	26.49 (100.00)	7.13 (27.58)	18.72 (72.42)	25.85 (100.00)	7.00 (27.22)	18.72 (72.78)	25.72 (100.00)
9.	Earthing – up	22.04 (100.00)	0.00 (0.00)	22.04 (100.00)	20.14 (100.00)	0.00 (0.00)	20.14 (100.00)	22.18 (100.00)	0.00 (0.00)	22.18 (100.00)	23.61 (100.0)	0.00 (0.00)	23.61 (100.00)	21.99 (100.00)	0.00 (0.00)	21.99 (100.00)
10.	Spraying pesticide	8.72 (100.00)	0.00 (0.00)	8.72 (100.00)	4.15 (100.00)	0.00 (0.00)	4.15 (100.00)	3.12 (100.00)	0.00 (0.00)	3.12 (100.00)	5.07 (100.0)	0.00 (0.00)	5.07 (100.00)	5.27 (100.00)	0.00 (0.00)	5.27 (100.00)
11.	Harvesting	10.39 (100.00)	0.00 (0.00)	10.39 (100.00)	10.51 (100.00)	0.00 (0.00)	10.51 (100.00)	10.59 (100.00)	0.00 (0.00)	10.59 (100.00)	10.60 (100.0)	0.00 (0.00)	10.60 (100.00)	10.52 (100.00)	0.00 (0.00)	10.52 (100.00)
12.	Total	111.60 (73.44)	40.27 (26.56)	151.87 (100.00)	102.56 (69.97)	44.01 (30.03)	146.57 (100.00)	103.32 (69.49)	45.36 (30.51)	148.68 (100.00)	109.60 (72.38)	41.83 (27.62)	151.43 (100.00)	102.23 (68.39)	47.41 (31.69)	149.64 (100.00)

Figures in the parentheses indicate percentage value.

Table-2 : Operation wise generation of employment in Banana production. (Man days / ha).

Sl. No.	Particular	Marginal	Small	Medium	Large	overall
1.	Land preparation	6.98 (4.60)	5.90 (4.03)	4.98 (3.35)	5.59 (3.69)	5.86 (3.92)
2.	Pit Digging	30.50 (20.08)	31.02 (21.16)	34.58 (23.26)	35.12 (23.19)	32.81 (21.92)
3.	Transplanting	13.79 (9.08)	13.82 (9.43)	13.73 (9.23)	14.27 (9.42)	13.90 (9.29)
4.	Fencing	5.55 (3.65)	5.50 (3.75)	5.10 (3.43)	5.12 (3.38)	5.32 (30.55)
5.	Manure application	9.67 (6.37)	8.65 (5.90)	7.21 (4.85)	7.30 (4.82)	8.21 (5.49)
6.	Fertilizer application	9.21 (6.07)	8.97 (6.12)	8.49 (5.71)	8.89 (5.54)	8.77 (5.86)
7.	Irrigation	10.04 (6.61)	12.34 (8.42)	12.21 (8.21)	10.51 (6.94)	11.27 (7.53)
8.	Weeding	24.98 (16.45)	25.57 (17.45)	26.49 (17.82)	25.85 (17.07)	25.72 (17.19)
9.	Earthing - up	22.04 (14.51)	20.14 (13.74)	22.18 (14.92)	23.61 (15.59)	21.99 (14.70)
10.	Spraying pesticide	8.72 (5.74)	4.15 (2.83)	3.12 (2.10)	5.07 (3.35)	5.27 (3.52)
11.	Harvesting	10.39 (6.84)	10.51 (7.17)	10.59 (7.12)	10.60 (7.00)	10.52 (7.03)
12.	Total	151.87 (100.00)	146.57 (100.00)	148.68 (100.00)	151.43 (100.00)	149.64 (100.00)

Figures in the parentheses indicate percentage to total employment generation.

Results and Discussion

Gender wise generation of employment in Banana production : Table-1 Gender wise employment generated in Banana production as presented in Table 5.10 revealed that on an average, the sample farmers had a total activities of around 149.64 man days per hectare. Out of that employment generated for male labour in total employment amounted 102.23 man days per hectare which constituted 68.39 per cent of the total employment generated in banana cultivation. The share of female labour in total employment was 47.41 man days per hectare which accounted for 31.69 per cent of the total employment.

The employment pattern of different farm size household did not show any definite trend with increasing farm size. Total employment generated for banana cultivation on different size of farms revealed that it was 151.87 man days in case of marginal farmers, 146.57 man days in case of small farmers, 148.68 man days in case of medium farmers, 151.43 man days per hectare for large farmers. The share of male and female labour was 73.44 per cent (110.60 man days per ha.) per cent and 26.56 per cent (40.27 man days per ha.) in case of marginal farms, 69.97 per cent and 30.03 per cent in case of small farms, 69.49 per cent and 30.51 per cent in case

of medium farms and 72.38 per cent 27.62 per cent in case of large farms.

The gender wise employment pattern in banana pointed out that no female labours were engaged in fencing, irrigation, earthing-up, spraying of plant protection chemical and harvesting of banana bunches. The employed that female labour did not contributed in these activities and these activities were performed by male laboures only.

Female laboures were found to be engaged in application of fertilizer, pit digging, transplanting and application of manure. Female laboures had a fair share in all these activities (46.98 per cent), (46.02 per cent), (44.22 per cent) and 40.93 per cent. It is interesting to note that they played a dominate role in weeding in which case their share in total employment was higher (72.78 per cent) than that of males (27.22 per cent). All other operation such as irrigation, earthing – up, fencing, land preparation, spraying and harvesting were dominated by male laboures mainly because these were considered to be arduous activities.

Operation wise generation of employment in banana cultivation : The operation wise generation of employment in banana production presented in Table-2 revealed that overall generation of employment was

149.64 man days per hectare. Female labourers had a fair share in all these activities (46.02 per cent, 44.02 per cent, 40.93 per cent, 46.98 per cent and 72.78 per cent, respectively). It is interesting to note that women played a dominant role in weeding in which case their share in total employment was higher (72.78 per cent) than that of males (27.22 per cent). Larger employment (32.81 man days per hectare) was generated through pit digging and accounted for (21.92 per cent) of total employment generated. Activity was 25.72 man days per hectare and constituted 17.19 per cent of total employment generated in banana cultivation. Earthing – up stood on third position in terms of generation of employment. It generated 21.99 man days per hectare and its share in total employment was 14.70 per cent. Transplanting of suckers in pits generated a substantial position of total employment amounting 13.90 man days per hectare and constituted 9.29 per cent of total employment. The contribution of irrigation was 11.27 man days per hectare to total employment and accounted for 7.53 per cent of total employment generated through harvesting (10.52 man days per hectare) accounted for 7.03 per cent of total employment. Other less important employment generating activities were fertilizer application (5.86 per cent), manuring application (5.49 per cent) and fencing (3.56 per cent) respectively.

Conclusions

It was observed that the total employment generated in banana cultivation was 149.64 man days per hectare. Out of that employment generated for male was 102.23 man days per hectare which accounted for 68.39 per cent of total employment and female was 47.41 man days per

hectare which accounted for 31.69 per cent. In all the four farm size households, pit digging was the main component with respect to employment generation followed by weeding, earthing up, transplanting, irrigation, harvesting, fertilizer application, manure application, land preparation, fencing and spraying in banana cultivation. The adoption of banana cultivation is a labour intensive, in the study area. The further reported that agricultural labourers were below poverty line due to unavailability of employment opportunities on one hand and unproductive expenses the other. Across the farm size categories marginal and small farmers devoted comparatively more time to operational activities, while medium –large farmers allocated more time for management for crop production. It was observed that banana cultivation is more profitable and labour intensive, therefore it fits well in the marginal and small farms production system. The small holder are relatively more efficient in cultivation in contrast to large farmers.

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Impact of Black Point of Disease on Wheat Grain Quality In North India

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Abstract

An experiment was conducted to determine the effect of different levels of black point infection caused by *A. alternata* fungal pathogens on some quality characters of wheat grain. Fresh seeds of popularly cultivated wheat varieties preferably viz., GW 366, GW 496, Lok 1 and GW 1 were collected after harvesting season from the farmers' fields of wheat growing areas of middle Uttarakhand and Gujarat districts viz., Sahaspur, Roorkee, Haridwar and Vadodara. Atleast 50 samples were collected from each of the districts. From the harvested seed lot five primary samples were collected and mixed to have composite samples. Working samples were prepared from composite samples by repeated halving method. The black point disease adversely affects seed quality viz. seed health, seed weight, seed germination seedling vigour, Infection of *A. alternata* affects milling quality because it increase the protein, fat, phosphorus, magnesium, boron whereas decrease in contents of carbohydrate, potassium, calcium, zinc and manganese, nitrogen, gluten and fatty acid content of grain. Besides, infected seeds reveal seed rot, necrosis and shriveling. High humidity due to prolong rainfall or heavy dew deposition during seed maturation favours black point. As our research findings variety gw 366 is highly sensitive to all these parameters.

Key Words : Black point, *A. alternata*, grain quality, wheat.

Introduction

Wheat (*Triticum aestivum* L.) belongs to family Gramineae. It is originated from South West Asia. Wheat has been described as "King of Cereals". It is a staple food of humans. Its value in human diet is in both as a source of carbohydrates and protein. It is cultivated in almost all the subtropical and temperate regions of the world. The major growing species of wheat in India is bread wheat (*Triticum aestivum*) accounting for more than 85 per cent of the total wheat area (Anon., 2019a). India is the second highest producer of wheat in the world. Punjab, Haryana, Rajasthan, Uttarakhand, Uttar Pradesh and Madhya Pradesh are major wheat producing states. It covers about 29.8 million hectares area with total production of 103.32 million tons (Anon., 2021). Banaskantha, Sabarkantha and Gandhinagar districts of Gujarat, Haridwar, Sahaspur, Roorkee are important wheat growing districts of Uttarakhand. The area under wheat crop in Uttarakhand is about 0.4 million hectares with the production of 0.8 million tons (Anon., 2021a). Wheat plants at all growth stages are prone to the attack of numerous diseases such as black stem rust, orange rust, yellow rust, powdery mildew, yellow ear rot, ear cockle, loose smut and black point of wheat (Fakir, 1999). Black point was first described in the United States in 1913 (Watkins and Prentise, 1997). Several fungi are infected to black point disease in wheat but in my study the pathogen *alternaria alternate* is main causes of black point disease. The black point disease adversely affects grain and seed quality. High humidity due to prolong rainfall or heavy dew deposition during

seed maturation favours black point. Wet weather promotes sporulation and infection by black point causing fungi (Watkin and Prentise, 1997). Black point of wheat is commonly encountered with bold wheat grain varieties under Uttarakhand conditions (Solanki *et al.*, 2006). Scientific information on various aspects related to black point of wheat in middle Uttarakhand is quite lacking. With a view to generate scientific information on various aspects related to black point of wheat. The present work was, therefore, undertaken to determine the effect of different levels of black point infection on some important quality characters of wheat grain.

Materials and Methods

Present investigation on studies on black point of wheat (*Triticum aestivum* L.) under middle Uttarakhand condition was under taken details of the materials and methods followed are described hereunder. The experiment was conducted at the Department of Plant Pathology, RCP College, Kishanpur, Roorkee during 2021-22 crop season. Seeds of a popular wheat varieties GW 366, GW 496, Lok 1 and GW 1 were collected after harvesting season from the farmers' fields of wheat growing areas of middle Uttarakhand and Gujarat districts viz., Sahaspur, Roorkee, Haridwar and Vadodara. Atleast 50 samples were collected from each of the districts.

1. Laboratory Procedures

Glassware cleaning : Standard qualities glasswares used for laboratory studies were washed with chromic acid solution (Potassium dichromate 80 gm. dissolved in 1000

ml. of distilled water and 60 ml. concentrated sulphuric acid added with constant stirring). Thus, washed glasswares were subsequently immersed in water for 24 hrs. Then rinsed with tap water and finally with distilled water.

Sterilization of glassware, culture medium, blotter paper and water : Glasswares were sterilized in a hot air oven at 160° C for 2 h. Both solid and liquid media as well as blotter paper and water were sterilized in autoclave at 121° C temperature and 1.1 kg/cm² pressure for 20 min. Blotter papers cut according to inner diameter of Petri plates were placed into a galvanized box before sterilization.

Peeled potatoes : 200 g
Dextrose : 20 g
Agar agar : 20 g
Distilled water : 1000 ml

Preparation of medium

The clean and peeled potatoes (200 g) were cut into small pieces. These pieces were boiled in 500 ml distilled water and the extract was collected by filtering through muslin cloth. Dextrose (20 g) and agar powder (20 g) were dissolved in another 500 ml of hot water. Both the solutions were mixed in one container and the final volume of one liter was dispensed into conical flasks, plugged with non-absorbent cotton and finally wrapped with aluminum foil. Further, they were sterilized in autoclave at 121° C temperature at 1.1 kg/cm² for 20 min.

Pouring of medium : Approximately 20 ml of luke warm PDA was poured aseptically in each of the Petri plate (110 and 90 mm diameter). The Petri plates were rotated and tilted for uniform spreading of medium, and were allowed to solidify. Isolation chamber was used to provide aseptic condition.

2. Symptomatology

Infected wheat seeds collected from each of the wheat growing selected pockets were examined visually by means of magnifying lens under artificial light as well as under stereoscopic microscope. Then, symptoms observed on seeds were described accordingly.

3. Assessment of infected seed samples in respect of seed health i.e. seed weight, seed germination and seedling vigour

1000 wheat seed were weighted after being picked at random. The paper towel method was used to examine the germination of seeds (Sahu and Agrawal, 2003). The paper towel method was used to examine the germination of seeds. The distilled water was used to soak one sheet of germination paper. On the first sheet, fifty seeds of the appropriate treatment were distributed uniformly. After

placing a second sheet of germination paper on top of the first, the sheet was carefully moistened. Both sheets were rolled along with wax coated paper. The rolled papers were incubated in seed germinator at 25° for seven days. At the end of incubation, rolled towel papers were carefully opened. Germinated and un-germinated seeds were counted from each of the treatments. Successful germination was defined as the seed sprouting a seedling. For each of the treatments, four replications of 100 seeds were kept. Total 400 seeds each of the samples were assessed. Seedling vigour was assessed on the basis of shoot and root length and per cent seed germination using following formula (Thippeswamy and Lokesh, 1997).

Vigour index (VI) = (Mean root length + Mean shoot length) × % of seed germination

4. Biochemical Analysis

Estimation of total soluble sugar by phenol-sulphuric acid method : Total soluble sugar estimation from the black point infected wheat seeds were determined by phenol-sulphuric acid method (Dubey *et al.*, 1956). Two hundred mg of flour sample was extracted for soluble sugar in 80 per cent ethanol. One mg of extract was evaporated to dryness and dissolved with 10 ml of distilled water in 30 ml volume test tube. In a similar way, 0.2, 0.4, 0.6, 0.8 and 1.0 ml of working standard glucose solution (0-100) was pipette into a series of tubes. The volume of each tube was adjusted to 1 ml with distilled water. One ml of 5 per cent phenol solution and 5 ml of H₂SO₄ were added to each tube and shaken well. Again after 10 min, the contents of the tubes were shaken and placed in an ice bath for 20 min. The absorbance was read at 490 nm. The amount of total sugar was calculated using the standard graph as per following formula.

Calculation

Total soluble sugar = Sample OD × Graph factor × Dilution factor

Estimation of total protein by Micro-kjeldahl method : Total protein estimation from black point infected wheat seeds were done by the standard procedure (Anon., 1965). Forty mg. of wheat flour was taken in the glass digestion tube. Two ml. of concentrated H₂SO₄ and the digestion mixture (1:3 of CuSO₄ and K₂SO₄) was added to the digestion flask tube. Then, the tubes were transferred on electric burner for 2 hrs. to carry out the digestion at 370° C. The content of the tube became colorless after digestion. This was the indication of completion of digestion. Then, 10 to 15 ml. of double distilled water was added to digestion tube followed by ten ml. of 40 per cent NaOH. As a result of which the whole solution turned black. Ten ml. of 4 per cent boric acid was taken into 250 ml. conical flask and two drops of mixed indicator were added to it. Then, the digestion tube containing the

Table-1 : Effect of black point disease on seed weight, seed germination, shoot length, root length and seedling vigour index (SVI).

Treatment	Weight of 1000 seeds (g)*	Seed germination (%)	Shoot length (cm)*	Root length (cm)*	Seedling vigour index
Variety (V) **					
GW 496 (V1)	48.57	97.50	4.67	11.37	1534.55
GW 366 (V2)	58.05	94.50	4.86	11.96	1589.41
Lok 1 (V3)	55.86	96.00	4.97	11.01	1537.74
S. Em. ±	0.82	1.31	0.11	0.22	24.58
C. D. 0.05%	2.43	NS	NS	0.67	NS
Category of seeds (C)					
Healthy seeds (C1)	50.22	98.00	5.02	12.29	1696.88
Infected seeds (C2)	58.86	94.00	4.65	10.60	1410.92
S. Em. ±	0.67	1.07	0.09	0.18	24.58
C. D. 0.05%	1.98	3.18	0.27	0.55	73.00
Interaction (V X C)					
V1C1	43.32	100.00	4.75	12.30	1706.90
V1C2	53.82	95.00	4.59	10.43	1362.20
V2C1	54.60	96.00	4.91	12.56	1677.46
V2C2	61.50	93.00	4.81	11.36	1501.37
V3C1	52.75	98.00	5.39	12.02	1706.29
V3C2	58.97	94.00	4.55	10.00	1369.19
S. Em. ±	1.16	1.86	0.16	0.32	42.58
C.D. 0.05	NS	NS	NS	NS	NS
C.V.%	4.27	3.86	6.52	5.56	5.48

NS=Non significant, *Average of four replications, ** Black point infected seeds

solution was steam distilled in KEMPLUS machine, and ammonia was trapped in the boric acid so that the solution in the conical flask turns blue. This solution was titrated with 0.02N H₂SO₄. The percentage of nitrogen and protein were calculated using following formula.

Calculation

$$\% \text{ N} = \frac{(\text{Titration reading of sample} - \text{Blank}) \times \text{Normality} \times 100 \times 14.007}{\text{Sample taken (mg.)}}$$

5.0 Statistical analysis

Data obtained from various aspects of present investigation were subjected to statistical analysis by making the use of analysis of variance technique (Steel and Torrie, 1980). The standard methods of analysis of variance for complete randomized design and transformations were used in the experiments. The test of significance among the treatments was worked out by 'F' test. The appropriate standard error (S.E.m. ±) was computed in each case. For the treatments effects, which were found significant, the critical difference (CD) at 5 per cent level of probability was worked out to compare two treatment means.

Results and Discussion

The present investigation on black point disease of wheat was undertaken at the Department of Plant Pathology, College of Agriculture, RCP College, Kishanpur, Roorkee. The results and discussion of present investigation on various aspects are presented hereunder:

Symptomatology : Critical observations of black point infected seeds of variety GW 496, GW 366 and Lok 1 collected from the farmers' fields of four districts of middle Uttarakhand and Gujarat viz., Sahaspur, Roorkee, Dehradun and Haridwar revealed following symptoms. Infected seeds revealed brownish-black discoloration in scattered manner on various parts of the seed. Seeds showed brownish-black discoloration prominently restricted to embryonic end of seed. The embryo of the seeds appeared quite shriveled. The floury endosperm of the severely infected seeds appeared brownish-black. Conspicuous brownish-black patches could be seen on the pericarp of infected seeds. Moreover, similar types of discoloration appeared on ventral crease and brush end of seeds. Observations of pericarp of severely infected seeds under the microscope revealed the presence of conspicuous fungal growth in some seeds. Flour colour of

Table-2 : Effect of black point disease on protein and total soluble sugar content of wheat seeds.

Treatments	Protein (%)	Total soluble sugar (mg)*
Variety (V)		
GW 496 (V1)	11.97	692.30
GW 366 (V2)	12.47	949.48
Lok 1 (V3)	12.37	627.63
S. Em. $\pm$	0.25	8.18
C.D. 0.05%	NS	24.32
Category of seeds (C)		
Healthy seeds (C1)	10.77	818.19
Infected seeds (C2)	13.77	694.74
S. Em. $\pm$	0.21	6.68
C.D. 0.05%	0.61	19.86
Interaction (V X C)		
V1C1	9.78	731.53
V1C2	14.17	653.07
V2C1	10.97	1008.21
V2C2	13.97	890.75
V3C1	11.57	714.84
V3C2	13.17	540.42
S. Em. $\pm$	0.36	11.58
C.D. 0.05%	1.06	34.39
C.V. %	5.38	3.06

NS=Non significant

infected seeds was dull white in contrast to creamish white of healthy seeds. Earlier, similar symptoms such as discoloration on embryo, pericarp, endosperm, brush end, ventral crease tissues and shriveled embryo etc. have been described by Weise (1987), Monaco *et al.* (2004) and Sisterna and Sarandon (2005). Such visible abnormalities of wheat seeds might have been produced partly due to one or more mycotoxins produced by pathogens during the infection. Moreover, congenial temperature and humidity during flowering and seed maturation period as well as faulty application of nitrogenous fertilizers might have favoured the growth of pathogen and thereby aggravated symptomatology. Williamson (1997) noted black point discoloration due to degradation of the seed coat. Further, he noted that this may be caused by increased levels of active enzymes and compounds in the seed coat that are triggered by humidity during the later stages of grain filling. Wang *et al.* (2002) correlated severe kernel discoloration to low temperature and high rainfall during the period of grain filling.

Assessment of infected seed samples in respect of seed health i.e. seed weight, seed germination and seedling vigour : Weight of 1000 wheat seeds was recorded from randomly drawn seeds. Seed germination test was carried out by paper towel method (Sahu and Agrawal, 2003). One sheet of germination paper was wetted by distilled water. Fifty seeds of respective treatment were placed on first sheet evenly. Second sheet of germination paper was placed on first sheet followed by

wetting the sheet carefully. Both sheets were rolled along with wax coated paper. The rolled papers were incubated in seed germinator at 250° for seven days. At the end of incubation, rolled towel papers were carefully opened. Germinated and un-germinated seeds were counted from each of the treatments. Emergence of seedling from the seed was considered as successful germination. Four replications each of 100 seeds were maintained for each of the treatments. Total 400 seeds each of the samples were assessed. Seedling vigour was assessed on the basis of shoot and root length and per cent seed germination using following formula (Thippeswamy and Lokesh, 1997).

Vigour index (VI) = (Mean root length + Mean shoot length) $\times$ % of seed germination

Effect of black point of wheat on seed weight, seed germination, shoot length, root length and seedling vigour index : Results on seed weight and seed health status i.e. seed germination, shoot length, root length as well as seedling vigor index (SVI) as influenced by black point disease of wheat in varieties GW 496, GW 366 and Lok 1 are presented in Table 1. With respect to varieties, GW 366 (V2) revealed significantly the highest seed weight (58.05g) which was at par to variety Lok 1 with 55.86g weight of 1000 seeds. Variety GW 496 revealed significantly the lowest seed weight (48.57g). However, results revealed non-significant differences among the varieties for seed germination, shoot length as well as seedling vigour index.

Variety GW 366 revealed significantly the highest root length (11.96 cm) which was at par with root length of variety GW 496 (11.37 cm) and Lok 1 (11.01 cm), respectively. Treatment effects of seed category were significant for all the parameters studied. Infected seeds (C2) revealed significantly higher seed weight (58.86g) over healthy seeds (C1) (50.22g). On the other hand, healthy seeds (C1) revealed significantly higher seed germination (98 %), shoot length (5.02 cm), root length (12.29 cm) and seedling vigour index (1696.88) over infected seeds (C2). In case of interaction between variety and category of seeds (V x C), the results showed non-significant differences for each of the parameters tested.

It is quite possible that fungi present in the seeds might have adversely affected the embryo of the seeds by producing one or more toxic metabolites thereby hampered the seed germination and other growth parameters. Bold seeds of the spike may partly lead to opening of floret for longer period during the grain development stage which might have allowed the pathogen to enter in the floret and cause higher infection to bold seeds as compared to normal seeds. Similar trend of findings have been reported earlier. Sisterna and Sarandon (2005) reported that black point infected seeds were heavier than healthy ones. Chaudhary *et al.* (1983) reported reduction in seed germination due to invasion of the pathogen on coleoptile and plumule. Hudec (2007) reported that fungal species of *Alternaria*, *Fusarium* and *Cochliobolus sativus* are able to kill or reduce embryo vigour.

Effect of black point disease on protein and total soluble sugar content of wheat seeds : Results on effect of black point disease on protein and total soluble sugar content are presented in Table-2. Among the varieties, the results revealed non-significant differences on protein content of wheat seeds, whereas significant differences were observed for total soluble sugar content. Variety GW 366 revealed significantly the highest sugar (949.48 mg) as against to 692.30 and 626.63 mg sugar in varieties in GW 496 and Lok 1, respectively.

With respect to category of seeds, infected seeds revealed significantly higher protein in infected seeds (13.77 %) over healthy seeds (10.77 %). However, total sugar content was significantly reduced in infected seed category (694.74 mg) as compared to healthy seed (818.19 mg). Interaction effects among the varieties and categories (V X C) were significant for both protein and sugar content. Treatment V1C2 showed significantly the highest (14.17 %) protein which was at par with V2C2 (13.97) and V3C2 (13.17). Treatment V2C1 revealed significantly the highest sugar which was as much as

(1008.21 mg). Sugar content of remaining interaction combinations ranged from 890.75 to 540.42 mg. In present study, it was quite interesting to note that infected seeds revealed higher protein and lower sugar contents. Higher protein in infected seeds might be partly due protein content of pathogen present. Moreover, pathogen may also trigger normal protein synthesis of plants after infection that might have increased protein content of black point infected seeds. Chaddha and Srivastava (1971) concluded that higher protein in fungus infected tissues might be associated with the activities of the pathogen. Yadav *et al.* (2004) found significant increase in protein content due to presence of intracellular mycelium of pathogen. Similar views have been put forward by Singh *et al.* (2005), who observed significant increase in protein content of infected plant tissues due to increased protein synthesis in infected host. Further, pathogens present in seeds may use sugar for their growth and development which might have caused reduction in sugar content of infected wheat seeds. Amira (2010) reported consumption of sugar by fungi during their parasitic activity.

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Influence of Plant Densities and Fertility Levels on Nutrient Content and Uptake of Sweet Corn (*Zea mays*. L. Ssp. *saccharata*)

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Abstract

A field experiment was conducted at Udaipur during *kharif* season of 2018 to work out optimum fertilizer dose and evaluate production potential of sweet corn. The treatment consisted of combination of 4 plant densities (55555, 66666, 83333 and 111111 plant ha⁻¹) and 4 fertility levels. The results of present experiment revealed that advancing plant densities from 55,555 to 1,11,111 significantly increased plant population at successive stages. The maximum nitrogen and phosphorus content and uptake were recorded under 55,555 plants ha⁻¹. Advancing plant densities from 55,555 to 1,11,111 plants ha⁻¹ decreased nitrogen and phosphorus content in grain and stover. The potassium content of grain did not vary significantly under various plant densities. The minimum nitrogen, phosphorus and potassium uptake were recorded under 55,555 plant ha⁻¹. Increasing plant density from 55,555 to 1,11,111 plants ha⁻¹ significantly improved uptake of nitrogen by grain, stover as well as total uptake. Application of 110 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹ brought about significant increase in nitrogen, phosphorus and potassium content and uptake of the grain and stover over 80 kg N + 30 kg P₂O₅ + 20 kg K₂O ha⁻¹. At the same time further increase in fertility level from 110 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹ to 140 kg N + 60 kg P₂O₅ + 50 kg K₂O ha⁻¹ increase nitrogen, phosphorus and potassium content and uptake to the varying extents.

Key words : Sweet corn, nutrient, content and uptake.

Introduction

After rice and wheat, maize (*Zea mays* L.) is the third most significant cereal crop and is considered a miracle crop. It is raised for food, animal feed, and a number of industrial products. In India, maize is grown on 8.86 m ha with the production and productivity of 31.51 m t and 3195 kg ha⁻¹, respectively (Govt. of India, 2021). Sweet corn is a hybridized variety of maize specifically bred by gene (S) to increase the sugar, thus it varies from normal corn as the gene "S" affects starch synthesis in seed endosperm and increase the level of polysaccharides (sugar) and decreases the level of starch content. Thus, the kernels of sweet corn are creamy and taste much sweeter than normal corn. Its soft and succulent grains, emerges as an alternative dish of urbanites namely vegetable roasted ears, soups, corn syrup, and sweeteners etc. The urban people have great interest in consuming green cobs and it is found that sweet corn is more delicious when it is steamed, boiled and consumed along with a pinch of salt and lemon mash as it increases the taste. The grain of sweet corn contains 15-20 per cent total soluble sugar at it soft dough stage. It also found a special niche in the preparation of native beer. Sweet corn can be harvested with 75-80 days after sowing. They are harvested earlier by 35 to 45 days compared to normal grain corn. After harvesting green cobs, plant of sweet corn is used as green fresh fodder or dry fodder. There is an increasing tendency to produce sweet corn at commercial level to augment the income of the farming community dwelling in

the outskirts of big cities and metropolis. Since there is limited scope to increase the area under sweet corn cultivation because of competition from other cereals and cash crops, the only alternative is through enhancement of productivity by various agronomic management factors.

Amongst various factors plant density is efficient management tool for maximizing sweet corn green cobs and green fodder yield by increasing the capture of solar utilization within the canopy (Meena *et al.*, 2017). Plant density for normal and hybrid maize has been optimized, but the recommended plant densities for normal, composite and hybrid maize may not be applicable for the speciality corn because of differences in their growth and development pattern (Kumar, 2008). Further the modern sweet corn hybrids tolerate higher plant densities than hybrids used in the past and the use of narrow plant to plant space has greater potential to enhance sweet corn cobs and fodder yield at crowded stands (Bhatt, 2012). It is an established fact that green cobs and green fodder yield potentials of the sweet corn cultivars are realized to the highest extent when they are grown under optimum agronomical environmental conditions. The proper mineral fertilization is considered to be one of the most important requisites in this respect (Singh *et al.*, 2011).

Materials and Methods

The experiment was laid out at the Instructional Farm, Rajasthan College of Agriculture, Udaipur. The farm is located at 24° 35' N latitude, 72° 42' E longitude with an

altitude of 579.5 m above the mean sea level. The total rainfall received during crop growth period was 42.9 cm.

The mean maximum and minimum temperature ranged between 27.9 to 32.2°C and 19.6 to 24.0°C with maximum and minimum relative humidity percentage ranged from 75.6 to 90.9 and 52.4 to 81.0 per cent, respectively. The treatments consisted of combination of four planting densities (D_1 : 55,555 plants ha^{-1} , D_2 : 66,666 plants ha^{-1} , D_3 : 83,333 plants ha^{-1} and D_4 : 1,11,111 plants ha^{-1}) and four fertility levels (F_1 : 80 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} , F_2 : 110 kg N + 40 kg P_2O_5 + 30 kg K_2O ha^{-1} , F_3 : 120 kg N + 50 kg P_2O_5 + 40 kg K_2O ha^{-1} and F_4 : 140 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1}). The experiment was laid out in randomized block design with factorial concept design with three replications. The soil of the experimental site was slightly alkaline in reaction with pH 7.6, low in organic carbon (0.78 %), medium in available nitrogen (285.6 kg ha^{-1}) and phosphorus (21.6 kg ha^{-1}) and high in available potassium (301.6 kg ha^{-1}). Bold and healthy seeds of sweet corn hybrid 'Sugar-75' were sown at a depth of 2-3 cm sown on 2 July 2018 as per treatments and harvested on 21 Sept 2018.

The sweet corn grain and stover samples collected at harvest from produce of each plots were oven dried and thereafter ground in laboratory mill. These samples were subjected to chemical analysis for determination of nutrient contents. The following standard methods for analysis were adopted.

(i) Nitrogen : (Lindner, 1944) Nessler's reagent colorimetric method.

(ii) Phosphorus : (Richards, 1968) Vanadomolybdate phosphoric yellow colour method.

(iii) Potassium : Richards (1968) Flame photometer method.

N and P uptake at harvest from grain and stover were computed by the following formula :

$$\text{Nutrient content (\%)} \times \text{Yield (kg ha}^{-1}\text{)} \\ = \frac{\text{Nutrient content (\%)} \times \text{Yield (kg ha}^{-1}\text{)}}{100}$$

The total uptake by the crop was calculated by summing up the uptake of sweet corn grain and stover.

Result and Discussion

Plant densities significantly influenced the nitrogen and phosphorus content of grain and stover. The maximum nitrogen content was recorded under 55,555 plants ha^{-1} . Advancing plant densities from 55,555 to 66,666, 66,666 to 83,333 and 83,333 to 1,11,111 plants ha^{-1} significantly decreased nitrogen content in grain. Advancing plant densities from 55,555 to 66,666, 66,666 to 83,333 and

83,333 to 1,11,111 plants ha^{-1} significantly decreased phosphorus content in stover to the magnitude of 4.2, 5.3 and 7.6 per cent, respectively. The potassium content of grain and stover did not vary significantly under various plant densities (Table-1). Advancing of plant densities from decreased nitrogen, phosphorus and potassium content of grain and stover which could be probably due to availability of lower space around each plant (Meena *et al.*, 2017). Increases in plant density caused competition for reproductive, vegetative part as well as on activity of root and thus caused its lower proliferation and development under higher plant population and result in lower mining of nutrient from soil. Since most of nutrient absorbed by plant during vegetative phase are translocated for vegetative growth and finally for development of reproductive part of the plants. Thus, the lower nitrogen and phosphorus content in grain and stover under higher plant density was expected. The K status of experimental soil was higher thus the plants under varying densities did not face competition for potassium and thus proved statistically at par under different plant densities (Choudhary, 2005 and Meena *et al.*, 2017).

It is evident from data that application of 110 kg N + 40 kg P_2O_5 + 30 kg K_2O ha^{-1} brought about significant increase in nitrogen, phosphorus and potassium content of the grain and stover over 80 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} . At the same time further increase in fertility level from 110 kg N + 40 kg P_2O_5 + 30 kg K_2O ha^{-1} to 120 kg N + 50 kg P_2O_5 + 40 kg K_2O ha^{-1} and 140 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1} though increase nitrogen content, however failed to exhibit significant superiority. Application of 110 kg N + 40 kg P_2O_5 + 30 kg K_2O ha^{-1} significantly increased potassium content of the stover by 2.7 per cent over 80 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} (Table-1). The significant improvement in nutrient status of sweet corn grain and stover could be on account of greater availability of nutrients in soil environment along with better extraction and translocation towards plant system. The externally applied nitrogen, phosphorus and potassium supported native available nutrients that increase nitrogen, phosphorus and potassium concentration in soil with increasing fertility which was sufficient to meet the requirement of crop for higher yield of sweet corn. A similar observation was made by (Kar *et al.*, 2006), (Kumar, 2008) and (Bhatt, 2012).

The variation in increasing plant densities was significant in terms of nitrogen, phosphorus and potassium uptake. The minimum nitrogen, phosphorus and potassium uptake was recorded under 55,555 plant ha^{-1} . Increasing plant density from 55,555 to 66,666 and 66,666 to 83,333 plants ha^{-1} significantly improved uptake of nitrogen, phosphorus and potassium by grain and stover (Table-2). At the same time further increase plant

Table-1 : Effect of treatments on nitrogen, phosphorus and potassium content.

Treatments	N content (%)		P content (%)		K content (%)	
	Grain	Stover	Grain	Stover	Grain	Stover
Plant densities						
55,555 Plants ha ⁻¹	1.802	0.928	0.372	0.124	0.403	1.14
66,666 Plants ha ⁻¹	1.759	0.894	0.364	0.119	0.401	1.14
83,333 Plants ha ⁻¹	1.720	0.843	0.344	0.113	0.399	1.14
1,11,111 Plants ha ⁻¹	1.679	0.804	0.324	0.105	0.395	1.13
SEm±	0.009	0.011	0.005	0.001	0.0025	0.008
CD (P=0.05%)	0.027	0.032	0.014	0.004	NS	NS
Fertility levels						
80 kg N + 30 kg P ₂ O ₅ + 20 kg K ₂ O ha ⁻¹	1.711	0.783	0.332	0.110	0.395	1.11
110 kg N + 40 kg P ₂ O ₅ + 30 kg K ₂ O ha ⁻¹	1.740	0.884	0.352	0.115	0.399	1.14
120 kg N + 50 kg P ₂ O ₅ + 40 kg K ₂ O ha ⁻¹	1.750	0.896	0.358	0.117	0.403	1.14
140 kg N + 60 kg P ₂ O ₅ + 50 kg K ₂ O ha ⁻¹	1.758	0.905	0.362	0.118	0.404	1.14
SEm±	0.009	0.011	0.005	0.001	0.0025	0.008
CD (P=0.05%)	0.027	0.032	0.014	0.004	NS	0.02

Table-2 : Effect of treatments on nitrogen phosphorus and potassium uptake.

Treatments	N uptake (kg ha ⁻¹)			P uptake (kg ha ⁻¹)			K uptake (kg ha ⁻¹)		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
Plant densities									
55,555 Plants ha ⁻¹	19.45	35.04	54.50	4.03	4.69	8.72	4.35	43.03	47.38
66,666 Plants ha ⁻¹	22.62	38.57	61.19	4.70	5.13	9.83	5.16	49.03	54.19
83,333 Plants ha ⁻¹	24.48	43.26	67.74	4.92	5.80	10.72	5.69	58.18	63.87
1,11,111 Plants ha ⁻¹	25.04	53.48	78.52	4.84	6.99	11.84	5.90	74.95	80.85
SEm±	0.55	1.36	1.81	0.16	0.20	0.35	0.14	1.78	1.89
CD (P=0.05%)	1.60	3.92	5.23	0.45	0.58	1.01	0.40	5.14	5.47
Fertility levels									
80 kg N + 30 kg P ₂ O ₅ + 20 kg K ₂ O ha ⁻¹	19.41	35.98	55.39	3.76	5.06	8.83	4.49	51.81	56.30
110 kg N + 40 kg P ₂ O ₅ + 30 kg K ₂ O ha ⁻¹	22.66	42.80	65.46	4.58	5.57	10.15	5.20	55.80	61.01
120 kg N + 50 kg P ₂ O ₅ + 40 kg K ₂ O ha ⁻¹	24.23	45.19	69.41	4.95	5.91	10.86	5.59	58.24	63.82
140 kg N + 60 kg P ₂ O ₅ + 50 kg K ₂ O ha ⁻¹	25.29	46.38	71.67	5.20	6.06	11.26	5.82	59.35	65.17
SEm±	0.55	1.36	1.81	0.16	0.20	0.35	0.14	1.78	1.89
CD (P=0.05%)	1.60	3.92	5.23	0.45	0.58	1.01	0.40	5.14	5.47

density failed to record significant variation in nutrient uptake by grain and stover. It is well known fact that nutrient uptake depends upon dry matter accumulation and content at cellular level. The concentration of nitrogen and phosphorus nutrient was lower under increasing plant density and potassium concentration was statistically at par in both the densities. Despite of lower nitrogen and phosphorus content, the higher nitrogen, phosphorus and potassium uptake by sweet corn grain, stover and total uptake may be attributed to significantly higher sweet corn grain and fodder yield under higher plant density over lower density. The results are in close accordance with findings of Kar *et al.* (2006), Kumar, (2008) and Bhatt, (2012).

Application of 110 kg N + 40 kg P₂O₅ + 30 kg K₂O

ha⁻¹ significantly increased nitrogen, phosphorus and potassium uptake by grain and stover over 80 kg N + 30 kg P₂O₅ + 20 kg K₂O ha⁻¹. Further increase in fertility level from 110 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹ to 120 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ failed to record significant variation. However, increase in fertility level from 110 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹ to 140 kg N + 60 kg P₂O₅ + 50 kg K₂O ha⁻¹ significantly increased nutrient up take by grain and stover (Table-2). The significantly increase in nitrogen, phosphorus and potassium uptake of grain and stover at harvest seems to be account of capabilities of sweet corn plants for efficient absorption, translocation and utilization of absorbed nutrients. The increase content of nutrient in sweet corn grain was expected as there was more translocation of nutrient from vegetative part to

towards grain (Singh *et al.*, 2011), (Suthar *et al.*, 2013) and (Kumawat *et al.*, 2014).

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Response of Pop Corn (*Zea mays* L. Everta) Varieties to Varying Fertility Levels

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Abstract

A field experiment was conducted during rainy season of 2016 at Instructional Farm, Rajasthan College of Agriculture, Udaipur to ascertain suitable pop corn variety and its fertility level. Treatment consisted four pop corn varieties viz., V L Amber pop corn, BPCH-6, V L pop corn-1 and Jawahar pop corn-11 and four fertility levels viz., 90 + 30, 110 + 40, 130 + 50 and 150 + 60 kg N + P₂O₅ ha⁻¹. The soil of experimental site was having medium fertility status. The results indicated that highest values of growth, yield attributing parameters, nutrient uptake, grain (17.97 q/ha), stover yield (24.47 q/ha), net return (₹157495/ha and B C ratio 5.97) were obtained with variety BPCH-6. Application of 130 + 50 kg N + P₂O₅/ha improved growth, yield components consequently grain (17.76 q/ha), stover (27.44 q/ha) over rest of the fertility levels and proved economically beneficial with net return (₹ 155058/ha) and B C ratio (5.85). At harvest experimental soil with BPCH-6 pop corn had significantly lower N and P status, however K status of soil did not vary significantly. Application of 150 + 60 kg N + P₂O₅/ha retained significantly higher N and P content in soil. K status did not differ significantly under varying fertility levels.

Key words : Fertility levels and pop corn and SSNM.

Introduction

Maize is an important cereal of our country. In Rajasthan this crop occupies 0.87 m ha area with production of 1.14 m t and productivity of 13.18 q/ha (DOA, 2016). Out of total production, 25 per cent of maize is consumed as staple food in various forms and among them pop corn is one of the most important one. Due to immense nutritionally rich food and high remunerative commercial value of pop corn, identification of suitable genotype having wider adaptability and responsiveness to fertilizer is considered essential for exploiting higher yield of pop corn in south eastern part of Rajasthan. Amongst nutrients, nitrogen and phosphorus is of paramount importance in plant system. The general recommendation of nitrogen and phosphorus for maize developed by researchers is based on crop responses over large areas. This often results in over or under fertilization leading to yield and economic losses. Thus considering these facts and paucity of research findings on these aspects in south-east Rajasthan, the present study was carried out with objectives to ascertain economically viable pop corn variety and nutrient recommendation for pop corn.

Materials and Methods

A field experiment was carried out during *kharif* 2016 at the instructional Farm, Rajasthan College of Agriculture, Udaipur, Rajasthan which is situated at 23°34'N latitude, 72°42'E longitude and 582.17 meter above the mean sea level. The soil of experimental site was clay loam in texture, having alkaline reaction (pH 7.6). The soil was medium in available nitrogen (271.4 kg/ha) and available phosphorus (17.4 kg/ha) but high in available potassium

(295.9 kg/ha). The treatment consisting 4 pop corn varieties (V L Amber pop corn, BPCH-6, V L pop corn-1 and Jawahar pop corn-11), 4 fertility levels (90 + 30, 110 + 40, 130 + 50 and 150 + 60 kg N + P₂O₅/ha) were tested in factorial randomized block design and replicated thrice. The crop was sown with onset of rain on 6th July 2016. In well prepared field, furrows were opened at 60 cm apart and seeds were placed manually at a depth of 3-4 cm. As per treatment nitrogen and phosphorus were applied through urea and DAP. One third of nitrogen and full dose of phosphorus were given as basal application at the time of sowing by drilling fertilizer in crop rows about 4-5 cm below the seeds. The remaining nitrogen was given in two equal splits viz., knee high stage and at 50 per cent tasseling stage as top dressing. In order to minimize weed competition, pre-emergence application of atrazine at 0.5 kg/ha followed by one hoeing and earthing up were carried out at 20 and 30 days after sowing, respectively. The growth efficiency parameters viz., crop growth rate and relative growth rate were computed empirically by the use of standard formulae. Different growth and yield attributes were computed on basis of average of five samples. The crop was harvested at physiological maturity which was determined by formation of black/brown layer in placental region of maize grain. Before harvesting the plants under each experimental unit, border row were harvested and removed from experimental field. Cobs from net plots were picked up and kept in gunny bags. After thorough drying these were shelled. After picking cobs, stover from net plot was harvested and sun dried for few days and weighed for individual plot and final stover yield was expressed in q/ha. The standard methods of analysis were adopted for estimation of protein, nutrient in grain and

Table-1 : Performance of pop corn varieties under varying fertility levels on growth and yield attributes of maize.

Treatments	Plant harvest (000/ha)	Height at harvest (cm)	Days to 50% silking	DM at 90 DAS (g)	LAI at 60 DAS	CGR 30-60 DAS	RGR 30-60 DAS	Grain weight/ plant	Grain/ cob	Cob length (cm)	Test weight (g)	Shelling (%)
Varieties												
V L Amber Pop corn	81.25	185.1	50.3	99.8	1.97	4.91	0.034	21.91	462.4	17.75	110.9	71.94
BPOCH-6	81.44	200.1	50.7	106.5	2.41	5.40	0.035	24.58	489.3	19.80	119.0	75.39
V L Pop corn-1	81.28	201.5	50.3	106.8	2.28	5.45	0.035	22.32	487.7	18.69	110.5	67.60
Jawahar Pop corn-11	81.46	201.3	50.3	107.1	2.30	5.42	0.034	22.06	481.7	18.50	105.9	71.84
SEm±	0.381	3.7	0.5	2.27	0.05	0.16	0.001	0.67	8.8	0.29	2.0	1.64
CD (P = 0.05)	NS	10.6	NS	6.56	0.15	0.46	NS	1.93	25.3	0.84	5.7	4.74
Fertility levels (kg ha⁻¹)												
90 kg N + 30 kg P ₂ O ₅	81.34	176.6	50.6	96.5	2.07	4.77	0.035	19.89	446.8	17.29	102.0	65.29
110 kg N + 40 kg P ₂ O ₅	81.35	197.6	50.7	105.4	2.27	5.31	0.035	22.73	485.0	18.37	110.3	70.03
130 kg N + 50 kg P ₂ O ₅	81.40	206.7	50.8	108.3	2.30	5.52	0.034	23.89	493.8	19.54	116.1	74.98
150 kg N + 60 kg P ₂ O ₅	81.33	207.2	49.5	110.0	2.33	5.59	0.034	24.36	495.6	19.54	117.8	76.48
SEm±	0.381	3.7	0.5	2.27	0.05	0.16	0.001	0.67	8.8	0.29	2.0	1.64
CD (P = 0.05)	NS	10.6	NS	6.56	0.15	0.46	NS	1.93	25.3	0.84	5.7	4.74

DM: Dry matter, LAI: Leaf area index, CGR: Crop growth rate, RGR: relative growth rate

Table-2 : Performance of pop corn varieties under varying fertility levels on yield, quality, nutrient status of soil and economics.

Treatments	Yield (q/ha)			Nutrient uptake by plant (kg/ha)			Protein content in grain (%)		Popping (%)			Nutrient status of soil (kg/ha)			Net returns (₹/ha)		B : C ratio
	Grain	Stover		N	P	K						N	P	K			
Varieties																	
V L Amber Pop corn	15.80	23.88		41.35	9.32	33.37	10.30		81.22			277.8	18.18	295.8	135274	5.13	
BPOCH-6	17.97	27.47		51.28	11.36	38.29	11.14		88.50			272.2	17.01	296.2	157495	5.97	
V L Pop corn-1	16.03	24.23		44.09	9.26	33.84	10.85		80.46			275.5	17.98	296.9	137660	5.22	
Jawahar Pop corn-11	16.10	24.34		43.42	9.34	34.02	10.58		79.47			275.9	17.91	296.2	138342	5.24	
SEm ±	0.45	0.68		1.31	0.32	1.01	0.05		1.47			1.45	0.21	1.7	4621	0.18	
CD (P = 0.05)	1.31	1.97		3.77	0.92	2.92	0.14		4.25			4.19	0.60	5.0	13346	0.51	
Fertility levels (kg ha⁻¹)																	
90 kg N + 30 kg P ₂ O ₅	13.75	19.83		35.33	7.52	27.98	10.32		77.47			269.2	17.18	296.7	115165	4.55	
110 kg N + 40 kg P ₂ O ₅	16.08	24.18		43.33	9.40	33.81	10.58		81.77			274.0	17.83	296.5	138418	5.30	
130 kg N + 50 kg P ₂ O ₅	17.76	27.44		49.86	10.93	38.17	10.97		84.71			278.5	17.95	296.4	155058	5.85	
150 kg N + 60 kg P ₂ O ₅	18.32	28.47		51.63	11.42	39.56	10.99		85.70			279.7	18.12	295.5	160129	5.86	
SEm±	0.45	0.68		1.31	0.32	1.01	0.05		1.47			1.45	0.21	1.7	4621	0.18	
CD (P = 0.05)	1.31	1.97		3.77	0.92	2.92	0.14		4.25			4.19	0.60	5.0	13346	0.51	

stover and for grain popping per cent. Data obtained were statistically analyzed in factorial randomized block design using the standard techniques of analysis of variance. To workout the most profitable treatment, economics of different treatments was calculated on the basis of prevailing market prices in terms of net return (₹/ha) and B:C ratio.

Results and Discussion

Performance of varieties : The varieties did not show variation in plant stand/ha at harvest. At harvest “BPCH-6”, “V L pop corn-1” and “Jawahar pop corn-11” was statistically at par and recorded significantly higher plant height and dry matter/plant over “V L Amber pop corn”. Days to 50 per cent silking were statistically equal in all pop corn varieties. Leaf area index of “BPCH-6” was statistically at par with “Jawahar pop corn-11” and “V L pop corn-1” however, proved significantly higher over “V L Amber pop corn”. The growth efficiency viz. CGR between 30-60 DAS was significantly higher in BPCH-6 over rest of varieties however, RGR between this duration failed to record significant variation amongst pop corn varieties. The various yield components namely grain weight plant⁻¹, grains cob⁻¹, length of cob, girth of cob, test weight and shelling percentage were significantly higher in variety “BPCH-6” compared to rest of the varieties. The productivity in terms of grain (17.97 q/ha), stover yield (27.47 q/ha) and biological yield (45.44 q/ha) realized with variety “BPCH-6” were significantly higher over rest of the varieties. Harvest index did not vary significantly amongst pop corn varieties. The total N, P and K uptake of pop corn grain and stover were significantly higher in variety “BPCH-6” over rest of the varieties. The quality parameters viz. protein content and popping percentage of grain were significantly higher in “BPCH-6” over rest of the varieties. The soils under cultivation of “BPCH-6” retained significantly lower N and P compared to rest of the varieties. The N and P status of soil under rest of three varieties were statistically at par. The pop corn varieties failed to record perceptible variations in available K content of soil after harvest of crop. The highest net returns (₹157495/ha) and B:C ratio (5.97) were realized with growing of variety “BPCH-6” which was significantly higher over rest of the varieties. The marked variation in growth, yield and quality parameters of pop corn varieties could be ascribed to their genetic capabilities to exploit available resources for their growth and development (Snehlata *et al.*, 2016 and Meena *et al.*, 2017).

Fertility levels : Fertility levels did not influence plant population recorded at harvest. The plant height and dry matter at harvest increased significantly by applying 130 kg N + 50 kg P₂O₅ ha⁻¹ over 110 kg N + 40 kg P₂O₅ ha⁻¹ and 90 kg N + 30 kg P₂O₅ ha⁻¹. Days to 50 per cent silking were not significantly influenced by fertility levels. An

application of 110 kg N + 40 kg P₂O₅ ha⁻¹ gave significantly greater leaf area index over 90 kg N + 30 kg P₂O₅ ha⁻¹. Further, increase in fertility levels did not produce any significant variation. Application 110 kg N + 30 kg P₂O₅ ha⁻¹ significantly increased CGR over 90 kg N + 30 kg P₂O₅ ha⁻¹ between 30-60 DAS. Further increase in fertility level failed to record statistical significance. However, RGR did not differ significantly under increasing fertility levels. Application of 130 kg N + 50 kg P₂O₅ ha⁻¹ significantly improved yield component over 90 kg N + 30 kg P₂O₅ ha⁻¹ consequently increased grain and fodder yield over 110 kg N + 40 kg P₂O₅ ha⁻¹ and 90 kg N + 30 kg P₂O₅ ha⁻¹. The cob plant⁻¹ and cob girth did not differ significantly amongst different fertility levels. Advancing nutrient application up to 130 kg N + 50 kg P₂O₅ ha⁻¹ significantly increased total N, P and K uptake grain and fodder over 90 kg N + 30 kg P₂O₅ ha⁻¹. An application of 130 kg N + 50 kg P₂O₅ ha⁻¹ significantly increased protein content and popping percentage of grain over 110 kg N + 40 kg P₂O₅ ha⁻¹ and 90 kg N + 30 kg P₂O₅ ha⁻¹. After harvest of crop, N and P retained in soil under application of 130 kg N + 50 kg P₂O₅ ha⁻¹ were significantly higher over 110 kg N + 40 kg P₂O₅ ha⁻¹ and 90 kg N + 30 kg P₂O₅ ha⁻¹. Further increase in fertility level though improved N and P status but failed to record statistical significance. K status did not differ significantly under different fertility levels. An application of 130 kg N + 50 kg P₂O₅ ha⁻¹ proved economically beneficial as it recorded significantly higher net returns and B:C ratio over 110 kg N + 50 kg P₂O₅ ha⁻¹ and 90 kg N + 30 kg P₂O₅ ha⁻¹. Further increase in fertility level marginally improved net returns and reduced B:C ratio, however, proved statistically at par with preceding level.

The significant improvement in nutrient status of plant parts resulted in better availability of nutrients for growth and development of the plant right from early stage which seems to have promoted height of plants and growth of individual leaf by way of active cell division, and their elongation. The larger canopy development could be reasoned for increased interception, absorption and utilization of radiant energy which in turn increased overall growth and yield. The results are in close conformity with findings of Kumar (2009), Nath *et al.* (2009), Meena *et al.* (2017), Choudhary *et al.* (2021) and Choudhary *et al.* (2022).

Based upon results it is concluded that for profitable pop corn production, variety “BPCH-6” should be grown by fertilizing 130 kg N + 50 kg P₂O₅ ha⁻¹.

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Enhance Growth, Productivity and Profitability of Single Cross Maize Hybrid (*Zea mays* L.) under Divers Hydrogel and Fertility Levels in Rainfed Condition of North-Western Himalayan Region

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Abstract

The present experiment has been conducted in *kharif* 2019 and 2020 at Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur with four level of hydrogel application (H₁: Control; H₂: 2.5 kg/ha; H₃: 5.0 kg/ha; H₄: 7.5 kg/ha) and four levels of fertility (F₁: 75 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹; F₂: 90 kg N + 45 kg P₂O₅ + 35 kg K₂O ha⁻¹; F₃: 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹; F₄: 120 kg N + 55 kg P₂O₅ + 45 kg K₂O ha⁻¹) using factorial randomized block design. Study revealed that soil application of hydrogel @ 7.5 kg/ha recorded significantly higher growth as well as grain and stover yield which remained at par on soil application of hydrogel @ 5.0 kg/ha over control. In case of economics value, significantly higher net return as well as B:C ratio recorded under application of hydrogel @ 5.0 kg/ha. In different fertility levels, application of 120 kg N + 55 kg P₂O₅ + 45 kg K₂O ha⁻¹ (F₄) recorded significantly higher growth, grain and stover yield which remained at par on soil application of 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ (F₃) over control. In case of economics value, significantly higher net return as well as B:C ratio recorded under application of (F₃). Our result suggested that application of hydrogel @ 5.0 kg/ha with 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ enhance growth, yield of maize hybrid and provide handsome financial value.

Key words : Hydrogel, maize hybrid, fertility levels, productivity.

Introduction

Maize (*Zea mays* L.) is an amazing crop and perhaps nature's one of the most important gifts to mankind. The crop is widely cultivated around the world, and a greater quantity of maize is produced each year than any other grain. Moreover, the huge potential for export has added the demand for maize all over the world. The demand for maize as an animal feed will continue to grow faster than the demand for its use as human food, particularly in Asia (Jakhar *et al.*, 2019). In India, it is an important crop not only in terms of acreage but also in context to their versatility for adoption under wide range of agro-climatic conditions. Currently, maize is cultivated over 9.72 million ha area with 28.64 million ton production and an average yield of 29.45 q ha⁻¹ (Govt. of India, 2020). In recent years, maize production has shown a remarkable increase which is mainly associated with significant genetic enhancement from the area of open pollinated varieties, composite breeding to double and three way hybrids and recent development in single cross hybrids which is first choice of farmers now a day.

The single cross hybrids replaced older varieties to the extent of 40 to 60 per cent (Singh *et al.*, 2017). These single cross hybrids are nutrient exhaustive and require very high dose of nutrients for survival (Singh, 2010 and Om *et al.*, 2014). The use of soil conditioners like super absorbent polymer (Hydrogel) has a great potential to

explore the existing water in soil for agricultural crops by increasing their production. When polymers are incorporated into the soil it is presumed that they retain large quantity of water which are released as required by plants under water stress and thus save and sustain their growth under partial stress condition. Amongst nutrients, nitrogen is one of the most important for plant growth and development. Next to nitrogen, phosphorus is of paramount importance for energy transfer in living cells by means of high energy phosphate bonds of ATP (Reddy and Reddy, 2002). Thus, it plays pivotal role in formation, translocation of carbohydrates, fatty acids, glyceroids and other essential intermediate compounds. The common recommendation of nitrogen, phosphorus and potash fertilization for rainfed hybrid and composite maize in Southern Rajasthan is 90 kg N, 30 kg P₂O₅ and 30 kg K₂O ha⁻¹. This recommendation, developed by researchers is based on crop responses over large areas and provide recommendation that lack variety/species specificity. As these recommendations are prescribed for large area, they do not take into account the spatial and temporal variability in soil supplying capacity. This often results in over- or under fertilization leading to yield and economic losses. The existing fertilizer recommendation of N, P and K for maize assumes that the need of nutrients is same for composite and single cross hybrid. But the needs of supplemental nutrients can vary greatly among composite and single cross hybrid varieties of maize due to genetic

variability, differences in crop growing conditions, soil management and climate (Suthar *et al.*, 2014). The national recommendation of nitrogen, phosphorus and potassium for single cross maize hybrid is 120 kg N, 60 kg P₂O₅ ha⁻¹ and 40 kg K₂O ha⁻¹ (Das *et al.*, 2010). Thus, there is a need to revise this ad-hoc recommendation of nitrogen, phosphorus and potassium for single cross maize hybrid under rainfed agro-climatic conditions of "Sub Humid Southern Plain and Aravalli Hills of Rajasthan". Considering these facts and paucity of research findings on these aspects in Southern Rajasthan, the study entitled "Performance of Single Cross Maize Hybrid (*Zea mays* L.) under Varying Hydrogel and Fertility Levels in Rainfed Condition of Southern Rajasthan" was conducted.

Materials and Methods

Site description : The field experiment was conducted during two consecutive years *i.e.* kharif 2019 and 2020 at Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. The soil of experimental field had pH, ds/m electrical conductivity and % organic carbon. Available N, P and K were kg/ha, respectively. The weather conditions during 2019 of study were friendly to hybrid maize growth (Fig.-1).

Treatments details and crop management : The experiment performed in factorial randomized block design with three replication and consisted of sixteen treatment combinations comprising of two factors *viz.* soil application of hydrogel and fertility levels. In soil application of hydrogel (H₁: Control; H₂: 2.5 kg/ha; H₃: 5.0 kg/ha; H₄: 7.5 kg/ha) and fertility levels (F₁: 75 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹; F₂: 90 kg N + 45 kg P₂O₅ + 35 kg K₂O ha⁻¹; F₃: 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹; F₄: 120 kg N + 55 kg P₂O₅ + 45 kg K₂O ha⁻¹) were taken for study. As per treatment, calculated quantity of nitrogen, phosphorus and potassium were applied through urea, DAP and MOP. One third of nitrogen and full dose of phosphorus and potassium were given as basal applications at time of sowing by drilling urea, DAP and MOP fertilizer in crop rows about 4-5 cm below the seeds. The rest two third nitrogen was applied in two equal splits *viz.*, knee high stage and at 50 per cent tasseling as top dressing. As per treatments calculated quantity of hydrogel was first mixed in sand and thereafter applied at time of sowing by drilling it in crop rows about 4-5 cm below the seeds. The crop was sown using 20 kg seed ha⁻¹. In well prepared field, furrows were opened at 60 cm apart and seeds were placed manually at 25 cm at a depth of 3-4 cm. Before sowing, seeds were treated with recommended fungicide to protect from diseases. To see the impact of hydrogel no irrigation was given during crop growth period and the crop was raised as rainfed crop.

Sample collection and analysis : During both the years, five randomly plants selected and all the growth parameters were recorded from the selected plants at 30, 60 DAS and at harvest. Total chlorophyll content of leaves at 50 per cent tasseling, was analysed by collecting fresh leaf samples from the crop and followed standard procedure. The total chlorophyll content was computed by following formula :

Total chlorophyll content (mg g⁻¹)

$$= \frac{20.2(A_{645}) + 8.02(A_{663})}{a} \times \frac{V}{1000 W}$$

Where,

a = Length of light path in cell (1 cm)

V = Volume of extract

W = Weight of leaf sample

The growth efficiency parameters *viz.*, crop growth rate and relative growth rate at successive duration *viz.* 30 to 60 DAS and 60 DAS to at harvest were computed by the use of following formulae suggested by Redford (1967).

$$\text{CGR (g m}^{-2} \text{ day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W₁ and W₂ are plant dry weight (g) at time t₁ and t₂, respectively.

$$\text{RGR (g g}^{-1} \text{ day}^{-1}) = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

W₁, W₂ are dry matter at time t₁ and t₂, respectively.

Number of cobs, cob length, grains/cob and yield attributes of five randomly selected plants was counted at harvesting and the mean value per plant under each plot was worked out. From each experimental plot, five plants were randomly selected and removed periodically at 30 and 60 DAS and at harvest of crop. After chopping, plants samples were placed separately in perforated paper bags and oven dried at 65°C till a constant weight was obtained. Later, these were weighed and dry matter was then expressed as g plant⁻¹.

Statistical data analysis : All the data were subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Cochran and Cox (1967). Wherever, the F value was found significant at 5 per cent level of significance, the critical difference (CD) values were computed for comparing treatment means.

Results

Growth parameters

Hydrogel level : Different levels of hydrogel application significantly affected plant height and dry matter accumulation at different growth stage (Fig. 2 and 3). Application of hydrogel up to 7.5 kg ha⁻¹ recorded highest plant height and dry matter accumulation at 30, 60 DAS and harvest but it was remained at par with application of hydrogel up to 5 kg ha⁻¹ over control in both the years. Soil application of hydrogel improve vigour of seedling and enabled plant to withstand moisture stress stresses at early stages of development by up-regulation of carbohydrates metabolism (Chandra *et al.*, 2015). Further increases in WHC and AWC through use of hydrogel enhance seedling growth by many folds through slow releases of plant nutrients (Choudhary *et al.*, 2019). It has been reported that treatment of soil application of hydrogel induced vigour of plant, improve growth due to many folds by increase of metabolic activities, enzymes α -amylase and protease activity through better availability of moisture and nutrients (Meena, 2020).

Fertility levels : Different levels of fertility significantly affected plant height and dry matter accumulation at different growth stage (Fig.-2 and 3). Application of fertilizers @ 120 kg N + 55 kg P₂O₅ + 45 kg K₂O ha⁻¹ recorded highest plant height and dry matter accumulation at 30, 60 DAS and harvest but it was remained at par with application of fertilizers @ 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ over 75 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹ in both the years. Maize is a highly nutrient exhaustive and highly fertilizer responsive crop needs special attention for its requirements for fertilizers especially for nitrogen, phosphorus and potassium (Bharti *et al.*, 2019, Choudhary *et al.*, 2021 and Choudhary *et al.*, 2022). It is well established fact that amongst plant mineral nutrients, nitrogen, phosphorus and potassium are considered to be most important for exploiting genetic behaviour of crop through growth and development (Halvin *et al.*, 2005). Phosphorus is involved in root proliferation and growth. It stimulates early root development and growth and there by helps to establish seedlings quickly.

Physiological parameters

Hydrogel level : Different levels of hydrogel application significantly affected LAI and chlorophyll content at different growth stage (Table-1). Application of hydrogel up to 7.5 kg ha⁻¹ recorded highest LAI at 30 and 60 DAS but it was remained at par with application of hydrogel up to 5 kg ha⁻¹ over control in both the years. Same trend were followed in chlorophyll content at 50 % tasseling stage. CGR at 30-60 DAS significantly affected by different levels of hydrogel application but did not affected significantly at 60 DAS to at harvest (Table-2). Application

of hydrogel up to 7.5 kg ha⁻¹ recorded highest CGR at 30-60 DAS but it was remained at par with application of hydrogel up to 5 kg ha⁻¹ over control in both the years. RGR at 30-60 DAS and 60 DAS to at harvest significantly affected by different levels of hydrogel application (Table-3). Application of hydrogel up to 7.5 kg ha⁻¹ recorded highest RGR at 30-60 DAS and 60 DAS to at harvest but it was remained at par with application of hydrogel up to 5 kg ha⁻¹ over control in both the years. Hydrogel might have up-regulated the α -amylase and protease activity in maize plant which in turn increase N, P and K content in leaves, grain and stover and protein contents in grain consequently induces the higher plant growth in maize reflected through higher values of plant height, dry matter accumulation, LAI, chlorophyll content, CGR and RGR. The results are in close accordance with findings of Yu *et al.* (2021) and Kumar *et al.* (2021).

Fertility levels : Different levels of fertility significantly affected LAI and chlorophyll content at different growth stage (Table-1). Application of fertilizers @ 120 kg N + 55 kg P₂O₅ + 45 kg K₂O ha⁻¹ recorded highest LAI at 30 and 60 DAS but it was remained at par with application of fertilizers @ 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ over 75 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹ in both the years. Same trend were followed in chlorophyll content at 50 % tasseling stage. CGR at 30-60 DAS significantly affected by different levels of fertility but did not affected significantly at 60 DAS to at harvest (Table-2). Application of fertilizers @ 120 kg N + 55 kg P₂O₅ + 45 kg K₂O ha⁻¹ recorded highest CGR at 30-60 DAS but it was remained at par with application of fertilizers @ 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ over 75 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹ in both the years. RGR at 30-60 DAS and 60 DAS to at harvest significantly affected by different levels of fertility (Table-3). Application of fertilizers @ 120 kg N + 55 kg P₂O₅ + 45 kg K₂O ha⁻¹ recorded highest RGR at 30-60 DAS and 60 DAS to at harvest but it was remained at par with application of fertilizers @ 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ over 75 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹ in both the years. These nutrients triggered the vigorous growth of plants, thereby achieving more plant height, LAI, chlorophyll content, CGR, consequently boosted dry matter production under increasing fertility levels. Similar response of growth parameters to increasing fertility levels was reported by Bhatt (2012), Meena *et al.* (2017), Bharti *et al.* (2019), Choudhary *et al.*, 2021 and Choudhary *et al.*, 2022.

Yield attributes and yield

Hydrogel level : Different levels of hydrogel application significantly affected cob length, girth of cob, grains/cob, grain weight and height of cob except cobs/plant (Table 4 and 5). Application of hydrogel up to 7.5 kg ha⁻¹ recorded highest cob length, girth of cob, grains/cob, grain weight

Table-1 : Effect of hydrogel levels and fertility levels on LAI and chlorophyll content of single cross hybrid maize.

Treatments	LAI						Chlorophyll content (mg g ⁻¹)		
	30 DAS			60 DAS			At 50 (%) tasseling stage		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Hydrogel levels (kg ha⁻¹)									
H ₁	1.367	1.421	1.394	2.79	2.83	2.81	2.11	2.14	2.13
H ₂	1.708	1.834	1.771	3.04	3.07	3.05	2.13	2.16	2.14
H ₃	1.990	2.130	2.060	3.10	3.21	3.16	2.26	2.33	2.30
H ₄	2.024	2.146	2.085	3.15	3.23	3.19	2.27	2.37	2.32
SEm±	0.025	0.033	0.013	0.05	0.03	0.02	0.02	0.02	0.01
C.D. (P = 0.05%)	0.072	0.096	0.036	0.14	0.10	0.07	0.05	0.07	0.03
Fertility levels (kg ha⁻¹)									
F ₁	1.253	1.372	1.312	2.78	2.83	2.80	2.10	2.15	2.13
F ₂	1.811	1.939	1.875	3.02	3.07	3.05	2.20	2.26	2.23
F ₃	2.003	2.104	2.054	3.13	3.21	3.17	2.23	2.30	2.26
F ₄	2.021	2.116	2.069	3.16	3.23	3.19	2.24	2.30	2.27
SEm±	0.025	0.033	0.013	0.05	0.03	0.02	0.02	0.02	0.01
C.D. (P = 0.05%)	0.072	0.096	0.036	0.14	0.10	0.07	0.05	0.07	0.03

Table-2 : Effect of hydrogel levels and fertility levels on CGR of single cross hybrid maize.

Treatments	30 to 60 DAS			60 DAS to at harvest		
	2019	2020	Pooled	2019	2020	Pooled
Hydrogel levels (kg ha⁻¹)						
H ₁	8.46	8.49	8.48	21.48	21.71	21.59
H ₂	10.65	11.18	10.92	21.59	21.28	21.44
H ₃	12.01	12.56	12.28	21.88	21.1	21.65
H ₄	12.37	12.98	12.68	21.89	21.69	21.79
SEm±	0.34	0.36	0.17	0.79	0.71	0.4
C.D. (P = 0.05%)	0.98	1.03	0.49	NS	NS	NS
Fertility levels (kg ha⁻¹)						
F ₁	8.86	8.95	8.91	21.46	21.44	21.44
F ₂	10.75	11.16	10.95	21.23	20.94	21.08
F ₃	11.91	12.34	12.13	22.04	22.08	22.05
F ₄	11.98	12.75	12.37	22.12	21.64	21.87
SEm±	0.34	0.36	0.17	0.79	0.72	0.4
C.D. (P = 0.05%)	0.98	1.03	0.49	NS	NS	NS

Table-3 : Effect of hydrogel levels and fertility levels on RGR of single cross hybrid maize.

Treatments	30-60 DAS			60 DAS to at harvest		
	2019	2020	Pooled	2019	2020	Pooled
Hydrogel levels (kg ha⁻¹)						
H ₁	0.049	0.0462	0.0476	0.0365	0.0361	0.0363
H ₂	0.053	0.0525	0.0528	0.0321	0.0309	0.0315
H ₃	0.0546	0.0543	0.0544	0.0305	0.0291	0.0298
H ₄	0.0547	0.0551	0.0549	0.0297	0.0287	0.0292
SEm±	0.0012	0.0011	0.0006	0.0012	0.001	0.0006
C.D. (P = 0.05%)	0.0035	0.0032	0.0017	0.0035	0.0029	0.0017
Fertility levels (kg ha⁻¹)						
F ₁	0.0506	0.0477	0.0492	0.0356	0.0349	0.0352
F ₂	0.0529	0.0516	0.0522	0.032	0.0308	0.0314
F ₃	0.0542	0.0541	0.0541	0.0307	0.0301	0.0304
F ₄	0.0536	0.0546	0.0541	0.0304	0.029	0.0297
SEm±	0.0012	0.0011	0.0006	0.0012	0.001	0.0006
C.D. (P = 0.05%)	0.0035	0.0032	0.0017	0.0035	0.0029	0.0017

Table-4 : Effect of hydrogel levels and fertility levels on number of cobs plant⁻¹, cob length and girth of cob of single cross hybrid maize.

Treatments	Cobs plant ⁻¹			Cob length (cm)			Girth of cob (cm)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Hydrogel levels (kg ha⁻¹)									
H ₁	1.23	1.35	1.28	15.06	16.55	15.81	13.45	14.04	13.74
H ₂	1.27	1.37	1.32	16.81	18.59	17.70	15.25	15.83	15.54
H ₃	1.30	1.39	1.39	18.33	20.16	19.24	15.51	15.96	15.74
H ₄	1.32	1.40	1.37	18.82	20.47	19.65	15.87	16.26	16.07
SEm±	0.04	0.05	0.02	0.40	0.37	0.20	0.27	0.23	0.14
C.D. (P = 0.05%)	NS	NS	NS	1.17	1.08	0.58	0.78	0.67	0.39
Fertility levels (kg ha⁻¹)									
F ₁	1.21	1.32	1.28	15.02	16.60	15.81	13.41	13.88	13.65
F ₂	1.27	1.38	1.32	16.89	19.30	18.09	15.06	15.56	15.31
F ₃	1.29	1.39	1.34	18.32	19.86	19.09	15.65	16.11	15.88
F ₄	1.35	1.43	1.38	18.81	20.01	19.41	15.96	16.53	16.25
SEm±	0.04	0.04	0.02	0.40	0.37	0.20	0.27	0.23	0.14
C.D. (P = 0.05%)	NS	NS	NS	1.17	1.08	0.58	0.78	0.67	0.39

Table-5 : Effect of hydrogel levels and fertility levels on grains cob⁻¹, grain weight cob⁻¹ and cob height of single cross hybrid maize.

Treatments	Grains cob ⁻¹			Grain weight cob ⁻¹			Cob height (cm)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Hydrogel levels (kg ha⁻¹)									
H ₁	237.8	247.6	242.7	98.1	101.4	99.8	87.31	89.33	88.32
H ₂	292.7	305.1	298.9	124.1	127.6	125.9	92.41	95.67	94.04
H ₃	329.4	340.4	334.9	136.0	138.5	137.3	95.01	98.69	96.85
H ₄	333.4	345.5	339.4	137.5	140.7	139.1	95.52	99.32	97.42
SEm±	4.37	3.41	2.21	1.69	1.61	0.86	1.62	1.83	0.82
C.D. (P = 0.05%)	12.63	9.84	6.25	4.89	4.65	2.43	4.67	5.29	2.33
Fertility levels (kg ha⁻¹)									
F ₁	239.8	247.5	243.6	102.1	105.9	104.0	88.66	91.23	89.94
F ₂	294.3	302.7	298.5	120.3	123.8	122.1	91.83	95.46	93.64
F ₃	328.2	342.0	335.1	135.7	138.8	137.3	93.60	97.69	95.64
F ₄	331.0	346.4	338.7	137.5	139.8	138.7	96.16	98.63	97.40
SEm±	4.37	3.41	2.21	1.69	1.61	0.86	1.62	1.83	0.82
C.D. (P = 0.05%)	12.63	9.84	6.25	4.89	4.65	2.43	4.67	5.29	2.33

Table-6 : Effect of hydrogel levels and fertility levels on grain and stover yield.

Treatments	Yield (kg ha ⁻¹)					
	Grain			Stover		
	2019	2020	Pooled	2019	2020	Pooled
Hydrogel levels (kg ha⁻¹)						
H ₁	3635	3939	3787	5959	6475	6217
H ₂	3911	4316	4114	6474	6898	6686
H ₃	4210	4688	4449	6986	7727	7357
H ₄	4302	4769	4535	7042	8023	7533
SEm±	75.66	101.48	38.95	127.01	108.63	64.28
C.D. (P = 0.05%)	218.53	293.11	110.18	366.84	313.76	181.83
Fertility levels (kg ha⁻¹)						
F ₁	3723	3907	3815	6044	6671	6358
F ₂	3958	4345	4152	6523	7249	6886
F ₃	4179	4711	4445	6967	7581	7274
F ₄	4197	4749	4473	6926	7622	7274
SEm±	75.66	101.48	38.95	127.01	108.63	64.28
C.D. (P = 0.05%)	218.53	293.11	110.18	366.84	313.76	181.83

Table-7 : Effect of hydrogel levels and fertility levels on net return and B : C ratio.

Treatments	Net Return (Rs ha ⁻¹)			B : C ratio		
	2019	2020	Pooled	2019	2020	Pooled
Hydrogel levels (kg ha⁻¹)						
H ₁	52987	59599	56293	2.08	2.39	2.23
H ₂	57850	66006	61928	2.19	2.46	2.32
H ₃	63112	73326	68219	2.29	2.61	2.45
H ₄	63612	74244	68928	2.18	2.53	2.36
SEm±	1471	1758	752	0.03	0.05	0.02
C.D. (P = 0.05%)	4249	5078	2129	0.09	0.14	0.05
Fertility levels (kg ha⁻¹)						
F ₁	53705	58158	55932	1.95	2.31	2.13
F ₂	58421	67017	62719	2.19	2.46	2.33
F ₃	62951	73928	68439	2.29	2.65	2.47
F ₄	62483	74072	68278	2.29	2.57	2.43
SEm±	1471	1758	752	0.03	0.05	0.02
C.D. (P = 0.05%)	4249	5078	2129	0.09	0.14	0.05

and height of cob but it was remained at par with application of hydrogel up to 5 kg ha⁻¹ over control in both the years. Same trend were followed in test weight (1000 grain weight).

Grain and stover yield also significantly affected by different levels of hydrogel application (Table-6). Application of hydrogel up to 7.5 kg ha⁻¹ recorded highest grain and stover yield but it was remained at par with application of hydrogel up to 5 kg ha⁻¹ over control in both the years. The soil application of hydrogel burst availability of moisture throughout growth period and subtle to attune its dynamic biological need at various growth phases of plant and thus plant exhibits antagonistic behaviour. Thus with soil application of hydrogel performed better physio-biochemical activities of maize plant from early growth phase to reproductive and grain filling stages which is clearly evinced with higher N, P and K content in grain and stover of maize. Their higher content and physio-biochemical activities enhanced chlorophyll content which denote for higher photosynthesis in hydrogel treated plots and signify the sustained supply of photo-assimilates from source to sink organ thus significantly contributes to higher source-activity and succeeding higher sink-strength (Yu *et al.*, 2015). Overall, it is assume that application of hydrogel enhanced cellular homeostasis and positively contribute source-activity and contributes to sink-strength viz., yield attributes and yield (Lemoine *et al.*, 2013).

Fertility levels : Different levels of fertility significantly affected cob length, girth of cob, grains/cob, grain weight and height of cob except cobs/plant (Table 4 and 5). Application of fertilizers @ 120 kg N + 55 kg P₂O₅ + 45 kg K₂O ha⁻¹ recorded highest cob length, girth of cob, grains/cob, grain weight and height of cob but it was remained at par with application of fertilizers @ 105 kg N +

50 kg P₂O₅ + 40 kg K₂O ha⁻¹ over 75 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹ in both the years. Same trend were followed in test weight (1000 grain weight). Grain and stover yield also significantly affected by different levels of fertility (Table-6). Application of fertilizers @ 120 kg N + 55 kg P₂O₅ + 45 kg K₂O ha⁻¹ recorded highest grain and stover yield over control in both the years. The better availability of inputs as evinced from N, P, and K content of leaves demonstrate reduce competition of these between developing structure consequently improving functional activities of each vegetative structure and caused vigorous growth of individual plant as reflected through increased dry matter production and yield attributes. Thus the significant increase in grain yield and stover yield with application of 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ seems to be due to direct effect in improving biomass plant⁻¹ at successive growth stages. Result was confined with the study of Dhaka, (2014), Rodinpuia *et al.* (2019), Van *et al.* (2020), Choudhary *et al.*, 2021 and Choudhary *et al.*, 2022.

Economics of experiment

Hydrogel level : Across the years as well as on pooled basis, the highest net return was recorded under soil application of 7.5 kg hydrogel ha⁻¹ which was statistically at par with 5.0 kg hydrogel ha⁻¹, however, proved significantly higher over rest of the levels (Table-7) but highest B:C ratio recorded under soil application of 5.0 kg hydrogel ha⁻¹.

Fertility levels : Irrespective of years as well as on pooled basis, application of 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ significantly increases net return and B:C ratio over 90 kg N + 45 kg P₂O₅ + 35 kg K₂O ha⁻¹ and 75 kg N + 40 kg P₂O₅ + 30 kg K₂O ha⁻¹.

Conclusions

From the present two year experimentation, it is

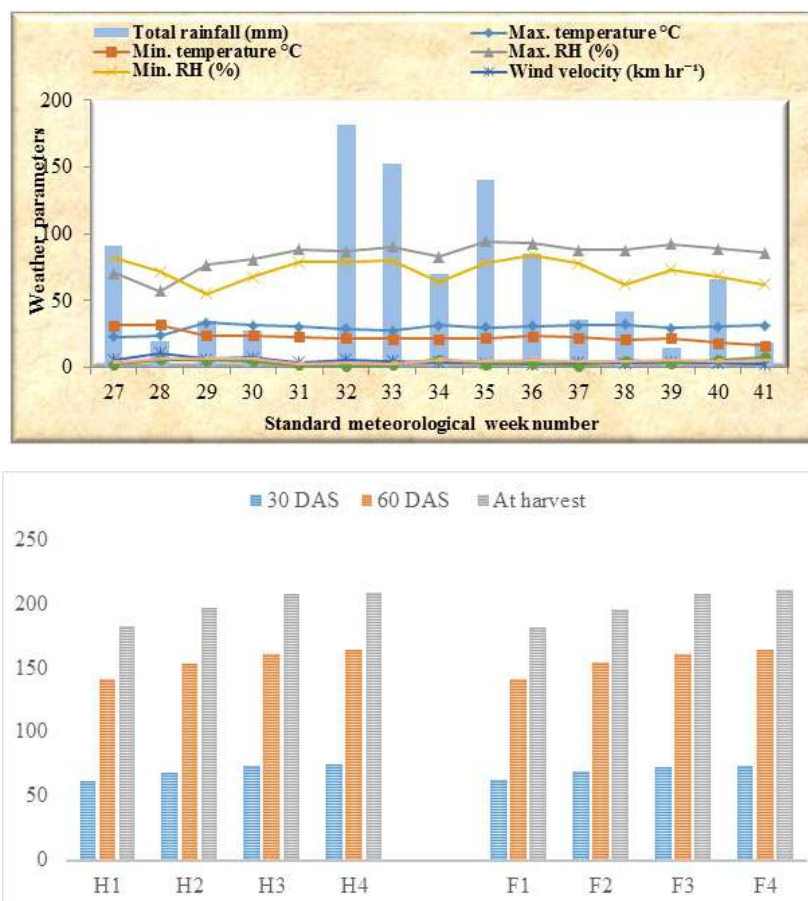


Fig.-2 : Effect of hydrogel levels and fertility levels on plant height at successive stages of single cross hybrid maize (pooled basis).

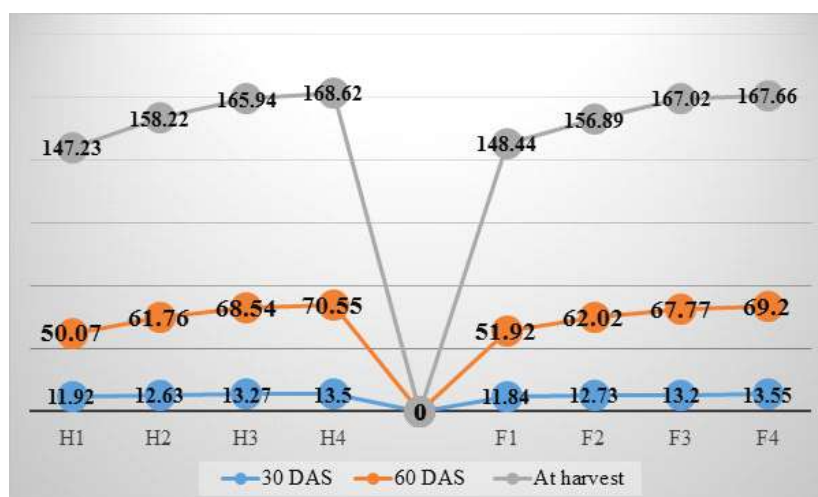


Fig.-3 : Effect of hydrogel levels and fertility levels on dry matter accumulation (g/plant) at successive stages of single cross hybrid maize (pooled basis).

concluded that application of hydrogel @ 5.0 kg/ha with 105 kg N + 50 kg P₂O₅ + 40 kg K₂O ha⁻¹ enhance growth, yield of maize hybrid and provide handsome financial value.

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Evaluation of Different Fungicides as Seed Dressers against Coriander Wilt Disease Caused By *Fusarium oxysporum* f.sp. *corianderii*

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Abstract

Among all the tested fungicides, complete inhibition of the fungal growth i.e. 100.00 per cent was recorded with Bavistin (carbendazim) at 200 ppm and 500 ppm the tested concentrations. The next best fungicides in order of fungal growth inhibition were Carbendazim + Mancozeb (companion), Topsin-M (thiophanate methyl), Vitavax (carboxin + thiram) and Benomyl (benlate) which inhibited the fungal growth by Carbendazim was found significantly superior at 200 and 500 ppm with (100%) inhibition of mycelial growth followed by Companion and Topsin-M at 500 ppm and with (100%). Seed treatment with Bavistin (carbendazim) resulted in lowest wilt incidence (10.39 per cent) Result showed that increase with seed yield 1011.15 kg/ha was recorded in Carbendazim followed by companion that showed wilt incidence of 12.22 per cent. Both these fungicides were found to be statistically at par with each other. Next effective seed dresser were Topsin-M and Vitavax that showed wilt incidence of 14.33 and 21.55 per cent, respectively. These fungicides were found to be at par with best fungicides. Seed treatment with Benomyl were found to be least effective which showed wilt incidence of 24.15 per cent and decrease with seed yield 617.90 kg/ha was recorded both the years.

Key Words : Wilt, coriander, *F. oxysporum*, fungicides

Introduction

Coriander occupied prime place amongst the seed spices grown in northern India particularly in Rajasthan. In India, it occupies 543.20 thousand hectares area with annual production 523.90 thousand tonnes. The average productivity of coriander seed is 964 kg/ha (Anonymous, 2013-14). Disease can also be a serious problem in coriander crop. The main diseases are noted *Fusarium oxysporum* causes coriander wilt (Narula and Joshi (1963), Srivastava 1972). The disease well as soil borne and the pathogen has been found to survive on root surface in the form of macroconidia and chlamydospores (Mathur and Mathur, 1970). Its seed transmission has also been demonstrated (Singh *et al.*, 1972). The mycelium of the pathogen has been observed in the embryo of cumin seed (Champawat, 1986).

Materials and Methods

In vitro evaluation of fungicides against *F. oxysporum* f. sp. *Corianderii* : To study the efficacy of five fungicides against cumin wilt pathogen (*F. Oxysporum* f. sp. *corianderii*) *in vitro* (Table 1). "Poisoned Food Technique" (Nene and Thapliyal, 1979) was employed. Systemic fungicides were tested at 100, 200 and 500 ppm, A 4 mm disc was cut aseptically from ten days old culture of the pathogen and was placed in center of each PDA poured Petri plate and these inoculated plates were incubated at 27 ± 1°C. After seven days of incubation, diameter of fungal growth was measured in

each case, by averaging two diameter of fungal colony at right angle to one another and the per cent inhibition was calculated by using the following formula (Bliss, 1934):

$$I = \frac{C - T}{C} \times 100$$

where,

I = Per cent growth inhibition

C = Colony diameter in control (mm)

T = Colony diameter in treatment (mm)

In vivo evaluation of fungicides as seed dresser against cumin wilt disease : With a view to know the efficacy of fungicides against under *in vivo* conditions, these fungicides were applied through seed treatment. The experiments were conducted during winter season of 2013-14 and 2014-15 at Agronomy farm, SKN College of Agriculture, Jobner in randomized block design (RBD) with four replication. Seeds of coriander variety RCr-435 were treated with different fungicides 2 g/kg seed in 100 ml Erlenmeyer flask and shaken thoroughly to give a uniform coating of respective chemicals and then air dried at room temperature. Chemical treated as well as untreated seeds were sown separately in plots containing *Fusarium* inoculated soil. The coriander seeds were sown in each plot. Each treatment was replicated four. The plots were irrigated on alternate day with uniform amount of water. Observations on disease incidence were recorded periodically up to 90 days after sowing.

Table-1 : *In vitro* efficacy of fungicides against *F. oxysporum* f.sp. *corianderii*.

Fungicides	Per cent inhibition of mycelial growth* Concentration (ppm)			Mean
	100	200	500	
Carbendazim	95.40 (77.62)	100.00 (90.00)	100.00 (90.00)	98.47
Carboxin + Thiram	80.42 (63.74)	84.91 (67.14)	100.00 (90.00)	88.44
Benomyl	72.10 (58.12)	74.29 (59.53)	85.50 (68.32)	77.29
Thiophanate methyl	84.12 (66.52)	91.90 (73.46)	100.00 (90.00)	92.00
Carbendazim + Mancozeb	86.00 (68.03)	96.30 (78.91)	100.00 (90.00)	94.10
Check	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
SEm+	0.87	0.86	0.97	
CD (p=0.05)	2.63	2.59	2.92	

*Average of four replications

Figures given in parenthesis are angular transformed values.

Table-2 : Effect of seed treatment with fungicides on wilt disease incidence and seed yield of coriander under field condition.

Fungicides	Dose (g/kg seed)	Per cent disease incidence*			Decrease in PDI over control (per cent)	Yield (kg/ha)*			Increase in yield over control (per cent)
		2013-14	2014-15	Mean		2013-14	2014-15	Mean	
Carbendazim	2.0	11.55 (19.87)	9.22 (17.68)	10.39 (18.80)	80.06	1002.30	1020.00	1011.15	187.61
Carboxin + Thiram	2.0	22.80 (28.52)	20.30 (26.78)	21.55 (27.66)	58.61	672.40	700.90	686.65	95.31
Benomyl	2.0	24.70 (29.80)	23.60 (29.06)	24.15 (29.43)	53.62	607.50	628.30	617.90	75.75
Thiophanate methyl	2.0	16.22 (23.75)	12.44 (20.65)	14.33 (22.24)	72.48	716.20	743.10	729.65	107.54
Carbendazim + Mancozeb	2.0	13.25 (21.35)	11.18 (19.53)	12.22 (20.46)	76.54	917.20	996.50	956.85	172.16
Control		53.40 (46.95)	50.74 (45.42)	52.07 (46.19)		335.25	367.90	351.58	
SEm+		0.67	0.69	0.74		24.13	27.58	22.01	
CD (p=0.05)		2.01	2.08	2.23		72.72	83.13	66.34	
CV (%)		5.63	6.50	6.60		6.81	7.43	6.07	

Results and Discussion

In vitro* evaluation of fungicides against *F. oxysporum* f. sp. *Corianderii : *In vitro* efficacy of five fungicides viz., Carbendazim, Carboxin + Thiram, Benomyl, Thiophanate methyl and Companion was tested at 100, 200, 500 ppm concentration against inhibition of mycelial growth of *Fusarium oxysporum*. The data presented in reveals that all the fungicides significantly inhibited the

mycelial growth of *Fusarium oxysporum* as compared to check. Carbendazim was found significantly superior at 200 and 500 ppm with (100%) inhibition of mycelial growth followed by Companion and Topsin- M at 500 ppm and with (100%). As the concentration of fungicides increased, the inhibition of mycelial growth was also increased and maximum inhibition was observed at 500 ppm concentration. Fungicides and concentration interaction was also significant. Benomyl was least effective. The

results presented in Table 1 reveal that all fungicides at different concentrations (100, 200 and 500 were also found inhibitory to fungal growth.

In vivo evaluation of fungicides as seed dresser against coriander wilt disease : Efficacy of five fungicides as seed dresser was tested at recommended dose 2 g/kg seed against wilt of coriander. Carbendazim was found significantly superior with (80.06%) disease control followed by Companion with (76.54%) disease control. Benomyl was least effective. It can be concluded that Carbendazim as seed dresser was most effective in controlling wilt of Coriander caused by *Fusarium oxysporum*. Two years pooled data on per cent disease incidence (Table 2) revealed that all the fungicides were significantly effective in reducing the wilt disease incidence over control (52.07 per cent). The minimum 10.39 per cent disease incidence was recorded with the application of Carbendazim by decreasing 80.06 per cent disease incidence. However, Companion was second best and recorded 12.22 per cent disease incidence by decreasing 76.54 per cent disease incidence. Thiophanate methyl and Carboxin + Thiram were found moderately effective where, 14.33 per cent, and 21.55 per cent, respectively disease incidence was recorded. Among the fungicides maximum 24.15 per cent disease incidence was recorded in the treatment of Benomyl respectively. Mean analysis of two year seed yield data of coriander was found statistically significant over control. Result showed that maximum 1011.15 kg/ha seed yield was recorded in Carbendazim with increasing 187.61 per cent seed yield followed by Companion recorded 956.85 kg/ha seed yield with increasing 107.54 per cent seed yield. Carboxin + Thiram and Thiophanate methyl recorded 729.65 kg/ha and 686.65 kg/ha seed yield. Minimum 351.58 kg/ha seed yield was recorded in control. Among the five fungicides, Carbendazim, was observed highly superior over other fungicides and recorded minimum 10.39 per cent disease incidence by decreasing 70.94 per cent disease incidence and maximum 1085.15kg/ha seed yield. Companion was observed second best and recorded 12.22 per cent disease incidence and 976.85kg/ha seed yield. Kala *et al.* (2013) evaluated against *F. oxysporum* under in field condition disease incidence was minimum in Carbendazim seed treatment followed by carboxin+thiram.

Maillem *et al.* (2015) was found Carbendazim (0.1%) and Tebuconazole (0.1%) were found superior in completely inhibiting *Fusarium oxysporum f.sp. ciceri* at recommended dosages. Raheja and Patel (2011), reported that under *in vivo*, seed treatment with Carbendazim resulted in highest seed germination and lowest cumin wilt incidence followed by Sixer. Singh *et al.* (2005), the seeds treated with Bavistin gave higher percentage of seed germination (94%) and minimum pre-

and post emergence mortality (0.66 and 0.10%) with less number of seedlings showing symptoms. Singh (2009) observed that two fungicides Carbendazim (0.1%) and Mancozeb (0.25%) at 45 DAS was found effective for control of coriander wilt and also increase seed yield. Bansal (2003) tested Carbendazim, Mancozeb, Captan, Thiram, and Topsin M at 0.2% concentration against *F. oxysporum* inducing fenugreek wilt under pot conditions. Carbendazim was found significantly effective followed by Mancozeb. Rana *et al.* (2005) reported that carbendazim was most effective in increasing seed germination, seedling stand and reducing the wilt incidence in okra. They also reported that among the other seed treatments with fungicides SAAF (carbendazim + mancozeb) was found to be significantly superior over mancozeb and thiram. Champawat (1990) reported that among the 10 fungicide tested under *in vitro* and *in vivo* against the cumin wilt pathogen, Bavistin (carbendazim) and RH 893 (thiophanate methyl) were the most effective in inhibiting the growth of pathogen under *in vitro* and in increasing the seed germination and seedling vigour under *in vivo*. Agnihotri and Sharma (1987) have reported carbendazim and thiram as best seed dressers against *F. oxysporum f. sp. cumini*. The present findings are in corroboration with the above mentioned earlier findings. Thus, it can be concluded from the above study that among the five tested fungicides Bavistin and Sixer can be promisingly used as seed dresser in managing the coriander wilt disease and increasing theseed yield.

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Cultural and Morphological Variability in Single Spore Isolates of *Fusarium oxysporum* f.sp. *corianderii* on Different Media

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Abstract

Among eight isolates from different districts surveyed, representing different groups of *Fusarium oxysporum* f.sp. *corianderii* incited wilt of coriander. Variability was observed in terms of cultural and morphological characters on different agar and broth media. PDA medium was found to be significantly superior and best suited among all media in the present investigations for growth and sporulation of the pathogen. All the isolates produced maximum mycelial growth on potato dextrose agar media followed by Czapek Dox agar media. Both these media were also found better for production of macro and micro-conidia. The *Fusarium oxysporum* f.sp. *corianderii* isolate I₂ showed maximum (256.13 mg) mean dry fungal biomass and isolate I₆ showed minimum (179.39 mg) mean dry fungal biomass on broth media.

Key words : Coriander, variability, *Fusarium oxysporum*, Media

Introduction

Fusarium oxysporum f. sp. *Corianderii*, incitant of wilt disease in coriander (*Coriandrum sativum* L.) is a destructive disease in major coriander growing districts of Rajasthan resulting into considerable economic losses. Annual yield losses due to wilt have been estimated 10%–60% (Singh and Reddy, 1991). Persistence of the pathogen in soil and its capacity to survive there for years even in the absence of host (Haware *et al.*, 1996) renders its management difficulty. The isolated pathogenic strains may vary morphologically, physiologically and in pathogenicity, thus studies were undertaken to find out variability in *Fusarium oxysporum* f.sp. *corianderii* and their effect on disease development.

Materials and Methods

Pure culture of different isolates of *Fusarium oxysporum* f.sp. *corianderii* collected from different coriander growing area of Rajasthan. A total of eight isolates obtained from the surveyed districts and a local isolate from Agronomy Farm of SKNCoA, Jobner were used in present study. Eight isolates of *Fusarium oxysporum* f. sp. *corianderii* were transferred on 2 per cent PDA in Petri dishes to study their cultural characters such as the colour of aerial mycelium, colony growth and pigmentation of substratum and sporulation.

The isolates were coded as :

Code	Place of collection of isolates
I ₁	Kota
I ₂	Bundi
I ₃	Baran
I ₄	Jhalawar
I ₅	Jodhpur
I ₆	Jaipur
I ₇	Sawai Madhopur
I ₈	Chittorgarh

(1) Cultural variability

(a) Variability on agar media : All the eight isolates were grown on different solid and broth media for their growth and sporulation. The composition of each medium used is given as under :

1. Modified Czapek Dox Agar Medium

Sodium nitrate	2.0 g
Dipotassium monohydrogen phosphate	1.0 g
Magnesium sulphate	0.5 g
Potassium chloride	0.5 g
Ferrous sulphate	0.01 g
Sucrose	30.0 g
Pentachloro nitrobenzene (PCNB)	500.0 mg
Yeast extract	2.0 g
Agar	20.0 g
Distilled water	1000.0 ml

2. Potato dextrose Agar (PDA)

Peeled potato	200 g
Dextrose	20 g
Agar	20 g
Distilled water	1000 l

3. Richard's medium

Potassium nitrate	10 g
Potassium dihydrogen phosphate	5 g
Magnesium sulphate	2.5 g
Ferric chloride	0.02 g
Sucrose	50 g
Agar	20 g
Distilled water	1000 ml

4. Broun's medium

Glucose	2.0 g
Asparagine	2.0 g
Potassium dihydrogen phosphate	1.25 g
Magnesium	0.72 g
Agar	20 g
Distilled water	1000

5. Malt extract agar

Malt extract	20.0 g
Dextrose	20.0 g
Peptone	1.0 g
Agar	25.0 g
Distilled water	1000 ml

6. Corn medal agar

Corn meal	30 g
Agar	20 g
Distilled water	1000 ml

7. Oat meal agar

Oat meal	30 g
Agar	20 g
Distilled water	1000 ml

8. Martin's agar

Potassium dihydrogen phosphate	1.0 g
Magnesium sulphate	0.5 g
Peptone	5.0 g
Dextrose	10.0 g
Rose Bengal (1%)	3.3 ml
Agar	20.0 g
Distilled water	1000 ml

9. Mung bean agar

Mung bean (crushed)	30 g
Agar	20 g
Distilled water	1000 ml

Required quantity of the above mentioned solid medium was prepared and sterilized at 1.05 kg per cm² pressure for 20 minutes. Sterilization of Petri dishes was done at 180°C for 2 h in a hot air oven. In each Petri dish, 25 ml of respective medium was poured. Each treatment was replicated four times. Each Petri

dishes/flask was inoculated with bit of 2 mm having a single germinating conidium maintained on plain agar. The inoculated Petridishes was incubated at 25±1°C temperature and observation on mycelial colour, mycelial growth characters, substrates colour and production of macro or micro conidia were recorded.

(b) Variability on broth media : All the nine solid media prepared using agar-agar were also tested as broth media by excluding agar-agar. After sterilization, 25 ml of each medium was poured into 100 ml conical flask, keeping quadruplicate for each treatment. The flasks were inoculated with 2 mm bit of the pathogen and were incubated in BOD incubator at 25±1°C. After seven days of incubation, mycelial mat was harvested on oven-dried and weighed whatman No.1 filter paper. Mycelial mat along with filter paper was dried at 60°C for over night in hot air oven and weighted. For conidial production, 3 separate flasks were maintained. The each of the eight isolates was cultured on each broth medium separately in Erlenmeyer flasks for 10 days at 25±1°C. The mycelial mat was fragmented in warring blender at low speed intermittently for a total time of 5 min. The homogenous suspension so obtained was strained through the muslin cloth and supernatants were received in a beaker. A drop of the suspension was taken on the slide and examined for conidia count under low power magnification. In each of 3 drops, 5 microscopic fields were observed and mean number of conidia in each isolate was calculated.

(2) Morphological variability : To detect morphological variability in conidia formed by different isolates, purified culture of each isolate was grown in PDA plate. From 7-day old culture of each isolate, 3 mm diameter bits were cut from periphery of the growth with the help of a sterilized cork borer. One such bit was transferred aseptically with the help of sterilized inoculation needle to inoculate one PDA plate. Four Petridishes each inoculated with 1 bit of the same isolate constituted 4 replications for that isolate. The inoculated Petridishes were incubated at 25±1°C temperature. On 7th day of inoculation, spores were collected from culture in each Petridish according to the following procedure. From each Petridish, constituting one replication, 3 bits (each of 3 mm diameter) were cut with the help of sterilized cork borer from random points on peripheral growth. Three bits were shaken in 5 ml water for 10 minutes on a horizontal shaker. The harvested spores were stained with dilute solution of cotton blue and examined microscopically. For each isolate, 10 macro- and 10 micro-conidia from the total number of spores separated out from 3 bits per replication were separately examined for their size,

shape and septation. Thus, 60 macro- and micro-conidia from each isolates were examined for their size, shape and septation.

Isolates were transferred separately on PDA in Petri dishes to study in detail for their discernible characters on the basis of cultural characters such as the amount and colour of aerial mycelium, colony growth and pigmentation of substratum.

Result and discussion

Cultural variability (A) Variability on Agar media : To know the cultural variability in pathogen isolates they were grown on different nutritional media. Mycelial pigmentation in cultures of the isolates varied with the type of medium, however, isolates I_2 , I_5 , I_7 and I_8 showed white mycelial pigmentation on all the media (Table 1). The colony diameters of all the isolates were 8.0 mm to 9.0 mm range equal on PDA and Czapek Dox medium. The colony diameters of all the isolates were smaller on Richard's and Broun's medium than on the other media. (Table-1)

Six types of mycelial growth characters and two types of margins were recorded in cultures of eight isolates on four different media. Mycelial growth characters varied with the type of medium, while majority of the isolates displayed either cottony or slightly cottony growth of aerial mycelium. Isolates I_4 and I_7 did not display these types of growth on any medium. None of the isolates displayed woolly growth on modified Czapek Dox agar medium. Poor felt-like growth was displayed only by isolate I_6 and that too not on PDA. Margins of the colonies of most of the isolates were smooth on PDA but reverse was observed on modified Czapek Dox and Broun's agar medium, where as margins of the colonies of the isolates were smooth on Richard's medium. Margins of the colonies of the isolates I_1 , I_5 and I_8 remained smooth irrespective of the type of medium. Different colours of substrate pigmentation were observed as a result of growth of different isolates on different media. One isolate producing one type of substrate pigmentation on one type of medium, produced different type of substrate pigmentation on different media, however, isolate I_1 and I_7 produced light yellow coloured substrate pigmentation on all the four media. Isolate I_3 produced dirty white coloured substrate pigmentation on all the four media. The formation of macro-conidia by different isolates was affected by the type of medium. The isolates differed amongst themselves in production of macro-conidia. On PDA, maximum number of macro-conidia were formed by isolate I_2 , I_3 and I_7 . On

Czapek Dox, maximum number of macro-conidia were formed by isolate I_1 and I_3 . Isolate I_6 and I_7 produced minimum number of macro-conidia modified Broun's agar medium. Most of the isolates could not sporulate as efficiently on modified Broun's agar medium as on the other three media. The formation of micro-conidia by most of the isolates was again not as efficient on modified Broun's agar medium as on other three media. Isolate I_2 produced maximum number of micro-conidia on PDA. Taking both macro-conidia and micro-conidia formation into account, it can be seen that I_2 produced maximum number of both micro-conidia and macro-conidia on PDA. Variability in colour of mycelium and sporulation *Fusarium oxysporum* f.sp. *ciceri* were also reported by Tatarwal *et al.* (2016), Mathur and Parsad (1967).

(B) Variability on broth media : The data on dry fungal biomass of different isolates on broth media revealed that mean dry fungal biomass of all the eight isolates was maximum (244.72 mg) on potato dextrose medium followed by Czapek Dox medium (238.98 mg). Almost all the isolates produced highest dry fungal biomass on potato dextrose medium except isolate I_6 which showed highest fungal dry mass on Czapek Dox medium (236.50 mg). The isolate I_2 produced maximum dry fungal biomass (256.13 mg) on potato dextrose medium and isolate I_7 showed minimum dry fungal biomass (139.30 mg) on Broun's medium whereas, isolate I_4 showed minimum dry fungal biomass (140.10 mg) on Martin's medium. (Table 2) In general, the potato dextrose, Czapek Dox and moong bean meal broth media were found excellent for macro- and micro-conidia formation. The potato dextrose showed highest number of macro-conidia of isolate I_2 , (46) and I_3 , (46) whereas, corn meal and Martin's media showed lowest macro-conidia of isolates I_1 and I_3 . (Table 3) Variation among wilt fungi is well known. In *Fusarium*, the more common variations are reduction in aerial mycelium or growth rate, changes in production of chlamydospores variation in production of macro and micro conidia and colony pigmentation. Teterwal *et. al* (2016), reported that variability of *Fusarium oxysporum* f.sp. *ciceri* the color of the mycelium and sporulation in different nine isolates. Mathur and Prasad (1967) also observed variability in pigmentation, topography, sporulation and relative production and size of macro and micro-conidia among isolates of coriander wilt *Fusarium oxysporum*. The morphological studies conducted by Reddy and Chaudhary (1985) also revealed that six isolates of *Fusarium oxysporum* f.sp. *ciceri* had variation in number and size of macro and micro-conidia, cultural

Table-1 : Cultural variability among eight isolates of *Fusarium oxysporum* f.sp. *corianderii* on different media at 10 days growth.

Isolates/Media	Colony diameter (cm)*	Mycelium colour	Mycelial growth characters	Substrate colour	Production of conidia	
					Macro conidia	Micro conidia
1. PDA						
I ₁	8.5	White	SC, SM	Light yellow	36	31
I ₂	9.0	White	CO, RM	Creamy	45	41
I ₃	8.7	White	WO, SM	Dirty white	43	20
I ₄	8.6	Pinkish	PD, SM	Pink	30	38
I ₅	8.2	White	CO, SM	Creamy	33	24
I ₆	8.0	Pinkish white	WO, SM	Voilet	39	16
I ₇	9.0	White	WO, RM	Light yellow	42	18
I ₈	8.3	White	CO, SM	Yellowish	37	20
2. Czapek Dox						
I ₁	8.3	White	SC, SM	Light yellow	40	20
I ₂	9.0	White	SC, RM	Light dark	37	23
I ₃	8.5	Violet	SC, RM	Dirty white	40	30
I ₄	8.0	White	PD, SM	Voilet	33	35
I ₅	8.5	White	CO, SM	Dark pink	35	32
I ₆	9.0	Pinkish yellow	PF, RM	Dirty white	30	27
I ₇	8.5	White	PS, RM	Light yellow	28	30
I ₈	8.1	White	PF, SM	Dirty white	32	24
3. Richard's	6.0	Pinkish White	SC, SM	Light yellow	25	21
I ₁						
I ₂	7.6	White	CO, SM	Pink	34	30
I ₃	6.8	White to cream	WO, SM	Dirty white	36	20
I ₄	7.4	Pinkish	PD, SM	Pink	28	22
I ₅	5.0	White	CO, SM	Creamy	30	24
I ₆	6.3	Pinkish white	PF, SM	Dark pink	20	22
I ₇	7.5	White	WO, SM	Light yellow	25	21
I ₈	6.2	White	PF, SM	Yellowish	22	20
4. Broun's						
I ₁	5.1	White	PS, SM	Light yellow	21	19
I ₂	6.0	White	CO, RM	Creamy	26	17
I ₃	4.9	White	PF, RM	Dirty white	35	19
I ₄	4.5	Pinkish	WO, RM	Pink	25	16
I ₅	3.3	White	CO, SM	Creamy	30	18
I ₆	4.0	Pinkish white	PF, RM	Voilet	17	13
I ₇	4.7	White	PS, RM	Light yellow	19	15
I ₈	3.9	White	SC, SM	Pink	22	18

SC= Slightly cottony growth, CO= Cottony growth, WO= Wooly growth, PS= Poor suppressed growth, PD= Poor growth slightly, PF= Poor felt light, SM= Smooth margin, RM= Roof margin

characters, growth pattern, pigmentation and sporulation. Six types of mycelial growth characters and two types of margins in cultures of 9 isolates of *Fusarium oxysporum* f.sp. *cumini* on three different media were also observed by Champawat (1986). He further reported that isolates varied in pathogenicity and produced sickle shaped macro and micro conidia.

Morphological variability : All the isolates produced sickle shaped macro-conidia. Amongst different isolates, isolate I₃ was produced conidia of minimum length (23.44 μ m) and isolate I₂ (31.15 μ m) produced conidia of maximum length as compared to other

isolates. (Table 4) The different isolates produced macro-conidia of varying width and the isolate I₆ showed significantly maximum width of conidia (5.19 μ m) than all other isolates. The isolate I₇ showed minimum width of conidia (3.47 μ m) that was at par with isolate I₅ and significantly lower than all other isolates. All the isolates showed wide variability in number of septa present (Table 4.6). The isolate I₇ produced significantly lowest number of septa (2.43) that at par with isolate I₃ and while isolate I₂ produced significantly highest (3.75) number of septa than all other isolates.

All the isolates formed ovoid micro-conidia. The

Table-2 : Effect of different broth media on Fungal biomass of *Fusarium oxysporum* f.sp. *corianderii* isolates.

Broth media	Dry fungal biomass (mg)*								Mean
	I ₁	I ₂	I ₃	I ₄	I ₅	I ₆	I ₇	I ₈	
Czapek Dox	246.72	229.40	231.37	227.41	231.25	236.50	240.52	241.97	238.98
Potato dextrose	253.47	256.13	249.18	243.21	240.16	224.20	243.84	247.63	244.72
Richard's	171.40	178.31	153.07	156.30	152.40	163.27	153.44	164.56	171.32
Broun's	146.10	147.52	162.10	151.87	154.10	156.86	139.30	145.95	164.05
Malt extract	242.51	185.21	181.51	163.75	169.32	165.42	167.13	191.50	192.15
Corn meal	187.23	184.60	194.65	186.39	163.05	179.29	164.37	176.40	188.43
Oat meal	236.54	205.12	181.20	191.60	207.29	191.41	198.03	187.67	206.23
Martins	161.43	166.73	163.81	140.10	164.21	155.57	159.31	160.05	170.07
Moong bean	197.69	187.33	191.14	165.23	151.36	142.05	154.51	161.42	177.44
Mean	198.70	256.13	189.78	180.65	181.46	179.39	180.05	186.35	

*Mean of four replications

isolate I₆ gave minimum length (7.92 m) whereas maximum length of micro-conidia was found in isolate I₂ (10.71 m). The different isolates did not show variation with regard to width of micro-conidia (Table 4). The isolate I₅, I₆ and I₈ did not differ significantly so far as number of septa is concerned. However, the isolates I₃, I₇ and I₄ produced significantly lower number of septa than I₂ that produced highest number of septa amongst all isolates. Thus, isolates of the pathogen showed great variation in morphological characters as reported by Mathur and Prasad (1967). Some isolates ceased sporulation on continuous culturing but regained it on passing through the host. Mall (1969) also observed two distinct type of macro and micro conidia. *Fusarium oxysporum* f. sp. *corianderii* isolates varied morphologically and in their pathogenic nature in the present investigations as earlier observed by Honnareddy and Dubey (2006) while studying pathogenic and genetic variability of *Fusarium oxysporum* f. sp. *ciceri* isolates collected from different parts of India. Similarly, Mandharea *et al* (2011) and Arvayo-Ortiz *et al.* (2011) also observed pathogenic and morphological variation in isolates of *Fusarium oxysporum* f. sp. *ciceri*, thereby, confirming the findings of present investigations.

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Cutting Management and Nitrogen Application Influences Grain Quality and Productivity of Dual Purpose Oat (*Avena sativa* L.)

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Abstract

A field experiment entitled "Productivity of Dual Purpose Oat (*Avena sativa* L.) as Influenced by Cutting Management and Nitrogen levels" was conducted during Rabi 2016-17 at Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan. The experiment comprised of 20 treatments combination having five cutting management treatments (one cut 50 DAS (C₁), one cut 60 DAS (C₂), one cut 70 DAS (C₃), two cut at 50 and 80 DAS (C₄) and two cut at 60 and 90 DAS (C₅) in main plot and four nitrogen level after each cut (control, 10, 20 & 30 kg ha⁻¹) in sub plots were laid out in split plot design and replicated thrice. The objective was found out suitable cutting management practice and nitrogen level after cutting of green fodder for grain production and best in economic performance of dual purpose oat. It may be inferred that in oat cutting at 50 DAS (C₁) and fertilized with 30 kg nitrogen ha⁻¹ (N₃) practice gave significantly higher growth parameters at harvest viz., plant height, dry matter accumulation, number of tillers and yield attributes at harvest viz., effective tillers plant⁻¹, number of grain panicle⁻¹, panicle length & test weight, quality parameters viz., Nitrogen content and uptake in grain and straw, crude protein content, grain & straw yield and harvest index as compared to all other treatment combination.

Key words : Oat, cutting management, nitrogen levels and yield.

Introduction

Oat (*Avena sativa* L.) is an important winter forage crop, grown under irrigated conditions of north and north-western regions of India because of its excellent growth character, quick regrowth and economic source of dietary energy. It rank sixth in the world in cereal production after wheat, maize, rice, barley and sorghum. The world area under oat is around 12.5 million ha. In India, it covers an area about one lakh hectare with fodder productivity of 30-45 t/ha (FAO., 2012). In India, it is mainly grown in Haryana, Punjab, Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, West Bengal and Gujarat where irrigation facilities are available (Joshi *et al.* 2015). It is locally known as "jari", and can also be grown on the foothills of Himalayas, such as Himachal Pradesh. This crop is generally grown in India for fodder purpose. But, its importance as grain has been felt due to its uses as animal feed and human consumption as it is one of the most nutritious grain cereals, high in protein and fibre. The protein of rolled (flakes) oat is generally greater than that found in other cereals grains. Oats are grown for use as grain as well as forage and fodder, straw for feeding, hay, haylage, silage and chaff. It is a good source of protein, fibre, and minerals. Green fodder contains about 10-12 per cent protein and supply abundant quantity of vitamin A and important minerals like Ca & Fe in addition to energy for the animals. Oat is now preferred as a functional food

rich source of fibre and also has antioxidant properties (Nirmalkumari *et al.* 2013). India accounts for the 15 per cent of the world's livestock population. The total present forage availability in India is estimated to be only 250 million tonnes against the 1400 million tonnes of green fodder and 440 million tonnes against the need of 950 million tonnes for dry fodder in 2001 (Chotiya and Singh, 2005). Being an exhaustive crop, oat requires large amount of nutrients particularly nitrogen for producing more yield. Application of nitrogen after cutting will ensure better regrowth and canopy thereby accumulated more stem carbohydrate and more seed yield in dual purpose oat. Among the major plant nutrients, nitrogen plays a pivotal role in quantitative as well as qualitative improvement in the productivity of fodders and grain production in dual purpose oat. There is possibility of utilizing the regrowth and its yield potential both for forage production and as seed production making it a dual purpose crop. Growing dual purpose oat would help the farmers to get green fodder as well as quality seeds for next year sowing (Singhal *et al.*, 2008) and other purposes.

Materials and Methods

The experiment was conducted at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur, during 2016-17, which is situated at South-Eastern part of Rajasthan at an altitude of 582.2 metre above mean sea level and at 24°35' N latitude and 74°42' E longitude. The region falls under agro-climatic zone IV 'a' (Sub-Humid

Southern Plains and Aravalli Hills) of Rajasthan. This zone possesses typical sub-tropical climatic conditions characterized by mild winters and moderate summers associated with low relative humidity during the months of April to September. The mean annual rainfall of Udaipur is 600.8 mm and zone IV 'a' range between 582-620 mm most of which is contributed by South-West monsoon from June to September. The mean weekly meteorological parameters recorded at Agrometobservatory, Rajasthan College of Agriculture, Udaipur during crop season. The perusal of data show that maximum and minimum temperatures during crop season ranged between 20.4 to 38.1°C and 5.6 to 18.6°C, and the maximum and minimum relative humidity ranged between 46.4 to 92.1 and 10.9 to 47.0 %, wind velocity maximum and minimum ranged between 4.3 km h⁻¹ to 1.7 km h⁻¹, sun shine hrs day⁻¹ maximum and minimum ranged between 9.5 hrs day⁻¹ to 5.4 hrs day⁻¹ respectively during crop growth period. Total amount of rainfall received during crop growing season was 3.6 mm. The selection of test crop variety was UPO-212. The crop was irrigated at 25 DAS, 45 DAS and after each cut. Crops were fertilized with nitrogen at 80 kg N ha⁻¹ through urea (1/2 dose was applied at planting, 1/2 dose at first irrigation). Phosphorus fertilizer dose 40 kg ha⁻¹ were given in basal application through DAP. Additional nitrogen after cutting was applied as per treatment.

The total chlorophyll content was computed by following formula :

Total chlorophyll (mg/g fresh weight of leaf)

$$= \frac{20.2(A_{645}) + 8.02(A_{663})}{a \times 1000 \times W} \times V$$

Where,

a = Length of light path in cell (1 cm)

V = Volume of extract and

W = Weight of leaf sample

Results and Discussion

Plant height : The result revealed that the plant height significantly affected by cutting management at harvest. The maximum plant height at harvest (142.7 cm) was recorded in C₁ treatment which was significantly superior over C₂, C₃, C₄ and C₅ by 6.4, 8.7, 12.8 and 19.7 per cent, respectively. The maximum plant height (141.4 cm) was recorded with the application of 30 kg N ha⁻¹ which was significantly superior over 0, 10 and 20 kg N ha⁻¹ by 17, 12.4, and 4.8 per cent, respectively.

Dry matter accumulation : The maximum dry matter accumulation at harvest (195.0 g) was observed in C₁ treatment which was significantly superior over C₂, C₃, C₄ and C₅ treatments. the dry matter accumulation at

harvest significantly affected by nitrogen application after cutting. The maximum dry matter accumulation at harvest (173.5 g) was recorded with the application of 30 kg N ha⁻¹ after each cutting which was significantly superior over 0 kg and 10 kg N ha⁻¹ by 7.8, 5.3 per cent and but statically at par with 20 kg N ha⁻¹. Jat *et al.* (2015) reported also similar results.

Number of tillers : The data presented in Table-1 shows that the number of tillers at harvest significantly affected by cutting management. The maximum number of tillers at harvest (210.1) was recorded in C₁ treatment which was significantly superior over C₂, C₃, C₄ and C₅ treatment. This might be due to more favourable weather situation between first cutting for green fodder and harvest for grain resulted into higher growth attributes. Similar findings were also reported by Sharma and Bhunia (2001) and Patel *et al.* (2011) in oat. The maximum number of tillers m⁻¹ (195.2) was recorded with the application of 30 kg N ha⁻¹ after each cutting which was significantly superior over 0, 10 and 20 kg N ha⁻¹ by 18.9, 11.9, and 5.1 per cent, respectively. Similar findings were reported by Rawat and Agrawal (2010).

Effective tiller m⁻¹ row length : The data (Table-2) shows that the cutting management had significantly affect on effective tiller. The C₁ treatment gave maximum effective tiller m⁻¹ row (74.7). C₁ treatment was found significantly superior over C₄ and C₅ but found at par with C₂ and C₃ treatment. It is explicit from the data in Table 4.6 that the effect of different nitrogen levels had significantly affect on effective tiller m⁻¹ at harvest. The application of 30 kg N ha⁻¹ after each cutting was significantly superior over 0 kg and 10 kg N ha⁻¹ but statistically at par with 20 kg N ha⁻¹. The maximum effective tiller m⁻¹ row (73.0) was recorded with 30 kg N ha⁻¹. Improvement in yield attributes with increasing nitrogen levels may be due to more translocation of photosynthates from source to sink. Increase in growth, yield attributes, grain and straw yield of oats with increasing nitrogen levels were also reported by Joon *et al.* (1988), Singh *et al.* (1993), Bhilare and Joshi (2007) and Patel *et al.* (2011).

Test weight : It is evident from the data (Table-2) that the cutting significantly affected the 1000 grain weight. The highest 1000 grain weight (39.8 g) was recorded in C₁ treatment. C₁ treatment was found significantly superior over C₂, C₃, C₄ and C₅ by 5.2, 10.2, 14.6 and 20.6 per cent, respectively in this respect. The effect of different nitrogen levels had significantly affect on 1000 grain weight. Application of 30 kg N ha⁻¹ found (37.6 g) significantly superior over control and 10 kg N ha⁻¹ by 8 and 4.7 per cent but it was statically at par with 20 kg N ha⁻¹. The results are in close accordance with findings of Singh *et al.* (2014) and Patel *et al.* (2011) in oat.

Table-1 : Effect of cutting management and nitrogen level on plant height, dry matter accumulation and number of tillers at harvest of oat (grain).

Treatments	Plant height (cm)	Dry matter accumulation (g)	Number of tillers
Cutting management			
50 DAS (C ₁)	142.7	195	210
60 DAS (C ₂)	134.2	185	198
70 DAS (C ₃)	131.2	172	182
50 and 80 DAS (C ₄)	126.5	140	161
60 and 90 DAS (C ₅)	119.2	143	148
S.Em.±	2.46	1.20	4.29
C.D. (P=0.05)	8.03	3.93	14.0
Nitrogen levels (kg ha⁻¹) after cutting			
0	120.8	160	164
10	125.8	164	174
20	135.2	168	185
30	141.4	173	195
S.Em.±	0.72	0.70	2.83
C.D. (P=0.05)	2.09	2.04	8.19

Table-2 : Effect of cutting management and nitrogen levels on yield attributes of oat (grain).

Treatments	Effective tillers m ⁻¹ row length	Panicle length (cm)	1000 grain weight (g)
Cutting management			
50 DAS (C ₁)	74.7	31.0	39.8
60 DAS (C ₂)	72.0	28.9	37.8
70 DAS (C ₃)	70.5	26.7	36.1
50 and 80 DAS (C ₄)	68.2	26.2	34.7
60 and 90 DAS (C ₅)	66.0	25.5	33.0
S.Em.±	1.28	0.56	0.63
C.D. (p=0.05)	4.19	1.85	2.05
Nitrogen levels (kg ha⁻¹) after cutting			
0	67.6	23.6	34.8
10	69.6	26.2	35.9
20	71.0	28.7	36.8
30	73.0	32.3	37.6
S.Em.±	0.86	0.34	0.45
C.D. (P=0.05)	2.48	0.99	1.31

Panicle length : The cutting had significantly affect on the panicle length of oat at harvest (Table-2). Significantly higher panicle length (31 cm) was produced under C₁ treatment which was and significantly higher over C₂, C₃, C₄ and C₅ treatments. It is evident from the data given in Table 4.6 reveals that the application of nitrogen after each cutting had significantly affect on the panicle length in oat at harvest. The highest panicle length (32.3 cm) was recorded under 30 kg N ha⁻¹ treatment which was significantly higher by 36.8, 23.2 and 12.5 per cent over 0, 10 and 20 kg N ha⁻¹, respectively. The significant increase in yield attributes observed under C₁ treatment compared to other treatment seems to have resulted on account of improved photosynthesis due to availing more favourable period after first cutting to the harvest.

Nitrogen content in grain and straw : It was revealed

from the data of Table-3 that cutting management had significantly affected on the nitrogen content in dual oat at C₃ treatment. The higher nitrogen content (0.56 per cent) was recorded under C₃ treatment. The maximum nitrogen per cent (Table 4.7) in grain (1.70 per cent) at C₁ treatment which was significantly superior over C₃ and C₅ treatment. Application of nitrogen had significantly affected on the nitrogen content grain and straw in dual oat at harvest. The maximum nitrogen content in straw (0.57 per cent) in grain (1.70 per cent) was recorded under 30 kg N ha⁻¹.

Nitrogen uptake by grain and straw : C₁ treatment gave maximum nitrogen uptake by grain (47.6 kg ha⁻¹) which was significantly higher over C₃, C₄ and C₅ by 16.3, 23.6 and 46.0 per cent, respectively. The maximum nitrogen uptake by straw (32.50 kg N ha⁻¹) in C₃ treatment which was significantly superior over C₄ and C₅ by 22.1 and 13.6 per cent, respectively. The maximum available nitrogen

Table-3 : Effect of cutting management and nitrogen levels on quality parameter of oat.

Treatments	Nitrogen (%)		Nitrogen uptake kg ha ⁻¹		Crude protein content (%)	
	Grain	Straw	Grain	Straw	Grain	
Cutting management						
50 DAS (C ₁)	1.70	0.49	47.6	30.8	2.30	
60 DAS (C ₂)	1.67	0.53	44.4	31.3	2.27	
70 DAS (C ₃)	1.64	0.56	40.9	32.5	2.16	
50 and 80 DAS (C ₄)	1.69	0.47	38.5	26.6	2.28	
60 and 90 DAS (C ₅)	1.65	0.52	32.6	28.6	2.28	
S.Em.±	0.01	0.004	1.08	0.74	0.024	
C.D. (P=0.05)	0.03	0.014	3.54	2.44	0.078	
Nitrogen levels (kg ha⁻¹) after cutting						
0	1.65	0.44	37.0	24.4	2.01	
10	1.66	0.50	39.7	29.1	2.20	
20	1.68	0.54	42.3	31.7	2.23	
30	1.70	0.57	44.3	34.6	2.34	
S.Em.±	0.008	0.003	0.93	0.33	0.012	
C.D. (P=0.05)	0.023	0.008	2.70	0.95	0.035	

Table-4 : Effect of cutting management and nitrogen levels on yield and harvest index.

Treatments	Grain yield (t ha ⁻¹)		Straw yield (t ha ⁻¹)		Harvest index (%)	
Cutting management						
50 DAS (C ₁)	2.80		6.22		30.98	
60 DAS (C ₂)	2.65		5.90		30.95	
70 DAS (C ₃)	2.48		5.74		30.24	
150 and 80 DAS (C ₄)	2.28		5.62		28.83	
60 and 90 DAS (C ₅)	1.97		5.48		26.37	
S.Em.±	0.066		0.127		0.730	
C.D. (P=0.05)	0.214		0.415		2.382	
Nitrogen levels (kg ha⁻¹) after cutting						
0	2.24		5.56		28.60	
10	2.39		5.79		29.11	
20	2.52		5.84		30.00	
30	2.60		5.99		30.18	
S.Em.±	0.050		0.054		0.416	
C.D. (P=0.05)	0.144		0.155		1.200	

Table-5 : Effect of cutting management and nitrogen levels on net returns and B : C.

Treatments	Net returns ha ⁻¹		B : C	
Cutting management				
50 DAS (C ₁)	100836		2.62	
60 DAS (C ₂)	102834		2.67	
70 DAS (C ₃)	105652		2.74	
50 and 80 DAS (C ₄)	106588		2.09	
60 and 90 DAS (C ₅)	108868		2.14	
S.Em.±	2798		0.068	
C.D. (P=0.05)	NS		0.221	
Nitrogen levels (kg ha⁻¹) after cutting				
0	95419		2.27	
10	102756		2.41	
20	107931		2.51	
30	113716		2.62	
S.Em.±	1963		0.045	
C.D. (P=0.05)	5670		0.129	

uptake by grain (44.3 kg ha^{-1}) and by straw (34.6 kg ha^{-1}) was recorded under 30 kg N ha^{-1} which was significantly higher over control and 10 kg N ha^{-1} . Similar results were reported by Singh (2004) and Alipatra et al. (2013). Higher nitrogen uptake by grain in C_1 treatment might be due to higher nitrogen content in grain and straw in C_1 treatment over other cutting management and amount of nitrogen uptake by the crop is largely determined by total dry matter yield (grain + straw)

Crude protein in grain : The data presented in Table-3 that the crude protein significantly affected by cutting management. The maximum crude protein (2.30 %) in C_1 treatment which was significantly superior over C_3 treatment. The maximum crude protein (2.34 %) was recorded with the application of 30 kg N ha^{-1} which was significantly superior over control, 10 and 20 kg N ha^{-1} by 16.4, 6.4, and 4.9 per cent, respectively. Crude protein content in grain and straw increased with increasing nitrogen levels because of availability of more nutrients which resulted in synthesis of more protein. Similar results have been reported by Singh et al. (1993).

Grain yield : The data in Table 4 indicate that different cutting management had significant effect on grain yield of dual oat. C_1 treatment yielded the highest grain yield (2.8 t ha^{-1}) which was significantly higher by 12.9, 22.8 and 42.1 per cent over C_3 , C_4 and C_5 treatment, respectively but was found at par with C_2 treatment. A perusal of data in Table 4.8 indicate that application of nitrogen after cutting had significantly affected on grain yield of dual oat. Application of 30 kg N ha^{-1} after each cutting gave highest grain yield (2.60 t ha^{-1}) which was significantly higher over 0 and 10 kg N ha^{-1} by 16.0 and 8.9 per cent but statistically at par with 20 kg N ha^{-1} . Singh et al. (2014) reported that the initial cutting at 60 DAS recorded significantly highest seed (1160 kg ha^{-1}) and straw yield (3531 kg ha^{-1}) yield over the initial cutting at 75 DAS and 90 DAS.

Straw yield : The data presented in Table 4 shows that the straw yield significantly affected by cutting management. The maximum straw yield (6.22 t ha^{-1}) was recorded in C_1 which was significantly superior over C_2 , C_3 , C_4 and C_5 treatment. The maximum straw yield (5.99 t ha^{-1}) with application of 30 kg N ha^{-1} which was significantly superior over control and 10 kg ha^{-1} by 7.7 and 3.5 per cent but statically at par with 20 kg N ha^{-1} .

Harvest index : It was found that the cutting management had significant affect on the harvest index of dual oat (Table 4). The maximum harvest index of 30.98 per cent was recorded under C_1 treatment which was significantly superior over C_4 and C_5 treatments.

A perusal of data in Table 4.8 indicate that application of nitrogen after each cutting had significant effect on grain

yield of dual oat. Application of 30 kg N ha^{-1} after cutting gave highest harvest index (30.18 %).

Net return : Data presented in Table 5 shows that the highest net return of $1,08,868 \text{ ha}^{-1}$ was obtained in C_5 treatment which was higher over C_1 , C_2 , C_3 and C_4 by 8032 , 6034 , 3216 and 2280 ha^{-1} respectively. The net return increased with increasing levels of nitrogen. The highest net return of 113716 ha^{-1} was recorded in 30 kg N ha^{-1} applied after cutting which was significantly higher over control, 10 and 20 kg ha^{-1} by 18297 ha^{-1} , 10960 ha^{-1} and 5785 ha^{-1} , respectively.

B:C ratio : Data reveals that cutting management had significant effect on B: C. The highest B:C of 2.74 was recorded in C_3 treatment which was significantly superior over C_4 and C_5 treatment. Data (Table 5) shows that application of 30 kg N ha^{-1} after cutting recorded maximum B C ratio (2.62) which was significantly superior over control (2.27) and 10 kg N ha^{-1} (2.41).

Conclusions

On the basis of the results of one year field experiment entitled "Productivity of Dual Purpose Oat (*Avena sativa* L.) as Influenced by Cutting Management and Nitrogen Levels" conducted during Rabi 2016-17, it may concluded that two cut at 60 and 90 DAS then left for grain production fertilized with 30 kg N ha^{-1} after each cutting is the best for achieving green fodder yield of 58.45 t ha^{-1} and grain yield of 2.10 t ha^{-1} which fetched maximum net return (123767 ha^{-1}). However, one cut at 70 days then left for grain production with 30 kg N ha^{-1} after cutting gave the highest B C ratio (2.97). The result are based one year experimentation hence they need to be validated by further experimentation before making final recommendation under study.

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Estimation of Ranking in Ashwagandha (*Withania somnifera* (L.) Dunal) Genotypes Over Diverse Environmental Conditions in Humid and Sub-Humid Southern Plains of Rajasthan (India)

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Abstract

Ashwagandha is one of the most important medicinal and aromatic plants in the humid and sub-humid southern plains of Rajasthan that provides high recompense to growers. Production of ashwagandha is limited due to lack of high-yielding as well as better adaptive cultivars. In order to identify high yielding stable genotypes across the diverse environmental conditions, we have evaluated eighteen lines of ashwagandha in a Completely Randomized Block Design over three different environments in Rajasthan during late *Kharif* 2020. According to the Eberhart and Russell model for stability analysis, UWS-48 and UWS-10 were identified as the most promising genotypes for early flowering, UWS-23 for early maturity whereas, UWS-48 and UWS-32 for shorter plant height. UWS-15 and UWS-110 can be used to increase the number of primary branches per plant, whereas, UWS-48 and UWS-111 for root length and UWS-59 and UWS-125 for dry root yield per plant, and UWS-125 and UWS-48 for maximum alkaloid content. Since these genotypes were indicated to be the most consistent across the environments for the traits mentioned, they can be successfully suggested to use in breeding programs. The study revealed that some reliable predictions regarding genotype and environment interaction, as well as its unpredictable components, played a relevant role in genotype stability. With this aim, the current study can be used to identify more productive genotypes in specific conditions, resulting in a large improvement in ashwagandha root productivity.

Key words : *Withania*, GxE interaction, stability, completely randomized block design, regression coefficient.

Introduction

Ashwagandha (*Withania somnifera* (L.) Dunal) is a medicinal and aromatic plant with a long history of cultivation. There are twenty-six species in the genus *Withania*, which is extensively found in South Asia and the Eastern Mediterranean region. Out of these only two species have been growing in India: *W. somnifera* and *W. coagulans* (Kaul 1957; Kumar *et al.*, 2007). Ashwagandha (*Withania somnifera* L. (Dunal); 2n = 48) (Schonbeck 1972; Hepper 1991; Mozaffarian 2003) is a most important medicinal herb that grows as a perennial shrub in the Solanaceae family. It's also known as winter cherry, Indian ginseng, and gooseberry. It grows wild as well as as a cultivated shrub in different parts of India (Kulkarni *et al.*, 1996).

Ashwagandha is both a tonic and a sedative due to its apoptogenic properties (Choudhary *et al.*, 1995). The pollination behavior and biology of flower as well as breeding system of Ashwagandha studied by (Mir *et al.*, 2012) which reveals the favorable anthesis time between 08:00 A.M. to 11:00 A.M. and the period of stigma receptivity coincides along with anther dehiscence. The biologically active various alkaloids are (ashwagandhine, cuscohygrine, anahygrine, tropine etc.), steroidal

constituents, including ergostane, withanolides (Zhao, *et al.*, 2002). The relative performance of genotypes for quantitative characteristics changes by environment, and the interaction of genotypes with environments has a significant impact on yield improvement. As a result, significant testing is necessary to choose genotypes with the least genotype and environment interactions and hence behave consistently in different environmental conditions.

Materials and Methods

Experimental materials : For the current study, eighteen genotypes of Ashwagandha were collected from the All India Coordinated Research Project on Medicinal and Aromatic Plants, Department of Genetics and Plant Breeding R.C.A, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan). The eighteen genotypes namely; UWS-7, UWS-10, UWS-14, UWS-15, UWS-23, UWS-32, UWS-37, UWS-44, UWS-48, UWS-56, UWS-59, UWS-62, UWS-93, UWS-95, UWS-110, UWS-111, UWS-125 and UWS-127.

Statistical Analysis : Separately environment wise analysis of variance for each character and each genotype was subjected to pooled analysis of variance (Singh 1985). The data collected from these separate sites was

submitted to a stability analysis using Eberhart and Russell's model (1966). Its simply based on regression. The basic model employed is as follows: $Y_{ij} = \hat{\alpha}_{0i} + \hat{\alpha}_i l_j + \ddot{\alpha}_{ij}$ where Y_{ij} is repercuision of i^{th} of variety in j^{th} locations, $\hat{\alpha}_{0i}$ is respond of genotype i , $\hat{\alpha}_i$ is regression coefficient of i^{th} variety to varying environments indices. l_j is the coded environmental index; $\ddot{\alpha}_{ij}$ is the regression deviation and three additional parameters were calculated namely mean (μ_i), regression coefficient (b_i) and non-significant variation ($S^2 d_i$) from regression line.

Estimation of alkaloid content (%) from root samples :

A 0.5 g powdered root sample was placed in a conical flask, which was then filled with 5mL chloroform and 2–3 drops of liquid ammonia. The materials were thoroughly combined and left to extract the alkaloids from the sample overnight. The mixture was filtered through cotton wool in a beaker the next day, and the residue was washed three times with 5–10mL of chloroform. This guarantees that the entire alkaloids in the solution are extracted completely. After drying the extracts on a hot plate, 10mL ethyl alcohol was added and thoroughly combined with a glass rod. To remove the ammonia odor from the sample, the liquid was allowed to evaporate. Then add 10mL of 0.01 N H_2SO_4 standard acid solutions. The alkaloid content (%) of root samples was calculated using the formula :

Alkaloid content (%) = $0.83 \times \text{volume of acid consumed by alkaloids}$

Results

In each context, significant genotypic variations were identified for all eight quantitative characteristics (table-1). A pooled analysis was performed on the mean genotypic data from different locations (table-2). MSS was tested against pooled deviation and it was found non-significant due to replications within environment while significant due to genotypes (G) and environments (E) for all the traits. All of the traits had significant component analyses of environment + genotype x environment. The mean sum square due to environment (linear) was significant for all features except the number of primary branches per plant after partitioning this variation into linear and nonlinear components. MSS was tested against pooled error, when MSS due to G x E was found to be highly significant for all the traits. As a result, stability analysis was done on all of the Ashwagandha traits investigated. The variation owing to Genotype x Environment was separated into Genotype x Environment (linear) and pooled deviation (nonlinear). The mean squares due to environment (linear) were highly significant for all the traits except the number of primary branches per plant. When Genotype x Environment (linear) was tested against pooled deviation, most of the traits were found to be highly significant with the exception of the number of primary branches per plant. For plant height and dry root yield per plant, the nonlinear

component coming from heterogeneity assessed as mean sum of square due to pooled deviation was significant.

Stability analysis through Eberhart and Russell model (1966) : Because of its versatility, performance stability is one of the most desired characteristics of any genotype. Stability measures, such as mean performance across environments, regression coefficient (b_i), and deviation from linear regression ($S^2 d_i$), were calculated for all attributes under consideration of The Eberhart-Russell model (1966) (table-3).

These stability criteria, as well as the mean value of characters influence a genotype's desirability. The linear regression coefficient (b_i) was used to assess responsiveness of genotype. The high b_i value indicates that the genotype is more responsive; such genotypes may thus be chosen for highly favorable environments (Below average stability). The fact that the regression coefficient (b_i) is close to one implies that it is more adaptable (Absolute stability). If, on the other hand, the regression coefficient (b_i) is low, the genotype can only be cultivated in poor environmental conditions (Above average stability). The deviation from regression ($S^2 d_i$) was used to assess stability. If $S^2 d_i$ deviates significantly from zero, the linear prediction is invalidated, whereas non-significant $S^2 d_i$ indicates that the performance of a genotype in a particular environment may be predicted.

Phenological traits analysis : Because it had a lower mean value (84.11 days followed by 85.56) than the general mean of 91.84 days (figure-1), a significant regression coefficient (1.26, 1.58) close to unity, and the least non-significant variation (-4.25, 8.37) from regression, the UWS-48 and UWS-10 were deemed to be the most stable for early blooming (table 3.1). With a mean value of 159.22 days (figure 2) lower than general mean (159.71), a significant regression coefficient value of 1.039 (unity), and a nonsignificant least deviation (-6.68) from linear regression, showed Below Average stability, UWS-23 was found to be the most stable for early maturity (table-3.1).

Other characters analysis : UWS-32 (36.48), followed by UWS-48 (36.51) had lower plant height than Average population (36.54) and having regression coefficients(b_i) of 1.07 and 0.83 respectively close to unity, with $S^2 d_i$ values 4.47 and 4.61, showed below average stability it means the genotype has lesser degree of adaptability to diverse environmental conditions (table-3.1). Mean performance of genotypes UWS-15 (3.94) and UWS-110 (3.76) for number of primary branches per plant was comparable to population mean (3.75) (figure 4), regression coefficient is 1.43 and 1.26 least non-significant deviation (0.02) from regression (table 3.2). Hence this genotype was desirable for good environment or

Table-1 : Environment wise analysis of variance for various traits in ashwagandha.

		MSS		
Source of variation	D.F	Udaipur	Badgaon	Banswara
Days to 50% Flowering				
Replication	2	10.69	6.50	51.39
Genotype	17	68.72**	64.95**	52.86**
Error	34	18.08	21.34	18.41
Days to 75% maturity				
Replication	2	39.19	1.24	14.39
Genotype	17	61.50*	34.63*	68.94*
Error	34	28.93	16.69	32.43
Plant height				
Replication	2	0.91	23.35	3.50
Genotype	17	102.44**	100.91**	27.06**
Error	34	6.93	7.98	10.13
Primary branches / plant				
Replication	2	8.00	4.02	4.96
Genotype	17	25.11**	25.19**	18.81**
Error	34	3.31	5.45	3.86
Root length per plant (cm)				
Replication	2	8.00	4.02	4.96
Genotype	17	25.11**	25.19**	18.81**
Error	34	3.31	5.45	3.86
Root diameter				
Replication	2	1.87	5.56	1.45
Genotype	17	39.80**	33.58**	54.14**
Error	34	1.53	1.75	0.48
Dry root yield / plant				
Replication	2	0.04	0.02	0.04
Genotype	17	2.06**	2.45**	1.74**
Error	34	0.05	0.04	0.04
Alkaloid content				
Replication	2	0.00	0.00	0.00
Genotype	17	0.01**	0.01**	0.01**
Error	34	0.00	0.00	0.00

*, ** = significant at 5% and 1% levels, respectively.

Table-2 : Pooled ANOVA (Mean Square) for phenotypic stability of various traits in ashwagandha.

S. No.	Characters	Genotypes [17]	E+ (G x E) [36]	E (L) [1]	G x E (L) [17]	Pooled Deviation [18]	Pooled error [102]
1.	Days to 50% flowering	41.57**	10.87**	41.12**	15.40**	4.92	19.28
2.	Days to 75% maturity	22.28**	15.89**	15.26	21.50**	10.62	26.02
3.	Plant height (cm)	34.70**	33.79**	500.90**	25.91**	15.29**	8.35
4.	No. of primary branches/plant	12.52**	1.12	3.38	1.71	0.78	4.20
5.	Root length (cm)	17.57**	2.82	8.53*	4.31*	1.10	4.21
6.	Root diameter (mm)	39.52**	1.93**	18.78**	2.30**	0.65	1.25
7.	Dry root yield (g)/plant	1.74**	0.16**	0.08**	0.23**	0.10**	0.04
8.	Alkaloid content (%)	0.01**	0.00**	0.00**	0.00**	0.00	0.00

Parenthesis represent corresponding degree of freedom, *, ** = significant at 5% and 1% levels, respectively.

Table-3.1 : Mean values and stability parameters (b_i and $S^2 d_i$) of the ashwagandha genotypes for various traits.

Genotypes	Days to 50% flowering			Days 75% to maturity			Plant height (cm)		
	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$
UWS-7	92.44	-4.27	9.04	157.56	11.61	42.59	39.56	0.55*	-1.46
UWS-10	88.56	1.58	18.37	158.11	-6.59	-8.54**	38.00	0.69	0.86
UWS-23	87.67	-0.82	-6.41*	159.22	1.39	-6.68	40.22	1.01**	-2.48
UWS-37	92.00	0.44	-4.21	156.56	-0.39	-8.51**	37.67	1.54**	-0.15
UWS-14	98.56	0.09	-4.37	162.67	-0.32	-6.76	37.22	1.21**	-1.33
UWS-15	93.11	6.46**	-1.93	162.00	1.57	-7.88	39.22	0.69	10.86*
UWS-32	95.78	-0.61	-0.09	154.89	-4.23	11.31	36.48	1.07	4.47
UWS-44	95.56	2.76	-1.56	163.44	-3.28	-8.64**	36.71	1.38**	2.52
UWS-48	84.11	1.26	-4.25	159.44	-4.85	-8.16**	36.51	0.83	4.61
UWS-56	88.33	-1.82	2.88	161.44	-4.04	-8.01**	39.44	1.33	11.06*
UWS-59	88.33	2.21**	-6.03	163.89	2.53	9.95	39.11	-0.42	23.83**
UWS-62	92.56	-0.70	-5.25**	158.67	6.50**	-8.28	37.44	-0.89	76.43**
UWS-93	94.89	3.46**	-6.22	161.44	4.30*	-6.27	30.89	0.26	36.66**
UWS-95	89.56	-0.38	-6.25**	158.00	-1.68	18.46	30.56	2.60**	1.29
UWS-110	93.11	5.06**	-4.47	157.67	-2.33	8.25	28.22	0.14	30.48**
UWS-111	88.78	2.76**	-6.02	159.33	4.33**	-7.91	37.22	0.94**	-0.76
UWS-125	95.89	1.86	4.78	163.78	9.18	38.09	34.00	3.12**	-0.37
UWS-127	93.89	-1.37	-5.11**	156.67	4.33**	-7.91	38.00	1.90**	8.64*
S.Em+	1.57	3.01		2.30	3.54		1.63	0.49	
Pop. mean	91.84	1		159.71	1		36.54	1	

*, ** = significant at 5% and 1% levels, respectively.

Table-3.2 : Mean values and stability parameters (b_i and $S^2 d_i$) of the ashwagandha genotypes for various traits.

Genotypes	No. of primary branches / plant			Root length (cm)			Root diameter (mm)		
	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$
UWS-7	3.52	1.60	0.38	20.44	-1.56	-1.37**	11.32	1.47	3.17
UWS-10	4.26	-2.26	0.03	20.56	-0.78	-1.39**	14.87	1.87**	-0.47
UWS-23	3.75	2.01	0.09	27.56	3.16	-0.29	8.39	-0.12	-0.27**
UWS-37	4.54	-1.84	0.29	25.11	2.05**	-1.33	14.00	1.36*	-0.16
UWS-14	4.07	5.21	0.03	22.33	0.63*	-1.37	6.69	0.07	0.15
UWS-15	3.94	1.43	0.02	25.33	3.08**	-1.25	8.33	-1.11	-0.39**
UWS-32	3.78	7.07	0.00	21.22	-6.85	-1.35**	11.33	-1.22	-0.34**
UWS-44	3.02	-1.13	0.80	18.11	0.88	-1.25	11.27	4.81**	1.04
UWS-48	3.78	-2.13	1.00	25.33	1.26	7.39	17.88	0.37	-0.35*
UWS-56	3.92	2.38	0.11	22.22	-2.05	-1.33**	8.87	0.38	-0.13
UWS-59	4.26	-0.60	0.11	23.22	0.61	1.60	15.51	0.13*	-0.41**
UWS-62	3.75	6.85	0.00	21.22	6.13*	0.83	14.79	2.80	2.08
UWS-93	3.98	2.12	-0.01	22.89	1.23	-0.27	12.82	1.29**	-0.29
UWS-95	3.70	-0.21	0.84	22.22	6.25**	-0.96	14.72	2.34	1.11
UWS-110	3.76	1.26	0.11	23.22	2.41	-0.52	9.44	0.25	-0.08
UWS-111	4.25	-4.54	0.06	26.56	1.77	-0.81	15.72	2.25*	0.34
UWS-125	2.61	-1.03	0.51	21.11	0.24	-1.35*	5.69	-0.14	-0.41**
UWS-127	2.69	1.80	0.05	24.67	2.01	-0.44	16.81	1.19**	-0.34
S.Em+	0.75	1.5		0.75	1.52		2.30	3.54	
Pop. mean	3.75	1		22.96	1		12.14	1	

*, ** = significant at 5% and 1% levels, respectively.

Table-3.3 : Mean values and stability parameters (b_i and S^2_{di}) of the ashwagandha genotypes for various traits.

Genotypes	Dry root yield / plant			Alkaloid content (%)		
	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
UWS-7	1.26	-1.80	0.06	0.34	-2.76	0.00*
UWS-10	2.46	0.52	0.10	0.35	15.64**	0.00
UWS-23	3.43	-4.27	-0.00	0.40	6.20**	0.00
UWS-37	2.39	-5.24	0.20	0.28	7.45**	0.00
UWS-14	2.06	0.91	0.01**	0.34	4.42**	0.00
UWS-15	2.38	5.44**	-0.00	0.34	-0.05	0.00
UWS-32	1.70	3.61**	-0.01**	0.34	-7.86	0.00**
UWS-44	3.63	-8.22	0.13	0.44	-0.80	0.00
UWS-48	1.24	-1.54	-0.01	0.35	1.76	0.00
UWS-56	1.74	-9.83	0.02**	0.32	-1.84	0.00**
UWS-59	3.12	1.58	0.01	0.33	-1.98	0.00
UWS-62	3.21	5.26**	-0.00	0.40	2.10**	0.00
UWS-93	2.07	7.45	0.26	0.27	-3.88	0.00*
UWS-95	1.21	3.35**	-0.00	0.28	1.51**	0.00
UWS-110	1.99	17.29*	0.19	0.26	1.84	0.00**
UWS-111	1.53	-0.35	0.15	0.34	2.70**	0.00
UWS-125	2.90	1.75	0.34	0.45	1.70	0.00
UWS-127	2.54	-8.93	0.17	0.36	-2.70	0.00**
S.Em±	0.23	4.90		0.004	1.25	
Pop. Mean	2.27	1		0.34	1	

*, ** = significant at 5% and 1% levels, respectively.

Table-4 : Mean dry root yield of selected genotypes evaluated over year and location in ashwagandha.

S. No.	Genotypes	Udaipur	Badgaon	Banswara
1.	UWS-7	1.15	1.12	1.5
2.	UWS-10	2.5	2.68	2.2
3.	UWS-23	3.2	3.5	3.6
4.	UWS-37	2.12	2.86	2.18
5.	UWS-14	2.1	1.91	2.16
6.	UWS-15	2.68	2.29	2.18
7.	UWS-32	1.89	1.56	1.64
8.	UWS-44	3.2	4.13	3.56
9.	UWS-48	1.16	1.29	1.28
10.	UWS-56	1.2	1.89	2.12
11.	UWS-59	3.2	2.96	3.2
12.	UWS-62	3.5	3.12	3.02
13.	UWS-93	2.49	2.22	1.5
14.	UWS-95	1.39	1.16	1.07
15.	UWS-110	2.91	1.18	1.89
16.	UWS-111	1.5	1.26	1.84
17.	UWS-125	3.57	2.12	3.02
18.	UWS-127	2.07	3.09	2.45
	Pop. Mean	2.32	2.241	2.245
		CD@5% =0.4	CD@5% = 0.32	CD@5% = 0.36

*, ** = significant at 5% and 1% levels, respectively.

environment under the control of human being (Below average stability). While the mean performance of genotype UWS-59 (4.56) was higher than population mean (3.75) but regression coefficient (0.60) was lower than unity with non-significant deviation (0.11) from regression and it showed genotype greater resistance to wide range of environmental conditions (above average stability).

Root yield and component traits analysis : The stability of distinct root yield components may influence root yield stability. As a result, information on the relative stability for distinct root characteristics is required to comprehend the many mechanisms that contribute to yield stability. Among the eighteen ashwagandha genotypes, two had higher mean values than the population mean (22.96),

respectively 25.33 (UWS-48), followed by 25.56 (UWS-111) (Figure 5) and their corresponding b_i values 1.26 and 1.77 with non-significant deviation (-0.81 and 7.34) from regression for root length and showed Above average stability, it means the genotypes had greater resistant to wide range of environmental conditions (table 3.2). The mean performance of genotypes UWS-127 (16.81 mm), UWS-10 (14.87), UWS-37 (14.00 mm) and UWS-93 (12.82 mm) (Figure 6) were higher than population mean (12.14 mm) and their respective regression coefficient (b_i) 1.19, 1.87, 1.36 and 1.29 close to unity with non-significant deviation (-0.34, -0.47, -0.16 and -0.29) from regression for root diameter (table 3.2). It means the genotypes would be better perform in well suited environment (Below average stability). In UWS-48 mean performance (17.88) higher than population mean (12.14) and their regression coefficient (b_i) (0.37) less than unity, with nonsignificant deviation (-0.35) from regression, that revealed genotype was better grown under poor environment (Above average stability). Economic part of ashwagandha is root. Yield is complex trait which is contributed by several component traits, Dry root yield per plant in ashwagandha depends on several root yield components. UWS-59 (3.12 g) followed by UWS-125 (2.90g) had the highest mean value of population mean (2.27g) (Figure-7) and their respective regression coefficient b_i 1.58 and 1.77 respectively, nonsignificant deviation (0.01 and 0.34) from linear regression, revealed that below average stability (table 3.3), it means the genotype performance can be predicted over environments, genotype would give better result in good environment (Below average stability). UWS -10 followed by UWS-14 higher mean values (2.46 and 2.36) (Figure 8) than population mean (2.27) and their corresponding regression coefficient b_i (0.52 and 0.91) lower than unity and nonsignificant deviation (0.10 and 0.01) from linear regression (table 3.3), it shows above average stability and the genotype gives better perform in poor environment. Alkaloid content in dried root samples was evaluated in the laboratory. UWS-125 (0.45) and UWS-48 (0.35) (Figure 8) were higher mean values over general mean (0.34) and regression coefficient is 1.70 and 1.76 respectively, showed non-significant (0.00) (table 3.3) least deviation from regression, which indicated the below average stability of the genotype over wide range of environmental conditions for improvement of alkaloid content in ashwagandha. UWS-44 (0.44%) high mean value than population mean (0.34%) and b_i value is 0.80, non-significant deviation from regression, revealed above average stability, it means the genotype would be better growth in poor environmental conditions for improvement of alkaloid content in ashwagandha.

Discussion

The non-significance of Mean sum square due to

replications in the same environment implied that there were no significant variations among replications in that environment, while the significance of Mean sum square due to Genotype and Environment for all attributes tested against Mean sum square due to pooled deviation demonstrated that these constituents played an important role in the cognizance of quantitative traits (Manubhai, 2020). The presence of significance Mean sum square as a result of linear response indicated that the environment was random and variable, and had a tremendous effect on trait development, variations like this can occur as a result of a genotype's linear response to the environment (Subasi *et al.*, 2021). Highly significant Mean sum square due to environment (linear) indicated a linear contribution of environmental parameters on genotypic performance in the current investigation. The relevance of Genotype and Environment interaction (linear) for most characteristics pointed that environmental index might be used to predict genotype behaviors in different environments more precisely and reliably. Since the linear function of the environmental components resulted in Genotype and Environment interaction. Non-relevance responses for a few characteristics, on the other hand, showed the presence of unpredictable components. These findings suggested that these characteristics might be caused by certain reasonable predictions about Genotype and Environment interactions, as well as their unexpected components. As a result, the current report coincided with the prior results (Sangwan *et al.*, 2013). The presence of nonlinear response of genotypes to different environment was demonstrated by characteristics with high Mean sum square of nonlinear components manifesting as heterogeneity evaluated by pooled deviation. For these qualities, the genotypes vary in terms of stability, making prediction more challenging. The current studies are consistent with those of the prior report (Kumar *et al.*, 2020).

Likewise, UWS-59 for number of primary branches per plant showed trait-wise results of genotypes that indicated unique adaptability to extreme conditions. The mean values of these genotypes were greater than the population mean, but the regression coefficient was considerably lower than unity, indicating a nonsignificant deviation from linear regression. Found similar results in their stability investigation of root characteristics in ashwagandha (Sangwan *et al.*, 2013). For root length, the genotypes UWS-48 and UWS-111 would be suited for a wide range of environmental conditions. In a favorable environment, genotypes UWS-127, UWS-10, UWS-37, and UWS-93 with higher mean and regression coefficient considerably more than unity may be ideal for improving root diameter. With significant regression coefficients of 1.70 and 1.76, genotypes UWS-125 as well as UWS-48 performed better in alkaloid content. Non-significant least

deviation from linear regression suggested that such genotypes would be suited for adverse conditions. Each genotype's potential yield may be reached using a specific set of agronomic methods. As a result, it is showed that real testing in a variety of conditions, both favorable and unfavorable, would be beneficial in identifying stable genotypes (Subasi and Basalma 2021). In *withania*, the phenotypic stability of parameters directly related to root yield, such as root diameter and root length (figures 13–16), should be considered during selection. From the current study, it was concluded that, genotypes that can be used directly for breeding programme are UWS-48 and UWS-10 for flowering time, UWS-23 for maturity duration and UWS-48 and UWS-32 for plant height and UWS-59 and UWS-125 for dry root yield per plant, UWS-127, UWS-10, UWS-37 and UWS-93 for root diameter, UWS-15 and UWS-110 for number of primary branches per plant UWS-111 and UWS-48 for root length as found most stable across average environment.

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Effect of Plant Geometry on Growth, Yield and Quality of Beetroot (*Beta vulgaris* subsp. *Vulgaris* L.)

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Abstract

A field experiment was conducted to study the during *rabi* season 2020-21 at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Rajasthan). The experiment consisted of twelve treatment combinations including four nitrogen levels (control, 30 kg N/ha, 60 kg N/ha & 90 kg N/ha) and three treatments of plant geometry (15 x 10 cm, 30 x 10 cm & 45 x 10 cm) were under taken in factorial randomized block design with three replications. The results of the study clearly indicated that spacing of 30 x 10 cm to beetroot significantly. However, the spacing of 30 x 10 cm was significantly increased root diameter, length of root, shoot : root ratio, root weight.

Key words : Beetroot, geometry, nitrogen and plant.

Introduction

Beetroot could be a made source of protein, carbohydrate, calcium, phosphorus and vitamin C. Hence, it is a perfect vegetable for health aware people (Deuter and Grundy, 2004). Red colour of roots is due to presence of betanine pigment. It has many healthful properties and helps in reduction of cardiovascular diseases and peripheral vascular diseases. Beetroot helps to cut back blood pressure, prevents plaque formation and reduces bad cholesterol, keeps diabetes under check, treat anemia, facilitate to alleviate fatigue, improve sexual health and stamina, protects from cancer etc. It is rich in vitamin and does not contain vital quantity of biological process factors like fat. Beetroot could be a made supply of carbohydrate (8.8 g), protein (1.7 g/100 g), calcium (200 mg), phosphorus (55 mg), minerals (0.8 g) and vitamin C (88 mg). Green leaves are rich in iron (3.1 mg), vitamin A (2100 I.U.), thiamine (110µg) and ascorbic acid (50 mg/100 g) (Bhat, 2007).

Beetroot contains between 16-18 per cent sucrose and have a vital role within the sucrose industry (Harveson, 2011). It has the natural food that boosts the energy in athletes because it contains one of the highest nitrates and sugar contents.

In India, beetroot is mostly grown in September to November in northern plains whereas in southern plains the sowing is done from July to November while March and July in hills. The seeds are planted at a depth of about 2.5 cm to confirm good germination with 45-60 cm x 8-10 cm distance.

The growth and yield of beetroot is influence by many factors like environment, soil, nutritional, attack of pest and disease and cultivation practices. In the

nutritional, nitrogen is vital and major nutrients has great role in its production. Nitrogen plays important role physiological and chemical characteristics of the crop. So, nitrogen may cause fascinating impact on sugar beet growth and yield characters (Kadam *et al.*, 2018). Nitrogen has the best effects on root yield and quality of sugar beet (Sincik and Canigenis, 2016).

Materials and Methods

The experiment comprised of 12 treatment combinations viz., four nitrogen levels viz., control (N₁), 30 Kg/ha (N₂), 60 Kg/ha (N₃) and 90 Kg/ha (N₄) and three levels of plant spacing viz., 15 x 10 cm (S₁), 30 x 10 cm (S₂) and 45 x 10 cm (S₃). As per treatment seed are sown in different plant density. There are three treatments of plant spacing viz., 15 cm x 10 cm (S₁), 30 cm x 10 cm (S₂) and 45 cm x 10 cm (S₃).

Results and Discussion

Root length : Data Table-1 stated that the different nitrogen levels had significantly affect on the length of root. The maximum length of root (15.27 cm) was observed under treatment N₃ (60 kg N/ha) which was significantly superior over rest of the treatment except N₄ treatment *i.e.* 90 kg N per ha applied as soil application, which was found statistically at par to it. This treatment (N₃) also registered an increase of 25.88 and 8.52 per cent more length of root over control and N₂ (30 kg N/ha) treatment, respectively. The effect of different plant spacing also significantly increased the length of root (Table-4.4). The maximum length of root (14.52 cm) was recorded under the S₂ (30 X 10 cm) treatment while minimum (13.70) was noted under S₁ treatment (15 x 10 cm). Treatment S₂ showed significantly higher length of root over rest of the treatments except S₃ treatment. This

Table-1 : Effect of nitrogen and plant geometry on root length and root diameter of beetroot.

Treatments	Root length (cm)	Root diameter (cm)	Root weight (gm)	Root : Shoot ratio
Nitrogen				
N ₁ (Control)	12.13	3.68	152.45	0.84
N ₂ (30 kg/ha)	14.07	4.87	160.32	0.89
N ₃ (60 kg/ha)	15.27	5.27	181.73	1.05
N ₄ (90 kg/ha)	15.20	5.22	179.67	1.00
SEm+	0.27	0.09	3.15	0.02
CD (p=0.05)	0.77	0.27	9.02	0.05
Plant spacing				
S ₁ (15 x 10 cm)	13.70	4.26	156.85	0.89
S ₂ (30 x 10 cm)	14.52	5.06	176.25	1.00
S ₃ (45 x 10 cm)	14.28	4.97	172.52	0.96
SEm+	0.23	0.08	2.73	0.02
CD (p=0.05)	0.67	0.23	7.81	0.04

treatment (S₃) was found statistically at par. The increased in length of roots under S₂ treatment registered 5.98 per cent more length of root as compared to S₁ treatment.

Diameter of root : The data presented to diameter of root has been showed in Table-1, which recorded that the different level of nitrogen significantly influenced root diameter of beetroot. The maximum diameter (5.27 cm) was recorded in N₃ treatment (60 kg N/ha), which was found significantly higher as compared to other treatments except N₄ treatment where 90 kg N per ha applied and found significantly at par to it. This treatment (N₃) showed that increase in diameter of root was 43.20 and 8.21 per cent higher over control and N₂ (30 kg N/ha) treatment, respectively. Different plant spacing also significantly influenced the diameter of root which was varied due to the variation of spacing. The maximum diameter (5.06 cm) of root was found with S₂ treatment *i.e.* 30 x 10 cm, which was found significantly superior over rest of treatments except S₃ (45 x 10 cm) treatment. The percentage increase in diameter of root under treatment S₂ was found to be 18.77 per cent higher over S₁ treatment (15 x 10 cm) spacing kept.

Fresh root weight : The data presented in Table-1, recorded that various nitrogen levels significantly affected the fresh weight of root. The maximum fresh weight of root (181.73 g) was recorded in N₃ treatment where nitrogen was applied @ 60 kg per ha, which was found significantly superior over rest of the treatment except N₄ *i.e.* 90 kg N per ha was found significantly at par to it. The increase in fresh weight of root in N₃ treatment was 19.20 and 13.35 per cent higher over control and 30 kg N per ha treatment, respectively.

Plant spacing : Further, the data revealed that different plant spacing also influenced in fresh weight of root at (Table-1). The maximum fresh weight of root (176.25 g) was showed under treatment S₂ *i.e.* 30 x 10 cm plant spacing and found significantly higher than other

treatments except S₃ treatment which was found significantly at par to it. The increase in fresh weight of root under S₂ treatment was found 12.36 per cent higher than S₁ (15 x 10 cm) treatment.

Root to shoot ratio : The application of different level of nitrogen significantly affected the root to shoot ratio at harvest as data presented in Table-1. The maximum root to shoot ratio (1.05) was recorded under the treatment N₃ (60 kg N/ha) which was found significantly higher than other treatments, while treatment N₄ where 90 kg N was applied as soil application was found at par with N₃ treatment. The mean increase in root to shoot under the treatment N₃ was found 25 and 17.97 per cent higher over control and N₂ (30 kg N/ha) treatment, respectively.

The perusal data revealed that the different plant spacing also significantly affected of root to shoot ratio (Table 1). The maximum root to shoot ratio (1.00) was recorded under the treatment S₂ (30 x 10 cm) which was significantly higher over other treatments except S₃ (45 x 10 cm) treatment, this treatment was also found at par with S₂ treatment. The increase in root to shoot ratio under treatment S₂ was 12.35 per cent higher over S₁ (15 X 10 cm) treatment.

Similarly, the soil application of 60 kg nitrogen per ha significantly increased the yield and yield attributes like root length (15.27 cm), root diameter (5.27 cm), root to shoot ratio (1.05), fresh weight of root (181.73 g), yield per plot (26.16 kg) and yield per hectare (261.60 q) of beetroot followed by 90 kg nitrogen per ha (N₄) as reported as at par with N₃ in beetroot. The significantly important in yield and yield attributes on account of application of important nitrogen fertilization might have attributed to the translocation of nutrient from soil, further, increased vegetative growth might have provide more sites of translocation of photosynthetes, which ultimately resulted increased in yield. During this respect, increasing

nitrogen application as soil chemical recorded considerably increase length, diameter and weight of roots. The result of previous review might have similar with Shalaby *et al.* (2003) in sugarbeet, Ismail and El-Ghait (2004) in sugarbeet, Trani *et al.* (2005) in table beet, Jambukar and Wange (2006) in beetroot, Jilani *et al.* (2010) in radish and Moniruzzaman *et al.* (2013) in carrot.

Conclusions

Root yield per plot and root yield per hectare under 30 x 10 cm plant spacing better than the plant spacing of 15 x 10 cm but 45 x 10 cm plant spacing was found at par. On the basis of experimental results, it can be concluded that the application of nitrogen of 60 kg per hectare with 30 x 10 cm plant spacing was found best to obtain higher growth, yield and quality attributes of beetroot. A combination of this treatment finding also revealed the maximum net return (Rs.179624/ha) with highest B:C ratio (2.06) statistically.

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Symptomatological Study of Powdery Mildew Disease of Rose under Temperate Conditions of Kashmir

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Abstract

Powdery mildew is one of the most important diseases of rose, both under green house and field conditions. The present investigation was carried out to record the status and symptomatological development of the disease under temperate conditions of Kashmir. Disease was prevalent in all the surveyed locations with disease incidence and intensity ranging from 16.33 to 45.00 and 7.67 to 31.47 percent respectively. Disease symptoms were observed on leaves, young floral buds, sepals, receptacle, canes and stem. Disease initially appeared on leaves as scattered white powdery patches which latter covered the whole leaf. The affected leaves developed reddish discoloration with chlorotic patches and latter the leaves became brittle and finally withered. Powdery growth also appeared on the young floral buds, sepals, receptacle and canes, which appeared in scattered patches and latter covered entire receptacle and spread along the stem. Cracks developed on the receptacle and twigs as the disease progressed.

Key words : Rose, powdery mildew, status, symptomatology.

Introduction

Rose represents one of the world's most important ornamental crop with significant capital accumulation and cultural significance. Roses were domesticated thousands of years back for a variety of purposes which include its use in gardening, perfumery and for health benefits (Guoliang, 2003; Rusanov *et al.*, 2009). The genus *Rosa* contains about 200 species and is an interspecific complex of tetraploid, triploid and diploid cultivars. Roses have endured extensive reticulate evolution, including interspecific hybridization, introgression, polyploidization and about 20 rose species are presumed to have amounted to the today's dynamic hybrid rose cultivars (Smulders *et al.*, 2019). Roses are affected by wide ranges of fungal diseases of which powdery mildew caused by *Podosphaera pannosa* is among the most common diseases (Deberner and Byrne, 2014). Powdery mildew causing fungi constitute of eighteen described genera with over 900 species worldwide (Braun and Cook, 2012; Marmolejo *et al.*, 2018) and forms a large group of obligate biotrophs (Erysiphales) that infect nearly 9176 dicotyledon and 662 monocotyledon host species, with 96 percent belonging to the Apocynaceae family (Takamatsu, 2004). *P. pannosa* is one of the common pathogens occurring on rosaceous plants. It occupies the position in the Cystothecaceae tribe and in turn contains two subgenera *Podosphaera* and *Sphaerotheca*.

Powdery mildew causes huge economic losses to

roses by affecting its flower production and market acceptability. Under favorable environmental conditions, the disease can be devastating to susceptible varieties by affecting all aerial plant parts including new young succulent leaves and floral buds. Typical symptom of powdery mildew disease is the appearance of white powdery pathogen growths on affected plant parts which represents the pathogen signs and in colonized host, signs and symptoms is cohesively described. Powdery mildew pathogen penetrates into the host cell, develops haustorial complex within it for nutrient uptake and alter the physiology of host cells throughout the establishment and maintenance of infection structures (O'Connell and Panstruga, 2006; Green *et al.*, 2002). Most of the powdery mildews are predominantly ectotrophs and resides upto epidermal cells of the plants however, *Leveillula*, *Phyllactinia*, and *Pleochaeta* possess endophytic parasitism (upto parenchyma cells) in which *Leveillula* are truly endoparasites (Takamatsu, 2004). Under Kashmir condition, powdery mildew has been observed affecting the rose by affecting its vigor, flower production and quality, both under green houses and field conditions (Amin *et al.*, 2018). Use of fungicides is still considered as an effective management option for the management of powdery mildew disease of different economically important crops including rose. For scheduling the fungicide spray programme against any plant disease, the knowledge about the initial appearance and subsequent development of the disease is prerequisite. The study

entitled “Symptomatology study of powdery mildew disease of rose under temperate conditions of Kashmir” was therefore undertaken to know the symptomatology development of the disease, which shall eventually help in devising the fungicide spray schedule for the effective management of this disease under Kashmir conditions.

Materials and Methods

Status of disease : Survey to access the status of powdery mildew disease of rose was conducted in twenty different locations of district Srinagar during the cropping season 2021 and 2022. Three sites from each location and ten plants from each site were randomly selected. From each selected plant ten leaves were randomly selected. In all hundred leaves were selected from each site for recording incidence and intensity.

The per cent disease incidence was calculated using the following formula :

$$\text{Per cent disease incidence} = \frac{\text{Number of infected leaves}}{\text{Total number of leaves assessed}} \times 100$$

The disease intensity was recorded on 0-6 scale as adopted by Wanasiri *et al.* (2020); where

Disease Rating Scale	Leaf area affected (%)
0	No symptoms of powdery mildew
1	1-20
2	21-40
3	41-60
4	61-80
5	81-100

Per cent disease intensity (PDI) was calculated as per the formula :

$$\text{Per cent disease intensity} = \frac{\text{Sum of the all numerical ratings}}{\text{Total number of leaves assessed} \times \text{highest value of rating}} \times 100$$

Symptomatology : Symptomatology study was carried out during the year 2022 under natural epiphytotic conditions. Five rose plants (Hybrid tea rose cv. Edmunds) were selected and tagged for the study at Research field of Division of Floriculture and Landscaping, SKUAST-Kashmir, Shalimar campus. The selected plants were kept unsprayed throughout the growing season. The plants were observed daily for recording the symptom development. First observation was taken as soon as the initial symptoms appeared and periodic observations at weekly interval were recorded with respect to development of powdery growth, plant parts affected and for other symptoms.

Results and Discussion

Status : Powdery mildew disease of rose was prevalent at all the surveyed locations with disease incidence and intensity ranging from 16.33 to 45.00 and 7.67 to 31.47 per cent, respectively (Table-1). The highest disease incidence of 45.00 per cent was observed at Theed location followed by Teilbal (42.00%) and Iqbal Park Srinagar (39.33%) while lowest disease incidence of 16.33 per cent was observed at Badamwari. Similarly, the highest disease intensity of 31.47 per cent was at Theed followed by Teilbal (28.67%) and Iqbal Park Srinagar (26.27%), while the lowest disease intensity of 7.67 per cent was observed at Badamwari. Occurrence of rose powdery mildew has been reported from all over the world including USA (Longree, 1939; Yarwood, 1944; Mence and Hildebrandt, 1966), United Kingdom (Radclyffe, 1861; Howden, 1968; Price, 1970), China (Leuand Kao, 1975), Netherland (Hajlaoui and Belanger, 1991), Italy (Pasini *et al.*, 1997), India (Butler and Bisby, 1931; Pathak, 1967) and many other countries. The varied levels of disease incidence observed at different surveyed locations may be attributed to dissimilar cultural and management practices adopted by the farmers while raising the crop. Besides, type of rose cultivar at these locations may vary in their level of susceptibility and resistance against the disease, can be another reason leading to the variation in disease severity.

Symptomatology : Symptom development of rose powdery mildew was recorded under natural epiphytotic conditions on Hybrid tea rose cv. Edmunds (Table 2). Symptoms on leaves appeared amphigenously during the last week of may month as young fungal colonies which were irregular and whitish in colour (Fig 1a) which later covered some portion of the leaf surface in the 2nd week of June (Fig 1b). Powdery mildew also appeared on the twigs. Later on white powdery growth turned grayish white in colour. During the last week of the June the disease caused reddish spots together with light chlorotic spots on the leaf surface (Fig 1c). With the progression of the disease these reddish spots expanded during the 2nd week of July (Fig 1d). Leaves became little brittle, withered, chlorotic along with reddish necrotic spots in the last week of July (Fig 1e). On the young floral buds, sepals, receptacle and canes, white fungal growth appeared during 3rd week of June (Fig 1f). Later during 1st week of July, the fungus formed thick white mycelium that covers the whole receptacle (Fig 1g), subsequently the white mycelium turned light creamy-yellow and spreaded along the young stem (canes) during 2nd week of July. Reddish irregular patches also appear beneath the mycelium on the twigs in the 3rd week of July (Fig 1h). At the later stages, disease was characterized by the development of cracks on the receptacle and twigs during 1st and 2nd week

Table-1 : Disease status of powdery mildew disease of rose at different locations of district Srinagar.

Location	Disease Incidence (%)	Disease Intensity (%)
Indira Gandhi Memorial Tulip garden	26.33	14.93
Jawaharlal Nehru Memorial Botanical Garden	33.33	21.00
Chashme Shahi Garden	38.33	25.47
Brain	35.33	23.73
Nowpora	24.66	16.53
Nishat Garden	32.33	21.47
Shalimar Garden	34.66	23.47
Harwan Garden	23.66	15.93
Naseem Bagh, Hazratbal	38.66	23.53
Teilbal	42.00	28.67
Theed	45.00	31.47
Khanyar	25.33	17.20
Sanatnagar	19.66	13.60
Badamwari, Rainawari	16.33	7.67
Nehru Park	20.66	13.13
Zabarwan Park	27.60	18.60
Iqbal Park Srinagar	39.33	26.27
Emporium Park	21.66	14.67
Shalimar Campus, SKUAST-K	28.66	18.80
Kashmir University, Hazratbal	22.66	15.53

Table-2 : Symptomatological development of powdery mildew disease on Hybrid tea rose cv. Edmunds.

Date of observation		Symptoms on leaves	Symptoms on other plant parts
Month	Week		
May	IV	Irregular white powdery patches on upper surface	-
June	I	White powdery growth increased in size	-
June	II	White powdery growth covered whole leaf surface of affected leaves	-
June	III	White powdery growth turned grayish white	Whitish powdery growth appeared on sepals, receptacle and young twigs
June	IV	Scattered reddish discolored irregular patches developed on affected leaf tissue	White powdery growth increased in size
July	I	Reddish discolored patches increased in size	Thick white mycelium covered whole receptacle
July	II	Coalescing of reddish spots of severely infected leaves	Mycelia growth covered young twigs and white mycelia growth turned creamy-yellow
July	III	Chlorotic patches developed which were intermingled with reddish discolored leaf tissue	Reddish spots appeared on the twigs
July	IV	Affected leaves became brittle and finally withered	-
August	I	-	Mycelial growth developed cracks on the receptacle
August	II	-	Cracks also developed along the twigs

of August (Fig.-1 i,j). Symptoms observed during the present investigation are more or less similar to the symptoms described earlier by different workers (Eken, 2005; Matysiak, 2021; Shetty *et al.*, 2011; Scott, 2021; Suthaparan *et al.*, 2010; Lima *et al.*, 2019). Eken (2005) and Matysiak (2021) reported whitish to grayish powdery patches on the affected parts of the rose plant as symptoms of powdery mildew disease. Leaf chlorosis, leaf curling, premature leaf drops and in severe cases death of

affected plants has also been reported (Shetty *et al.*, 2011; Scott, 2021). However in the present study leaf drop and death of the whole plant was not observed which can be attributed to different pathogen strains, cultivar and less favorable weather conditions under Kashmir conditions. Kumar and Chandel (2018) reported that the powdery mildew severity was dependent upon meteorological factors about 97.2 per cent for the disease development.

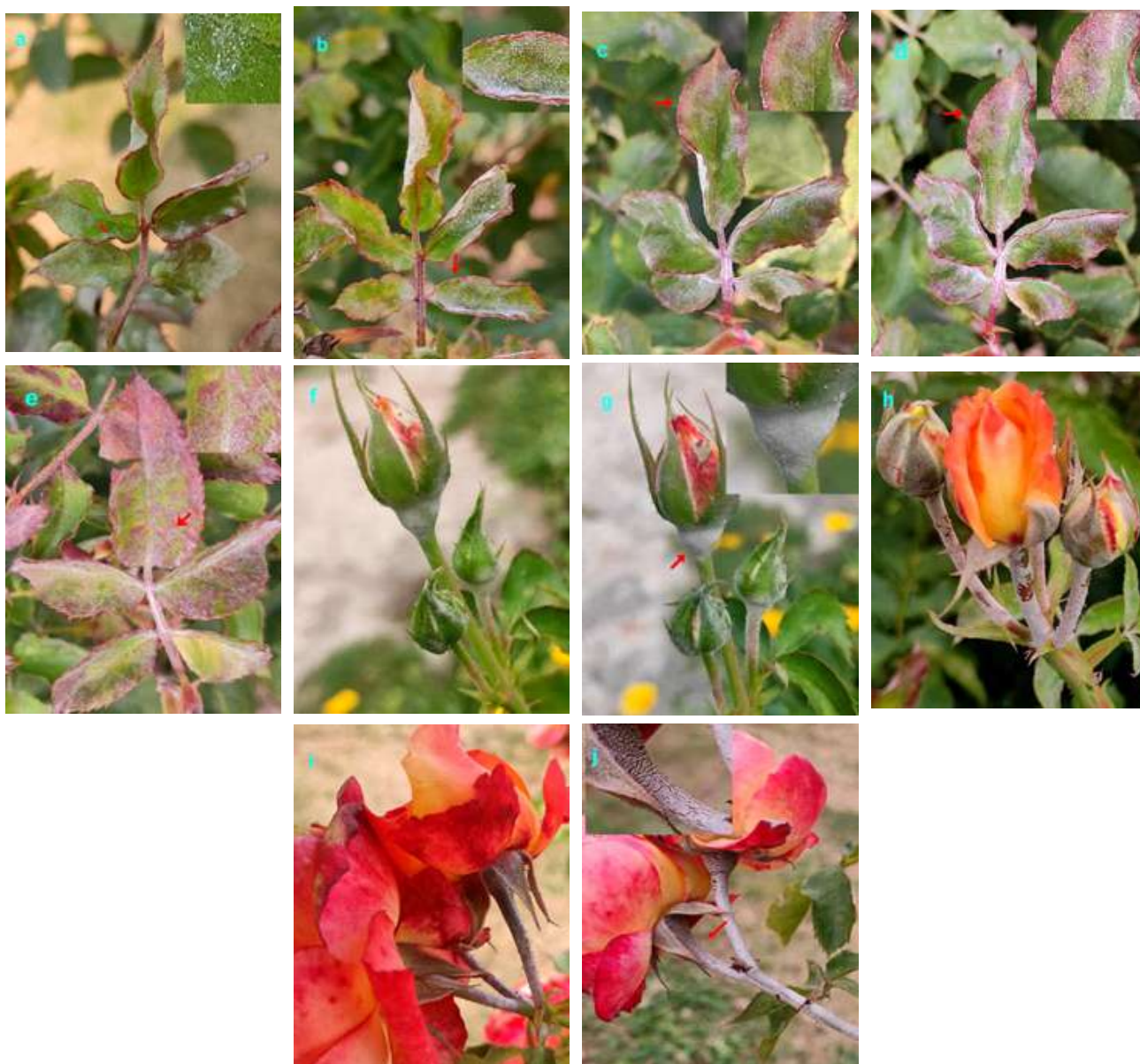


Fig-1 : Symptomatology development of rose powdery mildew :

- a-b: Powdery growth on leaves
- c-e: Reddish discoloration of affected leaves
- f-h: Powdery growth on flower buds and peduncles
- i-j: powdery growth on twigs

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Reducing Crop Vulnerability and Improving Yield of Pearl Millet under Moisture Stress Condition

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Abstract

A field experiment was conducted in RBD with three replications at AICRP on Pearl Millet, PC Unit, Jodhpur during *Kharif* 2017 and 2018 to study the effect of polymers and crop residues on the productivity, water use efficiency and microbial count of pearl millet. The performance of hybrid MPMH 17 was evaluated with ten different hydrogel and mulching treatments *i.e.* T1: Control (RDF), T2: T1 + Crop residue mulch @ 5.0 t/ha after 10-15 DAS, T3: T1 + Pusa Hydrogel dry application @ 5.0 kg/ha, T4: T1 + SPG 1118 dry application @ 5.0 kg/ha, T5: T1+ Pusa Hydrogel slurry application @ 5.0 kg/ha, T6: T1 + SPG 1118 slurry application @ 5.0 kg/ha, T7: T3 + Crop residue mulch @ 5.0 t/ha after 10-15 DAS and T8: T4 + Crop residue mulch @ 5.0 t/ha after 10-15 DAS, T9: T5 + Crop residue mulch @ 5.0 t/ha after 10-15 DAS and T10: T6 + Crop residue mulch @ 5.0 t/ha after 10-15 DAS. The maximum grain (16.5 q/ha) and stover yield (35.8 q/ha) were recorded in T8 (T4 + Crop residue mulch @ 5.0 t/ha after 10-15 DAS), which was 51.4 and 63.2% higher over the control. The stover yield was found at par T5, T7, and T8. The actinomycetes counts were found maximum in T₇ (33.9×10^5 CFU/g soil) followed by T₅ treatment (30.9×10^5 CFU/g soil).

Key words : Pearl millet, hydrogel, yield, growth, crop residue.

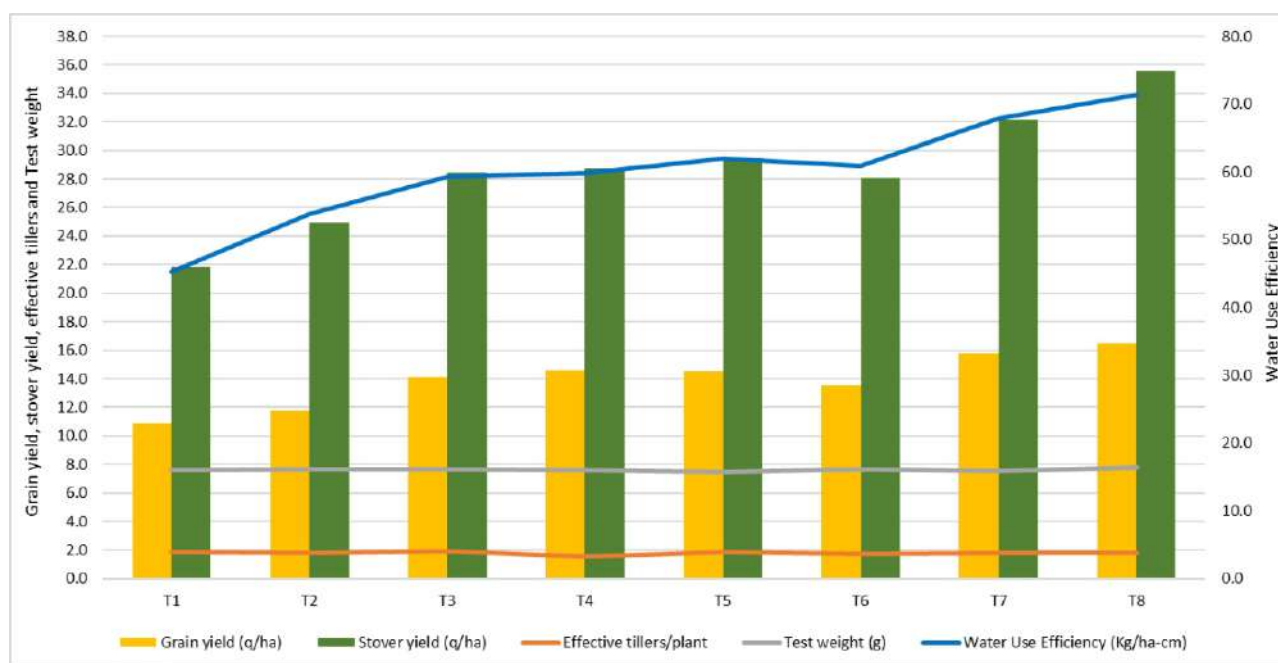
Introduction

Pearl millet (*Pennisetum glaucum* L.) is the most widely grown as staple food of poor people, small and marginal farmers in Asia and Africa. In India, pearl millet is the fourth most widely cultivated food crop after rice, wheat and maize. During 2019-20, pearl millet was grown in 7.41 million ha with an average production of 10.3 million tonnes and 1391 kg/ha productivity (1, 2). The major pearl millet growing states are Rajasthan, Maharashtra, Uttar Pradesh, Gujarat and Haryana contributing to 90% of total production in the country. Rajasthan contributes nearly 4.28 million tonnes in total pearl millet production in India. Pearl millet is grown mainly in Rajasthan where climatic condition is very harsh and drought is a common problem. Most of pearl millet in the state is grown in rainy (*Kharif*) season (June/July–September/October). Although pearl millet being a C₄ plant having high photosynthetic efficiency, more dry matter productivity and survival under adverse agro-climatic conditions with lesser inputs and more economic returns. It is critically important for food and nutritional security of humans and animals in arid and semi-arid regions that its productivity be further improved under moisture stress condition as it is - early maturing, drought tolerant, requiring minimal purchase inputs, mostly free from biotic and abiotic stresses and its inherent ability to endure high temperatures up to 42°C during reproductive phase enabling it for cultivation in adverse conditions, thus making it a *climate resilient crop*. It is well adapted to grow under most adverse agro-climatic conditions characterized by drought, low soil fertility and high temperatures.

The water is a key input for increased production and productivity. It alone can contribute up to 80-90% of grain production. Pearl millet is also grown with supplemental irrigation with high input and management condition in small pockets scattered throughout the pearl millet growing regions. However, the water resources in the state are not sufficient enough to support large area to obtain a maximum return for the input supplied. Agriculture sector consumes highest share of water (85%) as compared to industrial (15%) and domestic (5%) sectors but there is no possibility to reduce quantity of water in agriculture as it is the basis of life to produce food for everyone, hence the focus should be on agriculture sector for water saving without compromising on crop production (3). Hence, there is need to apply alternate options to maximization yield under moisture stress condition. There many types of soil moisture retainer products are being used. One of this type is hydrogel. Superabsorbent polymers (hydrogels) have been researched as potential soil amendments that could help improve soil hydraulic properties and make water more available to crops, especially in their critical growing stages (4). The hydrogel is not only used for moisture conservation, but also have enormous potential to maintain physico-chemical properties like bulk density, porosity, temperature, water holding capacity, CEC etc. and biological properties like microbial environment of the soil (5, 6). There are numerous literature reports focused on the characters and applications of hydrogels polymer. This paper focused on the application areas of the

Table-1 : Effect of hydrogel and mulching on yield and water use efficiency of pearl millet (mean of 2 years).

Treatments	Plant height (cm)	Effective tillers/plant	Test weight (g)	Grain yield (q/ha)	Stover yield (q/ha)	Water Use Efficiency (Kg/ha-cm)
T ₁	130.3	1.9	7.61	10.9	21.80	45.2
T ₂	126.8	1.8	7.68	11.8	24.97	53.8
T ₃	116.3	1.9	7.69	14.2	28.43	59.3
T ₄	121.7	1.6	7.61	14.5	28.78	59.9
T ₅	136.0	1.9	7.51	14.5	29.45	62.0
T ₆	122.3	1.8	7.68	13.5	28.05	60.9
T ₇	123.0	1.8	7.51	15.8	32.12	67.9
T ₈	129.0	1.8	7.80	16.5	35.57	71.4
CD at 5%	7.8	0.2	0.20	1.0	6.3	-
CV (%)	5.1	15.6	2.65	10.1	10.0	-



Graph-1 : Effect of Polymers and Crop Residues Treatments on Growth and Yield of Pearl Millet.

hydrogel in pearl millet i.e. water consumption and yield. In this regard, this work provides experimental results on the doses of hydrogel alone and in combination with crop residue mulch in terms of growth and yield of pearl millet along with water use efficiency of the crop.

Material and Methods

experiment was conducted in RBD with three replications at AICRP on Pearl Millet, PC Unit, Jodhpur during *Kharif* 2017 and 2018 to study the effect of polymers and crop residues on the productivity, water use efficiency and microbial count of pearl millet. The soil of the experiment field was loamy sand with low, nitrogen, medium phosphorus and high potassium content. The performance of hybrid MPMH 17 was evaluated with ten different hydrogel and mulching treatments *i.e.* T₁: Control (RDF), T₂: T₁ + Crop residue mulch @ 5.0 t/ha after 10-15 DAS, T₃: T₁ + Pusa Hydrogel dry application @ 5.0 kg/ha,

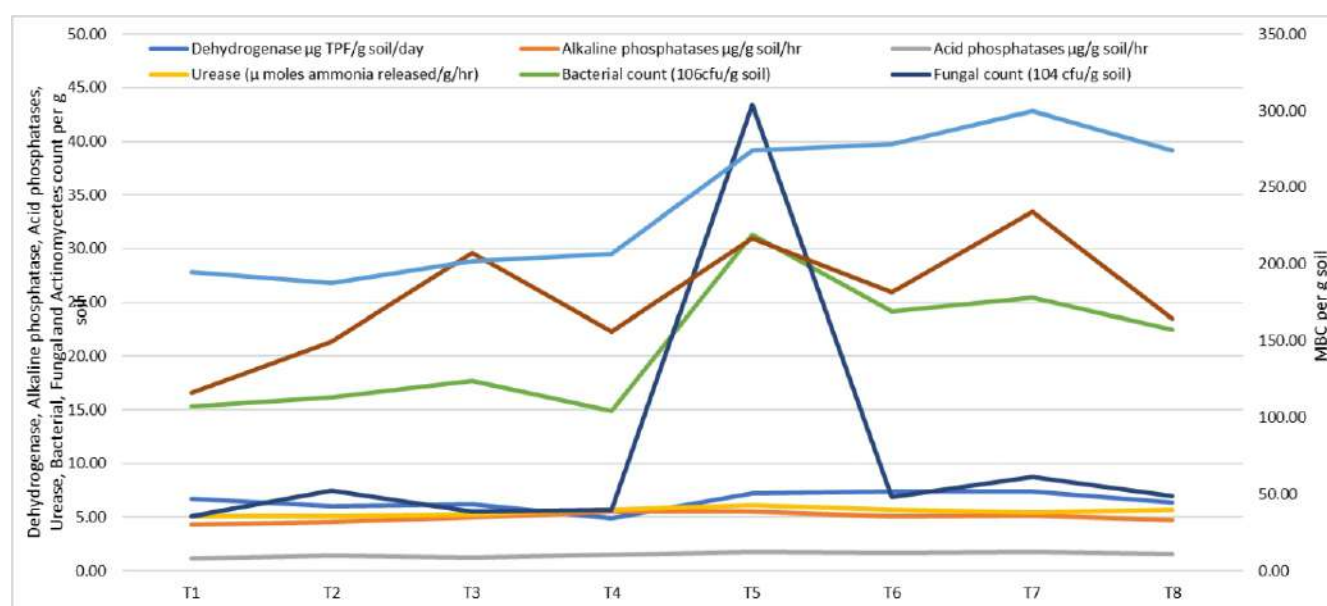
T₄: T₁ + SPG 1118 dry application @ 5.0 kg/ha, T₅: T₁ + Pusa Hydrogel slurry application @ 5.0 kg/ha, T₆: T₁ + SPG 1118 slurry application @ 5.0 kg/ha, T₇: T₃ + Crop residue mulch @ 5.0 t/ha after 10-15 DAS and T₈: T₄ + Crop residue mulch @ 5.0 t/ha after 10-15 DAS, T₉: T₅ + Crop residue mulch @ 5.0 t/ha after 10-15 DAS and T₁₀: T₆ + Crop residue mulch @ 5.0 t/ha after 10-15 DAS.

Results and Discussion

The perusal of the data in Table 1 revealed that use of crop residues, hydrogel and their combination resulted in improvement in the grain yield as compared to the control (RDF). The maximum grain (16.5 q/ha) and stover yield (35.8 q/ha) were recorded in T₈ (T₄ + Crop residue mulch @ 5.0 t/ha after 10-15 DAS), which was 51.4 and 63.2% higher over the control. Similar results were also reported by Ray et al (7) that 4 kg/ha hydrogel application recorded 34.6% higher grain yield over no hydrogel treatment

Table-2 : Effect of hydrogel and mulching on soil microbial population under pearl millet (mean of 2 years).

Treatments	Dehydrogenase g TPF/g soil/day	Alkaline phosphatases g/g soil/hr	Acid phosphatases g/g soil/hr	Urease (moles ammonia released/g/hr)	MBC g g ⁻¹ soil	Bacterial count (10 ⁶ cfu/g soil)	Fungal count (10 ⁴ cfu/g soil)	Actinomycetes count (10 ⁵ cfu/g soil)
T ₁	6.66	4.29	1.19	5.05	194.5	15.27	5.12	16.62
T ₂	5.97	4.58	1.41	5.10	187.7	16.17	7.50	21.37
T ₃	6.22	5.00	1.23	5.23	201.8	17.68	5.50	29.60
T ₄	4.87	5.47	1.51	5.70	206.7	14.88	5.65	22.25
T ₅	7.23	5.49	1.75	6.10	274.3	31.33	43.43	30.97
T ₆	7.36	5.09	1.64	5.67	278.3	24.13	6.87	25.98
T ₇	7.37	5.20	1.74	5.38	299.7	25.40	8.70	33.48
T ₈	6.35	4.76	1.61	5.68	274.0	22.45	6.97	23.48
CD at 5%	0.60	0.48	0.30	0.78	22.90	4.68	3.13	9.54
CV (%)	5.40	5.60	11.90	9.60	5.65	13.30	17.25	33.25



Graph-2 : Effect of hydrogel and mulching on soil microbial population under pearl millet.

whereas Saini (8) found higher growth and yield of pearl millet under application of 5.0 kg hydrogel/ha. The combined effect of hydrogel and mulching was still more effective in the present investigation and also earlier reports by Kasal et al (9) who reported that the treatment combination of 6 kg mulch and 100 grams hydrogel shown the significant effect on maize crop. The stover yield was significantly superior in the T₇ & T₈ treatments as compared to control (T₁) and application of 5.0 t/ha crop residues treatment (T₂). All the growth and yield attributes were found statistically at par among all the treatments. Water use efficiency (7.39 & 7.84 kg/ha-cm) was recorded maximum in the treatments T₇ & T₈ as compared to all other treatments. These results are in line with earlier reports that the grain, stover yield and WUE were significantly influenced by the hydrogel application (10)

The microbial counts studies (Table 2) revealed that dehydrogenase activity was recorded highest in the treatment T₇ (T₃ + Crop residue mulch @ 5.0 t/ha after 10-15 DAS) but statistically at par with T₁. Alkaline phosphatase population was found significantly higher in T₅ followed by T₇ being at par with all the treatments including control in the soil profile of 0-15 cm and 15-30 cm. Similar trend was also observed in acid phosphatase and urease populations. The MBC populations and bacterial count followed the trend of alkaline phosphatase. The fungal counts were found significantly superior in T₅. The actinomycetes counts were found maximum in T₇ (53.3x10⁵ CFU/g soil) followed by T₃ treatment (48.33x10⁵ CFU/g soil). The use of hydrogel composite reduced the negative effects of water-deficit stress on growth and development of plants and soil

microbial properties. However, of the magnitude of effect depended on the quantity of applied hydrogel (11). It has the extraordinary ability in improving biological properties of soil and simultaneously enhancing the water and nutrient use efficiencies and increasing the yield of various crops (12).

Conclusions

RDF + Crop residue mulch @ 5.0 t/ha after 10-15 DAS or RDF + Pusa Hydrogel slurry application @ 5.0 kg/ha can be used for higher yields of pearl millet under rainfed condition. The findings will be useful in improving productivity of pearl millet under moisture stress condition.

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Effect of Alkaline Biochar Amendments on C and Availability of Nutrients in Acid Soil

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Abstract

Rice straw biochar (RSBC), maize stover biochar (MSBC) gramme residue biochar (GRBC), and were prepared and characterized for various chemical, physical, and physico-chemical properties. 2/3rd lime requirement (LR) and all three biochars were chosen as an amendment for an acidic Alfisol. Over a 45-day span, changes in the soil's pH, exchangeable Al³⁺ and H⁺, cation exchange capacity (CEC), C, N, and micronutrient (Fe, Mn, Zn, and Cu) contents were evaluated. The greatest increases in pH of an acid soil with an initial pH of 5.05 were shown by lime (2/3rd LR) and GRBC, and all the biochars were also increased CEC and decreased the acid soil's total exchangeable acidity, exchangeable Al³⁺, and exchangeable H⁺. Available N (N_{av}), Available P (P_{av}), available K (K_{av}) and micronutrient cations contents in acid soil, increased whereas 2/3rd LR significantly decreased Mn_{av}, Zn_{av}, and Cu_{av} contents in soil. The co-benefits in terms of enhancing C contents in soil was also realised. Therefore, biochar could be an amendment efficient in maintaining fertility of acidic tropical soil along with remediation of soil acidity.

Key words : Biochar, biochar co-compost; soil acidity; soil nutrients.

Introduction

Soil acidification, impacts 30% to 40% of the world's arable land, is a significant problem in agricultural production (Kochian, 1995). Between 48 and 49 million hectares (Mha) of India's territory are thought to be covered by acidic soil, with about 25 Mha of that area having a pH below 5.5 and 23 Mha falling between 5.6 and 6.5 (Mandal, 1997). The abundance of plant nutrients and element toxicity are regulated by a diverse array of chemical and biological mechanisms that are influenced by soil acidity. The primary reasons limiting crop yield on such soils include aluminium (Al) and iron (Fe) toxicity, phosphate (P) deficiency, poor base saturation, impaired biological activity, and other acidity-induced soil fertility and plant nutritional issues (Msimbira and Smith, 2020, Kumar et al., 2012). Reclamation is therefore required to address the aforementioned problems and transform these acid soils into those that are suitable for the best crop output (Azeez, et al., 2022; Adams, 1984). The difficulty of obtaining pure/agricultural grade lime in the right amount and at the right time, as well as the higher cost associated with its procurement, are the primary barriers to using it as an amendment to reclaim acid soils. As a byproduct of the thermochemical conversion of lignocellulosic materials into advanced biofuels, biochar frequently contains a significant amount of ash that is naturally alkaline. Because it increases soil alkalinity and has the added benefit of storing carbon in the soil, it may be used as an alternative to lime (Deus et al., 2020, Weng et al., 2017). Biochar has been shown to enhance soil quality and fertility, nutrient retention, and nutrient

utilization efficiency (NUE), in addition to its environmental benefit (Nain et al., 2022; Laird et al., 2010) and it offers enormous potential for long-term carbon sequestration in soil (Yin et al., 2022; Purakayastha et al., 2015). The major limitations of using biochar alone are its poor nutrient contents and high C:N ratio. Biochar being highly porous has high surface area (wang et al., 2022; Van-Zwieten et al., 2009) and cation and anion exchange property thus, can hold more cationic and anionic forms of nutrients (Mukherjee et al., 2011). The effect of biochar on results chemical and biochemical changes in soil are the area in dark, demanding more research to be solved and henceforth, a justification for a wide range of organic wastes may be valuable. There is a paucity of information available on the effect of biochar on reclamation of acid soils and on enrichment of carbon and nutrients. So, this study will help to understand the efficacy of biochar to reclaim acid soil a prepared from rice straw, gram residue and maize stover. To address these questions, we prepared biochar from rice straw and gram residues. The biochars were characterized for various physical, chemical and physico-chemical properties. The biochars were compared with 2/3rd liming requirement for amelioration of soil acidity, enhancing cation exchange capacity, and C, N and micro nutrient cation content in soil.

Materials and Methods

Characterization of residue : Rice (*Oryza sativa* L.) straw, maize (*Zea mays* L.) stover and gram (*Cicer arietinum* L.) residue and cow dung samples were air-dried and then oven-dried in hot air oven at 60 ± 5 °C

until the attainment of constant weight. The dried plant and dung samples were ground, sieved (0.2 mm), and analyzed for total C and N of residue in a CHNS analyzer (Euro Vector make, Euro EA3000 model) by following the dry combustion method (Nelson and Sommers, 1982). The TC, TN and C:N ratio of rice straw (45.1% N, 0.46% P, 98:1 C:N), gram residue (46.5% N, 1.89% P, 25:1 C:N) estimated.

Preparation and characterisation of biochar : Rice straw, maize stover and gram residues were dried in the sun, weighted and cut into small pieces (30 - 50 mm) for preparation of biochar in an electrically operated temperature-controlled biochar maker at 400°C under constant flow of N₂ gas 1.5 min⁻¹. The temperature was increased at the rate of 2°C min⁻¹ until the final temperature reached to 400°C and kept in this temperature for 2 hours with the help of digital controller, and thereafter, pyrolysis unit was switched off to cool the chamber (Purakayastha *et al.*, 2015). Next day biochar was collected and weighted to document the conversion factor. After prepared biochar were grounded and sieved through 2 mm and 0.5 mm sieve for further analysis and stored in plastic bottles. The yield of rice straw biochar (RSBC) and gram residue biochar (GRBC) was 42, and 45%, respectively. The rice straw biochar (RSBC), Maize stover biochar (MSBC) and gram residue biochar (GRBC) was characterized for physical properties viz., bulk density (Veihmeyer and Hendrickson, 1948), particle density (Hernandez- Mena *et al.*, 2014), maximum water holding capacity (Baruah and Barthakur, 1997), ash, volatile matter, and fixed C content (Mukherjee *et al.*, 2011), pH and electrical conductivity (EC) (Lee *et al.*, 2013), cation exchange capacity (CEC) (Yuan *et al.*, 2011), calcium carbonate equivalent (CCE) (Rayment and Higginson, 1992), Total C and N contents (CHNS analyzer, Euro EA3000) by dry combustion method (Nelson and Sommers, 1982).

Three biochar as Rice straw biochar, maize stover biochar and gram residue biochar of alkaline nature was prepared by Nain *et al.*, (2022), which were characterized with respect to physical, chemical and spectral characters. In continuation with aforementioned study these biochars were selected for acid soil reclamation and to improve its fertility (Table-1 and 2).

Collection of soil samples and analysis : An acidic Alfisol (U.S. Soil Taxonomy) used in this study was collected from Ranchi, Jharkhand (85° 8' –85° 20' E, 23° 34' –23° 23' N), 612 to 691 m above m.s.l. This area has sub-humid climate with severe hot, dry summer and cool winter and average annual rainfall is about 1450 mm. The soils are red Typic Haplustalf with sandy clay loam texture and moderately acidic (pH 5.05) in reaction. The lime requirement (LR) of the acids soil was 2.45 g kg⁻¹ as measured by p-nitro phenol-triethanolamine-chromate acetate buffered at pH 7.5 (Shoemaker *et al.* 1961).

Incubation experiment : Three biochars, RSBC, MSBC, GRBC and 2/3rd of LR *i.e.*, 1.70 g CaCO₃ (laboratory grade pure) kg⁻¹ of soil and an absolute control were selected for comparisons. Air dried 2 mm sieved 80 g soil was placed in 100 ml beaker to which the biochar and biochar co-composts at the rate of 17.6 g kg⁻¹ each, CaCO₃ at the rate of 1.70 g kg⁻¹ were added, mixed uniformly with soil, and moistened to 2/3rd of maximum water holding capacity. All the beakers were covered with parafilm and incubated in a BOD incubator for 45 days at 37 °C. After 45 days of incubation, the soil samples were analysed for pH, electrical conductivity (EC), cation exchange capacity (CEC) (Jackson, 1973) and exchangeable acidity (EA) (McLean 1965). The total soil carbon (TSC) (Nelson and Sommers, 1982) was also estimated by a CHNS analyser (Euro Vector make, Euro EA3000 model). Soil inorganic C (SIC) content was determined by treating soil with dilute H₂SO₄ and trapping of CO₂ by dilute standard NaOH solution (Snyder and Trofymow, 1984). Soil organic C was estimated by the difference between TSC and SIC. Available nitrogen was measured by Alkaline potassium permanganate oxidized soil nitrogen (Subbiah and Asija, 1956), Available phosphorus was extracted by in the 0.03M NH₄F + 0.025 M HCl (Bray and kurts, 1945) was determined colorimetrically by ascorbic acid method (Watanabe and Olsen, 1965). DTPA extractable micronutrient cations, were determined by extracting soil by DTPA (Lindsay and Norvell, 1978) followed by AAS analysis.

Statistical analysis : Completely randomized design (CRD) was used for statistical analysis of data. Analysis of variance (ANOVA) was used for significance of data in a Window-based SPSS program. The mean data was separated by Duncan's Multiple Range Test at 5% level of significance.

Result

Properties of Biochar

Physical and physicochemical properties of Biochars

The pH_w and electrical conductivity (EC) of the biochar in water suspension (1: 10 w/v) and calcium carbonate equivalent (CCE) varied widely among the different types of feed stock used in the study. The highest pH (9.51) was recorded in GRBC, while the lowest was recorded in the MSBC (7.86) (Table 1) and the pH of RSBC (8.20) was in between the above two. The EC of the biochar varied from 4.16 dS m⁻¹ for MSBC to 6.56 dS m⁻¹ for GRBC. The CCE was observed highest in GRBC (42.1%), followed by RSBC (36.6%) and MSBC (29.7%). The cation exchange capacity (CEC) was recorded highest in GRBC [57.8 cmol (p+) kg⁻¹], while it was lowest in MSBC [54.2 cmol (p+) kg⁻¹] and RSBC was in between the above two.

GRBC had the highest BD of 0.27 Mg m⁻³ followed

Table-1 : Physical and chemical properties of biochar.

Parameter	Rice straw biochar	Maize stover biochar	Gram residue biochar
pH	8.20b [§] ± 1.34	7.86c ± 1.28	9.51a ± 1.55
EC (dS m ⁻¹)	6.19b ± 1.01	4.16c ± 0.68	6.56a ± 1.07
CEC [cmol (p ⁺) kg ⁻¹]	56.5a ± 9.23	54.2b ± 8.85	57.8a ± 9.44
CCE (%)	36.6b ± 5.98	29.7c ± 4.85	42.1a ± 6.88
BD (Mg m ⁻³)	0.21b ± 0.03	0.23b ± 0.04	0.27a ± 0.04
PD (Mg m ⁻³)	0.40b ± 0.07	0.43b ± 0.07	0.57a ± 0.09
Porosity (%)	48b ± 7.84	47b ± 7.68	53a ± 8.66
Moisture (%)	5.86b ± 0.96	6.80a ± 1.11	3.20c ± 0.52
MWHC (%)	593b ± 96.84	586b ± 95.69	660c ± 107.78
VM (%)	27.0a ± 4.41	23.0b ± 3.76	21.0c ± 3.43
Ash (%)	37.1b ± 6.06	31.1c ± 5.08	39.1a ± 6.39
C (%)	57.6c ± 9.41	62.6a ± 10.22	58.4b ± 9.54
N (%)	0.68b ± 0.11	0.67b ± 0.11	1.69a ± 0.28
C : N	85:1b ± 0.41	94:1a ± 0.49	35:1c ± 0.05

[§]Data followed by different lower-case letters in a row representing specific property is significant according to Duncan's Multiple Range Test at p = 0.05.

Data followed by ± representing Standard Deviation

EC: Electrical conductivity; CEC: Cation exchange capacity; CCE: Calcium carbonate equivalent; BD: Bulk density; PD: Particle density; MWHC: Maximum water holding capacity, VM: Volatile matter.

Table-2 : Total and water-soluble elemental composition of biochar.

Biochar		RSBC		MSBC		GRBC	
		T	WS	T	WS	T	WS
P	(%)	0.18	0.1	0.26	0.07	0.2	0.1
K	(%)	3.2	3	3.08	0.24	3.76	3.2
Na	(%)	0.69	0.23	1.5	1.13	0.39	0.17
Ca	(%)	4.65	0.25	2.21	1.45	5.16	0.31
Mg	(%)	1.14	0.14	1.12	0.7	1.28	0.16
Fe	(ppm)	3800	15.1	1825	20.7	909	5.3
Mn	(ppm)	119	4.8	229	8	130	5
Zn	(ppm)	154	69	1865	149	314	78
Cu	(ppm)	25	24	55	15.6	20	8.1
Cr	(ppm)	1.5	0.7	1.4	0.34	1.5	0.35
B	(ppm)	286	216	1121	244	305	273
Mo	(ppm)	25.2	2.2	9.1	2.4	4.3	1.3
Co	(ppm)	2.9	0.25	2.8	0.59	2.2	0.23
Ni	(ppm)	15	1.4	25.2	2.8	14.7	2.1
Se	(ppm)	43.9	0.15	115.2	0.83	33.03	0.13
As	(ppm)	0.16	0.33	1.64	0.54	0.95	0.53
Cd	(ppm)	0.42	0.05	0.49	0.32	0.42	0.11
Pb	(ppm)	0.86	0.7	3.5	1.7	0.1	N/A

by MSBC (0.23 Mg m⁻³) and RSBC (0.21 Mg m⁻³). A similar trend was also observed in the case of particle density (PD). GRBC recorded highest PD to the tune of 0.57 Mg m⁻³ followed by MSBC (0.43 Mg m⁻³) and RSBC (0.4 Mg m⁻³) (Table 4.1.2). The maximum water holding capacity (MWHC) of biochar varied widely and ranging in between 413% to 660%. Among the biochar produced

from different residues, the GRBC had the lowest MWHC value of 413%, while the MSBC had the highest MWHC value of 660% and the RSBC had shown 593% MWHC. The moisture content of biochar varied from 3.2% (GRBC) to 6.8% (MSBC), with in between value of 5.86% for RSBC. The ash and volatile matter contents in biochar also varied across various biochar. The ash content in

Table-3 : Effect of biochar, and lime amendments on properties of acidic soil.

Treatment	T1: RSBC	T2: MSBC	T3: GRBC	T4: 2/3rd LR	T5: Control
pH	6.46§c	6.32de	6.86a	6.88a	5.05f
EC (dSm ⁻¹)	0.69c	0.68c	0.58d	0.55d	0.31e
CEC [cmol (p+) kg ⁻¹]	10.59c	10.62c	12.01b	12.72a	9.12g
Ex A [cmol (p+) kg ⁻¹]	0.77g	0.88f	0.90f	0.83fg	1.50a
Ex Al ³⁺	0.53e	0.64cd	0.62d	0.72c	1.10a
Ex. H ⁺	0.23c	0.24c	0.28bc	0.11d	0.40a
TSC (g kg ⁻¹)	11.5a	11.8a	11.5a	7.70b	5.73c
SIC	3.47b	3.69a	3.50b	1.75c	0.65e
SOC	8.03a	8.11a	8.00a	5.95b	5.08c
TSN (g kg ⁻¹)	0.863b	0.823b	0.940a	0.680c	0.643c
Nav	0.125b	0.134b	0.168a	0.113b	0.092c
Pav Mg kg ⁻¹	38.a	35.5b	38.3a	35.7c	13.0d
Fe (mg kg ⁻¹)	41.7c	41.8c	41.4c	45.2c	41.4c
Mn	38.4cd	38.6cd	38.5cd	28.5e	84.5a
Zn	3.94bc	4.64b	4.01bc	2.44d	3.34c
Cu	1.99b	1.66bc	1.52bcd	1.08d	1.26cd

EA: -Total exchangeable acidity, Ex Al³⁺: - exchangeable Al³⁺, and H⁺: - exchangeable H⁺RSBC- Rice straw biochar; MSBC- Maize stover biochar; GRBC- Gram residue biochar; LR-Lime requirement. §Data followed by different lower-case letters in a row representing specific property is significant according to Duncan's Multiple Range Test at $p = 0.05$.

Data followed by $\pm$ representing Standard Deviation.

RSBC, MSBC and GRBC was 37.1, 31.1 and 39.1%, respectively. The volatile matter in RSBC, MSBC and GRBC were 27, 23 and 31%, respectively. The total C (TC), total N (TN) contents and C/N of different biochar were presented in Table 4.1.3. The TC content of biochars varied from 57.6, 62.6 and 58.4% for RSBC, MSBC and GRBC, respectively. The TN content of biochar varied from 0.67 to 1.69% and it was recorded highest in GRBC with the value of 1.69% followed by RSBC and MSBC with the value of 0.68% and 0.67%, respectively. The TC and TN content of all three biochar provided these biochar C/N of 85, 94 and 35 for RSBC, MSBC and GRBC, respectively.

Total elemental composition of biochar : Total elemental composition of the biochar prepared from different residues at 400oC is presented in Table 2. In all the three biochar, the major nutrients found were P, K, Na, Ca, Mg and Fe. Total phosphorus (P_{tot}) in MSBC, GRBC and RSBC were recorded as 2.60, 2.01 and 1.82%, respectively. Among the three biochar, total K (K_{tot}) content was highest in GRBC with a value of 3.76% followed by RSBC and MSBC with the value of 3.20, 3.08%, respectively. Total Na (Na_{tot}) in RSBC was lowest with a value of 0.39% and it was observed highest in MSBC with the value of 1.5%. RSBC recorded a value of 0.69%. Total Ca (Ca_{tot}) and Mg (Mg_{tot}) contents were recorded highest in GRBC with the value of 5.17% and 1.28%, respectively. MSBC was lowest in Ca_{tot} and Mg_{tot}

contents with the value of 2.21% and 1.12%, respectively. RSBC recorded 4.65% and 1.15% of Ca_{tot} and Mg_{tot} respectively. Among all the micronutrient cations, total Fe (Fe_{tot}) content was invariably higher in all the biochars ranged from 909 ppm (GRBC) to 3800 ppm (RSBC). MSBC showed 1825 ppm of Fe_{tot}. MSBC had shown highest contents total Mn (Mn_{tot}), Zn (Zn_{tot}) and Cu (Cu_{tot}), with value of 229, 1865 and 55 ppm, respectively. GRBC had 130, 314 and 20 ppm of Mn_{tot}, Zn_{tot} and Cu_{tot}, respectively. RSBC had 119, 154 and 25 ppm of Mn_{tot}, Zn_{tot} and Cu_{tot}, respectively. Total boron (B_{tot}) contents were 286 and 1121 ppm in MSBC and RSBC, respectively, while it was 305 ppm in GRBC. Heavy metals like Cr, Mo, Co, Ni, Se, As, Cd and Pb. were also present in biochar. The Cr_{tot} content in all the three biochar was near to 1.5 ppm. Similarly, Co_{tot} and Cd_{tot} contents were between 1.5 to 2.8 ppm in all the three biochar. RSBC recorded highest amount of Mo_{tot} (25.2 ppm) followed by MSBC (9.12 ppm) and GRBC (4.35 ppm) whereas Ni_{tot} content was highest MSBC (25.2 ppm) followed by RSBC (15.0ppm) and GRBC (14.7 ppm). Similar pattern was also observed in the case of Se_{tot} and Pb_{tot}, where MSBC showed highest content of Se_{tot} (115 ppm) and Pb_{tot} (3.57 ppm). RSBC secured the second place having 44.0 and 0.86 ppm of Se_{tot} and Pb_{tot}, respectively. The GRBC showed 33.0 and 0.107 ppm of Se_{tot} and Pb_{tot}, respectively. MSBC showed the highest content of As_{tot} (1.64 ppm) followed by GRBC (0.953 ppm) and MSBC (0.157 ppm).

Water-soluble elemental composition of biochar : The major water-soluble (ws) elements as determined from biochar-water extract were P_{ws} , K_{ws} , Ca_{ws} , Mg_{ws} and Na_{ws} (Table 4.1.5). GRBC was recorded to have notably higher amount of water-soluble K (K_{ws}) (3.2%) followed by RSBC (3.4%) and MSBC (0.242%). The water-soluble Na (Na_{ws}) content was observed highest in MSBC with the value of 1.13% followed by RSBC with 0.23% and 0.17% in GRBC. In the case of water-soluble P (P_{ws}), first, second and third places were secured by RSBC, GRBC and MSBC with the value of 1.03, 1.02 and 0.71%, respectively. The water-soluble Ca (Ca_{ws}) and Mg (Mg_{ws}) contents were recorded highest in MSBC with value of 1.5 and 0.70%, respectively. RSBC had shown lowest content of Ca_{ws} and Mg_{ws} with the value of 0.25 and 0.14%, respectively. GRBC had 0.31 and 0.16% Ca_{ws} and Mg_{ws} , respectively. Among all the micronutrient cations water-soluble Zn (Zn_{ws}) in all the biochar ranged from 69 ppm (RSBC) to 149 ppm (MSBC). GRBC had shown 78 ppm of Zn_{ws} .

Effect of biochar and lime amendments on changes in pH, electrical conductivity (EC), and cation exchange capacity (CEC) of an acid soil : Among all the treatments, the application of lime (2/3rd LR), GRBC showed the highest increments in pH of 6.88, 6.86, and 6.76, respectively of an acid soil having original pH 5.05. All the amendment treatments significantly increased the EC of soil. All the biochar performed well in reducing total exchangeable acidity. The biochars being at par with 2/3rd LR was most effective in reducing total exchangeable acidity of acid soil. In the exchangeable Al^{3+} content of acid soil was decreased most effectively by RSBC [from 1.10 to 0.53 cmol (p^+) kg^{-1}] which was followed by GRBC [0.62 cmol (p^+) kg^{-1}] and MSBC [0.64 cmol (p^+) kg^{-1}]. Lime was found most effective in reduction of exchangeable H^+ [from 0.40 to 0.11 cmol (p^+) kg^{-1}] followed by RS + GRBC (7:1) [0.17 cmol (p^+) kg^{-1}]. CEC of soil was recorded highest in lime treatment [12.72 cmol (p^+) kg^{-1}] followed by GRBC [12.01 cmol (p^+) kg^{-1}], MSBC [10.62 cmol (p^+) kg^{-1}], and RSBC [10.59 cmol (p^+) kg^{-1}].

Effect of biochar and lime amendments on carbon, availability of nutrients in an acid soil : The three biochars significantly enhances TSC, SOC and SIC contents in acid soil. Among all the amendment treatments 2/3rd LR showed least C contents in soil. The TSN was recorded highest in GRBC treatment (0.94 g kg^{-1}) with 47% increments, while other treatments except 2/3rd LR, on an average, showed 32% increase in TSN content. The 2/3rd LR ranked third jointly with the control treatment with respect to TSN content. Available N (N_{av}) content in soil followed almost similar trend as of TSN contents except 2/3rd LR which was significantly higher over the control treatment. Available P (P_{av}) in RSBC (56.7 mg kg^{-1}), and GRBC (56.7 mg kg^{-1}) being at par with

each other showed significantly higher P_{av} over the rest of the treatments. GRBC (245 mg kg^{-1}) showed highest available K (K_{av}) content in soil followed by RSBC (195 mg kg^{-1}) and 2/3rd LR (133 mg kg^{-1}), and MSBC (121 mg kg^{-1}) and increased the K_{av} contents in soil by 245, 195, 133, and 121%, respectively, over the control treatment. In general, the available Fe (Fe_{av}) content in soil was higher in biochar treatment. The available Mn (Mn_{av}), available Zn (Zn_{av}) and available Cu (Cu_{av}) contents in soil was highest in biochar treatments. It is worth mentioning that 2/3rd LR significantly decreased Mn_{av} , Zn_{av} , and Cu_{av} contents in soil.

Discussions

Properties of Biochar : This higher pH of biochar was ascribed to the factors which include organic functional groups and inorganic minerals forms due to charring residues at higher temperature (Yuan *et al.*, 2011;). The difference in pH_w of the different residue derived biochar was due to the difference in initial composition of the residues, ash content or inorganic fraction content and composition and organic fraction (Enders *et al.*, 2012). Like pH, the EC of biochars' is also reliant on the type of feedstock. The EC of the biochar also varied across the various feedstock used for preparation of biochar and depend upon its ash content (Song and Guo, 2012). CCE increased with increasing pH (Table 1) is strongly correlated with the ash content of biochar linearly thus to the pH_w also. Fraction of the ash (e.g., alkaline oxides, carbonates) in biochar can offer considerable alkalinity (Vassilev *et al.*, 2013a). GRBC had shown highest CCE off 42.1% followed by RSBC and MSBC biochar with 36.6 and 29.7% respectively. The presence of carbonates in biochar was also confirmed by X-ray diffraction done to characterize the mineral present in biochar samples (previous study of author: Nain *et al.*, 2022). It was testified that the higher contents of basic cations, carbonates and organic anions significantly contributed to the high alkalinity in biochar (Chintala *et al.*, 2014). FTIR spectra of biochar also showed lower absorption of energy at 3405-3408 cm^{-1} in GRBC and RSBC biochar indicating lesser amount of $RCOO^-$, Ph-OH (Pastorova *et al.*, 1994, Wu *et al.*, 2012, Bera, 2014), while higher absorption of energy in the phenolic- OH bending region 1381.15 to 1433.93 cm^{-1} (Bera *et al.*, 2017); showing high CEC in RSBC and GRBC than MSBC. In addition to the aliphatic moieties, Mukherjee *et al.* (2011) ascribed the CEC of biochar was due to the volatile matter (VM) present in the biochar matrix, which is lowest in case of GRBC (21%) and highest for RSBC (27%). So, CEC is a combine effect of many functional group and volatile moieties

The low bulk density of our biochar samples might be due to the larger size of the biochar particles (2 mm) than size of the biochar particles (0.5 mm) used by

Purakayastha *et al.* (2015). The residues used in our study are of non woody nature which also may be the reason behind the lower BD of biochars. The PD was higher than the BD as biochar is highly porous material (Antal and Gronli, 2003) was found reasonably and positively correlated with ash content (Bera *et al.*, 2017). Increasing ash content of biochar, from MSBC (31.12%) to GRBC (39.13%) could be an explanation to the increase in PD of biochar. The water holding capacity of biochars in our study showed the value 413, 593 and 660% for GRBC, RSBC and MSBC respectively. At lower temperature (400°C) the hydrophilic functional group did not start formation, cause water repellancy and thus low water holding capacity (Keiluweit *et al.*, 2010).

The nutrient content in biochar is mainly governed by the type of feedstock and also by pyrolysis temperature (Cantrell *et al.*, 2012). Major elements are present in biomass in large amounts; these elements are silica, calcium, potassium, sodium and magnesium. Minor minerals are present in smaller amounts and include sulphur, phosphorus, iron and manganese. Both major and minor minerals occur as oxides, silicates, carbonates, sulphates, chlorides and phosphates in biochar (Raveendran *et al.*, 1995). Simply, a part of total Ca, Mg, and P were water soluble against 94-80% K_{ws} in biochars. This indicates the formation of water-soluble K minerals and comparatively insoluble Ca, Mg, and P-bearing minerals in biochars. X-ray diffraction analysis of biochars and identification of minerals confirmed these findings. Greater water-soluble P (55.6, 26.9 and 50% for RSBC, MSBC and GRBC) (low-temperature biochars) was perhaps due to loss of carbon and the formation of less crystallized P-linked minerals (Bera *et al.*, 2017). The IR spectroscopy and X-ray diffraction analysis also displayed ample dissimilarity in the spectra in all three biochar samples. High K_{ws} and K_{tot} in all the biochar could explain the presence of sylvite mineral identified in the X-ray diffractogram and also confirmed by SEM-EDX images (Previous study by Authors Nain *et al.*, 2022). Similarly, the Ca and Mg were also present as calcite and dolomite mineral (Wu *et al.*, 2012). IR spectra also indicate the presence of chloride and carbonate in the biochar (Yuan *et al.*, 2011).

Effect of biochar on soil properties : Total soil C (TSC), soil organic C (SOC), and soil inorganic C (SIC) contents in soil amended biochars and 2/3rd LR (2/3rd Lime Requirement) were estimated after 45 days of incubation (Table 3). Invariably the biochars outperformed the lime treatment with respect to TSC 102%. Higher carbon content in the biochar leads to the increase TSC of the soils (Bera *et al.*, 2019) and due to relative inertness, biochar application contributes to the soil refractory C pool (Glaser *et al.*, 2001). The SOC contents also followed the

same trend as of TSC contents but the magnitude of increase in SOC content over the control was less than the TSC content. As compared to control, on an average the biochar treatments showed 58% increase in SOC content. Depending on the feedstock quality and volatile matter content, biochar has been found to increase the SOC over time in field as well as laboratory condition. Biochar have carbonate and bicarbonates which significantly contributed to SIC contents in soil as reported by others (Singh *et al.*, 2010)

Also, biochar was found superior in increasing the total soil N (TSN) content due to higher amount of N existing in biochars (Table 3). Available N (N_{av}) contents in soil followed almost similar trend as of TSN contents except 2/3rd LR which was significantly higher over the control treatment. The N_{av} content in soil was recorded highest in GRBC treatment (0.17 g kg⁻¹) over the control (0.09 g kg⁻¹), showing 82% increment over control. Biochar application significantly affects the mineralization-immobilization turnover of nutrients, which is modified by changing both microbial activities and community. Since biochar is a C-rich substrate with a high C/N ratio, upon its application to the soil, microorganisms are triggered to decompose the native soil organic matter (SOM) to acquire N via priming effect (Blagodatskaya and Kuzyakov, 2008). Biochar being rich in surface functional groups, including aromatic moieties, can alter cation and anion exchange capacities of soils, which further influences N retention also increases the cation exchange capacity (CEC), and consequently the ability for nutrient retention, e.g., NH_4^+ , which could improve soil fertility (Clough and Condon, 2010).

Available P (P_{av}) content in soil increased due to the application of various amendments. The P_{av} is generally low in acid soils because of its high P fixing capacity (DeLuca *et al.*, 2009). In this respect, biochar, produced from common crop residues could influence P transformation in soils directly or indirectly by three major mechanisms: (1) being a direct source of soluble P and exchangeable P, (2) modifying the soil pH and ameliorating various elements (e.g., Al^{3+} , Fe^{3+} , Fe^{2+} , Ca^{2+} , Mg^{2+}) that are responsible for making complex with P, and (3) acting as a source of C and energy for enhancing the microbial activities and P mineralization (DeLuca *et al.*, 2009). It was observed that the water-soluble P content was higher in RSBC and GRBC than MSBC (Table 2). and this information supports why RSBC and GRBC showed higher P_{av} than MSBC in soil. Biochars of alkaline nature have a liming effect on acid soils, therefore enhanced soil pH does proliferate negative charge which in order decreases sorption of P on soil clay mineral surfaces (DeLuca *et al.*, 2009). Due to the Interactions in between soil minerals and biochar may alter the surface

properties of soil minerals (Singh and Kookana, 2009), and influence sorption of P; accordingly, the availability of P. Liming also increases the amount of available P due to its effect on mineralisation and the pH of soil, as lime, in its most pure form, is made up of largely of Ca. Liming also stimulates microbial activity resulting enhancement of enzymatic activity (Acosta-Martinez and Tabatabai, 2000) thus enhances the available P content.

Since biochar and co-composts contain micronutrients like Fe, Mn, Zn, and Cu, therefore their application in soil could increase DTPA-extractable (available) micronutrient contents in soil. The increased nutrient content caused by biochar could be explained in part by the increased CEC of the growth media, and a reduction in nutrient leaching (Zhang *et al.*, 2016). But alkalinity provided by biochar can override the influence of micronutrient cations on the surface of biochar. No significant difference was noticed with respect to Fe_{av} content in soil amended with biochar, in spite of having water-soluble micronutrients. Biochar, on the other hand, reduced the Mn_{av} content in soil but they significantly increased Cu_{av} and Zn_{av} contents. Reduced or no effect on Fe_{av} , and Mn_{av} availability was noticed because of soil pH-induced micronutrient inactivation. This can be substantiated by the study conducted by Rogovska *et al.* (2014) who reported that among the micronutrients, soil extractable Mn and Fe decreased, while Cu and Zn increased due to the application of a mixed wood biochar.

Conclusions

The physical, chemical and physico-chemical properties of biochar could be effectively used to explain their behaviour as liming materials in acid soil from Ranchi, Jharkhand. Gram residue biochar (GRBC), maize stover biochar (MSBC), and rice straw biochar (RSBC) emerged as promising liming materials which were comparable with 2/3rd LR for neutralization of acidity and enhancing CEC of acid soil. In terms of other co-benefits derived out of different amendments, biochar was found most effective in enhancing C, N, P, K, and micronutrient contents (except Fe) and biological health of soil. The conventional remediation measure like 2/3rd LR, though, was effective in neutralising soil acidity but additional co-benefits in terms of enrichment soil C, increasing availability of nutrients, and overall biological health, it performed inferior to biochar. Therefore, biochar/ could be alternative to lime for remediation of acid soil. As the one-time application of biochar or for remediation of acid soil to raise the pH on an average over 6.5 is very high (17.6 g kg^{-1} soil), it is suggested that the rate could be divided into several splits for their applications to acid soil. As the results of the study are emanated from controlled laboratory experiments, these are indicative only, and,

therefore, further confirmation is needed through full scale field experimentation before recommendation.

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Empirical Relationship Between Prices and Arrivals of Mustard and Cumin in Rajasthan

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Abstract

Present study was undertaken by collecting monthly wholesale prices of cumin and mustard bean in Rajasthan. This study was based on the secondary data on arrival and prices of cumin and mustard in selected A.P.M.Cs., of Rajasthan for the period of 11 years i.e., from 2010-11 up to 2020-21. In the analysis the year wise correlation between monthly prices and arrivals of cumin and mustard shows negative and statistically non-significant relationship for most of the years. The findings of correlation analysis on monthly prices and arrivals of cumin during 11 years (2010-11 to 2020-21) showed that the negative and statistically significant correlation between prices and arrivals only in Jaipur mandi, while in case of mustard the correlation between prices and arrivals was positive (0.173) and statistically significant for the selected period in Jaipur mandi. The coefficient of variations (2010-11 to 2020-21) in prices of cumin was found to be highest in Jaipur, while for arrivals it was highest in Ajmer. For mustard coefficient of variations of prices and arrivals was highest in Sri Ganganagar.

Key words : Correlation, coefficient of variation, prices and arrivals.

Introduction

India has the second-largest arable land resources in the world. With 20 agro-climatic regions, all the 15 major climates in the world exist in India. The country also has 46 of the 60 soil types in the world. Agriculture plays a vital role in India's economy. 54.6 per cent of the total workforce is engaged in agriculture and allied sector activities (Census 2011). The share of agriculture in GDP increased to 19.9 per cent in 2020-21 from 17.8 per cent in 2019-20. Gross Value Added by agriculture, forestry, and fishing was estimated at ₹. 19.48 lakh crore (US\$ 276.37 billion) in FY20. According to the estimate, the share of the agriculture and allied sector in total GVA has improved to 20.2 percent in 2020-21 and 18.8 percent in 2021-22. India can be among the top five exporters of agro-commodities by shifting its focus on cultivation and effectively handholding farmers, according to the World Trade Centre. The total agricultural and allied products exports stood at US\$ 41.25 billion in FY2021 (Annual Report, Economic Survey 2020-21).

According to the fourth advance estimates for 2020-21, total food grain production in the country is estimated at a record 308.65 million tonnes, which is 11.15 million tonnes higher than that production of food grains of 297.50 million tonnes achieved during 2019-20. For FY 2021-22, the government has set a target to increase production by 3.9%. Production of horticulture crops in India reached a record 331.05 million metric tonnes (MMT) in 2020-21 (as per 3rd advance estimate), an increase of 10.5 million metric tonnes over FY2020.

The production of fruits, flowers, spices and honey is expected to rise (Agricultural Statistics at a Glance 2020-21).

Total oilseeds production in the country during 2020-21 was estimated at record 36.10 million tonnes which was higher by 3.35 million tonnes than the production of 33.22 million tonnes during 2019-20. Further, the production of oilseeds during 2020-21 was higher by 6.02 million tonnes than the average oilseeds production. Oilseed production in India has steadily increased since 2016-17 onward after showing a fluctuating trend prior to that. The survey estimated that the oilseed production in the country has grown by nearly 43 percent from 2015-16 to 2020-21. India has the largest livestock population of around 535.78 million, which translates to around 31% of the world population (Agricultural Statistics at a Glance, 2020-21).

Agricultural marketing plays a significant role in the movement of commodity from the producer to the consumer and in stabilizing the prices. Agricultural marketing plays an important role not only in stimulating production and consumption, but in accelerating the pace of economic development. The planned increase in agricultural output must be coordinated with changes in the demand and supply for agricultural commodities and marketing. This can be fruitful only when the producer's share in consumer's rupee increase considerably irrespective of the volume of the marketable surplus produced with the farmers. Therefore, marketing is rightly considered as an essential input in addition to improved

seed and fertilizer in modern agriculture (<https://indiaagronet.com>).

Prices are mirror of economy of the country. In general, prices for agricultural products are highly unstable compared to non-agricultural products. This price instability is directly linked to the biological nature of agricultural production (which suffers from climate instability or pests), also implying the difference between planned production and production obtained. Stable prices play an important role to determine the farm income. Agriculture supply is uncertain and this uncertainty in supply leads to fluctuations in prices. It is said that next to rains, prices are the greatest enemy of the farmer. As per price theory, prices are a function of demand and supply, but demand and supply are independently related to prices (Rastogi and Athaley, 2019). Agriculture being a biological industry and monsoon dependent lead to uncertainty in supplies of agricultural commodities and this uncertainty in supply leads to fluctuations in prices. The wide fluctuations affect the farmer's capacity of making sustained efforts for increasing production. This fluctuation in prices of agricultural commodity is greatest obstacle in the way of agricultural development (Benke, 2016).

The seasonal nature of agricultural production itself leads to price fluctuations. Seasonal variations also influence monthly price changes, as some crops can only be harvested once or twice a year, and for some of them, the possibility of storage is impractical. Hence price fluctuation in agricultural commodities is a common phenomenon due to their seasonal nature of production, wide ecological imbalances compared to other crops and seasonal demand for agricultural commodities (Thakare, Daundkar, Rathod and Bondar, 2017).

It is necessary to study the fluctuations in the monthly average price of agricultural commodities in various markets which help farmer to plan their sale. Considering this objective, the study of the relationship between market arrivals and prices is very useful. Larger production and larger arrivals affect adversely to the prices. As a result, the prices usually go down. The market information relating to market prices and arrivals over a period of time helps the growers to take decision about the future production pattern and sale of agricultural commodities in the market during specific period (Mohd. Et al., 2009).

Objectives : This study was devoted to discussion of substantive results, followed by economic interpretations and analytical inferences. This study has been deal with the estimation and interpretation of the relationship between prices and arrivals of selected agricultural commodities.

Research Methodology

The study was purposively confined to the state of Rajasthan. Secondary data in respect of arrivals in different markets and monthly prices of selected commodities for the period of eleven years from 2010-11 to 2020-21 was collected from Directorate of Economics and Statistics, Government of Rajasthan, Jaipur, Mandi offices of selected mandies and AGMARKNET (<https://agmarknet.gov.in>) to study the relationship between prices and arrivals.

Selection of the major crops of Rajasthan was done from the different commodity on the basis of rank of Rajasthan in production compared to all over India two crops viz. cumin and mustard were selected purposively for the detailed study. Jodhpur and Jalore for cumin, and Alwar and Bharatpur for mustard were selected on the basis of rank in production of the selected agricultural commodity in whole Rajasthan. Jaipur district of Rajasthan having biggest mandies was also selected purposively for the comparative study. For cumin Jodhpur and Bheenmal (Jalore) and for mustard Alwar and Bharatpur mandies were selected on the basis of maximum arrivals in mandies. Jaipur grain market mandi was also selected purposively for the comparative study of prices and arrivals as it is the biggest APMC of the Rajasthan.

Analysis of data

Relationship between prices and arrivals : This objective was divided into two parts viz: Correlation coefficient and coefficient of variation.

I. Correlation co-efficient was obtained to measure the nature and magnitude of association between arrivals and prices of selected commodities of the market.

II. Coefficient of variation was used to study the variability in arrivals and prices of selected agricultural commodities in the study area over the years.

Correlation : Correlation is a measure of intensity or degree of linear relationship between two variables (price and arrivals) for "n" pair of observations. To know the direction and extent of association between arrivals and prices, following formula was used to calculate correlation coefficient (r) :

$$r = \frac{(X_i - \bar{X})(Y_i - \bar{Y})}{(X_i - \bar{X})^2 (Y_i - \bar{Y})^2}$$

Where,

r = Correlation coefficient

X_i = Quantity of arrivals of selected commodity in i^{th} month/year (quintals)

Table-1.1 : Correlation between prices and arrivals of cumin in selected *mandies* of Rajasthan from year 2010-11 to 2020-21.

Years	Jaipur	Jalore	Jodhpur
2010-11	-0.308 ^{NS}	0.327 ^{NS}	0.561 ^{NS}
2011-12	-0.554 ^{NS}	-0.560 ^{NS}	-0.878**
2012-13	-0.450 ^{NS}	-0.138 ^{NS}	-0.508 ^{NS}
2013-14	-0.732**	-0.494 ^{NS}	-0.478 ^{NS}
2014-15	-0.073 ^{NS}	0.498 ^{NS}	0.788**
2015-16	-0.263 ^{NS}	-0.168 ^{NS}	-0.041 ^{NS}
2016-17	-0.686*	-0.074 ^{NS}	0.486 ^{NS}
2017-18	-0.591*	-0.792**	-0.774**
2018-19	-0.232 ^{NS}	-0.160 ^{NS}	-0.272 ^{NS}
2019-20	0.287 ^{NS}	-0.716**	-0.565 ^{NS}
2020-21	-0.175 ^{NS}	0.295 ^{NS}	0.702*

**Significance at 1% level of probability, *Significance at 5% level of probability, ^{NS}not significant.

Table-1.2 : Correlation between prices and arrivals of cumin in selected *mandies* of Rajasthan during 2010-11 to 2020-21.

Correlation	Jaipur	Jalore	Jodhpur
	-0.358**	0.029 ^{NS}	-0.108 ^{NS}

**Significance at 1% level of probability, ^{NS}not significant

Table-1.3 : Descriptive statistics of prices and arrivals of cumin in selected *mandies* of Rajasthan during 2010-11 to 2020-21.

Parameters	Jaipur		Jalore		Jodhpur	
Mean (Monthly)	Prices (Rs/q)	Arrivals (q)	Prices (Rs/q)	Arrivals (q)	Prices (Rs/q)	Arrivals (q)
	15906.208	20.674	13275.761	65.081	13163.795	695.927
Standard Deviation	3429.874	28.804	2605.989	170.366	2007.948	1010.847
Coefficient of Variation (Per cent)	10.00	139.30	19.60	261.70	15.20	145.20

X = Mean quantity of arrivals of selected commodity (quintals)

Y_i = Price of selected commodity (₹ /qt.) in i^{th} month or year

Y = Mean value of prices of selected commodity (₹ /qt.)

n = Number of observations.

Coefficient of variation (CV) : The coefficient of variation (CV) is a relative measure of variability that indicates the size of a standard deviation in relation to its mean. It is a standardized, unit-less measure that allows us to compare variability between disparate groups and characteristics. It is also known as the relative standard deviation (RSD).

The co-efficient of variation (CV) was computed to find out the extent of fluctuations in market arrivals and prices of selected commodities in the study market.

$$C.V. = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

Results and Discussion

Relationship between prices and arrivals of cumin

Correlation coefficient between prices and arrivals of

cumin : Year wise correlations between monthly prices and arrivals of cumin in selected *mandies* Jaipur, Jalore and Jodhpur are shown in table 1.1. The negative and statistically non-significant relationship was noticed for most of the years. Maximum significant correlation between prices and arrivals was seen in Jodhpur *mandi* during four years (2011-12, 2014-15, 2017-18 and 2020-21). In Jaipur *mandi* and Jalore *mandies* it was significant in three years and two years, respectively.

The correlation between monthly prices and arrivals of cumin during the period from 2010-11 to 2020-21, in selected *mandies*, are given in table 1.2. The results revealed the negative correlation between prices and arrivals in Jaipur *mandi*, whereas in Jodhpur and Jalore *mandies* it was found statistically non-significant.

Variations in prices and arrivals of cumin : The variability in prices and arrivals of cumin in Jaipur, Jalore and Jodhpur *mandies* during the period of 11 years i.e., from 2010-11 to 2020-21, was analyzed and depicted in table 1.3. Results revealed that the market arrival was highest in Jodhpur market with a mean of 695.92 quintals and lowest in the Jaipur with 20.674 quintals per month. The coefficient of variations in prices of cumin was found to be highest in Jalore (19.60 per cent) followed by (15.20 per cent) in Jodhpur and Jaipur (10.00 per cent). The

Table-1.4 : Correlation between prices and arrivals of mustard in selected *mandies* of Rajasthan from year 2010-11 to 2020-21.

Years	Jaipur	Alwar	Bharatpur
2010-11	-0.430 ^{NS}	-0.751**	-0.774**
2011-12	0.599**	0.443 ^{NS}	0.469 ^{NS}
2012-13	-0.483 ^{NS}	-0.753**	-0.680*
2013-14	-0.707*	-0.598*	-0.118 ^{NS}
2014-15	0.618*	0.047 ^{NS}	0.081 ^{NS}
2015-16	0.254 ^{NS}	0.384 ^{NS}	-0.630*
2016-17	-0.624*	-0.549 ^{NS}	-0.603*
2017-18	0.125 ^{NS}	-0.237 ^{NS}	0.336 ^{NS}
2018-19	0.732**	-0.898**	-0.839**
2019-20	0.572 ^{NS}	-0.115 ^{NS}	-0.099 ^{NS}
2020-21	-0.301 ^{NS}	0.006 ^{NS}	0.245 ^{NS}

**Significance at 1% level of probability, *Significance at 5% level of probability, ^{NS}not significant

Table-1.5 : Correlation between prices and arrivals of mustard in selected *mandies* of Rajasthan during 2010-11 to 2020-21.

Correlation	Jaipur	Alwar	Bharatpur
	-0.083 ^{NS}	-0.103 ^{NS}	0.002 ^{NS}

^{NS}not significant

Table-1.6 : Descriptive statistics of prices and arrivals of mustard in selected *mandies* of Rajasthan during 2010-11 to 2020-21.

Parameters	Jaipur		Alwar		Bharatpur	
	Prices (₹/q)	Arrivals (q)	Prices (₹/q)	Arrivals (q)	Prices (₹/q)	Arrivals (q)
Mean (Monthly)	3722.98	609.99	3735.12	12526.89	3674.30	3270.07
Standard Deviation	915.936	1448.028	798.891	23260.259	750.445	3544.883
Coefficient of Variation (Per cent)	24.60	237.30	21.30	185.60	20.40	108.40

highest variation in arrivals, as measured by coefficient of variation, was in Jalore (261.70 per cent) followed by Jodhpur (145.00 per cent) and Jaipur (139.30 per cent). In Jalore mandi it was quite higher as compared to other two *mandies*. Similar results were also obtained by Meena *et al.* (2020) in cumin and revealed that the variation in prices was comparatively lower than arrivals.

Relationship between prices and arrivals of mustard

Correlation coefficient between prices and arrivals of mustard : Table-1.4 shows year wise correlation between monthly prices and arrivals of mustard in Jaipur, Alwar and Bharatpur *mandies*. The results revealed statistically non-significant correlation between arrivals and prices of mustard for most of the years. Maximum significant correlation between price and arrivals was seen in Jaipur and Bharatpur *mandies* during five years while in Alwar it was significant in four years. Similar study was also done by Thombre and More (2013) in pigeon pea in Marathwada region of Maharashtra. The results revealed that the relationship between market arrivals and prices of pigeon pea was negative and statistically significant at 5 per cent level of probability.

The correlation between market arrivals and prices of mustard in selected *mandies* was also studied for the period from 2010-11 to 2020-21 by computing correlation

coefficients (table-1.5). The results revealed the correlation between prices and arrivals were found statistically non-significant in all three selected *mandies* viz; Jaipur, Alwar and Bharatpur.

Variations in prices and arrivals of mustard : The variability in prices and of mustard in Jaipur, Alwar and Bharatpur *mandies* during the period from 2010-11 to 2020-21 was analyzed and results are depicted in table 1.6. Results revealed that the market arrival was highest in Alwar *mandi* with the average of 12526.89 quintals per month and lowest in the Jaipur with 609.99 quintals per month. The coefficient of variations in prices of mustard was found to be highest (24.60 per cent) in Jaipur followed by (21.30 per cent) in Alwar and (20.40 per cent) in Bharatpur *mandies* during the study period. The highest variation in arrivals was in Jaipur (237.30 per cent) followed by Alwar (185.60 per cent) and Bharatpur (108.40 per cent).

Conclusions

Maximum significant correlation between prices and arrivals of cumin was seen in Jodhpur *mandi* during four years. In Jaipur *mandi* and Jalore *mandies* it was significant in three years and two years respectively. Maximum significant correlation between price and arrivals of mustard was seen in Jaipur and Bharatpur

mandies during five years while in Alwar it was significant in four years.

The results of correlation analysis on monthly prices and arrivals of cumin during 11 years (2010-11 to 2020-21) shows that the negative correlation between prices and arrivals in Jaipur and was found statistically significant only in Jaipur *mandi*. The correlation between market arrivals and prices of mustard was found statistically non-significant in all three selected *mandies* viz; Jaipur, Alwar and Bharatpur. Only in Jaipur *mandi*, there was statistically significant correlation between arrivals and prices of selected crops during the period.

The coefficient of variations (2010-11 to 2020-21) in prices and arrivals of cumin was found in Jalore. The coefficient of variations in prices and arrivals of mustard was found to be highest in Jaipur *mandi*. For cumin and mustard the variation in arrivals were more than the prices and were found in same *mandies*. Farmers Producer Organizations can help them in aggregating, storing and selling the produce at right place and at right time.

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Water Saving Technique through Mulching to Surge the Production of Horticultural Crops under Arid and Semi-Arid Conditions

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Abstract

The use of mulch in agriculture has very much increased in the last decade throughout the world. In India, the use of mulching has also increased keen interest for higher crop production under rainfed and water scarce conditions due to lot of benefits, such as increase or decrease in soil temperature, reduced weed pressure, moisture conservation, reduction of certain insect pests, higher crop yields and more efficient use of soil nutrients, etc. Here we review the use of mulches for horticultural crops production in arid and semi-arid climatic conditions in India. Major topics discussed are (1) mulching, (2) why need of mulching? (3) types of mulching, (4) advantages of mulching, (5) limitations of mulching, (6) criteria for the selection of mulching material. We found that despite multiple benefits, removal and disposal of polyethylene mulches remains a major horticultural, economic and environmental constraint; whereas, organic mulch and biodegradable plastic mulch are converted through microbial activity in the soil to carbon dioxide, water and natural substances. Accordingly additional information is required on the effect of biodegradable mulches on crop growth, microclimate modifications, soil biota, soil fertility and yields.

Key words : *Dust mulch, organic mulch, vertical mulch, plastic mulch.*

Introduction

Water stress is the key constraint for crop growth in arid and semi-arid regions of India, as the precipitation is low and uncertain in these areas. Efficient utilization of soil and water resources necessitates the adaptation of the appropriate water management techniques. In order to maintain water in the soil for longer period after an irrigation event, some additional materials such as organic matter, soil conditioners are added into or cover the soil. Soil conditioners both natural and synthetic; contribute significantly to provide a reservoir of soil water to plant on demand in the upper layers of the soil where the root systems normally develop.

Water use efficiency of dry matter production can be increased in different ways but chiefly by decreasing evaporation from the soil surface. Mulching with synthetic material and organic matter or crop residues are recognized practices, increasing the profitability of crops (Memon *et al.*, 2017). Mulching enhances plant growth, improves crop water productivity and controls salinity in the root zone. Plastic mulching has been used in various areas of the world for the higher production of vegetables in order to get maximum water use efficiency by the field crops (Shuhao *et al.*, 2014).

Mulching : Mulches refers to the artificial or natural materials covered on the surface of soil with an object to reduce evaporation and destruction of weeds resulting in greater use of light, fertilizers, air and water by crops which results in higher yield production consequently higher WUE. The use of crop residues, manure, leaves, peat and other organic materials as well as paper, glass wool, metal foil, cellophane and further convenient manufactured materials as mulches with or without shallow tillage, for the purpose of increasing soil productivity or we can say it is the process or practice of covering the soil/ground to make more favourable conditions for plant growth, development and efficient crop production.

Why Need of Mulching? : Mulching is required for various benefits such as prevent weed growth, conserve moisture, cool soil and keep temperature consistent, prevent erosion, add organic material, protect plants in winter, keep fruits and vegetables clean, preserve soil structure.

Evaporation from the soil surface significantly affects crop water use efficiency. Surface evaporation accounts for 25-50 per cent of total evapotranspiration (Liu *et al.*, 2002). Mulch can be helpful in improvising soil structure and steering of nutrients due to movement of earthworm

into the soil (Qin *et al.*, 2015). Mulching with production byproducts such as wheat straw increases water retention and prevents soil evaporation (Kar and Singh, 2004). This also ensures a more even moisture distribution throughout the soil profile, which further improves water use. Organic mulches also improve water use efficiency indirectly. As the organic mulch decomposes, humus is added to the soil, which increases its water holding capacity as well as enhance nutrient availability in soil. A mulch layer prevents weeds seedling growth by inhibiting light penetration to the soil surface (Ossom *et al.*, 2001). Lower weed prevalence significantly improves water use efficiency.

Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation. Thus, it facilitates for more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops.

Types of Mulching

Dust Mulch : Disrupting the soil drying process with tillage techniques that separate the upper layer of the soil from the lower layers, making the soil moisture film discontinuous. This loose surface of soil is called soil mulch or dust mulch. Interculturing creates soil mulch in growing crops and helps in closing deep cracks in Vertisols. In addition, the soil surface is made more receptive to water intake. If the surface of the soil is loosened, it acts as mulch for reducing evaporation.

Organic/Crop Residues or Stubble Mulch : Organic mulches are derived from plant and animal materials such as bark, grass clipping, dry leaves, straw, compost, manure, sawdust, newspaper, seaweed, peanut hulls etc. Organic mulch is efficient in reduction of nitrates leaching, improve soil physical properties, prevent erosion, supply

organic matter, regulate temperature and water retention, improve nitrogen balance, take part in nutrient cycle as well as increase the biological activity (Sarolia and Bhardwaj, 2012).

Vertical Mulch : Vertical mulch is a technique which consists of digging suitable trenches across the slope and thus making more surface is available for water absorption. The open trenches are likely get silted in short period. This however can be prevented by inserting organic form waste material like straw stubbles or stalks which is called filter. The filter should be resistant to decomposition and provide service for 3 to 4 years. Such trenches at suitable intervals provide portion of low density which helps to intake water at higher rates. Water thus percolates in a trench and gets distributed in the profile.

Plastic Mulch : Worldwide, the increase usage of polyethylene mulch is due to its benefits when applied in the field, *i.e.* increases soil temperature, especially in early spring, reduces weed problems, enhances moisture conservation, increases crop yields and leads to more efficient use of soil nutrients (Ban *et al.*, 2009; Hatami *et al.*, 2012; Kumar and Lal, 2012). The soil moisture content was higher under the mulched than the non-mulched treatment. The black plastic mulch reduced soil water evaporation and improve soil water retention. Under rainfed conditions of semi-arid regions, it is recommended to use polyethylene black plastic mulch as soil mulching to enhance growth and yield of summer vegetables (Mahadeen, 2014). Plastic mulching has a better effect on crop production or water-use efficiency (WUE) than traditional tillage patterns. Black and white plastic mulching improves WUE in potato plants by 31 per cent compared with the un-mulched ground (Li *et al.*, 2018).

Advantages of Mulching : Mulches are used for various reasons in agriculture but water conservation and erosion control are the most important objectives particularly in arid and semi-arid regions. Other reasons for use of mulching include soil temperature modification, weed



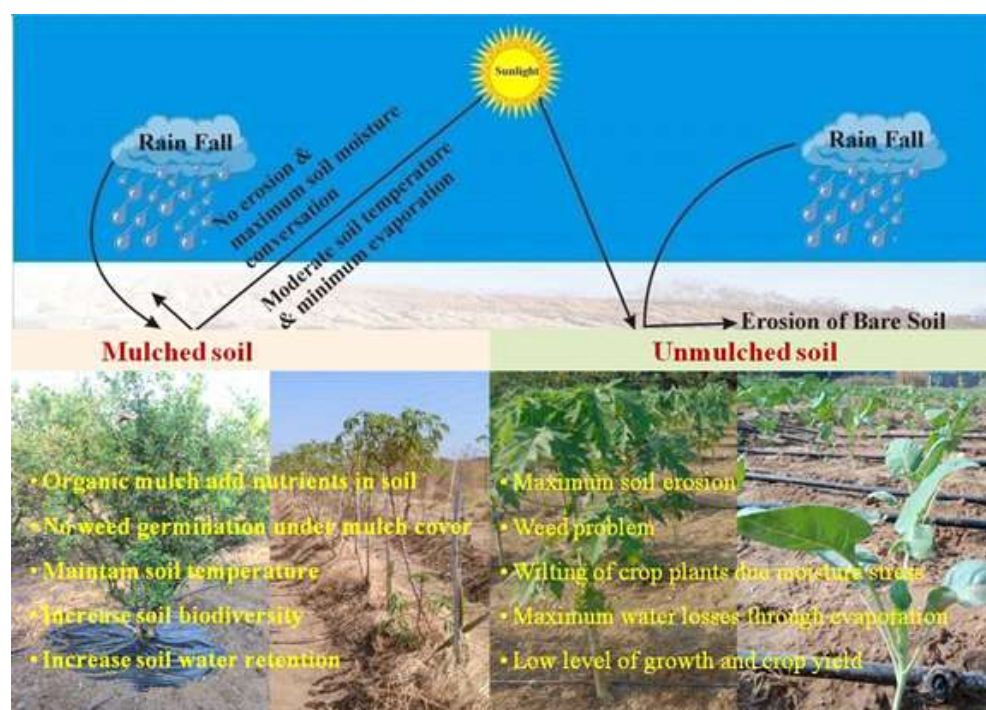


Fig-1 : Functioning of mulch materials when kept it at soil surface.

control, soil conservation and after decomposition of organic mulch add plant nutrients, improvement in soil structure, increase crop quality and yield. Mulching improves soil productivity, soil ventilation around the plant, aggregates the soil particles and drainage of excess water (Kader *et al.*, 2017). Mulching has various beneficial effects on horticultural crop production in arid and semi-arid regions, including an increase in soil moisture, reduces runoff and soil erosion, reduces weed growth, pest control, maintain soil temperature, increases plant growth and development, increases quality produce and yield, promotes earlier harvest of the crop, reduces fertilizer leaching, and protects the surface of the soil against unfavourable factors (Bhardwaj, 2013).

Sharma *et al.*, (1990) found that application of maize stalk mulching increased residual soil moisture in sandy

loam soil. Fabrizzi *et al.*, (2005) reported that soil temperature was increased during colder weather and decreased during warmer weather in mulched condition compared to in non-mulched condition. Some other benefits of mulching such as weed control, reduction of soil runoff and erosion, and improvement of plant earliness have also been recognized widely by both researchers and farmers (Jordan *et al.*, 2010).

Mulching is an important agronomic measure that not only dissipates the kinetic energy of the rain drops and prevents soil erosion, but also facilitates infiltration and reduces runoff and evaporation losses (Krishnappa *et al.*, 1999). Owing to its greater permeability to long wave radiation it can increase temperature around the plants during night in winter. Hence, polyethylene film mulch is preferred as mulching material for production of

Table-1 : Effect of plastic mulching on yield of fruits and vegetable crops.

Crop	Yield (t/ha)		Increase in Yield (%)
	Unmulched	Mulched	
Fruit Crops			
Guava	18.36	23.12	25.93
Mango	4.93	7.16	45.23
Papaya	73.24	120.29	64.24
Ber	7.02	8.92	27.06
Pineapple	10.25	11.75	14.63
Vegetable Crops			
Brinjal	36.73	47.06	28.12
Tomato	69.10	94.85	37.26
Okra	6.91	8.56	23.88
Bitter Gourd	20.12	25.63	27.39
Chilli	16.79	19.71	17.39

Bhattacharya *et al.*, 2018 (Source: NCPAH, New Delhi)

horticultural crops (Bhardwaj *et al.*, 2011). Now a day's application of black plastic mulch film is becoming popular and very good results have been achieved particularly in arid and semi-arid regions (Bhardwaj *et al.*, 2011).

Limitations of Mulching : Mulches can keep the soil too moist, restricting oxygen in the root zone on poorly drained soils. If mulch is applied close to or in contact with the stem, trapped moisture creates an environment conducive to development of diseases and pests. Many organic type of mulches also encourage and provide refuge or breeding locations for snails, slugs, mice, *etc.* that may attack the plants. Certain types of mulches such as hay and straw contain seeds that may become weeds (Patil *et al.*, 2013).

Perhaps a major limitation to commercial uses of plastic mulches is the disposal of the plastic film after use, which causes an environmental pollution problem. Although the part exposed to the light undergoes photo-degradation and contributes to the plastic's decomposition for photodegradable mulches (Gonzalez *et al.* 2002), the rest of the material is simply broken into pieces during soil preparation for a new crop, some pieces being buried and some remaining on the soil surface. The buried pieces are more difficult to decompose since they are less affected by light and high temperatures, creating serious soil problems whose environmental repercussion has not been fully evaluated.

Dead surface vegetative matter can provide a home/breeding ground for plant diseases, insects or rodents. Use of mulch not related to the succeeding crops will minimize much of the disease and insect effects. Use of stubble mulch only in the dry season will minimize all biological activity. For decomposition, the ideal carbon to nitrogen ratio (C/N) is 25 to 30. Dry, woody, or non-green straw, stalks, *etc.* have a C/N of 50 to 100. This tends to slow decomposition and deplete soil nitrogen temporarily.

The majority of plastic films are not biodegradable, so disposing of them without causing a negative environmental impact is also a persistent setback (Johnson, 1989). Biodegradable plastics are more expensive, and have yet to be widely adopted it might not be as effective as organic mulch at improving yields in arid and subtropical regions, because of the increase in soil temperature relative to organic mulches (Hanada, 1991). Plastic mulches also have a higher initial cost, while organic mulches can be more cost effective, especially if the mulch is a byproduct of other on-site operations.

Criteria for the Selection of Mulching Material

Cost of the material.

The crop selected to mulch.

The period when the mulch is to be used.

Best time or way for applying mulch.

Effect of mulching on vegetative crop growth and production.

Effect of mulching on soil physicochemical properties.

Conclusion

This review has covered the major concerns about the mulching types and their uses for production of optimum yield and quality in horticultural crops under arid and semi-arid climatic conditions. Fruits and vegetables cultivation under scare water condition or rainfed areas is not much popular while comparing to other systems of cultivation. However, it resolves the problem of rural poverty and malnutrition. Therefore, much concentration should be given for fruits and vegetable farming with the use of suitable mulching material that helps them conserve moisture, prevent weeds and improve soil health tremendously while producing more.

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Effect of Integrated Nutrient Management on Growth, Yield and Quality of Summer Okra [*Abelmoschus Esculentus* (L.) Moench]

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Abstract

Okra is an economically important ever liking vegetable crop grown in tropical and sub-tropical parts of the world. An experiment was conducted at College Farm, College of Horticulture, SDAU, Jagudan during the summer season of 2019 to 2021 to study the effect of integrated nutrient management on growth, yield and quality of summer Okra [*Abelmoschus esculentus* (L.) Moench]. The experiment was laid out in randomized block design and replicated thrice. Experiment consists of ten treatments viz., T₁ –100% RDN from fertilizer, T₂ –50% RDN from fertilizer + 50% RDN from FYM, T₃ –50% RDN from fertilizer + 50% RDN from Vermicompost, T₄ –50% RDN from fertilizer + 50% RDN from Neem cake, T₅ –50% RDN from fertilizer + 25 % RDN from FYM + Biofertilizer (*Azotobacter* + PSB), T₆ –50% RDN from fertilizer + 25% RDN from Vermicompost + Biofertilizer (*Azotobacter* + PSB), T₇ –50% RDN from fertilizer + 25% RDN from Neem cake + Biofertilizer (*Azotobacter* + PSB), T₈ –100% RDN from FYM, T₉ –100% RDN from Vermicompost, T₁₀ –100% RDN from Neem cake. The treatment T₃ resulted maximum number of branches per plant at 45 DAS (4.29) and 90 DAS (7.13), plant height at 45 DAS (28.59 cm) and 90 DAS (69.45 cm), number of fruits (21.13) per plant, green fruit yield (168.30 g) per plant and green fruit yield (8846 kg ha⁻¹). Whereas, maximum fruit length (10.90 cm) in T₄ and crude fibre content in fruit (7.94%) was observed in T₆. The maximum net income (Rs. 77978/-) and B:C ratio (1.81) were recorded with treatment T₄.

Key words : Okra, INM, PSB, neem cake, growth and yield, quality, summer okra.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] popularly known as lady's finger or bhindi, belongs to the family Malvaceae. It is one of the important vegetable grown extensively throughout India in summer and *khari* seasons and widely adopted vegetable in Indian kitchens. Besides the utility of its tender green fingers as a vegetable, it is used in soups and curries. Fingers are canned green or dried for off-season use by army at high altitudes and are exported thereby helping in earning foreign exchange. Okra has good nutritional value as the proximate composition of fruit (g/100 g) in dry weight basis ranged from moisture per dry matter 9.69–13.33 g, crude protein 10.25–26.16 g, crude fat 0.56–2.49 g, crude fibre 11.97–29.93 g, crude ash 5.37–11.30 g, utilizable carbohydrate 36.66–50.97 g, and gross energy 197.26–245.55 kcal/100 g. The mineral concentrations (mg/100 g) ranged from calcium (111.11–311.95 mg), Iron (18.30–36.68 mg), potassium (122.59–318.20 mg), zinc (3.83–6.31 mg), phosphorus (25.62–59.72 mg) and sodium (3.33–8.31 mg) on dry weight basis (Gemede *et al.*, 2016).

India produces near about 6.10 million tonne of okra

from 0.51 million ha area with productivity 12.0 t/ha. In Gujarat, it is grown either as inter- or sole crop. Gujarat occupies about 75.27 thousand hectares with total production of 921.72 thousand tonne with average productivity of 12.25 tonne ha⁻¹ during the year 2017-18 (Anonymous, 2018). There is a huge scope to increase the productivity of okra in Gujarat.

All the vegetable crops including okra require high doses of chemical fertilizers. The green revolution of previous decades and the intensive agriculture has depleted the soil and indicated wide spread deficiency of macro and micro-nutrients. Injudicious use of chemical fertilizers not only increased the cost of production but deteriorate the soil health also. Moreover, there is a high demand supply gap in fertilizers, to minimize the gap between demand and supply of fertilizers, sustain the soil health and reduce the cost of production by the use of other alternative conventional sources of plant nutrients *i.e.*, Crop residues, FYM, compost, oil cakes, bio-fertilizers *etc.* The combined use of chemical fertilizers, bio-fertilizers, organic manures *etc.* not only improved the yield and quality but also sustain the soil health. Therefore, it is known as an ecofriendly approach. Hence an experiment has been conducted to study the

effect of “Integrated nutrient management in summer okra”

Materials and Methods

An experiment on okra variety GAO 5 (procured from MVRS, AAU, Anand, Gujarat) was conducted at College Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan (Gujarat) India during summer seasons of the year 2019, 2020 and 2021 in a randomized block design and replicated thrice. Experiment consists of ten treatment viz., T₁ –100% RDN from fertilizer, T₂ –50% RDN from fertilizer + 50% RDN from FYM, T₃ –50% RDN from fertilizer + 50% RDN from Vermicompost, T₄ –50% RDN from fertilizer + 50% RDN from Neem cake, T₅ –50% RDN from fertilizer + 25% RDN from FYM + Biofertilizer (*Azotobacter* + PSB), T₆ –50% RDN from fertilizer + 25% RDN from Vermicompost + Biofertilizer (*Azotobacter* + PSB), T₇ –50% RDN from fertilizer + 25% RDN from Neem cake + Biofertilizer (*Azotobacter* + PSB), T₈ –100% RDN from FYM, T₉ –100% RDN from Vermicompost, T₁₀ –100% RDN from Neem cake. The land was brought to a fine tilth through ploughing and tillage. Irrigation channels and bunds were maintained properly. The crop was sown directly to the field at spacing 60 cm x 30 cm using seed rate 10 kg ha⁻¹ under investigation. Light irrigation was given immediately after sowing.

The recommended dose of NPK 100:50:50 kg ha⁻¹ were used for treatment application. The organic manures were applied two weeks before sowing as basal application in treatments T₂ to T₁₀. Quantity of organic manures were calculated on the basis of nitrogen content (0.5%, 1.0% and 5.2% N in FYM, Vermicompost and Neem cake, respectively) in them (Waranke and Barber, 1974). Full dose of phosphorus and potassium was applied as basal application through SSP and muriate of potash, respectively in all the treatments. Half dose of nitrogen as per treatment was applied just before the sowing. The remaining half dose of nitrogen was applied 35 and 60 days after sowing as per the treatment. Biofertilizers (*Azotobacter* + PSB) was applied as soil application @ 10.0 kg ha⁻¹ as per the treatments. All cultural practices were followed regularly during entire crop growth period and observations were recorded on growth, yield and quality traits i.e., plant population, number of branches per plant, plant height, fruit length (cm), number of fruits per plant, green fruit yield (g) per plant, green fruit yield (kg ha⁻¹), crude fibre content in fruit (%) were recorded.

Economics was calculated using economic parameters viz., gross realization, fixed cost, variable cost, total cost, net realization and benefit cost ratio as per treatments on the basis of interest on working capital, land

rent, management charge, existing market prices of inputs and output costs.

Gross realization (Rs./ha) = Fruit yield (kg/ha) x Selling price of fruit (Rs./kg)

Net realization (Rs./ha) and benefit : cost ratio of each treatment was calculated by using the following formula :

Benefit : Cost Ratio (B : C Ratio)

$$= \frac{\text{Gross realization (Rs./ha)}}{\text{Total cost of cultivation (Rs./ha)}}$$

A composite soil sample was collected from 0-15 cm depth with the help of *khurpi* and spade at before sowing of each year trial and processed for further analysis. The air dry and sieved soil samples were analyzed by standard methods viz., potentiometric method, conductivity meter, Walkley and Black's rapid titration method, alkaline KMnO₄ method, Olsen's method and flame photometric method for pH, EC, organic carbon, available nitrogen, available phosphorus and available potassium, respectively. The analyzed data (Table 1) of all the years showed that the soil having loamy sand in texture with mildly alkaline in reaction and free from any kind of salinity hazard. The soil was low in organic carbon and available nitrogen and medium in available phosphorus and high in available potassium status. Crude fibre content in okra fruits was determined as per the method suggested by AOAC (1960). The data were subjected to statistical analysis as per the method suggested by Panse and Sukhatme (1985) to draw logical conclusions.

Results and Discussion

Growth Parameters

Plant population : Data presented in Table-2 reveals that the application of different treatments has non-significant effect on plant population during individual years and pooled analysis at 45 and 90 days after sowing.

Number of branches per plant : Results (Table-3) indicated that the number of branches per plant significantly influenced by the application of various treatments in summer season of the year 2019, 2020 and 2021 at 45 and 90 days after sowing of okra except in 2020 at 90 DAS. However, non-significant effect was noticed in pooled analysis at both the growth stages. The maximum number of branches 6.40 & 8.47 in 2019, 3.13 & 7.60 in 2020 and 3.33 & 5.33 in 2021 at 45 & 90 DAS, respectively was observed with the application of treatment 50% RDN from fertilizer + 50% RDN from vermicompost (T₃).

Plant height at 45 and 90 DAS : Plant height

Table-1 : Physico-chemical properties of soil at before sowing of crop.

Year	Soil textural class	pH	EC (dSm ⁻¹)	Organic carbon (%)	Available nutrients (kg ha ⁻¹)		
					N	P ₂ O ₅	K ₂ O
2019	Loamy sand	7.85	0.243	0.261	202.0	22.4	308.6
2020		8.07	0.281	0.304	210.0	29.6	345.9
2021		7.96	0.256	0.248	198.3	24.7	301.4

Table-2 : Effect of integrated nutrient management on plant population of summer okra.

Treatment No.	Plant population per net plot at 45 DAS				Plant population per net plot at 90 DAS			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
T ₁	54.00	52.33	51.33	52.56	53.00	51.67	51.00	51.89
T ₂	54.00	52.33	51.33	52.56	53.00	51.67	51.00	51.89
T ₃	54.33	53.33	52.00	53.22	53.33	52.67	51.33	52.44
T ₄	55.00	52.67	50.67	52.78	54.00	52.00	50.33	52.11
T ₅	55.00	52.33	51.00	52.78	54.33	51.67	50.67	52.22
T ₆	55.00	52.67	51.67	53.11	54.00	52.00	51.33	52.44
T ₇	55.33	52.33	51.33	53.00	54.33	51.67	50.67	52.22
T ₈	54.00	52.00	50.67	52.22	53.00	51.00	49.67	51.22
T ₉	55.00	51.00	50.00	52.00	53.67	50.33	49.33	51.11
T ₁₀	55.00	51.67	50.00	52.22	53.33	51.00	49.33	51.22
S.Em.±	0.45	0.49	0.59	0.30	0.54	0.63	0.98	0.43
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
YxT CD at 5%	-	-	-	NS	-	-	-	NS

Table-3 : Effect of integrated nutrient management on number of branches of summer okra.

Treatment No.	Number of branches per plant at 45 DAS				Number of branches per plant at 90 DAS			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
T ₁	4.53	3.00	3.27	3.60	5.80	7.33	5.07	6.07
T ₂	5.73	3.00	3.00	3.91	7.67	7.40	5.13	6.73
T ₃	6.40	3.13	3.33	4.29	8.47	7.60	5.33	7.13
T ₄	6.00	3.00	3.07	4.02	8.33	7.33	5.20	6.96
T ₅	4.33	2.80	3.07	3.40	6.80	7.20	4.87	6.29
T ₆	5.87	2.87	2.93	3.89	8.27	7.07	5.07	6.80
T ₇	5.13	2.93	3.27	3.78	7.33	7.20	5.00	6.51
T ₈	4.00	2.53	3.07	3.20	6.40	7.20	4.60	6.07
T ₉	4.53	2.60	2.87	3.33	6.93	6.87	4.67	6.16
T ₁₀	4.20	2.73	3.07	3.33	6.33	7.13	4.73	6.07
S.Em.±	0.32	0.11	0.05	0.27	0.40	0.14	0.07	0.28
CD at 5%	0.96	0.33	0.14	NS	1.18	NS	0.20	NS
YxT CD at 5%	-	-	-	0.56	-	-	-	0.69

(Table-4) significantly influenced by the application of various treatments in summer season of the year 2019, 2020, 2021 and pooled data at 45 and 90 days after sowing of okra. The maximum plant height 39.50 cm & 72.23 cm in 2019, 23.37 cm & 69.06 cm in 2020, 22.90 cm (45 DAS only) in 2021 and 28.59 cm & 69.45 cm in pooled data at 45 & 90 DAS, respectively was observed with the application of treatment 50% RDN from fertilizer + 50% RDN from vermicompost (T₃). While, maximum significant plant height (67.73 cm) at 90 DAS was recorded in the year 2021. Moreover, pooled data showed that the treatment T₃ was remained at par with T₄, T₂, T₆ and T₁ at 45 DAS, while plant height at 90 DAS treatment T₃ was found at par with T₄, T₂ and T₆.

A significant difference in number of branches per plant is might be due to the application of organic and inorganic materials create the favorable micro environment and supply of the nutrients for the growth of the plant. In addition to the favorable aeration, organic matter enhances the ability of soil to increase water holding capacity and improve soil health. Similar results were obtained by Mishra *et al.* (2009), Gayatri and Reddy (2013), Kumar *et al.* (2017), Singh *et al.* (2018) and Miah *et al.* (2020) in okra. This could be further, confirmed by the facts that greater nutrient doses of nitrogen with organic supplements as vermicompost or biofertilizers is responsible for improvement in soil and plant nutrient status which enhances metabolic activities resulted

Table-4 : Effect of integrated nutrient management on plant height of summer okra.

Treatment No.	Plant height (cm) at 45 DAS				Plant height (cm) at 90 DAS			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
T ₁	29.47	22.67	22.23	24.79	56.60	68.08	66.14	63.61
T ₂	34.83	22.23	22.40	26.49	62.90	68.37	66.67	65.98
T ₃	39.50	23.37	22.90	28.59	72.23	69.06	67.06	69.45
T ₄	37.70	22.53	22.80	27.68	69.07	67.37	66.03	67.49
T ₅	26.67	21.37	22.27	23.43	55.27	64.98	67.21	62.48
T ₆	33.20	22.17	22.40	25.92	60.53	64.80	67.73	64.35
T ₇	30.67	21.47	22.30	24.81	57.27	64.19	65.91	62.46
T ₈	22.53	19.60	19.83	20.66	50.10	59.42	58.91	56.14
T ₉	24.23	19.43	19.67	21.11	53.40	59.10	59.07	57.19
T ₁₀	25.03	19.70	19.60	21.44	54.20	59.13	59.19	57.51
S.Em.±	1.98	0.49	0.28	1.57	1.93	1.50	0.65	1.76
CD at 5%	5.87	1.45	0.84	4.66	5.73	4.44	1.92	5.21
YxT CD at 5%	-	-	-	3.36	-	-	-	4.13

Table-5 : Effect of integrated nutrient management on yield parameters of summer okra.

Treatment No.	Fruit length (cm)				Number of fruits per plant			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
T ₁	8.27	11.56	9.91	9.91	18.60	24.53	14.07	19.07
T ₂	8.27	11.67	10.22	10.05	20.00	26.97	16.33	21.10
T ₃	8.83	11.93	10.37	10.38	20.67	26.50	16.23	21.13
T ₄	10.77	11.62	10.31	10.90	20.13	25.43	16.33	20.63
T ₅	9.67	11.32	10.07	10.35	17.93	25.60	16.77	20.10
T ₆	10.90	11.48	10.29	10.89	19.27	24.63	16.33	20.08
T ₇	10.83	11.31	10.15	10.76	19.13	24.30	16.13	19.86
T ₈	9.70	10.91	9.47	10.03	17.33	23.90	14.00	18.41
T ₉	9.83	10.89	9.42	10.05	16.67	24.20	14.17	18.34
T ₁₀	10.00	11.14	9.53	10.22	17.00	22.50	13.17	17.56
S.Em.±	0.33	0.16	0.10	0.37	0.81	0.55	0.89	0.43
CD at 5%	0.97	0.47	0.29	NS	2.40	1.62	NS	1.20
YxT CD at 5%	-	-	-	0.62	-	-	-	NS

Table-6 : Effect of integrated nutrient management on fruit yield of summer okra.

Treatment No.	Green fruit yield per plant (g)				Green fruit yield (kg ha ⁻¹)			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
T ₁	151.23	196.00	113.33	153.52	8091	10071	5742	7968
T ₂	160.57	210.00	126.00	165.52	8600	10768	6398	8589
T ₃	162.57	211.33	131.00	168.30	8767	11067	6704	8846
T ₄	160.23	208.67	132.00	166.97	8743	10796	6640	8726
T ₅	143.27	191.67	125.67	153.53	7810	9886	6353	8016
T ₆	155.03	196.67	130.67	160.79	8463	10188	6679	8443
T ₇	151.53	194.67	129.33	158.51	8319	10031	6541	8297
T ₈	132.23	179.00	105.00	138.74	7086	9107	5180	7124
T ₉	134.17	181.33	106.33	140.61	7325	9134	5207	7222
T ₁₀	135.80	180.00	105.00	140.27	7415	9138	5154	7236
S.Em.±	5.57	4.11	7.04	3.06	330	190	369	164
CD at 5%	16.55	12.22	20.91	8.63	981	566	1098	461
YxT CD at 5%	-	-	-	NS	-	-	-	NS

improvement in biomass production and economic yield (Ruby *et al.*, 2022).

Yield Contributing Traits and Yield

Fruit length : Data presented in Table-5 indicated that the application of various treatments was significantly

influenced the fruit length of okra in individual years only. Higher fruit length (10.90 cm) was observed with treatment T₆ in the year 2019, while in the year 2020 and 2021 it was recorded maximum (11.93 cm & 10.37 cm, respectively) with treatment T₃ (50% RDN from fertilizer +

Table-7 : Effect of integrated nutrient management on crude fibre content (%) in fruit of summer okra.

Treatment No.	Crude fibre content in fruit (%)			
	2019	2020	2021	Pooled
T ₁	10.83	10.20	10.83	10.62
T ₂	7.93	8.03	8.23	8.07
T ₃	8.07	7.97	8.07	8.03
T ₄	8.17	8.07	8.53	8.26
T ₅	8.80	8.23	8.33	8.46
T ₆	7.90	7.77	8.17	7.94
T ₇	8.50	8.13	8.43	8.36
T ₈	11.40	10.37	11.53	11.10
T ₉	11.07	11.23	11.42	11.24
T ₁₀	11.30	11.10	11.90	11.43
S.Em.±	0.30	0.24	0.23	0.15
CD at 5%	0.89	0.71	0.67	0.42
YxT CD at 5%	-	-	-	NS

Table-8 : Economics of the different treatments.

Treatment No.	Green fruit yield (kg ha ⁻¹)	Rs./ha					BCR
		Gross realization	Fixed cost	Variable cost	Total cost of cultivation	Net realization	
T ₁	7968	159360	73809	16393	90202	69158	1.77
T ₂	8589	171780	73809	27634	101443	70337	1.69
T ₃	8846	176920	73809	51658	125467	51453	1.41
T ₄	8726	174520	73809	22733	96542	77978	1.81
T ₅	8016	160320	73809	22628	96437	63883	1.66
T ₆	8443	168860	73809	34640	108449	60411	1.56
T ₇	8297	165940	73809	20177	93986	71954	1.77
T ₈	7124	142480	73809	38874	112683	29797	1.26
T ₉	7222	144440	73809	86922	160731	-16291	0.90
T ₁₀	7236	144720	73809	29075	102884	41836	1.41

50% RDN from vermicompost). However, in pooled data, effect of various treatments was observed non-significant.

Number of fruits per plant : Number of fruits per plant (Table-5) significantly influenced in the year 2019, 2020 and pooled analysis. Maximum number of fruits (20.67) was found with treatment T₃ (50% RDN from fertilizer + 50% RDN from vermicompost) in the year 2019 and pooled analysis (21.13), while in the year 2020 higher number of fruits (26.97) were recorded with treatment T₂. Pooled data showed that treatment T₃ was remained at par with treatments T₂, T₄, T₅ and T₆.

Green fruit yield per plant : The green fruit yield (g) per plant (Table-6) significantly influenced by the application of various treatments in the individual years and pooled. The maximum green fruit yield 162.57 g, 211.33 g & 168.30 g per plant was observed with the application of T₃ (50% RDN from fertilizer + 50% RDN from vermicompost) in the year 2019, 2020 and pooled data, respectively except in the year 2021 which was recorded with the treatment T₄ (50% RDN from fertilizer + 50% RDN from Neem cake). In pooled data T₃ was remained at par with the treatments T₄, T₂ and T₆.

Green fruit yield per hectare : Effect of different INM treatments on green fruit yield per hectare of summer okra was found significant (Table-6). During the course of investigation, the maximum and minimum green fruit yields were recorded with treatment T₃ and T₈, respectively. Application of 100% RDN (T₁) was equally effective with treatments T₂, T₃, T₄, T₅, T₆ and T₇ during the years 2019 and 2021. But INM treatments T₃, T₄, T₂ and T₆ were recorded significantly higher fruit yield than treatment T₁ in pooled data.

Application of 50% RDN from fertilizer + 50% RDN from vermicompost (T₃) recorded the maximum green fruit yield (8767 kg ha⁻¹ in 2019, 11067 kg ha⁻¹ in 2020, 6704 kg ha⁻¹ in 2021 and 8846 kg ha⁻¹ in pooled data) which was at par with treatments T₄, T₂, and T₆ in pooled data but significantly superior over rest of treatments. Thus, crop fertilized with fertilizer (50% RDN) + vermicompost (25% RDN) + biofertilizers (*Azotobacter* + PSB) was found best treatment for summer okra and also save the 25 per cent nitrogen (25 kg ha⁻¹) per hectare.

The advantageous effect of combined application of organic manures, chemical fertilizers and biofertilizers

increasing the vegetative growth and yield of plant can be attributed that might have acted complementary and supplementary to each other and resulted into adequate slow but steady supply of nutrients (Kumar *et al.*, 2017). Similarly, T₃ (50% RDN from fertilizer + 50% RDN from vermicompost) had the highest yield & yield contributing traits. The results are in conformity with Tyagi *et al.* (2016) who reported that combined use of organic and inorganic manures increased growth and yield of okra. The improvement in okra yield and yield related traits after the integration of RDF, FYM and vermicompost is might be due to the greater uptake of NPK and other micronutrients as reported by Kumar *et al.* (2022). These results also corroborate to the previous findings of Lal and Kumar (2016) and Bhu *et al.* (2017) in okra.

Quality Parameter

Crude fibre content in fruit (%) : Data (Table-7) revealed that application of various treatments significantly influenced on the fibre content in fruit during individual years and pooled analysis. The minimum fibre content in fruit (7.90%, 7.77% and 7.94%) was found with the application of 50% RDN from fertilizer + 25% RDN from Vermicompost + Biofertilizer (T₆) in the year 2019, 2020 and pooled analysis, respectively while in the year 2021 treatment T₃ (8.07%). However, in pooled analysis, treatment T₆ was remained at par with the treatments T₃, T₂, T₄ and T₇.

The low crude fibre content is desirable quality of okra that was obtained by combined application of organic manures, chemical fertilizer and biofertilizers which led to an improvement in the fruit quality. The quality and suitability of a vegetable for consumption, in a crop like okra is judged based on the crude fibre content of fruits. Nitrogen had a negative influence on the crude fibre content in the present study. Organic manures, higher level of nutrients and biofertilizers decreased the crude fibre content in okra fruits. Similar results were also reported by Mani and Ramanathan (1981), Wagh *et al.* (2014) and Maruthi *et al.* (2020) in okra.

Economics : The maximum yield (8846 kg ha⁻¹) and gross realization (Rs. 1,76,920/-) (Table-8) were recorded when summer okra crop fertilized with the application of T₃ (50% RDN from fertilizer + 50% RDN from vermicompost). However, the maximum net income (Rs. 77,978/-) and B:C ratio 1.81 (Table 6) were recorded when summer okra crop fertilized with the application of T₄ (50% RDN through fertilizer + 50% RDN through neem cake).

Conclusions

It is concluded that the application of 50 per cent RDN (50 kg N ha⁻¹) through fertilizer + 50 RDN through neem cake or 50% RDN through fertilizer + 25 per cent RDN through

vermicompost + *Azotobacter* and PSB culture (each 10 kg ha⁻¹) as soil application can be obtained higher fruit yield with better quality and net return.

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Canopy Management in Sub Tropical Fruit Crops

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Abstract

Canopy management in fruiting trees has been practiced over the years for increasing the productivity and quality of the fruits. Management of canopy architecture is one of the predominant technologies by which huge and unmanageable trees are properly managed to make them more productive. Canopy management is the manipulation of tree canopies to optimize its production potential with excellent quality fruits. Canopy management deals in fruit crops deals with the development and maintenance of their structure in relation to their size and shape for maximizing productivity with quality fruits. To optimize the utilization of light for increased yield of quality fruits, canopy management deserves greater attention by exploiting the various available techniques like training, pruning (dormant, summer and root pruning), branch orientation (bending), scoring, girdling, selection of proper rootstock, use of plant growth regulators or retardants, high density planting, appropriate use of fertilizer, deficit irrigation, use of genetically engineered plants with altered architectural characters would help in maintaining the ideal canopies of trees. The basic objective of canopy management is to maximize light interception to optimize light distribution within canopy and to maintain proper airflow. Canopy management enhances productivity, improves fruit quality, facilitates cultural practices and help in management of pest and disease. In new plantations initial training and pruning is given to develop strong framework of the tree whereas in old plantation the aim of canopy management is to reduce tree height and make provision of solar radiation inside the canopy by thinning excessive biomass.

Key words : Pruning, training, thinning, rootstock and plant growth regulators.

Introduction

There is currently a worldwide trends in fruit producing countries to accommodate more number of fruit plants per unit area by manipulating tree spacing and growth using canopy management and pruning technique. The canopy physically supports the fruit crop and markedly influences the yield and quality of fruits. The canopy configuration largely depends upon the orchard production system which is a combination of five variables i.e. (i) the variety (ii) the rootstock (iii) the tree spacing and (iv) the training system (v) use of plant growth regulators. The introduction of new production systems like Lincoln and Tatura trellis forms of canopy has brought significant transformation in the production system. Canopy management is based on the choice of tree size, number of tree per hectare and pruning technique so as to optimize the production of assimilation and its conservation into economic yield. We know that light is most important component of fruit production. It has a major role in flower induction as well as in fruit development through carbohydrate synthesis. The main aim is to optimize light distribution within the canopy and interception of light by different parts of the tree canopy in order to maximize the efficiency of light utilization in photosynthesis, fruit growth, fruit bud production and fruit coloring. Therefore, canopy

management in subtropical fruit is the most important cultural practices so as to optimize the production of assimilation and its conservation into economic yield, depending upon the choice of tree size, number of tree per hectare and pruning technique etc.

Why we need canopy management? : Light is critical to growth and development of trees and their fruits. The green leaves harvest the sunlight to produce carbohydrates and sugars which are transported to the sites where they are needed – buds, flowers and fruits. Better light penetration into the tree canopy improves tree growth, productivity, yield and fruit quality. The density and orientation of planting also impact light penetration in an orchard. Generally, in close planting, quicker shading becomes a problem.

Strong bearing branches tend to produce larger fruits. The problem of a fruit grower is initially to build up a strong and balanced framework of trees, then equip them with appropriate fruiting. Obviously, pruning in the early years has to be of a training type to provide strong and stocky framework with well-spaced limbs or any other desired shape. Appropriate canopy management encompasses the development of :

1. Strong frame of primary branches

2. Wider crotches in scaffold branches
3. Healthy and well distributed secondary and tertiary branches
4. Sufficient fruiting terminals in most productive areas
5. Healthy foliage with high photosynthetic efficiency to maximize the solar radiation use efficiency
6. Enough space for air circulation inside canopy

The main objectives of canopy management :

1. To get the higher yield with good quality
2. To regulate the tree architecture or form desire shape for high density planting system
3. Formation of strong crotches / crotch angle
4. To proper utilize air, light and temperature efficiently
5. To remove unwanted, overcrowding, dead disease and pest affected shoots
6. To facilitate the management practices like spraying, harvesting etc
7. To regulate exposure of plant to light and air
8. To make accessibility to machinery between rows
9. To maintain a good balance between root and shoot growth

Principles of canopy management :

1. Manipulation of tree canopies to optimize the production of quality fruits
2. Maximum utilization of light
3. Avoidance of built-up microclimate congenial for diseases and pest infestation
4. Convenience in carrying out the cultural practices
5. Maximizing productivity with quality fruit production
6. Economy in obtaining the required canopy architecture
7. Rejuvenation of declining in productivity and fruit quality in large over grown orchards
8. Reduction in extra expense in harvesting at large trees

Steps of canopy management :

1. Selecting dwarf cultivars: Mango: Amrapali and guava: L-49

2. Planting system : Square system with high density planting, rectangular system with high density planting and double hedge row

3. Use of dwarfing rootstock : Rootstocks are known to have a profound effect on the tree vigour, precocity, productivity, quality of fruits and longevity of varieties grafted on them. In this regards, standardized suitable dwarfing rootstocks for some fruit crops are given below :

I. Mango : Vellaikolumban, Olour

II. Citrus : Alemow, Flying Dragon, Troyer Citrange

4. Frame development : Process for frame development in subtropical fruits are :

1. Removing weak crotches
2. Tip pruning of long branches / breaking apical dominance to facilitate laterals
3. Obtaining specific tree form through manipulations
4. Adopting open centre or modified centre leader system

5. Developing open centre frame work : Mango

6. Allow the canopy to grow horizontally

7. Centre opening of grown up trees : To have stereo fruiting through centre opening in evergreen fruit plants.

Consideration :

Long unfruitful branches due to overcrowding of centre

Heavy incidence of pest and disease

Removal of upright branches from centre of tree

Impact :

Emergence of higher number of healthy shoots inside the canopy

More panicle and fruit set inside the canopy

8. Pruning of the shoots and excessive growth :

Pruning is judicious removal of plant parts to maintain optimum balance between vegetative and reproductive growth for enhanced productivity and fruit quality.

Tools adopted for canopy management :

1. Training
2. Pruning
3. Rootstock
4. Plant Growth Regulators
5. High Density Planting
6. Rejuvenation

1. Canopy management through training

Training : Judicious removal of plant part to give the plant particular shape required mainly in the initial years of crop growth to build up the strong framework

Objectives of training

Establish a strong tree framework

Facilitate management of tree and crop

Maintain productivity

To admit light up to centre of the tree and provide sufficient movement of air across the plant

To increase photosynthetic activity by exposing leaves to the sun

To provide strong scaffold system this could bear the heavy load of fruits, without limb breakage

Grape : Arora *et al.* (2010) recorded maximum yield/acre (9.30 tones/acre), TSS (16.20 %), TSS/acid ratio (28.90) and number of plants/acre (730) with minimum acidity (0.56 %) in Y-trellis system followed in grape. Whereas, maximum yield per vine (18.50 kg) and number of bunch (54.50) were through bower system in grape cv. Perlette. This is might be due to 60 % more light interception in Y-trellis system than bower system while in case of bower it might be due to more number of bunch per vine.

2. Canopy management through pruning :

Pruning : Judicious removal of plant part to obtained better and qualitative yield is termed as pruning

Objectives of pruning

To remove surplus branches

To obtain regular bearing

To remove diseased, damaged, insect infected and weak shoots

To thin out flowers and fruits

To have a balance between vegetative and reproductive growth

To control flowering and fruiting

Prevent formation of weak crotches

Regulate exposure to sunlight

What happens if you do not prune?

Faster growth

Less light penetration

Poor spray coverage

More difficult to manage

Methods of pruning :

(1) Heading back : Removal of terminal portion of shoot leaving basal portion intact is termed as heading back

(2) Thinning out : Selective and complete removal of part of the plant is termed as thinning out

(3) Ringing or girdling : In this process, a circular ring of bark measuring about 3 cm in length is removed. It hastens flowering and fruiting by allowing greater accumulation of photosynthates in upward portion of the plant

(4) Notching : Making a notch above a bud by removing a wedge shaped piece of bark is termed as notching. It check the influence of hormone and encourage growth

(5) Nicking : Making a notch below a bud by removing a wedge shaped piece of bark is termed as nicking. This

ensure accumulation of carbohydrates from the leaves to the bud and may result in the formation of fruit bud

Mango : Bamini *et al.* (2009) recorded significantly highest total number of fruits per tree (122.50) and fruit yield (39.37 kg/tree) in light pruning + soil application of paclobutrazol @ 2.3 g *a.i.* per tree in mango cv. Neelum. This might be due to adequate number of shoots with sufficient supply of carbohydrates maintaining a proper balance. Singh *et al.* (2010) found minimum days to panicle emergence (182.65) and maximum number of fruits per panicle (4.01), number of fruits per tree (53.22) and fruit yield (8.59 kg/tree) in treatment I, pruning 30 cm from apex. While maximum number of panicles/branch (5.66) was recorded in case of pruning 60 cm from apex in mango cv. Mallika. This is might be due to moderate pruning helped in establishing optimum balance in root: shoot ratio and endogenous hormonal contents *i.e.* growth promoter: inhibitor ratio.

Phalsa : Abid *et al.* (2012) recorded maximum number of cone/bush (13.66), number of sprouted shoots/cone (29.26), number of fruiting nodes/shoot (29.29), number of fruits/node (9.18), yield/ha (7080.5 kg), TSS (16.17 °Brix) and sugars (11.20%) in pruning level at 90 cm in phalsa. This might be due to shoots were longer in plants pruned have more number of cones/bush, number of sprouted shoots/cone, number of fruiting nodes/shoots and fruiting nodes. Lakra *et al.* (2018) recorded maximum number of canes per bush (13.67), number of sprouted shoot per cane (30.30), total number of flowering per plant (2927.41), length of shoots/ cane (84.64 cm), number of fruiting nodes/ shoots (27.72), number of leaves per shoots (23.46) and leaf area per plant (240.78 cm²) of phalsa in pruning level at 90 cm.

Pomegranate : Ghatul *et al.* (2019) observed that significantly maximum fruit weight (276.12 g) was noted under the treatment of T₅ (50 cm pruning). This might be due to utilization of whole photosynthates among fewer fruit in sever pruned trees. While, maximum total number of fruits per tree (84.29), fruit yield per tree (17.50 kg) and average yield per ha (211.01 q) were recorded under treatment T₂ (20 cm pruning). This might be due to the availability of more metabolite and retention of sufficient size of bearing shoot after pruning. Mishra *et al.* (2020) recorded significantly minimum days to first flowering (105.49), days taken to first fruit (147.80) with maximum number of flower/plant (95.16), number of fruits/plant (26.67) and fruit yield/plant (3.82 kg) in treatment T₄ (40 cm pruning). Whereas, maximum number of branches (7.79 and 10.24) were noted under treatment T₂ (20 cm pruning). This might be due to pruning which remove carbon starved, exhausted flowering and fruiting and promote new growth to build up carbohydrates reserves for flowering and allows the sprouting of lateral buds

which, ultimately influenced plant growth and other vegetative characteristics of the plant.

3. Canopy management through rootstock:

Use of dwarfing rootstock

Dwarfing rootstocks are economical, effective and environmentally safe means for controlling tree vigour for high density orchards

Rootstocks for high density planting must control tree size, reduce vigour and induce precocity or early fruiting

There are at least three categories of rootstock based on their vigour regulating features:

(a) Standard type : Trees on standard rootstock reach their full size potential and standard rootstock results in a tree that grows to 5 m or more in height

(b) Semi dwarfing rootstock : Produces a tree between 3 to 5 m tall, again dependent upon the scion cultivar in which the tree is grown, generally restricts tree height to less than 3 m and takes only two to three years to bear fruit

(c) True dwarfing rootstock : May be defined as a precocious one, results in a mature tree no larger than 2.5 m in height. For example, in mango 'Vellaikulumban' is identified as a dwarfing rootstock for 'Alphanso' mango

Grape : Jogaiah *et al.* (2013) found maximum cane diameter (8.85 mm) and pruned mass (2.98 kg/vine) in Thompson seedless grafted on Dogridge rootstock. While, maximum stock/scion ratio (1.013) and shoot length (129.00 cm) were in rootstock of St. George. This might be due to St. George have a more vigorous growth. Elaidy *et al.* (2019) found maximum shoot length (315.27 cm), shoot diameter (7.43 mm), number of leaves/ shoot (34.18), number of shoots/vine (71.67) and leaf area (195.78 cm) in grape grafted Salt Creek rootstock. This might be due to reflect the potential role of the rootstocks in decreasing the effect of salt stress on yield and fruit quality.

Sweet orange : Srivastav *et al.* (2005) found maximum plant height (229.80 cm), trunk diameter (4.98 cm), canopy volume (0.91 m³), fruit weight (183.88 g), fruit/ volume (182.32 ml) and fruit per plant (86.30) in sweet orange cv. Mosambi grafted on Karna Khatta rootstock. This might be due to more canopy volume, which provides more fruit bearing area in Karna Khatta as compared to Cleopatra Mandarin rootstock showing less vigorous growth of sweet orange cv. Mosambi. Ghosh *et al.* (2012) reported the maximum plant height (329 cm), basal girth (31 cm) and E-W canopy spread (440 cm) and N-S canopy spread (390 cm), average number of fruits per plant (58.20) and average yield per plant (7.90 kg) in sweet orange cv. Mosambi grafted on Karna Khatta

rootstock. This might be due to Karna Khatta have a better nutrient absorbing capacity from the soil.

4. Canopy management through plant growth regulators or retardants

Plant growth regulators

Organic compounds other than nutrient which in small amount promotes/inhibit or otherwise modify any physiological response in plants

Growth retardants : Tree height can be restricted by chemicals :

Three basic mechanisms :

(a) By killing the terminal buds of branches or severely inhibiting apical meristematic activity

(b) By reduced apical control

(c) By inhibiting internodes elongation without disrupting apical meristematic functions

Acid lime : Ranganna *et al.* (2017) recorded significantly higher fruit set (89.97 %) and lowest fruit drop percentage with spraying 2, 4-D @ 40 ppm during November + 20 ppm during February. While, maximum number of fruits per shoot was recorded with the application of paclobutrazol @ 5 ml per meter canopy 4 time starting from July to December as drenching. The reason for reduction of fruit drop is due to 2, 4- D application. It is reputed for its inhibition of fruit drop in various fruit crops by delaying. Arunadevi *et al.* (2019) recorded significantly higher fruit set (2.78%), number of fruits per trees (885.00), fruit yield (52.05 kg/tree) and tree spread N-S and E-W (2.93 m, 2.78 m) in treatment S₃F₂ (paclobutrazol 1.5 g a.i/ m² + NAA 200 ppm).

Guava : Kaur and Kaur (2017) observed that maximum fruit length (8.92 cm) and fruit weight (203.00 g) were recorded in treatment T₃ (NAA 100 ppm). Whereas, maximum fruit breadth (9.26 cm) and fruit yield (49.41 kg) were recorded in treatment T₆ (2, 4-D 50 ppm). Kapandis and Singh (2022) observed significantly maximum plant height (5.81 m), flowers/plant (178.58), buds/plant (151.80), fruits/plant (127.13) and plant spread E-W and N-S (6.00 m and 5.89 m) in treatment T₄ (NAA 200 ppm). This might be due to deblossoming of rainy season crop which increased the carbohydrate content in shoot and high carbohydrate was thought to increase fruit set in following winter.

5. Canopy management through high density planting

High density planting : It is defined as a method of planting wherein more number of plants are planted per unit area as compared to conventional planting density

Types of high density planting

1. Low HDP : < 250 trees per ha

2. Moderate HDP : 250-500 trees per ha
3. High HDP : 500-1250 trees per ha
4. Ultra HDP : >1250 trees per ha
5. Super HDP : 20,000 trees per ha (in apple orchards)
6. Meadow Orchard : 70,000 trees per ha (in apple and guava)

Use of dwarfing rootstock in subtropical fruit crops

Fruit crop	Dwarfing Rootstock
Mango	Vellaikolumban, Olour
Citrus	Alemow, Flying Dragon, Troyer Citrange
Guava	Pusa Srijan, Chinese Guava
Ber	<i>Zizipus rotundifolia</i> , <i>Zizipus nummularia</i>

Use of dwarf scion cultivars in subtropical fruit crops

Fruit crop	Cultivar
Mango	Amrapali, Arka Aruna, Ratna, Dashehari
Litchi	Culcuttia, China
Fig	Conardia, Excel
Pomegranate	Amlidana
Guava	L- 49, Pant Prabhat

Guava : Kumawat *et al.* (2014) recorded maximum number of fruit per plant (17.20), fruit weight (77.50 g), yield/plant (1.32 kg) and TSS/acid ratio (33.14) in 2.0 m x 2.0 m spacing. While, maximum estimated yield (5.72 t/ha) of guava cv. L-49 has noted at spacing of 1.0 m x 1.5 m. This is might be due to that better light interception and aeration are available for plants when they planted at spacing of 2.0 m x 2.0 m. Maximum estimated yield is due to more number of plants per hectare. Tiwari *et al.* (2018) found maximum total yield per plant (7.13 kg) of guava planted at 2.0 m x 2.0 m spacing. While, maximum total yield/ha (21.05 t) of guava cv. L-49 was noted as spacing of 2.0 m x 1.0 m. This is might be due to that better light interception and aeration are available for plants when they planted at spacing of 2.0 m x 2.0 m. Maximum total

yield per hectare is due to more number of plants per hectare.

Mango : Dalvi *et al.* (2010) found significantly maximum number of fruit per tree (89.00), average fruit yield (22.50 kg/tree) and average yield (6.40 t/ha) in the plants which were planted at 5.0 m x 5.0 m. While, maximum tree height (9.10 m) was mango tree the planted at 2.5 m x 10 m. Singh *et al.* (2012) recorded maximum fruit yield (4010.60 kg/ha) and minimum acidity (0.28 %) in double hedge row system. While, maximum fruit yield (24.14 kg/tree) was recorded through square system (100 tree/ha) in mango cv. Dashehari.

2. Canopy management through rejuvenation

Rejuvenation : “Rejuvenation is the process of pruning and after pruning management of the plants to make them productive by utilizing the root system which mean restoring the productive capacity of the fruit trees” **(OR)**

Rejuvenation means restoring the variety and freshness of plants

It is other name of renewal

It is practiced to restoring the fertility of tree

If the tree is showing huge decline in production, rejuvenation can restore its viability

Principles :

1. Trees have latent buds which are activated by heading back of branches at certain point to put forth new sprouts which grow into branches forming fruiting area

2. When the branches are cut back, imbalance is created in root: shoot ratio as a result new shoots arise from the plant to balance it

Mango : Parulekar *et al.* (2019) recorded that maximum hermaphrodite flowers (21.95%), number of fruits (142.25), fruit weight (257.53 g), yield per plant (33.80 kg) and yield per hectare (3.38 t) were observed with

Tools	Result	
Training	Grape vine trained through Y-trellis system produced significantly higher yield with better quality traits as compared to bower training system	
Pruning	Mango	Light pruning (Heading back of all scaffold branches) up to 100 cm with application of paclobutrazol @ 2.3 g a.i. per tree increased significantly fruit yield and yield contributing traits
	Phalsa	Phalsa Produced significantly higher vegetative growth with better fruit yield and quality when plants were pruned up to 90 cm
	Pomegranate	Pomegranate showed significantly maximum growth with better fruit quality and yield when plants were pruned up to 20 cm (light pruning)
Rootstock	Use of Karna Khatta for sweet orange and Dog Ridge & Salt Creek for grape as rootstocks significantly showed higher growth and fruit yield	
Plant growth regulators	Acid lime	Application of paclobutrazol with or without plant growth regulators at different time significantly increased fruit yield through maintaining tree canopy
	Guava	Application of 2,4-D @ 50 ppm as foliar spray produced maximum significantly fruit yield with yield contributing traits and qualitative parameters
High density planting	Mango and guava planted at spacing of 2.0 m x 1.0 m, 5.0 m x 5.0 m and double hedge row system (222 tree/ ha) as HDP showed significantly highest yield	

treatment rejuvenated mango plants. Jahangeer *et al.* (2012) observed increase fruit yield after rejuvenation during 1st year (40 kg/tree), 2nd year (82 kg/tree) and 3rd year (138 kg/tree) in rejuvenated plants as compared to non-rejuvenated plants.

Conclusions

From foregoing discussion it can be concluded that following tools of canopy management may be used to improve growth, yield and quality of sub tropical fruit crops.

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Effect of Foliar Spray of Nutrients and Organic Substances on Leaf Nutrient Status of Nitrogen, Phosphorus and Potassium Content of Apple Cv. Anna in Semi-Arid Region of Haryana, India

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Abstract

The present investigation was carried out at Horticulture Farm (PFDC), Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar Haryana during the year 2020-21 and 2021-22. To evaluate the effect of foliar application of nutrients and organic formulations on leaf nutrient status of nitrogen, phosphorus and potassium content of apple cv. Anna in semi-arid region. Altogether, there were eighteen treatments replicated three times in Randomized Block Design. The effect of the application of different nutrient and organic substances treatments was evident only on the nitrogen content of the leaf (N) whereas the effect was non-significant on the phosphorus and potassium nutrient content (P& K) of apple cv. Anna leaves. . Maximum leaf nitrogen content was observed with the application of 2% Urea (N) + 15% cow urine (T₁₂) which was statistically at par with 1.5% Urea (N) + 10% Urea (N) (T₁₁), 2% nitrogen + 4% Humic acid (T₃), 1.5% Urea (N) + 4% Humic acid (T₂), 1% Urea (N) + 5% cow urine during both years of experimentation.

Key word : nutrients, organic formulation, nitrogen, phosphorus and potassium.

Introduction

The common domesticated apple, *Malus × domestica* Borkh, is putatively an interspecific hybrid complex and belongs to the Rosaceae family. The origin and ancestry of the *Malus × domestica* complex are yet unknown. When Borkhausen first described *Malus × domestica* in 1803, it was believed that it originated as a hybrid that had come from *M. sylvestris* Mill. It is believed that it is indigenous to Western Asia. Regarding production, it is the most substantial deciduous fruit tree (Westwood 1993). Although it was regarded as a crop for temperate regions in the past, its cultivation is now increasing in sub-tropical and tropical climates. “Anna” is a cultivar of domesticated apples that is cultivated for a dual purpose, which ripens early and is suitable for a warm climate. Abba Stein developed “Anna” in the Ein Shemer kibbutz in Israel to produce an apple cultivar that is similar to the Golden Delicious and can be grown in sub-tropical and tropical climates. For sustained fruit production with high-quality fruits, climate, cultivar, rootstock, tree arrangement, canopy management, and nutrient supply of the trees are essential factors. It is well known that plant nutrients affect every physiological, morphological, and production activity in the tree system. The apple tree is a perennial crop that needs particular nutrients for the development of the fruit. The specifications of fertilizer application rates as

well as the appropriate application of suitable fertilization types are necessary for successful fertilization in the cultivation of apples generally. Regardless of the appropriately stated nutrient requirements for fruit trees, the type of fertilization utilized can significantly modify and upset the growth and development of a fruit tree if fertilizers are applied wrongly. Therefore, a balanced nutrient supply is among the most essential conditions for fruit quality, high yield, and healthy growth. Foliar fertilization offers several key benefits. It can be used throughout the growing season, allowing for the spraying of nutrient solutions in minute quantities and with individual nutrient compositions tailored to the needs at various stages of crop development (Haitova, 2013). It also allows for different application times after post-planting. Furthermore, when compared to applying nutrients to the soil, applying nutrients to leaves prevents nutrient loss, tie-up, or fixation (Suman *et al.*, 2017). Nitrogen is the primary nutrient that plants require in significant amounts when compared to other critical nutrients.

Nitrogen (N) availability influences apple tree growth, flower bud formation, yield, and fruit quality (Raese *et al.*, 2007). It is a component of the chlorophyll molecule that aids in the production of nucleic acids, cell division, and tissue development. It is required for

Table-1 : Effect of foliar application of nutrients and organic formulations on nitrogen in leaf of apple cv. Anna under Haryana condition.

Treatments No.	Treatments details	Nitrogen (%) in leaf					
		Before treatment application			After fruit harvest		
		2020-21	2021-22	Pooled Mean	2020-21	2021-22	Pooled Mean
T ₀	Control	1.81	1.84	1.83	1.82	1.86	1.83
T ₁	1% Nitrogen + 2% Humic acid	1.87	2.23	2.05	2.18	2.27	2.22
T ₂	1.5% Nitrogen + 3% Humic acid	1.89	2.29	2.09	2.27	2.32	2.29
T ₃	2.0% Nitrogen + 4% Humic acid	1.89	2.30	2.09	2.28	2.35	2.31
T ₄	200 ppm Boron + 2% Humic acid	1.79	1.96	1.87	1.93	1.98	1.95
T ₅	300 ppm Boron + 3% Humic acid	1.82	1.98	1.90	1.93	2.02	1.97
T ₆	400 ppm Boron + 4% Humic acid	1.82	1.99	1.90	1.93	2.02	1.98
T ₇	200 ppm Zinc + 2% Humic acid	1.83	1.99	1.91	1.95	2.06	2.00
T ₈	400 ppm Zinc + 3% Humic acid	1.83	1.99	1.91	1.95	2.08	2.01
T ₉	600 ppm Zinc + 4% Humic acid	1.84	2.01	1.93	1.98	2.09	2.03
T ₁₀	1.0% Nitrogen + 5% Cow urine	1.88	2.26	2.07	2.23	2.31	2.27
T ₁₁	1.5% Nitrogen + 10% Cow urine	1.89	2.32	2.10	2.30	2.38	2.34
T ₁₂	2.0% Nitrogen + 15% Cow urine	1.90	2.33	2.11	2.31	2.39	2.35
T ₁₃	200 ppm Boron + 5% Cow urine	1.85	2.04	1.95	2.01	2.11	2.06
T ₁₄	300 ppm Boron + 10% Cow urine	1.87	2.08	1.98	2.05	2.17	2.11
T ₁₅	400 ppm Boron + 15% Cow urine	1.86	2.11	1.98	2.10	2.14	2.13
T ₁₆	200 ppm Zinc + 5% Cow urine	1.85	2.14	1.99	2.12	2.17	2.13
T ₁₇	400 ppm Zinc + 10% Cow urine	1.86	2.17	2.01	2.14	2.22	2.18
T ₁₈	600 ppm Zinc + 15% Cow urine	1.87	2.18	2.02	2.16	2.26	2.21
	CD at 5%	-	-	-	0.08	0.06	0.06

deciduous tree growth when cells divide in the spring. Early-season fruit growth and canopy development necessitate a large amount of nitrogen, whereas later-season fruit quality development and tree acquisition of sufficient cold tolerance necessitate only a small amount.

Boron is an important non-metal micronutrient that significantly affects the growth and development of plants. One of the putative uses of boron is sugar transport. It is essential in the creation of the cell wall examples of processes include lignifications of the cell wall, the stability of cell walls, carbohydrate metabolism, phenol metabolism, indole acetic acid (IAA) metabolism, ribose nucleic acid (RNA) metabolism and as a component of the cell membrane (Parr and Loughman, 1983; Welch, 1995; Ahmad *et al.*, 2009). In addition, zinc is an essential trace element for plant development and growth because of its role in numerous enzymatic processes. It regulates protein and carbohydrate metabolism and serves as a cofactor for RNA-polymerase, making it crucial for protein synthesis (Wang and Faust, 1988). It also plays a role in the production of tryptophan, a precursor to IAA that may be a limiting factor in the growth of vascular tissue (Marschner, 1995). To attract pathogens in the

rhizosphere, zinc deficiency causes the plasma membrane to become porous and release organic substances. High levels of Zn in the soil are essential for fruit tree productivity, especially in apple. Deficiencies in micronutrients, especially Zn, have long been known to cause significant growth problems in apple orchards. Zinc application is crucial in boosting the productivity and quality of apples in many deciduous species. Reduced fruit set and yield, misshapen, poorly coloured, and browning fruit are all symptoms of a zinc deficiency. Due to a lack of zinc, apple fruits ripen too quickly and taste bland (Woodbridge, 1954; Wojcik, 2007). The by-product of organic matter breakdown, humic acid is mostly present in leonardite, peat, dung, and lignite coal. Humic acids are highly valuable for enhancing plant growth due to their high cation-exchange capacity (CEC), oxygen content, and average water-holding capacity. It is improving plant growth in response to their interactions with membrane transporters in plants that are in charge of nutrient uptake as well as membrane associated signal transduction cascades that control growth and development. Cow urine is a by-product of cattle production that is readily available to farm households in an integrated farming system. Its usage in crop production

Table-2 : Effect of foliar application of nutrients and organic formulations on phosphorous in the leaf of apple cv. Anna under Haryana condition.

Treatments No.	Treatments Details	Phosphorus (%) in leaf					
		Before treatment application			After fruit harvest		
		2020-21	2021-22	Pooled Mean	2020-21	2021-22	Pooled Mean
T ₀	Control	0.188	0.210	0.199	0.191	0.212	0.201
T ₁	1% Nitrogen + 2% Humic acid	0.224	0.252	0.238	0.252	0.258	0.255
T ₂	1.5% Nitrogen + 3% Humic acid	0.231	0.260	0.245	0.259	0.265	0.262
T ₃	2.0% Nitrogen + 4% Humic acid	0.243	0.268	0.255	0.262	0.271	0.266
T ₄	200 ppm Boron + 2% Humic acid	0.194	0.227	0.210	0.223	0.230	0.225
T ₅	300 ppm Boron + 3% Humic acid	0.195	0.228	0.212	0.224	0.230	0.226
T ₆	400 ppm Boron + 4% Humic acid	0.198	0.231	0.214	0.228	0.231	0.229
T ₇	200 ppm Zinc + 2% Humic acid	0.199	0.232	0.216	0.229	0.234	0.231
T ₈	400 ppm Zinc + 3% Humic acid	0.200	0.233	0.217	0.230	0.235	0.233
T ₉	600 ppm Zinc + 4% Humic acid	0.202	0.234	0.218	0.232	0.236	0.234
T ₁₀	1.0% Nitrogen + 5% Cow urine	0.237	0.262	0.250	0.256	0.267	0.262
T ₁₁	1.5% Nitrogen + 10% Cow urine	0.243	0.268	0.255	0.262	0.272	0.267
T ₁₂	2.0% Nitrogen + 15% Cow urine	0.251	0.272	0.261	0.263	0.274	0.268
T ₁₃	200 ppm Boron + 5% Cow urine	0.205	0.237	0.221	0.235	0.236	0.236
T ₁₄	300 ppm Boron + 10% Cow urine	0.205	0.238	0.222	0.236	0.241	0.239
T ₁₅	400 ppm Boron + 15% Cow urine	0.206	0.244	0.225	0.240	0.242	0.241
T ₁₆	200 ppm Zinc + 5% Cow urine	0.212	0.247	0.229	0.242	0.246	0.244
T ₁₇	400 ppm Zinc + 10% Cow urine	0.218	0.249	0.233	0.247	0.252	0.249
T ₁₈	600 ppm Zinc + 15% Cow urine	0.224	0.252	0.238	0.252	0.258	0.255
	CD at 5%	-	-	-	NS	NS	NS

is environmentally beneficial and has no negative effects on crops, people's health, or the ecology. Furthermore, it can be sprayed on crops during important growth stages unlike other organic sources that have issues with the gradual release of nutrients that impair crop growth. Additionally, because cow urine is organic, it has been shown to improve soil structure, act as plant hormones, and maximise the effectiveness of fertiliser use. Nitrogen, phosphorus, potassium, calcium, magnesium, chlorite, and sulphate are all abundant in cow urine. Keeping these aspects in view, an investigation entitled "Effect of foliar application of nutrients and organic formulations on leaf nutrient status of nitrogen, phosphorus and potassium content of apple cv. Anna in semi-arid region of Haryana".

Materials and Methods

The experiment was carried out in the Horticulture Farm (PFDC), Department of Horticulture and the chemical analysis was undertaken in the laboratory of the Department of Horticulture and Soil Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar during of the year 2020-21 and 2021-22. It is situated at 215.2 m above mean sea level with coordinates of 29° 10' N latitude and 75° 46' E longitudes. Altogether, there were eighteen treatments replicated three times in Randomized

Block Design. Various treatments are T₁- 1% Urea (N) + 2% Humic acid, T₂- 1.5% Urea (N) + 3% Humic acid, T₃-2.0% Urea (N) + 4% Humic acid, T₄- 200 ppm Boron + 2% Humic acid, T₅-300 ppm Boron + 3% Humic acid, T₆- 400 ppm Boron + 4% Humic acid, T₇- 200 ppm Zinc + 2% Humic acid, T₈-400 ppm Zinc + 3% Humic acid, T₉-600 ppm Zinc + 4% Humic acid, T₁₀-1.0% Urea (N) + 5% Cow urine, T₁₁-1.5% Urea (N) + 10% Cow urine, T₁₂-2.0% Urea (N) + 15% Cow urine, T₁₃-200 ppm Boron + 5% Cow urine, T₁₄-300 ppm Boron + 10% Cow urine, T₁₅-400 ppm Boron + 15% Cow urine, T₁₆-200 ppm Zinc + 5% Cow urine, T₁₇-400 ppm Zinc + 10% Cow urine, T₁₈- 600 ppm Zinc + 15% Cow urine.

Determination of nutrient elements

Nitrogen determination : Total nitrogen in leaves was calculated using Micro- Kjeldhal's as proposed by Jackson (1973), and the results were expressed as a percentage of nitrogen by dry weight.

Phosphorus determination : The Vanadomolybdate phosphoric yellow colour method was used to estimate total phosphorus content (Jackson, 1973). 5 ml of digested aliquot was pipetted into a 25 ml volumetric flask. The aliquot was placed in a volumetric flask with 5 ml of vanadomolybdate reagent. Once the solution had been

Table-3 : Effect of foliar application of nutrients and organic formulations on potassium in leaf of apple cv. Anna under Haryana condition.

Treatments No.	Treatments details	Potassium (%) in leaf					
		Before treatment application			After fruit harvest		
		2020-21	2021-22	Pooled Mean	2020-21	2021-22	Pooled Mean
T ₀	Control	1.573	1.640	1.606	1.619	1.648	1.634
T ₁	1% Nitrogen + 2% Humic acid	1.629	1.723	1.670	1.720	1.742	1.731
T ₂	1.5% Nitrogen + 3% Humic acid	1.631	1.733	1.674	1.729	1.750	1.740
T ₃	2.0% Nitrogen + 4% Humic acid	1.644	1.747	1.684	1.745	1.767	1.756
T ₄	200 ppm Boron + 2% Humic acid	1.578	1.668	1.623	1.644	1.687	1.666
T ₅	300 ppm Boron + 3% Humic acid	1.578	1.671	1.625	1.649	1.692	1.670
T ₆	400 ppm Boron + 4% Humic acid	1.584	1.678	1.631	1.651	1.692	1.671
T ₇	200 ppm Zinc + 2% Humic acid	1.589	1.673	1.631	1.659	1.694	1.676
T ₈	400 ppm Zinc + 3% Humic acid	1.587	1.683	1.635	1.658	1.701	1.680
T ₉	600 ppm Zinc + 4% Humic acid	1.593	1.688	1.641	1.667	1.708	1.688
T ₁₀	1.0% Nitrogen + 5% Cow urine	1.631	1.737	1.678	1.732	1.758	1.745
T ₁₁	1.5% Nitrogen + 10% Cow urine	1.643	1.749	1.686	1.746	1.768	1.757
T ₁₂	2.0% Nitrogen + 15% Cow urine	1.648	1.759	1.690	1.755	1.771	1.763
T ₁₃	200 ppm Boron + 5% Cow urine	1.600	1.689	1.642	1.676	1.715	1.695
T ₁₄	300 ppm Boron + 10% Cow urine	1.609	1.693	1.651	1.686	1.722	1.704
T ₁₅	400 ppm Boron + 15% Cow urine	1.609	1.698	1.654	1.686	1.729	1.708
T ₁₆	200 ppm Zinc + 5% Cow urine	1.604	1.697	1.650	1.690	1.728	1.709
T ₁₇	400 ppm Zinc + 10% Cow urine	1.611	1.699	1.655	1.695	1.735	1.715
T ₁₈	600 ppm Zinc + 15% Cow urine	1.620	1.709	1.660	1.706	1.748	1.727
	CD at 5%	-	-	-	NS	NS	NS

diluted to 25 millilitres and allowed to develop colour for 30 minutes, it was ready to be stored in the refrigerator. A UV-Spectrophotometer Spectronic 20D + at 470nm wavelength was used to measure the concentration of phosphorus in the solution after the colour had developed. A blank was run at the same time to achieve zero absorbance. Leaf phosphorus was calculated using a dry weight basis and expressed as a percentage.

Potassium determination : Total potassium content was estimated by flame photometer as suggested by Jackson (1973) and the results were expressed in per cent.

Results and Discussion

Nitrogen content : The nitrogen content in the leaf of apple cv. Anna before application of the treatments ranged from 1.81 % in T₀ (control) to 1.90 % in T₁₂ [2.0% Urea (N) + 15% Cow urine] in the year 2020-21 and 1.84 % in T₀ (control) to 2.33 % in T₁₂ [2.0% Urea (N) + 15% Cow urine] in the year 2021-22 (Table-1).

Different treatments of foliar application of nutrients and organic formulations had a significant effects on nitrogen content in the leaf of apple cv. Anna in the year 2020-21 (Table-1). The highest leaf nitrogen content (2.31 %) was recorded under 2% Urea (N) + 15% cow urine (T₁₂) which was statistically at par with 1.5% Urea (N) +

10% cow urine (T₁₁), 2% Urea (N) + 4% Humic acid (T₃), 1.5% Urea (N) + 4% Humic acid (T₂), and 1% Urea (N) + 5% cow urine (T₁₀). The lowest leaf nitrogen content (1.82 %) was recorded under control.

The foliar application of different nutrients and organic formulations had a significant effect on the leaf nitrogen content of apple cv. Anna in the year 2021-22 (Table-1). The highest leaf nitrogen content (2.39 %) was recorded under 2% nitrogen + 15% cow urine (T₁₂) which was statistically at par with 1.5% nitrogen + 10% cow urine (T₁₁), and 2% nitrogen + 4% Humic acid (T₃). The lowest leaf nitrogen content (1.86 %) was recorded under water spray (control).

The pooled data analysis of both years revealed that different foliar applications of nutrients and organic formulations had a significant effects on the nitrogen content in the leaf of apple cv. Anna. Maximum nitrogen content in leaf (2.35 %) was recorded under T₁₂ [2.0% Urea (N) + 15% Cow urine] which was statistically at par with T₁₁ (2.34 %), T₃ (2.31 %), T₂ (2.29 %) and significantly superior to rest of the treatments. The lowest nitrogen content (1.83 %) in the leaf of apple cv. Anna was recorded under control (T₀).

Phosphorus content (%) : The application of different foliar application of nutrients and organic formulations had

a non-significant effect on the phosphorus content of the leaves of apple cv. Anna during both the years *i.e.*, 2020-21 and 2021-22 (Table-2). The phosphorus content ranged from 0.188 % in T₀ (control) to 0.251 % in T₁₂ [2.0% Urea (N) + 15% Cow urine] before treatment application in the year 2020-21 which numerically increased at fruit harvest in most of the treatments after their application and ranged from 0.191 % in T₀ (control) to 0.263% in T₁₂ (2.0% Nitrogen + 15% Cow urine) at fruit harvest.

Similarly, the phosphorus content ranged from 0.210% in T₀ (control) to 0.272% in T₁₂ [2.0% Urea (N) + 15% Cow urine] before treatment application in the year 2021-22 which numerically increased in most of the treatments after their application and ranged from 0.212% in T₀ (control) to 0.274% in T₁₂ [2.0% Urea (N) + 15% Cow urine] at fruit harvest.

The pooled analysis of both years also showed a similar pattern for phosphorus content. Phosphorus content ranged from 0.199% in T₀ (control) to 0.261% in T₁₂ [2.0% Urea (N) + 15% Cow urine] before treatment application in both years. This numerically increased at fruit harvest in most of the treatments after their application and ranged from 0.201 % in T₀ (control) to 0.268 % in T₁₂ (2.0% Nitrogen + 15% Cow urine) at fruit harvest.

Potassium content (%) : It is evident from the data presented in Table-3 that different treatments failed to significantly affect the leaf potassium content during both years of experimentation. Potassium content ranged from 1.573% in T₀ (control) to 1.648% in T₁₂ [2.0% Urea (N) + 15% Cow urine] before treatment application in the year 2020-21. This numerically increased at fruit harvest in most of the treatments after their application and ranged from 1.619 % in T₀ (control) to 1.755 % in T₁₂ [2.0% Urea (N) + 15% Cow urine] at fruit harvest.

Likewise, the potassium content ranged from 1.640% in T₀ (control) to 1.759 % in T₁₂ [2.0% Urea (N) + 15% Cow urine] before treatment application in the year 2021-22 which numerically increased in most of the treatments after their application and ranged from 1.648 % in T₀ (control) to 1.771% in T₁₂ [2.0% Urea (N) + 15% Cow urine] at fruit harvest.

The pooled data analysis of both years also showed a similar pattern for potassium content. Potassium content ranged from 1.606 % in T₀ (control) to 1.690% in T₁₂ [2.0% Urea (N) + 15% Cow urine] before treatment application in both years. This numerically increased at fruit harvest in most of the treatments after their application and ranged from 1.634 % in T₀ (control) to 1.763 % in T₁₂ [2.0% Urea (N) + 15% Cow urine] at fruit harvest.

Conclusions

The highest content leaf content of nitrogen was found in 2% nitrogen + 15% cow urine (T₁₂). The phosphorus and potassium content of leaves was not affected by various treatments.

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Role of Protected Cultivation in Fruit Crops

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Abstract

India is the second largest producer of fruit crops in the world, still we are lagging in export potentiality, productivity and quality of fruits due to the impact of biotic and abiotic stress under present climate change scenario including increasing pressure on natural resources as well as decreasing land tenure with the ever-increasing population. As people aware of a nutritious and healthy diet, demand for quality fruit is also rise. The quality with higher production is difficult with the traditional system of cultivation and requires more scientific approach to meet increasing demand. With the rapid rise in demand for fruits leading to their high prices, technological innovations are inevitable, which can improve their productivity and ensure off-season supply. So the technology of greenhouse cultivation is started to grow crops by altering the micro-environment surrounding the crop so that the plant performs maximum to its considerable potential. Therefore, fruit crops grown under protected cultivation may be beneficial in increasing crop growth and better qualitative yield with stability of production and also makes commodities available which help to fetch higher price to grower.

Key words : Greenhouse, quality, yield.

Introduction

High density cultivation is getting more popular in fruit production because it enables the yield in short time. This method has encouraged dwarfing the trees by different applications and developing of dwarf trees under protected cultivation technique. It is the technique of providing favourable environmental conditions to the plants from the adverse climatic conditions such as wind, cold, precipitation, excessive radiation, excessive temperature and insect-pest. It has also of vital importance to create an ideal micro-climate around the plants. Environmental conditions are so modified that one can grow any plant in any place at any time by providing suitable environmental conditions. Due to climate change, water resources reduction, need to alleviate areas under cultivation and increasing greenhouse crops with goal of optimal use of water and soil resources. For this greenhouse structure may be used.

China is the world leader in greenhouse fruit production with the largest area under this technology. Various kinds of fruit, such as strawberry (*Fragaria × ananassa*), grape (*Vitis vinifera*), peach (*Prunus persica*), apricot (*Prunus armeniaca*), cherry (*Prunus avium*), plum (*Prunus domestica*) and citrus (*Citrus spp.*) have proved to be successful for protected cultivation worldwide. Three commercially important single-stemmed crops – banana (*Musa spp.*), pineapple (*Ananas comosus*) and papaya (*Carica papaya*) - are cultivated under greenhouse in the subtropics. Greenhouse mango (*Mangifera indica*)

cultivation is mainly done in Japan; however, Israel also started its commercial cultivation. In India greenhouse fruit cultivation is in its infancy as the only strawberry is commercially being grown under greenhouses. However, in fluctuating environmental conditions and losses in fruit crops due to various biotic and abiotic stresses, providing protection to the fruit crops for the off -season, quality and higher production will be a necessity in future. Therefore, this review article includes the findings of research on protected cultivation of fruit crops.

What about greenhouse

A. Greenhouse : Greenhouse is framed structure covered with any type of cladding material in which crops are grown under partially or fully controlled environmental conditions, which works under the principle of greenhouse effect. Transmission of light is depending upon covering material. Depending on transparency, greenhouse cover allows solar radiation to pass through but traps thermal radiation emitted by the objects within, thus increase the inside temperature and greenhouse effect occurs. Since this temperature rises within polyhouses, it is possible to grow off-season crops in a cold climate. During the summer months, the temperature is reduced to low by providing cooling equipment in polyhouses. Depending on transparency, the greenhouse cover allows solar radiation to pass through but traps thermal radiation emitted by the objects within, thus increasing the inside temperature termed as greenhouse effect. Hence, protected cultivation was found to be better than open-field cultivation in terms of physical, chemical

and quality parameter of fruits. It will also improve growth and survival of planting material comparatively as planting material prepared under protected structure shows better rooting and uniform growth. A major issue with modern greenhouse designs is the accumulation of heat inside the covered structures, which must either be removed or neutralized by energy-intensive refrigeration facilities. This problem was resolved by the design of naturally ventilated greenhouses where the temperature can be kept at the optimal level without any energy usage.

B. Environmental parameters under greenhouse : In our surrounding atmosphere CO₂ concentration is 0.03%. Inside greenhouse CO₂ concentration can raise upto 1000-2000 ppm. Plant use this CO₂ for photosynthesis. In polyhouse, during night time there is no photosynthesis but CO₂ is given out through respiration. This CO₂ remain accumulated around plants hence the CO₂ concentration is higher inside the polyhouse as compared to outside and this CO₂ is again used by plants growing in polyhouse for rapid photosynthesis. The frame work is covered by polythene hence inner temperature can rise upto 40 °C. To control the temperature inside the polyhouse, ventilation as well as cooling pads and fans are used.

C. Classification of greenhouse

1. Types of greenhouse based on the cost of installation : The types of greenhouse based on the cost of installation are given as follows :

(i) Low-cost polyhouse/greenhouse : The 700 gauge thick polythene sheet is supported by bamboo ropes and nails. The temperature inside the greenhouse is 6-10 °C higher than the outside temperature.

(ii) Medium cost greenhouse : It is more costly than low tech greenhouse. Galvanised iron (GI) pipes are used in Quonset-shaped polyhouses frame. The thickness of stabilized polythene, single coated Ultra Violet (UV), is 800 gauges. The exhaust fan is controlled thermostatically. Frames and glazing materials each have a life span of 20 years and 2 years.

(iii) Hi-tech greenhouse : The frame is made of aluminium or iron. Designs are dome or cone-shaped. These are highly durable, 5-6 times more costly, growing media used in greenhouses of this sort are peat, perlite, vermiculite, rock wool. Coconut fibres and rice husks are used as growing media in India since these materials are cheaper. Fertigation and spraying of pesticides are performed by fogging unit.

2. Types of greenhouse based on covering material

(i) Glass greenhouse : Only glass greenhouses with glass as the covering material existed prior to 1950. Glass as covering material has the advantage of greater interior light intensity. These greenhouses have higher air

infiltration rate which leads to lower interior humidity and better disease prevention. Lean-to type, even span, ridge and furrow type of designs are used for construction of glass greenhouse.

(ii) Plastic film greenhouse : Flexible plastic films including polyethylene and polyester are used as covering material in this type of greenhouses. Plastics as covering material for greenhouses have become popular, as they are cheap and the cost of heating is less as compared to glass greenhouses. The main disadvantage with plastic films is its short life. For example, the best quality ultraviolet (UV) stabilized film can last for four years only. Quonset design as well as gutter-connected design is suitable for using this covering material.

Plastic tunnels : These are miniature structures producing greenhouse like effect. Facilitates the entrapment of carbon dioxide thereby enhancing the photosynthetic activity. It protects plants from harsh climatic conditions. These are mainly used for raising nursery. Mainly use in strawberry cultivation.

(iii) Rigid panel greenhouse : In this type green house poly vinyl chloride or fibre glass-reinforced plastic or acrylic or polycarbonate use as cladding material. It is employed in the Quonset type frames or ridge and furrow type frame.

Advantage : More resistant to breakage and the light intensity is uniform throughout the greenhouse as compared to glass or plastic. Long life up to 20 years.

Disadvantage : Panels tend to collect dust, which results in darkening of the panels and subsequent reduction in the light transmission.

(iv) Net house : It is a framed or an inflated structure covered with shade net. Shade net is available in various percentage range (30-90% mesh). Shade net is also available in different colour viz., green, red, white, black, grey, blue etc. It is helpful for controlling temperature, light, water and moisture as per requirement resulting in best output and quality of crops. These are used to reduce adverse effect of scorching sun and rains.

Review on effect of protected cultivation with respect to growth, yield and quality of some fruit crops

1. Effect of protected cultivation on vegetative growth parameters

Banana : Refaie *et al.* (2012) reported maximum pseudo-stem girth (79.0 cm) and number of total leaves (49.4) in banana cv. 'Grand Naine' under red coloured shade net (50 %) due to required diffused radiation from the red net. Darini (2016) observed maximum number of leaves per plant (16.2), trunk diameter (21.5 cm) and suckers number (19.1) in cv. 'Harichal' under greenhouse conditions due to good light quality inside the greenhouse.

Mango : Medany *et al.* (2009) noted that two years old mango cv. 'Keitt' cultivated under white shade net was found superior with respect to overall plant growth than open field cultivation of mango in both seasons due to increased relative humidity, lower maximum temperature and light irradiance, higher minimum temperature and finally, lower wind speed compared to open field conditions.

Peach : Vukovic *et al.* (2017) assessed that peach (*Prunus persica*) and nectarine (*Prunus persica* var. *nucipersica*) trees had considerably higher leaf surfaces under the red net (37.82 ± 5.41 and 40.72 ± 7.87 cm², respectively).

Strawberry : Kumar and Ahad (2012) evaluated eight strawberry cultivars under naturally ventilated polyhouse conditions and observed the maximum plant spread (27.43 cm) and number of runners per plant (8.54) in cv. 'Chandler'. Pandey *et al.* (2016) observed maximum crown height (26.46 cm), plant spread (48.05 cm E-W & 44.06 cm N-S), fresh weight (115.00 g) and higher number of leaves (72.55) per plant in strawberry cv. 'Winter Dawn' grown under naturally ventilated polyhouse conditions because strawberry more response to natural ventilation. While strawberry plants grown in Fan pad system greenhouse reported maximum petiole length (15.35 cm).

2. Effect of protected cultivation on yield

Apple : Shahak *et al.* (2014) observed maximum fruit yield (89.1t ha⁻¹year⁻¹) and large fruits (4.2t/ha/year) in apple cv. 'Golden Delicious' grown under pearl coloured shade net (30 %) due to selective filtration of solar radiation and apple plant responded more to light intensity from pearl colour net. Vukovic *et al.* (2020) noted that maximum fruit mass (180.69 ± 24.82^a gm) apple cv. 'Granny Smith' grown in red net.

Banana : Darini (2016) observed maximum number of fruits per bunch (195.5) and fruit yield (30.2 t ha⁻¹) in banana cv. 'Harichal' under greenhouse conditions due to good light quality inside the greenhouse.

Grape : Kulkarni and Serat (2015) revealed that grape cv. 'Thompson Seedless' grown under green shade net (30 %) showed maximum bunch weight (363.40 g), berry weight (3.67 g), berry length (27.67 mm) and yield (24.22 t ha⁻¹) as compared to other shed nets.

Mango : Medany *et al.* (2009) observed a higher yield of mango during both years when using a white net compared to open field conditions. The reduction of radiation is responsible for the down-regulation of the leaves photosynthetic potential and, as a result, a lower saturated photosynthetic light intensity compared to the control.

Papaya : Gunes and Gubbuk (2011) recorded

significantly, maximum number of fruit per plant (63.7), fruit weight (460.0 g), fruit width (11.7 cm), fruit length (16.77 cm) and yield (28.3 kg plant⁻¹) in cultivar Sel-42 under greenhouse conditions because 'Sel 42' responded more to greenhouse condition as compared to other. Refaie *et al.* (2012) reported maximum bunch weight (18.7 kg), finger/bunch (249.9) and finger weight (77.8 g) in banana cv. 'Grand Naine' under red coloured shade net (50 %) due to required diffused radiation from the red net. Prakash *et al.* (2015) observed maximum number of fruit per plant (41.25), fruit weight (875.67 g), fruit length (16.34 cm), fruit yield (34.56 kg plant⁻¹), pulp weight (754.25 g), in papaya cv. 'Pusa Nanha' under fan pad system greenhouse conditions cause higher photosynthetic activity inside. Tyagi *et al.* (2015) revealed that papaya cv. 'Red Lady 786' produced maximum number of fruits per plant (46.0), fruit weight (841.67 g), fruit length (15.33 cm) and yield (38.84 kg plant⁻¹) as compared to other varieties of papaya grown under net house condition cause its ultra dwarf nature responded more to greenhouse condition as compared to other varieties. Kaur and Kaur (2017) found significantly maximum fruit weight (874.32 g), fruit length (22.68 cm), fruit breadth (11.93 cm) and fruit yield (35.15 kg plant⁻¹) when papaya cv. 'Red lady 786' grown under net house conditions due to good micro climatic condition which influence production of more photosynthates which result in better performance. Honore *et al.* (2019) observed that the maximum yield (14.20a kg m⁻²) parameters and fruit characteristics were obtained from cv. 'Intezza grafted' on female papaya rootstock under protected cultivation system. Salinas *et al.* (2021) recorded maximum total yield (35.5 kg m⁻²), commercial yield (32 kg m⁻²), fruits plant⁻¹ (101) and fruit weight (1173 gm) in active climate control modules. A higher rate of photosynthesis of plant grown under the more favorable conditions could explain higher growth and better fruit set.

Peach : Vukovic *et al.* (2017) evaluated that peach trees under red net had higher yield (1130.00±340.00 g) and higher fruit mass (163.73±36.42 g) than in control.

Pineapple : Levin *et al.* (2019) observed that fruits produced in greenhouse had maximum fruit length (10.88 cm) and fruit weight (662 g) with minimum crown length (9.71cm) and crown weight (96.81 g) than those produced in open field due to plant has more vegetative growth during flower induction under greenhouse and crown contribute to fruit growth.

Pomegranate : Meena *et al.* (2016) noted that maximum fruit weight (310 g), fruit length (83.39 mm) and yield (6.70 kg tree⁻¹) in three years old pomegranate cv. 'Mridula' grown under red shade net house (50 %) with 3.0 m height because red net provides required light intensity for lower temperature and it improve penetration of plant canopy as well as reduce far red spectral band.

Strawberry : Kadir *et al.* (2006) observed that strawberry cv. Chandler under high tunnel condition gave the maximum yield during both the years as compared to field condition because cv. 'Chandler' is more vigorous than cv. 'Sweet Charlie' and high tunnel provides favorable climatic condition. Kumar and Ahad (2012) evaluated eight strawberry cultivars under naturally ventilated polyhouse conditions and observed the maximum number of berries per plant (23.42) in cv. 'Chandler'. Whereas, the highest yield/plot (2.26 kg), berry weight (12.24 g) and berry length (5.10 cm) were recorded in cv. 'Tioga'. Pandey *et al.* (2016) observed maximum number of fruits per plant (29.00) and fruit yield per plant (242.77g) in strawberry cv. 'Winter Dawn' grown under naturally ventilated polyhouse conditions because strawberry more response to natural ventilation. Menzel *et al.* (2016) examined the effect of growing system and cultivar and breeding lines on the performance of plants and reported that Marketable yields were 38 per cent higher in tunnel-growing plants. Mishra (2021) noted maximum marketable fruit (96.48 %), net income per acre (868158.80) and BCR were noted under triple layer system. Whereas, maximum fruit yield (7734.63 kg acre⁻¹) was recorded under four layer system. However, maximum fruit set (87.68 %), number of fruit per plant (20) was noted under single layer system.

3. Effect of greenhouse cultivation on quality parameters

Banana : Darini (2016) observed maximum vitamin C content (55.7 mg 100g pulp⁻¹) in cv. 'Harichal' and TSS (12.7°B) in cv. Chains Cavendish under greenhouse conditions due to good light quality inside the greenhouse.

Grape : Kulkarni and Serat (2015) revealed that grape cv. 'Thompson Seedless' grown under green shade net (50 %) showed highest TSS (20.75°B) cause it provide required scattered light by diffused radiation.

Mango : Juntamanee *et al.* (2013) recorded that use of plastic roof over ten years old mango trees helped in reduction of anthracnose incidence at pre and post harvest period, decreased severity of fruit rot at ripening stage and completely controlled thrips damage on the fruit surface so alternately improve fruit quality.

Papaya : Prakash *et al.* (2015) shows maximum fruit firmness (1.97 kg cm⁻²), total soluble solids (11.3°B) and ascorbic acid (75.26 mg/ 100 g pulp) in cv. 'Pusa Nanha' under fan pad system greenhouse conditions over open-field production. Tyagi *et al.* (2015) revealed that papaya cv. 'Red Lady 786' produced TSS (13.0 °B) and total sugar (7.91 %) as compared to other varieties of papaya grown under net house condition. Kaur and Kaur (2017) found significantly maximum fruit weight (874.32 g), fruit length (22.68 cm), fruit breadth (11.93 cm), fruit firmness (1.94 kg cm⁻²), fruit volume (895.16 cc), TSS

(11.13 °B) and fruit yield (35.15 kg plant⁻¹) when papaya cv. 'Red lady 786' grown under net house conditions.

Pomegranate : Meena *et al.* (2016) noted that maximum colour value-L (46.38), total sugar (10.8 %) and ascorbic acid (13.52 mg 100gm pulp⁻¹) in three years old pomegranate cv. 'Mridula' grown under red shade net house (50 %) with 3.0 m height.

Strawberry : Kumar and Ahad (2012) evaluated eight strawberry cultivars under naturally ventilated polyhouse conditions and observed the maximum TSS (9.85 °B), TSS/Acid ratio (10.51), reducing sugar (6.27 %) and total sugar (8.09 %) in cv. 'Catskill'. Mishra (2021) noted maximum ascorbic acid (92.81 mg 100 ml juice⁻¹), total sugar (4.91%), sugar: acid ratio (6.19) and anthocyanin content of fruit (55.16 mg 100 g pulp⁻¹) with minimum acidity (0.82 %) under triple layer system.

Conclusions

Based on the above discussion it can be concluded that the protected cultivation of fruit crops are beneficial for increasing productivity with quality fruits due to favorable environmental conditions. Protected cultivation production system offers a great scope to identify suitable varieties for fruit crops and minimize insect and pest incidence. Protected cultivation technology is superior in terms of all growth, quality, yield and post harvest parameters as compared to open field cultivation of fruit crops which as under.

Future thrust

There is following future thrust by which more emphasis may be given on protected cultivation of fruit crops.

Need to standardize package of practices for protected cultivation of different fruit crops in different agro-climates.

Need to develop farmer friendly and cost-effective agro-techniques for protected cultivation.

Need to develop suitable varieties of fruit crops for protected cultivation.

Government support is highly required for the cultivation of protected fruit crops as they have long gestation period and the government should provide additional subsidy for growing perennial fruit crops.

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Role of Paclobutrazol in Fruit Crops

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Abstract

The ability of the crops to produce fruits throughout the year is great interest in recent years. The biennial bearing is very serious problem in fruit crop production. Therefore, application of paclobutrazol is most widely studied in view of its high potential for controlling plant growth and development of fruit crops in general. Paclobutrazol (PBZ) popular as a growth retardant. It is cell elongation and internode extension retardants that retards plant growth by inhibition of gibberellins biosynthesis. Its agronomic management includes it as widely use method to reduce vigour, promote flower induction and flower development in fruit trees with increased economic returns. The results obtained indicated that the application of PBZ can be effective in solving some problems related to flowering if it is applied in the right amount and at the right time. Its use banned in some countries because of concerns about residues that can cause harmful effects on the environment. Therefore, the aim of this review paper to collect, analyses and summaries relevant information on the use of PBZ in fruit tree production and its possible risks to the environment.

Key words : Paclobutrazol, growth retardant, gibberellin biosynthesis, environment.

Introduction

India is second largest fruit producer in the world which contributes about 70.49 lakh hectare area, 107.24 MT production with productivity 15.21 MT/ha (Anon. 2021). In India majorly fruit growing states are Andhra Pradesh, Maharashtra, Uttar Pradesh, Gujarat, Madhya Pradesh, Karnataka and Tamil Nadu. In the history of horticulture attempts were made to reduce the plant height and allow tree with a compact growth for easy agronomical practices in the orchard. The attempts were also made for the induction of early as well as synchronized flowering in orchard to achieve higher prices by early entry in the market. Irregular and alternate bearing in fruits is a major problem faced by fruit growers. This problem causes great economic loss to the growers with poor yield and selling of produce at low price during “on year” due to fruit glut in the market. In this regard, research workers have developed a number of methods to control tree size, early bearing, precocity in flowering, off season production and increase fruit quality etc. For manipulation of all these aspects growth regulators especially paclobutrazol (cultural) is being commonly used by the horticultural growers.

Plant growth regulators : Plants synthesize various compounds, including growth bioregulators, which promote and regulate their physiological processes (vegetative growth, flower induction, fruit set and fruit size increase). In addition, they influence the response to biotic and abiotic stresses. Traditional bioregulators

include auxins, gibberellins, cytokinins, and abscisic acid. Research also considers brassinosteroids, salicylic acid, triazoles, jasmonates, polyamines and recently strigolactones as bioregulators.

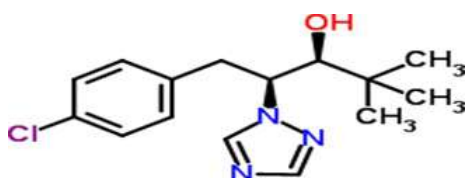
Growth bioregulators can be classified according to their mode of action (Table-1). It is reported that they can enhance plant defence mechanisms, promote cell division and growth, processes that help to increase yield and quality fruit. They can also delay or inhibit growth. They also play an important role in responses to stress and adaptation such as to water deficit, high temperatures, salinity and flooding.

Paclobutrazol (cultural) : PBZ was first announced in 1986 as a new bioregulator, which was introduced to the market by ICI Agrochemicals (now part of Syngenta). It is a synthetic compound [(2RS, 3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1H-1,2,4-triazol-1-yl)-pentan-3-ol], belonging to the triazole group. PBZ include: molecular weight 293.79, molecular formula C₁₅H₂₀ClN₃O, melting point 165-166 °C, density 1.22 g/ml and water solubility 35 mg/l. It has two chiral centers (two asymmetric carbons), hence the existence of two pairs of enantiomers [(2R, 3R) and (2S, 3S)] and [(2S, 3R) and (2R, 3S)]. The (2R, 3R) isomers displays substantial fungicidal activity, whereas the (2S,3S) isomers responsible for the growth regulating properties.

PBZ is found as an active ingredient in different concentrations like 23% SC, 25% SC and 40% SC. PBZ

Table-1 : Classification and mode of action of growth bioregulators.

Classes	Examples	Mode of action	Source
Auxin	Indoleacetic acid, Indolebutyric acid, Naphthalene acetic acid	Two biosynthesis routes, the main route by means of tryptophan. They promote cell division and expansion, apical dominance, root development, stimulate gibberellin synthesis and indirectly stimulate stem growth	Fahad <i>et al.</i> ; 2015; Munoz, 2016
Gibberellins	Gibberellic acid	It is synthesized through the terpenoid pathway in the plastids and cytoplasm, derived from the isoprenoid biosynthetic pathway, and among its functions it stimulates cell division and elongation, and is related to stem growth, seed germination, fruit development and flowering	Wang <i>et al.</i> ; 2020; Munoz, 2016; Hernandez Garcia <i>et al.</i> ; 2020)
Cytokinin	Zeatin, Thidiazuron	Stimulates cell division and differentiation leading to the formation of roots, leaves, flowers and fruits, extends the vegetative period and helps in the accumulation of nutrients, senescence and response to environmental stresses	Munoz, 2016; Obregon, 2021; Nisler, 2018
Ethylene	Ethylene	Diminishes stem and root growth. Help in flower development, fruit ripening, in addition to leaf and flower senescence and fruit abscission	Fahad <i>et al.</i> ; 2015
Absciscic acid	Absciscic acid	Induces embryo ripening, seed dormancy, vegetative growth and processes related to stress tolerance (stomata closure), ripening and fruit abscission	Munoz, 2016
Jasmonates	Jasmonic acid, Isojasmonic acid	Help signaling in plants to respond to biotic and abiotic stress. Promotes seed germination, root growth and flowering	Chavez, 2012; Fahad <i>et al.</i> ; 2015
Brassinosteroids	Brasinolide, Dolicolide, Epibrasinolide	Influence germination, Rhizogenesis, flowering, senescence, abscission and ripening processes. They also confer resistance to plants against abiotic and biotic stresses	Fahad <i>et al.</i> ; 2015
Silicates	Salicylic acid	Induces flowering, inhibits ethylene biosynthesis and increases growth. Enables stress regulation and stress Response	Chavez, 2012; Fahad <i>et al.</i> ; 2015
Polyamines	Putrescine, Spermidine, Spermine	Are involved in cell division and cell elongation, nucleic acid packaging, DNA replication and rooting	Munoz, 2016; Luna-Esquivel <i>et al.</i> ; 2014
Strigolactones	Strigol, Strigylacetate, Sorgolactone	Inhibit auxin transport, promote shoot and root growth	Waters <i>et al.</i> ; 2017
Triazoles	Paclobutrazol, Uniconazole	Reduce plant growth, decreasing competition between vegetative and reproductive growth through promote flower development and fruiting, improve tolerance to environmental or disease stress. Increase the concentration of chlorophyll and antioxidant enzymes such as superoxide dismutase, catalase, ascorbate and peroxidase.	Soumya <i>et al.</i> ; 2017; Fahad <i>et al.</i> ; 2015; Lopez, 2015



[(2RS, 3RS)-1-(4-chlorophenyl)- 4, 4-dimethyl-2-(1H-1, 2, 4-triazol-1-yl)-pentan-3-ol]

also known as commercially “Cultar” and “Bonzi” (Syngenta, USA), “Regalis Plus” (BASF, USA), “Austar” (Chemicals Direct Pty Ltd., Australia), Trimmit (Zeneca Agrochemical Products), Clipper and Sadabahar. It is a non-polar compound with a broad-spectrum nature that is mainly translocated through xylem.

There are different application methods of PBZ such as soil application, foliar application, trunk application, injection method. In soil application includes RB (ring basin) method, collar drenching and TSLP (trunk soil liquid pore) method.

Paclobutrazol inhibits gibberellins biosynthesis by blocking the conversion of kaurene and kaurenoic acid, which inhibits cell elongation and internode extension and ultimately retards plant growth. Gibberellins stimulate cell elongation. When gibberellin production is inhibited, cell division still occurs, but the new cells do not elongate. That result in the production of shoots with the same numbers of leaves and internodes compressed into a shorter length. Even reduction in the diameter of the trunk is noticed. Paclobutrazol treated trees shows increased production of the hormone absciscic acid and the chlorophyll component phytol, which are beneficial to tree growth and health. It also induce morphological modifications of leaves, such as smaller stomatal pores, increased number and size of surface appendages, thicker leaves, and increased root density that may provide improved environmental stress tolerance and disease resistance and it also has some fungicidal activity due to its capacity as a triazole to inhibit sterol

biosynthesis (Chaney, 2005). The Mode of action of plant growth regulators such as paclobutrazol is highly specific to cultivar, rate of application, cultivar, developmental stages and climatic condition.

Effects of paclobutrazol on various tree attributes :

Paclobutrazol application is desirable to control the vegetative growth and to reduce the canopy size since small trees capture and convert the sunlight into fruit biomass in a better way than larger trees because of more surface area. Increase in production with enhanced fruit quality can be achieved by managing the tree canopy. Manipulation in tree physiology with the use chemical growth retardants has been considered as an important determinant of productivity enhancement in many fruit crops. Recently, application of paclobutrazol is being commercialized for early and enhanced flowering with yield in mango, apple and pomegranate. Effect of paclobutrazol has reviewed on mango, apple and pomegranate in this paper which are given below.

1. Effect on vegetative growth

Many investigations have revealed the beneficial effects of PBZ in restricting vegetative growth and successful induction of flowering in mango and apple.

Apple : The application of paclobutrazol (1500 to 3000 ppm) at full bloom and 21 days after full bloom resulted in the reduction of shoot growth in “Golden delicious” apple (Greene, 1982). Five years old MM106 (*Malus domestica* Borkh.) trees growing under HDP (10000 trees/ha) treated with paclobutrazol at 250 mg per tree in August by Khurshid *et al.* 1997, showed reduced number of total shoots and buds. This showed that PBZ can be used to manipulate apple tree growth in high density apple production system.

Mango : Soil application of paclobutrazol recorded significant reduction in canopy volume by noticeable reduction in number of shoots per terminal and also checked the growth of new shoots (Tandel and Patel, 2011). Similarly, the growth inhibitory response of PBZ reported in different varieties of mango (Sarkar and Rahim, 2012) could be the consequences of modification in photosynthesis rate (Gonzalez and Blaikie, 2003) and carbohydrates (Upreti *et al.*; 2014) besides reductions in gibberellins (Upreti *et al.*; 2013). Gohel *et al.* (2021) observed significantly minimum number of new shoots per terminal and length of new shoot were recorded with application of paclobutrazol dose @ 8.5 g a.i. Kumar *et al.* (2019) observed minimum panicle length and shoot length in mango cv. Dashehari with the dose of paclobutrazol 60 ml/tree. The cultar reduces vegetative growth, shoot elongation and number of leaves in many fruit trees by interrupting gibberellic acid synthesis at kaurene stage (Burondkar and Gunjate, 1993) similarly results were

reported by other workers in mango (Ram *et al.*; 2005, Raj kumar *et al.*; 2007, Vijayalakshmi and Srinivasan, 2000; Hoda *et al.*; 2001, Nafeez *et al.*; 2010, Sarkar and Rahim, 2012).

2. Effect on flower bud differentiation

Mango : Flowering in mango is preceded by the differentiation of the flower bud in the shoots. Physiological maturity appears directly related with flower bud differentiation. In Indian sub-continent, the time of the flower bud differentiation has been reported by various workers to varying from October to December. In Baramasimango bud differentiation, most often, takes place twice a year, *i.e.* during May-June and September-October. Fluctuation in the time of flower bud differentiation is dependent on genetic, environmental and endogenous tree factors (Schaffer *et al.* 1994). Thus, flower bud differentiation seems to be depending on the fluctuations in temperatures and the fruit load borne by the tree during previous year. Ravishankar *et al.* (1979) found that flower bud differentiation in Alphonso mango, irregular or erratic bearing cultivar grown under the mild tropical climate of Dharwar (India) was initiated in early October and reached a peak by November. Singh (1958) reported the last week of December to be the critical time for flower bud differentiation under north Indian climate. Regulation of flowering in off season the application of cultar before flower bud differentiation or three months earlier than anticipated flowering has been effective in inducing flowering in mango without accompanying reduction in shoot length. However higher concentration leads to canopy and panicle compaction (Shinde *et al.* 2000). Gohel *et al.* (2021) observed days to flower bud initiation, days to 50% flowering and days to full bloom were significantly influenced by various time of paclobutrazol application. In other words, they reported application of paclobutrazol in mid-July suppressed vegetative growth and induced early and profuse flowering. Reddy and Kurian (2008) observed that under tropical climate, application of paclobutrazol for three consecutive years and then its discontinuation for the subsequent three years appears in twenty years old mango trees to be appropriate. However, the continuous optimum use of cultar in high density planting is imperative to manage canopy and to induce precocious flowering as it was also observed that young plants respond better than old ones. Soil application around the tree trunk (collar drench) was more efficacious than foliar application as it ensures proper uptake in inducing flowering and fruiting (Kulkarni *et al.* 2006).

The response to cultar varied with cultivar and crop load. The shoot retarding effect of cultar was generally limited in mango cv. Sensation, but was pronounced in Tommy Atkins. Moreover, the average fruit weight and

yield were increased with the rate of paclobutrazol in Sensation, whereas fruit weight and yield were reduced in Tommy Atkins (Singh and Bhattacharjee 2005). Singh *et al.* (2005) reported soil application of PBZ at 5 and 10 g per tree considerably increased the percentage of panicles and hermaphrodite flowers on twenty-five years old Dashehari mango trees. Soil application of paclobutrazol at 5 g per tree was most effective to induce higher number of flowering shoots in mango cv. Gulab Khas (Singh and Singh, 2006). Bagel *et al.* (2004) observed maximum number of flowering shoots/m² (30.32) and percentage of flowering shoots (96.15%) when Cultar applied alone (2.50, 3.75 and 5.00 g/ha) and in combination with NAA (20 ppm), on the flowering and fruiting of ten years old mango cv. Langra trees and they recorded flowering and fruiting was significantly increased by 7- 30%. Soil application of cultar promoted flowering, along with cauliflory and axillary flowering (Singh 2000). Four months later and monthly thereafter, 10 shoots were dipped in 2% potassium nitrate to assess flowering response. Flowering started only by November or 6 months after paclobutrazol application. By December, all trees treated with 1 g paclobutrazol per canopy diameter flowered in contrast to only 38% of the control trees.

3. Effect on flowering parameters and yield

The effects of PBZ on different flowering parameters such as regular, profuse and early flowering (Nartvaranant *et al.* 2000, Jogande and Choudary 2001, Karki and Dhakal 2003, Yeshitela *et al.* 2004, Blaikie *et al.* 2004, Singh and Ranganath 2006, Reddy and Kurian 2008, Hussien *et al.* 2012, Reddy *et al.* 2014, Patel *et al.* 2016), increased the number of perfect flowers and fruit set (Burondkar and Gunjate 1993, Kurian and Iyer 1993, Hoda *et al.* 2001, Singh 2000, Kumar *et al.* 2019) were reported in various fruit crops. All the available evidences opined that carbohydrate reserves played an important role in flower bud differentiation and they provide conditions favorable for the synthesis of substances which are required for flower bud differentiation (Suryanarayana, 1987 and Pongomboon *et al.* 1997). The high C:N ratio during flower bud differentiation was ascribed to the increased carbohydrate availability and is considered as an important factor in regulation of flowering in fruit crops (Jyothi *et al.* 2000 and Palanichamy *et al.* 2012).

Apple : The fruit set was increased in paclobutrazol treated trees @ 1500 and 3000 ppm due to an increase in initial fruit set in delicious apple (Greene, 1986) similar results were observed by Elfying *et al.* (1990) in McIntosh apples that the foliar application of paclobutrazol reduced pre harvest drop when applied within 5 weeks after full bloom.

Mango : Patel *et al.* (2016) observed highest fruit set in

paclobutrazol treated tree @ 18.4 g a.i./tree in mango cv. Alphonso. Similarly, results conformity obtained Padhiar (1999). Tandel and Patel (2011) observed highest number of fruits per tree and yield with higher benefit cost ratio in Alphonso, Kesar and Rajapuri with application of PBZ @ 5 g a.i. per tree in the month mid-July. The C:N ratio differs with growth of shoots in the varieties revealing its dependence on environmental conditions and prevailing metabolic balance. The paclobutrazol induced enhancement in C:N ratio has been reported in mango (Subhadrabandhu *et al.* 1997, Abdel Rahim *et al.* 2011, Rakshe and Nigade 2013, Upreti *et al.* 2013 and Upreti *et al.* 2014). Distinct differences in carbohydrate pattern are seen in vegetatively growing shoots and flowering shoots. Shoots that are going to differentiate into flower buds are the growing sinks and the actively dividing cells of induced flower buds require high energy (Davenport, 2007). Apparent increase in sugar levels during floral induction period has been reported in mango by several researchers (Jyothi *et al.* 2000, Abdel Rahim *et al.* 2008, Palanichamy *et al.* 2012).

Among the chemicals suggested, paclobutrazol is considered as one of the most versatile plant growth retardants which restricted vegetative growth and induced flowering in mango (Sarkar and Rahim, 2012). Early and intense flowering induced by PBZ may be the consequence of early shoot maturity and increased photosynthesis rate (Singh and Singh, 2003), carbohydrate accumulation (Abdel *et al.* 2011) and decline in flowering reducing hormone, gibberellins (Upreti *et al.* 2013), reduced panicle length (Vijayalakshmi and Srinivasan 2000, Hoda *et al.* 2001, Sarkar and Rahim 2012, Nafeez *et al.* 2010), increased the number of perfect flowers and fruit set (Singh 2000, Burondkar and Gunjate 1993, Kurian and Iyer 1993, Hoda *et al.* 2001) were reported in various fruit crops.

4. Effect on fruit set and yield

Mango : Bagel *et al.* (2004) were recorded maximum yield per tree (68.12kg), yield per hectare (106.25 q/ha) and yield increase over the control (29.85%) of 10 years old mango cv. Langra trees applied with cultar at 5.00 g/ha in combination with 20 ppm NAA. Soil application of paclobutrazol at 5 g/tree was most effective to improve the fruit set (EFSA, 2018), fruit retention during the off year. The highest yields of 70.50 and 68.70 kg per tree during the off year were recorded under soil application of paclobutrazol at 5 and 10 g/tree, respectively (Singh and Singh, 2006). Increase in fruit set per panicle is due to retardation of plant vigour by growth retardant. Benjawanet *et al.* (2006), reported that PBZ had no significant effect in extending number of days from flower initiation up to full bloom. PBZ also had no significant effect in delaying fruit maturity age but fruit sets were significantly increased with

PBZ rates applied. PBZ had a highly significant effect on fruit length but significantly decreased fruit thickness. Fruit yields were significantly increased with PBZ application.

The best application rate of PBZ was found length of 5 cm. This treatment gave the highest mango edible fruit yield of 48281.25 kg/ha.

5. Effect on fruit quality

Fruit quality improvement with respect to pulp content, TSS, TSS to acid ratio, total sugars and reducing sugars in response to PBZ application can be related to the assimilate partitioning in plant. The greater suppression of vegetative growth causes assimilates demand in unidirectional manner to the developing fruit, resulting in high quality fruits from PBZ treated plants.

Mango : Singh and Dillon (1992) reported that soil application of PBZ to Dashehari mango recorded higher fruit yield and high TSS to acid ratio compared to foliar application, while fruit weight to stone and pulp to stone ratio did not differ significantly. Vijaylaxmi and Srinivasan (2000) in an experiment with 10 years old Alphonso mango trees treated with paclobutrazol (10 ml), KNO₃ (1%), urea (1%), ethep (200 ppm), NAA (20 ppm) or mepiquat chloride (500 ppm) found that among all the treatments, paclobutrazol (10 ml) resulted in increased ascorbic acid content, total sugars and reducing sugars, TSS, acidity and sugar to acid ratio in harvested fruits. The soil drenching of paclobutrazol at 3.0 ml per meter canopy diameter to the mango cv. Totapuri was done in order to study the role of carbohydrates in the paclobutrazol induced floral initiation by Upreti *et al.* (2014). Similar results observed by Reddy *et al.* (2014). The results indicated that paclobutrazol induced flowering was accompanied by an increase in starch in leaf concomitant with increased insoluble sugars like sucrose, glucose and fructose in apical buds as well as inhibition in the amylase activity in association with increase in the activities of acid invertase, sucrose phosphate synthase and sucrose synthase in the apical buds.

The improvement in fruit quality parameters such as high edible portion, longer shelf life, higher TSS, increased vitamin C, lower titrable acidity, high dry matter content and high reducing and total sugars with PBZ was reported by Vijaylakshmi and Srinivasan (2000), Hoda *et al.* (2001), Sarkar and Rahim (2012), Reddy *et al.* (2014), Kumar *et al.* (2019) in different varieties of mango. An increase in the contents of ascorbic acid and carotenoids which are documented as potential antioxidants with PBZ application has also been reported in mango (Reddy *et al.* 2014). However, non-significant effect on fruit quality with PBZ application was reported by Tandel and Patel (2011) and Upreti *et al.* (2013).

6. Effects on physiological attributes

Effect on leaf water potential (LWP) the PBZ induced increase in LWP is speculated as the result of increased root hydraulic conductivity, reduced transpiration, and increased ABA levels. Increased ABA reduces the transpiration losses by inducing stomatal closure (Hauser *et al.* 1990). As ABA is known to induce stomatal closure and is expected to reduce the water loss through transpiration.

Mango : The increased water levels due increased ABA are expected to induce bud dormancy which could be of relevance to flower bud differentiation in mango (Kulkarni 1988, Murti *et al.* 2001, Abdel *et al.* 2011, Upreti *et al.* 2013). The relation of cultar on the water use in terms of soil moisture content, gas exchange attributes of Dashehari mango was also studied indicated that the cultar has capacity to retain the moisture to some extent and the trees are less sensitive to fluctuation in water supply and may be better able to withstand drought conditions (Singh and Singh, 2003).

7. Effect on mechanism of nutrient uptake

Mango : Werner (1993) reported that cultar treated mango trees showed an increase of N, Ca, Mn, Zn and B contents and decreased contents of P, K and Cu. On the other hand, the significant increase in the root activity towards the trunk and close to soil surface and sparser root activity in the subsoil zone and in drip line area in paclobutrazol treated mango plants was observed by Kotur (2006). Paclobutrazol also promotes the avoidance of salt stress in mango by increasing the levels of photosynthetic pigments, water content, K⁺ uptake and uptake of harmful Na⁺ and Cl⁻ ions (Kishor *et al.* 2015).

8. Effect on regulation of flowering in off season

Mango : Soil application of paclobutrazol at 5 g per tree was most effective to induce higher number of flowering shoots in mango cv. Gulab Khas (Singh and Singh 2006, Reddy *et al.* 2014). Similar reports were obtained by Bagel *et al.* (2004) in 10 years old mango cv. Langra trees. Soil application of Cultar promoted flowering, along with cauliflower and axillary flowering (Singh 2000).

9. Effect on fruit splitting

Pomegranate : El-Khawaga (2003) studied the effect of foliar sprays with paclobutrazol and zinc sulphate on splitting and yield of pomegranate during 2001 and 2002 seasons. They found significantly minimum fruit splitting (26.50% and 24.10%) with treatment foliar spray of paclobutrazol 150 ppm in first week of June in 2001 and 2002, respectively.

Conclusions

From the forgoing discussion, it can be concluded that

application of PBZ at different doses and times through different application methods, depending upon crops, it significantly reduced the vegetative growth traits *i.e.* shoot elongation, panicle length, panicle diameter, internode extension, flowering period *etc.* It also increased reproductive traits *i.e.* flowering percentage, fruit setting, fruit yield and quality parameters with minimum PLW, spoilage and fruit splitting in mango, apple and pomegranate.

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Correlation and Path Analysis for Tuber Yield and its Component Characters in Greater Yam (*Dioscorea alata* L.)

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Abstract

Correlations and path coefficient were studied in 30 Greater Yam (*Dioscorea alata* L.) genotypes for 22 quality and yield contributing characters. The correlation coefficients were determined to find out the inter relationship among the characters studied. Tuber yield per vine was found highly significant positive genotypic and phenotypic correlation with leaf width, weight of tuber, petiole length, diameter of tuber, vine length at harvest and significant positive genotypic and phenotypic correlations with moisture, tuber length which indicated that yield could be increased by improving traits. Path coefficient analysis studies done to study the cause and effect relationship revealed that moisture, dry matter, number of leaves, first leaf emergence, diameter of tuber, petiole length, number of sprouts per seed tuber, total phenol, internode length, starch content, weight of tuber, vine length at harvest, ascorbic acid and total sugar had high positive direct effects on tuber yield per vine. Hence, direct selection for these traits is done for improving tuber yield per vine.

Key words : Greater yam, correlation coefficients, path coefficient analysis.

Introduction

Yam is a vine plant, cultivated for its large and edible underground tubers. Greater Yam (*Dioscorea alata* L.) is a member of the family Dioscoreaceae, native to South-East Asia and it has chromosome number of $2n=40$. Yams are cultivated for consumption by more than 100 million people especially in many developing countries like India (Lebot, 2009). Tubers are boiled with mushrooms, cooked with vegetables and mixed with rice. Tuber paste is applied on cancerous wounds, leprosy, gonorrhoea, blood pressure and in skin diseases. Yam is second to cassava as the most important tropical root crop but from a nutritional standpoint, it is better than cassava on account of its higher vitamin 'C' and crude protein content. It has relatively high levels of oxalates. It contains steroid saponins and also sapogenins, such as diosgenin, which is the starting material for synthesis of many steroidal hormones used as anti-inflammatory, androgenic estrogenic and contraceptive drugs. Yield being a complex character, is dependent upon a number of traits. Before initiating an effective selection programme, it is necessary to know the importance and association of various components among each other and with yield. In improvement programme correlation analysis is important. It provides an idea about relationship between traits. The correlation characters can be used for indirect selection if main economically important traits have low variability. The path coefficient

analysis provides an effective mean for partitioning of direct and indirect cause of association. Hence, the present study was undertaken to estimate the genotypic correlations and the direct and indirect effects of component characters on yield in greater yam.

Materials and Methods

The study was conducted at Hi-Tech Unit, Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during *kharif* (June, 2018 to February, 2019). The material for the present study comprised of 30 genotypes of greater yam were collected from different places. The experiment was laid out in a Randomized Block Design (RBD) with three replications. The recommended cultural practices were followed for raising good crop. Five randomly selected plants for each genotype were tagged for the purpose of recording the observations on different growth and quality characters viz., days to emergence, first leaf emergence, number of leaves (30 DAE), number of sprouts per seed tuber, vine length at 45 DAE, internode length, vine length at harvest, leaf width, petiole length, tuber length, diameter of tuber, number of tuber per vine, weight of tuber, stem girth, tuber yield per vine, starch, ascorbic acid, moisture, TSS, total sugar, total phenol, dry matter. Phenotypic and genotypic correlation coefficient of all the characters were worked out as per formulae suggested by Al-Jibouri *et al.* (1958). The significance of the phenotypic and genotypic correlation coefficients was

Table-1 : Genotypic (above diagonal) and phenotypic (below diagonal) correlation analysis in greater yam.

Character	Days to emergence	Days to first leaf emergence	Days to first leaf emergence ce	No. of leaves (30 DAE)	No. of sprouts per seed tuber	Vine length 45 DAE (cm)	Internode length (cm)	Vine length at harvest (cm)	leaf width (cm)	Petiole length (cm)	Tuber length (cm)	Diameter of tuber (cm)	No. of tuber per vine	Weight of tuber (kg)	Stem girth (cm)	Tuber yield per vine (kg)	Starch content (g/100g)	Ascorbic acid (mg/100g)	Moisture (%)	TSS (°B)	Total sugar (g/100g)	Total phenol (mg/100g)	Dry matter (%)
Days to emergence																							
Days to first leaf emergence	0.98**																						
No. of leaves (30 DAE)	-0.10	0.98**																					
No. of sprouts per seed tuber	-0.11	-0.15	0.96**																				
Vine length 45 DAE (cm)	-0.17	-0.11	-0.05	0.06																			
Internode length (cm)	0.18	0.17	-0.05	0.32	0.01																		
Vine length at harvest (cm)	0.08	0.05	-0.05	0.06	-0.05	0.01																	
leaf width (cm)	-0.80**	-0.76**	-0.72**	-0.07	-0.05	-0.03																	
Petiole length (cm)	0.08	0.05	0.07	0.12	0.07	0.07	0.08																
Tuber length (cm)	-0.03	-0.06	0.29	0.27	0.30	0.23	0.23	0.16															
Diameter of tuber (cm)	0.09	0.11	0.08	0.08	0.06	0.08	0.33	0.54**	0.39*	0.43*	0.58**	0.51**	-0.23	0.50**	0.10	0.33	0.00	-0.07	0.27	0.09	0.02	0.06	-0.27
No. of tuber per vine	0.12	0.11	-0.15	-0.14	0.06	-0.15	-0.24	-0.18	0.62**	0.64**	0.58**	0.66**	-0.14	0.65**	0.12	0.60**	-0.01	-0.22	0.46*	0.13	0.03	-0.21	-0.46*
Weight of tuber (kg)	0.08	0.08	0.03	0.01	0.02	0.03	0.37*	0.63**	0.80**	0.75**	0.51**	0.66**	-0.33		0.31	0.89**	0.03	-0.06	0.44*	0.09	0.43*	0.11	-0.44*
Stem girth (cm)	0.06	0.06	0.10	0.20	0.10	0.20	0.10	0.40*	0.05	0.08	0.27	0.26	-0.27	0.35	-0.36*	0.23	0.08	0.05	-0.02	0.02	0.20	0.39*	0.02
Tuber yield per vine (kg)	0.08	0.07	0.06	0.06	0.08	0.06	0.31	0.61**	0.88**	0.77**	0.38*	0.63**	-0.06	0.89**	0.30	0.09	0.10	-0.07	0.36*	0.16	0.35	0.24	-0.36*
Starch content (g/100g)	-0.11	-0.17	0.23	0.16	0.23	0.21	-0.03	0.11	0.02	-0.09	0.02	0.01	0.04	0.04	0.09	0.09		-0.09	0.08	0.15	0.35	-0.31	-0.08
Ascorbic acid (mg/100g)	0.35	0.32	-0.02	-0.30	-0.02	-0.35	-0.06	0.01	-0.16	-0.26	-0.06	-0.20	-0.11	-0.06	0.04	-0.07	-0.08		-0.36	0.29	-0.07	0.40*	0.36
Moisture (%)	-0.08	-0.10	0.09	0.03	0.09	0.12	0.11	0.14	0.39*	0.52**	0.25	0.40*	-0.18	0.41*	-0.02	0.33	0.11	-0.34		0.10	-0.04	-0.39*	-1.00**
TSS (°B)	0.22	0.19	-0.20	-0.20	0.20	-0.24	-0.22	0.10	0.05	-0.00	0.08	0.12	0.18	0.09	0.01	0.16	0.14	0.29	0.09		-0.19	0.15	-0.10
Total sugar (g/100g)	-0.16	-0.23	0.17	0.17	-0.05	0.16	0.19	0.37*	0.24	0.09	0.02	0.04	-0.23	0.42*	0.18	0.34	0.35	-0.07	-0.03	-0.19		-0.09	0.04
Total phenol (mg/100g)	0.21	0.21	-0.21	-0.21	-0.06	-0.26	0.01	0.03	0.07	0.01	-0.02	-0.15	0.33	0.04	0.15	0.12	-0.15	0.23	-0.22	0.09	-0.06		0.39*
Dry matter (%)	0.08	0.10	-0.03	-0.03	-0.09	-0.12	-0.11	-0.14	-0.39*	-0.52**	-0.25	-0.40*	0.18	-0.41*	0.02	-0.33	-0.11	0.34	-1.00**	-0.09	0.03	0.22	

*, ** Significant at 5% and 1%, respectively.

Table-2 : Genotypic path analysis for tuber yield per vine (kg) in greater yam.

Character	Days to emergence	Days to first leaf emergence	No. of leaves (30 DAE)	No. of sprouts per seed tuber	Vine length 45 DAE (cm)	Internode length (cm)	Vine length at harvest (cm)	Leaf width (cm)	Petiole length (cm)	Tuber length (cm)	Diameter of tuber (cm)	No. of tuber per vine	Weight of tuber (kg)	Stem girth (cm)	Starch content (g/100g)	Ascorbic acid (mg/100g)	Moisture (%)	TSS (°B)	Total sugar (g/100g)	Total phenol (mg/100g)	Dry matter (%)	r
Days to emergence	-2.45	1.31	-3.42	0.14	4.22	0.01	-0.08	0.05	-0.02	0.06	-0.07	-0.01	0.01	0.04	-0.08	0.10	-73743.04	-0.05	-0.02	0.30	73743.01	0.01
Days to first leaf emergence	-2.40	1.33	-3.45	0.13	4.28	-0.03	-0.11	0.06	-0.01	0.09	-0.13	-0.01	0.01	0.05	-0.13	0.09	-84534.46	-0.04	-0.03	0.32	84534.44	-0.02
No. of leaves (30 DAE)	2.70	-1.48	3.10	-0.20	-3.86	-0.03	0.03	0.15	-0.18	0.06	-0.21	0.01	-0.04	0.02	0.10	-0.09	31024.25	0.05	0.02	-0.20	-31024.25	-0.07
No. of sprouts per seed tuber	-0.40	0.20	-0.76	0.83	0.20	-0.23	0.14	-0.02	-0.05	-0.21	0.27	-0.01	-0.00	-0.02	0.15	-0.01	60835.68	-0.05	-0.01	0.01	-60835.65	0.06
Vine length 45 DAE (cm)	2.57	-1.42	2.98	-0.04	-4.02	-0.03	0.07	0.11	-0.09	-0.06	0.02	0.01	-0.02	-0.01	0.14	-0.10	101375.86	0.05	0.02	-0.29	-101375.81	-0.03
Internode length (cm)	-0.03	-0.07	-0.16	-0.32	0.17	0.60	0.08	-0.52	0.33	-0.31	0.28	0.02	0.20	0.01	-0.04	-0.02	152377.67	0.06	0.03	-0.02	-152377.60	0.36
Vine length at harvest (cm)	0.46	-0.35	0.18	0.26	-0.66	0.11	0.43	-0.68	0.39	-0.47	0.54	0.01	0.27	-0.09	0.06	0.00	123596.65	-0.02	0.05	0.10	-123596.68	0.58**
leaf width (cm)	0.08	-0.05	-0.30	0.01	0.29	0.21	0.20	-1.49	0.88	-0.19	0.66	0.00	0.35	0.05	-0.00	-0.04	332506.57	-0.01	0.03	0.13	-332506.48	0.89**
Petiole length (cm)	0.04	-0.01	-0.54	-0.04	0.34	0.20	0.17	-1.31	1.01	-0.21	0.67	0.00	0.33	0.05	-0.08	-0.07	455458.44	0.00	0.01	0.06	-455458.28	0.77**
Tuber length (cm)	0.20	-0.17	-0.26	0.26	-0.33	0.27	0.30	-0.42	0.31	-0.68	0.59	0.01	0.22	-0.04	0.00	-0.02	201622.18	-0.02	0.00	0.04	-201622.13	0.33
Diameter of tuber (cm)	0.14	-0.15	-0.56	0.19	-0.06	0.14	0.20	-0.84	0.58	-0.35	1.17	0.01	0.29	-0.04	-0.00	-0.06	341575.60	-0.02	0.00	-0.15	-341575.48	0.60**
No. of tuber per vine	-0.35	0.18	-0.52	0.09	0.70	-0.22	-0.09	0.07	-0.06	0.16	-0.17	-0.06	-0.16	0.12	0.03	-0.03	-134056.76	-0.04	-0.03	0.36	134056.70	-0.07
Weight of tuber (kg)	-0.07	0.02	-0.30	-0.00	0.16	0.27	0.27	-1.21	0.77	-0.34	0.77	0.02	0.44	-0.11	0.02	-0.02	328696.75	-0.02	0.05	0.07	-328696.65	0.89**
Stem girth (cm)	0.25	-0.19	-0.16	0.05	-0.16	-0.02	0.11	0.22	-0.14	-0.07	0.14	0.02	0.14	-0.37	0.04	0.01	-17554.32	-0.00	0.02	0.27	17554.37	0.23
Starch content (g/100g)	0.36	-0.30	0.53	0.22	-1.00	-0.05	0.05	0.00	-0.15	-0.00	-0.01	-0.00	0.01	-0.03	0.56	-0.02	58267.83	-0.03	0.04	-0.22	-58267.78	0.10
Ascorbic acid (mg/100g)	-0.92	0.47	-1.08	-0.02	1.51	-0.05	0.01	0.25	-0.28	0.05	-0.26	0.01	-0.03	-0.02	-0.05	0.26	-266529.29	-0.06	-0.01	0.28	266529.15	-0.07
Moisture (%)	0.24	-0.15	0.13	0.07	-0.55	0.12	0.07	-0.67	0.62	-0.19	0.54	0.01	0.19	0.01	0.04	-0.09	740199.30	-0.02	-0.01	-0.28	-740199.03	0.36*
TSS (°B)	-0.58	0.27	-0.73	0.20	1.04	-0.18	0.05	-0.08	-0.00	-0.06	0.15	-0.01	0.04	-0.01	0.08	0.08	74244.59	-0.19	-0.02	0.11	-74244.58	0.16
Total sugar (g/100g)	0.45	-0.35	0.60	-0.05	-0.70	0.15	0.18	-0.38	0.09	-0.01	0.04	0.01	0.19	-0.07	0.20	-0.02	-32861.48	0.04	0.11	-0.06	32861.42	0.35
Total phenol (mg/100g)	-1.05	0.60	-0.90	0.01	1.63	-0.02	0.06	-0.27	0.08	-0.04	-0.25	-0.03	0.05	-0.14	-0.18	0.10	-291086.94	-0.03	-0.01	0.71	291086.85	0.24
Dry matter (%)	-0.24	0.15	-0.13	-0.07	0.55	-0.12	-0.07	0.67	-0.82	0.19	-0.54	-0.01	-0.19	-0.01	-0.04	0.09	-740199.30	0.02	0.01	0.28	740199.03	-0.36*

Residual = 0.2760, *, ** Significant correlation with dependent char at 5% and 1%, respectively

Table 3: Phenotypic path analysis for tuber yield per vine (kg) in greater yam.

Character	Days to emergence	Days to first leaf emergence	No. of leaves (30 DAE)	No. of sprouts per seed tuber	Vine length 45 DAE (cm)	Internode length (cm)	Vine length at harvest (cm)	Leaf width (cm)	Petiole length (cm)	Tuber length (cm)	Diameter of tuber (cm)	No. of tuber per vine	Weight of tuber (kg)	Stem girth (cm)	Starch content (g/100g)	Ascorbic acid (mg/100g)	Moisture (%)	TSS (°B)	Total sugar (g/100g)	Total phenol (mg/100g)	Dry matter (%)	r
Days to emergence	0.65	-0.60	0.11	0.01	-0.21	0.00	-0.00	0.05	-0.02	-0.02	-0.01	0.02	0.06	0.01	0.00	-0.01	-2239.38	0.01	0.03	-0.01	2239.39	0.08
Days to first leaf emergence	0.64	-0.61	0.10	0.01	-0.20	0.00	-0.01	0.06	-0.02	-0.02	-0.00	0.02	0.06	0.01	0.00	-0.01	-2518.37	0.01	0.04	-0.01	2518.38	0.07
No. of leaves (30 DAE)	-0.47	0.41	-0.15	-0.00	0.24	0.01	0.04	0.07	-0.01	-0.04	-0.01	-0.02	0.01	0.02	-0.00	0.01	829.80	-0.01	-0.03	0.01	-829.81	0.06
No. of sprouts per seed tuber	0.11	-0.10	0.02	0.04	-0.00	-0.01	0.05	0.03	-0.00	-0.08	-0.02	0.01	0.01	0.01	-0.00	0.00	2315.49	0.01	0.01	0.00	-2315.49	0.08
Vine length 45 DAE (cm)	-0.52	0.46	-0.14	-0.00	0.26	0.00	0.05	0.05	-0.01	-0.06	-0.02	-0.02	0.02	0.02	-0.00	0.01	3260.98	-0.01	-0.03	0.01	-3260.99	0.06
Internode length (cm)	0.05	-0.03	-0.02	-0.01	0.02	0.06	0.04	0.19	-0.05	-0.10	-0.03	-0.04	0.27	0.01	0.00	0.00	2898.77	-0.01	-0.03	-0.00	-2898.78	0.31
Vine length at harvest (cm)	-0.02	0.03	-0.04	0.01	0.08	0.01	0.16	0.31	-0.08	-0.20	-0.06	-0.03	0.46	0.04	-0.00	-0.00	3749.46	0.00	-0.07	-0.00	-3749.47	0.61**
leaf width (cm)	0.06	-0.07	-0.02	0.00	0.02	0.02	0.08	0.58	-0.15	-0.11	-0.07	-0.01	0.59	0.01	-0.00	0.00	10272.96	0.00	-0.04	-0.00	-10272.98	0.88**
Petiole length (cm)	0.08	-0.09	-0.01	0.00	0.02	0.02	0.08	0.52	-0.16	-0.12	-0.07	-0.01	0.55	0.01	0.00	0.01	13796.67	-0.00	-0.02	-0.00	-13796.70	0.77**
Tuber length (cm)	0.05	-0.04	-0.02	0.01	0.06	0.02	0.12	0.23	-0.07	-0.27	-0.06	-0.03	0.37	0.03	-0.00	0.00	6575.81	0.00	-0.00	0.00	-6575.83	0.38*
Diameter of tuber (cm)	0.04	-0.03	-0.01	0.01	0.04	0.02	0.08	0.36	-0.10	-0.16	-0.11	-0.02	0.49	0.03	-0.00	0.01	10652.42	0.00	-0.01	0.00	-10652.44	0.63**
No. of tuber per vine	0.08	-0.07	0.02	0.00	-0.04	-0.01	-0.03	-0.02	0.01	0.05	0.01	0.15	-0.24	-0.03	-0.00	0.00	-4664.25	0.01	0.04	-0.01	4664.26	-0.06
Weight of tuber (kg)	0.05	-0.05	-0.00	0.00	0.01	0.02	0.10	0.47	-0.12	-0.14	-0.07	-0.05	0.73	0.04	-0.00	0.00	10771.47	0.00	-0.08	-0.00	-10771.49	0.89**
Stem girth (cm)	0.04	-0.03	-0.03	0.00	0.05	0.01	0.06	0.03	-0.01	-0.07	-0.03	-0.04	0.26	0.11	-0.00	-0.00	-584.64	0.00	-0.03	-0.00	584.65	0.30
Starch content (g/100g)	-0.07	0.10	-0.02	0.01	0.05	-0.00	0.02	0.01	0.02	-0.00	-0.00	0.01	0.03	0.01	-0.00	0.00	3019.22	0.01	-0.06	0.00	-3019.22	0.09
Ascorbic acid (mg/100g)	0.23	-0.20	0.05	-0.00	-0.09	-0.00	0.00	-0.09	0.04	0.02	0.02	-0.02	-0.05	0.01	0.00	-0.03	-8877.69	0.01	0.01	-0.01	8877.71	-0.07
Moisture (%)	-0.06	0.06	-0.00	0.00	0.03	0.01	0.02	0.23	-0.09	-0.07	-0.04	-0.03	0.30	-0.00	-0.00	0.01	26442.04	0.00	0.01	0.01	-26442.10	0.33
TSS (°B)	0.14	-0.11	0.03	0.01	-0.06	-0.01	0.02	0.03	0.00	-0.02	-0.01	0.03	0.06	0.00	-0.00	-0.01	2468.22	0.04	0.03	-0.00	-2468.23	0.16
Total sugar (g/100g)	-0.11	0.14	-0.03	-0.00	0.04	0.01	0.06	0.14	-0.02	-0.01	-0.00	-0.03	0.31	0.02	-0.00	0.00	-808.65	-0.01	-0.18	0.00	808.65	0.34
Total phenol (mg/100g)	0.14	-0.13	0.03	-0.00	-0.07	0.00	0.01	0.04	-0.00	0.01	0.02	0.05	0.03	0.02	0.00	-0.01	-5838.43	0.00	0.01	-0.03	5838.44	0.12
Dry matter (%)	0.06	-0.06	0.00	-0.00	-0.03	-0.01	-0.02	-0.23	0.09	0.07	0.04	0.03	-0.30	0.00	0.00	-0.01	-26442.04	-0.00	-0.01	-0.01	26442.10	-0.33

Residual = 0.2279, *, ** Significant correlation with dependent char at 5% and 1%, respectively.

tested as given by Panse and Sukhatme (1985). The path coefficient analysis was carried out as per procedure suggested by Wright (1921) and further executed by Dewey and Lu (1959).

Results and Discussion

Correlation Coefficient Analysis : The correlation coefficient analysis helps us in establishing the kind of association between yield and its component characters, making selection easier for yield-component characters. Estimates of phenotypic and genotypic correlation coefficient between yield and its 21 component characters in all possible combinations are presented in Table-1. The correlation coefficient results of the present investigation on greater yam germplasm revealed that tuber yield per vine showed highly significant positive genotypic and phenotypic correlation with leaf width ($r_g=0.89$, $r_p=0.88$), weight of tuber ($r_g=0.89$, $r_p=0.89$), petiole length ($r_g=0.77$, $r_p=0.77$), diameter of tuber ($r_g=0.60$, $r_p=0.63$), vine length at harvest ($r_g=0.58$, $r_p=0.61$) and significant positive genotypic and phenotypic correlations with moisture ($r_g=0.36$), tuber length ($r_p=0.38$). It showed significant negative correlation with dry matter ($r_g= -0.36$) at genotypic level. Days to emergence showed highly significant correlation with days to first leaf emergence ($r_g=0.98$, $r_p=0.98$) both at phenotypic and genotypic level. Sahu *et al.* (2017) reported a positive significant correlation for sweet potato between tuber yield and tuber diameter which completely supported the present finding. The results were in partial agreement with the previous findings of Rao *et al.* (2017) for cassava as the study presented a positive correlation with vine length at harvest, tuber length and plant dry matter for tuber yield/vine. The analogous results were reported by Mukherjee *et al.* (2016) for dry matter content show negative significance with tuber yield per vine in taro.

Path Coefficient Analysis : The path coefficient analysis introduces us to the comparable significance of various yield-component characters by evaluating direct and indirect contributions of the characters towards yield. Table-2 indicated that the highly significant positive correlation for tuber yield per vine revealed by leaf width and weight of tuber (0.89**) followed by petiole length (0.77**), diameter of tuber (0.60**), vine length at harvest (0.58**), moisture (0.36*) at genotypic level. Table 3 indicated that the significant positive correlation for tuber yield per vine revealed by weight of tuber (0.89**) followed by leaf width (0.88**), petiole length (0.77**), diameter of tuber (0.63**), vine length at harvest (0.61**) tuber length (0.38*) at phenotypic level.

The results (Table-2 and 3) revealed that highest indirect effect showed by moisture. Moisture showed highest positive direct effect followed by dry matter

number of leaves, days to first leaf emergence, diameter of tuber, petiole length, number of sprouts per seed tuber, total phenol, internode length, starch content, weight of tuber, vine length at harvest, ascorbic acid, total sugar. The results partially agree with the findings of Rao *et al.* (2017) for cassava, Mukherjee *et al.* (2016) for taro, Mohanty *et al.* (2016) for sweet potato, Velayudhan *et al.* (2000) for taro.

In the present experiment, the data revealed that moisture showed highest positive direct effect on tuber yield per vine. Keeping above results in mind tuber with high moisture and having more number of leaves, less days to first leaf emergence, more diameter of tuber, petiole length, number of sprouts per seed tuber, total phenol, internode length, starch content, weight of tuber, vine length at harvest, ascorbic acid, total sugar should be considered in selection criteria for increasing tuber yield per vine. So the selection of above mentioned traits having direct and indirect effect on yield may lead to improvement in tuber yield per vine in greater yam. The present study suggested that more emphasis should be given to selecting genotype with higher tuber yield, which is confirmed by the finding of Vimal *et al.* (2019) for elephant foot yam, Tripura *et al.* (2016) for potato and Paul *et al.* (2013) for elephant foot yam.

Conclusions

The results of correlation studies suggest that tuber yield per vine can be improved by selecting characters leaf width, weight of tuber, petiole length, diameter of tuber, vine length at harvest, moisture and tuber length. Emphasis must be given for characters having high direct effects like moisture, dry matter, number of leaves, first leaf emergence, diameter of tuber, petiole length, number of sprouts per seed tuber, total phenol, internode length, starch content, weight of tuber, vine length at harvest, ascorbic acid and total sugar while exercising selection to improve the yield. The data revealed that highest indirect effect showed by moisture. These characters should be given paramount attention as the major component characters in determining tuber yield in a selection programme aimed at improving genetic potential of greater yam.

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Effect of Phospho Enriched Compost and Zinc on Yield Attributes and Yield of Blackgram (*Vigna mungo* L.) in Typic Haplustepts

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Abstract

A field experiment was conducted during *kharif* season of 2018 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur (Rajasthan) to study the effect of the phospho enriched compost and zinc on yield attributes and yield of blackgram. The treatments consisting of four levels of phospho enriched compost (PEC) (0, 2, 4 and 6 t ha⁻¹) and four levels of zinc (0, 2, 4 and 6 kg ha⁻¹) were applied to the blackgram var. PU-31 as soil application with uniform application of nitrogen and phosphorus as per recommended doses. The application of enriched compost @ 4 t ha⁻¹ and zinc @ 4 kg ha⁻¹ as along with the recommended dose of fertilizer results in significantly highest yield attributes and yield of blackgram in Typic Haplustepts.

Key words : Blackgram, phospho enriched compost, zinc, yield attributes, yield.

Introduction

Blackgram (*Vigna mungo* L.) is one of the important pulse crop in India and important *Kharif* Season pulse crop in Rajasthan. Blackgram is a rich source of protein, Fat, mineral nutrients and phosphorus. In India, blackgram is grown on 5.03 million hectare (mha) area with a production of 3.28 million tonnes (mt) and an average productivity of 652 kg ha⁻¹ (Government of India, 2017-18). In Rajasthan it occupies an area of 5.96 lakh hectare area with a production of 2.98 lakh tonnes with the productivity 500 kg ha⁻¹ (DAC&FW, 2021-22). Enriched composting is fundamentally a microbiological process accomplished by the combined process of bacteria, actinomycetes, fungi and protozoa which are either present in the composting material or are introduced externally to speed up composting and enrich the compost. Enriched compost is considered a valuable organic fertilizer, supplying nutrients for the crop and hence saving substantial amount of chemical fertilizers (Erhart *et al.*, 2005).

In India, zinc is considered as the third important yield limiting nutrient after the nitrogen and phosphorus, respectively (Takkar and Randhawa, 1978). It is essential for photosynthesis and nitrogen metabolism and important for the stability of cytoplasmic ribosome's, cell division, dehydrogenase, proteinase, peptidase enzymes and in the synthesis of tryptophan, a component of some proteins and a compound needed for production of growth hormones (auxin) such as indole acetic acid. Reduced growth hormone production in zinc deficient plants causes the shortening of inter-nodes and smaller leaves. Most of the soils of Rajasthan were deficient in zinc and assigned low availability of zinc in coarse textured soils with medium organic carbon content (Singh and Singh, 1981).

Materials and Methods

Experimental site : The experiment was laid out at Institutional Farm (Agronomy), Rajasthan College of agriculture, Udaipur during *kharif* season of 2018. The Rajasthan College of agriculture, Udaipur is situated at an altitude of 579.5 metres above mean sea level and at 24°34' North latitude and 73°42' East longitude. This region falls under agro-climatic zone-IVa (Sub- humid Southern Plain and Aravalli Hills) of Rajasthan. The experiment was laid out in factorial randomized block design and replicated thrice in the plot size of 4.0 m x 3.0 m (12m²).

Statistical analysis : The data recorded for different parameters were analyzed with the help of analysis of variance (ANOVA) technique for a factorial randomized block design. The results are presented at 5% level of significance (P=0.05).

Preparation of Phospho enriched compost: For the preparation of phosphorus enriched compost, chopped maize straw (5-6 cm size, 15 kg on air-dry weight basis, 30 ± 1°C), soaked in water for 24 h, was mixed thoroughly with required quantities of RP and waste mica. A uniform dose of urea solution @ 0.25 kg N per 100 kg of maize straw (air dry weight basis, 30 ± 1 °C) was added to reduce the C/N ratio, while fresh cow dung @ 10 kg per 100 kg of maize straw was made into slurry and added to each product as natural inoculants. Phosphate solubilizing microorganism @ 50 g per 100 kg of maize straw was also added in each treatment. Whole of the composting mass was mixed thoroughly and put in the cemented pits. The composting pit was covered with jute bag sheets for maintaining of moisture. Turning was performed after 15, 30 and 60 days of composting to

Table-1 : Effect of phospho enriched compost and zinc on number of nodules per plant, number of pods per plant and number of seeds per pod of blackgram.

Treatments	Number of nodules per plant	Number of pods per plant	Number of seeds per pod
Phospho enriched compost levels (t ha⁻¹)			
Control (PEC ₀)	23.45	30.01	3.30
2 (PEC ₁)	25.91	32.49	3.74
4 (PEC ₂)	28.09	34.88	4.01
6 (PEC ₃)	30.01	37.01	4.18
S.Em±	0.732	0.820	0.063
CD (P=0.05)	2.114	2.368	0.182
Zinc levels (kg ha⁻¹)			
Control (Zn ₀)	23.06	29.99	3.38
2 (Zn ₁)	25.81	32.41	3.67
4 (Zn ₂)	28.90	35.02	4.01
6 (Zn ₃)	29.69	36.96	4.17
S.Em±	0.732	0.820	0.063
CD (P=0.05)	2.114	2.368	0.182

Table-2 : Effect of phospho enriched compost and zinc on seed and straw yield (kg ha⁻¹) of blackgram.

Treatments	Seed yield	Straw yield
Phospho enriched compost levels (t ha⁻¹)		
Control (EC ₀)	642.96	1175.22
2 (EC ₁)	730.03	1353.96
4 (EC ₂)	919.16	1521.22
6 (EC ₃)	1001.07	1632.77
S.Em±	29.59	43.64
CD (P=0.05)	85.47	126.04
Zinc levels (kg ha⁻¹)		
Control (Zn ₀)	640.76	1174.73
2 (Zn ₁)	732.86	1354.09
4 (Zn ₂)	917.65	1520.88
6 (Zn ₃)	1001.95	1633.49
S.Em±	29.59	43.64
CD (P=0.05)	85.47	126.04

provide adequate aeration and proper moisture was maintained to 60 % of water holding capacity throughout the experiment. The composting was continued for 120 days. The chemical composition of phospho enriched compost (N 0.847±0.017, P 1.215±0.024, K 1.157±0.023 and Zn 35.1± 0.7, respectively) used in field experiment.

Results and Discussion

Number of nodules per plant and number of pods per plant

Effect of phospho enriched compost level : The application of phospho enriched compost level increased the number of nodules per plant and number of pods per plant of blackgram significantly (Table-1). The significantly maximum number of nodules per plant (30.01) and maximum number of pods per plant (37.01) were observed under the treatment PEC₃ (Phospho enriched compost @ 6 t ha⁻¹). The number of nodules per plant and number of pods per plant were increased significantly up to PEC₂ @ 4 t ha⁻¹ which was also found to be statistically

at par with PEC₃ @ 6 t ha⁻¹. The application of various source and levels of phospho enriched compost significantly increase the grain and stover yield Mali *et al.* (2017).

Effect of zinc level : The application of zinc increased the number of nodules per plant and number of pods per plant of blackgram significantly (Table-1). The maximum number of nodules per plant (29.69) and maximum number of pods per plant (36.96) were observed under the treatment Zn₃ (@ 6 kg ha⁻¹). The number of nodules per plant and number of pods per plant were increased significantly up to Zn₂ @ 4 kg ha⁻¹ which was also found to be statistically at par with Zn₃ @ 6 kg ha⁻¹. Saini (2003) reported that the application of zinc @ 5 kg ha⁻¹ significantly increased the seeds per pod, number of pods) as compared to control in mungbean.

Number of seeds per pod : Effect of phospho enriched compost level : The application of phospho enriched compost level increased the number of seeds per pod of blackgram significantly (Table-1). The significantly

maximum number of seeds per pod (4.18) were observed under the treatment PEC₃ (Phospho enriched compost @ 6 t ha⁻¹) the minimum (3.30) under control (PEC₀). However, the increase was significant upto PEC₂ which was also found to be statistically at par with PEC₃. The number of seeds per pod were recorded as 11.76, 17.71 and 21.03 with application of PEC₁, PEC₂ and PEC₃, respectively as compared to control (PEC₀). Saha and Hajra (2001) reported that application of phospho-compost at 2.5 t ha⁻¹ along with 50 per cent recommended dose of NPK gave significantly maximum plant growth, nodulation, dry matter accumulation and seed yield as compared 100 percent recommended dose of NPK fertilizers.

Effect of zinc level : The application of zinc increased the number of seeds per pod significantly (Table-1). The significantly maximum number of seeds per pod (4.17) were observed under the treatment Zn₃ (@ 6 kg ha⁻¹) and the minimum (3.38) under control (Zn₀). However, the increase was significant upto Zn₂ which was also found to be statistically at par with Zn₃. The treatments Zn₁, Zn₂ and Zn₃ increased the number of pods per plant to the extent of 7.90, 15.71 and 18.64 per cent, respectively over control (Zn₀).

Yield

Effect of phospho enriched compost level : The application of phospho enriched compost enhanced the seed and straw yield of blackgram significantly (Table 2). The maximum seed yield (1001.07 kg ha⁻¹) and straw yield (1632.77 kg ha⁻¹) was observed under the treatment PEC₃ (Enriched compost @ 6 t ha⁻¹). The seed and straw yield were increased significant upto PEC₂ @ 4 t ha⁻¹ which was also found to be statistically at par with PEC₃ @ 6 t ha⁻¹. The increase in seed and straw yield was to the extent of 11.92, 30.04 and 35.77 per cent and 13.20, 22.74 and 28.02 per cent with the application of phospho enriched compost @ 2, 4 and 6 t ha⁻¹, respectively as compared to control (PEC₀). The significant increase in seed and straw yield under the influence of PEC was largely a function of improved growth and yield attributes which eventually contributed in increased seed and straw yield. The incorporation of PEC in the soil ensures successive and almost continuous supply of macro and micro nutrients to the blackgram over the entire crop growth period (Biswas 2011). The inter relationship between yields attributes and its seed and straw yield had also been observed by Mali *et al.* (2017).

Effect of zinc level : The application of zinc increased enhanced the seed and stover yield of blackgram significantly (Table-2). The maximum seed yield (1001.95 kg ha⁻¹) and straw yield (1633.49 kg ha⁻¹) was observed under the treatment Zn₃ (@ 6 kg ha⁻¹). The seed and straw

yield were increased significant upto Zn₂ @ 4 kg ha⁻¹ which was also found to be statistically at par with Zn₃ @ 6 kg ha⁻¹. The application 2, 4, 6 kg Zn ha⁻¹ increased the seed yield and straw yield to the extent of 12.57, 30.17 and 36.05 per cent and 13.25, 22.76 and 28.08 per cent, respectively, as compared to control (Zn₀).

Conclusions

Based on the above findings it may be inferred that substantial improvement in number of nodules per plant, number of pods per plant, number of seeds per pod and seed and straw yield could be obtained with the application of phospho enriched compost @ 4 t ha⁻¹ and zinc @ 4 kg ha⁻¹. Therefore, in this tract for blackgram variety PU-31, the application of phospho enriched compost @ 4 t ha⁻¹ and zinc @ 4 kg ha⁻¹ as a most profitable dose is being recommended for higher seed yield in sub-humid Southern hills and Aravali region of Rajasthan.

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Effect of Different Nutrient Management Practices on Root Growth and Partial Factor Productivity of Rice Under Zero-Tilled Upland Condition in Eastern India

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Abstract

A field experiment was conducted at Central Rain-fed Upland Rice Research Station (CRURRS), Hazaribagh, research station in Jharkhand with the objective to determine better nutrient management practices for zero till upland rice and their effect on yield and nutrient use efficiency. The experiment was laid out in split-plot design with three replications having three rice cultivar Vandana, Anjali and CR Dhan 40 in main plot and four nutrient management practices [soil test fertilizer recommendation meter (STFR), integrated nutrient management (INM), soil test crop response equation (STCR) and recommended dose of fertilizers (RDF)] in sub-plot. The partial factor productivity of applied NPK and root dry weight was recorded highest in CR Dhan 40 among the different rice cultivars. INM (50 % RDF+ 50% Organics) based NPK dose [40 kg N, 28 kg P₂O₅, 10 kg K₂O (50%) + 6 t/ha FYM (50%) + lime 1 t/ha] recorded the highest values (32.74 kg grain yield/kg NPK) of partial factor productivity and root growth followed by STCR and STFR. Therefore, based on research findings, it can be concluded that rice cultivar “CR Dhan 40” with STFR and INM based fertilization may enhance the productivity and profitability of upland rice in the Eastern regions of India.

Introduction

Rice (*Oryza sativa* L.) is the second most important grain crop in India, after wheat (FAO, 2017). It is cultivated in 43.38 million hectares (mha), with an annual production of 104.32 million tons (mt), and an average national productivity of 2.40 tons per hectare (t/ha) (FAO, 2017). To address the growing demand for the food, feed and industrial sectors, as well as to access the export markets, rice production would still need to increase by additional 143 mt to cope with 40% world population and to raise average food consumption to 3130 kcal/person/day by 2050 (FAO, 2017). In Asia, rice is commonly grown with wet tillage land preparation (puddled soil) by transplanting seedlings from nursery. Repeated puddling adversely affects soil physical properties by destroying soil aggregates, reducing permeability in subsurface layers, and forming hard-pans at shallow depths (Sharma *et al.*, 2004).

Flooded rice culture with puddling and transplanting is considered one of the major sources of methane (CH₄) emissions and accounts for 10-20% (50-100 Tg/year) of total global annual CH₄ emissions (Pathak *et al.*, 2005; IPCC, 2001) which limit inclusion of lowland rice in crop rotation (Tripathi *et al.*, 2005). Puddling and transplanting require large amount of water and labour, both of which are becoming increasingly scarce and expensive, making rice production less profitable. Upland rice is recently

getting momentum, which is grown in rain-fed, naturally well-drained soils, without surface water accumulation, normally without phreatic water supply, and normally not bunded (Saharawat *et al.*, 2010). Upland rice is grown annually on about 17 million ha worldwide—10.5 million ha in Asia (Fairhurst *et al.*, 2007). It is of utmost importance to change the present production practices to attain optimal yield with high nutrient use efficiency and high-water productivity in deficit areas. Globally 23% of rice is being cultivated as direct seeded rice (DSR) (Rao *et al.*, 2007). In DSR, rice crop is directly sown in the field rather than by transplanting, where seedlings are prepared in the nursery and then transplanted to the main field. There are three principal methods of DSR viz., dry seeding (sowing dry seeds into dry soil), wet seeding (sowing pre-germinated seeds on puddled conditions) and water seeding (sowing seeds into standing water). DSR methods have several advantages over transplanted rice (TPR) method. Dry-seeding of rice with subsequent aerobic soil conditions eliminates the need of puddling and subsequent submerged soil conditions, thus reducing the overall water demand and providing opportunities for water and labour savings (Sharma *et al.*, 2004).

The development of early maturing varieties and improved nutrient management techniques along with increased availability of chemical weed management methods have encouraged many farmers in the

Table-1 : Effect of varieties and nutrient management on partial factor productivity of rice.

Treatment	PFP (kg grain yield/ kg NPK applied)
Varieties (V)	
Vandana	25.8
Anjali	25.5
CR Dhan 40	30.08
SEm±	0.33
CD (P=0.05)	1.29
Nutrient management (NM)	
STCR	28.26
STFR	25.36
INM	32.74
RDF	21.84
SEm±	0.94
CD (P=0.05)	2.80
Interactions (V×NM)	NS

Table-2 : Effect of varieties and nutrient management on root volume and root dry weight.

Treatment	Root volume (cm ³)	Root dry weight (g)
Varieties (V)		
Vandana	3.05	2.07
Anjali	2.51	2.00
CR Dhan 40	2.76	1.59
SEm±	0.17	0.06
CD (P=0.05)	NS	0.25
Nutrient management (NM)		
STCR	2.50	1.93
STFR	2.86	1.98
INM	3.11	1.95
RDF	2.62	1.70
SEm±	0.18	0.06
CD (P=0.05)	NS	0.18
Interactions (V×NM)	S	S

Philippines, Thailand and India to switch from TPR to DSR (Farooq *et al.*, 2011). Nutrient removed by the crops far exceeds the amount provided through fertilizer, causing a much greater strain on the native soil reserves. Among nutrients, nitrogen deficiency limits rice production the most worldwide. Fertilizer use is one of the major factors for the continuous increase in rice production; more than 20% of N fertilizer produced worldwide is used in the rice fields of Asia. Irrigated and rain-fed lowland rice systems account for 92% of total rice production and nutrients applied as fertilizers account for 20–25% of total production costs in these rice systems. Of the total 172.2 Mt fertilizer (N + P₂O₅ + K₂O) consumed globally during 2010–11, 14.3% (24.7 Mt) was used in rice fields (Heffer, 2013). The imbalance and indiscriminate use of fertilizer adversely affects the productivity and nutrient use efficiency in rice crop (Borah *et al.*, 2016). Managing the location specific variability in nutrient supply is a key strategy to overcome the current mismatch of fertilizer rates and crop nutrient demand in upland rice environments.

In India, conservation agriculture (CA) has been widely promoted in rice-wheat cropping system to sustain

the productivity and soil health in a long run (FAO, 2012). CA is a farming system that promotes maintenance of a permanent soil cover, minimum soil disturbance (*i.e.*, zero tillage), and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and improved and sustained crop production (FAO, 2012). ZT rice has several advantages such as it involves low fuel consumption in land preparation, reduced labour costs, improved soil health and quality and conserves soil moisture with higher water use efficiency (WUE) and NUE of about 15-20% along with higher yield (Saharawat *et al.*, 2010). Baligar *et al.* (2001) reported that NUE of applied fertilizers is about 25-35% or lower for N, less than 10% for P and close to 40% for K in rice crop. These lower NUE could be due to significant losses of nutrients by leaching, run-off, gaseous emission and fixation by soil. These losses can potentially contribute to degradation of soil and water quality and eventually lead to overall environmental degradation. Nutrient management could be one of the most important options to enhance the yield and NUE in ZT rice. ZT with organic nutrient source is one more

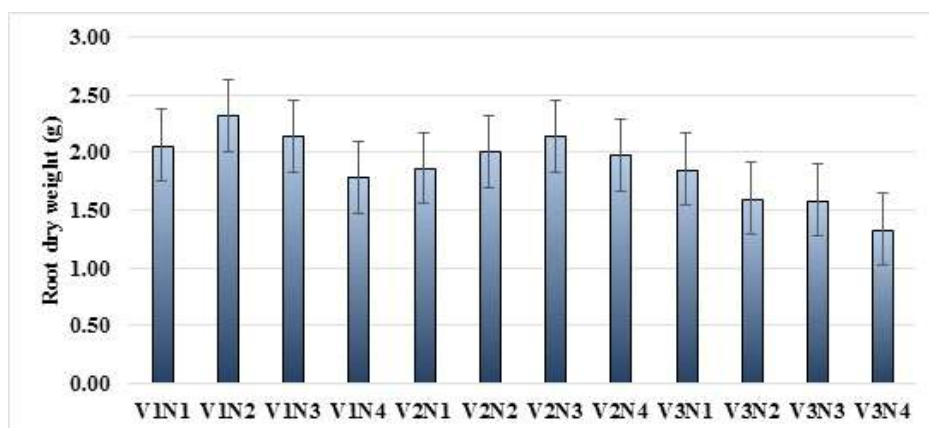


Figure-1 : Interactive effect of rice varieties and nutrient management practice on root dry weight. [NM1:STCR, NM2:STFR, NM3:INM, NM4:RDF]

promising option to enhance the productivity and sustainability (Bhan and Behera, 2014).

Materials and Methods

Experimental site : The experiment was conducted at Shankarpura farm's Block A7-MP of ICAR-CRURRS, Hazaribagh, Jharkhand located at latitude of 23°56' N and longitude of 85°21' E, and an altitude of 614 meters above the mean sea level. Hazaribagh district comes under NARP- classified agro-climatic zone Eastern plateau and hill regions, and sub region-central north-eastern plateau region of Jharkhand which is characterized by humid and sub-humid tropical climate. In Jharkhand, maximum temperature varies between 26°C to 32°C and minimum temperature varies between 12.9°C to 22.6°C during the crop growing season, respectively being warm and humid. April, May and June are the hottest and December, January and February are the coldest months in the Jharkhand. The maximum and minimum relative humidity recorded is 67.4% and 36.3%, respectively. The average rainfall of the district is 783 mm of which 700 mm of rainfall is precipitated during the months of June to September. The experimental field was under rice-fallow cropping system during the last five years. The initial soil physical characteristics reveals the mechanical composition as red with textural class as Sandy clay loam. Moisture at 1/3 and 15 bar tension is 28.72 and 14.87 % respectively. Soil chemical characteristics were as pH 5.2, EC is 0.29 (m mhos cm⁻¹), organic carbon as 0.39 % , available-N,P, and K were 220, 15.6 and 420 kg/ha respectively.

Treatment details : The experiment was laid out in split-plot design with three replications having three rice cultivars Vandana, Anjali and CR Dhan 40 in main plots and four nutrient management practices. Soil test fertilizer recommendation meter (STFR), integrated nutrient management (INM)[(50 % RDF+ 50% Organics) based NPK dose (40 kg N, 28 kg P₂O₅, 10 kg K₂O (50%) + 6 t/ha FYM (50%) + lime 1 t/ha)]soil-test crop response equation (STCR) and recommended dose of fertilizers (RDF) in

sub-plots. Treatments were allocated randomly on the experimental units. The experimental field was kept under zero-till conditions.

Partial factor productivity of NPK (PFP, kg grain/kg NPK applied) : Partial factor productivity (PFP) is worked out by dividing the total grain yield to the nutrient applied.

$$PFP = \frac{\text{Yield under treatment (kg / ha)}}{\text{Amount of nutrient added (kg / ha)}}$$

Results and Discussion

Partial factor productivity : The partial factor productivity was significantly influenced with different rice varieties and nutrient management practices. The rice variety, CR Dhan 40 recorded the highest partial factor productivity (30.08 kg grain yield/kg NPK) followed by Anjali and Vandana. INM (50 % RDF+ 50% Organics) based NPK dose [40 kg N, 28 kg P₂O₅, 10 kg K₂O (50%) + 6 t/ha FYM (50%) + lime 1 t/ha] recorded the highest values (32.74 kg grain yield/kg NPK) of partial factor productivity as optimal doses of NPK incremental with grain yield enhanced the partial factor productivity (Table-1) (Chaudhary *et al.*, 2017). A high application of NPK in STFR and STCR without any incremental increase in grain yield was the reason behind low values of partial factor productivity.

Root Growth Parameters : Nutrient management (NM) practices significantly influenced the root parameters like root volume and dry weight. There was non-significant difference in root volume due to different cultivable varieties and different NM practices (Table-2). The interaction between rice varieties and nutrient management practices on root volume was found significant (Table-2).

There was significant difference in root dry weight due to different cultivable varieties and different NM practices (Table 2). The interaction between rice varieties and nutrient management practices on root dry weight

also found significant (Table-2 and figure-1). Interaction effect for Table 2 shows that adoption of NM1 in the variety Vandana and CR Dhan 40 decreased the root volume by 73.07% and 9.3 % respectively than adoption of NM2, whereas the adoption of NM2 in variety Anjali increased the root volume by 9.03% than NM1. Similarly, the adoption of NM4 in the variety Vandana decreased the root volume by 19.83% than NM3, whereas it was decreased by 33.55 % in the CR Dhan 40.

Interaction effect for Table 2 shows that adoption of NM2 in the variety Vandana and Anjali increased the root dry weight by 12.13 % and 8.06 % respectively than adoption of NM1, whereas the adoption of NM2 in variety Anjali decreased the root dry weight by 13.51% than NM1. Similarly, the adoption of NM4 in the variety Vandana decreased the root dry weight by 16.35% than NM3, whereas it was decreased by 15.8 % in the CR Dhan 40.

Partial factor productivity(PFP) and Root Growth were significantly influenced by the different varieties and nutrient management practices. CR Dhan 40 rice cultivar recorded the highest PFP and more root growth due to the vigorous growth and high yield potential of CR Dhan 40 enhanced and accumulated higher nutrients compared to the rest of varieties (Fageria *et al.*, 2010. Partial factor productivity(PFP) and Root Growth was recorded higher in STFR and INM followed by STCR and RDF. The balanced application of nutrient enhanced the synchronized availability of nutrients in the soil to the crop plant. In STCR and INM, the increase in nutrient uptake was enhanced with the application of lime and FYM (Fageria *et al.*, 2014). Furthermore, activated microbial community and organic acid in the soil enhanced the availability of P in soil from to the plant rhizosphere (Fageria *et al.*, 1995 and Fageria *et al.*, 2014).

Conclusions

Based on the research findings, it can be concluded that rice cultivar CR Dhan 40 rice cultivar recorded the highest partial factor productivity(PFP) and more root growth than other varieties. The partial factor productivity(PFP) and root growth was higher in STFR and INM followed by STCR based NPK fertilization.

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Collection, Isolation, Purification and Identification of Chilli Anthracnose (*Colletotrichum* spp.) Disease and its Biointensive Management Approach

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Abstract

Chilli is a widely grown vegetable crop throughout the world. However, chilli anthracnose is a major constraint in chilli production leading to huge economic losses worldwide. *Colletotrichum* is a large genus of Ascomycete fungi, containing species that cause anthracnose diseases on a wide range of crops of economic value. The present studies on Isolation, identification and purification of *Colletotrichum capsici* causing anthracnose of chilli and investigate the effect of bioagents. Findings of the present investigation revealed that after purification of *Colletotrichum capsici* were identified on the basis of colony colour, pattern of growth and pattern of acervuli formation on PDA. The fungus produced fairly white to light mouse grey, circular, fluffy mycelium with black colour acervuli which were scattered all over the colony growth against light with the naked eyes and later confirmed with the help of microscope. Microscopic examination of different isolates revealed that the mycelium was septate bearing aseptate unbranched conidiophores. Conidia were sickle shaped, hyaline, unicellular, and fusiform curved with narrow ends. The average dimensions of conidia which possessed large oil globule in the centre, Acervuli contained abundant dark brown niddle like septate setae with several septations and pointed brown tips. After the pathogenicity test of *Colletotrichum capsici* (test fungus) the fungus was produced same symptoms on the crop. The use of appropriate integrated management practices, such as cultural, mechanical, chemical, and biological control, are important in chilli anthracnose disease prevention and control. Emphasis is laid on the use of biological control because it is cost effective and eco-friendly, and is an appropriate approach for disease management. The use of resistant cultivars is the cheapest, easiest, safest, and most effective means of controlling crop diseases. But, since no resistant cultivars of chilli have been developed and commercialized, it is very important to develop biological management strategies.

Key words : Collection, identification, *Colletotrichum*spp, biological control.

Introduction

Chilli (*Capsicum* spp.) is an important vegetable crop in tropical and subtropical climates and the fresh or dried fruit is a major culinary ingredient in many cuisines. Chilli has numerous health benefits for humans, fresh green chilli fruits have more Vitamin C than citrus fruits, while red chilli fruits have more Vitamin A than carrots. Capsaicin, the spice's active ingredient, has antioxidant, anti-mutagenic, anti-carcinogenic, and immunomodulatory properties, inhibiting bacterial growth and platelet activation.

Chilli suffers from several seed borne fungal fruit rot disease viz., Alternaria rot, Alternaria fruit rot, Anthracnose, Aspergillus rot, Black rot, Black fruit rot, Die-back, Ripe fruit rot, Cladosporium fruit rot, Charcoal fruit rot, Grey mold rot, Phytophthora and Rhizopus rot caused by *Alternaria alternata*, *A. solani*, *Alternaria tenuis*, *Aureobasidium pullulans*, *A. capsici* annum, *Aspergillus niger*, *Botrytis cinerea*, *Brachysporium senegalensis*, *Cladosporium herbarum*, *Colletotrichum capsici*, *C. coccodes*, *C. gloeosporioides*, *C. dematium*,

C. piperatum, *C. multisetorum*, *C. lindemuthidum*, *C. acutatum*, *C. lini*, *Drechslera quatrinesis*, *Drechslera halodes*, *D. rostrata*, *Fusarium moniliforme*, *F. solani*, *Macrophomina phaseolina*, *Periconiabyssoides*, *Phomopsis capsici*, *Phytophthora capsici* and *P. parasitica*, respectively (Sultana and Khan, 1988; Mirdha and Siddiqui, 1989; Sultan *et al.*, 1992; Basak, 1994; Basak *et al.*, 1991; Basak *et al.*, 1994; Datar, 1995; Dhyani *et al.*, 1990; Khodke and Gahukar, 1993; Khodke and Gahukar, 1995; McGovern and Polstion, 1995; Prabhavathy and Reddy, 1995; Kumar and Mahmood, 1986; Raut *et al.*, 1989; Rout and Rath, 1972, Kulshrestha *et al.*, 1976 and Suryawanshi and Deokar, 2000, respectively). Among different rots reported on chilli fruits, ripe fruit rot disease (*Colletotrichum* spp.) was alone reported to be a serious and destructive disease of chilli and it causes considerable damage, inflicting severe quantitative and qualitative losses (Anand *et al.*, 2009; Anand *et al.*, 2010). The disease is both seed borne and air borne and affects seed germination and vigour to a greater extent (Saxena *et al.*, 2016).

Literature search revealed that no systematic seed pathological study has been conducted on seed borne inoculum of *Colletotrichum* in chilli seeds. Use of fungicide to control the disease because several adverse effect i.e. development of resistance in the pathogen, residual toxicity, pollution in the environment, high cost (Bajipai and Kang, 2012). Therefore, it has become necessary to adopt ecofriendly approaches for better crop health and yield. In addition to biocontrol agents, induced resistance by chemicals may provide an efficient approach to plant protection.

Material and Methods

The fruit samples of chilli showing typical fruit rot symptoms were collected in perforated polythene bags from chilli growing fields and brought to the laboratory for isolation, identification and purification of the mycoflora, associated with disease. For the isolation of *Colletotrichum capsici* Potato dextrose agar media (Peeled and sliced potato - 200 g, Dextrose-20.0 g, Agar-agar -20.0 g, Distilled water - 1000 ml) is used during course of investigation. The experimental study was conducted using Borosil make glassware were used throughout the experiment. After cleaning the glassware with the detergent, they were thoroughly washed with tap water, rinsed with water and dried before use. Petri plates were sterilized in hot air oven at 180 °C for two hours. Potato dextrose agar (PDA) medium and distilled water used during this experimental study were sterilized at 15psi (121.6 °C) for 15-20 minutes in an autoclave. The inoculation needle and other metallic instruments were sterilized by dipping them in alcohol and heating over a flame. Surface sterilization of plant parts and diseased materials were done by dipping them in 0.1 percent mercuric chloride for 30 seconds followed by three washings in sterilized distilled water. And also the compound microscope (Olympus 10x, 40 x magnifications) was used for observing fungi. Hot air oven and autoclave were used for sterilization of glassware, Petriplates and media respectively. Incubators were used for incubating test materials/cultures at 25±2 °C temperature.

Methodology

Preparation of Potato Dextrose Agar Media : For the preparation of PDA, potato slice were boiled into 500 ml of water until they become soft. The supernatant was filtered. The supernatant and melted agar was then mixed, measured and the volume was restored to 1000 ml with hot water. It was again boiled for 5 minutes and then dextrose was added. The medium was poured into flask and culture tubes. The mouth of flask and culture tubes was plugged with cotton plug and sterilized in an autoclave at the pressure of 15 pound/square inch (1.05

kg/cm²) for 15 minutes and temperature goes up to 121.6 °C which are sufficient for proper sterilization.

Isolation of Pathogen : Small pieces of infected tissue (2-3mm in length) were cut at the junction of diseased and healthy portion with the help of disinfected blade after surface sterilizing the sample with alcohol. These bits were surface sterilized in 0.1 per cent mercuric chloride solution (HgCl₂) for 30 seconds followed by three washing with sterilized distilled water in Petri-plates under aseptic conditions using laminar air flow. These bits were air dried by placing on sterilized blotting paper. Five bits were transferred aseptically to the Petri-plates containing sterile potato dextrose agar (PDA) medium. Inoculated Petri plates were incubated at 25 ± 2 °C for five to seven days and examined at frequent intervals to see the growth of the fungus/conidia developing from different pieces. (Ahmad *et al.*, 2013).

Purification of Pathogen : The fungus was further purified by single hyphal tip method. The fungus was grown by inoculating in the centre of a plain agar plate. The fungus spread out with its hyphal strands in search of nutrients. These hyphal strands could be located under low power of the microscope in the inverted Petri-plate and the isolated hyphal tips marked with marker. These tips were carefully transferred to potato dextrose agar slants and maintained at normally 25 ± 2 °C for 10 days. Identification of Pathogen Morphological and cultural characters of isolated fungi were recorded and compared with standard text for establishing their identity (Singh, 1978; Booth and Sutton, 1984; Brayford, 1993; Chowdhry, *et al.*, 2000).

Pathogenicity Test : Pathogenicity of purified fungus was tested by employing semi ripe chilli fruits puncher method under laboratory condition. Different treatments followed under this methods, included distilled water inoculation, without injury inoculation, injury+inoculation. The spore suspensions of fungus was prepared by adding 10 ml of sterilized distilled water with 10 day of old culture grown on PDA in 20 ml test petriplate and maintaining the spore concentration of 10⁶ spores / ml. The sample of anthracnose affected chilli fruits collected from the field were surface sterilized with 0.1 per cent mercuric chloride solution for 30 seconds and washed thrice with sterilized distilled water. These chilli fruits were air dried by placing on sterilized blotting paper and subsequently inoculated with spore suspension of purified fungus *C. capsici* respectively. The inoculated fruits were placed in moist chambers maintained under plastic tray box using wet blotting papers in four layers and incubated at 25±2 °C. The disease development was recorded after 5, 7, and 10 days of inoculation using with different treatments under inoculation method and also calculated percent disease intensity on fruits in different cultivars/germplasm.

Inoculated untreated seeds was used as control. Seeds were sown in pots. Observations were recorded after 10 days on seed germination, pre-and postemergence mortality and root / shoot length. Seedling vigour was also calculated by following formula suggested by Abdul Baki and Anderson (1973).

Vigour index = Germination (%) x (Root length + shoot length).

S.No.	Bioagents	Dose
(i)	<i>Trichoderma viride</i>	5.0 ml / 10 gm seeds (108 cfu/ml)
(ii)	<i>T. harzianum</i>	5.0 ml / 10 gm seeds (108 cfu/ml)
(iii)	<i>T. polysporum</i>	5.0 ml / 10 g seeds (108cfu/ml)
(iv)	<i>Pseudomonas fluorescens</i>	5.0 ml / 10 g seeds (48 hrs old culture)

Result and Discussion

Results revealed that after purification of *Colletotrichum capsici* were identified on the basis of colony color, pattern of growth and pattern of acervuli formation on PDA. The fungus produced fairly white to light mouse grey, circular, fluffy mycelium with black coloured acervuli which were scattered all over the colony growth against light with the naked eyes and later confirmed with the help of microscope. Microscopic examination of different isolates

brown niddle like septate setae with several septations and pointed brown tips. After the pathogenicity test of *Colletotrichum capsici* (test fungus), the fungus was produced same symptoms on the crop.

Present findings are conformity with the findings of Desai and Prasad (1955), Sutton (1973), and Kulshrestha et al. (1976). *Colletotrichum capsici* (Sydow) Butler and Bisby is the well distributed, adopted and known nomenclature assigned to the fungus causing anthracnose of chilli. However, after critical examination, Kulshrestha and co-workers (1976) have been listed and considered at as a synonym of *Colletotrichum dematium* (Persoon, ex. Fries) Groove based on the curved spores. The concept of Kulshrestha and coworkers (1976), Sutton (1973), Desai and Prasad (1955) has been adopted. This nomenclature has been used by several other workers (Kaur et al., 1985; Kumar and Mahmood, 1986; Lee et al., 1986 and Siddiqui et al., 1977).

Bio-agents : Results of bioagents seed treatments against seed borne *Colletotrichum capsici* presented in Table-1 indicated that maximum per cent seed germination (82.35%) was recorded in *Trichoderma viride* treated seeds followed by *T. harzianum* (81.50%). All the



(A) Symptoms of chilli Anthracnose on fruit.



(B) Spore of *Colletotrichum* spp.



(C) Pure culture of *Colletotrichum capsici*.

revealed that the mycelium was septate bearing aseptate unbranched conidiophores. Conidia were sickle shaped, hyaline, unicellular, fusiform curved with narrow ends. The average dimensions of conidia which possessed large oil globule in the centre, Acervuli contained abundant dark

bioagents treated seed significantly increased the seed germination except seed treated with *Pseudomonas fluorescens* (71.56%%) as compared to control (70.00%). All the bioagents were significantly superior in reducing pre- and post-emergence mortality over control. Maximum

Table-2 : Effect of bioagents seed treatment against *Colletotrichum capsici* on seed germination, pre- and post mortality and vigour index.

S.No.	Treatments	Dose %	Percent germination	Per cent mortality		Root* length (cm)	Shoot* length (cm)	Vigour index
				Pre emergence	Post emergence			
(i)	<i>Trichoderma viride</i>	5.0 ml/10 gm seeds (108 cfu/ml)	82.35 (65.12)	6.00 (14.18)	6.80 (15.12)	3.30 (10.47)	3.65 (10.94)	572.33
(ii)	<i>T. harzianum</i>	5.0 ml / 10 gm seeds (108 cfu/ml)	81.50 (64.52)	8.75 (17.16)	9.75 (18.15)	3.15 (10.31)	2.70 (9.46)	476.77
(iii)	<i>T. polysporum</i>	5.0 ml / 10 gm seeds (108 cfu/ml)	77.50 (61.68)	2.65 (9.28)	6.10 (14.30)	2.45 (8.91)	2.15 (8.53)	356.50
(iv)	<i>Pseudomonas fluorescens</i>	5.0 ml / 10 g seeds (48 hrs old culture) (108 cfu/ml)	71.56 (57.73)	10.50 (18.91)	10.50 (18.91)	2.50 (9.10)	2.25 (8.53)	339.91
(v)	Control	-	70.00 (56.79)	20.00 (26.56)	15.00 (22.79)	2.50 (9.10)	2.30 (8.72)	336.00
SEm	-	-	1.49	0.32	0.38	0.23	0.21	9.77
C.D.at 5%	-	-	4.49	0.95	1.14	0.67	0.64	29.21

reduction in pre- and post-emergence mortality was observed in *Trichoderma polysporum* (2.65% / 6.10%) followed by *T. viride* (6.00% / 6.80%), while it was minimum in *Pseudomonas fluorescens* bioagent treated seeds (10.50 per in each) in comparison to control (20.00% / 15.00%), respectively. The vigour index observed to significantly higher in seed treated with *Trichoderma viride* (572.33) and *T. harzianum* (476.77) in comparison to *T. polysporum* and *P. fluorescens*. Minimum vigour index was observed in control (336.00) and no significant difference was observed in seed treated with *T. polysporum* and *P. fluorescens* in comparison to control.

Conclusions

Anthrachnose disease can occur on leaves, stems, and both pre and post-harvest fruits. Typical fruit symptoms are circular or angular sunken lesions, with concentric rings of acervuli that are often wet and produce pink to orange conidial masses. Under severe disease pressure, lesions may coalesce. Conidial masses may also occur scatteredly or in concentric rings on the lesions. The acervuli of *Colletotrichum capsici* were disc shaped, waxy, sub epidermal, typically with dark needle like septate setae, conidiophore short, simple, conidia hyaline, single celled, ovoid or oblong. Among bioagents used *Trichoderma viride* followed by *T. harzianum* proved to be effective in improving seed germination and vigour index by reducing pre and post emergence mortality and number of seedlings showing symptoms.

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The Effect of Different Isolated *Colletotrichum* Spp. on Seed Germination and Seedling Vigour

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Abstract

The study was undertaken to evaluate Identify the different *Colletotrichum* spp. along with other fungi associated with chilli seeds collected from infected fruits. In the present studies which were carried out at the experimental farm of SKN, Jobner during 2008. It was observed from the data presented in the Table 4.11 that *Alternaria* sp., *Aspergillus flavus*, *A. niger*, *Colletotrichum capsici*, *Fusarium* sp. and *Rhizopus* sp. and were associated with black seeds. The fungi, observed on brown and shrivelled seeds were *Alternaria* sp., *Aspergillus niger*, *A. flavus*, *Colletotrichum capsici*, *Rhizopus* sp., *Alternaria alternata*, *Colletotrichum* sp., and *A. niger* were dominant mycoflora of all discoloured and shrivelled seeds. *C. capsici* was dominantly associated with black to brown and shrivelled seeds. The per cent association of *Colletotrichum* sp. was 31.51, 18.75 and 22.78 with black / brown and shrivelled seeds, respectively.

Key words : *Colletotrichum* sp., *Alternaria alternata*, *A. flavus*,

Introduction

Chilli (*Capsicum annum* L.) commonly known as “Mirchi” or “Mirch” is an important spice and cash crop of India belongs to the family Solanaceae and is a native of tropical America and West India. Chilli is a perennial sub-shrub produces fruit in groups. Chilli is a self as well as cross pollinated crop and mature fruits are red in colour.

Chilli fruits has importance in our daily diet and is specially liked for its pungency and spicy taste. The pungency of fruit due to the presence of a crystalline volatile alkaloid called capsaicin. It is also used to flavour, soups, stews, sauces, chutney, salad for preparing pickle curry, sambar, rasam and other savory dishes. Extracts of chillies are used in the production of ginger beers and other beverages. It has several medicinal properties and also used as counter irritants in lumbago, neuralgia, rheumatic disorders and also useful in atomic dyspepsia (Pruthi, 1993). Its paste is externally used as a rubefacient and as a local stimulant for the tonsil and in tonsillitis (Nadkarni, 1972).

Chilli is an important and widely grown cash crop in India and it cultivated in largest area of the world with the production over one million tonnes (Anonymous, 1999). In Rajasthan, chilli cultivated in its all regions with an average yield 10.8 q/ha. Amongst different chilli growing

region, Jaipur region (Ajmer, Jaipur, Dausa, Sikar and Jhunjhunu) stands 4th in its area and production with an average yield 8.05 q/ha and which is less in comparison to state average yield (10.83 q/ha) as well as average yield of Jodhpur (10.18 q/ha), Kota (13.62 q/ha) and Bharatpur (22.25 q/ha) region (Anonymous, 2003-04).

One of the important factors which limits the production in Jaipur region and specially in its, Ajmer, Sikar, Dausa, Jhunjhunu districts in comparison to other region is the poor health of seeds where most of the farmers generally used the seed collected from stored ripe red fruits infected with rots for raising the seedlings in nurseries and that take heavy toll of the crop at all the stages right from sowing to harvest and also in transit, marketing and storage. Chilli suffers from several seed borne fungal fruit rot disease viz., *Alternaria* rot, *Alternaria* fruit rot, *Anthraco*se, *Aspergillus* rot, *Black rot*, *Black fruit rot*, *Die-back*, *Ripe fruit rot*, *Cladosporium* fruit rot, *Charcoal fruit rot*, *Grey mold rot*, *Phytopathora* and *Rhizopus* rot caused by *Alternaria alternata* *A. solani*, *Alternaria tenuis*, *Aureobasidium pullulans*, *A. capsici* *annuum*, *Aspergillus niger*, *Botrytis cinerea*, *Brachysporium senegalensis*, *Cladosporium herbarum*, *Colletotrichum capsici*, *C. coccodes*, *C. gloeosporioides*, *C. dematium*, *C. piperatum*, *C. multisetorum*, *C. lindemuthidnum*, *C. acutatum*, *C. lini*, *Drechslera quatrinalensis*, *Drechslera halodes*.

Materials and Methods

Purification and Identification of Seed Mycoflora :

Isolated seed mycoflora was purified by two methods viz; (a) Single Spore Technique and (b) Hyphal Tip Method.

Single Spore Technique : In case of Single Spore Technique serial dilutions of spore suspension from 10 days old culture were made in sterilized distilled water until a dilution containing 10-15 spores was achieved. 1-2 ml of this diluted spore suspension was poured in Petri-dish containing solidified 1 per cent Plain Agar autoclaved at 1.045 kg/cm^2 for 15 minutes under aseptic conditions. Spore suspension was evenly distributed by tilting the Petri-dish in various directions. After few minutes, excess suspension was removed from Petri-dishes. Inoculated Petri-dishes were incubated at $22 \pm 1^\circ\text{C}$ for 24 hours. Germinating single spore was located and marked under the microscope with the help of dummy objective and transferred on 2 per cent PDA slants, aseptically. Inoculated slants were subsequently allowed to grow and sporulate.

Hyphal Tip Method : The method is same as described earlier except that instead of single spore, hyphal tip was marked and transferred on 2 per cent PDA slants.

The fungi isolated by method described and purified by method described under 3.5 were maintained by periodical transfer on PDA. Seed mycoflora were identified on the basis of morphological characters. Identity of the *Colletotrichum* sp. cultures was got confirmed from Indian Type Culture collection, Identification/culture Supply Service, Division of Plant Pathology, IARI, New Delhi-110012.

To know the seed-borne inoculum of *Colletotrichum* sp. in seeds, incidence in different seed samples was calculated based on incidence of different fungi recorded in methods mentioned and further studies were carried out only on *Colletotrichum* sp.

Effect of *Colletotrichum* sp. on seed germination and seedling vigour (Pathogenicity Test) : Four tests were performed as follows :

Soil Inoculation Technique : *Colletotrichum* sp. observed on chilli seeds were grown, separately on autoclaved sorghum seeds (20 g sorghum + 10 ml distilled water) contained in 250 ml conical flasks. These flasks were inoculated with acervuli/spore/mycelial suspension prepared from 10 days-old fungal culture. Flasks were shaken every day to avoid clumping. Autoclaved soil (Soil : FYM = 3:1, autoclaved at 1.045 kg/cm^2 for 1 hour for 3 consecutive days) was filled up in 30 cm earthen pots (pre-sterilized with 0.1 per cent HgCl_2 solution for 3 minutes followed by 3 washing with sterilized distilled water) and were inoculated with *Colletotrichum* sp.

separately. For inoculation, the upper 4 cm layer of the soil was thoroughly mixed with sorghum seeds supporting fungal growth. The pots were covered with polythene bags and left for 24 hours in a cage house ($22-25^\circ\text{C}$). On next day, apparently healthy surface sterilized seeds were sown in pots at the rate of 5 seeds/pot x 20. One hundred seeds were sown for the pathogenicity. Apparently healthy surface sterilized seeds sown in un inoculated sterilized soil served as control. The pots were watered regularly. Observations on seed germination, pre- and post-emergence mortality and root/shoot length were recorded on 10th days of sowing, respectively.

Seed Inoculation Technique : One hundred apparently healthy surface sterilized seeds were taken. The seeds were then rolled, separately on 10 days-old sporulating culture of each *Colletotrichum* sp. thriving on PDA contained Petri-dishes. Inoculated seeds were sown in 30 cm earthen pots (Pre-sterilized and having autoclaved soil as described at the rate of 5 seeds per pot x 20. The uninoculated surface sterilized apparently healthy seeds served as control. These pots were kept in cage house ($22-25^\circ\text{C}$). The pots were watered regularly. Observations on seed germination, pre- and post-emergence mortality and root / shoot length were recorded on 10th day of sowing, respectively.

Seedling vigour was also calculated by following formula suggested by Abdul Baki and Anderson (1973).

Vigour index = Germination (%) x (Root length + shoot length)

Spray Inoculation Technique : The method suggested by Mathur *et al.* (1973) was followed to observe the symptoms on seedlings and grown-up plants. Fifteen days old seedling, raised from disinfected seeds in plastic plots having autoclaved soil (Soil : FYM = 3:1) were inoculated by spraying with spore suspension of ten day old culture of *Colletotrichum* sp. The seedlings were sprayed to run off. Plastic pots having inoculated seedlings were kept in a humid chamber for 48 hours. Check plants were sprayed with distilled water only. Each treatment comprised of 20 seedlings (5 seedlings / pot x 4). The sprayed seedlings were accommodated in a polythene house where temperature ranged from 25 to 30°C . Plants were inspected on 10th and 15th day of incubation. Isolations were carried out from inoculated plant parts showings disease systems.

Fruit Inoculation Technique : The method described by Mridha and Siddique (1989) was followed to observe the effect of *Colletotrichum* sp on fruits. Freshly harvested green / red (ripe) fruits of chilli were obtained from the farmer's field. The fruits were surface sterilized with 0.1% HgCl_2 solution followed by 3 washings with sterilized distilled water and pricked with a sterilized needle. Forty fruits (Ten fruits/ replications x 4) of each category (green /

Table-1 : Mycoflora associated with discoloured/disfigured chilli seeds, isolated by Agar Plate Method with special reference to *Colletotrichum capsici*.

Mycoflora	Per cent incidence /category*			
	Black	Brown	Shrivelled	Apparently healthy seeds
<i>Alternaria</i> sp.	13.00	8.00	10.00	4.00
<i>Aspergillus flavus</i>	12.22	10.00	7.00	5.00
<i>Aspergillus niger</i>	8.21	7.00	6.00	4.00
<i>Colletotrichum capsici</i>	14.00	9.00	6.00	1.00
<i>Fusarium</i> sp.	6.00	5.00	2.50	2.00
<i>Rhizopus</i> sp.	12.00	15.00	7.00	4.00
Total per cent mycoflora	65.43	54.00	38.50	20.00
<i>Colletotrichum capsici</i> (%)	21.39	16.66	15.58	5.00

*Sample size 200 seeds

red ripe) were artificially inoculated with 5 mm disc ten days culture of *Colletotrichum* sp. Uninoculated injured and uninjured fruits served as control. In all four replications were maintained. The fruits were incubated at 22°C. After 10 days of inoculation fruits were examined and isolations were made from inoculated fruits which showed disease symptoms. Per cent disease incidence (PD Inc.) and intensity (PD Int.) was calculated by using disease rating scale as follows :

0 = No infection (showing no disease symptoms)

1 = 1-10% fruit area infected

2 = 10.1-25 % fruit area infected

3 = 25.1-50% fruit area infected

4 = 50.1-75% fruit area infected

5 = 75.1 % and above fruit area infected

Formulae to calculate per cent disease incidence and PDI were as follows :

(i) Per cent disease incidence (PDInc.)

$$= \frac{\text{Total number of infected fruits}}{\text{Total number of fruits assessed}} \times 100$$

(ii) Per cent disease intensity (PDInt.)

$$= \frac{\text{Sum of all numerical ratings}}{\text{Total number of fruits assessed}} \times 100$$

maximum diseaserating

Association of mycoflora with discoloured/disfigured seeds : Since all samples contained disfigured (shrivelled) / discoloured (black and brown) seeds, it was considered imperative to find out the association of fungi particularly *Colletotrichum* sp. with particular category of seeds. To detect these fungi a sample of 200 seeds of each category was taken at random. The seeds were surface sterilized with 0.1 per cent HgCl₂ solution and analysed by Agar Plate Method .

Histopathology : To observe the exact location of *Colletotrichum* sp. in the seeds collected, Component Plating Method was followed :

Component Plating : The method suggested by Singh et

al. (1980) with slight modification was followed. Fifty seeds of highly contaminated seed sample, selected at random were used for detection of fungi. Seeds were washed individually (one seed per test tube) three times with tap water and finally with sterilized distilled water and then soaked in distilled water for 24 hours. Each seed was then dissected aseptically in to different parts i.e. seed coat, endosperm and embryo with a pair of sterilized needles under stereobionocular microscope. Each component was surface disinfected with 0.1 per cent HgCl₂ solution followed by three washing with sterilized distilled water and then components of individual seed were plated at equal distance in Petri-dish having three moistened blotting papers. The dishes were incubated at 22±1°C under 12 hours alternating cycles of light and darkness. After 10 days, seed components were examined for presence of *Colletotrichum* sp.

Results and Discussion

Association of mycoflora with disfigured and discoloured seeds : It was observed from the data presented in the Table-1 that *Alternaria* sp., *Aspergillus flavus*, *A. niger*, *Colletotrichum capsici*, *Fusarium* sp. and *Rhizopus* sp. and were associated with black seeds. The fungi, observed on brown and shrivelled seeds were *Alternaria* sp., *Aspergillus niger*, *A. flavus*, *Colletotrichum capsici*, *Rhizopus* sp., *Alternaria alternata*, *Colletotrichum* sp., and *A. niger* were dominant mycoflora of all discoloured and shrivelled seeds. *C. capsici* was dominantly associated with black to brown and shrivelled seeds. The per cent association of *Colletotrichum* sp. was 31.51, 18.75 and 22.78 with black / brown and shrivelled seeds, respectively.

Histopathology

Component Plating : *Alternaria* sp., *Aspergillus flavus*, *A. niger*, *Fusarium* sp., *Colletotrichum capsici* and *Rhizopus* sp. were observed in all the seed components viz.; pericarp, endosperm and embryo Incidence of these fungi was higher in pericarp than endosperm and embryo. Amongst the total per cent mycoflora, the per cent infection of *Colletotrichum capsici* in pericarp, endosperm

and embryo were observed to be 16.66, 10.20 and 3.44 per cent, respectively.

Association of seed borne *Colletotrichum capsici* with fruit rot of was earlier reported by Kumar and Muhammad, 1986, Perane and Joi, 1980 and Mridha and Siddique, 1989). The same fungi were also found to be caused fruit rot by inoculating the healthy surface sterilized fruits - green (unripened) / red (ripened). Red (ripened) fruits found to be more susceptible than green (unripened) fruits as they have higher per cent disease incidence and - intensity, respectively.

In the present investigation, discoloured (brown and black) and deformed seeds (shrivelled) were observed in all the six seed samples. On plating (Potato Dextrose Agar medium) these abnormal surface sterilized seeds yielded *Colletotrichum capsici* and other fungal species belonging to genera *Alternaria*, *Aspergillus*, *Fusarium* and *Rhizopus*. Association of *Colletotrichum capsici*, *C. graminicola* and some other fungi belong to genera *Alternaria* sp., *Aspergillus* sp., *Fusarium* sp. and *Rhizopus* sp. with cumin, pearl millet, fenugreek, clusterbean, sorghum and chickpea have also been reported by Kumhar, 1997, Kumhar, 1999, Singh, 2001, Jain, 1990 and Ahmed and Reddy, 1993, respectively.

The component plating test revealed the presence of *Colletotrichum capsici* along with *Alternaria alternata*, *Aspergillus flavus*, *A. niger*, *Fusarium* sp. and *Rhizopus* sp. in different components of the chilli seeds i.e. pericarp, endosperm and embryo. Incidence of *Colletotrichum capsici* observed to be more in pericarp, endosperm and embryo. Besides these, presence of other fungal species viz., *Alternaria alternata*, *Aspergillus flavus*, *A. niger*, *Fusarium* sp. and *Rhizopus* sp. were also detected by component plating method in different parts of seed. Presence of *Alternaria* sp. *Fusarium* sp. and *Colletotrichum capsici* in different components of chilli seed have also been reported by Basak, 1998, Basak et al., 1974 and Basak et al., 1996.

Conclusions

It was observed from the data presented in the Table-1 that *Alternaria* sp., *Aspergillus flavus*, *A. niger*, *Colletotrichum capsici*, *Fusarium* sp. and *Rhizopus* sp. and were associated with black seeds. The fungi, observed on brown and shrivelled seeds were *Alternaria* sp., *Aspergillus niger*, *A. flavus*, *Colletotrichum capsici*, *Rhizopus* sp., *Alternaria alternata*, *Colletotrichum* sp., and *A. niger* were dominant mycoflora of all discoloured and shrivelled seeds.

C. capsici was dominantly associated with black to brown and shrivelled seeds. The per cent association of *Colletotrichum* sp. was 31.51, 18.75 and 22.78 with black / brown and shrivelled seeds, respectively.

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Effect of Integrated Nitrogen Management on economics of Garlic

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Abstract

A field experiment was conducted at the Horticulture Farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) during Rabi season 2020-21 and 2021-22 to study the Effect of Integrated Nitrogen Management on economics of Garlic. The economics of the maximum B: C ratio (5.01) was obtained in treatment combination $O_1B_1N_3$ (100% RD of N through inorganic fertilizers + biofertilizer inoculation + nano urea @ 75 ml ha) and maximum net returns (₹ 478660 ha⁻¹) was obtained in treatment combination $O_1B_1N_3$ (100% RD of N through inorganic fertilizers + biofertilizer inoculation + nano urea @ 75 ml ha). This treatment combination was found to be the best and significantly superior over rest of the treatment combinations during experimentation except treatment combination $O_1B_0N_3$, $O_1B_0N_2$, $O_1B_1N_2$ and $O_2B_1N_3$, which were statistically on par in pooled analysis.

Introduction

Garlic (*Allium sativum* L.), is an important bulb crop widely used as a spice or condiment. It's one of the major members of Alliaceae family and known by various local names in different parts of India. In India, it is commonly known as Lahsun. It is originated from central asia and later on spread to mediterranean region (Kigori *et al.*, 2005).

It has higher nutritive value than other bulbs crops. It is specially rich in protein, carbohydrate and ascorbic acid. About 142 calories of energy can be obtained from 100 g of garlic. Garlic contains 59 percent moisture, 6.4 g protein, 1469 k cal energy, 0.5 g fats, 33.1 g carbohydrates, 1.5 g fiber, 181 mg Ca, 153 mg P, 1.7 mg Fe, 17 mg Na, 401 mg K, 0.08 mg riboflavin, 0.25 mg thiamine, 0.06 mg nicotinamide and 10.8 mg ascorbic acid per 100 g of edible portion (Lorenz and Maynard, 1988). Garlic is used in flavouring of foods, preparing chutneys, pickles, curry powder, tomato ketchup, etc.

Looking at the high nutrient requirement of different varieties and hybrids of garlic, farmers often use inorganic fertilizers as they provide quick supply of nutrients to the plants. Use of chemical fertilizers has pushed up the agricultural production. However, among major nutrients nitrogen is lost in soil through leaching or to the atmosphere because of denitrification (Jha *et al.*, 2006). Availability of N, is of prime importance for photosynthesis and maintaining plant turgor. An adequate supply of nitrogen is associated with vigorous vegetative growth and most efficient use of available inputs leading to higher productivity. However, the efficiency of soil applied

nitrogen for *rabi* crops hardly exceeds 50 per cent which means that nearly half of the total nitrogen applied through soil, goes waste and may pollute the water bodies or atmosphere. Therefore, it becomes imperative to tap new methods of enrichment soil as well as plant with nitrogen and thus the possibility of using various sources of nitrogen in crop production needs special attention. A colourless, odourless, water-soluble amino compound known as alliin is present in uninjured cloves of garlic. On injury of the cells, an enzyme, alliinase comes in contact with alliin and causes breakdown into sulphur containing product allicin (diallyl thiosulfate) which gives typical odour of fresh garlic. Diallyl disulfide possess the true garlic odour (Hazara and Som, 2006).

Materials and Methods

Present study was carried out at the experimental farm of Department of Horticulture, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) during rabi season, 2020-21. The climate of this region is typically semi-arid characterized by aridity of the atmosphere, scarcity of water with extremity of temperature both during summer and Winter. The maximum temperature touches around 45.50C during May and June, while in December and January it falls below 10C. The average rainfall varies between 400-500 mm. The experiment consisted of 24 treatment combinations with six levels of inorganic fertilizers, organic manures along with bio fertilizers. The treatments with their symbols are described as under (O_1B_0 – 100% RD via Inorg. Frt. without Biofert, O_1B_1 – 100% RD via Inorg. Frt. with Biofert, O_2B_0 – 75% RD via Inorg. Frt. & 25 OM without Biofert, O_2B_1 – 75% RD via

Inorg. Frt. and 25 OM with Biofert, O_3B_0 – 50% RD via Inorg. Frt. and 50% OM without Biofert, O_3B_0 – 50% RD via Inorg. Frt. and 50% OM with Biofert) and four levels of nano urea (N_0 -control, N_1 - Nano urea @ 25 ml/ha, N_2 -Nano urea @ 50 ml/ha, N_3 -Nano urea @ 75 ml/ha) in Split Plot Design with three replications.

The recommended dose of nitrogen for garlic crop is 120 kg/ha. The vermicompost was applied at the time of planting and urea applied three equal split doses *i.e.*, first dose at planting time, second dose at 30 days after planting and third dose at 45 days after planting. Application of bio-fertilizers was done as per treatment. For this 125 g of Jaggery was mixed in one liter of boiled water and then cooled to normal temperature and (2ml) add one packet of *Azotobacter* and mix it well nano urea was prepared from IFFCO outlet as one liter packing. Foliar spray of nano urea was done as per treatment twice *i.e.* at 30 DAP and 45 DAP as per treatments and control plot sprayed with distil water. The required dose of nano urea was mixed in distill water @ 600 liters of water per hectare at the time of foliar spray.

Economics

1. **Total cost** = Common cost + Treatment cost

2. **Net return** (₹/ha) Net return (₹/ha) of individual treatment was calculated by deduction of cost of cultivation from the gross return of particular treatment. Net return = Gross Return – Total Cost of Cultivation

3. **Benefit** : Cost ratio : In order to find out net benefit : cost ratio, the net return from individual treatments was divided by their respective cost of cultivation, which included cost of treatment also.

B : C Ratio = Net return/ Total Cost of Cultivation

In order to evaluate the effect of different treatments on vegetative growth and yield characters, the data were statistically analyzed as per Panse and Sukhatme (1989).

Results

Net returns (₹/ha) : It is obvious from the data (Table-1) that net returns in garlic were influenced to a great extent by nitrogen management through organic manures and inorganic fertilizer alongwith biofertilizer during both the years as well as in pooled analysis. The highest net return of Rs. 426445/ha was recorded with application of 100% RD of N through inorganic fertilizers + biofertilizer inoculation (O_1B_1) which was significantly higher over 75% RD of N through inorganic fertilizers + 25% N through organic manure (O_2B_0), 50% RD of N through inorganic fertilizers + 50% N through organic manure (O_3B_0) and 50% RD of N through inorganic fertilizers + 50% N through organic manure + biofertilizer inoculation (O_3B_1). The application of 100% RD of N through inorganic fertilizers +

biofertilizer inoculation (O_1B_1) recorded 11.85, 43.85 and 33.50 per cent increase in net returns over O_2B_0 , O_3B_0 and O_3B_1 , respectively in pooled analysis.

It is further evident from the data (Table-1) that net returns was also significantly influenced with foliar application of nano urea. Foliar application of nano urea @ 75 ml/ha obtained significantly higher net returns of garlic than control and nano urea @ 25 ml/ha during experimentation. However, foliar application of nano urea @ 50 ml/ha remained at par to nano urea @ 75 ml/ha during both the years and in pooled analysis. The magnitude of increase in net return was 34.50 and 15.08 per cent more over control and nano urea @ 25 ml/ha during pooled analysis, respectively.

Interaction effect (OB X N) : It is evident from data presented in Table-2 that interaction effect of nitrogen management through organic manures and inorganic fertilizers alongwith biofertilizer and foliar application of nano urea was also found significant on net returns of garlic. The maximum net returns was obtained in treatment combination $O_1B_1 N_3$ (100% RD of N through inorganic fertilizers + biofertilizer inoculation + nano urea @ 75 ml ha). This treatment combination was found to be the best and significantly superior over rest of the treatment combinations during experimentation except treatment combination $O_1B_0 N_3$, $O_1B_0 N_2$, $O_1B_1 N_2$ and $O_2B_1 N_3$, which were statistically at par in pooled analysis.

B:C ratio : A perusal of data (Table-3) exhibits that nitrogen management through organic manures and inorganic fertilizer alongwith biofertilizer brought out perceptible variation in B: C ratio of garlic. Application of 100% RD of N through inorganic fertilizers (O_1B_0) recorded the significantly highest B: C ratio of garlic than rest of the treatments except 100% RD of N through inorganic fertilizers + biofertilizer inoculation (O_1B_1).

Further reference of data presented in (Table-3) reveals that increasing levels of nano urea also significantly influenced the B:C ratio in garlic. Foliar application of nano urea @ 75 ml/ha, being at par with foliar application of nano urea @ 50 ml/ha significantly increased the B: C ratio as compared to rest of the treatments.

Interaction effect (OB X N) : It is evident from data presented in table-4 that interaction effect of nitrogen management through organic manures and inorganic fertilizer alongwith biofertilizer and foliar application of nano urea significantly affected the B: C ratio of garlic. The maximum B: C ratio was obtained in treatment combination $O_1B_1 N_3$ (100% RD of N through inorganic fertilizers + biofertilizer inoculation + nano urea @ 75 ml ha). This treatment combination was found to be the best and significantly superior over rest of the treatment

Table-1 : Effect of integrated nitrogen management on net returns of garlic.

Treatments		Net returns (Rs/ha)		
		2020-21	2021-22	Pooled
N application through organic, inorganic and biofertilizer sources				
100% RD via Inorg. Frt. without Biofert	O ₁ B ₀	412529	421879	417204
100% RD via Inorg. Frt. with Biofert	O ₁ B ₁	421811	431079	426445
75% RD via Inorg. Frt. & 25% OM without Biofert	O ₂ B ₀	375976	386576	381276
75% RD via Inorg. & 25% OM with Biofert	O ₂ B ₁	391576	404276	397926
50% RD via Inorg. Frt. & 50% OM without Biofert	O ₃ B ₀	292094	300794	296444
50% RD via Inorg. Frt. & 50% OM with Biofert	O ₃ B ₁	314669	324194	319431
SEm +		9876	10907	7357
CD (P = 0.05)		31120	34365	21703
CV (%)		9.29	9.99	
N application through Nano urea				
Control	N ₀	305105	315085	310095
Nano urea @ 25 ml/ha	N ₁	357624	367206	362415
Nano urea @ 50 ml/ha	N ₂	397727	408093	402910
Nano urea @ 75 ml/ha	N ₃	411981	422147	417064
SEm +		6311	6043	5395
CD (P = 0.05)		18136	17365	15108
CV (%)		7.27	6.78	

Table-2 : Interactive effect of integrated sources of nitrogen on net returns of bulb.

Treatments		N ₀	N ₁	N ₂	N ₃
		(control)	(NU 25 ml)	(NU 50 ml)	(NU 75 ml)
2020-21					
100% RD via Inorg. Frt. without Biofert	O ₁ B ₀	319498	406485	450673	473460
100% RD via Inorg. Frt. with Biofert	O ₁ B ₁	342628	410685	455473	478460
75% RD via Inorg. Frt. & 25% OM without Biofert	O ₂ B ₀	363395	375382	385170	379957
75% RD via Inorg. & 25% OM with Biofert	O ₂ B ₁	303795	370582	434570	457357
50% RD via Inorg. Frt. & 50% OM without Biofert	O ₃ B ₀	237663	277650	316038	337025
50% RD via Inorg. Frt. & 50% OM with Biofert	O ₃ B ₁	263651	304961	344438	345625
For OB at same level of N					
SEm+		16637			
CD (P=0.05)		50348			
For N at same or different levels of OB					
SEm+		13584			
CD (P=0.05)		41109			
2021-22					
100% RD via Inorg. Frt. without Biofert	O ₁ B ₀	328498	415485	459673	483860
100% RD via Inorg. Frt. with Biofert	O ₁ B ₁	351698	421085	464273	487260
75% RD via Inorg. Frt. & 25% OM without Biofert	O ₂ B ₀	373595	384582	398370	389757
75% RD via Inorg. & 25% OM with Biofert	O ₂ B ₁	317195	383582	446370	469957
50% RD via Inorg. Frt. & 50% OM without Biofert	O ₃ B ₀	245463	286050	325238	346425
50% RD via Inorg. Frt. & 50% OM with Biofert	O ₃ B ₁	274063	312450	354638	355625
For OB at same level of N					
SEm+		16831			
CD (P=0.05)		50603			
For N at same or different levels of OB					
SEm+		13742			
CD (P=0.05)		41317			
Pooled					
100% RD via Inorg. Frt. without Biofert	O ₁ B ₀	323998	410985	455173	478660
100% RD via Inorg. Frt. with Biofert	O ₁ B ₁	347163	415885	459873	482860
75% RD via Inorg. Frt. & 25% OM without Biofert	O ₂ B ₀	368495	379982	391770	384857
75% RD via Inorg. & 25% OM with Biofert	O ₂ B ₁	310495	377082	440470	463657
50% RD via Inorg. Frt. & 50% OM without Biofert	O ₃ B ₀	241563	281850	320638	341725
50% RD via Inorg. Frt. & 50% OM with Biofert	O ₃ B ₁	268857	308706	349538	350625
For OB at same level of N					
SEm+		13606			
CD (P=0.05)		41427			
For N at same or different levels of OB					
SEm+		11109			
CD (P=0.05)		33825			

Table-3 : Effect of integrated nitrogen management on B:C of garlic.

Treatments		B:C ratio		
		2020-21	2021-22	Pooled
N application through organic, inorganic and biofertilizer sources				
100% RD via Inorg. Frt. without Biofert	O ₁ B ₀	4.32	4.42	4.37
100% RD via Inorg. Frt. with Biofert	O ₁ B ₁	4.15	4.25	4.20
75% RD via Inorg. Frt. & 25% OM without Biofert	O ₂ B ₀	3.61	3.72	3.67
75% RD via Inorg. & 25% OM with Biofert	O ₂ B ₁	3.56	3.67	3.62
50% RD via Inorg. Frt. & 50% OM without Biofert	O ₃ B ₀	2.60	2.67	2.63
50% RD via Inorg. Frt. & 50% OM with Biofert	O ₃ B ₁	2.65	2.73	2.69
SEm +		0.08	0.09	0.06
CD (P = 0.05)		0.25	0.30	0.18
CV (%)		7.98	9.17	
N application through Nano urea				
Control	N ₀	2.89	2.98	2.93
ONano urea @ 25 ml/ha	N ₁	3.39	3.48	3.43
Nano urea @ 50 ml/ha	N ₂	3.76	3.86	3.81
Nano urea @ 75 ml/ha	N ₃	3.90	3.99	3.95
SEm +		0.07	0.07	0.05
CD (P = 0.05)		0.19	0.19	0.15
CV (%)		8.06	7.84	

combinations except O₁B₀N₃ and O₁B₀ N₂ being at par with each other during experimentation.

Discussion

Effect of organic manures and inorganic fertilizer along with biofertilizer on economics : The economics worked out from the two years of field experimentation revealed that basal application of increasing levels of organic manures and inorganic fertilizer along with biofertilizer significantly affected the net returns and B: C ratio of garlic. Application of 100% RD of N through inorganic fertilizers + biofertilizer inoculation (O₁B₁) recorded maximum and significantly better net returns of 426445/ha and B: C ratio of 4.20 in the pooled study over the rest of the treatments which is primarily due to higher bulb yield comparatively less additional cost of N. Gebretsadik and Dechassa (2018) both reported significant improvements in yield attributes and yield as a result of N application.

Effect of nano urea on economics : The economics worked out from the two-year field experiment revealed the beneficial effect of foliar application of nano urea on growth, yield and storage of garlic. The maximum and significantly better net returns of 417064/ha and B:C ratio of 3.95 were obtained with the application of nano urea @ 75 ml/ha over control in the pooled study. These results can be directly correlated with the corresponding increase in the yield of garlic due to the efficient utilization of nano urea and their direct effect on net returns and benefit cost

ratio. According to recent studies nano urea has the possibility to revolutionize agricultural systems. Manjunatha *et al.* (2016) recorded that application of fertilizers in the form of nano particles, enable slow and controlled release of nutrients for the plants' which ultimately led to increase in the crop production with less adverse effect on environment (Scott and Chen, 2013).

Conclusions

On the basis of the experiment as well as economic point of views, an application of organic manures, inorganic fertilizer along with biofertilizer and nano urea on produced its significant impact on net returns and cost of benefits ratio.

The maximum B: C ratio (5.01) was observed in treatment combination O₁B₁ N₃ (100% RD of N through inorganic fertilizers + biofertilizer inoculation + nano urea @ 75 ml ha) and maximum net returns (₹ 478660 ha⁻¹) was obtained in treatment combination O₁B₁ N₃ (100% RD of N through inorganic fertilizers + biofertilizer inoculation + nano urea @ 75 ml ha).

Future Scope

The research work can be helpful to researchers for further investigation and also may be useful to crop growers for opting suitable combination of organic, inorganic, bio-fertilizers and nano urea to enhancing the economics of garlic.

Table-4 : Interactive effect of integrated sources of nitrogen on B:C ratio of bulb.

Treatments		N ₀ (control)	N ₁ (NU 25 ml)	N ₂ (NU 50 ml)	N ₃ (NU 75 ml)
2020-21					
100% RD via Inorg. Frt. without Biofert	O ₁ B ₀	3.35	4.26	4.72	4.96
100% RD via Inorg. Frt. with Biofert	O ₁ B ₁	3.38	4.05	4.49	4.71
75% RD via Inorg. Frt. & 25% OM without Biofert	O ₂ B ₀	3.49	3.61	3.70	3.65
675% RD via Inorg. & 25% OM with Biofert	O ₂ B ₁	2.76	3.37	3.95	4.16
50% RD via Inorg. Frt. & 50% OM without Biofert	O ₃ B ₀	2.11	2.47	2.81	2.99
50% RD via Inorg. Frt. & 50% OM with Biofert	O ₃ B ₁	2.22	2.57	2.91	2.91
For OB at same level of N					
SEm+		0.16			
CD (P=0.05)		0.49			
For N at same or different levels of OB					
SEm+		0.13			
CD (P=0.05)		0.40			
2021-22					
100% RD via Inorg. Frt. without Biofert	O ₁ B ₀	3.44	4.35	4.81	5.06
100% RD via Inorg. Frt. with Biofert	O ₁ B ₁	3.46	4.15	4.57	4.80
75% RD via Inorg. Frt. & 25% OM without Biofert	O ₂ B ₀	3.59	3.70	3.83	3.75
75% RD via Inorg. & 25% OM with Biofert	O ₂ B ₁	2.88	3.49	4.06	4.27
50% RD via Inorg. Frt. & 50% OM without Biofert	O ₃ B ₀	2.18	2.54	2.89	3.08
50% RD via Inorg. Frt. & 50% OM with Biofert	O ₃ B ₁	2.31	2.64	2.99	3.00
For OB at same level of N					
SEm+		0.17			
CD (P=0.05)		0.51			
For N at same or different levels of OB					
SEm+		0.14			
CD (P=0.05)		0.42			
Pooled					
100% RD via Inorg. Frt. without Biofert	O ₁ B ₀	3.39	4.30	4.76	5.01
100% RD via Inorg. Frt. with Biofert	O ₁ B ₁	3.42	4.10	4.53	4.76
75% RD via Inorg. Frt. & 25% OM without Biofert	O ₂ B ₀	3.54	3.65	3.77	3.70
75% RD via Inorg. & 25% OM with Biofert	O ₂ B ₁	2.82	3.43	4.00	4.21
50% RD via Inorg. Frt. & 50% OM without Biofert	O ₃ B ₀	2.15	2.50	2.85	3.04
50% RD via Inorg. Frt. & 50% OM with Biofert	O ₃ B ₁	2.27	2.60	2.95	2.96
For OB at same level of N					
SEm+		0.13			
CD (P=0.05)		0.40			
For N at same or different levels of OB					
SEm+		0.11			
CD (P=0.05)		0.33			

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Role and Impact of ICT in Library Science

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Abstract

Technology for creating, storing, managing, and communicating information is referred to as information and communication technologies (ICTs). ICTs can be used to support both teaching and learning, as well as research activities, such as collaborative learning and inquiry, in education. The development of ICT has changed the traditional concept of libraries, changed the nature of collections, and changed the needs of users for teaching and learning. There are many components of ICT, including computers (hardware and software), the Internet, wireless technology, radio frequency identification (RFID), and the use of library resources. A wide variety of information resources can be accessed according to the needs of users, including e-books, e-journals, library networks, and web OPACs. Library users are adopting electronic habits, making extensive use of ICT, such as computers, the Internet, the Web, Intranets, Extranets, and other technologies. As a result, library users are placing new demands on their libraries. They require access to the most current information, updated information resources, and ICT facilities that they can use for their work.

Key words : *Library science, ICT, information and communication technology.*

Introduction

ICT, short for information and communications technology, encompasses the infrastructure and components that enable modern computing systems. This includes the internet, mobile connectivity through wireless networks, traditional technological devices such as landline phones, television and radio as well as new technologies like AI and robotics. All these technological advancements are used across the globe. [1]

Although there is no specific definition that can define the term ICT, it is an extensional term for information technology (IT) which mainly focuses on the role of unified communications and integrates with telecommunications including telephone lines, wireless signals, and computers. Additionally, it contains all the software, audio, visual, middleware, and storage tools that enable users to store, transmit, access, understand, and manipulate information. [1]

Telephonic communication, audio and visual networks are also merged with computer systems by using a single cable or any link system. In addition to cell phones, radio, television, computers, and satellite systems, ICT is a broader term that refers to all communicational devices.[1]

In addition to video conferencing and distance learning, ICT with analogue technology also offers various services and appliances. In Information and Communications Technology (ICT), computing, telecommunications, and governance policies are converged to describe the ways in which information should be accessed, secured, processed, transmitted,

and stored. Although ICT is sometimes used as a synonym for information technology (IT) in some parts of the world, both terms have slightly different meanings depending on their context. In the United States, for example, IT is commonly used when discussing technology in terms of business operations, whereas ICT is more commonly used in the context of education and government. [1]

In many parts of the world, ICT has become an umbrella term as analog communication links are being replaced with digital communication links, and professionals are needed to manage this convergence. ICT employees can expect to work in roles that include improving digital literacy, data literacy, and using emerging technologies to optimize legacy communication channels in order to achieve this objective. This includes researching how emerging artificial intelligence technologies such as generative AI, augmented reality (AR) and virtual reality (VR) can be used responsibly to support traditional communication theories. [2]

ICT in libraries : As a result of ICTs, human life has changed in different ways in the 21st century. With the advent of ICTs, the world has been thrown into a new society called the Knowledge Society or Information Society. Thus, the world has become a global village. The internet where you can migrate from one computer chain to another is called the super information highway. In the information age, ICTs have profoundly affected socio-cultural, political, educational, and economic changes. One of the main areas deeply affected by ICTs, the library. [3]

Due to the fact that libraries are the primary places

for information and knowledge, they have become virtual, so information services are now available beyond physical walls. The first and foremost ICT component that libraries can adopt is the computer for library automation and to have an in-house database of library holdings in electronic form. [3]

As many primary journals are becoming published in CD form, it becomes necessary to equip the libraries to maximize the use of information. The use of e-mail, online retrieval networks, multimedia, and the internet are other important technologies that enable faster access to information. ICT can be used to capture, store, manipulate, and distribute information. Providing new services faster, providing need-based services to users and utilizing the user for better information services, supporting all types of library functions. [3]

For effective library operations and services, the following ICT facilities and resources can be used :

?The use of barcode equipment for circulation and stock verification is becoming more common, efficient and time-saving.

?The Bulletin Board System, or BBS, is a computer system that runs software that allows users to connect and log in using a terminal. By logging in, a user can upload and download software and data, read news and bulletins, and exchange messages through electronic mail or public message boards with other users.

SDI & CAS Services : The library has begun offering current-awareness services such as Table of Contents (TOC), List of New Arrivals of Journals and Books, Press Clippings, Research Digests, and Abstracting and Indexing services. Users are informed of new resources on specified topics using tools and resources that are used for selective dissemination of information.

The term online chat refers to any form of communication that uses the Internet to transmit text-based messages instantly between senders and receivers. It can be used in libraries for online reference services, as well as real-time consultation services. Online chat can be used both for point-to-point and multicast communication between one sender and many recipients.

With the widespread use of computer technology, information transmission processes have dramatically evolved throughout all fields of human endeavor. In virtually all ICT applications, the computer is integrated with other devices in order to function efficiently. It can be referred to as the backbone, nucleus or hub of an application.

An organized collection of data, usually in digital form, used for one or more purposes is a database. There is a wide variety of bibliographical databases and full-text resources available in libraries, which are arranged in a way that supports processes that require the information by modeling relevant aspects of reality.

A scanner is an important part of modernizing libraries. It scans text, images, and content pages of books and can be used to establish a digital and virtual library.

The implementation of e-Books in an academic library is strongly dependant upon the various factors such as Content, Software and Hardware Standards, Protocols, Digital Rights Management, Accessibility, Storage, Privacy Issues, Market Tendencies, Pricing Policies and Features. They represent an ideal way of extending the digital collection available 24/7 and helping users to quickly locate and apply for the content they need for their research.

Electronic document delivery services:

Document delivery services currently combine paper, digital, and electronic media; they are hybrids. In libraries, ICT-based interlibrary lending systems are used to deliver digital copies of journal articles and other documents to library users' desktops [mainly in Portable Document Format (PDF)] via electronic networks.

Journals: Electronic journals can be defined broadly as any journal, magazine, newsletter, or type of electronic serial publication that is published electronically. Various technologies can be used to access the information, including the World Wide Web, Gopher, ftp, telnet, email, and listservs over the internet. Often, publishers who offer print subscriptions also offer free electronic subscriptions to their journals. Publishers such as Emerald Elsevier, Kluwer, Springer, Highwire, John Wiley, and others provide e-journals.

Electronic mail (E-mail): You can also send and receive emails through this medium. Using e-mail, you can send and receive messages from remote areas with enhanced networks. E-mail is commonly used with internet facilities. It is also useful in several aspects of library environments. Thus, e-mail may have a significant impact on the dissemination of information.

Electronic resources: The collection of electronic resources on magnetic and optical media has a substantial impact on university libraries' collections.

Electronic resources can be accessed using traditional media such as CDRoms, the internet, e-journals, online database databases, e-books, OPACs, blogs, wikis, podcasts, etc.

Indexing and abstracting services shorten and summarize documents and assign descriptors for referencing them.

In institutional repositories, digital copies of the intellectual output of an institution, particularly a research institution, can be collected, preserved, and disseminated online. As part of this, a university includes materials such as journal articles, both preprints (preprints) and postprints (postprints) of peer review, as well as theses and dissertations.

Full-text on-line service: A full-text database is a collection of documents or other information in the form of a database that offers online access to the full text of each referenced document.

Digital libraries rely on digital formats such as CD-ROMs to store information. Virtual libraries do not have physical space.

It does not have a physical structure but can be accessed through a network.

Users can use social media networks like Twitter, Facebook, LinkedIn for educational discussion groups, listservs, etc.

?Libraries offer online reader consultations and reference services to help readers find the right information. [9]

To provide the right information to the right person at the right time and according to their interests, needs, and reading level. [9]

The entrance and competitive exams like NEET, GPSC, UPSC, NET, SET, CAT, GATE etc are kept in a special section for the students concerned and the teachers preparing for the exams tutorials are provided in digital format.

Portals are a way of combining existing services to provide users with an enhanced, personalized experience. Through the seamless integration of services such as customization and authentication, they allow the individual access to a broad range of printed and electronic resources. Portals can be either commercial or free, with three primary categories - consumer (YAHOO, MSN, AOL), vertical (serving a specified audience) and business (web-based resources tailored to subjects or topics). [9]

Benefits of ICT in libraries : ICTs have drastically changed library practices. Their utilization has proven to

be beneficial in multiple areas, including education, health, agriculture, business and commerce. Olise (2010) found that the incorporation of ICTs leads to the digitization of traditional materials such as books and journals as well as the emergence of virtual libraries. This allows educational researchers to access up-to-date literature with greater efficiency and encourages collaboration between individuals regardless of their geographical location. [10]

You can find up-to-date information on any subject using the internet. ICTs are also being used in agriculture to provide farmers with information concerning their plants and animals, which will ultimately improve their productivity. Likewise, earlier research findings can be accessed through the internet.

Computers are widely used in the professional realm to automate manual processes. Through the use of ICTs, libraries can locate, store, and disseminate information resources such as e-mail and CD-ROMs. Similarly, digitization - the conversion of print materials into electronic form - may also be performed using ICT tools. Acquisition, cataloguing, circulation and serials management are all examples of duties that have been successfully automated in libraries with the help of available software. [10]

The academic libraries in Indian setup have been preparing themselves on a corporate basis; a platform for ICT-based information services. With the advent of the Internet, information services have changed dramatically. Internet has become a boon to libraries as well as information seekers, breaking down the distance barrier. As a teaching and research tool, it has become popular, easy to use and inexpensive. As a result of the Internet, librarians are changing the way they view information sources. The publisher is considered the fastest, most accurate and most effective way to communicate among academics, researchers, executives and business people. It is therefore becoming more common to use the internet for information services and current awareness services in libraries today, and it is also true that the internet has become a part of the library environment. [11]

Conclusions

Adopting best practices can be a great way to upgrade the quality of library services. By utilizing best practices in academic institutes, we can make sure the library collection and users are well connected, and reap the most benefits from it. Libraries have been using various best practices for administration, management, collection, services and technology-based service implementation. Besides offering current information to users, this will also bring about visible enhancements in the use of information sources /services, as well as user contentment. The

above best practices of each university/college library create their own image in the minds of students, faculty and society. Students watch library professionals because they are knowledge managers. Information and communication technology (ICT) has radically changed university libraries and information services. It has created an environment in which rapid continuous change has become the norm. As the library's collection no longer defines its value, it is a rival among many others in the information society. ICT has reduced the library from its status as a custodian of our literary heritage to that of a competitor. Due to online access and the rise of virtual university libraries, the concept of the university library as a physical entity is being eroded.

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Ontology and its Impact on Library Science : A Review

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Abstract

The ontology provides machine-interpretable ideas and the connections between them in a specific field. Every day, Library & Information Science is evolving and the advances in technology are reflected in much of the work being done on the subject. Traditional search engines struggle to capture data by analyzing the semantics meaningfully, forcing users to dedicate extra time and expertise to decode it. The semantic web could replace its conventional counterpart considering that it is adept at dealing with common web difficulties.

Key words : *Ontology, library science, ICT, semantic web.*

Introduction

An ontology is a representation, formal name, and definition of concepts, data, and entities that constitute one, many, or all domains of discourse in computer science and information science. Using a set of concepts and categories that represent a subject area, an ontology illustrates the properties of a subject area and how they are interrelated. A discipline or field uses ontologies to organize data and limit complexity. Each uses ontological assumptions to frame explicit theories, research, and applications. New ontologies may facilitate problem solving within the domain. Translating research papers within each field is a problem made easier when experts from different countries maintain a controlled vocabulary of jargon between each of their languages. [1]

Marxist economics, for instance, emphasizes the ontology and definition of economics as a primary concern, as well as other economic subfields. An example of economics relying on information science occurs when a simulation or model is used to enable economic decisions, such as determining what capital assets are at risk and by what amount. [1] Ontologies from both computer science and philosophy strive to embody ideas, entities and occurrences, as well as all their interlocking attributes and affiliations, within a network of classifications. There is a multitude of research on the challenges of ontology construction (such as the works of Quine and Kripke in terms of philosophy, or Sowa and Guarino in the area of computer science), with disputes about how much normative ontology is feasible (including foundationalism and coherentism in philosophy, and BFO/Cyc in AI). [2]

Applied ontology is seen as the successor to preceding philosophic endeavours, though much of the current work focuses on creating a restricted lexicon for specialised domains, rather than on first principles, fixed

essences or the question of which is more primary - enduring objects or processes. Artificial intelligence has been accorded the majority of attention in regards to applied ontology, particularly with reference to subfields like natural language processing and machine translation within knowledge representation. However, ontology editors are also routinely employed in fields such as education without an intention to add to AI. [2] The above best practices of each university/college library create their own image in the minds of students, faculty and society. [2]

Ontology in libraries : An Ontology library system is a library system that provides a range of features for administering, customizing and harmonizing ontology groups. It must meet the requirements of re-use of existing ontologies. To this end, an Ontology library should grant easy access and supply effective tools for retrieving applicable ontologies and bringing them into line with upper-level ontologies and ontology representation languages. Thus, it should comprise of an efficient framework to store and manage ontologies, a straightforward environment for editing, exploring and inferring from them, as well as robust standardization assistance through the provision of upper-level ontologies and standardized ontology representation languages. [3]

Recently, mounting effort has been spent surveying research concerning ontology from a number of points of view, like representation languages [3], development [3], and learning approaches [3]. Nonetheless, there has not been an analysis of ontology library systems. In this paper, we have chosen to explore the existing library systems and identify the primary criteria to evaluate their capabilities. Additionally, we will assess various suggestions against these criteria in order to encourage the re-use of ontologies. For this purpose, a library system must at least be able to do the following :

Ontology re-use through open storage, identification, and versioning.

Providing easy access to existing ontologies and advanced assistance in adapting ontologies to certain domain and task-specific circumstances (instead of requiring them to be created from scratch) promotes ontology reuse. [4]

The key to developing knowledge sharing and re-use to its full potential is to provide access to upper-layer ontologies and standard representation languages. [4]

It is possible to further specify the above aspects as follows :

It is the main function of an ontology library system to facilitate the reuse of knowledge (ontologies). After all, the goal of ontologies is to allow knowledge to be shared and reused [5]. An ontology library system's re-use functionality depends heavily on open storage, identification, and versioning.

Is the ontology easily accessible (via a client-server architecture, peer-to-peer, etc.) for remote access and editing? [5]

Are ontologies classified according to some existing or homemade categories? (Classifying ontologies is an important step in reorganizing them so users can easily search and identify relevant ontologies. The article emphasizes that library systems are capable of reorganizing ontologies; and (c) Are ontologies stored in modules? (A modular ontology library system enables the re-use, mapping, and integration of ontologies; it ensures proficient re-use of ontologies). [6]

A unique identifier must be assigned to each ontology in the ontology library system.

Ensure consistency between different versions of ontologies by versioning (how to maintain the changes of ontologies in an ontology library system).

Ontology library systems should make it easy to extend and update ontologies. They should provide a user-friendly environment for searching, editing, and reasoning ontologies. The search and modification of existing ontologies are important aspects of an ontology library system. [6]

Is a library system capable of providing certain searching facilities, such as keyword-based searching or other advanced searching? Does it feature an adequate browsing feature?

Ontology library system editing (how to add, delete, and edit specific ontologies). An ontology library

system should have the ability to modify stored ontologies as well as add new ontologies. How does the system support this feature? Can it be used remotely and cooperatively?

Is it possible to derive any query-answering behavior from the ontology? How does the system support ontology evaluation and verification? [7]

Ontology library systems should adhere to existing or available standards, such as standardized ontology representation languages and standardized taxonomies.

Does the ontology library system support multiple standard ontology languages, such as RDFs1, XMLs2 or DAML+OIL3?

Upper-level ontologies (does the ontology library system have any roots in existing upper-level ontologies like Upper Cyc Ontology, SENSUS, MikroKosmos, PENNMAN Upper Model, or IEEE Upper-layer Ontology?): The upper-level ontology captures and models the basic concepts and knowledge that could be re-used in creating. [7]

Ontology library system

WebOnto : Developed by the Knowledge Media Institute at the Open University (UK), WebOnto is an ontology library system that allows for collaborative creation, browsing, and editing of ontologies. In addition to providing a direct manipulation interface for displaying ontological expressions, it also includes Tadzebao, an ontology discussion tool that can be used synchronously or asynchronously. [8]

Ontolingua : The Ontolingua server and representation language were developed at Stanford University's Knowledge Systems Laboratory in the early nineties. As a repository of ontologies (ontology library system), the server assists users in generating new ontologies and amending existing ones collaboratively. Different formats can be converted from the ontology stored on the server. [8]

DAML Ontology library system : The DAML Ontology Library System, associated with the DARPA Agent Markup Language Program which began in August 2000, is focused on developing the tools and language necessary for Semantic Web concept. Available in XML, HTML, and DAML formats, it contains a catalogue of ontologies that have been created using DAML. Furthermore, new ontologies may be uploaded to the public library system.

SHOE (University of Maryland, USA) : The University of Maryland (USA) developed SHOE (Simple HTML Ontology Extensions). As a markup language, SHOE is also the first web-semantics language developed, and it

has been used for a variety of purposes, including food safety for the US Food and Drug Administration and military logistics planning.

Ontology Server (Vrije Universiteit Brussels, Belgium)

: Developed by the Vrije Universiteit in Brussels, Ontology Server combines ontology engineering with database semantics. It manages and understands ontologies using database techniques. As a result of various syntactical constructs offered by DBMSs, database diagrams can display objects, subtype taxonomies, integrity constraints, derivation rules, etc. [9]

IEEE Standard Upper Ontology (IEEE) : The IEEE Standard Upper Ontology (SUO) Working Group has made considerable efforts in drawing on a great many ontologists to craft a standard top-level ontology that can enable various applications. Through their easy-to-use library system available on their website, they offer access to a set of categorized ontologies such as those expressed in SUO-KIF, formal ontologies and linguistic ontologies/lexicons. To make navigation easier, basic hyperlinks are attached to the respective homepages (see Figure 9). However, the system does not possess any clear management, adaptation or standardization features as discussed earlier. It is worth mentioning the first effort to combine multiple SUO sources into a unified and accessible ontology. This was accomplished by bringing together David Whitten's structural ontology, John Sowa's upper ontology, Allen's temporal logic, Russell and Norvig's upper ontology, Casati and Varzi's formal theory of holes, Barry Smith's formal theory of boundaries, Borgo, Guarino and Masolo's formal theory of physical objects, the Core Plan Representation and the Agents and Numbers Ontologies stored on the Ontolingua server. [9]

ONIONS : The ONIONS methodology was first proposed in the early 1990s as a way of dealing with conceptual discrepancies. Through its stratified design, it consists of a library system featuring well-documented and formalised generic ontologies, a cognitively clear top level, and intermediate modules containing the most generic concepts from the domain. These modules rely upon both the generic ontologies and the top level in order to make up the appropriate domain ontology. ONIONS focus on developing a comprehensive ontology library system for medical terminology, utilizing logic description-based design principles and generic theories. Leveraging LOOM, a knowledge representation system which facilitates classification services in the description logic, this library includes local definitions to create multi-local, integrated ones. This system also entails steps surrounding the dissemination, usage, categorization and authentication of models. [10]

Conclusions

Ontology libraries serve as a platform for the storage of various types of ontologies generated from different sources and provide data providers and application developers with the ability to share and reuse them. An ontology is a formal description of knowledge, including concepts in a domain, as well as the relationships between them. This allows organizations to gain a better understanding of their data by creating a common understanding and making explicit domain assumptions. The benefits of Ontologies include improved quality in entity analysis, increased use, reuse and maintainability within information systems, and facilitated sharing of domain knowledge across independent software applications - all with a common vocabulary.

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Influence of Social Media on Library Science Growth

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Abstract

Forty-four percent of libraries post daily on Facebook, while 25 percent also post daily on Twitter. Through social media platforms such as these, librarians are able to share events and pictures, educate others about services, highlight their collections, and demonstrate support for other libraries. This form of communication allows for a much wider reach than a local system alone, enabling information to be shared with distant people. Social media can also simplify operations for librarians and help library users build better relationships with the staff. An added upside is that customers now have direct access to the library—enabling them to inquire about available books, services, and office hours—and the library receiving immediate feedback in return.

Key words : *Social media, libraries on social media, facebook, twitter.*

Introduction

The present digital age has greatly impacted the thinking of individuals and collective bodies, as well as how service providers operate. The speedy development of IT and its accompanying services has improved the standards of living. ICTs have led to a transformation in social media and other forms of communication. Initially, there was great confidence that computers and internet would provide lifelong working opportunities, but upon the emergence of social media, the way people communicate saw an extraordinary shift. Social media makes it easier for people to connect, share and receive data from any part of the world. This mode of communication has profoundly altered the attitude, thought processes and outlook of service providers throughout the globe. [1]

It has been acknowledged that social media have revolutionized communication with the public, providing a means of accessing scholarly society and introducing library sources and services from their own home. LIS professionals are able to leverage platforms such as LinkedIn, MySpace, Web 2.0, Blogs, WhatsApp, QQ, and WeChat to interact with users at distant locations and promote their offerings. Moreover, Twitter is proving particularly useful for library staff, as it facilitates access to library resources and services. In this way, Library Professionals are able to use efficient communications methods to meet the requirements of library patrons. [1]

The number of libraries using different forms of social media is growing, bringing library users closer to sources and services. Scholars [8] have found that librarians are utilizing these platforms for professional development in their respective fields. Particularly in the present day of social networking, it meets the need of library professionals to prepare themselves for upcoming

challenges. It is pivotal for them to be equipped with skills and knowledge to meet the needs and wants of library users in future. Besides, [2] suggest that these technologies are creating an interactive environment through which communication among users and librarians takes place. Moreover, with the increased utilization and adoption of social media, those working in libraries are becoming more cognizant about the requirements of their patrons. Consequently, these tools assist them immensely when dealing with issues and challenges promptly. Amongst librarians, Facebook is the most popular network followed by Twitter and blogs. [2]

The present age of information is booming, causing a shift in how people perceive and process information. Everyone is eager to obtain and share information, however, are uncertain about how to collect and distribute it at once. Moreover, advancements in ICTs have transformed the function of information professionals. Social networks websites which enable communication from one person to another or from one group to many have been developed due to ICTs. According to Wikipedia (2019), telegraphy was introduced in the 1840s and acted as the base of social media. This technology has opened up access to a plethora of data, allowing individuals with different backgrounds and locations to exchange their knowledge effectively. A variety of these sites are widespread - e.g Facebook, Twitter, YouTube, WeChat, Instagram, QQ, QZone, Weibo etc - therefore offering users more options. [3]

Twitter is a key tool in promoting library sources and services. In this digital age, social media has become the most cost-effective way to advertise library offerings. In addition, it helps create an atmosphere that is conducive to offering good service to library users. Facebook stands out for marketing library sources and services at minimal

cost, with the added bonus of allowing library staff to maximize their product's usage among potential patrons. [3]

Social media influence on libraries

Social Networking Services (SNS) encompasses two main formats—profile-oriented sites and content-oriented sites. However, SNS differ from one another and may be categorized in more ways than one. [4]

SNS based on profiles : Profile-based services are generally structured around profile pages that consist of information regarding each individual member, such as an image, likes and dislikes. The likes of Bebo, Facebook and MySpace perfectly exemplify this. To evolve his/her space, users may contribute to one another's sites by writing comments or adding content or external links via message walls, comment or evaluation tools. Widgets are also utilised to either supplement profiles with additional details or incorporate information stemming from other online networking platforms and web services. [4]

SNS based on content : When it comes to social networking services, content plays a primary role in forming connections and groups. A prime example is Flickr, a photo-sharing site where people post pictures and comment on other's photos. Other services that have content-focused communities are Shelfari, which focuses on members' bookshelves, YouTube.com for video-sharing, and last.fm for audio files that the user listens to. All these sites let users create profiles but they mainly rely on content created by the user to form connections and interactions. Moreover, there are many people who have "empty" accounts just so they can view their friends' or families' permission-protected pictures. [5]

SNS with white labelling : Most social networking services provide users with the tools to create mini-communities. Platforms such as PeopleAggregator and Ning, introduced in 2004, offer a distinct model, based on the creation and membership of individual social networking sites. This means people can design their own "mini MySpaces"—sites that promote certain interests, events or activities. However, starting and operating a social networking service also requires increased responsibility from the creator or host of the site. [5]

Virtual environments with multiple users : It is possible for users to interact with avatars – virtual representations of site members – on sites like Second Life and World of Warcraft, online virtual environments. Although users have profile cards, their functional profiles are the characters they customise or build and control. Friends lists are usually private and are not displayed publicly. [6]

SNS on mobile devices : A number of social network sites, such as MySpace and Twitter, offer mobile versions of their services, allowing members to communicate with their friends via their phones. In addition to Web-based social networking services, mobile-only and mobile-led communities are also emerging, including profiles and media sharing. MYUBO, for example, allows users to share and view videos through mobile networks. [6]

Updates on microblogging/presence : Micro-blogging services such as Twitter and Jaiku make it possible to distribute brief (140 characters, with spaces included) posts publicly or among contact groups. Primarily intended for use with mobile devices, they are widely used and examined on the web too. Various services offer "status notifications" – short messages that can be updated to keep people informed of your frame of mind or activity. These can be monitored within the website, delivered to cell phones as text messages, or exported for reading elsewhere or showing off elsewhere. This type of communication encourages users in an ongoing dialogue and connection with their online networks. [7]

Search for people : People search is an essential part of web development. Sites such as Wink allow for searches across public profiles from multiple social media platforms, obtaining results based on name, interests, location and other information shared publicly. This type of people search goes beyond the boundaries of each separate platform, although all data should already be accessible to everyone.

As users' attitudes towards libraries are changing day by day, social networks can be used to provide user-centered service in social library settings. Users need the most practical and timely information in the age of e-learning. However, providing quick and easy retrieval of information to users is a great challenge for libraries. Therefore, libraries should find and search for some new techniques for the use of social networking sites (SNS) in libraries is increasing significantly. Libraries are utilising this platform to engage with patrons and promote academic collaboration, as Bell (2007) revealed. Students also take advantage of this opportunity, exchanging information on any topic or subject. Additionally, libraries have implemented SNS walls for communication purposes, imparting pertinent information to users. Academic Libraries should look to modern trends to strengthen their service delivery. Social Networking, mobile applications, and online check in/check out are efficient technologies to achieve this. To stay up-to-date with these developments, libraries must invest in relevant technologies and upgrade library staff skills in Information Technology (IT). Understanding and using social

networking sites correctly will increase the effectiveness of libraries operations. [7]

Benefits of social media in library system

Whether it is MySpace, Facebook, Instagram, or TikTok, social media has become a huge part of everyone's life. Since most users (and non-users!) have a presence on all these different platforms, they are channels that should be used by all libraries. Social media is integral to businesses in every sector, from massive firms to small-scale bakers. Data from Forbes shows that 43% of consumers go online to find new brands and 36% or more do their shopping via social networks. This indicates that having an internet presence is essential for companies in order to meet prospects and maintain relationships with current customers. Even the least likely of industries, like libraries, can gain advantages by joining in on the social media trend. Here are a few reasons why: [8]

Enhance the customer experience : Having a social media account will give customers access to ask questions about books, services, and office hours. You'll also be able to receive feedback directly too. In today's digital age, users have grown accustomed to receiving an answer within the hour. Delay in responding may result in the customer losing interest. Additionally, libraries can conveniently network with each other on these platforms. [8]

Create a community : Having an active social media presence can be a great way to gain loyal followers, all of which may be potential customers. Social Media Today advises that you should go beyond just content alone; instead make sure you tailor your posts for each platform. For example, Twitter might be used for news and quick updates, whilst Facebook or Instagram could be used to share interesting book recommendations. This will give people much more of a reason to follow you.

Increase visibility and awareness : Facebook is the standard platform for businesses, given its generous monthly user base of more than 2.7 billion people. However, it's smart to vary your social media presence. Instagram has become the modern search engine for the digital era, and its emphasis on visuals and aesthetics makes it a great avenue for libraries to promote their services. You can showcase books with photographs, offer glimpses of your space, as well as narrate visitors' stories. Moreover, you can give virtual tours and provide tutorials on how to borrow literature—the opportunities are endless! [9]

Engage tech-savvy audiences : Thanks to social

media, it's easy to connect with people from around the world and introduce them to the modern library. With digital services such as loaning digital media and access to online databases, libraries have come a long way in meeting the needs of patrons. To be viewed as a credible provider of these services, one must demonstrate proficiency with social media. [9]

Librarians' primary goal is to make library resources accessible to patrons, so if social networking sites can help accomplish this goal, they should be actively pursued. In order to attract and serve Distance Education students, a library's social networking site wall linked to its website can reap great results. Through social networking sites, any person can communicate and deliver a message to a distant target. [10]

Conclusions

Day after day, access to Internet and computers is on the rise. In this modern age, nobody pays any heed to printed material; thus, librarians must develop innovative ways of making libraries interesting for patrons, such as incorporating social networking sites. This will also help establish good relations between librarians and users alike, advertise library services, announce various programs/events and more. Digital libraries coupled with Internet allow for people to obtain resources without physically visiting the library. Library staff should consequently consider alternative options of how to fulfill users' needs; now that social media's popularity has skyrocketed, it would be wise not to leave this avenue untapped. Utilizing social media makes possible for users to participate in creating library products/services. Library authorities can disseminate library news, materials etc via said portals on their website or wall and keep their patrons informed no matter where they are located. Nowadays many libraries in India and overseas facilitate such usage through their website.

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Genetic Variability Assessment using Metroglyph Analysis among Rice Genotypes

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Abstract

A study was carried out executed at the research farm, of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar during the Kharif season of 2019. Ten parameters viz., panicle length days to 50% flowering, plant height, area under disease progress curve (AUDPC), days to maturity, number of panicles per plant, test weight, filled grains per panicle, number of tillers per plant, grain yield per plant. 14 genotypes were subjected to metroglyph analysis. Among all the studied cultivars, significant genetic variability was recorded for different agro-morphological characters.

Introduction

Rice (*Oryza sativa* L.) is an annual monocotyledonous cereal grass encompassed within the genus *oryza* and the family *Gramineae*. The genus *Oryza* comprises of the twenty wild species and 2 cultivated species i.e., *oryza sativa* (cultivated around the world) and *oryza glaberrima* (mainly cultivated in Africa). Around the world, rice fill in as the staple nourishment for more than 2.5 billion individuals and it likewise fills in as day to day calorie intake upto 50 to 80%. The demand for rice will grow by 2.5% per year in the upcoming decades. Over centuries rice production has been largely dependent on the irrigated lowland rice system, but in present day scenario sustainability of rice production in the lowland areas is under menace by water shortage, water contamination and competition for water use. Hence due to impeding water crisis and water exhaustive nature of the rice farming drives the need to search an alternative approach that increases the water productivity of rice. Thus, one such forthcoming approach of rice cultivation is aerobic rice cultivation which reduces the water demand in rice production and increases the water use efficiency. In general, aerobic rice cultivation is affected by similar pest and diseases as transplanted rice; however, certain diseases like blast, brown spot, seedling blight and foot rot show higher levels of outbreak under aerobic condition.

Among them, brown spot of rice whose causal organism is *Bipolaris oryzae* (teleomorph = *Cochliobolus miyabeanus*) is considered as the deadliest disease of rice which is known to have worldwide occurrence. The variation and diversity in pathogen population often make host plant resistance short lived and unstable due to the advent of novel or more contagious races of the pathogens. Therefore, there is endless need for screening and identification of effective and broad-spectrum brown spot resistance genes in diverse germplasm for deployment in high yielding varieties to achieve the sustainable production of rice. So to study genetic

diversity and to select suitable selection criterion Metroglyph analysis method was used in this study.

Materials and Methods

The present investigation was executed at the research farm, of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar during the Kharif season of 2019. Ten parameters viz., panicle length days to 50% flowering, plant height, area under disease progress curve (AUDPC), days to maturity, number of panicles per plant, test weight, filled grains per panicle, number of tillers per plant, grain yield per plant. For the estimation of AUDPC, an epiphytotic condition for the brown spot was created by artificial inoculation by using the inoculum collected from Department of Plant Pathology, RPCAU, Pusa, Bihar after 65 days after sowing by using an aerosol sprayer. The disease intensity % was estimated by carrying out the field scoring for three times during the entire cropping period, i.e. 20th October, 5th November, 20th November. Screening for brown spot resistance consists of visual scoring of affected plants following disease rating scale of Standard Evaluation System of Rice published by IRRI (2013). During scoring the tagged plants inside each plot was visually assessed for percent foliar affected area at fifteen days span. Disease intensity % (PDI) was calculated using the following formula :

$$\text{Disease intensity \%} = \frac{\text{Sum of all numerical ratings}}{\text{Number of plants observed}} \times \frac{100}{\text{Maximum rating}}$$

The percent disease intensity (PDI) was estimated by carrying out the field scoring for three times during the entire cropping period, i.e. 20th October 2019, 5th November 2019, 20th November 2019. Then the integration of PDI readings (disease severity) recorded from the rice variety estimated the values of AUDPC. AUDPC also summarizes the level of disease intensity along a period which is computed using the following formula as given by "Campbell and Madden (1990)".

Table-1 : Mean performance of 14 Rice genotypes for 10 characters.

S. No.	Genotype name	DFF	DM	PH	PL	NTP	NPP	FGP	TW	GYPP	AUDPC
1.	Sebati	92	116	70.4	15.6	8.66	6.3	51.66	29.36	36.51	410.79
2.	Udyagiri	79	101	100	21	8.66	7	67.66	26	36.52	451.26
3.	Khira	93	116	100.2	16.2	18.66	8	68	37.52	35.42	455.42
4.	Sahabhagi dhan	76	113	114.4	23.4	9.66	6.33	55.33	28	36.12	468.51
5.	Satabdi	93	116	84.8	17.6	7	6	58.66	24.52	38.34	360.81
6.	BUD110	88	114	103.4	20.8	14.66	8.33	64.33	24	36.21	437.41
7.	PS-4	80	109	102.8	22.2	8.33	6	52.33	25.16	38.56	391.56
8.	CO-49	78	101	89.4	18.8	11	6	58.66	23.6	36.15	454.85
9.	CSR35	92	126	101.6	23.8	9	7.33	67	29.24	36.52	401.04
10.	Pant sughandh dhan21	93	123	123.6	24.4	7	5.66	65.33	16	36.35	401.5
11.	Karanti	87	116	93.2	20.6	8	7.33	65.33	35.12	36.98	468.88
12.	Haryana Basmati	96	126	104.2	22.2	9.66	5.66	94	14.68	38.71	383.04
13.	SKL6	70	103	85.4	20	8	5.33	57.33	20.52	38.56	340.42
14.	Kutchigisim	98	122	150.2	26.4	12.33	6.66	58.33	31.36	36.51	481.2
	Min	70.00	101.00	70.40	15.60	7.00	5.33	51.66	14.68	35.42	340.42
	Max	98.00	126.00	150.20	26.40	18.66	8.33	94.00	37.52	38.71	481.20
	Range	28.00	25.00	79.80	10.80	11.66	3.00	42.34	22.84	3.29	140.78
	Range/3	9.33	8.33	26.60	3.60	3.89	1.00	14.11	7.61	1.10	46.93
	Min+(Range/3)	79.33	109.33	97.00	19.20	10.89	6.33	65.77	22.29	36.52	387.35
	Min+(Range*2/3)	88.67	117.67	123.60	22.80	14.77	7.33	79.89	29.91	37.61	434.27

$$AUDPAC = \frac{1}{n} \sum_{i=1}^n (Y_i - Y_i) 0.5 (T_i - T_i)$$

Where,

Y_i = PDI on i^{th} date

T_i = date of scoring of the disease

n = numbers of dates on which disease was scored.

Metroglyph and Index score method proposed by Anderson (1957) were used for analysis of various traits. X and Y co-ordinates of octagon glyph represents no. of tillers per plant (NTP) and Test weight (TW) respectively (Table 4). Rest of the traits were represented by rays in different position on octagon and octagon in turn represents genotypes whereas variable ray length represents the range of the character i.e., A genotype having low range by short, medium range by medium and high range by long ray length (3). Index score was calculated by summation of values (1,2 and 3) given to short, medium and long ray length respectively (Table 3).

Results and Discussion

Mean performance of 14 Rice genotypes for 10 characters presented in Table-1. Ranges of low, medium and high levels for different traits were calculated (Table-2). Index score and signs used for various characters are given in Table-3. Total 6 groups have been constructed using 10 characters in scatter diagram (Table-4).

Group I represented by low no. of tillers per plant and Test weight, included 3 genotypes two of them genotype 10 and 12 scored high for days to 50% flowering, days to

maturity, panicle length whereas genotype 13 scored medium for panicle length and high for grain yield per plant and for rest of the traits were scored low. For plant height the genotype 10 scored high and for rest of traits scored low while genotype 12 scored medium for plant height and high for filled grain per panicle and grain yield per panicle and low for no. of panicle per plant and AUDPC. Group II represented by low no. of tillers per plant and medium Test weight, comprises of maximum genotypes, three genotypes i.e., 1,5,9 scored high for days to 50 % flowering and genotype 2 and 4 scored low whereas medium score in genotype 7. Three genotypes i.e., 1,4,5 scored medium for days to maturity and genotype 2 and 7 scored low whereas high score in genotype 9. For plant height genotype 1 and 5 score low, 2 and 4 score medium, and 7 and 9 score high. For panicle length 1,5 genotype score low,4,7,9 genotype score high and genotype 2 score medium. For no. of panicle per plant genotype 1,4,5,7 score low and genotype 2,9 score medium. For filled grain per panicle genotype 1,4,5,7 score low and genotype 2,9 score medium. For grain yield per plant genotype 1,2,4,9 score low and genotype 5,7 score high. For AUDPC genotype 5,7,9 score low, 1 score medium, and 2,4 score high. Group III represented by low no. of tillers per plant and high Test weight comprises only one genotypes which shows medium score for maximum trait and high score for AUDPC and low score for plant height and filled grain per panicle. Group V represented by medium no. of tillers per plant and Test weight, comprises of two genotypes 6 and 8. Genotype 6 shows medium score days to 50%

Table-2 : Categorisation of genotypes into low, medium and high range of each character with their symbols and sign.

Categories		DFF	DM	PH	PL	NTP	NPP	FGP	TW	GYPP	AUDPC	Ray Length
Low	Range	70-79.33	101-109.33	70.4-97.00	15.6-19.20	7-10.89	5.33-6.33	51.66-65.77	14.68-22.29	35.42-36.52	340.42-387.35	—
	Genotypes	2,4,8,13	2,8,7,13	1,5,8,11,13	1,3,5,8	1,2,4,5,7,9,10,11,12,13	1,4,5,7,8,10,12,13	1,4,5,6,7,8,10,11	10,12,13	1,2,3,4,6,8,9,10,14	5,12,13	
Medium	Range	79.33-88.66	109.33-117.66	97-123.6	19.20-22.8	10.89-14.77	6.33-7.33	65.77-79.88	22.29-29.90	36.52-37.61	387.35-434.27	—
	Genotypes	6,7,11	1,3,4,5,6,7,11	2,3,4,6,7,9,12	2,6,11,13	6,8,14	2,9,11,14	2,3,9	1,2,4,5,6,7,8,9	11	1,6,7,9,10	
High	Range	88.66-98	117.66-126	123.6-150.20	22.8-26.4	14.77-18.66	7.33-8.33	79.88-93.99	29.90-37.51	37.61-38.71	434.27-481.20	—
	Genotypes	1,3,5,10,11,12	9,10,12,14	10	4,7,9,10,12	3	3,6	12	11,14	5,7,12,13	2,3,4,8,11,14	
Ray Position												

Table-3 : Index scores of all the genotypes with characters under study.

Genotypes	DFF	DM	PH	PL	NTP	NPP	FGP	TW	GYPP	AUDPC	Sum of scores
1. Sebati	3	2	1	1	1	1	1	2	1	2	15
2. Udyagiri	1	1	2	2	1	2	2	2	1	3	17
3. Khira	3	2	2	1	3	3	2	2	1	3	22
4. Sahabhagi dhan	1	2	2	3	1	1	1	2	1	3	17
5. Satabdi	3	2	1	1	1	1	1	2	3	1	16
6. BUD110	2	2	2	2	2	3	1	2	1	1	18
7. PS-4	2	1	2	3	1	1	1	2	3	1	17
8. CO-49	1	1	1	1	2	1	1	2	1	3	14
9. CSR35	3	3	2	3	1	2	2	2	1	1	20
10. Pant sughandh dhan21	3	3	3	3	1	1	1	1	1	1	18
11. Karanti	2	2	1	2	1	2	1	3	2	3	19
12. Haryana Basmati	3	3	2	3	1	1	3	1	3	1	21
13. SKL6	1	1	1	2	1	1	1	1	3	1	13
14. Kutchigisim	3	3	3	3	2	2	1	3	1	3	24

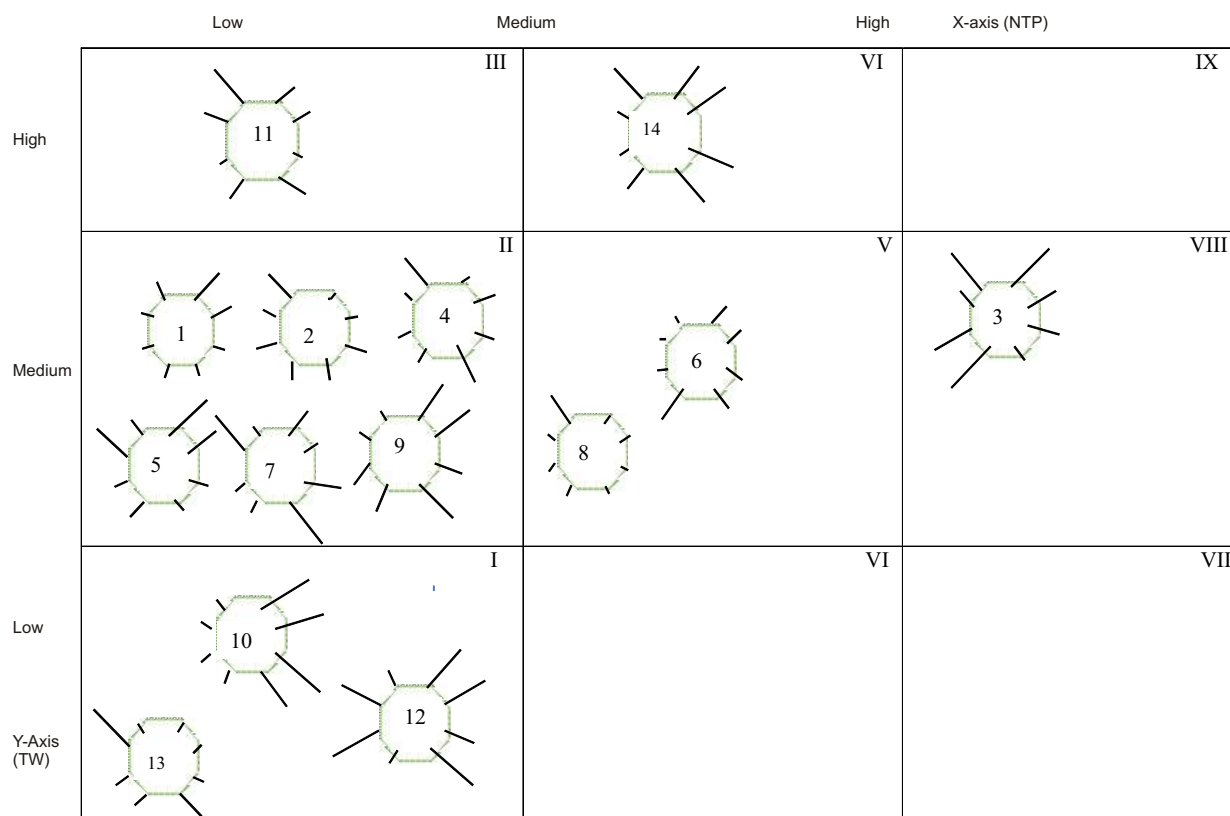
flowering, days to maturity, plant height, panicle length, low score for filled grain per panicle, grain yield per plant, AUDPC and high value for no. of panicle per plant while genotype 8 represent high value for AUDPC and low value for rest of the traits. Group VI represented by medium score for no. of tillers per plant and high Test weight comprises only 14th genotypes which shows low score for filled grain per panicle, grain yield per plant and medium score for number of panicle per plant and low score for remaining traits. Group VIII represented by high score for no. of tillers per plant and medium Test weight comprises only 3th genotypes which shows low score for panicle length, grain yield per plant and medium score for days to maturity, plant height and filled grain per panicle

and high score for days to 50% flowering, no. of panicle per plant, AUDPC.

Similar study was conducted to assess genetic diversity by Gomathinayagan *et al.* (1981), Kotaiah *et al.* (1986), Ibrahim *et al.* (1990), Regina *et al.* (1992), Cheema *et al.* (2004) in rice, Rashid *et al.* (2007) in basmati rice mutants, Sravani *et al.* (2022).

The present study of rice genotypes reflected lots of variability among these genotype for characters under study. This variability can be utilised in various breeding programme for crop improvement. On the basis of scatter diagram and index score, genotype Kutchigisim and Khira were found superior for among all the genotype under study.

Table-4 : Scatter diagram of glyph-array arrangement using 14 Rice genotypes.



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Study on Yield, Quality and Profitability of Maize (*Zea mays* L.) as Influenced by Foliar Application of Nanofertilizers

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Abstract

A field experiment was conducted during *kharif* 2020 at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan), to study the effect of foliar application of nanofertilizers on yield, quality and profitability of Maize (*Zea mays* L.) crop under Typic Haplustepts soil of sub-humid southern plain of Rajasthan. The present investigation was carried out in randomized block design having 12 treatments which were replicated three times. The twelve treatments are T₁ (100% PK (Control)), T₂ (100% PKZn), T₃ (100% NPK), T₄ (100% PKZn + two sprays of nano N), T₅ (100% PKZn + two sprays of nano N (2X)), T₆ (100% NPK + two sprays of nano Zn), T₇ (100% PK + two sprays of nano N + nano Zn), T₈ (100% RDF (NPKZn)), T₉ (100% PKZn + 50% N + two sprays of nano N), T₁₀ (100% NPK + 50% Zn + two sprays of nano Zn), T₁₁ (100% PK + 50% NZn + two sprays of nano N + nano Zn) and T₁₂ (100% PK + 50% NZn + two sprays of nano N + nano Zn + nano Cu). Results revealed that the foliar application of 100% PK + 50% NZn + two sprays of nano N + nano Zn + nano Cu (T₁₂) significantly increased the biological yield, seed protein content, seed protein yield, net return and BC ratio of maize over control. However, the application of 100% PK + 50% NZn + two sprays of nano N + nano Zn + nano Cu was found statistically at par with 100% PK + 50% NZn + two sprays of nano N + nano Zn in same observations. Thus, foliar application of 100% PK + 50% NZn + two sprays of nano N + nano Zn can be recommended to enhance yield, quality and profitability of maize under Typic Haplustepts soil.

Introduction

Nanotechnology is an innovative approach for revolutionize the agriculture sector with aiming 'sustainable intensification' which focuses on increasing food production while maintaining the economic and environmental equity (Sekhon, 2014). Nanotechnology provides scientific principles and practices to design a materials and structures at nanoscale level generally less than 100 nm size which is known as nanomaterials. Nanomaterials differ from conventional materials having specific composition with unique property like small size, high surface area, high reactivity and catalytic activity (Verma and Kapoor, 2020). A smart delivery system of nanofertilizer is seen because of its multidisciplinary character like remotely coordinated, a specific and targeted approach and release nutrient slowly or in controlled way which helps to dodge the biological barriers (Nair *et al.*, 2010). Nanofertilizers require in small quantity have higher use efficiency than conventional fertilizers. In this context nanofertilizers are better substitute to conventional fertilizers as they are eco-friendly, cost effective, maintain soil fertility and plant health, enrich the nutritional value of food and reduce environmental hazards. We require nanofertilizer to improve crop management in order to meet the rising population's food demand while maintaining sustainability.

The green revolution neglects the other major crop excluding Wheat, Rice, Jawar which led to the inter-crop

disparity and due to excessive use of chemical and pesticides the problem of soil degradation and disjunction in biodiversity is observed. So today's scenario demands crop diversification and maize is promising option for diversifying agriculture. Maize is world's leading cereal crop having versatile nature because of its great adaptability to wider range of agro climatic conditions ranging from tropical to subtropical and temperate climate.

Nitrogen fertilizer have great significance to enhance the maize production as nitrogen is a key component in plant metabolism and essential constituent of protein, nucleic acids, ATP, NADH, NADPH, enzymes as well as of cytochrome and chlorophyll (Demari *et al.*, 2016). Zinc is important metal component of nearly 200 enzymes and most important are carbonic anhydrase, alcoholic dehydrogenase and Zn-Cu-super oxide dismutase. Zinc plays a fundamental role in photosynthesis, protein and carbohydrate synthesis and regulate auxin synthesis (Hafeez *et al.*, 2013). Copper act as transitional element which actively participate in physiological redox process. It is necessary element for many proteins like plastocyanin, Cu-Zn-SOD, cytochrome c oxidase, diamine oxidase and polyphenol oxidase which involved in the electron transfer system in photosynthesis, detoxification of superoxide radical in process of photosynthesis, respiration, lignification process, respectively (Yruela, 2009).

Table-1 : Effect of foliar application of nanofertilizers on yield, quality and economics of maize.

	Treatments	Biological Yield (kg ha ⁻¹)	Seed Protein Content (%)	Seed Protein Yield (kg ha ⁻¹)	Net return (₹ ha ⁻¹)	BC ratio
T ₁	100% PK (Control)	8503.74	9.00	27163.67	55868.24	2.90
T ₂	100% PKZn	8540.78	9.06	29448.93	56678.08	3.13
T ₃	100% NPK	9172.08	9.44	28327.05	62222.28	3.33
T ₄	100% PKZn + two sprays of nano N	10046.67	9.81	34882.42	67332.34	3.34
T ₅	100% PKZn + two sprays of nano N (2X)	10100.34	9.94	35493.50	68057.07	3.38
T ₆	100% NPK + two sprays of nano Zn	10841.88	10.37	40425.20	76022.36	3.67
T ₇	100% PK+ two sprays of nano N + nano Zn	10227.77	10.00	36437.69	70635.18	3.56
T ₈	100% RDF (NPKZn)	9858.02	9.68	33829.71	67091.17	3.12
T ₉	100% PKZn + 50% N + two sprays of nano N	10872.25	10.50	41054.41	77287.07	4.02
T ₁₀	100% NPK + 50% Zn + two sprays of nano Zn	11620.90	10.81	45229.97	83883.81	4.27
T ₁₁	100% PK + 50% NZn + two sprays of nano N + nano Zn	12456.47	11.32	50653.03	89849.55	4.28
T ₁₂	100% PK +50% N Zn + two sprays of nano N + nano Zn + nano Cu	12477.01	11.50	51569.88	90221.11	4.41
	SEm±	130.31	0.128	719.913	2689.184	0.13
	CD(P= 0.05)	382.18	0.375	2111.433	7887.107	0.39

Materials and Methods

Experimental site and soil : The field experiment was conducted during *kharif* 2020 at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur (Rajasthan) located at 24° 35' north latitude, 72° 42' east longitude, and 579.5 meters above mean sea level. The area is part of Rajasthan's agro-climatic zone IVa (Sub-Humid Southern Plain and Aravalli Hills). The soil of experimental area was clay loam (38.82%, silt 26.58% and clay 34.60 %) in texture, saline in reaction (8.40), normal in electrical conductivity (0.81 dSm⁻¹), medium in soil organic carbon (0.55%), low in soil available nitrogen (260.20 kg ha⁻¹), phosphorus 16.09 kg ha⁻¹, high in potassium (350.47 kg ha⁻¹), high in zinc (1.99 mg kg⁻¹) and copper (1.58 mg kg⁻¹).

Experimental Design and Treatments : The experiment was laid out in a randomized block design and replicate three times in plot size of 5 x 4.2 m (21m²). The seed of PM 9 (Pratap Makka 9) maize variety was used for this experiment. The twelve treatments viz, T₁ (100% PK (Control), T₂ (100% PKZn), T₃ (100% NPK), T₄ (100% PKZn + two sprays of nano N), T₅ (100% PKZn + two sprays of nano N (2X or double dose), T₆ (100% NPK + two sprays of nano Zn), T₇ (100% PK + two sprays of nano N + nano Zn), T₈ (100% RDF (NPKZn), T₉ (100% PKZn + 50% N + two sprays of nano N), T₁₀ (100% NPK + 50% Zn + two sprays of nano Zn), T₁₁ (100% PK + 50% NZn + two sprays of nano N + nano Zn) and T₁₂ (100% PK + 50% N Zn + two sprays of nano N + nano Zn + nano Cu). The recommended dose of nitrogen (90 kg ha⁻¹) was applied in two equal splits, the half as basal and the remaining half

was top dressed at the time of first irrigation. The basal dose was applied through urea after adjusting the quantity supplied through diammonium phosphate. The whole quantity of phosphorus (40 kg ha⁻¹), potassium (30 kg K₂O) and zinc (25 kg ZnSO₄ ha⁻¹) was basally applied through diammonium phosphate, muriate of potash and zinc sulphate heptahydrate, respectively.

Application of Nanofertilizers : The foliar application of nanofertilizer was given twice 1st at 21 days after sowing and 2nd at 42 days after sowing as per treatments with the help of a knapsack sprayer with flat fan nozzle. Foliar spray of nano N was applied @ 4 ml l⁻¹ water while a double dose of nitrogen @ 8 ml l⁻¹ water was applied in T₅. Nano Zn @ 2 ml l⁻¹ water was given in all zinc treatments except T₁₀, T₁₁ and T₁₂ in which nano zinc applied @ 1.25 ml l⁻¹ water. Nano Cu was given @2 ml l⁻¹ water as per the scheduled treatments.

Seed Protein content : Protein content in seed was obtained by multiplying the per cent nitrogen (N) content by 6.25 (A.O.A.C., 1960).

$$\text{Protein content (\%)} = \text{N content (\%)} \times 6.25$$

Seed Protein yield : The seed protein yield was estimated by multiply seed protein content with seed yield.

Benefit cost ratio : This ratio was calculated by dividing net return with cost of cultivation for each treatment to see the economic viability of treatment. Benefit-cost ratio was calculated by using following formula :

$$\text{BC ratio} = \frac{\text{Net return (Rs. ha}^{-1}\text{)}}{\text{Total cost (cost of cultivation + cost of treatment) (Rs. ha}^{-1}\text{)}}$$

Statistical Analysis : The obtained data were statistically analyzed with the techniques of analysis of variance as described by Steel and Torrie (1960). The comparison in the treatment mean was tested by critical difference (CD) at 5% ($P=0.05$) level of significance.

Results and Discussion

Yield : The foliar application of nanofertilizers (N, Zn and Cu) resulted in significantly higher biological yield of maize over control (Table-1). The foliar application of nanofertilizers, separately (nano N, nano Zn and nano Cu) and combinedly (nano N + nano Zn, nano N + nano Zn + nano Cu) significantly enhanced the biological yield of maize over control. The highest biological yield ($12477.01 \text{ kg ha}^{-1}$) was recorded with the application of 100% PK + 50% NZn + two sprays of nano N + nano Zn + nano Cu (T_{12}) followed by 100% PK + 50% NZn + two sprays of nano N + nano Zn (T_{11}), 100% NPK + 50% Zn + two sprays of nano Zn (T_{10}), 100% PKZn + 50% N + two sprays of nano N (T_9) and 100% NPK + two sprays of nano Zn (T_6). The lowest biological yield ($8503.74 \text{ kg ha}^{-1}$) was recorded under control (T_1). However, T_{12} and T_{11} were found statistically at par with each other but superior to other treatments in biological yield. The application of 100% PK + 50% NZn + two sprays of nano N + nano Zn + nano Cu (T_{12}) and 100% PK + 50% NZn + two sprays of nano N + nano Zn (T_{11}) enhance the biological yield upto 46.72 % and 46.49 % over control, respectively. The foliar application of nano nutrients allow easy penetration of nutrients through leaves mainly by cuticles and stomata pathway and finally transport to the conducting system which may helps in quick and easy absorption of nutrients by leaves as they 100 % soluble (Fernández and Eichert, 2009). Thus higher absorption of nutrients may promote better vegetative and reproductive growth, resulting in higher biological yield of maize. The great potentialities of nano fertilizers may ensure the high availability of nutrients to plants in controlled way during the whole crop growth period which may stimulate the various metabolic process, resulting in more shoot and root biomass production, high photosynthetic activity, and more translocation of assimilate products in grain and stover which could ultimately contribute to biological yield (Elshayb *et al.*, 2021). Nano size having high surface area to volume ratio which facilitates faster absorption of nutrients and reduces leaching losses thus increases the nutrient use efficiency. Higher nutrient efficiency of N, Zn and Cu could be the associated with the higher biological yield of maize. The application of nano fertilizers (N, Zn and Cu) improved chemical, soil microbial population and enzymatic properties of soil which may help plants to improve yield of maize crop (Khardia *et al.*, 2022). The foliar application of nano nitrogen may show prominent

effect by increasing the leaf, leaf area, more utilisation of solar radiation in photosynthesis which tends to enhance vegetative growth and thus improve the biomass and biological yield. These results were supported by Samui *et al.* (2022) who revealed that application of 100% RDN + foliar spray of nano-urea @ 4 ml L^{-1} , twice at knee stage and tasseling stage increasing the biological yield of *rabi* maize over control. Another reason might be zinc's function in carbonic anhydrase activity which increases chlorophyll synthesis and photosynthetic activity of the plants. These results were consistent with previous reports that the soil application of ZnSO_4 @ 24 Kg ha^{-1} + foliar application of ZnO NP @ 60 ppm increased the grain and stover yield over control (Elshayb *et al.*, 2021). The present study also observed the higher biological yield with nano copper which could be due its crucial function in photosynthesis systems, which highly correlate with plant biomass and yield (Van Nguyen *et al.*, 2021). However, there was no significant effect of nano copper on biological yield compared to combine application of nano nitrogen and zinc as in T_{11} . These result were consistent with earlier studies in mustard (Sharma *et al.*, 2022), wheat (Meena *et al.*, 2021) and in maize (Tondey *et al.*, 2022).

Quality : The seed protein content and seed protein yield of maize were significantly increased with foliar application of nanofertilizers (N, Zn and Cu) over control (Table-1). The maximum seed protein content (11.50%) and seed protein yield ($51569.88 \text{ kg ha}^{-1}$) were recorded with application of application of 100% PK + 50% NZn + two sprays of nano N + nano Zn + nano Cu (T_{12}) followed by 100% PK + 50% NZn + two sprays of nano N + nano Zn (T_{11}), 100% NPK + 50% Zn + two sprays of nano Zn (T_{10}), 100% PKZn + 50% N + two sprays of nano N (T_9) and 100% NPK + two sprays of nano Zn (T_6). The minimum seed protein content (9%) and seed protein yield ($27163.67 \text{ kg ha}^{-1}$) was recorded under control. The increased in seed protein content and seed protein yield were in order of 27.77% and 25.77 %, 89.84 % and 86.47 % with application of 100% PK + 50% NZn + two sprays of nano N + nano Zn + nano Cu (T_{12}) and 100% PK + 50% NZn + two sprays of nano N + nano Zn (T_{11}) over control, respectively. The seed protein content and protein yield increased with foliar application of nanofertilizers (N, Zn and Cu) might be associated with the increased availability of nitrogen, zinc and copper throughout the cropping period resulting in increased nitrogen, zinc and copper content in plant. Nitrogen and zinc is one of the main constituents required for amino acids, nucleic acids and proteins synthesis, therefore increased nitrogen and zinc absorption may associate with increase in the seed protein content and protein yield (Al-Juthery *et al.*, 2019). N involved in several enzyme like nitrate reductase, nitrite reductase, glutamine synthase, GOGAT, glutamate

dehydrogenase, responsible for nitrogen metabolism (Kishorekumar *et al.*, 2020). The positive impact of zinc and copper on these seed quality traits may be due to the versatile role as cofactor of the enzymes related to starch synthesis and crystallization (Castillo-Gonzalez *et al.*, 2018). Another reason for the improvement in protein may be due to enhanced cation-exchange ability of the root tissue, which in turn increased the absorption of essential nutrients, especially nitrogen that is responsible for the higher protein content. Results are supported by the studies on the nanozeourea and showed that crude proteins recorded in nanozeo urea treated maize plants in black and red soils were 26.1% and 36.1%, higher than urea fertilized treatments. Another study was conducted by Tondey *et al.* (2022) on nano ZnO NPs and revealed that seed coating and priming with nano ZnO NPs was effective in increasing protein content over ZnSO₄. The soluble protein content in roots of *Brassica pekinensis* increased with application of 10 and 100 mg L⁻¹ nCuO treatments over control (Wang *et al.*, 2020).

Economics : The significantly higher net return and BC ratio as shown in Table-1 was recorded with application of nano fertilizers (N, Zn and Cu) over control. The maximum net return (90221.11 ? ha⁻¹) and BC ratio (4.41) was found under T₁₂ (100% PK + 50% NZn + two sprays of nano N + nano Zn + nano Cu) which were at par with T₁₁ (100% PK + 50% NZn + two sprays of nano N + nano Zn). It is clear from the data that application of nano fertilizers significantly enhanced the biological yield which ultimately resulted in more net return and BC ratio. This result was in agreement with Kumar *et al.* (2020).

Conclusions

From the foregoing results, it is concluded that the foliar application of 100% PK + 50% NZn through urea and zinc sulphate heptadrydate + two sprays of nano N@2 ml l⁻¹ + nano Zn@1.25 ml l⁻¹ significantly increased the biological yield, seed protein content, seed protein yield, net return and BC ratio of maize over control and can be recommended in Typic Haplusteps soil of Sub-Humid Southern Plain and Aravalli Hills Region of Rajasthan.

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Effect of Integrated Nutrient Management on Growth Parameters of Papaya (*Carica papaya* L.)

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Abstract

The experiment was carried out on papaya cv. GJP 1 during the year 2019-20 and 2020-21 at College of Horticulture, SDAU, Jagudan and laid out in randomized block design with three replications. Total ten treatments viz., RDF through chemical fertilizers (T₁), 50% RDN through urea + 50% RDN through Neem cake (NC) (T₂), 50% RDN through urea + 50% RDN through Castor cake (CC) (T₃), 50% RDN through urea + 25% RDN through NC + 25 % RDN through CC (T₄), 40% RDN through urea + 40% RDN through NC + Biofertilizers (BF) (T₅), 40% RDN through urea + 40% RDN through CC +BF (T₆), 40% RDN through urea + 20% RDN through NC + 20% RDN through CC +BF (T₇), 30% RDN through urea + 30% RDN through NC +BF (T₈), 30% RDN through urea + 30% RDN through CC +BF (T₉), 30% RDN through urea + 15% RDN through NC + 15% RDN through CC + BF (T₁₀). FYM @ 10 kg per plant along with *Trichoderma* @ 5 g were applied in all the treatments, while biofertilizers (*Azotobacter*, PSB and KSM) @ 10 ml each per plant were applied as per treatments at the time of planting. Nitrogen through urea was applied in four equal splits (at 60, 120, 180 and 240 days after planting) as per treatments, however, treatments of organic manures were applied in two equal splits (at the time of planting and 60 days after planting). The revealed results indicated that the significant maximum plant height (95.50 cm, 177.79 cm, 200.00 cm, 232.84 cm and 261.62 cm) and stem girth (10.26 cm, 18.90 cm, 30.31 cm, 42.88 cm and 48.70 cm) were recorded at 60, 120, 180, 240 and 300 days after transplanting with the application of 50% RDN through urea + 50% RDN through castor cake along with common dose of FYM @ 10 kg per plant, *Trichoderma* @ 5 g per plant and biofertilizers (*Azotobacter*, PSB and KSM) @ 10 ml each per plant at the time of planting. Therefore, it could be concluded that combined use of organic manures and biofertilizers with chemical fertilizers play an important role in ensuring better growth i.e., plant height and stem girth of papaya.

Key words : FYM, castor cake, neem cake, biofertilizers, urea, plant height, stem girth.

Introduction

Papaya (*Carica papaya* L.) is an evergreen herbaceous commercial fruit crop of tropical and subtropical regions and belongs to the family Caricaceae. In India, the cultivated area of papaya was 138 thousand hectares with 5989 thousand MT production during 2017-18 (Anonymous, 2018). In Gujarat, it was 20.31 thousand acreage with 1256.51 thousand MT production in the year 2017-18.

After green revolution, it becomes a practice in agriculture to get maximum production by using more chemical fertilizers only for few selected plant nutrients that creates imbalance in nutrient supply leading to decline in soil fertility, crop productivity and sustainability. While organic sources contain number of plant nutrients in lesser quantity so its alone are not sufficient to fulfil the requirements of high nutrients demand of crops like papaya because of its simultaneous vegetative growth required for more flowering and fruiting. Organic manures slowly release nutrients into the soil that easily available

to plants throughout the crop growth period and eco-friendly nature. The major drawback of adopting organic agriculture is that it would not be possible to feed billions of people exclusively through organic cultivation. Hence, combined use of chemical fertilizers along with organic manures and biofertilizers play an important role in ensuring better growth which results in better qualitative fruit yield. Moreover, all forms of fertilizers viz., mineral, organic manures and biofertilizers have a great impact on soil fertility and soil properties (Šimon and Madaras, 2020). While organic manures generally increase the pool of soil organic carbon (SOC) and nitrogen (Maillard and Angers, 2014), mineral fertilizers increase carbon inputs indirectly through higher production of crops and post-harvesting residues. On the other hand, the mineral nitrogen fertilizers significantly promote decomposition processes and may cause depletion of the SOC over time. The agricultural approaches depending only on mineral fertilizers, without use of organic manures, often lead to degradation of the soil environment, such as decrease in soil pH, reduction of organic carbon content

or reduced availability of nutrients (Menšík *et al.*, 2018). The soil organic matter (SOM) is crucial for the processes improving soil physical properties, such as maintaining a suitable soil structure, the thermal regime or the water dynamics in the soil. The SOM also significantly affects the biochemical processes, such as nutrient cycling, binding and decomposition of hazardous substances and elements, and biological properties of the soil. The high SOM content increases the nutrient supply and soil buffering capacity. Therefore, the maintenance or increase of the SOM content is particularly important for maintaining the productivity of the agroecosystems and for ensuring food safety in the future.

Therefore, additionally the use of biofertilizers along with organic manures play a significant role in fixing atmospheric nitrogen, production of growth promoting substances and make phosphorus and potassium available to the plants. Several strains of phosphate solubilizing bacteria and fungi as well as potassium solubilizing microorganisms are isolated (Nautiyal *et al.*, 2000; Sane and Mehta, 2015). The mechanism of these microorganisms involves in secretion of organic acids which lower the pH and increase the availability of sparingly soluble phosphorus sources and solubilize the fixed potassium in soil. Biofertilizers have shown positive interaction with organic manures for restoration of soil fertility and maintained the productivity of soil. In this regard, the present study was aimed at assessing the suitable combination of organic, inorganic fertilizers and biofertilizers for papaya cultivation to increase vegetative growth.

Materials and Methods

The experiment was carried out on papaya cv. Gujarat Junagadh Papaya 1 (GJP 1) with spacing 1.5 m x 1.5 m during the year 2019-20 and 2020-21 at College Farm, College of Horticulture, SDAU, Jagudan, Dist.- Mehsana (Gujarat). The experiment was laid out in RBD with three replications. Total ten treatments were evaluated in the present study viz., RDF through chemical fertilizers (T_1), 50% RDN through urea + 50% RDN through Neem cake (NC) (T_2), 50% RDN through urea + 50% RDN through Castor cake (CC) (T_3), 50% RDN through urea + 25% RDN through NC + 25 % RDN through CC (T_4), 40% RDN through urea + 40% RDN through NC + Biofertilizers (BF) (T_5), 40% RDN through urea + 40% RDN through CC + BF (T_6), 40% RDN through urea + 20% RDN through NC + 20% RDN through CC + BF (T_7), 30% RDN through urea + 30% RDN through NC + BF (T_8), 30% RDN through urea + 30% RDN through CC + BF (T_9), 30% RDN through urea + 15% RDN through NC + 15% RDN through CC + BF (T_{10}). The irrigation was applied through drip method using four drippers (4 lph) per plant at interval of three days.

The recommended dose of fertilizers 200:200:250 g N-P₂O₅-K₂O per plant for papaya were used for treatment calculation. Quantity of organic manures were calculated based on nitrogen content (4.28% and 5.23% N in castor cake and neem cake, respectively) in them (Waranke and Barber, 1974) and applied as per treatments at the time of planting. FYM @ 10 kg per plant along with *Trichoderma* @ 5 g were applied in all the treatments, while biofertilizers (*Azotobacter*, PSB and KSM) @ 10 ml each per plant were applied as per treatments at the time of planting. Nitrogen through urea was applied in four equal splits (at 60, 120, 180 and 240 days after planting) as per treatments and recommended dose of phosphorus and potassium were applied at the time of planting in treatment T_1 , however, treatments of organic manures were applied in two equal splits (at the time of planting and 60 days after planting)

The soil samples were collected from different spots of experimental plot from various layers (0-15, 15-30 and 30-60 cm) before planting and as per treatments after harvest of crop. The composite soil samples were air dried in shadow, gently crushed with a wooden roller and passed through a 2.00 mm sieve. The processed soil samples were used for determination of various soil parameters using standard methods of analysis. Experimental field soil was loamy sand in texture, mildly alkaline, non-saline in nature, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium.

Observations on plant height and stem girth were measured at 60, 120, 180, 240 and 300 days after transplanting. The data were recorded for these parameters during investigation and statistically analyzed by a procedure appropriate to the design of experiment as described by Panse and Sukhatme (1985). The significance of difference was tested by "F" test at 5 per cent level.

Results and Discussion

Growth parameters : The height and stem girth of papaya plants were measured at 60, 120, 180, 240 and 300 days after transplanting.

Plant height (cm) : The data presented in Table-1 and 2 showed that the height of plants was significantly influenced by the application of different treatments in both years and pooled analysis. Based on pooled data, maximum plant height (95.50 cm, 177.79 cm, 200.00 cm, 232.84 cm and 261.62 cm) was recorded at 60, 120, 180, 240 and 300 days after transplanting with the application of 50% RDN through urea + 50% RDN through castor cake (T_3) which was found statistically at par with treatments T_2 and T_4 at 60, 120, 180, 240 and 300 DAT in

Table-1 : Effect of integrated nutrient management on plant height of papaya.

Treatment No.	Plant height (cm)					
	60 DAT			120 DAT		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	77.00	75.33	76.17	153.10	144.67	148.88
T ₂	90.33	92.67	91.50	172.19	173.00	172.59
T ₃	92.67	98.33	95.50	175.24	180.33	177.79
T ₄	89.00	86.67	87.83	169.51	173.67	171.59
T ₅	82.00	80.67	81.33	159.97	162.67	161.32
T ₆	78.67	85.33	82.00	155.39	172.67	164.03
T ₇	75.33	84.67	80.00	151.19	169.67	160.43
T ₈	73.67	78.00	75.83	148.52	155.00	151.76
T ₉	67.33	75.33	71.33	140.12	153.00	146.56
T ₁₀	68.67	77.33	73.00	142.79	149.33	146.06
S.Em. +	4.69	3.82	2.88	6.87	7.63	4.93
CD @ 0.05	13.93	11.35	8.21	20.42	22.68	14.04
Y x T	-	-	NS	-	-	NS
SEm±	-	-	4.28	-	-	7.26

Where DAT= Days after transplanting

Table-2 : Effect of integrated nutrient management on plant height of papaya.

Treatments No.	Plant height (cm)								
	180 DAT			240 DAT			300 DAT		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	172.00	168.00	170.00	201.75	190.33	196.04	224.78	217.00	220.89
T ₂	190.67	196.00	193.33	226.08	225.00	225.54	249.40	255.67	252.53
T ₃	194.00	206.00	200.00	231.34	234.33	232.84	255.25	268.00	261.62
T ₄	187.33	200.33	193.83	221.48	222.67	222.07	246.32	260.67	253.49
T ₅	179.67	178.67	179.17	210.96	205.00	207.98	234.32	233.67	233.99
T ₆	174.67	194.67	184.67	205.04	217.33	211.19	228.17	244.67	236.42
T ₇	170.33	183.67	177.00	204.71	214.00	209.36	226.63	243.67	235.15
T ₈	168.67	171.67	170.17	196.49	189.33	192.91	216.78	222.67	219.72
T ₉	160.67	170.00	165.33	190.57	198.33	194.45	209.70	227.67	218.68
T ₁₀	162.00	168.00	165.00	190.90	196.33	193.62	210.32	221.33	215.83
S.Em. +	7.13	9.17	5.44	7.77	9.46	5.74	8.51	11.34	6.62
CD @ 0.05	21.18	27.25	15.50	23.10	28.11	16.36	25.29	33.69	18.84
Y x T	-	-	NS	-	-	NS	-	-	NS
SEm±	-	-	8.21	-	-	8.66	-	-	10.03

Where DAT= Days after transplanting

pooled analysis. Moreover, it was also found at par with treatment T₆ at 120 and 180 DAT.

Stem girth (cm) : The data showed in Table-3 and 4 indicated that the stem girth of papaya plants significantly increased with the application of treatments in both the years and pooled analysis. On the basis of pooled data, maximum stem girth (10.26 cm, 18.90 cm, 30.31 cm, 42.88 cm and 48.70 cm) was recorded at 60, 120, 180, 240 and 300 days after transplanting with the application of 50% RDN through urea + 50% RDN through castor cake (T₃) which it was remained at par with treatments T₄ and T₂ at 180, 240 and 300 DAT and also at par with treatment T₄ at 120 DAT.

The increase in plant height and stem girth might be

due to the fact that proper combination of urea and castor cake provides nutrients in suitable proportion and amount at right time which hastens the plant height and stem girth. The increase in plant height and stem girth may be due to an improvement in soil physical properties, nutrient availability and increase in nutrients uptake, growth of beneficial soil microorganisms and released growth factors such as auxins, cytokinins and gibberellins in the root zone (Godara and Bakshi, 2021). Similarly, Yadav (2006); Shrivastava (2008); Singh and Varu (2013); Singh and Tripathi (2020) reported that use of integrated nutrient management approach showed better results with respect to plant height and stem girth in papaya crops. Lakshmi Devi *et al.* (2020) observed that synergistic effect of both organics and bio-fertilizer (castor cake + T.

Table-3 : Effect of integrated nutrient management on stem girth of papaya.

Treatment No.	Stem girth (cm)					
	60 DAT			120 DAT		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	7.54	7.67	7.60	15.67	15.83	15.75
T ₂	8.96	9.33	9.15	16.98	17.83	17.41
T ₃	9.52	11.00	10.26	17.97	19.83	18.90
T ₄	8.20	9.67	8.93	16.98	18.67	17.83
T ₅	7.90	8.83	8.37	16.33	16.50	16.41
T ₆	7.77	9.33	8.55	15.67	17.67	16.67
T ₇	8.00	9.00	8.50	16.00	16.50	16.25
T ₈	7.20	7.17	7.19	14.69	15.50	15.09
T ₉	7.07	8.17	7.62	15.02	15.67	15.34
T ₁₀	7.30	7.17	7.24	15.02	15.83	15.42
S.Em. +	0.42	0.67	0.38	0.57	0.93	0.51
CD @ 0.05	1.24	1.99	1.09	1.71	2.76	1.46
Y x T	-	-	NS	-	-	NS
SEm±	-	-	0.56	-	-	0.77

Where, DAT= Days after transplanting

Table-4 : Effect of integrated nutrient management on stem girth of papaya.

Treatment No.	Stem girth (cm)								
	180 DAT			240 DAT			300 DAT		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	24.16	26.67	25.42	33.42	37.00	35.21	39.97	42.67	41.32
T ₂	26.53	31.00	28.77	37.23	46.00	41.62	44.98	48.67	46.82
T ₃	27.45	33.17	30.31	37.42	48.33	42.88	45.06	52.33	48.70
T ₄	26.53	32.17	29.35	36.71	45.33	41.02	44.66	50.00	47.33
T ₅	25.09	28.17	26.63	34.36	38.67	36.51	41.67	43.67	42.67
T ₆	24.65	29.50	27.07	33.93	43.33	38.63	41.56	48.00	44.78
T ₇	24.99	26.67	25.83	34.29	39.67	36.98	41.80	44.33	43.07
T ₈	23.56	25.50	24.53	32.78	37.00	34.89	40.00	41.00	40.50
T ₉	23.97	26.17	25.07	33.10	37.33	35.22	40.24	42.17	41.20
T ₁₀	23.80	26.33	25.06	33.17	35.33	34.25	40.52	41.33	40.92
S.Em. +	0.80	1.74	0.92	1.08	2.77	1.49	1.27	2.47	1.34
CD @ 0.05	2.37	5.17	2.63	3.21	8.24	4.24	3.77	7.34	3.82
Y x T	-	-	NS	-	-	NS	-	-	NS
SEm±	-	-	1.35	-	-	2.11	-	-	1.96

Where, DAT= Days after transplanting

harzianum + A.M fungi) has brought significant changes in plant growth parameters of papaya at nursery stage.

Conclusions

From the present study, it could be concluded that combined use of organic manures and with chemical fertilizers play an important role in ensuring better growth which further results in better qualitative fruit yield. Therefore, the application of 50% RDN through urea + 50% RDN through castor cake along with 10 kg FYM and 5 g *Trichoderma* per plant were found significantly maximum for plant height and stem girth at 60, 120, 180, 240 and 300 days after transplanting.

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Bioefficacy of Different Insecticides against Sucking Pests of Okra (*Abelmoschus esculentus* L.)

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Abstract

During the Kharif season 2018-2019 at the Vegetable Research Farm, IAS, BHU, Varanasi, U.P., the research was conducted. Different insecticides were checked against sucking pests of okra (aphids, jassid, and whitefly). Overall performance of different insecticide treatments against sucking pests on okra population based on the mean concluded that treatment with Diafenthiuron 50% WP @ 300 g a. i./ha expressed superior control over all sucking pests under experiment after both the sprays. The efficacy of various treatments leading to increase in the yield over control was in order of Diafenthiuron 50% WP (@ 300 g a. i./ha) > Thiamethoxam 25% WG (@ 25 ga.i./ha) > Dinotefuran 20% SG (@ 30 ga.i./ha) > Profenofos 50 % EC (@ 500 ml a.i./ha) > Thiacloprid 21.7 % SC (@ 30 ml a.i./ha) > Tobacco dust powder (@ 5 kga.i./ha) and Azadirachtin 0.03% EC (@ 2.5 lit/ha). Hence, Diafenthiuron 50% WP @ 300 g a. i./ha was observed to be superior to the rest of the treatments in terms of both decline in population and yield effect.

Key words : Sucking pest (aphid, jassids whitefly), okra, bio-efficacy, insecticides.

Introduction

India is one of the leading vegetable growing countries in the world. India stands second after China in vegetable production. Vegetables play a significant role in the human diet and provide Minerals, Vitamins, and Carbohydrates which other food compounds are deficient. Uttar Pradesh stands 1st in area and production of vegetables, according to current database. It has an area of 1.47 lakh ha and production of about 28.62 lakh tons for vegetables. The area under okra crop is 51 lakh hectares with the production of 6.21 lakh tons (National Horticulture Mission Database, 2018-19). Among the various types of vegetables, okra (Bhindi) *Abelmoschus esculentus* (L.) (Commonly known as lady's finger) is one of the most choicest vegetable and it is the second largest cultivated vegetable in the world. Okra is grown in approximately all part of the world viz. tropical and subtropical part of the world. In India also, it is grown in all part of the country like Andhra Pradesh, Assam, Bihar, Gujrat, Maharashtra, Orissa, Rajasthan, and Uttar Pradesh and West Bengal. Okra alone accounts for 70% of the 30% return earned from exports of vegetables other than onion among cultivated vegetables (Dhankar *et al.*, 2001). Tender pods of okra are used as vegetable in a variety of cooking preparations. The dry roots and stems of okra plant are used for purifying the sugar cane juice when preparing gur (Chauvan, 1972). Mature fruits and stems of okra having crude fiber are used in the paper industry. The greenish yellow edible oil is also extracted from okra seeds. The nutrient quantity of okra seed (*Abelmoschus esculentus*

Moench) has been analyzed during studies. Okra seeds contains at least 21 percent protein, 14 percent lipids, and 5 percent ash. Complete removal of seed hulls through grinding and sifting produced a meal with 33 percent protein, 26 percent lipids, and 6 percent ash (Savello *et al.*, 1980). The oil has a pleasant test and smell and having the amount of unsaturated fatty acids such as oleic acid and linoleic acid. The oil percentage is approximately as high as 40 percent. Okra gives vitamins compound, a calcium compound, potassium compound and other mineral components which are generally lacking in the diet of developing countries like India (IBPGR, 1990). Okra is one of the major economically important vegetable crop which alone has 21 percent of total exchange earnings from export of vegetable crops from India. Insect pests are one of the most significant limitations in okra production. Among them, the sucking pest complex composed of aphid (*Aphis gossypii* Gloner), whitefly (*Bemisia tabaci* Genn) and jassid (*Amrasca biguttula biguttula* Ishida) are significant pests and causes a production drop of 17.46 percent in okra (Sarkar *et al.*, 1996). In the initial stage of the crop aphids, leafhopper and whitefly are significant pests that damage the crops, weaken them and decrease output (Krishnaiah, 1980). The output decline owing to the appearance of leafhopper in okra is 54 to 66 percent (Satpathy *et al.*, 2004). Whitefly is mainly known among the top hundred pests of insects with a pandemic spread and damages many significant crops including vegetable tubers, fiber plants and ornamental. It is also identified as the cause for deadly 'yellow vein mosaic disease' apart from their immediate harm by sucking crop sap.

Management of the pest is very hard due to its fast motion from one crop to another, elevated reproductive capacity and living environment (Fouly *et al.*, 2011). Kulkarni (1924) in Maharashtra reported yellow vein mosaic as a significant disease. It had first emerged in 1950 in Maharashtra in epidemic shape (Capoor and Varma, 1950). Subsequently, the disease's epidemic onset was recorded from various okra-growing nations (Tripathi and Joshi, 1967 and Chelliah the disease occurs in endemic and mostly epidemic type in all of India's okra countries, threatening okra production. If crops become infected within 20 days of germination, their development will be slowed, few leaves and tiny fruits will be founded and the losses will be very large. Damage magnitude decreases with delay in plant disease. The insect that transmits yellow vein mosaic virus fly-borne virus species belong to the genus Aphids and jassids is a significant sucking pest of okra. Using piercing and sucking type of mouth parts, both nymphs and adults suck the crop sap. Aphids secrete the honeydew on the leaves, which in turn causes sooty mold fungus development and decreases the younger leaves, the infestation is seen larger than on the older leaves. For some plant viruses, aphids also work as vectors. Jassids are significant pests that suck the cell sap of the crop, decrease output. It was disclosed that, failure to control them in the initial phases caused a yield loss of 54.04 percent to the actual yield. (Chaudhary and Dadeech, 1989). Number of insecticides assessment for their relative efficacy, specificity, selectivity as well as the value of control operation. Current studies have been carried out with the following: To study the bio-efficacy of different insecticides.

Materials and Methods

The field experiments were taken out at the Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to study the "bioefficacy of different insecticides against sucking pests of okra (*Abelmoschus esculentus* L.)". Varanasi lies between the longitude of 82° 98' 14.2404" E., Latitude of 25° 19' 18.0624" N and at an altitude of 129.93 m. from mean sea level (MSL).

Application of insecticides : With the help of Knapsack sprayer, two foliar sprays of insecticides were given when the insect population reached ETL level. The first application of insecticide was done 35 days after sowing. The untreated control plot were simply sprayed with water. The amount of spray used per hectare was 500 liter. At the start and while changing from one insecticide to another during processing, due care was taken to clean the spray tank with water. During the morning hours, all sprays were performed to prevent drifting from one therapy plot to another owing to strong storms.

Method of recording observations of bio-efficacy of different insecticides against sucking pest of okra :

For recording the population of aphids, jassid and whitefly were three leaves/ plant five plants were randomly selected and tagged in each treatment plot. Three leaves per plant one each from the top, bottom and middle of each plant were tagged and used for counting the pest. The readings were taken one day before each spray and continued till 3, 7 and 10 days after spray. The number of surviving individuals were counted post treatment.

Statistical analysis of bio-efficacy of different insecticides :

The data obtained from sucking pest of okra before and after each spray was subjected to statistical analysis. They were transformed using square root transformation. Differences for different treatments were calculated at 5 % level of significance. By calculating CD at a probability level of 5 percent, the variations between means were confined to further analysis. Data was analyzed by the website "OPSTAT".

Yield data : The yield of marketable okra fruits per plot was recorded at every picking. The treatment wise total yield was calculated by summation of the yield obtained per plot in every picking. The total yield obtained in kg (per /plot) was converted in ton (q/ha.). Additional yield of control plot was also calculated.

The percent improvement in yield over controlled plot in different treatments was calculated by using the following formula :

$$\text{Increase in yield (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

Results and Discussion

Aphids

First insecticidal spray : Three days after first insecticidal spray. On the third day after the first insecticidal spray we took same tagged plants and counted the number of aphids from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (0.867) aphids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha (1.267) aphids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2500 ml a.i./ha (2.933) aphids per 3 leaves/plant followed by control (7.333) aphids from per 3 leaves per plant. (Table-1)

Seven days after first insecticidal spray. During the seven days after the spray of treatment it was observed that the least population of aphids was recorded from the treatment Diafenthiuron 50% WP @ 300 g a.i./ha (1.133) aphids from 3 leaves per plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha (2.133) aphids

from per 3 leaves/plant. The least control over insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2500 ml a.i./ha(3.533) aphids from per 3 leaves/plant followed by control (8.133) aphids from per 3 leaves per plant. (Table-1)

Tendays after first insecticidal spray During the Seven day after the spray of treatment it was observed that the least population of aphids was recorded from the treatment Diafenthion 50% WP @ 300 g a.i./ha(2.867) aphids from per 3 leaves /plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(3.800) aphids from 3 leaves /plant. The least control over insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2500 ml a.i./ha (4.867) aphids from per 3 leaves/plant followed by control plot (8.467) aphids from per 3 leaves/plant. (Table 1). When we did the overall mean of population of aphids after the first insecticidal spray we found that maximum amount of control on aphid population was given by Diafenthion 50% WP @ 300 g a.i./ha(1.622) mean aphid population from per 3 leaves/plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(2.466) mean aphid population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of aphids as such, Diafenthion 50% WP @ 300 g a.i./ha>Thiamethoxam 25% WG @ 25 g a.i./ha>Dinotefuran 20% SG@ 30 g a.i./ha>Profenofos 50 % EC @ 500 ml a.i./ha>Thiacloprid 21.7 % SC@ 30 ml a.i./ha>Tobacco dust powder @ 5 kg a.i./ha>Azadirachtin 0.03% EC @ 2.5 lit/ha.

Second insecticidal spray : Three days after second insecticidal spray On the third day after the second insecticidal spray we took same tagged plants and counted the number of aphids from three different leaves of plant and noted that Diafenthion 50% WP @ 300 g a.i./ha gave maximum reduction in population (0.400) aphids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(0.867) aphids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(2.467) aphids per 3 leaves/plant followed by control (14.733) aphids from per 3 leaves per plant. (Table-1).

Seven days after second insecticidal spray During the seventh day after spraying of different insecticides we observed that the least population of aphids was recorded from the treatment Diafenthion 50% WP @ 300 g a.i./ha(0.600) aphids from per 3 leaves /plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.333) aphids from per 3 leaves/plant, and the least control of insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2.5 lit/ha(3.133) aphids from per 3 leaves/plant followed by control (13.066) aphids from per 3 leaves per plant. (Table-1)

Ten days after second insecticidal spray On 10th day after second insecticidal spray we noted that Diafenthion 50% WP @ 300 g a.i./ha was a consistent performer in controlling aphid population (1.400) aphids from 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(2.400) aphids from per 3 leaves /plant, and the least control with maximum population was that of Azadirachtin 0.03% EC @ 2.5 lit/ha(3.533) aphids from per 3 leaves/plant followed by control plot (11.533) aphids from per 3 leaves/plant. (Table 1) So finally when we did the overall mean of population of aphids after the second insecticidal spray we found that maximum amount of control on aphid population was given by Diafenthion 50% WP @ 300 g a.i./ha(0.800) mean aphid population from per 3 leaves/plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.533) mean aphid population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of aphids as such, Diafenthion 50% WP @ 300 g a.i./ha>Thiamethoxam 25% WG @ 25 g a.i./ha>Dinotefuran 20% SG@ 30 g a.i./ha>Profenofos 50 % EC @ 500 ml a.i./ha>Thiacloprid 21.7 % SC@ 30 ml a.i./ha>Tobacco dust powder @ 5 kg a.i./ha>Azadirachtin 0.03% EC @ 2.5 lit/ha. An overall performance of different insecticide treatments against aphid population based on the mean concluded that treatment with Diafenthion 50% WP @ 300 g a. i./ha was to be the most efficient and considerably superior of all other treatments in decreasing the aphid population to the minimum point. Thiamethoxam 25% WG @ 25 g a.i./ha was the next finest insecticide to decrease the aphid population. Next best was noted Dinotefuran 20% SG@ 30 g a.i./ha followed by Profenofos 50 % EC @ 500 ml a.i./ha, Thiacloprid 21.7 % SC@ 30 ml a.i./ha, Tobacco dust powder @ 5 kg a.i./ha and Azadirachtin 0.03% EC @ 2.5 lit/ha similar studies is found by Sathyanet al.(2016) noted that Diafenthion 50% WP @ 300 g a. i./ha and Thiamethoxam 25% WG @ 25 g a.i./ha was the best to reduce the aphid population. Pawaret al. (2016) also noted similar results like Thiamethoxam 25 WG 25 g a.i./ha was the second best insecticide to reduce the aphid population

Jassid

First insecticidal spray : Three days after first insecticidal spray On the third day after the first insecticidal spray we took same tagged plants and counted the number of jassid from three different leaves of plant and noted that Diafenthion 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.733) jassids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.467) jassids per 3 leaves /plant, and the least control of population was

Table-1 : Efficacy of different insecticidal treatment on the population of aphids after 1st and 2nd spray.

Tr. No.	Insecticide	Doses g a.i/ha	Average number of aphids per three leaves per plant									
			First spray					Second spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Overall mean	1 DBS	3 DAS	7 DAS	10 DAS	Over all mean
T ₁	Azadirachtin 0.03% EC	2500 ml	5.667 (2.58)	2.933 (1.983)	3.533 (2.129)	4.867 (2.42)	3.777	4.867 (2.422)	2.467 (1.862)	3.133 (2.033)	3.533 (2.129)	3.044
T ₂	Thiacloprid 21.7 % SC	30 ml	5.800 (2.601)	1.533 (1.591)	2.467 (1.862)	4.133 (2.266)	2.711	4.133 (2.266)	1.067 (1.437)	1.533 (1.591)	2.933 (1.983)	1.844
T ₃	Profenofos 50 % EC	500 ml	5.800 (2.605)	1.600 (1.612)	2.333 (1.826)	3.867 (2.206)	2.600	3.867 (2.206)	1.133 (1.460)	1.600 (1.612)	2.667 (1.915)	1.800
T ₄	Diafenthiuron 50% WP	300 gm	5.800 (2.601)	0.867 (1.366)	1.133 (1.460)	2.867 (1.966)	1.622	2.867 (1.966)	0.400 (1.183)	0.600 (1.265)	1.400 (1.548)	0.800
T ₅	Thiamethoxam 25% WG	25 gm	6.133 (2.662)	1.467 (1.570)	2.133 (1.770)	3.800 (2.191)	2.466	3.800 (2.191)	0.867 (1.366)	1.133 (1.527)	2.400 (1.844)	1.533
T ₆	Dinotefuran 20% SG	30gm	5.867 (2.608)	1.267 (1.505)	2.200 (1.789)	4.000 (2.236)	2.488	4.000 (2.236)	0.867 (1.366)	1.533 (1.59)	2.800 (1.949)	1.733
T ₇	Tobacco dust powder	5kg	5.933 (2.629)	2.467 (1.862)	2.933 (1.982)	4.267 (2.295)	3.222	4.267 (2.295)	1.600 (1.612)	1.867 (1.693)	3.067 (2.016)	2.178
T ₈	Untreated control		5.867 (2.610)	7.333 (2.886)	8.133 (3.022)	8.467 (3.077)	7.978	8.467 (3.077)	14.733 (3.967)	13.066 (3.751)	11.533 (3.54)	13.111
	SE(m) ±		(0.138)	(0.077)	(0.023)	(0.018)		(0.018)	(0.019)	(0.025)	(0.018)	
	C.D. at 5%		N/A	(0.025)	(0.690)	(0.056)		(0.056)	(0.059)	(0.075)	(0.055)	

Table-2 : Efficacy of different insecticidal treatment on the population of Jassid after 1st and 2nd spray.

Tr. No.	Insecticide	Doses g a.i/ha	Average number of aphids per three leaves per plant									
			First spray					Second spray				
			1 DBS	3DAS	7DAS	10DAS	Overall mean	1DBS	3DAS	7 DAS	10DAS	Over all mean
T ₁	Azadirachtin 0.03% EC	2500 ml	6.067 (2.656)	3.667 (2.160)	4.400 (2.324)	6.200 (2.683)	4.756	6.200 (2.683)	3.733 (2.176)	4.533 (2.352)	6.267 (2.696)	4.844
T ₂	Thiacloprid 21.7% SC	30 ml	6.000 (2.640)	2.467 (1.862)	2.733 (1.932)	4.133 (2.266)	3.111	4.133 (2.266)	1.667 (1.633)	1.867 (1.693)	2.867 (1.966)	2.133
T ₃	Profenofos 50% EC	500 ml	6.267 (2.693)	2.467 (1.807)	2.867 (1.966)	3.200 (2.049)	2.778	3.200 (2.049)	1.267 (1.505)	1.467 (1.57)	1.667 (1.633)	1.467
T ₄	Diafenthiuron 50% WP	300 gm	6.267 (2.695)	1.733 (1.653)	2.067 (1.751)	3.133 (2.033)	2.311	3.133 (2.033)	0.867 (1.366)	1.067 (1.437)	1.533 (1.591)	1.156
T ₅	Thiamethoxam 25% WG	25 gm	5.667 (2.581)	1.467 (1.570)	2.000 (1.732)	3.467 (2.113)	2.311	3.467 (2.113)	0.933 (1.390)	1.267 (1.505)	1.867 (1.693)	1.356
T ₆	Dinotefuran 20% SG	30gm	5.933 (2.630)	1.867 (1.693)	2.267 (1.807)	3.533 (2.128)	2.556	3.533 (2.128)	1.133 (1.460)	1.333 (1.527)	2.133 (1.770)	1.533
T ₇	Tobacco dust powder	5kg	6.000 (2.646)	3.533 (2.129)	4.133 (2.266)	5.733 (2.595)	4.467	5.733 (2.595)	1.533 (1.591)	3.933 (2.221)	5.467 (2.542)	3.644
T ₈	Untreated control		6.333 (2.705)	9.800 (3.286)	13.933 (3.864)	12.133 (3.624)	11.955	12.133 (3.077)	9.733 (3.276)	6.333 (2.708)	6.733 (2.781)	7.600
	SE(m) ±		(0.082)	(0.017)	(0.017)	(0.024)		(0.024)	(0.021)	(0.016)	(0.018)	
	C.D. at 5%		N/A	(0.053)	(0.052)	(0.072)		(0.072)	(0.066)	(0.048)	(0.055)	

given by Azadirachtin 0.03% EC @ 2.5 lit/ha(3.667) jassids per 3 leaves/plant followed by control (9.800) jassids from per 3 leaves per plant. (Table-2).

Seven days after first insecticidal spray During the seventh day after spraying of different insecticides we observed that the least population of jassid was recorded from the treatment Diafenthiuron 50% WP @ 300 g a.i./ha(2.067)jassids from 3 leaves /plant, which was

followed by Thiamethoxam 25% WG @ 25 g a.i./ha(2.000)jassids from per 3 leaves/plant, and the least control of insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2.5 lit/ha(4.400)jassids from per 3 leaves/plant followed by control (13.933)jassids from per 3 leaves per plant. (Table-2).

Ten days after first insecticidal spray On 10th day after first insecticidal spray we noted that Diafenthiuron

Table-3 : Efficacy of different insecticidal treatment on the population of whitefly after 1st and 2nd spray.

Tr. No.	Insecticide	Doses g a.i/ha	Average number of aphids per three leaves per plant									
			First spray					Second spray				
			1 DBS	3DAS	7DAS	10DAS	Overall mean	1DBS	3DAS	7 DAS	10DAS	Over all mean
T ₁	Azadirachtin 0.03% EC	2500 ml	6.133 (2.667)	3.867 (2.206)	4.800 (2.408)	5.467 (2.543)	4.711	5.467 (2.543)	3.467 (2.113)	4.267 (2.294)	4.733 (2.394)	4.156
T ₂	Thiacloprid 21.7 % SC	30 ml	5.933 (2.633)	3.200 (2.049)	3.867 (2.206)	4.867 (2.422)	3.978	4.867 (2.422)	2.600 (1.897)	3.133 (2.033)	3.933 (2.221)	3.222
T ₃	Profenofos 50 % EC	500 ml	6.333 (2.706)	3.200 (2.049)	3.733 (2.176)	4.733 (2.394)	3.888	4.733 (2.394)	2.467 (1.862)	2.733 (1.932)	3.733 (2.176)	2.978
T ₄	Diafenthiuron 50% WP	300 gm	6.467 (2.731)	1.467 (1.57)	2.467 (1.862)	3.133 (2.033)	2.355	3.133 (2.033)	0.733 (1.316)	1.267 (1.505)	1.533 (1.591)	1.178
T ₅	Thiamethoxam 25% WG	25 gm	6.267 (2.688)	3.133 (2.033)	3.667 (2.16)	4.600 (2.366)	3.800	4.600 (2.366)	2.267 (1.807)	1.667 (1.915)	3.333 (2.082)	2.756
T ₆	Dinotefuran 20% SG	30gm	6.200 (2.683)	2.333 (1.826)	3.133 (2.033)	4.067 (2.251)	3.177	4.067 (2.251)	1.533 (1.591)	2.067 (1.751)	2.533 (1.880)	2.044
T ₇	Tobbaco dust powder	5kg	6.533 (2.744)	3.533 (2.129)	4.533 (2.352)	5.400 (2.53)	4.489	5.400 (2.530)	2.867 (1.966)	3.667 (2.160)	4.467 (2.338)	3.677
T ₈	Untreated control		6.000 (2.629)	6.467 (2.732)	6.800 (2.793)	8.667 (3.109)	7.311	8.667 (3.109)	9.933 (3.306)	8.400 (3.751)	8.733 (3.120)	9.022
	SE(m) ±		(0.024)	(0.021)	(0.016)	(0.018)		(0.020)	(0.018)	(0.016)	(0.006)	
	C.D. at 5%		(0.072)	(0.066)	(0.048)	(0.055)		(0.060)	(0.055)	(0.050)	(0.019)	

DBS = Day before spray DAS = Days after spray PROC = Percent reduction over control *Mean of three replication

Table-4 : Percent increase in the okra yield over control.

Insecticide	Doses (a.i./ha)	Yield per plot (kg/ 6 m ²)	Yield obtained (Q/ha)	% Increase in yield over control
Azadirachtin 0.03% EC	200 ml	4.92	82.13	10.28
Thiacloprid 21.7% SC	30 ml	5.90	98.47	32.35
Profenofos 50% EC	500 ml	6.20	103.42	39.00
Diafenthiuron 50% WP	300 gm	7.11	118.54	59.32
Thiamethoxam 25% WG	25 gm	6.67	111.89	50.38
Dinotefuran 20% SG	30 gm	6.66	110.11	47.99
Tobacco dust powder	5 kg	5.31	88.63	19.12
Untreated control	0	4.46	74.40	

50% WP @ 300 g a.i./ha was a consistent performer in controlling jassid population (3.133) jassid from 3 leaves /plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(3.200) jassid from 3 leaves /plant, and the least control with maximum population was that of Azadirachtin 0.03% EC @ 2.5 lit/ha(6.200)jassid from per 3 leaves/plant followed by control plot (12.133) jassid from per 3 leaves/plant (Table 4.5). When we did the overall mean of population of jassid after the first insecticidal spray we found that maximum amount of control on jassid population was given by Diafenthiuron 50% WP @ 300 g a.i./ha(2.311) mean jassid population from per 3 leaves/plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(2.311) mean jassid population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of jassid as such, Diafenthiuron 50% WP @ 300 g a.i./ha >Thiamethoxam 25% WG @ 25 g a.i./ha >Dinotefuran

20% SG@ 30 g a.i./ha >Profenofos 50 % EC @ 500 ml a.i./ha >Thiacloprid21.7 % SC@ 30 ml a.i./ha >Tobacco dust powder@ 5 kg a.i./ha >Azadirachtin 0.03% EC @ 2.5 lit/ha.

Second insecticidal spray : Three days after second insecticidal spray On the third day after the second insecticidal spray we took same tagged plants and counted the number of jassid from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (0.867) jassids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(0.933) jassids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(3.733) jassids per 3 leaves/plant followed by control (9.733) jassid from per 3 leaves per plant. (Table-2).

Seven days after second insecticidal spray On seven day after the second insecticidal spray we took

same tagged plants and counted the number of jassid from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.067) jassids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.267) jassids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(4.533) jassid per 3 leaves/plant followed by control (6.333) jassid from per 3 leaves per plant. (Table-2).

Ten days after second insecticidal spray On Ten day after the second insecticidal spray we took same tagged plants and counted the number of jassid from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.533)jassids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.867) jassids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(6.267) jassid per 3 leaves/plant followed by control (6.733)jassid from per 3 leaves per plant. (Table 2). So finally when we did the overall mean of population of jassid after the second insecticidal spray we found that maximum amount of control on jassid population was given by Diafenthiuron 50% WP @ 300 g a.i./ha(1.156) mean jassid population from per 3 leaves/plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.356) mean jassid population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of jassid as such, Diafenthiuron 50% WP @ 300 g a.i./ha >Thiamethoxam 25% WG @ 25 g a.i./ha >Dinotefuran 20% SG@ 30 g a.i./ha >Profenofos 50 % EC @ 500 ml a.i./ha>Thiacloprid21.7 % SC@ 30 ml a.i./ha>Tobacco dust powder@ 5 kg a.i./ha>Azadirachtin 0.03% EC @ 2.5 lit/ha. The performance of various insecticide treatments against jassid population based on their mean concluded that treatment with Diafenthiuron 50% WP @ 300 g a. i./ha was to be the most efficient and considerably superior of all other treatments in decreasing the jassid population to the minimum point. Thiamethoxam 25% WG @ 25 g a.i./ha was the next finest insecticide to decrease the jassid population. Next best was noted Dinotefuran 20% SG@ 30 g a.i./ha followed by Profenofos 50 % EC @ 500 ml a.i./ha, Thiacloprid21.7 % SC@ 30 ml a.i./ha,Tobacco dust powder @ 5 kg a.i./ha and Azadirachtin 0.03% EC @ 2.5 lit/hasimilar studies is found by Muhammad *et al.* (2014) found that Dinotefuran and Thiamethoxam was best to reduce whitefly population, Sathyan *et al.*(2016) was also noted that Dinotefuran and Thiamethoxam was best for jassid control. Bisthet al. (2017) found thiamethoxam-25 WG (1.00) was documented with highest possible jassid mortality.

Whitefly

First insecticidal spray : Three days after first insecticidal spray On the third day after the first insecticidal spray we took the same tagged plants and counted the number of white fly from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.467) whiteflies from per 3 leaves/plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(2.333) white fly per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(3.867) whiteflies per 3 leaves/plant followed by control (6.467) white fly from per 3 leaves per plant. (Table-3) .

Seven days after first insecticidal spray During the seventh day after spraying of different insecticides we observed that the least population of white fly was recorded from the treatment Diafenthiuron 50% WP @ 300 g a.i./ha(2.467) white fly from 3 leaves /plant, which was followed by Dinotefuran 20% SG@ 30 g a.i./ha(3.133) white fly from per 3 leaves/plant, and the least control of insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2.5 lit/ha(4.800) white fly from 3 leaves / plant followed by control (6.800) whitefly from per 3 leaves per plant. (Table 3)

Ten days after first insecticidal spray On the 10th day after first insecticidal spray we noted that Diafenthiuron 50% WP @ 300 g a.i./ha was a consistent performer in controlling whitefly population (3.133) whiteflies from 3 leaves /plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(4.067) white fly from 3 leaves /plant, and the least control with maximum population was that of Azadirachtin 0.03% EC @ 2.5 lit/ha(5.467) whiteflies from per 3 leaves/plant followed by control plot (8.667) whiteflies from per 3 leaves/plant. (Table 3) When we did the overall mean of population of whiteflyafter the first insecticidal spray we found that maximum amount of control on white fly population was given by Diafenthiuron 50% WP @ 300 g a.i./ha(2.355) mean whitefly population from per 3 leaves/plant, which was followed by Dinotefuran 20% SG@ 30 g a.i./ha(3.177) mean whitefly population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of whiteflyas such, Diafenthiuron 50% WP @ 300 g a.i./ha >Dinotefuran 20% SG@ 30 g a.i./ha >Thiamethoxam 25% WG @ 25 g a.i./ha >Profenofos 50 % EC @ 500 ml a.i./ha >Thiacloprid 21.7 % SC@ 30 ml a.i./ha >Tobacco dust powder@ 5 kg a.i./ha >Azadirachtin 0.03% EC @ 2.5 lit/ha.

Second insecticidal spray : Three days after second insecticidal spray On third day after the second insecticidal spray we took same tagged plants and counted the number of whitefly from three different leaves

of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (0.733) whiteflies from per 3 leaves/plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(1.533) whitefly per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(3.467) whitefly per 3 leaves/plant followed by control (9.933) whitefly from per 3 leaves per plant. (Table-3).

Seven days after second insecticidal spray On seven day after the second insecticidal spray we took same tagged plants and counted the number of whitefly from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.267) whitefly from per 3 leaves/plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(2.067) white fly per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(4.267) whitefly per 3 leaves/plant followed by control (8.400) whitefly from 3 leaves per plant. (Table-3)

Ten days after second insecticidal spray On Ten day after the second insecticidal spray we took same tagged plants and counted the number of whitefly from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.533) whitefly from per 3 leaves/plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(2.533) whitefly per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(4.733) white fly per 3 leaves/plant followed by control (8.733) whitefly from 3 leaves per plant. (Table 3) So finally when we did the overall mean of population of whitefly after the second insecticidal spray we found that maximum amount of control on whitefly population was given by Diafenthiuron 50% WP @ 300 g a.i./ha 1.178 mean whitefly population from per 3 leaves/plant, which was followed by Dinotefuran 20% SG@ 30 g a.i./ha(2.044) mean whitefly population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of whitefly as such, Diafenthiuron 50% WP @ 300 g a.i./ha >Dinotefuran 20% SG@ 30 g a.i./ha >Thiamethoxam 25% WG @ 25 g a.i./ha >Profenofos 50 % EC @ 500 ml a.i./ha >Thiacloprid 21.7 % SC@ 30 ml a.i./ha >Tobacco dust powder@ 5 kg a.i./ha >Azadirachtin 0.03% EC @ 2.5 lit/ha. The performance overview of different insecticide treatments against whitefly population based on their mean conclude that Diafenthiuron 50% WP @ 300 g a. i./ha was found to be the most efficient and considerably superior of all other treatments in decreasing the whitefly population to the minimum point. Dinotefuran 20% SG@ 30 g a.i./ha was the next finest insecticide to decrease the whitefly population closely followed by Thiamethoxam 25% WG @ 25 g a.i./ha. Profenofos 50 % EC @ 500 ml

a.i./ha, Thiacloprid 21.7 % SC@ 30 ml a.i./ha, Tobacco dust powder @ 5 kg a.i./ha and Azadirachtin 0.03% EC @ 2.5 lit/ha were the next best similar studies is found by Chaitanya and Kumar (2018) was noted similar studies to this study and found that Thiamethoxam 25WG was the best among all to control whitefly population. Afzalet *et al.*(2014) found diafenthiuron and thiamethoxam were found to be the most effective against whitefly upto 7 days after application. Kumar et al. (2017) and Mahesh (2017) was also found similar results dinotefuran and thiamethoxam were found to be the most effective against whitefly.

Yield (Q /ha) : All plots treated with untreated control 74.40 Q / ha. Among 300 g a.i./ha treated plots showed the highest yield 118.54 Q / ha a.i./ha (111.89 Q/ha) and Diafenthiuron 50% WP @ 300 g a.i yield obtained from Profenofos 50 % EC @ 500 ml a.i./ha &Thiacloprid 21.7 % SC @ 30 ml a.i./ha treated plot were at par with each with (103.42 Q/ha) & (98.47 Q/ha) respectively. The biorationals treatment comprising of Tobacco dust a.i./ha & Azadirachtin 0.03% EC @ 2.5 lit/ha gave relatively lower yield of (88.63 Q/ha) and (82013 Q/ha) respectively when compare (Table 4.) Experimental ~42~ All plots treated with test insecticides lead to more yield when compared with untreated control 74.40 Q / ha. Among all the insecticides, Diafenthiuron 50% WP treated plots showed the lowest insect population and thus obtained the highest yield 118.54 Q / ha closely followed by Thiamethoxam 25% WG @ 25 g a.i./ha (111.89 Q/ha) and Diafenthiuron 50% WP @ 300 g a.i./ha (110.11 Q/ha). The yield obtained from Profenofos 50 % EC @ 500 ml a.i./ha & Thiacloprid 21.7 % SC @ 30 ml a.i./ha treated plot were at par with each with (103.42 Q/ha) & (98.47 Q/ha) respectively. The biorationals treatment comprising of Tobacco dust powder @ 5 kg a.i./ha &Azadirachtin 0.03% EC @ 2.5 lit/ha gave relatively lower yield of (88.63 Q/ha) and (82013 Q/ha) respectively when compared to chemical treatments done

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Sub-surface Drip Irrigation : Potential and Challenges

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Abstract

Efficient and precise use of water in the irrigation system is the need of hour. Subsurface drip irrigation is one such alternative technique varying from conventional surface drip irrigation technique. By minimising evaporation, it uses water more efficiently than surface irrigation. It although needs expert design and maintenance, but also a very effective method that transports the water directly to the roots and is especially appropriate for arid and windy locations.

Key words : Sub-surface drip, emitters, poly-vinyl chloride, low density polyethylene.

Water is not only an essential element for our survival but is also an important vehicle for economic development of nation. Although it is a renewable resource; its reserve in nature is limited and therefore, we have to plan for its sustainable development and efficient management so that growing demand of burgeoning population, expanding agriculture, industries and rapid urbanization can be met. So, the efficient and precise water use by irrigation systems is becoming increasingly important especially in arid and semi-arid regions with limited water resources. Drip system is one of the appropriate water saving technique having many advantages over other types of irrigation. It covers an area of 3.57 lakh ha in India. Sub-surface drip irrigation is the advanced technique of drip system.

Subsurface drip irrigation (SDI) is the irrigation of crops through buried plastic tubes containing embedded emitters located at regular spacings. The emitters and the lateral lines are laid below the ground level within the root zone of the crop. Sub-surface drip system was introduced on commercial basis in mid-1980s, though they are still not widely used.

Potential/Advantages

In sub-surface system the tubes remain underground and does not interfere with tillage or other cultural operations

High degree of control over water application with the potential for high uniformity of application

This system can effectively provide water and nutrients for many crops, even in areas with high seasonal rainfall

This system has better water distribution efficiency

Sub-surface drip system is labour saving and avoids evaporation losses from the land surface

This system prevents the formation of soil surface crusts.

Germination of weeds is reduced

Multiple cropping and ratoon cropping is easier in this system as the laterals remain in place

Sub-surface drip system has great performance even in windy and arid locations

In case of irrigations with pre-treated wastewater, the risk of direct contact with the crops and labourers is reduced

Irrigation cost is reduced by 20 to 50% with an average of 32%

Electricity consumption is reduced by about 31%

Saving of fertilizers vary from 7 to 42%

Increased productivity of produce by about 45%

Income enhancement of famers with average of 48%

Challenges/ Disadvantages

Risk of clogging by salts, bacterial slimes, algae, etc.

Emitter can be damaged or blocked by root hairs

Laterals can be damaged by heavy machinery

Manual cleaning of emitters and laterals is not feasible in sub-surface drip system

Restricted root development

Damage from rodents

High cost of installation

Design Principles : The sub-surface drip irrigation system has a similar design as common surface drip irrigation system. The system layout consists of a settling pond, pumping unit, pressure relief valve, check valve or back flow prevention valves, hydrocyclone separator, fertilizer unit, screen or disc

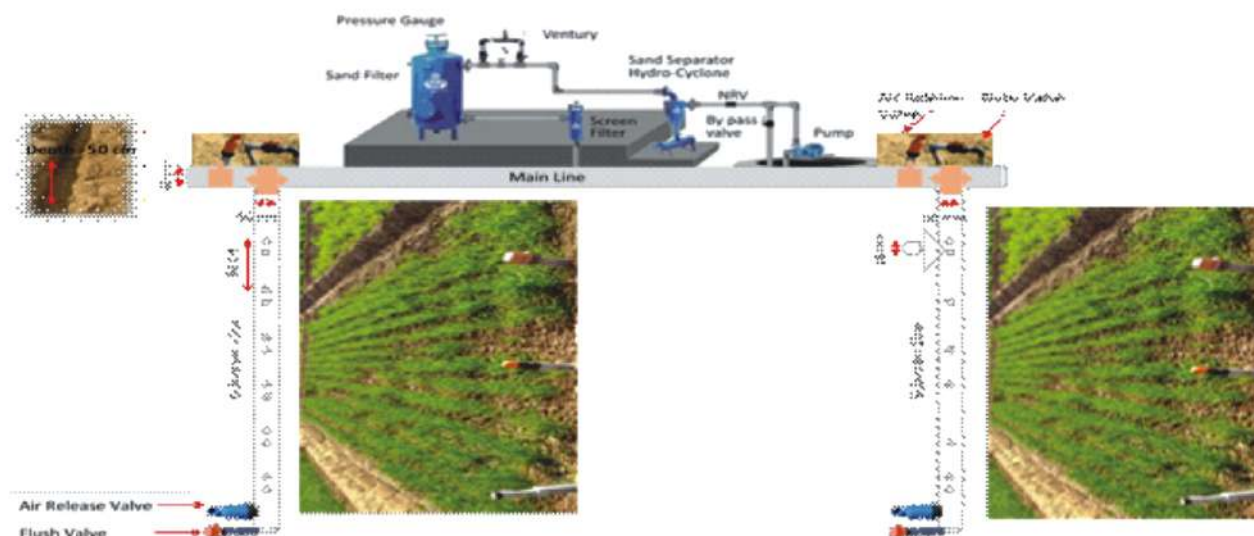


Fig.-1 : Layout of sub-surface drip irrigation.



Fig.-2 : (a) Laying of main line, (b) Laying of sub-main with punched laterals, (c) Gate and air release valve,

filter, pressure regulators, air vent valves, PVC (Poly Vinyl Chloride) pipes and LDPE (Low Density Polyethylene) laterals delivering water to the crop (Fig.-1). Sub-surface installations are preferred in semi-permanent and permanent installations, particularly for crops in which ratooning is practiced in lawns and landscapes.

The water distribution system consists of following components :

(a) Main line – It transports water within the fields. Rigid PVC and HDPE (High Density Polyethylene) pipes are used to minimize corrosion and clogging. It is laid underground (Fig.-2(a)). Pipes of 65 mm diameter and above with a pressure rating of 4 to 10 kg/sq.cm are recommended for main pipes.

(b) Sub-main line – It is also laid underground. It is connected to the main line through a gate valve and air release valve (Fig.2 (c)). It distributes water uniformly to a number of lateral lines (Fig.2(b)). At the end of sub-main, air release valve and a flush valve is

connected and raised above ground (Fig.-2(d)). Rigid PVC, HDPE and LDPE are used as sub-main pipes. Pipes of 32-75 mm with a pressure rating of 6 kg/sq.cm are recommended for sub-mains.

(c) Laterals- They are the pipes on which drippers are mounted or within which they are inserted. They are made of LDPE or LLDPE (Linear Low-Density Polyethylene). They are connected to the sub-main pipe or main pipe through a manifold. They are laid underground at a depth of 20-60cm. At the end of laterals a flush valve, air release valve and vacuum breaker is connected and raised above ground (Fig.-3). Laterals range in diameter from 1 to 3 mm with a pressure rating of 2.5 kg/sq.cm.

Cost : The initial cost of installation of sub-surface drip system is high. The cost depends on water source, water quality, choice of material, soil characteristics, crop and degree of automation. The normal life expectancy is 12 years. The system can be used even longer with good maintenance and high water quality.

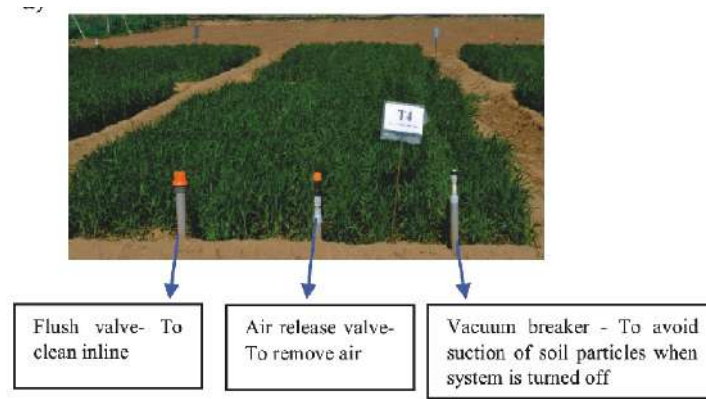


Fig.-3 : Field view of flush valve, air release valve and vacuum breaker.

Operation and maintenance : The performance and life of any system depends on how well it is designed, operated and maintained. It should either be automatically controlled or regularly inspected. Repairing the buried pipes is difficult, cumbersome and time-consuming. To prevent damage from rodents, precautionary measures should be undertaken. The mechanical components such as pumps, valves and filters need to be maintained as well as checked and cleaned regularly. The proper functioning of the filter system of a subsurface drip irrigation facility is crucial to the whole system. Systems must be designed so that mainlines, sub-mains, manifolds and laterals can all be flushed. Mainlines, sub-mains and manifolds are flushed with a valve installed at the very end of each line. It is important to flush the lines at least every 2 weeks during the growing season

Applicability : Subsurface drip irrigation systems are highly efficient irrigation systems that apply accurate amounts of water directly to the root zone, preventing water loss through evaporation and other negative effects of surface irrigation. This is especially suitable for arid, semi-arid, hot, and windy areas with limited water supply. However, as the system is relatively complex and most likely automated, it is more suitable for medium to large-scale production.

Government initiatives : The Pradhan Mantri Krishi Sinchayee Yojana of Government of India (motto of 'Har Khet Ko Paani') on Micro Irrigation aims to enhance water use efficiency in the agriculture sector

by promoting appropriate technological interventions and encouraging the farmers to use water saving and conservation technologies. Micro irrigation popularizes to ensure 'Per drop-More crop'.

PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) Scheme aims to meet all the electricity related needs of farmers and install solar power system to solarise pumps.

Making use of both the schemes the farmers can increase their income promoting sustainable agriculture and create protective irrigation by harnessing rain water at micro level through 'Jal sanchay' and 'Jal Sinchan'. Even water deficient, waste land and undulating land areas can easily be brought under cultivation due to ease of irrigation. So, the farmers should be encouraged to use them for conservation and saving of water and improved yield.

Know PMKSY and PM-KUSUM Scheme

PMKSY is a centrally sponsored scheme formulated amalgamating ongoing schemes viz. Accelerated Irrigation Benefit Programme (AIBP) of the Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR, RD&GR), Integrated Watershed Management Programme (IWMP) of Department of Land Resources (DoLR) and the On Farm Water Management (OFWM) of Department of Agriculture and Cooperation (DAC).

PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) Scheme is aimed at ensuring energy security for farmers in India.



Epidemiology of Anthracnose of Safed Musli Caused by *Colletotrichum chlorophyte*

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Abstract

The present investigation was carried out to assess the effect of environmental factors in relation to development of anthracnose disease of Safed Musli (*Chlorophytum borivillianum*) during Kharif 2013 and 2014 at RCA Udaipur which is quite destructive in all the Safed Musli growing areas of Southern Rajasthan. Disease progress was influenced by different weather factors viz., temperature, relative humidity, and sunshine hrs. The maximum AUDPC value (area under disease progressive curve) 85.5 and 83.5 were recorded on plants sown on 25th June and the lowest value 68.5 and 61.0 on the sown-on 5th June, in 2013 and 2014, respectively. The positive correlation was found between dependent variable per cent disease index and sunshine hrs. The study also revealed that all other independent variables (maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, and total rainfall) showed negative correlation with per cent disease index for anthracnose of safed musli.

Key Words : Anthracnose, temperature, relative humidity, rainfall, safed musli, sunshine.

Introduction

Safed Musli (*Chlorophytum borivillianum* Santapau and Fernandez) is a promising medicinal herb with great economic potential commonly known as 'Dholi Musli' belongs to class Monocotyledons, family Anthericaceae (Liliaceae). It is vegetatively propagated through fingers and the edible part is fasciculated roots(fingers) which have high alkaloid contents. It is an important medicinal and nutritional plant with aphrodisiac properties and as the herbal alternative to 'Viagra' raised its popularity even among Western countries (Thakur et al., 2009a, 2009b and 2009c, Sharma and Mazumdar, 2012; Sharma and Chandrul, 2017; Bhat et al., 2018). Safed Musli cultivated in Kharif season and predominantly distributed in tropical and subtropical forests of the world up to 1500 m altitude (Nayar and Sastry, 1988; Oudhia, 2001a; Raghavendra et al., 2005 and Chakraborty and Aeri, 2009). As per APEDA report annually about 6792 ton of Safed Musli products worth 72 million are exported from India. In India it is mostly confined to Northern Indian states, and its natural distribution has been found in Bastar Forest (M.P.), Dang Forest (Gujarat), Maharashtra and few parts of Karnataka and some districts of Rajasthan (Jagtap et al., 2009; Meena and Rao, 2010; Deshwal and Trivedi, 2011; Rai and Lalramnghinglova, 2011 and Sri ram et al., 2012). In Rajasthan, it naturally grows in Mount Abu, Mahi, Udaipur, Kota, Jhalawar, Chittorgarh and Arawali hills of Southern Rajasthan (Santapau and Fernandez, 1955). Among the diseases of Safed Musli, Anthracnose is most common disease caused by *Colletotrichum chlorophyti*; which significantly reduces the yield as well

as quality of crop and causes economic losses (Tetarwal et al., 2017, Meena and Kadam, 2021). Anthracnose disease can occur on leaves, stems, flowers and fruits (Isaac, 1992). The typical symptoms of anthracnose are in the form of sunken lesions that range in colour from dark red to tan black, generally describe as anthracnose disease (Wharton and Dieguez-Urbeondo, 2004). The disease starts in the form of small brownish spots on lamina, more commonly on its margin or tip. The spots gradually elongate and cover an appreciable area of the leaf. Environmental factors play a significant role in the development of disease epidemics. Epidemics caused by *Colletotrichum* species generally occur in rainy, humid, and warm weather, with temperatures ranging between 20°C and 30°C (Shabi and Katan, 1983; Ngugi et al., 2000; Sharma and Kulshrestha, 2015; Kamle and Kumar, 2016). The relationships between rainfall intensity, duration, crop geometry, and inoculum dispersal may result in different levels of disease severity. (Dodd et al., 1992). The effects of temperature often interact with other factors, such as leaf surface wetness, humidity, light or competitive micro-biota (Royle and Butler, 1986). The duration of surface wetness, on the other hand, appears to have the most direct influence on pathogen germination, infection, and growth on the host. Generally, infection occurs during warm, wet weather. Temperatures around 27°C and high humidity (averaging 80%) are ideal for the development of anthracnose disease (Roberts et al., 2001). The favourable host, pathogen and weather conditions lead to establishment of disease (Agrios, 2005). Thus, before proposing a disease management strategy, a thorough understanding of the disease's

epidemiology should be studied. Keeping this under view the epidemiological experiments have been planned in this study.

Materials and Methods

Weather conditions affect the disease severity of anthracnose of Safed Musli. This experiment was conducted by sowing of Safed Musli in field under in small plots 3m long paired rows in 3 replications at different dates of sowing viz., June 5, 15 and 25 in *kharif* 2013 and 2014. After 40 days the plants were inoculated with a moderate inoculum density (1×10^3 conidia ml^{-1}), and disease severity scores were recorded on 0-5 scale, at weekly intervals. Meteorological data was collected from Agromet lab, Department of Agronomy, R.C.A., Udaipur. The correlation of disease development with factors like maximum and minimum temperature, relative humidity, sunshine/cloudy days, and rainfall were studied.

Results and Discussion

The experiment was conducted to find out the influence of weather factors on the development of anthracnose on the local land race of safedmusli during *Kharif* 2013 and 2014. The sowing was done on different dates i.e., 5th, 15th and 25th June, 2013 and 2014. Forty days old plants were inoculated with virulent isolate of *C. chlorophyti* (Udrc1) with 1×10^{-3} conidia ml^{-1} spore suspension. Observations for disease severity were recorded as per detail given in Materials and Methods. To know the relationship between the disease severity (dependent variable) and the weather factors (maximum temperature, minimum temperature, maximum per cent relative humidity and minimum per cent relative humidity), the multiple linear regression analysis and for (sunshine and rainfall) correlation coefficient analysis was done with 5th June sown plants. By fitting this equation, the contribution of weather factors in the development of anthracnose was observed.

Kharif 2013

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 \quad R^2 = 0.845884$$

$a = -138.1788$, $b_1 = 5.152082$, $b_2 = -11.997940$, $b_3 = 3.064683$, $b_4 = -0.475046$, $b_5 = 0.583328$, $b_6 = 1.805784$. Thus, the equation comes to: $Y = -138.1788 + (5.152082X_1) + (-11.997940X_2) + 3.064683X_3 + (-0.475046X_4) + 0.583328X_5 + 1.805784X_6$ $b_1 = 5.152082$:

It means that holding X_2 (minimum temperature), X_3 (maximum relative humidity), X_4 (minimum relative humidity), X_5 (Sunshine) and X_6 (Total rainfall) constant a 1% increase in X_1 (maximum temperature), lead on average to about 5.152082 per cent decrease in Y (Per cent disease index). $b_2 = -11.997940$: It means that holding X_1 , X_3 , X_4 , X_5 and X_6 constant a 1 per cent increase in X_2 (negatively correlated to Y) lead on average

to about -11.997940 per cent decrease in Y . $b_3 = 3.064683$: It means that holding X_1 , X_2 , X_4 , X_5 and X_6 constant a 1 per cent increase in X_3 lead on average to about 3.064683 per cent decrease in Y . $b_4 = -0.475046$: It means that holding X_1 , X_2 , X_3 , X_5 and X_6 constant a 1 per cent increase in X_4 (negatively correlated to Y) lead on average to about -0.475046 per cent decrease in Y . $b_5 = 0.583$:

The correlation coefficient between per cent disease index and sunshine hrs was 0.583, it indicates is a positive correlation, between the per cent disease index, indicating higher disease severity with the increase in sunshine. $b_6 = 1.805784$: It means that holding X_1 , X_2 , X_3 , X_4 and X_5 constant a 1 per cent increase in X_6 lead on average to about 1.805784 per cent decrease in Y . $R^2 = 84$ per cent, it means variation at 84 per cent explain by dependent variables (disease severity) and remaining it is 11 per cent variable is unexplained. Anthracnose based on weather parameters on different dates of sowing. The one graph fitted closely confirming the accuracy of the equation (Fig.-4 & 4a). All inoculated plants were periodically observed for disease severity on 0-5 scale and area under disease progressive curve (AUDPC) were calculated. Considerable variations were observed in AUDPC in three different dates of sowing and correlation with weather factors on disease development. In the first planting on 5th June and inoculated on 15th July the AUDPC was 8.5, in the next week it was 12.7 and in the third week (56 -day old plants) it reached to 15.0. The AUDPC in the following 31st to 36th weeks ranged for 18.0-39.0. In the 37th to 42nd week the AUDPC was high (46.5-68.5) in the plots sown on 5th June. The plots which sown on 15th June and inoculated on 25th July, the AUDPC in the first week after inoculation (30th July-5th Aug.) was 18.0. It progressed slowly and ranged between 24.0 and 46.5 for the next 5 weeks (31st to 35th weeks). In the following weeks (36th to 42nd), there was a sharp increase in AUDPC, which reached 55.0, 61.0, 65.0, 66.0, 69.5, 73.0, and 76.0. (Table1 & Fig.-4). In the plants sown on 25th June and inoculated on 5th Aug. AUDPC was 28.0. It was higher than the first two sown dates. It increased to 32.5 on next week and remained in the 32.5-39.0 range for next 32nd to 34th weeks, respectively. Higher AUDPC was recorded in the 35th to 37th weeks in the plots sown on 28th June (45.0, 49.0 and 58.2 AUDPC, respectively) as compared to 34.0-46.5 and 46.5-61.0 in those sown on 5th June and in 15th June, the former set, the AUDPC in the following weeks was 72.5, 79.0, 83.5, 84.0 and 85.5. Where, in later sown of Safed Musli (15th & 25th June), AUDPC was much higher as compared to early sown (5th June). It was observed that the disease progressed faster when the temperature maximum ranged from 27.1-30.5 °C and minimum from 21.4-14.9 °C as compared to

29.0-30.2 °C maximum and 23.2-23.5 °C minimum during 30th July to 20th August 2013. The age of plants also seemed to be important as disease progression was faster on 24th Sept. to 28th Oct. (38th to 42nd weeks). Studies on the effect of weather factors on disease development revealed that AUDPC was 28.5 on 5th June sown plots due to 60.1 to 89.4 per cent relative humidity and 22.7-30.6 °C temperature, followed by 40.5 and 39.5 on 15th and 25th June sown plots, respectively. From the 3rd Sept. to 18th Sept., 2013 was moderate period for anthracnose development as during this period the RH minimum and maximum ranged from 50.1-81.9 per cent coupled with minimum and maximum temperature 22.4-22.8 and 31.0-32.9 °C and AUDPC was 39.0 on 5th June sown plants followed by 55.0 and 49.0 on 15th June and 25th June sown plants, respectively (in 36th week). The period from 19th Sept to 28th Oct., 2013 was found to be highly favourable for disease development with more severity was observed as compared to progressive phase during this period. The minimum and maximum temperature range was 14.9-22.8 °C and 27.1-33.0 °C accompanied with minimum and maximum relative humidity range between 31.1-84.4 and 79.7-90.6 per cent and total rainfall ranging from 2.5-13.7 mm respectively, in progress phase AUDPC value was found range from 68.5-85.5 almost stable (Table-1; Fig.-4 & 4a).

Kharif 2014

$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6$ $R^2 = 0.878886$

$a = -127.5767$ $b_1 = 5.277402$ $b_2 = -11.203963$ $b_3 = 2.0454620$ $b_4 = -0.503068$ $b_5 = 0.4313205$ $b_6 = 1.703532$
Thus, the equation comes to: $Y = -127.5767 + (5.277402X_1) + (-11.203963X_2) + 2.0454620X_3 + (-0.503068X_4) + 0.4313205X_5 + 1.703532X_6$ $b_1 = 5.277402$:

It means that holding X_2 (minimum temperature), X_3 (maximum relative humidity), X_4 (minimum relative humidity), X_5 (Sunshine) and X_6 (Total rainfall) constant a 1% increase in X_1 (maximum temperature), lead on average to about 5.277402 per cent decrease in Y (Per cent disease index). $b_2 = -11.203963$: It means that holding X_1 , X_3 , X_4 , X_5 and X_6 constant a 1 per cent increase in X_2 (negatively correlated to Y) lead on average to about -11.203963 per cent decrease in Y . $b_3 = 2.0454620$: It means that holding X_1 , X_2 , X_4 , X_5 and X_6 constant a 1 per cent increase in X_3 lead on average to about 2.0454620 per cent decrease in Y . $b_4 = -0.503068$: It means that holding X_1 , X_2 , X_3 , X_5 and X_6 constant a 1 per cent increase in X_4 (negatively correlated to Y) lead on average to about -0.503068 per cent decrease in Y . $b_5 = 0.431$: The correlation coefficient between per cent disease index and sunshine hrs was 0.431, it indicates is

a positive correlation, between the per cent disease index, indicating higher disease severity with the increase in sunshine. $b_6 = 1.703532$: It means that holding X_1 , X_2 , X_3 , X_4 and X_5 constant a 1 per cent increase in X_6 lead on average to about 1.703532 per cent decrease in Y . $R^2 = 87$ per cent, it means variation at 84 per cent explain by dependent variables (disease severity) and remaining 11 per cent variable is unexplained. Anthracnose based on weather parameters on different dates of sowing. The one graph fitted closely confirming the accuracy of the equation (Fig.-5 & 5a). All inoculated plants were evaluated for disease severity on a 0-5 scale, and the area under the disease progressive curve (AUDPC) was calculated. Considerable variations were observed in AUDPC in three different dates of sowing, as well as a correlation with weather factors on disease development. In the first planting on 5th June and inoculated on 15th July the AUDPC was 7.0, in the next week it was 10.5 and in the third week (59 days old plants) reached to 12.0. The AUDPC in the following 31st to 36th weeks ranged from 15.0 to 43.5. In the 37th to 42nd week the AUDPC was high (47.0-61.0) in the plots sown on 5th June. In the plots sown on 15th June and inoculated on 25th July the AUDPC in the first week after inoculation (30th July to 5th Aug.) was 17.0. It progressed slowly and upto next 5 weeks (31st to 35th weeks), it ranged between from 23.0 – 38.5. In the following weeks (36th to 42nd weeks) there was a sudden increase in AUDPC and it reached to 47.0, 50.0, 55.5, 59.0, 63.5, 65.0 and 68.0 in the following weeks (Table2 & Fig.-5). In the plots sown on 25th June and inoculated on 5th Aug. AUDPC was 27.0. It was higher 27.0 than those first two dates sown (7.0 and 17.0). It increased to 32.0, respectively on next week and the AUDPC was 35.5, 44.0 and 48.5 during next 33rd, 34th and in 35th weeks, respectively. Higher AUDPC was recorded in the 36th to 37th weeks in the plots sown on 25th June (56.0 and 63.5) as compared to 43.5-47.0 and 47.0-50.0 in those sown on 5th June and in 15th June the former set, the AUDPC in the following weeks was 70.0, 74.0, 77.5, 80.0 and 83.5. While, in later sown of Safed Musli (15th & 25th June), AUDPC was much higher as compared to early sown (5th June). It was observed that the disease progressed faster when the maximum temperature ranged from 28.7 to 32.5 and minimum temperature from 19.4-21.4 °C (36th to 38th weeks) as compared to 27.8-30.3 °C maximum and 23.5-23.9 °C minimum during 30th July to 20th August 2014. The age of plant also seemed to be important as disease progression was higher on 1st Sept. to 28th Oct. (39th to 42nd weeks). Studies on the effect of weather factors on disease development, the AUDPC was 18.5 on the 5th June sown plots with 63.0 to 89.9 percent relative humidity and 23.5- 31.9 °C temperature, followed by 25.5 and 32.0 on the 15th and 25th June sown plots,

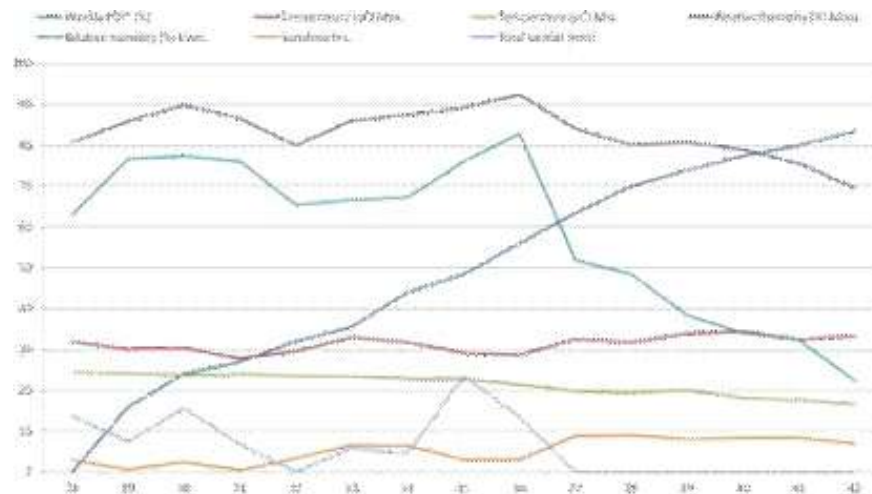


Fig-1a : Effect of environmental factors on development of anthracnose in safedmusli planted on 5th June at experimental field during *Kharif* 2013.

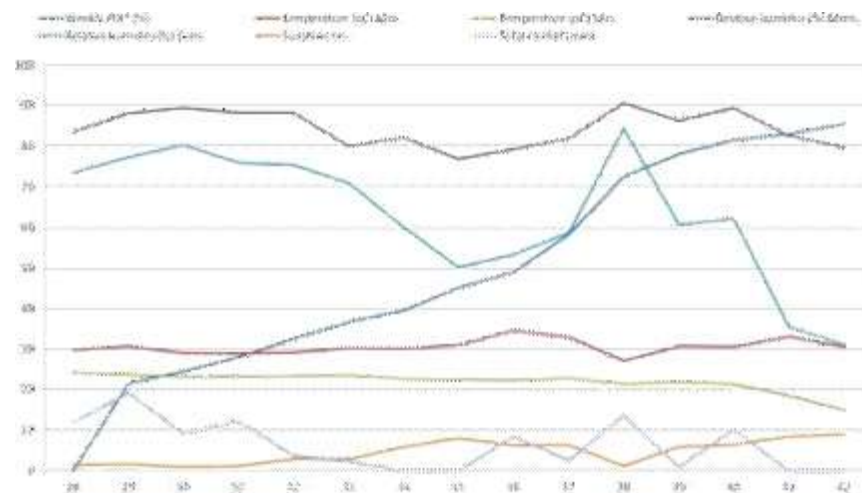


Fig-1b : Effect of environmental factors on development of anthracnose in safedmusli planted on 15th June at experimental field during *Kharif* 2013.

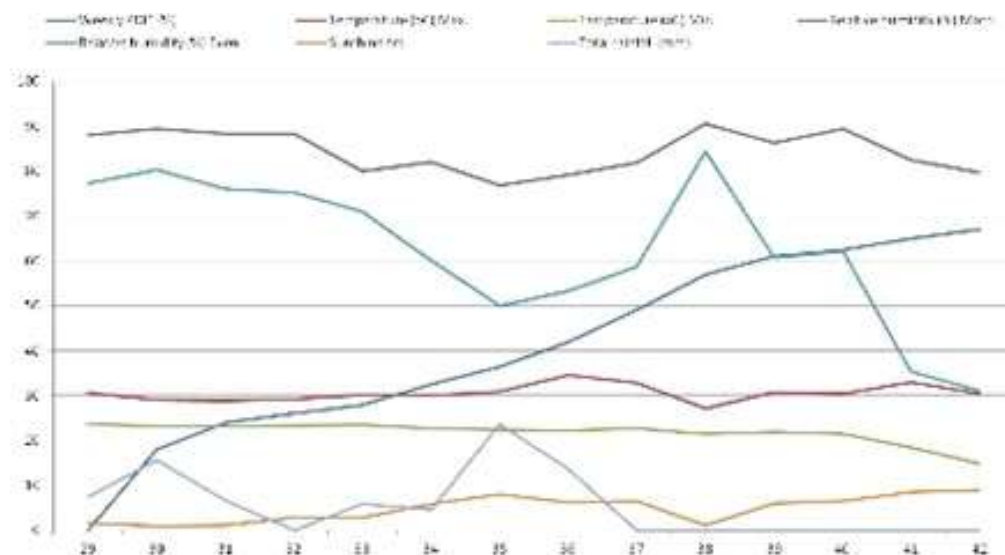


Fig-1c : Effect of environmental factors on development of anthracnose in Sated Musli planted on 25th June at experimental field during *Kharif* 2013.

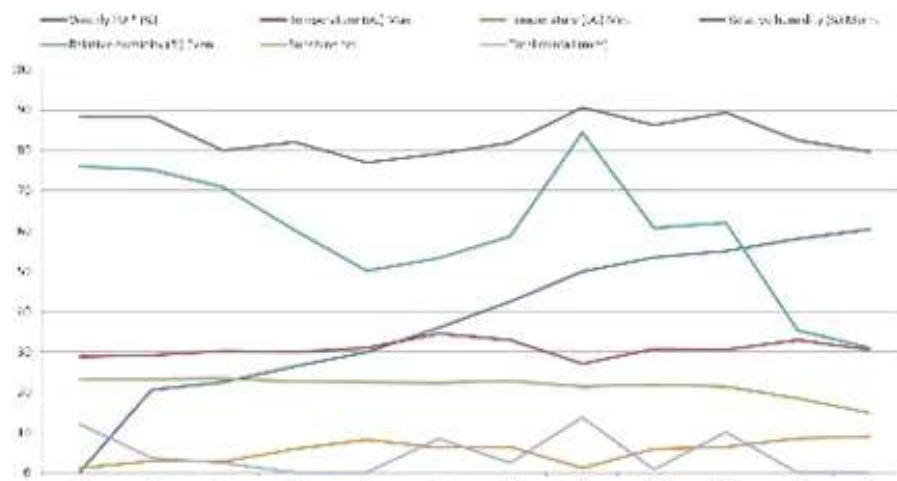


Fig-1a : Effect of environmental factors on development of anthracnose in safedmusli planted on 5th June at experimental field during *Kharif* 2013.

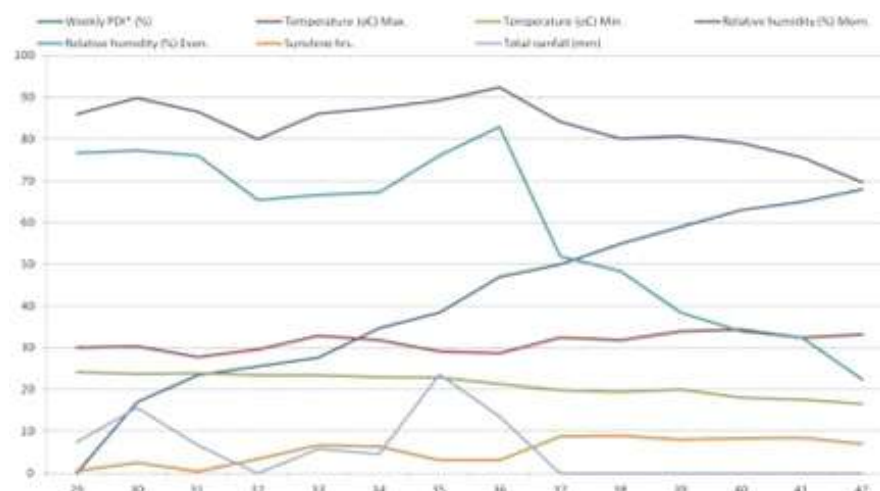


Fig-2b : Effect of environmental factors on development of anthracnose in Safed Musli planted on 15th June at experimental field during *Kharif* 2014.

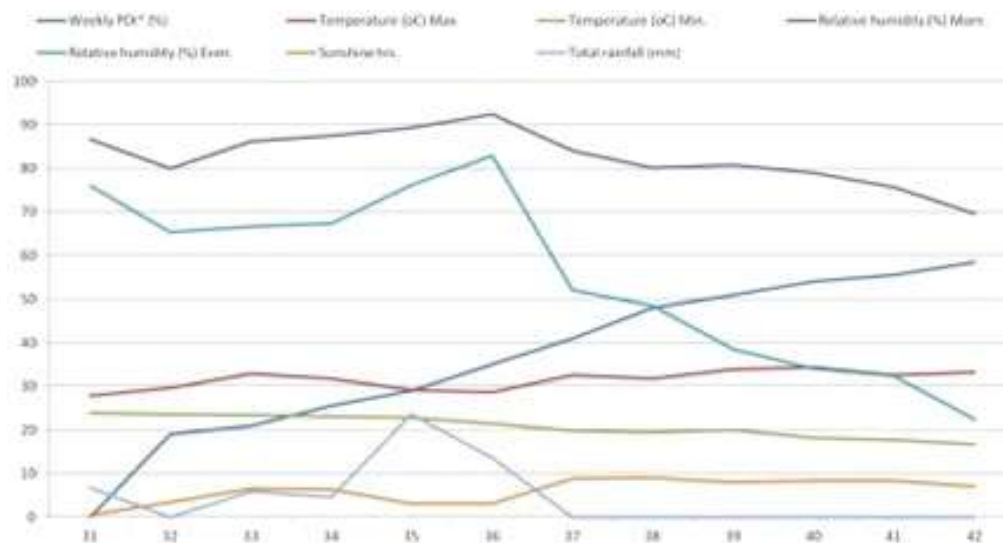


Fig-2c : Effect of environmental factors on development of anthracnose in Safed Musli planted on 25th June at experimental field during *Kharif* 2014.

Table-1 : Anthracnose development on Safed Musli in relation to weather parameters with different dates of sowing during Kharif 2013*.

Std. week	Meteorological weeks	Temperature (°C)		Relative humidity (%)		Sunshine hrs.	Total rainfall (mm)	AUDPC**		
		Max.	Min.	Max.	Min.			Inoculation		
								15 th July	25 th July	5 th Aug.
28	16-22, July	29.7	24.2	83.6	73.4	1.5	12.0	8.5	0	0
29	23-29, July	30.6	23.6	88.1	77.3	1.6	19.1	12.7	0	0
30	30, July-5 Aug.	29.0	23.2	89.4	80.3	1.0	9.1	15.0	18.0	0
31	6-12, Aug.	28.8	23.2	88.3	76.0	1.1	12.2	18.0	24.0	28.0
32	13-19, Aug.	29.2	23.3	88.3	75.3	2.9	3.7	20.5	26.0	32.5
33	20-26, Aug.	30.2	23.5	80.0	71.0	2.8	2.4	22.5	35.0	36.6
34	27, Aug–2, Sept.	30.0	22.7	82.1	60.1	5.9	0.0	28.5	40.5	39.5
35	3-9, Sept.	31.0	22.4	76.9	50.1	8.1	0.0	34.0	46.5	45.0
36	10-16, Sept.	34.6	22.3	79.2	53.3	6.2	8.5	39.0	55.0	49.0
37	17-23, Sept.	32.9	22.8	81.9	58.7	6.4	2.5	46.5	61.0	58.2
38	24-30, Sept.	27.1	21.4	90.6	84.4	1.1	13.7	53.0	65.0	72.5
39	1 Sept.-7, Oct.	30.7	21.9	86.3	60.7	6.0	0.9	57.5	66.0	79.0
40	8-14, Oct.	30.5	21.4	89.4	62.1	6.4	10.1	59.0	69.5	83.5
41	15-21, Oct.	33.0	18.5	82.6	35.4	8.5	0.0	63.0	73.0	84.0
42	22-28, Oct.	30.5	14.9	79.7	31.1	9.0	0.0	68.5	76.0	85.5

*Mean of three replications, *Plants inoculated 40 DAS, **Observation started 7days after inoculation and at weekly intervals & 1st sown-5th Jun, 2nd -15th Jun., 3rd-25th.

Table-2 : Anthracnose development on Safed Musli in relation to weather parameters with different date of sowing during Kharif 2014*.

Std.week	Meteorological weeks	Temperature (°C)		Relative humidity (%)		Sunshine hrs.	Total rainfall (mm)	AUDPC**		
		Max.	Min.	Max.	Min.			Inoculated on		
								15 th July	25 th July	5 th Aug.
28	16-22, July	31.9	24.3	80.7	63.0	2.9	13.7	7.0	0	0
29	23-29, July	30.1	24.2	86.0	76.6	0.6	7.4	10.5	0	0
30	30, July-5 Aug.	30.3	23.7	89.9	77.3	2.4	15.6	12.0	17.0	0
31	6-12, Aug.	27.8	23.9	86.6	76.0	0.4	6.7	15.0	23.0	27.0
32	13-19, Aug.	29.6	23.5	80.0	65.4	3.4	0.0	18.5	25.5	32.0
33	20-26, Aug.	32.9	23.4	86.1	66.6	6.6	5.8	32.5	27.0	35.5
34	27, Aug–2, Sept.	31.8	23.0	87.4	67.3	6.4	4.5	38.5	34.5	44.0
35	3-9, Sept.	29.1	22.8	89.3	76.1	3.1	23.6	41.0	38.5	48.5
36	10-16, Sept.	28.7	21.4	92.4	82.9	3.0	13.5	43.5	47.0	56.0
37	17-23, Sept.	32.5	19.8	84.1	52.0	8.8	0.0	47.0	50.0	63.5
38	24-30, Sept.	31.8	19.4	80.1	48.4	8.9	0.0	50.5	55.5	70.0
39	1 Sept.-7, Oct.	33.9	20.0	80.7	38.4	8.0	0.0	53.0	59.0	74.0
40	8-14, Oct.	34.4	18.1	79.0	34.0	8.3	0.0	55.5	63.5	77.5
41	15-21, Oct.	32.5	17.6	75.6	32.4	8.4	0.0	57.0	65.0	80.0
42	22-28, Oct.	33.2	16.6	69.6	22.4	7.0	0.0	61.0	68.5	83.5

*Mean of three replications; *Plants inoculated 40 DAS, **Observation started 7days after inoculation and at weekly intervals & 1st sown-5th Jun, 2nd -15th Jun., 3rd-25th Jun.

Supplementary Table-1 : Mean weekly meteorological data recorded during experimental period 2013-14. location: RCA, Udaipur (June to Oct. 2013-14).

Date	Week No	Temperature (°C)		R.H. (%)		Wind velocity km/hr	Sunshine (Hrs)	Total rain (mm)	Evap. mm
		Max.	Min.	Max.	Min.				
4-10 June	22	37.9	26.6	63.4	44.1	6.7	6.8	2.1	8.5
11-17 June	23	34.7	25.8	76.1	53.9	5.5	5.9	2.5	6.8
18-24 June	24	33.5	24.3	74.6	51.9	6.6	7.1	4.2	7.4
25 Jun-1July	25	33.2	25.8	74.4	54.1	8.4	4.1	1.3	7.0
2-8 July	26	32.9	24.8	80.6	62.6	5.8	2.1	1.8	4.6
9-15 July	27	30.7	24.1	81.0	70.1	5.5	1.8	10.5	3.8
July 16-22	28	29.7	24.2	83.6	73.4	4.5	1.5	12.0	3.0
July 23-29	29	30.6	23.6	88.1	77.3	3.4	1.6	19.1	2.3
July 30-Aug.5	30	29.0	23.2	89.4	80.3	4.0	1.0	9.1	1.9
Aug. 6-12	31	28.8	23.2	88.3	76.0	3.7	1.1	12.2	2.0
Aug. 13-19	32	29.2	23.3	88.3	75.3	4.8	2.9	3.7	3.2
Aug. 20-26	33	30.2	23.5	80.0	71.0	5.7	2.8	2.4	3.5
Aug. 27-Sep.2	34	30.0	22.7	82.1	60.1	4.6	5.9	0.0	4.9
Sep. 3-9	35	31.0	22.4	76.9	50.1	4.4	8.1	0.0	5.1
Sep. 10-16	36	34.6	22.3	79.2	53.3	2.5	6.2	8.5	5.3
Sep. 17-23	37	32.9	22.8	81.9	58.7	3.5	6.4	2.5	4.3
Sep. 24-30	38	27.1	21.4	90.6	84.4	5.3	1.1	13.7	1.5
Sep. 1-Oct. 7	39	30.7	21.9	86.3	60.7	3.4	6.0	0.9	4.3
Oct. 8-14	40	30.5	21.4	89.4	62.1	2.7	6.4	10.1	1.5
Oct. 15-21	41	33.0	18.5	82.6	35.4	1.8	8.5	0.0	3.6
Oct. 22-28	42	30.5	14.9	79.7	31.1	2.9	9.0	0.0	2.7
29-4 Nov.	43	30.4	14.2	79.0	31.4	1.4	8.6	0.0	2.9

respectively. During 20th Aug. to 9th Sept. 2014(33rd, 34th and 35th weeks) was a moderate period for anthracnose development, as the minimum and maximum relative humidity levels ranged between 66.6-89.3 per cent and coupled with minimum and maximum temperature 22.8-23.4 and 29.1-32.9 and AUDPC was 41.0 on 5th June sown plants followed by 38.5 and 48.5 on 15th June and 25th June sown plants. The period from 10th Sept. to 23rd (36th and 37th weeks) the AUPDC was increased with highly moderate and AUPDC was recorded as 43.5 and 47.0 in 5th June sown plots followed by 47.0, 50.0 in 15th and 25th June sown plots 56.0 and 70.0 was recorded. The period from 1st Sept to 28th Oct., 2014 (39th to 42nd weeks) was found to be highly favourable for disease development and more severity observed than during the progressive phase. The minimum and maximum temperature range was 16.6-20.0°C and 32.5-34.4°C accompanied with minimum and maximum relative humidity range between 22.4-38.4 and 69.6-80.7 per cent in progress phase. The disease was found to be almost stable with a AUDPC value ranging from 61.0 to 83.5 percent. (Table- 1; Fig.-5 & 5a).

To understand the effect of various weather factors on development of anthracnose on Safed Musli, the disease progression was studied on plants by staggered weekly sowing under pathogen inoculation. Based on disease severity, area under disease progressive curve (AUDPC) was calculated. In the current study, the AUDPC values were lower in the weeks near to sowing in 2013. (4th to 5th weeks).When the temperature was ranged from 23.2-30.6°C and relative humidity 73.4-89.4 per cent. With increase the temperature (27.1-32.90 °C max.), RH (81.9-90.6%) and total rainfall also during Sept., 2013 (37th to 39th weeks), the disease progression was much faster and AUDPC values were obtained. It appeared that despite different age of the Safed Musli, the temperature of 30.5-33.0°C were the most confined during the month of October, 2013.In 2014, AUDPC values increased gradually in the weeks preceding sowing (28th to 32nd weeks), when the temperature ranged from 23.5-31.9°C and relative humidity ranged from 65.4-89.9%. Increases in temperature (28.7-33.9°C max.), RH (80.1-92.4%), and total rainfall during September, 2014 (36th to 39th weeks) accelerated

Supplementary Table-2 : Mean weekly meteorological data recorded during experimental period 2014-15, location: RCA, Udaipur (June to Oct.2014-15).

Date	Week No	Temperature (°C)		R.H. (%)		Wind velocity km/hr	Sunshine (Hrs)	Total rain (mm)	Evap. mm
		Max.	Min	Max.	Min.				
4-10 June	22	42.4	28.4	46.3	22.7	5.9	9.3	0.0	12.3
11-17 June	23	37.2	26.6	69.0	39.1	9.9	8.0	0.0	10.8
18-24 June	24	36.2	26.9	67.7	42.3	10.6	7.6	0.0	10.8
25 Jun–1 July	25	36.2	25.9	64.7	36.0	11.0	9.3	0.0	11.7
2-8 July	26	36.4	27.0	64.1	34.3	9.3	6.3	0.0	10.3
9-15 July	27	35.4	25.5	74.7	50.1	6.2	5.3	1.7	6.9
July 16-22	28	31.9	24.3	80.7	63.0	6.2	2.9	13.7	5.3
July 23-29	29	30.1	24.2	86.0	76.6	5.1	0.6	7.4	2.9
July 30-Aug. 5	30	30.3	23.7	89.9	77.3	4.2	2.4	15.6	3.3
Aug. 6-12	31	27.8	23.9	86.6	76.0	4.0	0.4	6.7	2.8
Aug. 13-19	32	29.6	23.5	80.0	65.4	5.8	3.4	0.0	3.5
Aug. 20-26	33	32.9	23.4	86.1	66.6	2.8	6.6	5.8	4.7
Aug. 27-Sep. 2	34	31.8	23.0	87.4	67.3	3.6	6.4	4.5	4.2
Sep. 3-9	35	29.1	22.8	89.3	76.1	4.5	3.1	23.6	3.5
Sep. 10-16	36	28.7	21.4	92.4	82.9	1.6	3.0	13.5	2.4
Sep. 17-23	37	32.5	19.8	84.1	52.0	2.8	8.8	0.0	4.5
Sep. 24-30	38	31.8	19.4	80.1	48.4	2.5	8.9	0.0	4.1
Sep.1-Oct. 7	39	33.9	20.0	80.7	38.4	1.9	8.0	0.0	3.7
Oct. 8-14	40	34.4	18.1	79.0	34.0	2.6	8.3	0.0	4.7
Oct. 15-21	41	32.5	17.6	75.6	32.4	2.0	8.4	0.0	3.7
Oct. 22-28	42	33.2	16.6	69.6	22.4	1.8	7.0	0.0	4.3
29-4 Nov.	43	31.1	18.4	71.4	31.9	1.9	4.7	0.0	3.9

Supplementary Table-3 : Progression of anthracnose on Safed Musli in relation to weather parameters with AUDPC during Kharif 2013-14.

	D.F.	S.S.	M.S.
Regression	6	7602.1682	1267.0280
Residual	8	1385.0733	173.1342
Total	14	8987.2415	

Supplementary Table-4 : Progression of anthracnose on Safed Musli in relation to weather parameters with AUDPC during Kharif 2014-15.

	D.F.	S.S.	M.S.
Regression	6	6109.7650	1018.2942
Residual	8	841.9461	105.2433
Total	14	6951.7111	

disease progression and yielded AUDPC values. It appeared that despite different age of the Safed Musli, the temperature of 32.5-34.4°C were the most confined during the month of October, 2014. While sunlight had no effect on anthracnose development throughout the season in both years. These observations are useful for timely application of fungicide for checking further spread of the disease. This seems to be crucial stage for prophylactic spray of fungicides were useful to suppress the disease.

Little information is available on the effect of

temperature and RH on *C. dematium* and *C. chlorophyti*. In general, isolates of the species *C. Gloeosporioides* have been reported to have optimal growth temperatures ranging from 25-28 °C (Bernstein, *et al.*, 1995). Temperatures around 27 °C and high humidity (80.0%) are optimum for the development anthracnose disease (Roberts *et al.*, 2001). The epidemiology of several anthracnose diseases of tropical crops has been studied by many workers at various stages of crop development (Freeman *et al.*, 1998; Jeger and Plumbley, 1998 and Kim *et al.*, 2004). According to Gautam *et al.* (2012) the *C. gloeosporioides* causing leaf spot of *Pedilanthus-*

tithymaloides, which begins in June-July and spreads with the rainy season, when temperatures ranged from 25-30°C and lasts up to the end of winter season. There were no symptoms observed during the summer.

Conclusions

In the year 2013, the period between 10th Sept. to 7th Oct., was much more favourable for disease development and severity, comparison to progress phase. During the experiment, the minimum and maximum temperatures were 21.4-22.8 and 27.1-34.6 °C, respectively, with minimum and maximum relative humidity 53.3-84.4 and 79.2-90.6, resulting in a higher AUDPC value on plants inoculated on June 25th, followed by 76.0 on June 15th, and lowest on June 5th sown plants. In the year 2014, the period between 10th Sept. to 14th Oct., was much more favourable for disease development and severity, during the period was observed in comparison to progression phase. The minimum and maximum temperature ranging from 18.1-21.4 and 28.7-34.4 °C accompanied with minimum and maximum relative humidity 52.0-82.9 and 79.0-92.4 AUDPC was higher on plants inoculated on 25th June followed by plants sown on June 15th and 5th.

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Tank Mix Formulation of Atrazine and New Generation Herbicides against Complex Weed Flora of Maize (*Zea mays* L.)

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Abstract

A field experiment was conducted on clay loam soil during *kharif*, 2017 at Instructional Agronomy Farm, Rajasthan College of Agriculture, Udaipur to find out the Effect of tank mix formulation of atrazine and new generation herbicide against complex weed flora of maize (*Zea mays* L.). The results of the experiment revealed that the lowest total weed density at 30 DAS was recorded with tank mix application of atrazine 0.5 kg/ha+ tembotrione 0.125 kg/haPoE at 15 DAS. All the weed control treatments were also found significantly superior in reducing dry matter of monocot, dicot and total weeds compared to weedy check at 30 DAS. The minimum total weed dry matter at this stages (2.85, g/m²) were observed under atrazine 0.5 kg/ha + tembotrione 0.125 kg/haPoE at 15 DAS and it was closely followed by atrazine 0.5 kg/ha + topamezone 0.025 kg/haPoE at 15 DAS (3.89, g/m²). An application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/haPoE at 15 DAS resulted in maximum weed control efficiency of 96.99% at 30 DAS. The application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha as PoE at 15 DAS recorded the tallest plants (47.0 cm) with greatest dry matter accumulation per plant (18.04g) at 30 DAS. The maximum gross and net return (5/ha and ₹ 71009/ha and benefit cost ratio (2.57) were also obtained under application of atrazine 0.5 kg/ha+ tembotrione 0.125 kg/haPoE at 15 DAS, leading all other treatments significantly behind.

Key words : Weed dynamics, mixtures, atrazine, tembotrione, post-emergence, maize, net return.

Introduction

Maize (*Zea mays* L.) is the third most important cereal in the world; it is one of the most versatile crops having wider adaptability under varied agro-climatic conditions. It is also known as “Queen of Cereals”. Maize in India, contribute nearly 9% in the national food basket and more than ₹100 billion to the agricultural GDP at current price, cultivated on 9.25 m ha area with production of 23.67 m t at a productivity of 2.53 t/ha. In Rajasthan, this crop occupied 0.90 m ha area with production of 1.60 m t and productivity of 1.70 t/ha (Agricultural Statistics at a Glance, 2016). Being rainy season crop, it has high yielding crop but weed infestation is one of the major constraints in cultivation of maize. Maize is infested by a wide range of weed flora; *Commelina benghalensis*, *Echinochloa colona*, *Trianthema portulacastrum*, *Dinebra retroflexa*, *Amaranthus viridis* and *Digera arvensis* dominate during the crop growth period. The most critical period for crop-weed competition is first six weeks after planting of crop which may reduce yield by 28-100% (Dass *et al.*, 2012). During this period, weeding is essentially required physical and mechanical means are expensive and many times timely operations are not possible due to continuous rains in monsoon season (Chopra and Angiras, 2008).

Materials and Methods

The experiment was carried out at research farm of

Raasthan college of Agriculture, Udaipur (24°35' N latitude and 73°42' E longitude. an altitude of 582.5 meter above mean sea level). The soil of experimental had low in nitrogen, medium in phosphorus, high in potassium and slightly alkaline and calcareous in nature. The soil of the experimental field was clay loam in texture. The experiment was laid out in randomized block design with 13 treatment combination tested were as follows weedy check, atrazine 0.5 kg/ha at 10 DAS, atrazine 0.5 kg/ha at 15 DAS, atrazine 0.5 kg/ha at 20 DAS, atrazine 0.5 kg/ha + halosulfuron 0.09 kg/ha at 10 DAS, atrazine 0.5 kg/ha + halosulfuron 0.09 kg/ha at 15 DAS, atrazine 0.5 kg/ha + halosulfuron 0.09 kg/ha at 20 DAS, atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 10 DAS, atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS, atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 20 DAS, atrazine 0.5 kg/ha + topamezone 0.118 kg/ha at 10 DAS, atrazine 0.5 kg/ha + topamezone 0.118 kg/ha at 15 DAS and atrazine 0.5 kg/ha + topamezone 0.118 kg/ha at 20 DAS. The result were analyzed taking consideration of weed parameters such as weed density, weed dry matter, weed control efficiency and plant parameter such as plant population, plant dry matter, plant height, harvest index and economics like as gross return, net return and B:C ratio. Weed control efficiency was calculated at 30 DAS using the following formula (Mani *et al.*, 1968).

The harvest index of both crops were calculated by dividing the economic yield (grain yield) by biological yield

Table-1 : Effect of herbicides on weed density in Maize at 30 DAS.

Treatment	Weed density (m ⁻²)				
	<i>Echinochloa colona</i>	<i>Dinebra retroflexa</i>	<i>Digera arvensis</i>	<i>Commelina benghalensis</i>	<i>Trianthema Portulacasirum</i> <i>Amaranthus Viridis</i>
Weedy check	9.56 (91.00)	5.61 (31.00)	5.33 (27.88)	4.00 (15.50)	3.07 (8.93)
Atrazine 0.5 kg ha ⁻¹ at 10 DAS	2.79 (7.30)	3.08 (9.00)	1.60 (2.06)	2.64 (6.50)	1.75 (2.55)
Atrazine 0.5 kg ha ⁻¹ at 15 DAS	3.28 (10.25)	3.71 (13.25)	1.99 (3.45)	2.91 (8.00)	1.87 (3.00)
Atrazine 0.5 kg ha ⁻¹ at 20 DAS	3.53 (12.00)	3.77 (13.75)	2.77 (7.15)	3.12 (9.25)	1.91 (3.15)
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 10 DAS	2.53 (5.93)	3.00 (8.50)	1.46 (1.64)	2.45 (5.50)	1.48 (1.69)
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 15 DAS	2.80 (7.35)	2.83 (7.50)	1.84 (2.90)	2.66 (6.50)	1.87 (3.02)
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 20 DAS	3.73 (13.40)	3.50 (11.73)	2.20 (4.33)	2.87 (7.75)	2.02 (3.57)
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 10 DAS	1.68 (2.33)	1.59 (2.02)	0.71 (0.00)	1.96 (3.36)	1.84 (2.88)
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 15 DAS	1.42 (1.52)	1.35 (1.33)	0.71 (0.00)	1.39 (1.43)	1.15 (0.83)
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 20 DAS	1.45 (1.60)	1.51 (1.78)	1.25 (1.08)	1.53 (1.83)	1.49 (1.73)
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 10 DAS	1.68 (2.33)	1.59 (2.03)	0.90 (0.38)	1.99 (3.46)	1.75 (2.55)
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 15 DAS	1.43 (1.55)	1.37 (1.38)	1.00 (0.67)	1.45 (1.60)	1.46 (1.63)
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 20 DAS	1.64 (2.20)	1.58 (2.00)	1.25 (1.07)	1.84 (2.88)	1.63 (2.15)
SEm +	0.06	0.04	0.10	0.05	0.02
LSD(P=0.05)	0.17	0.11	0.30	0.14	0.07

(* $\sqrt{x}$ 0.5 Transformed values and Data in parenthesis are original values)

Table-2 : Effect of herbicides on weed dry matter in Maize at 30 DAS.

Treatment	Weed dry matter (g m ⁻²)					
	<i>Echinochloa colona</i>	<i>Dinebra retroflexa</i>	<i>Digera arvensis</i>	<i>Commelina benghalensis</i>	<i>Trianthema portulacastrum</i>	<i>Amaranthus Viridis</i>
Weedy check	47.73	16.26	14.48	8.11	4.70	3.71
Atrazine 0.5 kg ha ⁻¹ at 10 DAS	3.83	4.72	1.09	3.42	1.33	0.97
Atrazine 0.5 kg ha ⁻¹ at 15 DAS	5.38	6.95	1.81	4.19	1.56	1.68
Atrazine 0.5 kg ha ⁻¹ at 20 DAS	6.29	7.21	3.75	4.84	1.64	2.47
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 10 DAS	3.11	4.46	0.85	2.89	0.89	1.55
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 15 DAS	3.86	3.93	1.54	3.42	1.58	1.84
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 20 DAS	7.03	6.15	2.27	4.07	1.87	2.15
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 10 DAS	1.22	1.06	0.00	1.76	1.49	0.97
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 15 DAS	0.80	0.70	0.00	0.75	0.44	0.18
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 20 DAS	0.84	0.93	0.57	0.96	0.90	0.77
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 10 DAS	1.22	1.06	0.20	1.81	1.34	0.86
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 15 DAS	0.81	0.72	0.35	0.84	0.84	0.33
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 20 DAS	1.15	1.05	0.55	1.51	1.14	1.02
SEm +	0.52	0.14	0.13	0.15	0.04	0.10
LSD(P=0.05)	1.51	0.40	0.37	0.43	0.13	0.29

and expressed as percentage (Donald and Hamblin, 1976).

Results and Discussion

Effect on weeds : The data reflected that proportion of density of monocot to dicot weeds in weedy check plots at 30 DAS 1:0.31. Likewise the dry matter record in corresponding plots revealed that the monocot versus dicot weed proportion was 1:0.32 at 30 DAS. The magnitude of existence of monocot and dicot weeds indicated that the crop suffered stress from a mixed flora of weeds.

The results (Table-3). indicated that all herbicide treatments either alone or tank mix application caused marked reduction in weed density and dry matter of monocot, dicot and total weeds at 30 DAS. However, the trend of effects of weed control treatments was not similar for monocot and dicot weeds. Among weed control treatments, minimum weed density, weed dry matter of monocots, dicots and total weeds was observed under atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS. *Commelina benghalensis*, *Echinochloa colona*, *Trianthema portulacastrum*, *Dinebra retroflexa*, *Amaranthus viridis* and *Digera arvensis* were effectively controlled by post-emergence tank mix application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS. The results corroborate the findings of Stanzen *et al.* (2016) and Rana *et al.* (2017). The greatest weed control efficiency of monocots, dicots and total weeds (96.89, 97.32 and 96.99% respectively) was acquired by mixture of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS.

Effect on crop : Plant population of maize was not significantly affected by weed control treatments. It was clear from data in (Table-2) that combination of herbicide and herbicide alone have no significant influence on plant population at 30 DAS. The post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS recorded the highest plant height at 30 DAS (47.0 cm) which was higher to rest of the treatments. Compared to weedy check, this weed control treatments resulted in 39.3% increase in plant height. The maximum dry matter was accumulated by plants when weeds were controlled by atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS (18.04 g/plant). However, the statistical analysis revealed that it was at par with atrazine 0.5 kg/ha + topamezone 0.118 kg/ha at 15 DAS (17.83 g/plant), atrazine 0.5 kg/ha + topamezone 0.118 kg/ha at 20 DAS (17.05 g/plant), atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 20 DAS (17.00 g/plant), atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 10 DAS (16.53 g/plant) and atrazine 0.5 kg/ha + topamezone 0.118 kg/ha at 10 DAS (16.33 g/plant). The result also have been reported by Singh *et al.* (2012), Rao *et al.* (2009), Nazreen and Subramanyam (2017).

Table-3 : Effect of treatments on weed density (No./m²), weed dry matter (g/m²) and weed control efficiency (%) at 30 DAS in maize.

Treatments	Weed density*			Weed dry matter			Weed control efficiency		
	Monocot weeds	Dicot weeds	Total weeds	Monocot weeds	Dicot weeds	Total weeds	Monocot weeds	Dicot weeds	Total weeds
Weedy check	11.75 (137.50)	6.67 (43.95)	13.49 (181.45)	72.11	22.90	95.01	0.00	0.00	0.00
Atrazine 0.5 kg ha ⁻¹ at 10 DAS	4.83 (22.80)	2.63 (6.43)	5.45 (29.23)	11.97	3.39	15.35	83.40	85.20	83.85
Atrazine 0.5 kg ha ⁻¹ at 15 DAS	5.66 (31.50)	3.19 (9.65)	6.45 (41.15)	16.52	5.05	21.57	77.08	77.94	77.29
Atrazine 0.5 kg ha ⁻¹ at 20 DAS	5.96 (35.00)	3.94 (15.00)	7.11 (50.00)	18.34	7.85	26.20	74.56	65.71	72.43
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 10 DAS	4.52 (19.93)	2.61 (6.30)	5.17 (26.22)	10.45	3.29	13.74	85.47	85.65	85.52
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 15 DAS	4.67 (21.35)	3.14 (9.39)	5.59 (30.74)	11.21	4.96	16.17	84.44	78.34	82.97
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 20 DAS	5.78 (32.88)	3.53 (12.00)	6.74 (44.87)	17.24	6.29	23.54	76.05	72.51	75.22
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 10 DAS	2.87 (7.71)	2.28 (4.72)	3.59 (12.43)	4.04	2.46	6.50	94.39	89.26	93.16
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 15 DAS	2.18 (4.27)	1.29 (1.17)	2.44 (5.44)	2.24	0.62	2.85	96.89	97.32	96.99
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 20 DAS	2.39 (5.21)	2.18 (4.27)	3.16 (9.47)	2.73	2.24	4.97	96.21	90.20	94.76
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 10 DAS	2.88 (7.82)	2.25 (4.59)	3.59 (12.40)	4.10	2.40	6.49	94.31	89.51	93.17
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 15 DAS	2.24 (4.53)	1.83 (2.92)	2.81 (7.44)	2.37	1.52	3.89	96.71	93.38	95.90
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 20 DAS	2.75 (7.08)	2.39 (5.20)	3.57 (12.28)	3.71	2.71	6.42	94.85	88.15	93.23
SEm +	0.05	0.07	0.06	0.51	0.16	0.50	NA	NA	NA
LSD(P=0.05)	0.16	0.20	0.18	1.50	0.47	1.47			

(*√x 0.5 Transformed values and Data in parenthesis are original values); NA: Not analysed.

Table-4 : Effect of herbicides on plant population, plant height (cm), plant dry matter (g/plant) at 30 DAS and economics of maize.

Treatment						
Plant population	Plant height	Plant dry matter	Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	B : C ratio	
Weedy check	33.7	11.33	43788	20690	0.90	
Atrazine 0.5 kg ha ⁻¹ at 10 DAS	45.1	12.27	73340	49332	2.05	
Atrazine 0.5 kg ha ⁻¹ at 15 DAS	46.1	13.80	64380	40372	1.68	
Atrazine 0.5 kg ha ⁻¹ at 20 DAS	44.2	14.17	67605	43597	1.82	
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 10 DAS	35.6	7.33	61819	30311	0.96	
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 15 DAS	35.3	7.27	62369	30861	0.98	
Atrazine 0.5 kg ha ⁻¹ + Halosulfuron 0.09 kg ha ⁻¹ at 20 DAS	39.0	7.53	69143	37635	1.19	
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 10 DAS	43.5	16.53	92143	64813	2.35	
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 15 DAS	47.0	18.04	98635	71009	2.57	
Atrazine 0.5 kg ha ⁻¹ + Tembotrione 0.125 kg ha ⁻¹ at 20 DAS	41.9	17.00	94059	66433	2.40	
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 10 DAS	39.0	16.33	92677	65026	2.35	
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 15 DAS	41.9	17.83	89361	61710	2.23	
Atrazine 0.5 kg ha ⁻¹ + Topramezone 0.025 kg ha ⁻¹ at 20 DAS	44.3	17.05	88589	60938	2.20	
SEm +	1.5	0.59	3789	3789		
LSD(P=0.05)	4.5	1.73	11061	11061		

Economics : Compared to weedy check, all the weed management treatments resulted in significantly higher gross and net returns from the maize crop. However, the magnitude increase in net returns varied. The maximum net return (71009/ha) were realised by applying atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS, which was 243.2% higher over weedy check. Net returns obtained through these treatments were higher over rest of the treatments which was at par with atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 20 DAS (66433/ha), atrazine 0.5 kg/ha + topamezone 0.118 kg/ha at 10 DAS (65026/ha), atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 10 DAS (64813/ha), at 15 DAS (61710/ha) and 20 DAS (60938/ha). The data revealed that all the herbicides applied either singly or as mixtures resulted in significantly high net returns over weedy check. Further, these herbicide mixtures applications gave significantly higher net returns over other applied herbicides.

The economic analysis of treatments in term of B C ratio revealed that all the weed control treatments tended to surpass weedy check. Alike net returns, the highest B C ratio (2.57) was obtained by controlling the weeds through atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS. However, the B C ratio obtained through atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 20 DAS (2.40), atrazine 0.5 kg/ha + topamezone 0.118 kg/ha at 10 DAS (2.35), atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 10 DAS (2.35) were at par. The weedy check lagged behind rest all the herbicidal weed control treatments. This is in accordance with findings of Sivamurugan *et al.* (2017) and Akhtar *et al.* (2017).

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Awareness Regarding Self-Defense among School Going Girls

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Abstract

Self-defense training in today's competitive world has taken very significant place to protect the female girls from any violence occurring to them. In today's situation teenage girls going to any places without any safety measures is one of the risk factors in society. Nurturing a sense of awareness in adolescents, providing knowledge of how to meet life's challenges and encouraging and reinforcing healthy choices help them develop the social competence and self-confidence. This study was conducted with the aim to assess the awareness regarding self-defense of school going girls of Udaipur, Rajasthan. The sample was selected purposively from four schools within the municipal limits of Udaipur city, having the similar infrastructural facilities. Standardized self-structured questionnaire was used to find out the awareness regarding self-defense of school going girls. The findings of the study revealed that, in case of physical aspect and psycho-social aspect, majority the school going girls were having medium level of awareness regarding self-defense. But in case of economic aspect, majority respondents were having low level of awareness regarding self-defense. In case of overall awareness level, majority of respondents were having medium level of awareness regarding self-defense. The results are in line with the study conducted by Mathew and Pillai (2016) depicted that more adolescents girls were aware about their self-protection but unfortunately not practicable to the current situation faced in Indian scenario.

Key words : Awareness, self-defense, physical aspect, psycho-social aspect, economic aspect.

Introduction

"Is there anything we can do to protect today's girls from physical and sexual victimization?" is a common arising question troubling many 21st-century feminists. Such a question has particular saliency when we acknowledge that, despite half a century of activism, the rates of violence against women show little signs of abating. As awareness of the prevalence of sexual abuse and violence has grown, more recognition has been given to the vulnerabilities faced by young girls in particular. The sexual assault of girls in childhood and adolescence is widely accepted as being of high prevalence (Finkelhor *et al.*, 2014) and often linked to inflated risks of experiencing repeat victimization (Filipas and Ullman, 2006; Messman Moore and Long, 2003). Adolescent years are identified as particularly risky for many, when sexual assault can occur by the hands of both close adults and peer group members, resulting in commonly cited risk of sexual violence for adolescent girls' prevalence rates as one in four for girls (Finkelhor *et al.*, 2014). Extensive social, physical and mental health impacts can result and manifest in a variety of ways including sexual risk-taking, depression, and posttraumatic stress disorder (McFarlane *et al.*, 2005; Ullman and Brecklin, 2002). The severity of the consequences leads to growing emphasis on the importance of awareness-raising education and prevention efforts to school going girls (Young *et al.*,

2009). The obvious here question arises, "How, when, where women and girls expected to learn how to resist?" Here for solution of these situation, self-defense count as a great option. They should be made aware of the provision of services for the victims like counselling, free legal aid, financial benefit for their help and support. Self-defence is considered as the most important education that woman needs in the current world (Panda and Tiwari, 2022). Self-defense would enable the girls to learn clear strategies that would help to keep them safe as well as to support other people victimized by violence and abuse. Also, the extensive research on the effectiveness of empowerment-focused self-defense courses has yielded enormously positive outcomes. These include improvements in self-esteem, self-efficacy, assertiveness and physical self-defense skills as well as reduced levels of fear (Brecklin, 2008; Brecklin and Ullman, 2005; Hollander, 2004, 2014; Orchowski, Gidycz, and Raffle, 2008).

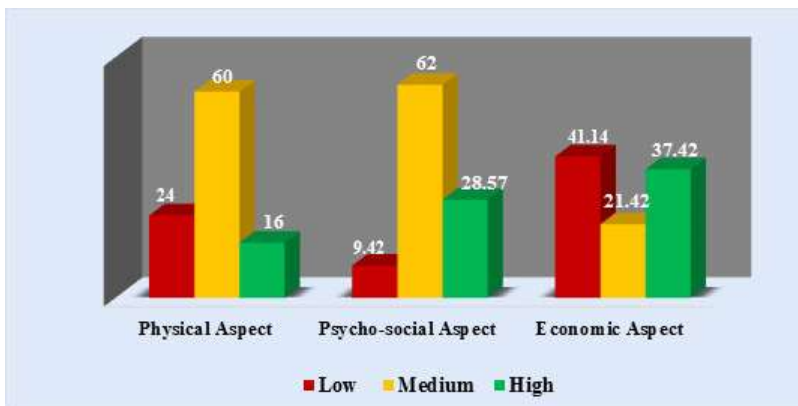
Materials and Methods

The present study was conducted in four government schools located within the municipal limits of Udaipur city of Rajasthan to ensure optimum personal contacts for data collection. The sample for the study was comprised of 350 school going girls belonging to 6th, 7th and 8th classes of selected government (middle and higher secondary schools). The data were collected from sample

Table-1 : Aspect wise distribution of the respondents on the basis of awareness regarding Self-defense. (N=350)

S. No.	Aspects of Awareness regarding Self-defense	Low	Medium	High
1.	Physical Aspect	84 (24.00)	210 (60.00)	56 (16.00)
2.	Psycho-Social Aspect	33 (9.42)	217 (62.00)	100 (28.57)
3.	Economic Aspect	144 (41.14)	75 (21.42)	131 (37.42)

Figures in parenthesis indicate percentage.

**Fig.-1 : Aspect wise distribution of the respondents on the basis of awareness regarding Self-defense.**

by administering self-constructed structured scale consisted of background information and Awareness Scale regarding Self-Defence (ASSD). Then the data were subjected to frequency and percentages analysis to measure the levels of awareness of school-going girls regarding self-defence.

Results and Discussion

The data in table-1 presents the aspect wise distribution of the respondents on the basis of awareness regarding Self-defense which is also portrayed in the graphical representation given in Fig. 1. The results depicted that in case of physical aspect, majority (60.00 %) of the school going girls were having medium level of awareness regarding self-defense followed by 24.00 per cent were having low level of awareness and 16.00 per cent were having high level of awareness respectively. Regarding psycho-social aspect, majority (62.00 %) of the school going girls were having medium level of awareness regarding self-defense followed by 28.57 per cent were having high level of awareness and 9.42 per cent were having low level of awareness regarding self-defense respectively. In case of economic aspect, 41.14 per cent respondents were having low level of awareness regarding self-defense followed by 37.42 per cent and 21.42 per cent were having high and medium level of awareness regarding self-defense respectively.

The reason could be behind this, the respondents were concerned about their safety but Information on the strategies to be safe in any situation is very scarce and difficult to obtain also the respondents were had the misconception that getting self-defense classes is

expensive. The present research findings are in line with the previous research done by Abeid *et al.*, 2014 that, there is a clear connection between safety and security of young women with economic status which ultimately rooted in conditions of poverty, disadvantage and lack of opportunity. Adeogun *et. al.*, 2016 concluded in their research that most women who showed interested in learning self-defense, they faced common barriers like logistical issues, such as time, expense, and the availability of classes.

The data in table-2 presents the percentage distribution of the respondents on the basis of level of awareness regarding self-defense which is also portrayed in the graphical representation given in Fig. 2. The result from the table-2 indicated that majority (76.29 %) of respondents were having medium level of awareness regarding self-defense followed by 15.42 per cent were having high level of awareness level and 8.28 per cent were having low level of awareness regarding self - defense.

The results are in line with the study conducted by Binsu and Pillai (2016) depicted that adolescent girls were aware about their self-protection but unfortunately not practicable to the current situation faced in Indian scenario. According to research done by Kaur (2015), girl students still do not possess adequate knowledge or information about their safety. Shockingly revealing is the lack of preparedness of girls for their safety as the results show that majority of them had never taken any training in self-defense though each one of them hiring cab or auto at night, carry a mobile (rather a smartphone), still many of them do not have emergency or the helpline numbers

Table-2 : Distribution of the respondents on the basis of Level of Awareness regarding Self-defense. (N=350)

S. No.	Levels of Awareness regarding Self-defense	Frequency	Percentage
1.	Low Awareness Level	29	8.28
2.	Medium Awareness Level	267	76.29
3.	High Awareness Level	54	15.42

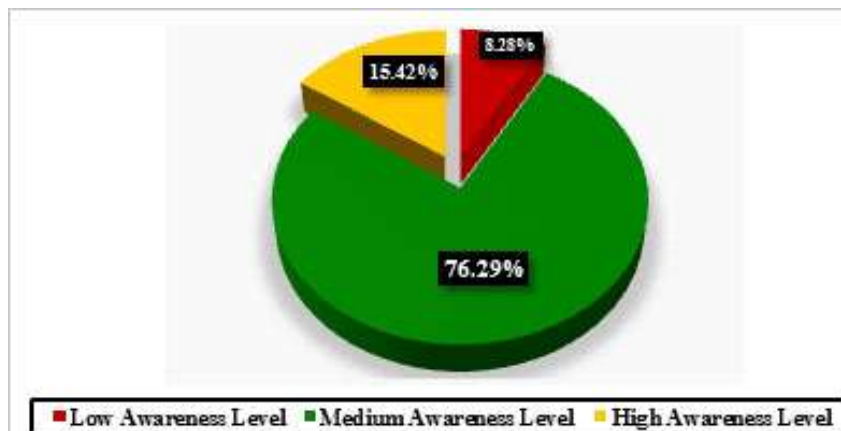


Fig.-2 : Distribution of the respondents on the basis of Level of Awareness regarding Self-defense.

on their speed dial. Even the institutes from where they have passed out or where they are continuing their studies do not do any self-defense training organized any seminar or any awareness program on women safety.

Conclusions

Proclamations of growing gender equality are undermined by the prevalence of violence against women, spousal homicide statistics, and the unrelenting objectification and sexualization of female bodies (Hatton and Trautner, 2013; Szymanski *et al.*, 2011). The self-defense courses emerge as a vital strand contributing in both direct and indirect ways for prevention of physical and sexual violence. Girls and women need education and training to be able even to recognize the wide range of controlling and victimizing behaviors they experience, let alone know how to resist them. Just as we teach children road safety to help them negotiate traffic, we need to teach girls and women relationship safety to help them negotiate life. Unlike much safety advice which may limit women's freedom, self-defense seeks to expand knowledge about the various laws and incorporating self-defence training sessions in the school curriculum for adolescent girls can help empower girls in the future (Panda and Tiwari, 2022).

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Efficacy of Fungicides Against Powdery Mildew of Pea Incited By *Erysiphe polygoni* DC.

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Abstract

Pea is an important vegetable crop grown in the cool season through the world. It belongs to family *Leguminosae* and sub family *Papilionaceae*. The central Asia was regarded as the birth place of all legumes including pea whereas Asia Secondary Centre of origin. Powdery mildew of pea caused by *Erysiphe polygoni*. Major symptoms of powdery mildew disease is the presence of white floury patches appeared on the leaves as well as stems, tendrils, pods and in the severe condition its cover whole plant parts except root region and finally plant become older. The symptoms almost covered the whole plant become comparatively greyish brown and the infected parts convey dull appearance. In extreme or in severe condition the infected leaves, pods were fall down from plant. The experiment for efficacy of chemicals against the disease conducted at farm of SKNCOA, Jobner during Rabi season 2021. Six treatments with one control viz. Hexaconazole, Tebuconazole, Propiconazole, Bupirimate, Wettable sulphur and Copper oxychloride were applied as foliar spray. From the results, it is evident that all the treatments exhibited effectiveness over the powdery mildew of pea. However, among the treatments, Hexaconazole found to be the most effective fungicide performing better than others in controlling powdery mildew disease of pea.

Introduction

Pea (*Pisum sativum* L.), a beneficial agricultural crop belongs to the *Leguminosae* family, has possible to withstand icy temperature which is widely cultivated across the world (Tulbek *et al.*, 2017). Pea is a rabi season crop and favourable temperature for pea is 21 to 28°C for its growth and production.

The vegetable pea fits to the family (Fabaceae) *Leguminosae*. "*Pisum sativum* L." sub species "*Hortense*" initiated from common field pea. *Pisum sativum* sub species "*arvense*" is considered to be native to Ethiopia, the Mediterranean and Central Asia. It has chromosome number $2n=14$.

Pea was originated from Southwestern Asia, possibly in Northwestern India, Pakistan or adjacent areas of former USSR and Afghanistan.

Frost can harm the plants during flowering stage. High humidity gloomy weather condition results into feast of fungal diseases like damping-off and powdery mildew. Right temperature for growth of pathogen at 13-18°C.

Pea is generally cultivated for the fresh green seeds, tender green pods, dried seeds and foliage and cooked as a vegetable market fresh. Pea can be canned and frozen. Dry pea is used as whole, split as dal, boiled and made into flour. Pea crop has great agronomic value. Pea plant root contain nitrogen fixating bacteria (*Rhizobium* bacteria) and its increase soil fertility.

Powdery mildew is the major disease of pea throughout the world. Powdery mildew is the air borne

disease worldwide distribution in severe form it reduces 24-27% pod weight, 21-30% pod number and up to 70% reduction in total yield loss.

Major effect of Powdery mildew found on the plant at maturity stage, during pod formation stage, generally its cover whole plant in severe form except root. it is severe in dry weather condition unlike the downy mildew severe in wet weather condition. Late sowing varieties more damage and early varieties more damage. Varieties maturing in January month escape the maximum intensity of the disease. It is serious fungal disease and it occurs almost every year in severe epidemic form, during hot and dry climate and night temperature at or below the dew point.

Materials and Methods

Efforts were made to manage the disease by applying foliar application of fungicides. Following fungicides were used as along with control. Field experiment was conducted during Rabi 2021. Sowing was done in the last week of November using local cultivar of pea in randomized block design with 7 treatments including control in three replications.

Table-1 : List of fungicides.

Treatment	Name fungicides	Concentration (%)
T ₁	Hexaconazole	0.1
T ₂	Tebuconazole	0.1
T ₃	Propiconazole	0.1
T ₄	Bupirimate	0.1
T ₅	Wettable Sulphur	0.2
T ₆	Copper oxychloride	0.1
T ₇	Control	-

Table-2 : Effect of fungicides on powdery mildew of pea under natural field condition.

Treatment	Fungicide	Concentration (%)	*PDI	Per cent disease control
T ₁	Hexaconazole	0.1	13.85 (21.85)	76.55
T ₂	Tebuconazole	0.1	29.55 (32.93)	49.97
T ₃	Propiconazole	0.1	18.68 (25.61)	68.38
T ₄	Bupirimate	0.1	32.46 (34.73)	45.05
T ₅	Wettable sulphur	0.2	20.35 (26.81)	65.55
T ₆	Copper oxychloride	0.1	35.16 (36.37)	40.48
T ₇	**Control	-	59.07 (50.23)	0.00
	SEm+		1.03	
	CD (P=0.05)		3.17	

*Average of three replication, **Untreated

Figure in parenthesis are angular transformed values

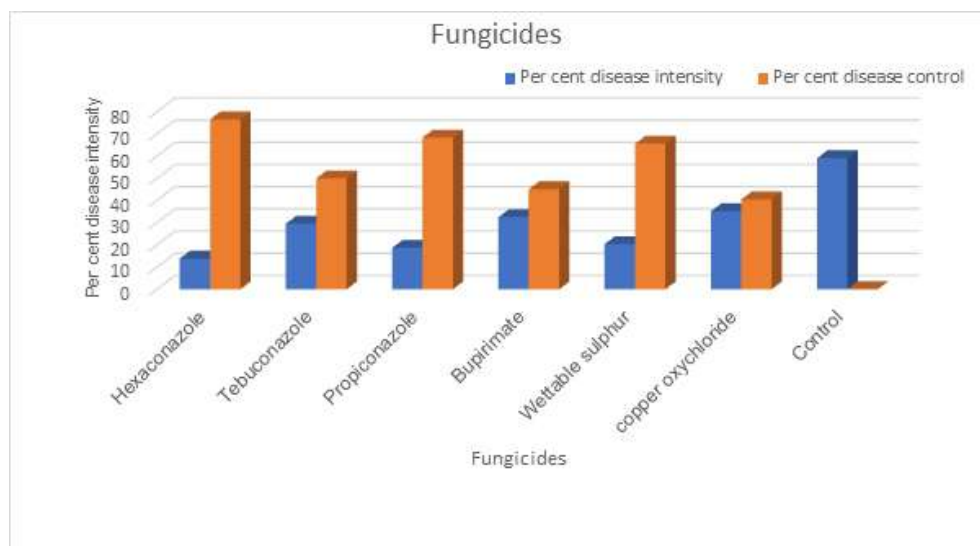


Fig.-1 : Effect of fungicides on powdery mildew of pea under natural field condition.

Applications of fungicides were done by two foliar, first at 45 DAS and second at 75 DAS. Per cent disease intensity was recorded after 15 days of second spray by examining 20 leaves from 10 randomly selected plants per plot starting from the initiation of disease using 0-5 rating scale.

Results and Discussion

The efficacies of fungicides were assessed for management of powdery mildew of pea by spraying two times (first at before disease appearance and second at after disease appearance) at 45 days and 75 days after sowing under field condition.

Per cent disease intensity discovered that all the fungicide were significantly effective in falling the powdery mildew disease intensity over control (58.31 per cent). The minimum 13.85 per cent disease intensity was noted with the application of Hexaconazole by decreasing 76.55 per cent disease intensity. The second-best fungicide was Propiconazole with 18.68 per cent disease intensity by decreasing 68.38 per cent disease intensity over control.

Wettable sulphur, Tebuconazole and Bupirimate with 20.35, 29.55 and 32.46 per cent disease intensity by decreasing 65.55, 49.97 and 45.05 per cent disease intensity over control (58.307 per cent). Maximum disease intensity was observed of Copper oxychloride with 35.16 per cent disease intensity over control.

Among six fungicides, hexaconazole was found minimum 13.85 per cent disease intensity with two foliar spray and its decreased 76.55 per cent disease intensity over control and second best recorded propiconazole with 18.68 per cent disease intensity.

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Genetic Variability Assessment in Garlic (*Allium sativum* L.) Genotypes

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Abstract

The present investigation was conducted to estimate genetic variability analysis among 24 genotypes of garlic for fifteen characters comprised of bulb yield and its contributing characters. These genotypes were planted in Randomized Block Design with three replications during *Rabi* season, 2019-20 at SKN College of Agriculture, Jobner. On the basis of mean performance, the genotype Agrifound Parvati-2 was the highest yielder followed by HG-17, G-386 and JWRG-1. These genotypes may further be utilized in breeding programme aimed at improving bulb yield of garlic. Analysis of variance indicated presence of considerable variability for all the fifteen characters. High GCV and PCV were observed for clove length, pyruvic acid, clove girth, clove weight, cloves per bulb, neck thickness, equatorial diameter. High estimates of heritability along with high genetic advance as per cent of mean was observed for pyruvic acid, clove length, clove girth, plant height, clove weight, equatorial diameter, chlorophyll content, neck thickness, polar diameter, clove per bulb. Therefore, these characters can aid in selection programme.

Key words : *Allium sativum*, garlic, variability, heritability, genetic advance, GCV and PCV

Introduction

Garlic (*Allium sativum* L.) is one of the most important remunerative bulbous spice and medicinal crops grown in world. It is the second most widely cultivated bulb crop after onion, which belongs to family Amaryllidaceae, with diploid chromosome number 16. The primary centre of origin of garlic is Central Asia and Southern Europe whereas, Mediterranean region is considered as its secondary centre of origin (Brewster, 1994). The most probable wild progenitor of garlic is *Allium longicuspis* Regel (Vvedensky, 1944). The crop has been recognized as a valuable spice and condiment throughout India imparting flavour, aroma and taste. It is consumed both fresh and in dried form. In India and other Asian and Middle East countries, garlic is used for food preparation, chutney, pickles, curried vegetables, meat preparation and tomato ketchup etc (Shinde *et al*, 2003). In many regions, people use fresh leaves as salad. Garlic has high nutritive value than other bulb crops and has good export potential as fresh bulb as well as in the dehydrated form.

Study of variability is the most important aspect for improvement in yield of any crop. Garlic displays considerable variability with respect to morphological traits, yield, quality attributes as well as resistance to important insect pests and diseases. It also reflects adaptation to wide range of soil types, temperature and day length, making its farming possible from tropical to temperate regions.

The information regarding magnitude of variability

present in a particular crop is an important pre-requisite to initiate any systematic breeding programme. Genetic variation is helpful in selection of suitable genotypes for any breeding programme. The adequacy of genotype collection is determined by the amount of genetic variability present in that genotype.

Materials and Methods

The experiment was laid out at Horticulture farm, SKN College of Agriculture, Jobner (Jaipur) (Rajasthan). during "*rabi*" season of 2019-20. Twenty-four genotypes of garlic used in the present experiment were collected from NHRDE, Karnal, HAU, Hissar and CHF, Jhalawar. The experiment was laid out in randomized complete block design with three replications and each replication consisting of twenty-four genotypes. The seeds material (cloves) were planted in row at 15 cm apart by hand dibbling method and spacing within the row was maintained, 10 cm. The standard cultural practices as mentioned in package of Practices for Vegetables crops by Thamburaj and Singh were followed to raise the healthy crop stand. Five plants were randomly selected from each genotype and following observations were recorded for plant height, leaves per plant, chlorophyll content, equatorial diameter, polar diameter, neck thickness, clove length, clove girth, cloves per bulb, clove weight, bulb weight, days to maturity, bulb yield, TSS & pyruvic acid content in garlic bulb. The variability parameters were estimated by Panse and Sukhatme (1978), co-efficient of variation was calculated by Burton (1952), Heritability in broad sense and genetic advance

were estimated by the following formula given by Johnson *et al.* (1955) [8] and Allard (1960) [1] respectively.

Results and Discussion

Analysis of Variance : The analysis of variance had significant variability for all the attributes among different genotypes of garlic. The estimates of mean sum square due to genotypes (MSg) were highly significant for all the 15 characters *i.e* plant height, leaves per plant, chlorophyll content, equatorial diameter, polar diameter, neck thickness, clove length, clove girth, cloves per bulb, clove weight, bulb weight, days to maturity, bulb yield, TSS & pyruvic acid content in garlic bulb (Table 4.1), indicating the presence of genetic variability. Similar findings were reported earlier by Alam *et al.* (2010), Tsega *et al.* (2011), Panse *et al.* (2013), Khar *et al.* (2015), Kumar *et al.* (2015), Bhatt *et al.* (2017), Raja *et al.* (2017), Mishra *et al.* (2018) and Hussien *et al.* (2019).

Coefficient of variation : The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the characters studied. The phenotypic coefficient of variation varied from 5.26% for days to maturity to 21.84% for clove length. Data mentioned in Table-2 clearly indicated that high coefficient of variations were recorded for clove length (21.84) followed by clove girth (20.19), pyruvic acid (19.39), clove weight (14.22), cloves per bulb (14.10), neck thickness (13.95), equatorial diameter (13.83), plant height (12.88), polar diameter (12.31), chlorophyll content (12.24), bulb yield/ha (11.79), bulb weight (11.77), number of leaves (11.09), TSS (6.00) and days to maturity (5.26). The data presented in same Table-2 clearly revealed that highest genotypic coefficient of variation was observed for clove length (20.14) followed by pyruvic acid (19.17), clove girth (18.21), clove weight (13.21), plant height (12.78), equatorial diameter (12.77), neck thickness (12.22), chlorophyll content (11.87), cloves per bulb (11.78), polar diameter (11.31), bulb weight (10.62), bulb yield/ha (10.58), number of leaves (10.33), TSS content (5.25) and days to maturity (4.14). In contrast high and significant variation was reported earlier for most of the traits by Hosamani *et al.* (2010); for bulb diameter by Awale *et al.* (2011); for plant height, average bulb weight and bulb yield by Dubey *et al.* (2010), Khar *et al.* (2015), Pyasi and Tiwari (2016), Sabir *et al.* (2017); for clove weight, bulb weight, bulb polar diameter, bulb equatorial diameter and number of cloves per bulb by Dewangan and Sahu (2012), Singh *et al.* (2012 b), Raja *et al.* (2017); for number of cloves per bulb, total soluble solids (TSS) by Mishra *et al.* (2018), Esho (2015), Hussien *et al.* (2019). Thus Phenotypic coefficient of variation indicates that selection based on phenotypic performance would be rewarding.

Heritability : Heritability denotes the proportion of genetically controlled variability expressed by a particular character or a set of characters which are very important biometrical tools for guiding plant breeders for adoption of appropriate breeding procedures. In the present investigation the heritability estimates were very high for most of the characters except days to maturity.

The results obtained from the present investigation reported high heritability for plant height, pyruvic acid, chlorophyll content, number of leaves, clove weight, equatorial diameter, clove length, polar diameter, bulb weight, clove girth, bulb yield/ha, neck thickness, TSS content, cloves per bulb. Similar, estimates of high heritability have been reported by different workers such as for High heritability was observed for plant height, average weight of cloves, yield per hectare, leaf length, equatorial diameter and average weight of bulbs by Pyasi and Tiwari (2016), Sabir *et al.* (2017); for clove weight, bulb weight, bulb polar diameter, bulb equatorial diameter and number of cloves per bulb by Dewangan and Sahu (2012), Raja *et al.* (2017); for number of cloves per bulb, total soluble solids (TSS) by Esho (2015), Mishra *et al.* (2018) and Hussien *et al.* (2019).

Genetic advance : Genetic advance helps in predicting the extent of improvement that can be achieved for improving the different characters. The estimated values of genetic advance as percentage of mean were classified in to three groups which includes high (more than 40%), moderate (15-40%) and low (less than 15%). In the present experiment, the moderate estimate of genetic advance as percentage of mean was observed in characters like pyruvic acid, clove length, clove girth, plant height, clove weight, equatorial diameter, chlorophyll content, neck thickness, polar diameter, clove per bulb, number of leaves, bulb weight, bulb yield/ha. Whereas the low estimate of genetic advance as percentage of mean was observed for TSS content and days to maturity.

High genetic advance as recorded in the present investigation was earlier reported for clove width, plant height, leaf length, yield per plant, cloves per bulb, average clove weight by Kassahun *et al.* (2010), Dhall and Brar (2013), Vatsyayan *et al.* (2013), Sabir *et al.* (2017); for number of leaves per plant & total yield by Hussien *et al.* (2019); for bulb yield, cloves per bulb, polar and equatorial diameter of bulbs by Dubey *et al.* (2010).

However, moderate genetic advance as recorded in the present investigation was earlier reported for number of leaves per plant, plant height, neck thickness and TSS content by Singh *et al.* (2010).

Heritability and genetic advance : Heritability with genetic advance provide more reliable information about

Table-1 : Mean sum of square for all characters in garlic genotypes.

S. No.	Plant Character	Replication (d.f. = 2)	Genotype (d.f. = 23)	Error (d.f.=46)
1.	Plant height(cm)	0.108	128.16**	0.648
2.	No. of Leaves	0.011	1.73**	0.084
3.	Chlorophyll (mg/g)	0.001	0.03**	0.001
4.	Equatorial diameter (cm)	0.075	0.95**	0.052
5.	Polar diameter (cm)	0.047	0.59**	0.034
6.	Neck thickness (cm)	0.001	0.03**	0.003
7.	Clove length (cm)	0.085	1.02**	0.057
8.	Clove girth(cm)	0.016	0.22**	0.016
9.	Cloves per bulb	1.054	9.32**	1.178
10.	Clove weight(g)	0.009	0.10**	0.005
11.	Bulb weight	0.846	13.62**	0.963
12.	Days to maturity	4.424	123.42**	20.962
13.	T.S.S.	1.979	12.35**	1.147
14.	Pyruvic acid (μ moles/g)	3.165	153.70**	1.185
15.	Bulb yield (q/ha)	0.875	602.03**	45.078

Where, d.f. - Degree of freedom, **Significance at 1%.

Table-2 : Mean, range, variance, genotypic and phenotypic coefficients of variation, heritability (broad sense) and genetic advance for yield and other attributes of garlic.

S.No.	Character	Mean	Range	GCV	PCV	Heritability (%)	GA	GA as % of Mean
1.	Plant height (cm)	50.97	39.68-60.38	12.78	12.88	98.49	13.33	26.13
2.	No. of Leaves	7.18	5.75-8.36	10.33	11.09	86.72	1.42	19.81
3.	Chlorophyll (mg/g)	0.88	0.66-1.02	11.87	12.24	93.94	0.21	23.69
4.	Equatorial diameter (cm)	4.30	3.15-5.45	12.77	13.83	85.28	1.04	24.3
5.	Polar diameter (cm)	3.80	3.08-4.53	11.31	12.31	84.52	0.81	21.43
6.	Neck thickness (cm)	0.84	0.61-1.01	12.22	13.95	76.76	0.18	22.07
7.	Clove length (cm)	2.82	1.76-3.96	20.14	21.84	85.02	1.08	38.26
8.	Clove girth (cm)	1.44	0.85-1.84	18.21	20.19	81.40	0.48	33.86
9.	Cloves per bulb	13.57	10.54-17.92	11.78	14.10	69.74	2.83	20.26
10.	Clove weight (g)	1.39	1.07-1.79	13.21	14.22	86.27	0.35	25.27
11.	Bulb weight	19.33	15.86-23.68	10.62	11.77	81.40	3.81	19.74
12.	Days to maturity	141.06	132-153	4.14	5.26	61.97	9.47	6.71
13.	T.S.S.	36.81	32.35-40.16	5.25	6.00	76.51	3.48	9.46
14.	Pyruvic acid (μ moles/g)	37.19	23.42-45.29	19.17	19.39	97.72	14.52	39.04
15.	Bulb yield (q/ha)	128.75	105.65-157.41	10.58	11.79	80.46	25.17	19.55

selection, the character showing high heritability with high genetic advance can be easily improved by selection.

In the present experiment high heritability with high genetic advance as percentage of mean was observed for bulb dry weight, bulb yield per plant, plant height, clove length, clove weight and cloves per bulb by Khar *et al.* (2015), Kumar *et al.* (2015) and Jethava *et al.* (2018); for

number of cloves per bulb, clove length, total soluble solids (TSS), clove width and bulb yield per plant by Mishra *et al.* (2018); for neck thickness, clove equatorial diameter by Singh *et al.* (2018).

High heritability and moderate genetic advance as per cent of mean was observed for number of leaves per plant, plant height, neck thickness and TSS content by

Singh *et al.* (2010), Sandhu *et al.* (2015); for stem diameter and bulb polar diameter by Yadav *et al.* (2012).

Conclusions

The analysis of variance found that high and significant difference among the genotypes of garlic for all the characters showing thereby considerable amount of genetic variability which were amenable for improvement. The estimate of mean sum square due to genotypes (MSg) were high and significant for all the characters of garlic. These characters indicating the presence of genetic variability in the garlic genotypes. The values of phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation (GCV) in general.

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Influence of Nutrients and Growth Regulators on The Quality of Pomegranate (*Punica granatum* L.) Cv. Ganesh

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Abstract

A study entitled “Influence of Nutrients and Growth Regulators on the Quality of Pomegranate (*Punica granatum* L.) cv. Ganesh” was carried out at Horticulture Farm Department of Horticulture, College of Agriculture, Choudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. The experimental plot was laid out in a randomized complete block design with three replications and ten treatments. The quality parameters such as Total soluble solids (%), Titratable acidity (%), Total sugars (%), Reducing sugar (%), Non-reducing sugar (%) and Sugar acid ratio over control were recorded during course of the investigation. The study results indicated that, the superior values for Total soluble solids (14.85%), Titratable acidity (0.54%), Total sugars (13.24%), Reducing sugar (11.87%), Non-reducing sugar (1.37%) and Sugar acid ratio (24.52) were recorded in a plant treated with T₇ treatment T₇-GA₃ (100ppm) Which was closely followed by treatment T₆-(GA₃ (75 ppm).

Key words : Pomegranate, Ganesh, TSS, Titratable acidity and GA₃ (75 and 100ppm).

Introduction

The pomegranate (*Punica granatum* L.), which belongs to the monogeneric Punicaceae family, is mainly found in Iran, where it is believed to have originated. Additionally, it is grown economically in nations such as India, Morocco, Spain, Egypt, Afghanistan, Myanmar, Japan, China, the United States, and Central Asia. Pomegranate has eight gametic chromosomes (Yasui., 1936). It is a well-known and well-loved fruit plant. Pomegranate is derived from the Latin name of the fruit, *Malum granatum*, which means “grainy apple.” Pomegranate is grown commercially in Maharashtra, Karnataka, Andhra Pradesh, Gujarat, Uttar Pradesh, Tamil Nadu and Rajasthan in India. In India, the total area under this fruit is currently 261 thousand hectare with an annual production of 2315 thousand MT (Anonymous, 2020). In Haryana, it covers an area of 216 hectare and produces 26.13 MT per year (Anonymous, 2020).

The adoption of an integrated nutrient management (INM) strategy is essential for preserving the health of the land and increasing the output of high-quality fruits. By maximizing the advantages from all potential sources of plant nutrients in an integrated manner, integrated nutrient management is the process of keeping soil fertility and nutrient availability to plants at an optimal level in order to retain intended agricultural output. As a result, it is a traditional approach in which we first determine what exactly is required by plants for optimum level of

production, in what different forms at what different timings in the best possible method and how best these forms can be integrated to achieve highest productivity levels with efficiency at economically acceptable limits in an environment friendly manner. Adopting strategies such as applying organic manures (such as FYM and vermicompost) and using bio fertilizers in addition to inorganic fertilizers can help accomplish integrated nutrient management (Muhammad et al., 2000).

Materials and Methods

The present investigation “Influence of Nutrients and Growth Regulators on the Quality of Pomegranate (*Punica granatum* L.) cv. Ganesh” were carried out on seven-year-old plants of Pomegranate cv. Ganesh at the Experimental orchard of Department of Horticulture, CCS Haryana Agricultural University, Hisar during the year of 2018-19 and 2019-20. The details related to materials used and methodologies adopted for the present study are described under the following headings. The detail of the treatments is: T₁ (control), T₂ CaNO₃ (1 %), T₃ CaNO₃ (3 %), T₄ CaNO₃ (5 %), T₅ GA₃ (50 ppm), T₆ GA₃ (75 ppm), T₇ GA₃ (1000 ppm), T₈ Borax (0.2 %), T₉ Borax (0.4 %) and T₁₀ Borax (0.6 %) with randomized block design with three replications (Panse and Sukthme, 1995). Foliar spray of GA₃ and nutrients was done on individual tree canopy with the help of Hand pump sprayer. Other cultural operations were attended regularly and timely in the experimental plot along with effective management of pest and disease during the experiment period. The first foliar

spray of GA₃ and nutrients was done at 3rd week of March and second was done at last week of May during both the year of 2018-19 and 2019-20, respectively. respectively. Quality parameters were analysed different methods i.e., Titratable acidity (%), Reducing sugar (%), Non-reducing sugar (%) and Sugar acid ratio :

$$\text{T.A. (\%)} = \frac{\text{Titre value} \times \text{Normality of NaOH} \times \text{Volume made up (ml)} \times \text{Eq. Wt. of acid}}{\text{Volume of sample taken for estimation} \times \text{weight of sample taken} \times 100}$$

$$\text{Reducint sugars (\%)} = \frac{\text{X} \times \text{Dilution factors}}{5 \times 1000} \times 100$$

$$\text{Sugar acid ratio} = \frac{\text{Total sugars in fruit (\%)}}{\text{Titrateable acidity in fruit (\%)}}$$

Results and Discussion

Quality attribute characters : Data pertaining to the effect of different nutrients and growth regulators application on total soluble solids has been presented in Table 1. Perusal of the data revealed that all the treatments of nutrients and growth regulators affected total soluble solids significantly during both the years of study.

During the year 2018-19, maximum total soluble solids (14.50 %) was observed with treatment T₇ i.e. GA₃ (100 ppm) followed by T₆ i.e. GA₃ (75 ppm), T₅ i.e. GA₃ (50 ppm) and T₁₀ i.e. Borax (0.6%) however minimum total soluble solids (13.07 %) was observed with treatment T₁ i.e. Control.

In the year 2019-20, maximum total soluble solids (14.85 %) was noticed in treatment T₇ i.e. GA₃ (100 ppm) which was significantly higher than all other treatments except statistically T₆ i.e. GA₃ (75 ppm) and T₅ i.e. GA₃ (50 ppm) while it was minimum with treatment T₁ i.e. Control (13.13 %).

Data present regarding to the effect of different nutrients and growth regulators treatments had significantly influence on titratable acidity during both the years (Table 1). During the year 2018-19, lowest titratable acidity (0.58 %) was observed in treatment T₇ i.e. GA₃ (100 ppm) which was found statistically at par with treatment T₆ i.e. GA₃ (75 ppm) while it was highest (0.84 %) observed in treatment T₁ i.e. Control.

During the year 2019-20, lowest titratable acidity (0.54 %) was noticed in treatment T₇ i.e. GA₃ (100ppm) while it was highest (0.83 %) in treatment T₁ i.e. Control. All the treatments significantly superior over the control.

Data pertaining to the effect of different nutrients and growth regulators treatment application on total sugar has been presented in Table 2. Perusal of the data revealed

that all the treatments affected total sugar significantly during both the years of study.

During the year 2018-19, maximum total sugar (13.14 %) was observed in treatment T₇ i.e. GA₃ (100 ppm) which remained statistically at par with treatments T₆ i.e. GA₃ (75 ppm) and T₅ i.e. GA₃ (50 ppm) whereas minimum total sugar (11.20 %) was observed in treatment T₁ i.e. Control.

During the year 2019-20, maximum total sugar (13.24 %) was observed in treatment T₇ i.e. GA₃ (100 ppm) which remained statistically at par with treatment T₆ i.e. GA₃ (75 ppm) and minimum total sugar (11.27 %) was observed in treatment T₁ i.e. Control.

Data pertaining to the effect of different nutrients and growth regulators treatment application on reducing sugar has been presented in Table 2. Perusal of the data revealed that all the treatments affected reducing sugar significantly during both the years of study. During the year 2018-19, maximum reducing sugar (11.80 %) was observed in treatment T₇ i.e. GA₃ (100ppm) which remained statistically at par with treatment T₆ i.e. GA₃ (75 ppm) however minimum reducing sugar (10.17 %) was observed in treatment T₁ i.e. Control. During the year 2019-20, maximum reducing sugar (11.87 %) was observed in treatment T₇ i.e. GA₃ (100ppm) which remained statistically at par with treatment T₆ i.e. GA₃ (75 ppm) and minimum reducing sugar (10.22 %) was observed in treatment T₁ i.e. Control.

The effect of different treatments of nutrients and growth regulators application on non- reducing sugar has been presented in Table 3. Perusal of the data revealed that all the treatments of nutrients and growth regulators influenced the non -reducing sugar significantly during both the years of study.

During the year 2018-19, maximum non-reducing sugar (1.29 %) was observed in treatment T₆ GA₃ (75 ppm) which remained statistically at par with treatments T₇ i.e. GA₃ (100 ppm), T₉ i.e. Borax (0.4 %) and T₁₀ i.e. Borax (0.6 %) and minimum (0.98 %) was observed in treatment T₁ i.e. Control.

During the year 2019-20, among the all treatment significantly superior improved. Maximum non-reducing sugar (1.37 %) was observed in treatment T₆ i.e. GA₃ (75 ppm) which remained statistically at par with treatments T₂ i.e. CaNO₃ (1 %) and T₉ i.e. Borax (0.4 %) while minimum (1.00 %) was observed in treatment T₁ i.e. Control.

The sugar: acid ratio of two seasons of Pomegranate as influenced by various nutrients and growth regulators treatments have been presented in Table 3. Perusal of the data showed that all the treatments of nutrients and

Table-1 : Effect of nutrients and growth regulators on total soluble solids and titratable acidity of pomegranate.

Treatment	Total Soluble Solids (%)		Titratable acidity (%)	
	2018-19	2019-20	2018-19	2019-20
T ₁ -Control	13.07	13.13	0.84	0.83
T ₂ -CaNO ₃ (1%)	13.58	13.70	0.81	0.78
T ₃ -CaNO ₃ (3%)	13.76	13.95	0.79	0.76
T ₄ -CaNO ₃ (5%)	13.85	14.05	0.76	0.73
T ₅ -GA ₃ (50ppm)	14.27	14.38	0.64	0.62
T ₆ -GA ₃ (75 ppm)	14.36	14.45	0.61	0.59
T ₇ -GA ₃ (100ppm)	14.50	14.85	0.58	0.54
T ₈ -Borax (0.2%)	13.98	14.13	0.70	0.67
T ₉ -Borax (0.4%)	14.03	14.20	0.74	0.71
T ₁₀ -Borax (0.6%)	14.13	14.25	0.67	0.65
SEm±	0.16	0.17	0.01	0.01
C.D. at 5%	0.46	0.51	0.04	0.03

Table-2 : Effect of nutrients and growth regulators on total and reducing sugars of pomegranate.

Treatment	Total sugars (%)		Reducing sugars (%)	
	2018-19	2019-20	2018-19	2019-20
T ₁ -Control	11.20	11.27	10.17	10.22
T ₂ -CaNO ₃ (1%)	11.45	11.95	10.21	10.52
T ₃ -CaNO ₃ (3%)	11.52	11.67	10.27	10.39
T ₄ -CaNO ₃ (5%)	11.56	11.87	10.39	10.61
T ₅ -GA ₃ (50ppm)	12.57	12.72	11.31	11.35
T ₆ -GA ₃ (75 ppm)	12.86	12.99	11.50	11.55
T ₇ -GA ₃ (100ppm)	13.14	13.24	11.80	11.87
T ₈ -Borax (0.2%)	11.85	12.03	10.56	10.70
T ₉ -Borax (0.4%)	12.17	12.34	10.85	10.92
T ₁₀ -Borax (0.6%)	12.41	12.53	11.11	11.17
SEm±	0.19	0.16	0.10	0.12
C.D. at 5%	0.58	0.47	0.31	0.36

Table-3 : Effect of nutrients and growth regulators on non-reducing sugars and sugar: acid ratio of Pomegranate.

Treatment	Non-reducing sugar (%)		Sugar/acid ratio	
	2018-19	2019-20	2018-19	2019-220
T ₁ -Control	0.98	1.00	13.33	13.58
T ₂ -CaNO ₃ (1%)	1.18	1.36	14.14	15.32
T ₃ -CaNO ₃ (3%)	1.19	1.22	14.58	15.36
T ₄ -CaNO ₃ (5%)	1.11	1.20	15.21	16.26
T ₅ -GA ₃ (50ppm)	1.20	1.30	19.64	20.52
T ₆ -GA ₃ (75 ppm)	1.29	1.37	21.08	22.02
T ₇ -GA ₃ (100ppm)	1.27	1.30	22.66	24.52
T ₈ -Borax (0.2%)	1.23	1.26	16.93	17.96
T ₉ -Borax (0.4%)	1.25	1.35	16.45	17.38
T ₁₀ -Borax (0.6%)	1.24	1.29	18.52	19.28
SEm±	0.02	0.02	0.23	0.29
C.D. at 5%	0.06	0.07	0.69	0.87

growth regulators influenced sugar: acid ratio significantly during both the years of study.

During the year 2018-19, highest sugar: acid ratio (22.66) was observed in treatment T₇ i.e. GA₃ (100 ppm) while lowest sugar: acid ratio (13.33) was observed in treatment T₁ i.e. Control.

During the year 2019-20, highest sugar: acid ratio (24.52) was noticed in treatment T₇- GA₃ (100ppm) and

lowest sugar: acid ratio (13.58) was observed in treatment T₁ i.e. Control. All the treatment statistically increased over the control.

Mineral nutrients and plant growth hormones affect production and fruit quality either directly or indirectly. Most effects are indirect and act via alteration of vigour and capacity, and thereby the partitioning of primary and secondary photosynthetic metabolites such as

carbohydrates, organic acids, proteins, growth regulators and flavour compounds (Taghliavini *et al.*, 2000).

The total soluble solids (TSS) and titratable acidity (TA) of fruits were significantly differed among the treatments. The higher total soluble solids and sugar/acid ratio was observed in the treatment GA₃ (100 ppm). As regards the TSS, gibberellins helped to increase it in this context. It may be the reason that the spraying of GA₃ has influenced the physiological processes, particularly respiration and photosynthesis, which ultimately leads to accumulation of more dry matter, minerals and carbohydrates in fruit. It might be due to the increased activity of amylase by application of GA₃ as reported by Pawar *et al.* (2005). The lowest acidity was recorded in treatment GA₃ (100 ppm). The reduction in acidity might be due to more accumulation of sugars in the fruit. The similar results were obtained by Eaida *et al.* (2013) and Hasani *et al.* (2012) in Pomegranate. Increase in the TSS might be due to more rapid translocation of sugars from leaves to developing fruits.

Fruit quality is one of the important goals in any production system besides targeting for maximum fruit yield per unit area. In Pomegranate, apart from average fruit weight, the quality is determined by total soluble solids, total sugars, reducing sugars and sugar: acid ratio. The results of the present experiment on improving the quality of Pomegranate fruits indicated that spraying GA₃ (100 ppm) had recorded the maximum total sugar and reducing sugar. This could be explained from the light of findings of Ghosh *et al.* (2009) reported that improvement in TSS of fruits due to GA₃ spray may be due to the fact that application of these growth regulators after fruit set probably improved the physiology of leaves, thereby causing better translocation of vital components in the fruit followed by assimilation and utilization of photosynthates by the developing fruit. The significant improvement in reducing sugar might be due to formation and translocation of carbohydrate which improves the fruit quality which was reported by Pathak and Mitra (2008) in litchi. These positive effects of boron on reducing sugar were also in agreement with the findings of Bhatt *et al.* (2012) in Mango.

Conclusions

On the basis of results obtained, it may be concluded that application of the treatments T7 GA₃ @ 100 ppm proved most effective in enhancing Quality parameters during the experiment i.e., (total soluble solids, titratable acidity, total

sugar and reducing sugar) also found superior in treatment GA₃ @ 100 ppm which was found at par with treatment T6 GA₃ @ 75 ppm. This research. In future this aspect can be further investigated and tested in screening for quality attributes at arid region of Haryana.

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Performance of Brinjal (*Solanum melongena* L.) Cultivars and Hybrids in Terms of Yield and Fruit Quality Characters on under Shade-Net House Conditions of Western Rajasthan

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Abstract

An experiment was carried out during Rabi 2018-19 at the College of Agriculture, Jodhpur. Twelve cultivars and hybrids of brinjal performance were studied under shade-net house conditions of western Rajasthan. Analysis of variance showed high significant variance among the cultivars and hybrids for all the characters under study. The results on yield parameters revealed that the 'Pusa Uttam' produced the maximum number of clusters plant⁻¹ (52.40) and 'Pusa Kaushal' produced the highest flowers cluster⁻¹ (6.93). The variety 'Pusa Hybrid-6' were produced the highest number of fruits plant⁻¹ (36.20), fruit yield plant⁻¹ (1.65 kg), fruit yield plot⁻¹ (32.21 kg) and fruit yield ha⁻¹ (509.69 q). The variety 'Pusa Hybrid-6' was identified as higher yielder under shade-net house conditions. The qualitative fruit colour of various cultivars and hybrids of brinjal was observed and noted as purple, dark purple, light purple, greenish purple, violet purple and purple with white strips and all the cultivars and hybrids were non-spiny except 'Soyla Local' and 'MAHY Kalpataru'. The brinjal cultivars and hybrids were observed for fruit shape and it was noted as round, long and oval. The fruits having highest TSS (5.10 °Brix) were noted in 'Pusa Hybrid-6'. Under the shade-net house conditions, it will ensure the safer production of brinjal without using harmful chemicals and also provide off-season supply of quality brinjal with attractive colour and better taste.

Key words : Brinjal, cultivars, hybrids, performance, shade-net house.

Introduction

Brinjal (*Solanum melongena* L.) belongs to the family Solanaceae. It is a common and popular vegetable in our diet from ancient times and is known as poor man's vegetable. Brinjal fruits are good source of Ca, Fe and vitamins particularly 'B' group. It contains carbohydrates (4%), Protein (1.4%), fat (0.3%), calcium (18 mg), phosphorus (47 mg), iron (0.9 mg), chlorine (52 mg), vitamin A (124 IU), thiamine (0.4 mg), riboflavin (0.11 mg) and ascorbic acid (12 mg) per 100g of fresh edible part (Hazra and Som, 1999). Brinjal is also valued for its decholesterolizing property primarily due to presence of polyunsaturated fatty acid (linoleic and lenolenic) present in flesh and seeds of fruit in higher amounts. Brinjal occupies fourth position in production among vegetable crops in India covering 0.73 million hectares (7.11% of total vegetable area) with a productivity of 17.53 tonne ha⁻¹ (Anonymous, 2018). In Rajasthan brinjal growing area is 5.42 thousand hectares and production of 29.60 thousand metric tonnes with productivity of 5.46 tonne ha⁻¹ (Anonymous, 2018). The productivity of brinjal is affected by a number of factors viz. environment, soil, production technology, plant protection and varieties.

Shade-net house and other protected cultivation practices offer distinct advantages of earliness, higher

productivity and quality particularly pesticide residue free produce, besides higher returns to growers. The scenario of insect pests under protected cultivation is vastly different compared to the pest problems under open field (Rani and Reddy, 2001). Net-houses act as a barrier between adult and larvae of the insect and inside grown plants; as a result, crop is escaped from the pest attack. Although there are a number of cultivars and hybrids of brinjal available in local market but their screening for suitability for cultivation under shade-net house conditions of arid Western Rajasthan has not been conducted. In view of this requirement, this study was undertaken to find out the suitable cultivar/hybrid under shade-net house.

Materials and Methods

The experiment entitled "To Study Performance of Brinjal (*Solanum melongena* L.) Cultivars and Hybrids under Shade-net House Conditions of Western Rajasthan" was conducted during the Rabi season of 2018-19 at College of Agriculture, Jodhpur, Rajasthan. The treatments comprised of twelve brinjal cultivars and hybrids viz, 'Pusa Hybrid-5', 'Pusa Shyamla', 'Pusa Hybrid-6', 'Pusa Upkar', 'Pusa Kaushal', 'Pusa Uttam', 'Pusa Hybrid-9', 'Pusa Anupam', 'Soyla Local', 'MAHY 80', 'MAHY Kalpataru' and 'Sungro F₁ Hybrid Brinjal No. 117'. The experiment was laid out in randomized block design with three replications.

The nursery was sown in different rows on a raised bed followed by normal nursery practices. Each cultivar/hybrid was transplanted in raised bed with 5 m length and 0.90 m width (on top portion) two rows with spacing of 60 cm and 45 cm between rows and plants, respectively. Irrigation applied as per need by low pressure drip system. All the recommended cultural practices were followed to raise a healthy crop. The data thus obtained were analyzed statistically for Performance of brinjal cultivars and hybrids.

Results and Discussion

3.1 Number of clusters/plant : The maximum number of clusters plant⁻¹ (52.40) was produced in 'Pusa Uttam' which was at par with 'Pusa Anupam' (50.47) and 'Pusa Hybrid-6' (49.80), while the minimum number of clusters plant⁻¹ (19.70) was recorded in 'MAHY 80'. The differences amongst the genotypes could further be attributed to their genetic makeup. The findings are in accordance with the reports of Chaturvedi *et al.* (2016) and Tripathy *et al.* (2017).

Number of flowers/cluster : The maximum number of flowers cluster⁻¹ (6.93) was produced in 'Pusa Kaushal' followed by 'Pusa Uttam' (5.80), whereas the minimum number of flowers cluster⁻¹ was produced in 'MAHY 80' (2.51). The variations in flower production amongst the cultivars and hybrids could be directly related with the availability to photosynthates as well as their genetic makeup resulting in differential hormonal content and photosynthetic efficiency. The results are in agreement with the results of Chaturvedi *et al.* (2016).

Number of fruits/cluster : The maximum number of fruits cluster⁻¹ (1.09) was noted in 'MAHY 80' followed by 'Pusa Shyamla' (0.83), while the minimum number of fruits cluster⁻¹ (0.05) in 'MAHY Kalpataru' (Table 2). The significant variations in number of fruits cluster⁻¹ might be due to differential production of different flower types (long, medium and short styled) which directly affects the pollination and fertilization and ultimately fruit set which might have been further influenced by the protected cultivation conditions as there was in general low fruit set. The results are in accordance with findings of Chaturvedi *et al.* (2016) and Tripathy *et al.* (2017).

Number of fruits/plant : The maximum number of fruits plant⁻¹ was recorded in 'Pusa Hybrid-6' (36.20) followed by 'Pusa Hybrid-9' (28.10), while the minimum number of fruits plant⁻¹ was recorded in 'MAHY Kalpataru' (2.30). This influence by long duration and significant difference was found due to variations in pollination, environmental factors and different type of flowers in clusters. The findings are in accordance to with reports of Mehraj *et al.* (2015), Gogoi *et al.* (2018), Chaudhary *et al.* (2017) and Chinthagunti *et al.* (2018).

Fruit diameters : The broadest fruit diameter (5.02 cm) was noted in 'MAHY 80' at marketable stage, whereas the narrowest fruit diameter (2.37 cm) in 'Pusa Hybrid-5' (Table-1). The maximum fruit diameter (8.59 cm) at physiological maturity was recorded in 'Pusa Upkar' which was at par to 'MAHY 80' (8.43 cm) and 'Pusa Hybrid-6' (8.37 cm), while the minimum fruit diameter was recorded in 'Pusa Anupam' (2.97 cm). The differences in fruit diameter amongst the cultivars and hybrids of brinjal could be primarily attributed to their genetic make as fruits of different shapes such as long, oval, round etc. are produced by different genotypes. Similar results have been reported by Singh *et al.* (2014), Chaturvedi *et al.* (2016), Chaudhary *et al.* (2017) and Gogoi *et al.* (2018).

Fruit length : The maximum fruit lengths at marketable stage (14.07 cm) and physiological maturity stage (17.07 cm) were found in 'Pusa Hybrid-5', whereas the minimum fruit lengths at marketable stage (5.66 cm) recorded in 'Pusa Hybrid-6' and at physiological maturity stage (7.33 cm) in 'MAHY Kalpataru' (Table 1). The significant differences for fruit length amongst the cultivars and hybrids of brinjal could be attributed to their genetic makeup as brinjal varieties are classified into different shapes of fruits as per their differential growth in terms of length and breadth which is important varietal genetic character. Similar results have been reported by Mehraj *et al.* (2015), Malshe *et al.* (2016) and Rahul *et al.* (2017).

Fruit weight : The maximum fruit weight at marketable stage was recorded in 'MAHY 80' (72.74 g), while the minimum fruit weight in 'Pusa Anupam' (39.85 g) (Table 1). The maximum fruit weight at physiological maturity stage was recorded in 'Sungro F₁ Hybrid Brinjal No. 117' (234.0 g), while the minimum fruit weight in 'Pusa Anupam' (81.37 g). The variations in fruit weight amongst the cultivars and hybrids could be primarily attributed to their genetic makeup controlling fruit shape and size. The results also find support from reports of Malshe *et al.* (2016), Tripathy *et al.* (2017) and Chinthagunti *et al.* (2018).

Fruit yield/plant : The maximum fruit yield plant⁻¹ were recorded in 'Pusa Hybrid-6' (1.65 kg) followed by 'Pusa Hybrid-9' (1.56 kg), while the minimum fruit yield plant⁻¹ was recorded in 'MAHY Kalpataru' (0.15 kg). The differences in fruit yield plant⁻¹ might be due to variance in flower types, pollinations, photosynthesis efficiency. The findings are in accordance to with reports of Chaudhary *et al.* (2017) and Chinthagunti *et al.* (2018).

Fruit yield/plot : The highest fruit yield plot⁻¹ (32.21 kg) was recorded in 'Pusa Hybrid-6' followed by 'Pusa Hybrid-9' (30.44 kg), whereas the lowest fruit yield plot⁻¹ (1.61 kg) was recorded in 'MAHY Kalpataru'. Similar

Table-1 : Effect of different cultivars and hybrids of brinjal on fruit diameter, fruit length and fruit weight at marketable stage and physiological maturity stage of fruit.

Cultivar/Hybrid	Fruit diameter (cm)		Fruit length (cm)		Fruit weight (g)	
	At marketable stage	At physiological maturity stage	At marketable stage	At physiological maturity stage	At marketable stage	At physiological maturity stage
Pusa Hybrid-5	2.37	3.10	14.07	17.07	47.26	98.50
Pusa Shyamla	2.74	3.67	13.39	15.57	41.06	87.77
Pusa Hybrid-6	4.34	8.37	5.66	9.51	48.51	225.77
Pusa Upkar	4.83	8.59	5.90	9.50	52.58	186.87
Pusa Kaushal	2.67	3.13	12.00	16.23	46.91	86.47
Pusa Uttam	4.95	7.07	7.49	10.17	58.74	229.44
Pusa Hybrid-9	4.52	6.73	6.88	9.20	60.95	188.50
Pusa Anupam	2.47	2.97	13.86	16.80	39.85	81.37
Soyla Local	3.89	4.97	8.02	7.95	56.24	143.60
MAHY 80	5.02	8.43	6.85	9.70	72.74	227.80
MAHY Kalpataru	4.99	5.50	6.65	7.33	60.23	84.83
Sungro F ₁ Hybrid Brinjal No. 117	4.38	7.47	7.85	10.33	63.09	234.00
Mean	3.93	5.83	9.05	11.61	54.01	165.24
SEm±	0.13	0.14	0.29	0.21	1.79	4.08
CD (P=0.05)	0.38	0.43	0.87	0.64	5.27	11.98
CV (%)	5.75	4.37	5.70	3.25	5.76	4.52

Table-2 : Effect of different cultivars and hybrids of brinjal on number of clusters plant⁻¹, number of flowers cluster⁻¹, number of fruits cluster⁻¹, number of fruits plant⁻¹, yield plant⁻¹, yield plot⁻¹ and estimated yield ha⁻¹.

Cultivar/Hybrid	No. of clusters plant ⁻¹	No. of flowers cluster ⁻¹	No. of fruits cluster ⁻¹	No. of fruits plant ⁻¹	Fruit yield plant ⁻¹ (kg)	Fruit yield plot ⁻¹ (kg)	Fruit yield ha ⁻¹ (q)
Pusa Hybrid-5	42.13	4.47	0.59	24.80	1.02	19.32	305.72
Pusa Shyamla	29.97	3.13	0.83	24.73	0.95	17.72	280.31
Pusa Hybrid-6	49.80	3.87	0.73	36.20	1.65	32.21	509.69
Pusa Upkar	39.33	3.80	0.50	19.47	0.96	18.53	293.23
Pusa Kaushal	37.73	6.93	0.77	26.67	1.18	22.40	354.41
Pusa Uttam	52.40	5.80	0.40	21.13	1.12	21.42	338.99
Pusa Hybrid-9	48.20	4.40	0.58	28.10	1.56	30.44	481.62
Pusa Anupam	50.47	4.27	0.18	9.13	0.35	5.65	89.35
Soyla Local	32.93	2.73	0.22	7.20	0.38	6.34	100.27
MAHY 80	19.70	2.51	1.09	21.47	1.36	26.15	413.78
MAHY Kalpataru	45.63	4.33	0.05	2.30	0.15	1.61	25.48
Sungro F ₁ Hybrid Brinjal No. 117	32.23	3.57	0.75	24.33	1.33	25.18	398.47
Mean	40.04	4.15	0.55	20.46	1.00	18.91	299.28
SEm±	1.08	0.12	0.02	0.71	0.04	0.69	10.89
CD (P=0.05)	3.18	0.35	0.05	2.09	0.10	2.01	31.93
CV (%)	4.69	5.03	5.67	6.04	6.15	6.30	6.30

results have also been reported by Ahmad *et al.* (2016) and Chaudhary *et al.* (2017).

Fruit yield/ha : The highest fruit yield ha⁻¹ (509.69 q) was recorded in 'Pusa Hybrid-6' followed by 'Pusa Hybrid-9' (481.62 q), whereas the lowest fruit yield ha⁻¹ (25.48 q) was recorded in 'MAHY Kalpataru'. The results also find

support from reports of Rahul *et al.* (2017) and Chinthagunti *et al.* (2018).

Total soluble solids (°Brix) : The variety 'Pusa Hybrid-6' had fruits with the highest TSS (5.10 °Brix) followed by 'MAHY Kalpataru' (4.87 °Brix) and 'Pusa Upkar' (4.77°Brix), whereas the lowest TSS was observed in

Table-3 : Effect of different cultivars and hybrids of brinjal on fruit colour, fruit shape, fruit spininess and fruit TSS.

Cultivar/Hybrid	Fruit colour	Fruit shape	Fruit spininess	Fruit TSS (°Brix)
Pusa Hybrid-5	Dark Purple	Long	Absent	3.73
Pusa Shyamla	Light Purple	Long	Absent	3.87
Pusa Hybrid-6	Purple	Round	Absent	5.10
Pusa Upkar	Purple	Round	Absent	4.77
Pusa Kaushal	Violet Purple	Long	Absent	4.07
Pusa Uttam	Dark Purple	Oval	Absent	4.00
Pusa Hybrid-9	Dark Purple	Oval	Absent	4.07
Pusa Anupam	Light Purple	Long	Absent	3.93
Soyla Local	Greenish purple	Oval	Present	4.70
MAHY 80	Dark Purple	Round	Absent	4.13
MAHY Kalpataru	Purple with white strips	Oval	Present	4.87
Sungro F1Hybrid Brinjal No. 117	Dark Purple	Oval	Absent	3.80
Mean	-	-	-	4.25
SEm±	-	-	-	0.07
CD (P=0.05)	-	-	-	0.20
CV (%)	-	-	-	2.84

'Pusa Hybrid-5' (3.73 °Brix). The differences in TSS content of fruits could be due to the genetic makeup of the genotypes influencing the accumulation of photosynthates and moisture content. The findings are supported by the reports of Tripathy *et al.* (2017) and Chinthagunti *et al.* (2018).

Fruit colour : The fruit colour of 'Pusa Hybrid-5', 'Pusa Hybrid-9', 'Pusa Uttam', 'MAHY 80' and 'Sungro F₁ Hybrid Brinjal No. 117' was noted as dark purple, 'Pusa Kaushal' as violet purple, 'Pusa Hybrid-6' and 'Pusa Upkar' as purple, 'Pusa Anupam', 'Pusa Shyamla' as light purple, 'Soyla Local' as greenish purple and 'MAHY Kalpataru' as purple with white strips (Table 3). Similar results regarding the variation in colour of the fruits were reported by Sanaset *et al.* (2012), Reshmika *et al.* (2016) and Tripathy *et al.* (2017).

Fruit Shape : The fruit shape was observed as oval in 'Pusa Hybrid-9', 'Pusa Uttam', 'Soyla Local', 'MAHY Kalpataru' and 'Sungro Hybrid Brinjal No. 117'; long in 'Pusa Hybrid-5', 'Pusa Shyamla', 'Pusa Kaushal' and 'Pusa Anupam', and round in 'Pusa Hybrid-6', 'Pusa Upkar' and 'MAHY 80' (Table 3). The variation in brinjal fruit shape was also noticed by Sanas *et al.* (2012) and Tripathy *et al.* (2017).

Fruit spininess : Fruits of all the cultivars and hybrids were non spiny except 'Soyla Local' and 'MAHY Kalpataru' (Table-3). The fruit qualitative parameters viz. fruit colour, shape and fruit spininess were noted and presented as their typical genetical characters. These characters could be absolutely attributed to their genetic makeup which could have been influenced by the prevailing environmental conditions. The observed results are in accordance with findings of Reshmika *et al.* (2016).

Conclusions

The brinjal 'Pusa Hybrid-6' resulted as the highest yielder under shade-net house conditions of western Rajasthan providing the highest number of fruits plant⁻¹ (36.20), fruit yield plant⁻¹ (1.65 kg), fruit yield plot⁻¹ (32.21 kg) and fruit yield ha⁻¹ (509.69 q) followed by 'Pusa Hybrid-9' number of fruits plant⁻¹ (28.10), fruit yield plant⁻¹ (1.56 kg), fruit yield plot⁻¹ (30.44 kg) and fruit yield ha⁻¹ (481.62 q). On quality parameters the brinjal 'Pusa Hybrid-6' resulted as the highest fruit TSS (5.10 °Brix) followed by 'MAHY Kalpataru' (4.87 °Brix) and 'Pusa Upkar' (4.77°Brix) under shade-net house conditions of western Rajasthan. Under the shade-net house conditions, it will ensure the safer production of brinjal without using harmful chemicals. It will also provide off season supply of quality brinjal with attractive colour and better taste.

However, the fruit set was observed to be low in almost all cultivars and hybrids studied under shade-net house conditions of western Rajasthan. Therefore, further studies under protected conditions on brinjal may be planned and undertaken with use of pollinators or vibrators for improved fruit set.

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Study on Date of Planting and Size of Bulblets on Growth Attributes of *Kharif* Onion (*Allium cepa* L.) Cv. Agrifound Dark Red

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Abstract

The studies were carried out to Study on date of planting and size of bulblets on growth and yield attributes of *kharif* onion. The experiment consisting 15 treatments combination with two factors i.e. date of planting with five levels (20th July, 30th July, 10th August, 20 August and 30th August) and size of bulblets with three levels (1.5 to 2.0 cm, 2.0 to 2.5 cm and 2.5 to 3.0 cm) in Factorial Randomized Block Design with three replications. The individual effect of date of planting D₂ (30th July) recorded maximum plant height at 60 DAP (41.14 cm), numbers of leaves per plant at 60 DAP (7.12), length of leaf at 60 DAP (34.39 cm) width of leaf at 60 DAP (0.79 cm), maximum chlorophyll content in leaves at 45 DAP (0.57 mg/g) pseudostem length at 60 DAP (4.72 cm). Similarly, the individual effect size of bulblets B₂ (2.0 to 2.5 cm) found maximum plant height at 60 DAP (40.38 cm), numbers of leaves per plant at 60 DAP (7.27), length of leaf at 60 DAP (35.37 cm) width of leaf at 60 DAP (0.82 cm), maximum chlorophyll content in leaves at 45 DAP (0.55 mg/g) pseudostem length at 60 DAP (4.55 cm) compared to other treatments.

Key words : Onion, date of planting, size of bulblets, growth attributes.

Introduction

Onion (*Allium cepa* L.) belongs to the family Amaryllidaceae. It is widely grown herbaceous biennial vegetable crop with cross pollinated and monocotyledonous behavior having diploid chromosomes number (2n=16). Onion is cultivated in India thousands of year. It originated from the region of Central Asia. Western Asia and Mediterranean Sea are the secondary centers of origin. India is the second largest producer of onion in the world followed by China with production of 21,564 thousand million tons from an area of 1,270 thousand hectares (Anonymous, 2016-17). The major onion producing states in India are Maharashtra, Karnataka, Madhya Pradesh, Bihar, Gujarat, Rajasthan, Andhra Pradesh, Uttar Pradesh, and Orissa which together account for 96 per cent of total area and production in the country. Maharashtra is the largest producer of the onion with production of 5,361.96 MT followed by Karnataka 3,227.04 MT. In Rajasthan, it is grown extensively in the district of Alwar, Ajmer, Jodhpur, Sikar, Jhalawar, Nagaur, Bharatpur and Jhunjhunu. In Rajasthan onion covers 67.50 thousand hectares area producing 805.0 thousand metric tonnes with the productivity of 12.3 MT per ha (NHB, 2016-17)

The edible portion of onion is a modified leaf is known as bulb and develop under ground. The immature and mature bulbs are eaten raw or they may cooked and eaten as vegetable and commonly used as condiments and spice for flavoring and enriching various cuisines. It is

also used in the form of dehydrated (form of flask, rings, kibbers and powder), freezing, canning, and pickling (in vinegar or brine). Onion oil, produced by steam distillation, is used to a limited extent for flavoring food. Use of onion in soups and sauces is very common.

Onion bulbs and leaves are nutritionally rich in minerals like calcium, potash and phosphorus (Ullah *et al.*, 2005). According to Fenwick and Hanley (1990), common onion contains 88.6-92.8 per cent moisture, 0.9-1.6 per cent protein, 0.2 per cent fat, 5.2-9.0 per cent carbohydrates, 0.6 per cent ash, 190 – 540 mg calcium, 200 – 430 mg phosphorus, 80-110 mg potash, 31-50 mg sodium, 81-150 mg magnesium, 0.5-1 mg aluminium, 0.1-1 mg barium, 1.8-2.6 mg iron, 0.8-7 mg selenium, 0.6-1 mg boron, 0.05-0.64 mg copper, 1.5-2.8 mg zinc, 0.5-1.0 mg manganese, 50-51 mg sulphur, 0.3 mg vitamin D, 0.05 mg riboflavin, 0.2 mg nicotinic acid, 10 mg vitamin C, 16 µg folic acid, 0.9 µg biotin, 0.14 mg pantothenic acid and 23-38 cal energy per 100 g of edible portion. Besides, onion is characterized by its distinctive flavors and pungency which is due to sulphur containing compounds found in the scale of bulb.

Nutritionally, Onion is rich in fibers, vitamins, minerals (sodium 16%) and has high vitamin B₆ (1.7 mg). Onion contains volatile oil known as Allyl-propyl-disulphide, which is the major flavoring component in onion. Fresh onion bulb and whole plant on steam distillation yield 0.1- 0.2 per cent and 0.05- 0.09 per cent essential oils, respectively. Onion is widely used for

several conditions linked to the blood system and heart including high cholesterol, heart attack, coronary heart disease and hypertension.

In Maharashtra, onion is cultivated thrice a year *i.e.* *kharif* crop, late *kharif* and Rabi crop. However, in North India it is largely cultivated as Rabi crop. The *Kharif* onion is grown on very limited scale. In Rajasthan, *kharif* onion is commercially grown in Alwar district using bulblets. Crop grown from seedling during rainy season generally gets damaged due to heavy rainfall. Raising of seedling during May- June in Rajasthan is growing also problematic due to high temperature followed by rainfall. Hence, including Jhalawar technique of *kharif* onion is required to be standardised under different climatic conditions in order to get good price and round the year availability of onion.

In Jhalawar, the area under *kharif* onion is negligible. High rainfall (average 1000 mm) and high temperature are major problem in successful cultivation of *kharif* onion. High temperature at the time of nursery limit the germination followed by damaging of seedling. Further high rainfall during transplanting damage most of the seedling in the situation sets produced from February grown nursery are raider on component of fresh seedlings and can tolerate heavy rainfall.

Materials and Methods

A field experiment to study the “Study on date of planting and size of bulblets on growth and yield attributes of *kharif* onion (*Allium cepa* L.)” was conducted at Vegetable Farm, Department of Vegetable Science, College of Horticulture & Forestry, Jhalrapatan city, Jhalawar during *Kharif*, 2017-18.

The experiment consisting 15 treatments combination with two factors *i.e.* date of planting with five levels (20th July, 30th July, 10th August, 20 August and 30th August) and size of bulblets with three levels (1.5 to 2.0 cm, 2.0 to 2.5 cm and 2.5 to 3.0 cm) in Factorial Randomized Block Design with three replications each. The treatment combinations are T₁–20th July and 1.5 to 2.0 cm, T₂–20th July and 2.0 to 2.5 cm, T₃–20th July and 2.5 to 3.0 cm, T₄–30th July and 1.5 to 2.0 cm, T₅–30th July and 2.0 to 2.5 cm, T₆–30th July and 2.5 to 3.0 cm, T₇–10th August and 1.5 to 2.0 cm, T₈–10th August and 2.0 to 2.5 cm, T₉–10th August and 2.5 to 3.0 cm, T₁₀–20th August and 1.5 to 2.0 cm, T₁₁–20th August and 2.0 to 2.5 cm, T₁₂–20th August and 2.5 to 3.0 cm, T₁₃–30th August and 1.5 to 2.0 cm, T₁₄–30th August and 2.0 to 2.5 cm and T₁₅–30th August and 2.5 to 3.0 cm.

Experimental details : Brief details of the experiment are as under:

- (i) Crop : Onion
- (ii) Name of variety : Agrifound Dark Red
- (iii) Experimental design : R.B.D. (Factorial)
- (iv) Treatment details : Two factors
- (v) Size of bulblets
 - (a) 1.5 to 2.0 cm
 - (b) 2.0 to 2.5 cm
 - (c) 2.5 to 3.0 cm
- A. Date of planting
 - (a) 20th July
 - (b) 30th July
 - (c) 10th August
 - (d) 20th August
 - (e) 30th August
- (v) Total number of treatment : $3 \times 5 = 15$
- (vi) Number of replications : 3
- (vii) Spacing : 15 × 10 cm
- (viii) Net plot area : 6.00 m²
- (ix) Net cultivated area : 300 m²
- (x) Number of bulblets per plot : 390
- (xi) Total number of plots : 45

Results and Discussion

The result of present study clearly indicate that plant height at 60 DAP, number of leaves per plant at 60 DAP, length of leaf at 60 DAP, width of leaf at 60 DAP, chlorophyll content in leaves (mg/g) at 45 DAP, pseudostem length at 60 DAP were significantly increased by different date of planting as compared to other date of planting.

The maximum value of growth parameters *i.e.* Plant height at 60 DAP (41.14 cm), number of leaves per plant at 60 DAP (7.12), length of leaf at 60 DAP (34.91 cm), width of leaf at 60 DAP (0.79 cm), chlorophyll content in leaves (0.57 mg/g), pseudostem length at 60 DAP (4.72 cm) recorded under date of planting of treatment D₂ (30th July) and minimum values of growth parameter *i.e.* Plant height at 60 DAP (33.36 cm), number of leaves per plant at 60 DAP (6.24), length of leaf at 60 DAP (30.26 cm), width of leaf at 60 DAP (0.71 cm), chlorophyll content in leaves (0.47 mg/g), pseudostem length at 60 DAP (3.72 cm) was recorded under treatment D₂ (30th July) respectively. Similar observations were recorded by Katwale and Bisen (1986), Mondal and Brewster (1986), Gautam *et al.* (2006), Ansari (2007), Nayee *et al.* (2009),

Table-1 : Individual effect of date of planting and size of bulblets on growth attributes plant height at 60 DAP, number of leaves per plant at 60 DAP, width of leaf at 60 DAP and chlorophyll content in leaves at 45 DAS.

Treatments	Plant height (cm) At 60 DAP	Number of leaves per plant at 60 DAP	Width of leaf (cm) at 60 DAP	Chlorophyll content in leaves (mg)
D ₁	33.36	6.24	0.71	0.47
D ₂	41.14	7.12	0.79	0.57
D ₃	37.91	6.56	0.75	0.53
D ₄	37.82	6.73	0.74	0.52
D ₅	37.81	6.43	0.73	0.50
SEm ±	1.44	0.26	0.02	0.01
C.D. (p=0.05)	2.95	0.53	0.04	0.03
B ₁	35.74	5.88	0.66	0.49
B ₂	40.38	7.27	0.82	0.55
B ₃	36.71	6.53	0.74	0.52
SEm ±	1.11	0.20	0.01	0.01
C.D. (p=0.05)	2.28	0.41	0.03	0.02

D₁ = 20th July, D₂ = (30 July), D₃ = (10 August), D₄ = (20th 150 kg/ha), D₅ = (30th August), B₁ = (1.5 to 2.5 cm), B₂ = (2.0 to 2.5 cm) and B₃ = (2.5 to 3.0 cm)

Barche *et al.* (2013) in garlic, Mohanta and Mandal (2014), and Sharma and Jarial (2017) in *kharif* onion.

This might be due to the growth and yield of cultivated crop plants are mainly influenced by two factors viz., genetical and cultural or management. Genetic makeup and environment are the factors which depict the performance of a cultivar by influencing all important traits (Brewster, 1994). Planting time is one of important factor that greatly influence the growth and yield of onion (Mondal and Brewster, 1986). Crop is exposed to a great seasonal fluctuation of temperature and photoperiod (day length), both having a strong influence on the growth and development of garlic (Pooler and Simmon, 1993). The performance of garlic largely depends on the time of planting as the vegetative growth is encouraged under short day and cool temperature. While long day and high temperature is favorable for better bulb development Subrata *et al* (2010). The main phonological stages in the garlic are number of days from planting to emergence, emergence to bulb formation, clove sprouting, leafing, bulb initiation and maturation. Linear relationship has been found between the number of leaves and thermal time above 0° under field conditions.

The size of bulblets B₂ (2.0 to 2.5 cm) had The result of present study clearly indicate that Plant height at 60 DAP, number of leaves per plant at 60 DAP, length of leaf cm 60 DAP, width of leaf at 60 DAP, chlorophyll content in leaves (mg/g) at 45 DAP, pseudostem length at 60 DAP were significantly increased by size of bulblets as compare to other size of bulblets.

The maximum value of growth parameters *i.e.* plant height at 60 DAP (40.38 cm), number of leaves per plant at 60 DAP (7.27), length of leaf at 60 DAP (35.37 cm) width

of leaf at 60 DAP (0.82 cm), chlorophyll content in leaves (0.55 mg/g), pseudostem length at 60 DAP (4.55 cm) was recorded under treatment B₂ (2.0 to 2.5 cm) and minimum values of growth parameter *i.e.* Plant height at 60 DAP (35.74 cm), number of leaves per plant at 60 DAP (5.88), length of leaf at 60 DAP (31.72 cm), width of leaf at 60 DAP (0.66 cm), chlorophyll content in leaves (0.49 mg/g) and pseudostem length (3.82 cm) was recorded under the treatment B₁ (1.5 to 2.0 cm) respectively. These results are collaborated with the findings by Movalia (1996), Gupta *et al.* (1999), Sankar *et al.* (1999), Singh *et al.* (2001), Singh *et al.* (2002), Khurana *et al.* (2003) and Arya *et al.* (2006).

This may be due to plants grown from bulbs as compared to bulblets because bulb have more food reserves, hence results in earlier emergence Kalasareddi *et al.* (1997). The results regarding bulb size are in agreement with those obtained by Ahmad *et al.* (2009), who illustrated that plants grown from large bulbs required minimum days to bolting. The increase in plant height might be due to intra plant competition for light, moisture, space, nutrients and aeration. This is resulted in elongation of flower stalk height, may be due to elongation of cells and number of cells due to cell division. (Mane *et al.*, (2007).

The interaction effect of date of planting and size of bulblets on plant height at 60 DAP, width of leaf at 60 DAP, chlorophyll content in leaves (mg) at 45 DAP and pseudostem length at 60 DAP was recorded non - significant.

Conclusions

The effect of date of planting and size of bulblets had increased significantly growth, yield and quality attributes.

The individual effect of planting D₂(30th July) and size of bulblets B₂(2.0 to 2.5 cm) exhibited maximum plant height at 60 DAP(41.14 and 40.38 cm), numbers of leaver per plant at 60 DAP (7.12 and 7.27),length of leaf at 60 DAP (34.91 and 35.37 cm), width of leaf at 60 DAP(0.79 and 0.82 cm), maximum chlorophyll content in leaves at 45 DAP (0.57 and 0.55 mg /g).

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Impact of Different Levels of Vermicompost and Foliar Application of Micronutrients on Growth and Yield Attributes of Cabbage (*Brassica oleracea* Var. Capitata)

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Abstract

This field experiment was conducted to study the Impact of different levels of vermicompost and foliar application of micronutrients on growth and yield of cabbage (*Brassica oleracea* var. *capitata*) during *rabi* season of 2019-20 at Horticulture Farm, Department of Horticulture, S.K.N College of Agriculture, Jobner, Jaipur, Rajasthan. The experiment was consisting 16 treatments viz., four levels of vermicompost (control, vermicompost @ 5.0 t/ha, vermicompost @ 7.5 t/ha and vermicompost @ 10 t/ha) and four levels of foliar application of micronutrient (control, iron @ 0.5%, boron @ 0.2% and zinc @ 0.5% per ha) with the combination was laid out in FRBD (Factorial Randomized Block Design) with three replications.

The results indicated that the vermicompost @ 10 t/ha significantly increased plant height, number of leaves, leaf area, equatorial and polar diameter, weight of head, volume of head, head yield of cabbage. Although, application of vermicompost @ 7.5 t/ha was found statistically at par to vermicompost @ 10 t/ha. While, the significant decrease days at maturity was found in treatment vermicompost @ 10 t/ha over control and V₁ (vermicompost @ 5 t/ha).

Key words : Vermicompost, micronutrients, growth, yield, cabbage.

Introduction

Cabbage (*Brassica oleracea* var. *Capitata* L.) is the most important cole crops which belongs to family Brassicaceae and normal having chromosome, no. 2n=18 and it originated at Western Europe and Mediterranean region. It is mainly grown in temperate region for seed production. However, its cultivation is successful in the tropical and sub-tropical regions of the world. Cabbage is herbaceous, biennial, dicotyledonous flowering plant distinguished by a short stem up to which a compact mass of leaves, usually green but in some varieties having red or purplish in colour. Compact mass of leaves is known as head, which is economically yield of cabbage.

It is cultivated all over the world viz., China, Russia, Korea, Japan Indonesia and especially in India. India is the second largest producer of cabbage in the world with an area of 4 lakh ha with total production of 9039 thousand metric tonnes and having productivity 22.6 metric tonnes per hectare after China (Anonymous 2019). Among cole crops in production cabbage ranks first in the world as well as in India. It covers 4% of total area under vegetables. It is cultivated during all the seasons (*Rabi*, *Kharif* and *Summer*) but mainly in *Rabi* season crop. The major growing states of cabbage are Uttar Pradesh, Orissa, Bihar, Assam, West Bengal, Maharashtra and

Karnataka. In Rajasthan, the area under cabbage cultivation is 1.20 thousand with the production in 11.69 thousand metric tonnes. (Anonymous, 2019).

The present vegetable production is not sufficient to meet the requirement of present population and hence, there is immense scope to diversify the area and production under cultivation of vegetable and other crops or by adopting new technology generated in respect of variety and its seed, proper planting season, spacing, management practices, manuring and fertilizer control of pests and diseases. Cabbage is a high feeder of nutrients. Therefore, the judicious application of macro and micronutrients along with required dose of organic manures is essential for getting high yield of quality produce of cabbage.

Materials and Methods

Field experiment entitled "Impact of Different Levels of Vermicompost and Foliar Application of Micronutrients on Growth and Yield of Cabbage (*Brassica oleracea* var. *capitata*)" was conducted at horticulture farm, Department of Horticulture S.K.N. College of Agriculture, Jobner (Jaipur) during *Rabi* season, 2019-20. Geographically, Jobner is situated 45 km in West of Jaipur on 26°5' North latitude, 75° 20' East longitude and at an altitude of 427 meters above mean sea level. This region falls under

Agro-Climatic Zone-III A (Semi- Arid Eastern Plain zone) of Rajasthan.

Variety Golden Acre it takes about 65-80 days from transplanting to head formation. It has fewer outer leaves which are cup shaped and arranged in two whorls. The heads are solid, short core and weighing of about 1.0-1.5 kg.

Results and Discussion

Vegetable Growth

Plant height (cm)

Vermicompost : The data showed the effect of different levels of vermicompost on the plant height of cabbage has been presented in Table-1 The perusal of data revealed that the plant height at 60 DAT was significantly affected by various levels of vermicompost. The maximum plant height at harvest (22.49 cm) was recorded with vermicompost @ 10 t/ha (V_3). The per cent increase in plant height in this treatment at harvest was 25.08 and 12.51 per cent, respectively over control and vermicompost @ 7.5 t/ha. Application of vermicompost @ 7.5 t/ha (V_2) was found to be statistically at par with vermicompost @ 10 t/ha (V_3).

Micronutrient : Different micronutrient levels significantly influenced the plant height at 60 DAT. The mean maximum plant height at 60 DAT was (22.93 cm) observed in M_3 (Zinc @ 0.5%), which was found to be significantly higher over M_0 and M_2 respectively. The mean increase in plant height 26.62 and 7.30 per cent at 60 DAT higher over M_0 and M_2 respectively under M_3 treatment. Treatment M_1 found statistically at par with treatment M_3 .

Number of leaves per plant (in number)

Vermicompost : The data presented in Table-1 revealed that application of vermicompost @ 10 t/ha (V_3) significantly increased the number of leaves per plant at 60 DAT over its preceding levels. Significantly higher number of leaves per plant (16.03 cm) was recorded under treatment V_3 . Which was statistically at par with treatment V_2 . The magnitude of per cent increase in plant height with the application of vermicompost @ 10 t/ha was 58.56 and 26.02 over control, vermicompost @ 5.0 t/ha, respectively.

Micronutrient : The number of leaves per plant at 60 DAT was also significantly influenced by different levels of micronutrient. The maximum number of leaves at 60 DAT (15.49 cm) was found in M_3 level, which was significantly higher to M_0 and M_2 but statistically at par with M_1 . The mean maximum number of leaves increased under the treatment of M_3 , which was found to be 34.67 and 16.59

per cent at 60 DAT higher as compared to M_0 and M_2 , respectively.

Chlorophyll content (mg/100 g)

Vermicompost : The data presented in Table-1 revealed that chlorophyll content in leaves significantly influenced by the application of different levels of vermicompost at 60 DAT of cabbage. The maximum chlorophyll content (0.789 mg/100g) cm at 60 DAT was recorded under treatment V_3 (vermicompost @ 10 t/ha), while minimum chlorophyll content (0.585 mg/100 g) was recorded under control. The treatment V_3 was observed as significantly superior over rest of the treatments with an increase in plant height as (34.87 and 15.18 per cent) over control and V_1 (vermicompost @ 5.0 t/ha) at harvest of cabbage, which treatment V_2 found statistically at par with V_3 (vermicompost @ 10 t/ha).

Micronutrients : The data presented in Table-1 indicated that chlorophyll content in leaves was influenced by the application of different micronutrient fertilizers at 60 DAT of cabbage. The chlorophyll content ((0.780 mg/100g) was observed to be maximum under treatment M_3 (zinc @ 5%), whereas, the minimum chlorophyll content (0.590 mg/100g) was recorded under control. The treatment M_3 was observed as significantly superior over control and M_2 . The increase in chlorophyll content as (24.36 and 11.79 %) was recorded under treatment M_3 over control and M_2 at 60 DAT of cabbage. While treatment M_1 found statistically at par with M_3 .

Leaf area (cm²)

Vermicompost : The data presented in Table-1 revealed that application of different levels of vermicompost significantly increased the leaf area. The mean maximum leaf area was (272.64) observed in V_3 treatment (vermicompost @ 10 t/ha), which was found to be significantly superior to V_0 and V_1 , but it was statistically at par with V_2 treatment. The mean increase in leaf area under V_3 treatment was observed to be 22.47 and 9.87 per cent more as compared to V_0 and V_1 , respectively.

Micronutrient : The different micronutrient levels also had significant effect on leaf area. The maximum leaf area (271.73) was recorded with M_3 (zinc @ 5%), which was significantly higher over control and M_2 but statistically at par with M_1 . The mean leaf area under the treatment M_3 was observed to be 17.06 and 8.92 per cent more over control and M_2 , respectively.

Days to maturity (in days)

Vermicompost : The data presented table-1 revealed that the different organic manure had significant decrease on the days to maturity. The minimum days to maturity (70.45) was recorded under treatment V_3 (vermicompost

Table-1 : Impact of different levels of vermicompost and foliar application of micronutrients on growth and yield attributes.

Treatment	Plant height (cm)	No of leaves per plant	Chloro-phyll content	Leaf area	Days at maturity	Weight of head	Equatorial diameter	Polar diameter	Volume of head	Yield
Different levels of vermicompost										
V ₀ (Control)	17.98	10.11	0.585	222.61	80.66	491	9.95	8.85	647.93	242.22
V ₁ (Vermicompost @ 5.0 t/ha)	19.99	12.72	0.685	248.14	76.34	634	11.24	10.26	759.60	313.09
V ₂ (Vermicompost @ 7.5 t/ha)	21.67	15.10	0.750	266.75	72.38	710	12.35	11.51	884.28	350.49
V ₃ (Vermicompost @ 10 t/ha)	22.49	16.03	0.789	272.64	70.45	744	13.10	11.85	912.25	367.53
SEm+	0.54	0.36	0.020	5.92	1.37	13	0.29	0.31	16.64	6.12
CD (p=0.05)	1.57	1.03	0.059	17.09	3.95	36	0.84	0.89	48.05	17.67
Miconutrients										
M ₀ (Control)	18.11	10.12	0.590	225.38	80.64	550	10.03	8.91	686.38	271.48
M ₁ (Iron @ 0.5%)	21.37	15.42	0.750	265.55	72.37	697	12.27	11.52	856.13	343.95
M ₂ (Boron @ 0.2%)	19.72	12.92	0.688	247.48	76.46	607	11.31	10.24	784.70	299.88
M ₃ (Zinc @ 0.5%)	22.93	15.49	0.780	271.73	70.36	725	13.03	11.80	876.85	358.02
SEm+	0.54	0.36	0.020	5.92	1.37	13	0.29	0.31	16.64	6.12
CD (p=0.05)	1.57	1.03	0.059	17.09	3.95	36	0.84	0.89	48.05	17.67
CV (%)	9.17	9.15	10.06	8.12	6.32	6.78	8.67	10.11	7.20	6.66

Table-2 : Interactive effect of different levels of vermicompost and foliar application of micronutrients on weight of head (g) Volume of Head (cc), Yield (q/ha).

Treatments	Weight of Head (g)				Volume of Head (cc)				Yield (q/ha)			
	V ₀	V ₁	V ₂	V ₃	V ₀	V ₁	V ₂	V ₃	V ₀	V ₁	V ₂	V ₃
M ₀	440	560	589	610	595.10	710.40	714.00	726.00	217.28	276.54	290.86	301.23
M ₁	525	681	760	820	618.10	835.90	960.50	1010.00	230.62	303.70	320.99	344.20
M ₂	467	615	650	697	657.60	752.60	856.60	872.00	259.26	336.30	375.31	404.94
M ₃	530	680	840	850	720.90	739.50	1006.00	1041.00	261.73	335.80	414.81	419.75
SEm+	25.25				33.28				12.24			
CD (p=0.05)	72.91				96.11				35.34			

@ 10 t/ha) and maximum (80.66) under control. The treatment V₃ was observed as significantly lower over rest of the treatments, which was statistically at par with V₂ (vermicompost @ 7.5 t/ha). The decrease in days to maturity under treatment V₃ was found to be 14.49 and 8.36 per cent lower as compared to control and V₁ (vermicompost @ 5 t/ha), respectively.

Micronutrient : The foliar spray of different micronutrient also significantly decrease influenced the days to maturity (Table-1) The minimum days to maturity (72.37) recorded with M₃ (zinc @ 0.5%), which was statistically at par with M₁ (Fe @ 0.5%) and significantly lower over control and M₂ (Boron @ 0.2%). The decrease in days to maturity under treatment M₃ was registered to be 14.62 and 8.68 per cent lower over control and M₂, respectively.

Yield Attributes and Yield

Weight of head (gm)

Vermicompost : The data is presented in table-1 showed

that weight of head influenced significantly with different levels of vermicompost application. The maximum weight of head (744 g) was recorded under treatment V₃ (vermicompost @ 10 t/ha) and found significantly higher over treatment V₀ and V₁, and found statistically at par with V₂. The treatment V₃ (vermicompost @ 10 t/ha) registered an increase of 34.01 and 14.78 per cent more weight of head over treatment V₀ and V₁, respectively.

Micronutrient : The data given in table-1 indicate that the foliar spray of different micronutrient significantly increased the weight of head. Significantly higher weight of head (725 g) was recorded with treatment M₃ (zinc @ 0.5%) over M₀ and M₂ and found statistically at par to M₁ (Fe @ 0.5%). The increase in weight of head under treatment M₃ was registered to be 24.14 and 16.28 per cent more over control and M₂, respectively.

Interaction

A perusal of data in table 2 revealed that the combined effect of different levels of vermicompost and foliar

application micronutrient was found to be significant on cabbage weigh of head. The significantly higher weight of head (850 and 840 gm) was recorded with treatment V_3M_3 and V_2M_3 , respectively, being statistically at par with each other and significantly superior over V_0M_0 .

Equatorial diameter (cm)

Vermicompost : The data pertaining to equatorial diameter has been presented in Table-1 Different levels of vermicompost significantly influenced the equatorial diameter. The mean maximum equatorial diameter (13.10 cm) was recorded in V_3 (vermicompost @ 10 t/ha), which was found to be significantly more to V_0 and V_1 but it found statistically at par with V_2 . The mean increase in equatorial diameter under V_3 treatment was found to be 24.05 and 14.20 per cent more over to V_0 and V_1 , respectively.

Micronutrient : The foliar spray of different micronutrient levels also significantly affected the equatorial diameter. Maximum equatorial diameter (13.03 cm) was recorded with the treatment M_3 . The treatment M_3 was found significantly superior than control and M_2 but statistically at par with M_1 . The mean increase in equatorial diameter under the treatment M_3 was recorded to be 23.02 and 13.20 per cent higher over M_0 and M_2 , respectively.

Polar diameter (cm)

Vermicompost : The data is presented in table-1 showed that polar diameter influenced significantly with different levels of vermicompost. The maximum polar diameter (11.85 cm) was recorded under treatment V_3 (vermicompost @ 10 t/ha) and found significantly higher over treatment V_0 and V_1 , but it found statistically at par with V_2 . The treatment V_3 (vermicompost @ 10 t/ha) registered an increase of 25.32 and 13.42 per cent more polar diameter over treatment V_0 and V_1 , respectively.

Micronutrient : The data given in table-1 indicate that the foliar spray of different micronutrient levels significantly increased the polar diameter. Significantly higher polar diameter (11.80 cm) was recorded with treatment M_3 (zinc @ 0.5%) over M_0 and M_2 and found statistically at par to M_1 (Fe @ 0.5%). The increase in polar diameter under treatment M_3 was registered to be 24.49 and 13.22 per cent more over control and M_2 , respectively.

Volume of head (cc)

Vermicompost : Application of different levels of vermicompost had significant effect on volume of head table-1 and The significantly higher volume of head (912.25 cc) was recorded with the treatment V_3 (vermicompost @ 10 t/ha) followed by V_2 (vermicompost @ 7.5 t/ha), being statistically at par with each other and found significantly superior over control and V_1 . The increase in volume of head under treatment V_3 was found

to be 40.79, 20.10 and per cent higher as compared to control and V_1 (vermicompost @ 5.0 t/ha), respectively.

Micronutrient : The data given in table-1 indicate that the volume of head was influenced significantly by the foliar application of micronutrient. Treatment M_3 registered maximum value of 876.85 cc for volume of head which was significantly superior over M_0 and M_2 . The increase in the volume of head under treatment M_3 was 27.75 and 11.74 per cent more over control and M_2 , respectively, being statistically at par to M_1 where only 2.42 per cent increase in volume of head was recorded.

Interaction

A perusal of data in table-2 revealed that the combined effect of different levels of vermicompost and foliar application of micronutrient was found to be significant on volume of head. The significantly higher volume of head (1041 and 1006 cc) was recorded with treatment V_3M_3 and V_2M_3 , respectively, being statistically at par with each other and significantly superior over V_0M_0 .

Yield (q/ha)

Vermicompost : The data in table-1 that head yield per hectare influenced significantly with different levels of vermicompost. The treatment V_3 (vermicompost @ 10 t/ha) registered maximum head yield (367.53 q/ha) followed by V_2 (vermicompost @ 7.5 t/ha) although, it was significantly superior over control and V_1 . But found statistically at par with treatment V_2 . The increase in head yield under treatment V_3 was found to be 51.73 and 17.39 per cent higher as compared to control and V_1 (vermicompost @ 5.0 t/ha), respectively.

Micronutrient : A critical examination of data in same table further indicates that the foliar application of micronutrient significantly increased the head yield per hectare (q). The highest head yield (358.02 q/ha) registered under treatment M_3 (zinc @ 0.5%) which was statistically at par to M_1 (Fe @ 0.5%) but significantly superior over control and M_2 . The increase in head yield under treatment M_3 was to the tune of 31.88 and 14.70 over control and M_2 , respectively.

Interaction

A perusal of data in table-2 revealed that the combined effect of different levels of vermicompost and foliar application of micronutrient was found to be significant on cabbage head yield per hectare. The significantly higher head yield per hectare (419.75, 414.81 and 404.94 q) was recorded with treatment V_3M_3 , V_2M_3 and V_3M_2 , respectively, being statistically at par with each other and significantly superior over V_0M_0 .

The results of field experiment entitled "Impact of different levels of vermicompost and foliar application of

micronutrients on growth, yield and quality of cabbage (*Brassica oleracea* var. *capitata*)” have been presented in the preceding chapter. The significance of observations with specific responses under various treatments are being discussed forth with and references in support of results have also been cited.

Vermicompost

Effect on growth attributes and growth : The results of present investigation indicated that different levels of vermicompost, increased plant height, number of leaves per plant, chlorophyll content in leaves and leaf area per plant (except days at maturity). The Table (1,2) show that application of vermicompost @ 10 t/ha increased the plant height, number of leaves per plant, chlorophyll content in leaves and leaf area per plant, which were significantly higher over to control and vermicompost @ 5.0 t/ha, but at par to vermicompost @ 7.5 t/ha.

These findings clearly indicated that vermicompost played a significantly role on enhancing the growth of cabbage. Improvement in plant height, number of leaves and leaf area per plant with the application of vermicompost might be due to better moisture holding capacity, supply of micronutrients and availability of major nutrients due to favorable soil condition, (Reddy *et al.*, 1998). The physiological parameters pertaining to photosynthesis, stomatal conductance and transpiration also exhibited significant increment with NPK supplied through vermicompost. It indicates that the increase in these physiological parameters might be attributed to increased in absorption from soil enhanced carbohydrate assimilation and production of new tissues which have ultimately increased vegetable growth. The increase in chlorophyll content in leaves might be due to improved nutritional environment in the rhizosphere as well as its utilization in plant system, leading to enhanced translocation of nutrients and vitamins (Choudhary *et al.* 2012). These results are close conformity with the findings of Reddy *et al.* (1998), Sharhidhara *et al.* (1998), Tomar *et al.* (1998), Goswami *et al.* (2017 in tomato and cabbage, Ali *et al.* (2018), Singh *et al.* (2018) and Salwa *et al.* (2019) in cabbage.

Effect on yield attributes and yield : Data on various yield attributes and yield revealed that application of different levels of vermicompost increased the weight of head, equatorial and polar diameter of head, volume of head and head yield. The Table (1,2) show that application of V₃ treatment (vermicompost @ 10 t/ha) enhanced all the above parameters significantly over to control (V₀) and V₁ i.e. 5.0 t/ha vermicompost. The beneficial effect of vermicompost on yield attributes and yield might be due to enhanced supply of macro and micronutrients during entire growing season, significant

increase in yield under the influence of vermicompost was largely a function of improved growth and the consequent increase in different yield attributes and yield as mentioned above. Further, vermicompost increase the efficiency of added chemical fertilizers in soil activities on N fixing bacteria and increased the rate of humification. Humic acid in vermicompost enhances the availability of both native and added micronutrients in soil and thus, yield attributes and yield of cauliflower increased. The significant improvement in yield attributes and yield on account of vermicompost @ 10 t/ha along with nutrients from soil particularly at later stage of crop growth might have enhanced the rate of photosynthesis further, increased vegetative growth might have provide more sites for translocation of photosynthates which ultimately increased the yield. These results are in accordance with the findings of Reddy *et al.* (1998), Tomar *et al.* (1998) and Oliveira *et al.* (2001), Ali *et al.* (2018), Singh *et al.* (2018) and Salwa *et al.* (2019) in cabbage.

Conclusions

On the basis of one year experimental results, it may be concluded that application of vermicompost @ 10 t/ha (V₃) with foliar application of Zn @ 0.5% found significantly better in terms of yield, Thus application of vermicompost @ 7.5 t/ha (V₂) and foliar application of Zn @ 0.5% (M₃) may be recommended for cabbage crop.

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Productivity of Crops as Influenced By Conservation Agriculture Practices in Rice-Maize Cropping System

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Abstract

A field experiment was conducted on a fixed site during rainy season (*kharif*) and winter season (*rabi*) of 2010-11 and 2011-12 at the research farm of Indian Agricultural Research Institute, New Delhi, to assess the effect of tillage and residue management practices on yield attributes and productivity of crops in rice (*Oryza sativa* L.) – maize (*Zea mays* L.) cropping system. Direct seeding under unpuddled condition, transplanting under puddled condition, brown manuring and mungbean residue incorporation before sowing of direct-seeded rice (DSR) were practiced in rice, while zero-till sowing, conventional till sowing and rice residue application with zero-till maize were tested in maize crop. During 2010 transplanted rice (TPR) produced significantly higher yield attributes and yield (5.37 t/ha). However during second year mungbean residue incorporation with DSR produced significantly at par yield attributes and yield (5.04 t/ha) than the TPR (5.2 t/ha). All the residue management treatments performed almost similarly with direct seeded rice, while lowest yield (4.56 t/ha) was recorded under DSR – ZTM. In maize, during first year conventional till maize (TPR-CTM) performed significantly better (4.21 t/ha) than the rest of the treatments but in second year mungbean residue + direct-seeded rice – zero till maize + rice residue- mungbean (MBR+DSR-ZTM+RR-MB) produced significantly higher yield (3.62 t/ha) than the no-residue maize grown after DSR and lowest yield (3.43 t/ha) was recorded under zero-till maize (DSR-ZTM), which was grown after DSR. In 2011-12, conventional till maize performed at par with MBR+DSR-ZTM+RR-MB. However all the residue management treatments performed almost at par.

Key words : Brown manuring, direct-seeded rice, productivity, residue management transplanted rice, zero-tillage.

Introduction

Rice (*Oryza sativa* L.) and maize (*Zea mays* L.) are important cereals to contribute food security and income in South Asia. These crops are grown either as a monoculture or in rotations in tropical and sub-tropical environments of South Asia. In the irrigated and favorable rainfed lowland areas, rice-rice (R-R), rice-wheat (R-W), and rice-maize (R-M) are the predominant cropping systems (Timsina *et al.*, 2011). Similarly, rice and maize are grown on 3.5 M ha in Asia, of which, 1.5 M ha is in South Asia. These crops are grown in sequence on the same land in the same year either in double or triple-crop systems to meet the rice demand of a rapidly expanding human population, and maize demand of livestock and poultry (Timsina *et al.*, 2010). The efficiency of input use, viz. water, fertilizer and others depends on tillage, cropping systems and crop establishment practices. It is, therefore, essential that soil environment be manipulated suitably for ensuring a good crop stand and improving resource-use efficiency. Intensive soil cultivation has worldwide resulted in the degradation of agricultural soils with decrease in soil organic matter and loss of soil structure, adversely affecting soil functioning and causing

a long-term threat to future yields (Pingali *et al.*, 2004). Resource degradation problems are manifesting in several ways in the present day agriculture. Declining soil carbon and fertility and water table are reflecting in loss of soil biodiversity, multiple nutrient deficiencies and increasing inputs use to maintain yields. To alleviate these problems and to fulfil the basic needs of human beings and regulate farm income, withstand weather aberrations, control price fluctuation, ensure balanced food supply, conserve natural resources, reduce the chemical fertilizer and pesticide loads and create employment opportunity, crop improvements and conservation agriculture show a lot of promise (Gill *et al.*, 2009). In spite of the intensive research efforts to raise the productivity level of these crops, there are still large gaps between biologically and climatically achievable potential yields, and research station and on-farm yields (Timsina *et al.*, 2010). Further, there are reports of decline or stagnation in the system productivity, which have raised concerns about the regional food security. Rice wheat is the dominant cropping system in the north-western plain zone and a lot of research work has been done on different aspects of this system for improving productivity but there is lack of information on rice – maize cropping system on different

aspects viz. resource-conserving techniques, such as direct-seeding of rice, brown manuring with *Sesbania aculeata*, zero-till sowing of maize as well as residue management on productivity, profitability and soil health. Rice maize is an emerging cropping system in many parts of India but its potential is yet to be assessed in north-western plain zone. Comparative evaluation of direct-seeded and transplanted rice, and the performance of following crops of maize under conventional and zero tillage conditions require a thorough investigation. In addition, the issues of cold injury in maize is a major concern, and require suitable mitigation measures through timely sowing, residue management, relay cropping with mungbean etc. Information on all these aspects is not available, hence the present comprehensive study was carried out to study the effect of tillage and residue management on yield attributes and productivity of crops in rice-maize cropping system.

Materials and Methods

A field experiment was conducted on a fixed site during rainy season (June to October) and winter season (November to April) of 2010-11 and 2011-12 at the research farm of Indian Agricultural Research Institute, New Delhi (28.4° N latitude, 77.1° E longitude and 228.6 m above mean sea level). The mean annual rainfall of Delhi is 672 mm and more than 80% generally occurs during the monsoon season (July-September) with mean annual evaporation of 850 mm. The soil at site was sandy clay loam with bulk density of 1.48 Mg/m³ and field capacity of 25.4 % (w/w). It had 0.54 % organic carbon, 170.6 kg KMnO₄ oxidizable N/ha, 18.6 kg 0.5 N NaHCO₃ extractable P/ha, 275 kg 1.0 N NH₄OAc exchangeable K/ha, 8.0 pH and 0.36 dS/m EC in the top 15 cm of soil. The treatments comprised viz. direct-deeded rice – zero-till maize (DSR-ZTW), direct-deeded rice – zero-till maize + rice residue (DSR-ZTW+RR), direct deeded rice + brown manuring–zero-till maize (DSR+BM-ZTM), direct-deeded rice + brown manuring–zero-till maize + rice residue (DSR+BM-ZTM+RR), mungbean residue + direct deeded rice- zero-till maize + relay mungbean (MBR+DSR-ZTM+MB), mungbean residue + direct deeded rice –zero-till maize + rice residue + relay mungbean (MBR+DSR-ZTM+RR+MB), transplanted rice – conventional till maize (TPR-CTM) and transplanted rice – zerotill maize (TPR-ZTM). The experiment was laid out in randomized block design and replicated thrice. Rice ‘PRH 10’ and maize ‘HQPM 1’, varieties were taken for experimentation. The sowing for direct-seeded rice and nursery raising was done in the second forth-night of June and transplanting of seedling was done in second week of July, while rice was harvested in the last week of October during both the years. Zero-till and conventional till maize

was sown in the first week of November and second week of November respectively and harvested in first week of May during both the years. For brown manuring practice seeds of *sesbania* @ 40kg/ha, was broadcasted together with the sowing of direct-seeded rice as per treatments and than *sesbania* crop was knocked down at 30 days after sowing with 2,4-D ester. Sowing of relay mungbean was done into the respective treatments in the second forth-night of march by broadcasting in the standing maize crop and after one picking of pods, it's residues was incorporated into soil in respective treatments through rotavator in June before sowing of direct-seeded rice. After harvesting of rice, it's chopped residue was applied into respective treatments @ 5.0 t/ha before sowing of zero-till maize. The cultivation of both season crops was done with the recommended package of practices. The number of irrigations applied in direct-seeded rice, transplanted rice, zero- till maize, and conventional till maize were 11, 21, 7, 7 and 17, 23, 9, 9 during 2010-11 and 2011-12 respectively. Comparatively higher number of irrigations was applied during 2011-12 in rice crop due to shortage of rainfall. All the growth parameters, yield attributes and yield were recorded as per standard methods at different intervals and at harvest.

Results and Discussion

Yield attributes and productivity of rice : The yield attributes viz. effective tillers/m², grains/panicle, panicle length, were significantly influenced by tillage, crop establishment methods and brown manuring during 2010. Transplanted rice under puddled condition produced significantly higher yield attributes than the direct-seeded rice and brown manuring + direct-seeded rice in 2010. Under brown manuring treatments the effective number of tillers was recorded significantly lower than others due to initial crowding effect of dhaincha. However, other yield attributes were recorded almost similar under direct seeded rice with brown manuring and without brown manuring treatments. During second year the yield attributes under mungbean residue incorporated treatments (MBR+DSR-ZTM+RR-MB and MBR+DSR-ZTM-MB) were recorded significantly similar with transplanted treatments (TPR). In second year, the treatments where rice residue was applied in previous zero-till maize crop and brown manuring practice followed in rice were produced higher yield attributes than the without residue direct-seeded treatments. Tillage and different residue management practices were failed to produced any significant variation into test weight of rice during both the years. Productivity of rice in terms of grain, straw and biological yield was significantly influenced due to tillage and residue management. During first year the transplanted rice produced significantly higher yields than

Table-1 : Yield attributes of rice as influenced by tillage, crop establishment, brown manuring and residue management.

*Treatment	2010				2011			
	Effective tillers/m ²	Grains/panicle	Panicle length (cm)	1000-grain weight (g)	Effective tillers/m ²	Grains/panicle	Panicle length (cm)	1000-grain weight (g)
¹ DSR-ZTW	225.3	90.7	25.6	24.78	252.8	98.4	26.1	24.11
¹ DSR-ZTW+RR	223.4	88.8	25.3	24.72	261.3	102.5	26.2	24.29
² DSR+BM-ZTW	190.5	84.7	25.4	24.65	259.5	101.1	26.2	24.58
² DSR+BM-ZTW+RR	188.5	82.2	25.2	24.57	272.7	105.5	27.1	24.61
¹ MBR+DSR-ZTW+ MB	222.2	86.5	25.3	24.73	268.6	103.4	27.5	24.57
¹ MBR+DSR-ZTW+RR+MB	220.6	87.6	25.1	24.69	281.8	107.3	28.4	24.80
³ TPR-CTW	297.0	109.4	28.8	24.94	295.4	108.1	28.2	24.71
³ TPR-ZTW	294.8	106.5	28.4	24.88	297.3	111.5	28.7	24.73
SEm±	3.71	3.39	0.19	0.27	4.26	1.91	0.32	0.14
CD (P=0.05)	11.24	10.28	0.58	NS	12.92	5.80	0.98	NS

*Treatments with superscript 1, 2, and 3 were maintained similarly in 2010.

Table-2 : Productivity of rice as influenced by tillage, crop establishment, brown manuring and residue management.

*Treatment	2010				2011			
	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
¹ DSR-ZTM	4.66	7.22	11.91	39.18	4.56	7.22	11.31	38.73
¹ DSR-ZTM+RR	4.62	7.16	11.78	39.26	4.79	7.28	11.60	39.73
² DSR+BM-ZTM	4.36	6.97	11.33	38.78	4.72	7.21	11.44	39.70
² DSR+BM-ZTM+RR	4.30	6.88	11.18	38.47	4.85	7.45	12.00	39.42
¹ MBR+DSR-ZTM+MB	4.56	7.14	11.70	39.63	4.81	7.40	12.07	39.43
¹ MBR+DSR-ZTM+RR+MB	4.61	7.02	11.63	38.61	5.04	7.68	12.49	39.72
³ TPR-CTM	5.37	7.97	13.34	40.27	5.52	8.17	13.55	40.32
³ TPR-ZTM	5.30	7.93	13.24	40.17	5.58	8.21	13.73	40.44
SEm±	0.12	0.20	0.27	0.27	0.11	0.16	0.23	0.41
CD (P=0.05)	0.36	0.62	0.81	NS	0.35	0.48	0.69	NS

*Treatments with superscript 1, 2, and 3 were maintained similarly in 2010.

the rest treatments but in second year TPR produced significantly similar yields with the treatments where mungbean residue was incorporated. Mungbean residue incorporated treatments produced significantly higher yield than the rest residue treatments except DSR+BM-ZTM+RR treatment. Dhiman *et al.* (2000) also reported similar findings. Lowest yield was recorded under the treatment (DSR-ZTM) where no-residue was applied during both the seasons. Residue management practices over time enhances the physico-chemical properties of soil, which results better yields. Under transplanted rice, better availability of water, nutrients and less weed infestation resulted comparatively higher yields (Johnson *et al.*, 2002). Harvest index remained significantly unaffected due to tillage and residue management practices during both the years.

Yield attributes and productivity of maize : The yield attributes (cob length, grains/cob, and cob weight) were

influenced due to tillage and significantly higher yield attributes recorded under conventional till maize (TPR-CTM) during 2010-11. However during second year mungbean residue incorporation in previous rice crop and zero-till maize with rice residue (MBR+DSR-ZTM+RR-MB) produced significantly at par yield attributes than the conventional till maize (TPR-CTM) which was grown after puddled transplanted rice. During second year poorest performance of the yield attributes were recorded under zero-till maize (DSR-CTM) which was grown after DSR. Tillage and residue management practices could not affect 1000-grain weight significantly. Tillage, residue management and brown manuring in previous crop could not affect grain, straw and biological yields significantly during 2010-11. However, significantly higher yields were recorded under mungbean residue incorporated in previous direct-seeded rice and zero-till maize with rice residue treatment (MBR+DSR-ZTM+RR+MB) than the

Table-3 : Yield attributes of maize as influenced by tillage, crop establishment, brown manuring and residue management.

*Treatment	2010-11				2011-12			
	Cob length (cm)	Grains/cob	Cob weight (g)	1000-grain weight (g)	Cob length (cm)	Grains/cob	Cob weight (g)	1000-grain weight (g)
¹ DSR-ZTM	15.1	382.1	95.5	217.27	14.9	378.3	92.4	216.60
² DSR-ZTM+RR	15.6	384.2	96.2	218.07	15.4	380.4	93.6	217.40
DSR+BM-ZTM	15.7	388.3	96.7	218.93	15.5	384.5	94.1	218.27
DSR+BM-ZTM+RR	15.8	391.8	97.4	220.83	15.6	388.0	94.9	220.17
¹ MBR+DSR-ZTM+MB	15.5	382.5	95.8	217.50	15.8	393.6	95.2	221.15
² MBR+DSR-ZTM+RR+MB	15.4	384.3	96.0	218.87	15.9	396.9	95.8	222.52
TPR-CTM	16.3	406.8	100.5	223.80	16.2	401.4	98.7	223.67
TPR-ZTM	15.9	393.3	97.7	220.53	15.7	386.8	95.3	219.87
SEm±	0.20	4.14	0.94	1.54	0.23	4.24	1.11	1.69
CD (P=0.05)	0.59	12.56	2.84	NS	0.68	12.85	3.37	NS

*Treatments with superscript 1 and 2 were maintained similarly in 2010-11.

Table-4 : Productivity of maize as influenced by tillage, crop establishment, brown manuring and residue management.

*Treatment	2010-11				2011-12			
	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
¹ DSR-ZTM	3.75	5.53	9.27	40.39	3.36	5.77	9.13	36.79
² DSR-ZTM+RR	3.81	5.60	9.41	40.51	3.43	5.81	9.23	37.11
DSR+BM-ZTM	3.87	5.64	9.51	40.71	3.48	5.89	9.37	37.15
DSR+BM-ZTM+RR	3.93	5.68	9.61	40.91	3.54	6.03	9.56	36.99
¹ MBR+DSR-ZTM+MB	3.77	5.55	9.32	40.45	3.58	6.14	9.73	36.84
² MBR+DSR-ZTM+RR+MB	3.80	5.60	9.40	40.46	3.62	6.21	9.83	36.90
TPR-CTM	4.21	6.03	10.23	41.11	3.83	6.42	10.22	37.34
TPR-ZTM	3.90	5.66	9.56	40.77	3.50	5.89	9.39	37.28
SEm±	0.07	0.09	0.15	0.69	0.08	0.12	0.18	0.84
CD (P=0.05)	0.22	0.27	0.46	NS	0.24	0.38	0.53	NS

*Treatments with superscript 1 and 2 were maintained similarly in 2010-11.

no-residue treatments and it perform at par with conventional till maize. During second year lowest yield performance was recorded under zero-till maize, which was grown after direct deeded rice. The performance of maize in 2010-11 was better than 2011-12 due to favourable weather conditions. Tillage and residue management practices could not bring any significant change in harvest index during both the year of study. Mungbean cultivation and residue incorporation improves soil properties and fertility status which resulted better yields of succeeding crops (Adil *et al.*, 2010). Manguiat *et al.* (1997) also reported positive effects of mungbean cultivation and residue incorporation. Similarly rice residue application increases organic matter into the soil over time, smoother weeds growth and maintain moisture in soil for longer time and finally owing to better yield of crops (Singh *et al.*, 2011) The yield of wheat after puddled transplanted rice was recorded lower than the wheat

grown after direct-seeded rice, this might be due to deterioration of soil properties due to puddling in rice crop (Yadav *et al.*, 2004)

This investigation indicates that MBR+DSR-ZTW/M+RR-MB conservation agriculture practice was performed better than other conservation agriculture based tillage and residue management practices in rice-maize cropping system. Tillage and residue management practices played a significant role in productivity enhancement of cereals rice and maize. In this study mungbean residue incorporated treatments produced significantly higher yield than the rest residue treatments except DSR+BM-ZTM+RR treatment in case of rice. However in case of winter maize, mungbean residue incorporation in previous rice crop and zero-till maize with rice residue (MBR+DSR-ZTM+RR-MB) practice produced significantly at par yield attributes and

field than the conventional till maize (TPR-CTM) which was grown after puddled transplanted rice.

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Studies on Genetic Divergence in Germplasm of Turmeric (*Curcuma longa* L.)

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Abstract

In these studies, the genetic diversity observed between different turmeric genotypes showed a low variance. All genotypes were divided into 6 groups and a high number of genotypes were grouped into cluster-III. The following six clusters show genetic divergence. The average intra cluster distance was higher in cluster-V and smaller in cluster-I. As turmeric is a plant that is propagated by vegetatively and hybridization is not carried out sparingly, however, in areas where flowers bloom with turmeric, crossing between genotypes of different clusters can be done at experimental levels. Therefore, crossing genotypes belonging to the same cluster cannot be expected to produce superior hybrid species or segregates. While, the highest inter cluster distance recorded collections between group II and III. The variety that is characterized by a high inter cluster distance will vary in phenotypic performance and therefore, the chances of getting good hybrids / transgressive segregants are more on the basis of the results obtained.

Key words : Turmeric and genetic divergence.

Introduction

Genetic diversity is a necessary participation in selecting hybridization parents and modifying the highest genotypes in any breeding program. The prevalence of wide variation in yield component, yield and quality in turmeric (*Curcuma longa* L.) genotypes is common (Subbarayudu *et al.* 1976, Reddy *et al.* 1989, Nirmal & Yamgar 1998). The concept of D² was originally developed by Mahalanobis (1936) but the introduction of this genetic diversity method was proposed by Rao (1952). The higher the genetic variation between parents the greater the chances of attaining transgressive segregation. Generations based on different genes are expected to show a wide range of genetic variants that provide a large area for high yielding segregates in the advance generation. It is a powerful tool for obtaining a balanced estimate of diversity among living organism and is widely used to assess diversity. To maintain this purpose, 25 cultivars of turmeric were tested and D² was performed to test for genetic divergence in genotypes.

Materials and Methods

Experiments with twenty-five genotypes of turmeric were obtained from a different source. The test is set to Randomized Block Design with three replications. Each genotype species was planted at 45 (Row × Row) × 20 cm (Plant × Plant) spacing in a plot size of 1m × 1m. Recorded data for various growth, yield and quality parameters following standard procedures. The calculations of Mahalanobis (1936) D², based on mean and demographic variation were used to generate genetic variation among

the 25 genotypes of turmeric in all 21 characters. Moreover, based on D² values, genotypes were classified into different clusters according to Tocher's method (Rao, 1952).

Results and Discussion

On the basis of the functioning of the various factors, the clustering pattern of the 25 different genotypes of turmeric is presented in Table 1.1. All genotypes were collected in 6 clusters. The highest number of genotypes were grouped into cluster-III (8) followed by cluster-I (6), cluster-II (5), cluster-IV (2), V (2) and VI (2) respectively.

The range of the intra cluster was the highest in cluster-V (1160.873) and the smallest in cluster-I (502.601). While, the highest inter-cluster distance (11105.680) was recorded between cluster-V and VI and the lowest (1008.119) was observed between cluster-I and III (Tables 1.2 and 1.3).

Cluster means to the different character modes presented in Table-1.4. The highest mean is found in cluster-VI for plant height (159.58 cm), number of leaves per plant (22.13), leaf width (19.81 cm), girth of stem (8.54 cm), girth of mother rhizomes per plant (3.78 cm), girth of primary rhizomes per plant (2.73 cm), length of mother rhizomes per plant (10.22 cm), number of primary rhizomes per plant (10.77), number of secondary rhizomes per plant (17.71), fresh weight of primary rhizomes per plant (243.86 g), dry weight of rhizomes per plant (194.68 g) and yield per plant (761.53 g). Similarly, higher studies indicating the number of tillers per plant (4.10) and the girth of the second rhizomes per plant (2.27

Table-1.1 : Clustering pattern of twenty-five genotypes of turmeric on the basis of genetic divergence.

Cluster	Number of genotypes	Genotypes
I	6	Krishna, Laka Dong, JWRH-13, JWRH-6, JWRH-1, JWRH-2
II	5	JWRH-10, JWRH-4, JWRH-11, JWRH-12, JWRH-15
III	8	Patangadi, JWRH-14, Belogaum local, GNT-1, Keshar, JWRH-17, Erode local, JWRH-7
IV	2	JWRH-3, JWRH-9
V	2	Salem, JWRH-16
VI	2	JWRH-5, JWRH-8

Table-1.2 : Intra and inter cluster distance (D) of turmeric.

Cluster	I	II	III	IV	V	VI
I	502.601	1189.867	1008.119	1221.88	1797.077	5856.486
II		862.556	1142.226	2486.093	2748.944	4258.648
III			598.275	2015.491	2776.807	4299.470
IV				679.82	1400.706	9472.641
V					1160.873	11105.680
VI						942.782

Table-1.3 : Average inter and intra cluster D and D² values of turmeric.

Cluster	I	II	III	IV	V	VI
I	22.41	34.49	31.75	34.95	42.39	76.52
II		29.36	33.79	49.86	52.43	65.25
III			24.45	44.89	52.69	65.57
IV				26.07	37.42	97.32
V					34.07	105.38
VI						30.70

Table-1.4 : Cluster means for different characters among twenty-five genotypes.

S. No.	Character	Cluster					
		I	II	III	IV	V	VI
1.	Plant height (cm)	143.52	142.52	147.35	146.56	126.28	159.58
2.	Number of tillers per plant	4.10	2.64	3.65	3.43	2.67	0.50
3.	Number of leaves per plant	20.54	20.68	21.46	20.52	21.16	22.13
4.	Leaf width (cm)	16.75	16.51	18.42	18.37	16.32	19.81
5.	Leaf length (cm)	79.62	78.85	82.63	87.58	71.13	82.98
6.	Girth of stem (cm)	5.69	6.15	6.53	5.80	5.00	8.54
7.	Girth of mother rhizomes per plant (cm)	2.56	3.19	2.69	1.91	2.14	3.78
8.	Girth of primary rhizomes per plant (cm)	2.21	2.46	2.40	1.91	2.30	2.73
9.	Girth of secondary rhizomes per plant (cm)	2.27	2.21	2.16	1.89	1.97	1.88
10.	Length of mother rhizomes per plant (cm)	5.28	6.85	5.01	5.44	4.77	10.22
11.	Length of primary rhizomes per plant (cm)	7.15	7.92	7.32	7.37	6.44	7.59
12.	Length of secondary rhizomes per plant (cm)	5.99	5.82	6.16	5.70	4.66	5.10
13.	Number of mother rhizomes per plant	1.05	1.20	1.11	1.08	1.26	1.07
14.	Number of primary rhizomes per plant	6.83	6.95	8.02	10.69	5.62	10.77
15.	Number of secondary rhizomes per plant	12.75	12.10	12.95	15.97	8.73	17.71
16.	Fresh weight of primary rhizomes per plant (gm)	242.60	172.31	211.63	168.57	179.48	243.86
17.	Fresh weight of secondary rhizomes per plant (gm)	142.28	235.91	149.89	132.89	171.83	87.69
18.	Dry weight of rhizomes per plant (gm)	76.50	107.94	113.20	47.61	65.38	194.68
19.	Days to harvest	252.25	252.20	236.03	263.96	226.99	233.83
20.	Curcumin content (%)	1.91	2.10	3.04	2.01	2.19	2.16
21.	Yield per plant (gm)	434.10	492.05	502.63	328.40	288.28	761.53

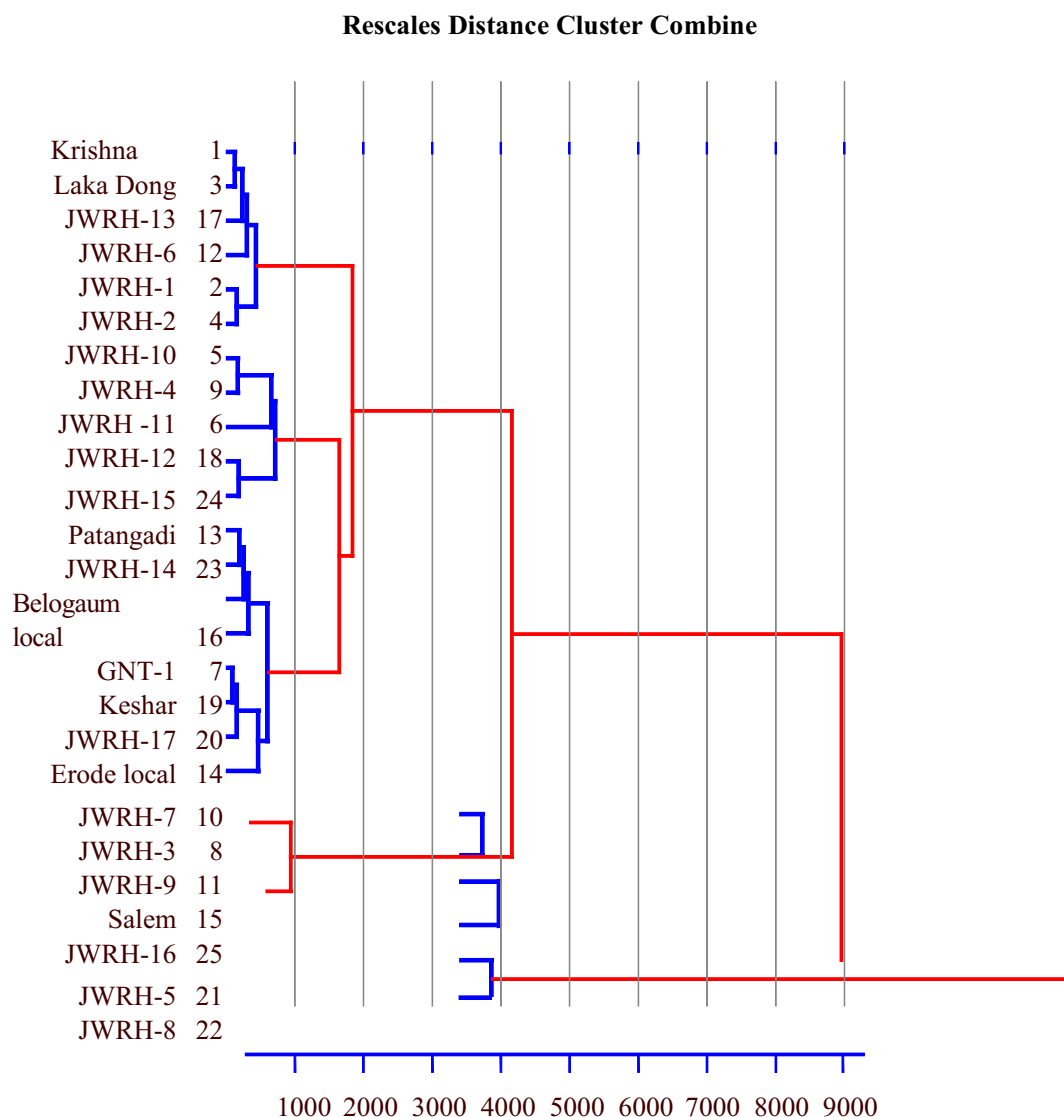


Fig. -1 : Dendrogram of 25 genotypes of turmeric based on squared Euclindan distance.

cm) were identified in cluster-I. The length of the primary rhizomes per plant (7.92 cm) and the fresh weight of secondary rhizomes per plant (235.91 g) were found to be the highest in cluster-II and cluster-III had the highest average length of the secondary rhizomes per plant (6.16 cm) and curcumin content% (3.04%). Cluster-IV had the highest value leaf value (87.58 cm) and harvest days (263.96), while cluster-V had the highest number of mother rhizomes per plant (1.26) only (Verma *et al.*, 2014 and Gupta *et al.*, 2015).

The level of genetic variation between 25 turmeric genotypes using quality and quantity factors. The turmeric germplasm appears to have a small gene base that received a high degree of genetic erosion and selective stress. The given method of analysis may be helpful in selecting different parents and expanding the germplasm

base of the turmeric site for future breeding programs (Jan *et al.*, 2012).

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Effect of Different Organic Based Nitrogen Sources on Chlorophyll Content and Yield Attributes under Rice-Wheat Cropping System

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Introduction

Rice-wheat is the major cropping system covering an area of 13.5 million hectares across the Indo-Gangetic Plains (IGP) of South Asia (Ladha *et al.*, 2003) and feeds about one-fifth of world population (Saharawat *et al.*, 2010). Rice-wheat cropping system as a result of several decades of continuous cropping and contrasting edaphic requirements of the two cereals, have shown evidence of soil nutrient depletion and imbalances, low nutrient use efficiency, a general reduction in soil organic matter and stagnating yields (Ladha *et al.*, 2003). The soils are now exhibiting loss of nutrients and are no longer showing increased production with increasing supply of nutrients (Benbi and Brar, 2009). The continuous use of inorganic fertilizers increases the cost of production, deteriorates soil health and pollutes the environment. Optimum use of organic manures like FYM and vermicompost provides all essential nutrients to plant and improves physical, chemical and biological properties of soil. It is a step towards sustainable agriculture as it reduces the stress of pollution on the nature and the judicious use of resources optimises the productivity (Purohit *et al.*, 2020).

Nitrogen is one of the most important limiting nutrients for rice production that directly influences growth, development and yield of crop. It often limits the rice yield. Use of vermicompost causes significant increase in the population of beneficial microorganisms such as mycorrhizal fungi and phosphate dissolving bacteria and fungi in the soil. Vermifertilizer helps in the maintenance of better environment and results in sustainable agriculture (Senapati, 1996). Application of organic manures is desirable for sustained supply of Zn and Cu to maintain the crop production at high levels by overcoming nutritional disorder especially micronutrients, inclusion of different manures in combination with fertilizers helps to take care of the soil health (Mishra *et al.*, 2006). Brown manuring is a practice which involves co-cultivation of rice along with green manure crop like sesbania and is efficiently able to manage weed

population by nearly half without any adverse effect on the yield of rice (Singh *et al.*, 2007). Crop residue enhances the soil properties, micronutrient supply and productivity in rice-wheat cropping system. Mycostraw is a paddy straw after mushroom cultivation. Paddy straw is used as substrate in cultivation of oyster mushroom. Use of mycostraw may be more beneficial than paddy straw as it easily get mineralized into the soil due to its low C: N ratio. The combined use of mycostraw, vermicompost, green manuring *in-situ* and biofertilizer along with inorganic fertilizers can be a good option.

Materials and Methods

The experiment entitled was conducted at University Research Farm, Dr. Rajendra Prasad Central Agricultural University, Bihar, Pusa (Samastipur) during *kharif* and *rabi* seasons of 2020-22. The soil was calcareous with the presence of 26.6 per cent free calcium carbonate. The soil order of the experimental field was Entisol, sandy loam in texture with medium available N (253 kg/ha), low P (9.61 kg/ha) and K (76.43 kg/ha). Rice variety Rajendra Kasturi and wheat variety HD 2967 was used as test crop. The experiment was laid out in Randomized Block Design (RBD) with thirteen treatments viz., T₁ - 75% RDN (Recommended Dose of Nitrogen), T₂ - 100% RDN, T₃ - 125% RDN, T₄ - 100% RDN +Wheat Straw (WS) 3t/ha + BM, T₅ - 100% RDN +Wheat Straw (WS) 3t/ha + VC (25% N) + BM(Brown Manuring) + Bio fertilizer, T₆ - 100% RDN + Myco Straw (1t/ha) + BM+ Bio Fertilizer, T₇ - 75% RDN +Wheat Straw (WS) 3t/ha + BM, T₈ - 75% RDN +Wheat Straw (WS) 3t/ha + VC (25% N) + BM, T₉ - 75% RDN + Myco Straw (1t/ha) + BM+ Bio Fertilizer, T₁₀ - Wheat Straw (WS) 3t/ha + VC (25% N) + Myco Straw (1.5t/ha), T₁₁ - Wheat Straw (WS) 3t/ha + VC (25% N) + Myco Straw (1.5t/ha) + BM + Bio fertilizer, T₁₂ - Control and it was replicated thrice.

Result and Discussion

Number of panicle/m² : The data showed that the crop under nutrient stress (control) had the minimum number of panicles (239). While the application of T₅-100 RDN +

Table-1 : Effect of different organic based nitrogen sources on chlorophyll content and yield attributes under rice-wheat cropping system.

Treatments	Chlorophyll content in flag leaf (SPAD value) (2020)	Number of panicles/m ² (2020)	Number of grains/panicles (2020)
T ₁ -75% RDN	39.20	259	110
T ₂ -100% RDN	41.60	272	117
T ₃ -125% RDN	41.80	267	118
T ₄ -100% RDN +Wheat Straw (WS) 3t/ha + BM	44.10	283	124
T ₅ -100% RDN +Wheat Straw (WS) 3t/ha + VC (25% N) + BM + Biofertilizer	45.20	318	132
T ₆ -100% RDN + Myco Straw (1t/ha) + BM+ Bio Fertilizer	43.40	277	125
T ₇ -75% RDN +Wheat Straw (WS) 3t/ha + BM	42.30	272	121
T ₈ -75% RDN +Wheat Straw (WS) 3t/ha + VC (25% N) + BM	44.70	294	126
T ₉ -75% RDN + Myco Straw (1t/ha) + BM+ Bio Fertilizer	42.50	269	120
T ₁₀ -Wheat Straw (WS) 3t/ha + VC (25% N) + Myco Straw (1.5t/ha)	41.20	256	112
T ₁₁ -Wheat Straw (WS) 3t/ha + VC (25% N) + Myco Straw (1.5t/ha) + BM +Bio fertilizer	41.50	262	113
T ₁₂ -Control	36.30	239	94
SEm (±)	1.32	13.10	4.69
CD (p=0.05)	3.87	38.66	13.79

wheat straw (WS) 3t/ha + VC (25% N) + BM + Biofertilizer significantly increased the number of panicles and this treatment was statistically superior to all other treatments.

Number of grains/panicles : Data indicates that in comparison to control, application of plant nutrients in the form of organic manure and inorganic fertilizer resulted in a significant increase in grains per panicle. Application of T₅-100% RDN + wheat straw (WS) 3t/ha + VC (25% N) + BM + Biofertilizer gave a significantly higher number of grains per panicle and it was followed by T₈- 75% RDN + wheat straw (WS) 3t/ha + VC (25% N) + BM (126 grains/panicle) and it was found at par with T₆-100% RDN + Mycostraw (1t/ha) + BM + Biofertilizer and T₇.75% RDN + wheat straw (WS) 3t/ha + BM.

Chlorophyll content in flag leaf stage : The data showed that the application of nutrients through either inorganic sources or their combination with organic sources significantly influenced chlorophyll content in flag leaf at flowering stage. Application of 100% RDN +Wheat Straw (WS) 3t/ha + VC (25% N) + BM + Biofertilizer (T₅) registered significant improvement in chlorophyll content in flag leaf stage with 45.20. These were significantly higher over treatments with lower chemical fertilizer and control.

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Response of Cabbage (*Brassica Oleracea* Var. Capitata L.) to Irrigation Intervals and Different Types of Mulches

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Abstract

A field experiment was conducted to study the response of cabbage (*Brassica oleracea* var. capitata L.) to irrigation intervals and different type of mulches on growth and yield parameters during *Rabi* season of 2019-20 at Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur. The experiment consisted of sixteen treatment combinations with four irrigation intervals (6, 9, 12 and 15 days) and four types of mulches (control, white polythene, black polythene and mustard straw) in randomized block design with three replications. The results of study clearly indicated that application of irrigation at 9 days interval as well as black polythene mulch significantly increased the plant height, number of leaves per plant, plant spread, leaf area and total chlorophyll content in leaves and head yield of cabbage. The interactive effect of irrigation at 9 days interval along with black polythene mulch was found statistically at par to application of irrigation at 12 days interval along with mustard straw mulch with respect to head yield q/ha (349.63 q/ha).

Key words : Yield attributes, irrigation intervals, mulches, cabbage.

Introduction

Cabbage (*Brassica oleracea* var. capitata L.) is a biennial crop of temperate region. It is mainly cultivated in Orissa, West Bengal, Uttar Pradesh, Bihar, Karnataka, Maharashtra, Gujarat, Punjab and Himachal Pradesh (Fageria *et al.*, 2003). In Rajasthan, it is mainly grown in Jaipur, Ajmer, Alwar, Sriganganagar, Tonk, Sikar, Jodhpur, Bundi, Bharatpur, Nagaur and Rajsamand. It contains Vitamin-A (2000 IU), thiamine (0.06 mg), riboflavin (0.03 mg), vitamin-C (124 mg/100 g) and also contains minerals like potassium, phosphorus, calcium, sodium and iron (Fageria *et al.*, 2003). Cabbage is used as salad, boiled, cooked dehydration and pickling purposes. It neutralizes acidity, improves digestion and appetite (Katyal and Chadha, 1985).

Mulching plays an important role in maximizing yield potentials of the crop in the arid and semi-arid regions as it may be proved beneficial by reducing water losses. Mulching has been advocated as an effective means for conserving soil moisture inside the soil. It works as an insulating material against heat or cold and also as a surface barrier to check evaporation from soil surface. Mulches can be differentiated into organic and inorganic mulches. Organic mulches include pine bark, bark chips, compost, leaf mould, lawn clippings, pea straw, stable straw, spoiled lucerne, seaweed, mushroom compost, hay, feathers, eucalyptus mulch, manures, papers and others. However, Inorganic mulches include: gravel, scoria, crushed rock and synthetic plastics of various colours (Unger, 1975).

Black polyethylene mulch is used most widely because it effectively decreases or eliminates most weed growth by inhibiting photosynthesis. The use of black polyethylene mulch increases yield and earliness of vegetables in the spring (Dittmar & McRae, 2012). Black polyethylene is popular for cool seasons because it warms the soil by contact (Hochmuth *et al.*, 2008). Mulches were found to act as a barrier to the action of rainfall that compacts soil and inhibits root growth. Black plastic significantly enhanced root growth and facilitated higher nutrient uptake, thereby promoting plant growth and development (Kumara and Dey, 2011).

Besides Mulching, Irrigation also plays an important role in maximizing yield potentials of crop. Water is one of the most important factors in successful crop production. It makes up by weight, the major portion of vegetables (about 75% or more) and regulates growth and development in the plants. It is essential for photosynthesis as solvent, act as carrier of nutrients and maintains turgidity of living cells. It is also a constituent of protoplasm reagent in many important physiological processes including photosynthesis and hydrolytic processes such as hydrolysis of starch to sugar and promotes activity of soil micro-organisms. Efficient utilization of available water is therefore, necessary to ensure maximum crop production. Water economy in crop production is of special importance in Indian agriculture and particularly in Rajasthan state where nearly 6.24 lakh ha out of 22.2 lakh ha of cultivated area is under irrigation. Appropriate Irrigation interval is to increase irrigation

efficiencies by applying the amount of water needed to replenish the soil moisture to desire level, saves water resources and energy. Therefore, it is important to irrigate the crop at right stage under prevailing climatic conditions in order to utilize scarce water resources effectively for crop production. Surface irrigation such as furrow, check basin and border are the most common methods in India.

Materials and Methods

A field experiment entitled “Effect of irrigation intervals and mulches on growth and yield of cabbage (*Brassica oleracea* var. capitata L.)” was conducted at the Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur, during *Rabi* season 2019-20. The climate of Durgapura is typically semi-arid characterized by extremes of temperature both in summer and winter, low rainfall and moderate relative humidity. The crop was transplanted on 07/02/2019 and harvested as last picking on 20/05/2019. The maximum and minimum temperature during the growing season of cabbage fluctuated 35.0 and 2.0°C, respectively. The relative humidity ranged from 52 to 70 per cent. While, the mean value of evaporation from USWB class pan ranged from 2.0 to 5.3 mm. Total rainfall received during the experimentation was 22.4 mm. The soil of experimental site was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon with low available nitrogen, phosphorus & sulphur and medium in potassium content. Water of this area is partially saline in nature. The pH and EC of water were 8.1 and 1.9 d/Sm, respectively.

Treatment details and methods of application : The experiment was laid out in Randomized block design with comprised of 16 treatment combinations viz. four irrigation intervals (6, 9, 12, and 15 days) and four different mulches (control, white polythene, black polythene and mustard straw). The treatments were randomly allocated to different plots using random table of Fisher and Yates (1963). The crop was irrigated immediately after transplanting. Further, irrigation was given twice at an interval of 2-3 days upto the establishment of seedlings. Thereafter, irrigation was applied as per treatment (6, 9, 12 and 15 days intervals) through check basin method. FYM procured from college dairy farm was applied in the experimental field @ 300 q/ha as basal and thoroughly mixed in the soil. A uniform dose of manures and fertilizers were also applied manually at the time of field preparation. Both the white & black polythenes of 200 gauge and mustard straw were put into bed size 1.8 x 1.8 m and the holes of 1 x 1 inch were made on polythene sheets as per the plant and row to row distance. These prepared polythene sheets and mustard straw @ 5t/ha including 1 cm thickness as mulch on top soil of the beds were spread over the randomly selected beds and thereafter,

transplanting was done. About five weeks old seedlings of cabbage were transplanted in the field, when average height of seedlings was about 10 cm. and between row to row and plant to plant distance was kept 45 cm x 45 cm. The root portion along with leaves attached to the head was cut with the help of sharp sickle and observations of tagged plants were recorded.

Results and Discussion

Effect of Irrigation Intervals on Growth attributing characters : The analysis of data indicated that irrigation intervals and mulches significantly affected the growth parameters (Table-1) of cabbage at different stages of crop growth. Application of irrigation at 9 days interval (I_2) recorded the maximum plant height (22.31 cm), number of leaves per plant (19.12) and average leaf area (280.48 cm²) at 45 DAT (days after transplanting) while minimum were recorded under I_4 (15 days interval) and proved superior over 6 days (I_1) and 15 days (I_4) irrigation interval with 18.99 and 45.82 per cent higher plant height, 11.87 and 27.28 per cent more number of leaves per plant and 16.80 and 30.18 per cent higher average leaf area respectively. Application of 12 days (I_3) irrigation interval was found to be statistically at par with application of 9 days (I_2) irrigation interval.

This pattern of results, obtained reflect that the negative trend of increasing the irrigation intervals from I_1 to I_4 level that is 6 days to 15 day interval, in no mulch plot was safely and almost completely counteracted by the placement of white and black polythene and mustard straw mulch in their respective irrigation plots. But this negative trend could not be completely counteracted by the presence of mulches in I_4 level of irrigation i.e. 15 days of interval. Similar results were obtained by Rahman *et al.* (1989) who reported that the growth of cabbage increased with increasing irrigation rates. Growth of plant depends on cell expansion and enlargement which is probably most sensitive physiological aspect of a plant to water deficit leading to reducing plant productivity (Larson, 1992) and ultimately affect plant height. Phenolic compounds produced in plants during water stress also respond to reduce plant growth (Lyu and Blum, 1990, Blum *et al.*, 1991 and Einhelling and Souza, 1992).

Plant spread had significant effect on different irrigation intervals and mulches at 50 days after transplanting of cabbage crop (Table 1). The maximum plant spread (2660.05 cm²) and total chlorophyll content (0.764 mg/g) in leaves were observed with treatment I_2 (9 days irrigation interval) at 50 days after transplanting. This treatment was found to be significantly superior over rest of the treatments with an increase in plant spread as 17.67 and 37.28 per cent and 10.8 and 36.68 per cent as

Table-1 : Effect of irrigation intervals and mulches on growth attributes and yield of cabbage.

Treatments	Plant height (cm)	Number of leaves per plant	Plant spread (cm)	Leaf area (mm)	Chlorophyll content (mg/100g)	Yield	
						Kg/plot	Q/ha
Irrigation intervals							
I ₁ (6 days)	18.76	16.87	2260.66	240.14	0.688	9.03	278.77
I ₂ (9 days)	22.33	19.14	2660.06	280.50	0.763	10.87	335.56
I ₃ (12 days)	21.58	18.29	2517.57	272.33	0.744	10.07	310.86
I ₄ (15 days)	15.32	13.83	1937.64	215.47	0.558	8.07	249.01
SEm+	0.50	0.48	72.35	4.57	0.013	0.14	4.14
CD (P=0.05)	1.42	1.37	208.94	13.18	0.041	0.40	11.94
Mulches							
M ₀ (Control)	15.79	13.64	1997.09	216.86	0.559	8.54	263.46
M ₁ (White polythene)	19.15	17.25	2277.88	249.13	0.698	9.42	290.62
M ₂ (Black polythene)	22.76	19.47	2701.43	278.97	0.772	10.44	322.10
M ₃ (Mustard straw)	20.40	17.76	2399.54	263.48	0.723	9.66	298.02
SEm+	0.50	0.48	72.35	4.57	0.013	0.14	4.14
CD (P=0.05)	1.42	1.37	208.94	13.18	0.041	0.40	11.94

Table-2 : Interactive effect of irrigation intervals and mulches on head yield (kg/plot and q/ha) of cabbage.

Treatments	Mulches levels				Irrigation intervals			
					Head yield (kg/plot)		Head yield (q/ha)	
	I ₁	I ₂	I ₃	I ₄	I ₁	I ₂	I ₃	I ₄
M ₀	7.98	10.26	8.74	7.17	246.42	316.54	269.63	221.23
M ₁	8.85	10.83	10.02	7.97	273.09	334.32	309.14	245.93
M ₂	10.70	11.33	10.91	8.80	330.37	349.63	336.79	271.60
M ₃	8.59	11.07	10.62	8.34	265.19	341.73	327.90	257.28
SEm+				0.28				8.27
CD (P=0.05)				0.80				23.88

chlorophyll content in leaves (mg/g) over treatment I₁ (6 days) and I₄ (15 days irrigation interval), respectively. Whereas, it was found statistically at par to treatment I₃ (12 days interval). In case of plants it might be due to that number of irrigations improved photosynthetic efficiency. Which could be attributed to the developed canopy with the increase of irrigation level (Begum *et al.*, 2001 and Gohari, 2013). Frequent watering to the soil especially during the early growth stages of the crop prevented water stress and kept the soil in available moisture condition that help to improve plant growth and the increased curd yield (Gomes *et al.*, 2000). Xylem water potential varied with water supply and therefore, it may be quite effective to monitor moisture stress in plants (Katerji *et al.*, 1987). Increasing the soil water stress decreases leaf water potential. The obtained results are in good harmony with those of Byari and Rabighi (1996) who found that increasing of irrigation frequency caused an increase in number of leaves of eggplant.

Effect of Mulches on Growth attributing characters :

The data regarding the effect of different mulches on the Growth characters of cabbage has been also presented. The perusal of data in the same Table revealed that the

plant height, number of leaves per plant and average leaf area at 45 days after transplanting was significantly affected by various mulches. The maximum plant height (22.66 cm), number of leaves per plant (19.47) and average leaf area (278.97 cm²) of cabbage at 45 days after transplanting was recorded with application of black polythene (M₂) which was significantly superior than rest of the treatments but treatment M₁ (white polythene) and M₃ (mustard straw mulch) were found statistically at par to it. The increase in average leaf area was registered at the tune of 28.63 per cent under treatment M₂ over control at 45 days after transplanting. It might be due to that black polythene mulch significantly enhanced root growth and facilitated higher nutrient uptake, thereby promoting plant growth and development (Kumara and Day, 2011). Mulches were also found to act as a barrier for weed growth. Begum *et al.* (2001) and Gohari (2013) also observed the similar results of mulching. Salisbury and Ross (1988) also reported that low water availability adversely affects the hormonal balance in development of plant and assimilate translocation.

Similarly, application of different mulches also significantly influenced plant spread and total chlorophyll

content in leaves over control, M_1 (white polythene) and M_3 (mustard straw mulch) of cabbage. The maximum plant spread (2701.43 cm^2) and chlorophyll content (0.772 mg/g) was recorded with treatment M_2 (black polythene), being significantly superior over rest of the treatments. The increase in plant spread was recorded at the tune of 35.27 per cent over control and 38.03 and 10.58 and 6.77 per cent higher chlorophyll content in leaves over control, M_1 (white polythene) and M_3 (mustard straw) at 50 days after transplanting, respectively. It is known that the moisture conserving effect of straw mulch increases with the amount applied. Russel (1940) stated that an amount of 3000 pounds of mulch per acre (3.4 t/ha) is about the smallest rate that is effective to minimize the evaporation rate. Therefore, the relatively small amounts of straw applied would not be expected to be effective in conserving soil moisture (Verma and Kohnke, 1951). The reason for soil moisture retained by white plastic mulch to be lower than soil moisture retained by mustard straw mulch might be due to that White plastic mulch allowed less amounts of water into the soil. However, mustard straw allowed more water thus being able to retain more water in the soil (Masarirambi *et al.* 2013).

Effect of Irrigation Intervals on yield : The data presented in Table-1 revealed that application of different irrigation intervals significantly increased head yield of cabbage. The maximum and significantly higher head yield of 10.87 kg/plot and head yield (335.56 q/ha) were obtained with the irrigation at 9 days interval (I_2) followed by treatment I_3 (12 days interval). However, it was noticed as minimum head yield of 8.07 kg per plot and 249.01 q/ha was registered under I_4 (15 days interval). The increase in head yield kg/plot and q/ha of cabbage under I_2 was recorded as 34.7 per cent and 34.76 per cent higher over treatment I_4 . The increase in yield and yield attributes obtained with irrigation intervals might be due to increased photosynthesis favoured by improved photosynthesis effect as well as source to sink relationship (Anonymous, 2000). The significant improvement in the mustard seed yield might be due to the cumulative effect of significant improvement in the value of yield attributes like number of siliqua per plant, number of seeds/siliqua and test weight (Piri *et al.* 2011). Prasad and Ehsanullah (1988), Katole and Sharma (1991) and Ehsanullah *et al.* (1991) reported an increase in seed yield of mustard due to irrigation.

Effect of Mulches on yield : Data (Table-1) further indicated that use of different mulches also had significant effect on head yield of cabbage. Use of black polythene mulch (M_2) observed to be the most superior treatment to head yield ($10.44 \text{ kg per plot}$ and 322.10 q/ha) over rest of treatments and registered 22.25, 10.82 and 8.07 per cent more head yield kg per plot and 22.26, 13.12 and 10.31

per cent more yield q/ha of cabbage over control, white polythene (M_1) and mustard straw (M_3), respectively. Moniruzzaman *et al.* (2007) also reported the increase in curd yield of cauliflower due to black polythene mulching might occur from better moisture utilization by fall of temperature during winter checking evaporation loss and lesser competition of weeds. Similar results were also reported by Saifullah *et al.* (1996) and Pessala (1994) in cabbage and khol rabi, respectively. Plants under polyethylene mulch (silver on black) produced larger fruit and have higher fruit yield per plant because of better plant growth due to favourable hydro-thermal regime of soil complete weed free environment (Parmar *et al.* 2013). These results were in consonance with those of Rudich *et al.* (1978), Battikhi and Ghawi (1987),

Interaction effect on head yield : Interactive effect of different irrigation intervals with mulches was found to be significant on head yield per plot and per hectare (Table-2). The combined application of irrigation at 9 days interval + black polythene mulch (I_2M_2) proved significantly higher over rest of treatment combinations except treatment combinations I_2M_3 , I_3M_2 , I_2M_1 , I_1M_2 and I_3M_3 which were found statistically at par to it. This treatment combination (I_2M_2) registered 58.02 per cent higher head yield kg per plot and treatment combinations I_2M_2 , I_2M_3 , I_3M_2 , I_2M_1 , I_1M_2 and I_3M_3 registered 58.04, 54.46, 52.24, 51.12, 49.33 and 48.22 per cent higher yield quintal per hectare than I_4M_0 (15 days irrigation interval without mulch), respectively. The significant increase in yield under the application of irrigation intervals and mulches was largely a function of improved growth and subsequent increase in average weight of head (kg/plant), head yield (kg/plot), head yield (q/ha) and other yield attributes as described above. The interactive advantages of combined application of irrigation intervals and mulches generally proved superior to the use of each component separately.

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Effect of NPK and Sulphur on Growth and Yield Attributes of Cauliflower (*Brassica oleracea* Var. *Botrytis* L.)

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Abstract

A field experiment was conducted at Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur during Rabi season 2020. The experiment consisting four levels of NPK (0, 75, 100 and 125% RD of NPK) and four doses of sulphur (0, 20, 40 and 60 kg sulphur ha⁻¹) with total 16 treatment combinations were tested in randomized block design with three replications. Results revealed that application of 125 per cent recommended dose of NPK and sulphur doses @ 60 kg ha⁻¹ to the cauliflower crop significantly increased the plant height (cm) at 30, 60 DAT and at harvest, number of leaves, leaf area, average weight of curd (g), total curd yield (kg plot⁻¹ and q ha⁻¹) and volume of curd (CC) as compared to control, 75 per cent recommended dose of NPK and 20 kg sulphur ha⁻¹ but statistically at par with 100 per cent recommended dose of NPK with 40 kg sulphur ha⁻¹. Application of sulphur @ 60 kg ha⁻¹ was found to be non significant in case of days taken to curd initiation over different sulphur doses. The combined application of 100 per cent recommended dose of NPK with 40 kg sulphur ha⁻¹ proved to be most superior treatment combination in terms of average weight of curd (g), total yield of curd per plot (kg), total curd yield (q ha⁻¹) because resulting saving of 25 per cent recommended dose of NPK and 20 kg sulphur ha⁻¹.

Key words : Cauliflower, NPK, sulphur, growth and yield.

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is the most popular vegetable crop among cole crops belong to the family Cruciferae. It is being grown round the year for its white and tender curd. In India, two separate groups of cauliflower are commonly grown viz. Indian or tropical types (originated in India) and the annual temperate or European type also known as 'Erfurt' or snowball type. The Indian types form curds at 20 to 25 °C and the temperate types require a temperature of 10 to 16 °C for curd formation. The Indian types are resistant to water logging and heat. The typical Indian or Tropical cauliflower have been developed from the inter-crossing of Cornish type (biennial) with European strains. Tropical types have more variability and strong self-incompatibility. Temperate types have less variability and less or no self-incompatibility. It has small thick stem, bearing whorl of leaves and branched tap root system. The main point develops into shortened shoot system whose apices make up the convex surface of curd. It is used as fried vegetable, dried vegetable, making soup and pickles. In Rajasthan, Cauliflower is grown extensively in the district of Ajmer, Alwar, Tonk, Sikar, Bundi, Bharatpur, Nagaur, Rajsamand, Ganganagar, Jaipur and Jodhpur. Total area of cauliflower in Rajasthan about 9.42 thousand ha with an annual production of about 36.61 thousand tonnes and productivity about 3.89 MT (Anonymous, 2013).

Among various essential plant nutrients, nitrogen is an essential for plant growth, development and

reproduction. Nitrogen is associated with vigorous vegetative growth. It is helpful in large size compact curd development. The proper use of nitrogen improve the curd size, nutrient value and reduces the chances of buttoning (Markovic and Diurovaka, 1990). Phosphorus is a constituent of nucleic acid, phytin and phosphorus. So, an adequate supply of phosphorus in early stage of plant life is an important in laying down the primordia for the reproductive parts of the cauliflower. It is also an essential constituent of majority of enzymes which are of great important in the transformation of energy in carbohydrate and fat metabolism and also in respiration in plants (Yawalkar *et al.*, 1996). Potassium imparts increased vigour and disease resistance to plant. It also regulates water conduction within the plant cell and water loss from the plant by maintaining the balance between anabolism, respiration and transpiration. Thus reduces tendency to wilt and help in better utilization of available water which ultimately help in the formation of protein and chlorophyll and quality (Rutkauskienė and Poderys, 1999). Sulphur is an essential plant nutrient and it stands next to primary nutrients in importance. Sulphur plays a vital role in biosynthesis of certain amino acids (cysteine, cystine and methionine) that are essential component of protein and also help in the synthesis of coenzyme-A and formation of chlorophyll and nitrogenase enzyme. Further, sulphur also provides winter hardiness and drought tolerance, control of insect pests and disease *etc.* Two natural growth regulators, thiamin and biotin contain sulphur. Sulphur occurs in glutathione that is important in oxidation

reduction reaction (Kanwar, 1976). It is one of the constituents of vitamin B₁, some volatile oils and amino acids like methinine (21% S). It is involved in various metabolic and enzymatic processes in the plant (Goswami, 1988). The substantial decrease in SO₂ emission to less than 10 kg ha⁻¹ of S further intensified S deficiency in plants, because as much as 30 per cent of its total amount can be absorbed from SO₂ in the air. The S cycle and its effect on plants are often compared to N (oxidation in soil and reduction in plants). The main difference is that S from organic compounds can be re-oxidised to SO₄-S in plants (Vanek *et al.*, 2001).

Materials and Methods

The field experiment entitled “Effect of NPK and sulphur on growth, yield and quality of cauliflower (*Brassica oleracea* var. *botrytis* L.)” was conducted at the Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur during *Rabi* season 2020. The experiment was comprised of 16 treatment combinations carried out in Randomized Block Design (RBD) with four levels of NPK (0, 75, 100 and 125 % RD of NPK) and Sulphur (0, 20, 40 and 60 kg ha⁻¹). The recommended dose of NPK for cauliflower is 120 kg, 80 kg and 80 kg per ha respectively. Full dose of P₂O₅, K₂O and half dose of N in various treatments were applied manually as the basal dose at the time of transplanting. Remaining dose of nitrogen was given as top dressing in two split doses at 30 and 45 days after transplanting. Sulphur was applied as per treatment through agriculture grade elemental sulphur and was broadcasted uniformly before transplanting and incorporated in the soil. Seeds of cauliflower cv. Pusa Synthetic obtained from National Seed Corporation and treated with 0.02 per cent *Thiram* to save the seedlings from damping off disease. A thin layer of powdered leaf mould was used to cover the seeds. Regular watering was done. The seedlings were ready for transplanting in 4-5 weeks. Five weeks old seedlings were transplanted on 24 October 2018, when average height of seedlings was about 10-12 cm. The distance between row to row and plant to plant was kept at 45 x 45 cm. Thus, 16 plants were accommodated in each plot. The transplanting was done in evening hours followed by light irrigation.

Results and Discussion

Effect of NPKs on growth attributes : The effect of NPK on plant height and number of leaves per plant of cauliflower at different stages of growth presented in Table-1 shows different NPK levels significantly influenced the plant height and number of leaves per plant at different stages of growth. The mean maximum plant height at 30, 60 DAT and at harvest was (30.85, 46.59 and 58.25 cm, respectively) and number of leaves per plant at

30, 60 DAT and at harvest (13.02, 18.24 and 24.96, respectively) was recorded under F₃ i.e. 125 per cent recommended dose of NPK, which was found to be significantly higher over F₀ and F₁ but statistically to at par to F₂ treatment. The data reported in same table revealed that days taken to curd initiation varied non-significantly due to different fertility levels. Leaf area and chlorophyll content of cauliflower also significantly influenced by different fertility levels. The mean maximum leaf area was (868.30 cm²) and chlorophyll content (1.40 mg g⁻¹) recorded under F₃ (125 per cent recommended dose of NPK), which was found to be significantly higher over F₀ and F₁ but it was statistically at par with F₂. The mean minimum leaf area (695.98 cm²) was recorded in F₀ (control).

The results of present investigation (Table 1) showed that increasing different fertility levels significantly increased the plant height, leaf area and number of leaves per plant under F₂ treatment (100% RD of NPK). However different fertility levels were found to be non significant to curd initiation of cauliflower. It might be due to that fluctuation in the day and night temperature during curd initiation. The maximum temperature in 3rd week was recorded 23° C however, it was 27° C in 1st week of January. Significantly increased the plant height, leaf area and number of leaves per plant might be due to the better nutritional environment in the root zone for growth and development of the plant by the application of NPK. The NPK are considered as one of the major nutrient required for proper growth and development of the plant. Besides this, nitrogen is a main constituent of protoplasm, cell nucleus, amino acids, proteins, chlorophyll and many other metabolic products (Kumhar, 2004). Phosphorus is a constituent of nucleic acid, phytin and phospholipids. The beneficial influence of phosphorus in early stages of growth may be explained by early stimulation of root system through efficient translocation to the root of certain growth stimulation compounds formed on account of protoplasmic activity of tops in phosphorus fed plants, when enhanced absorption of nitrogen and other nutrient and their utilization. So an adequate supply of phosphorus in early stage of plant life is an important in laying down the primordial for the reproductive parts of the cauliflower (Thakur *et al.*, 1991). The response to potassium fertilization in terms of overall improvement in growth parameters in further supported by the fact that the leaching losses of potassium were more in light textured soils. Therefore, potassium fertilization improved overall crop growth in terms of plant height, number of leaves per plant. Potassium helps in the protein and chlorophyll formation ultimately the NPK are used for better vegetative growth. The result are close conformity with

Table-1 : Effect of NPKs and sulphur on growth attributes of cauliflower.

Treatments	Plant height (cm)			No. of leaves per plant			Days taken to curd initiation	Leaf area (cm ²)	Chlorophyll content (mg/g)
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest			
Fertility levels									
Control (F ₀)	25.63	39.73	47.88	9.66	15.51	20.50	65.59	695.98	1.07
75 per cent RD of NPK (F ₁)	27.74	42.95	53.11	10.93	17.02	21.79	61.07	786.32	1.24
100 per cent RD of NPK (F ₂)	30.69	45.14	57.03	12.53	17.93	24.38	56.54	853.98	1.35
125 per cent RD of NPK (F ₃)	30.85	46.56	58.25	13.02	18.21	24.96	54.87	868.30	1.40
SEm+	0.86	0.76	1.09	0.29	0.29	0.54	2.40	14.00	0.04
CD at 5%	2.48	2.19	3.14	0.84	0.84	1.57	NS	40.44	0.11
Sulphur levels (kg/ha)									
Control (S ₀)	25.16	39.87	48.71	9.97	15.44	19.12	64.03	690.12	1.03
Sulphur 20 kg ha ⁻¹ (S ₁)	28.22	43.10	53.05	11.27	17.04	22.59	60.13	787.18	1.23
Sulphur 40 kg ha ⁻¹ (S ₂)	30.71	45.32	56.95	12.33	17.99	24.81	56.84	856.28	1.36
Sulphur 60 kg ha ⁻¹ (S ₃)	30.81	46.10	57.56	12.57	18.20	25.11	57.07	871.00	1.44
SEm+	0.86	0.76	1.09	0.29	0.29	0.54	2.40	14.00	0.04
CD at 5%	2.48	2.19	3.14	0.84	0.84	1.57	NS	40.44	0.10

Table-2 : Effect of NPKs and sulphur on yield attributes of cauliflower.

Treatments	Average weight of curd (g)	Volume of curd (cc)	Curd yield (kg/plot)	Curd yield (q/ha)
Fertility levels				
Control (F ₀)	213.80	150.78	3.42	105.60
75 per cent RD of NPK (F ₁)	286.62	211.37	4.59	141.56
100 per cent RD of NPK (F ₂)	358.70	247.36	5.74	177.15
125 per cent RD of NPK (F ₃)	371.65	264.66	5.95	183.55
SEm+	5.62	6.98	0.09	2.74
CD at 5%	16.24	20.16	0.26	7.92
Sulphur levels (kg/ha)				
Control (S ₀)	214.15	147.13	3.43	105.77
Sulphur 20 kg ha ⁻¹ (S ₁)	286.25	212.53	4.58	141.37
Sulphur 40 kg ha ⁻¹ (S ₂)	358.36	248.19	5.73	176.98
Sulphur 60 kg ha ⁻¹ (S ₃)	372.02	266.32	5.95	183.73
SEm+	5.61	6.98	0.09	2.74
CD at 5%	16.22	20.16	0.26	7.92

the finding of Baghel and Singh (1995), Patil *et al.* (2003), Kumhar (2004), and Abd el-All and EL- Shabrawy (2013).

Effect of NPKs on yield attributes : The perusal of data presenting in Table shows that the effect of NPK had significant influence on the average weight and volume of curd. The mean maximum average weight of curd (371.65 g) and volume of curd (264.66 CC) was observed in F₃ *i.e.* 125 per cent recommended dose of NPK, which was found to be significantly higher over F₀ and F₁ but it was statistically at par with F₂ *i.e.* 100 per cent recommended dose of NPK. Whereas, minimum volume of curd (150.76 CC) was recorded under F₀ treatment. In case of yield data reveals that total yield of curd per plot and ha⁻¹ was significantly influenced by various fertility levels. The maximum yield of curd per plot (5.95 kg) and total curd yield ha⁻¹ (183.55 q ha⁻¹) was recorded under 125 per cent

recommended dose of NPK (F₃) followed F₂ and F₁. While minimum curd yield per plot and ha⁻¹ (3.42 kg, 105.60 q ha⁻¹) was recorded under control. The maximum yield of curd per plot and ha⁻¹ under the treatment F₃ was found significantly more over to F₀ and F₁ but it was statistically at par with F₂ treatment.

The application of 100 per cent recommended dose of NPK significantly increased the average weight of curd (g), curd yield per plot (kg), curd yield per ha⁻¹ and volume of curd (CC) (Table-2). However 100 per cent recommended dose of NPK (F₂) was statistically at par to 125 per cent recommended dose of NPK (F₃) in all the above characters. This might be due to the fact that increased NPK levels, helped in the expansion of leaf area and chlorophyll content which together might have accelerated the photosynthetic rates and in turn increased

Table-3 : Interactive effect of NPKs and sulphur on yield attributes of cauliflower.

Treatments	Fertility levels											
	Average weight of curd (g)				Curd yield (kg/plot)				Curd yield (q ha ⁻¹)			
Sulphur levels	F ₀	F ₁	F ₂	F ₃	F ₀	F ₁	F ₂	F ₃	F ₀	F ₁	F ₂	F ₃
Control (S ₀)	148.98	199.71	249.07	258.96	2.38	3.20	3.99	4.14	73.57	98.62	123.00	127.88
Sulphur 20 kg ha ⁻¹ (S ₁)	199.13	266.94	332.91	346.13	3.19	4.27	5.33	5.54	98.34	131.82	164.40	170.93
Sulphur 40 kg ha ⁻¹ (S ₂)	248.42	333.02	420.31	431.81	3.97	5.33	6.72	6.91	122.68	164.45	207.56	213.24
Sulphur 60 kg ha ⁻¹ (S ₃)	258.79	346.92	432.65	449.84	4.14	5.55	6.92	7.20	127.80	171.32	213.65	222.14
SEm+	11.25				0.18				5.48			
CD (0.05)	32.49				0.52				15.83			

the supply of carbohydrates to plants. The application of 100 per cent recommended dose of NPK favoured the metabolic and auxin activities in plant and ultimately resulted in increasing curds weight, volume of curd finally the total yield. However, potassium does not increase the yield of plant but indirectly supported to yield. These results are also in close conformity with the finding of Batel *et al.* (1997), Everaerst and Boou (2000), Yaldas *et al.* (2008) and Abd el-All and EL- Shabrawy (2013).

Effect of sulphur on growth attributes : The result of present investigation have shown that increasing levels of sulphur significantly increased the plant height and number of leaves per plant (Table-1), while days taken to curd initiation decreased with higher levels of sulphur. The results revealed that application of sulphur at the rate of 40 kg ha⁻¹ have significantly increased the plant height and number of leaves per plant as compared to 20 kg sulphur per ha and control. The maximum plant height of 30.81, 46.13 and 57.56 cm at 30, 60 DAT and at harvest and number of leaves per plant of 12.57, 18.23 and 25.11 cm at 30, 60 DAT and at harvest, respectively were recorded with 60 kg S ha⁻¹. However, 60 kg ha⁻¹ was found statistically at par to it. The interaction effect of fertility levels and sulphur dose on plant height, number of leaves per plant and days taken to curd initiation was found to be non-significant. It is obvious, because of the fact that application of sulphur has been reported to improve not only the availability of sulphur but of other nutrient too, which are considered important for growth and development of plant. Increased vegetative growth of cauliflower due to sulphur application in the present investigation is in close conformity with the finding of Bhagavatagoudra and Rokhade (2001) and Mahmud *et al.* (2005).

Application of different sulphur doses had significant effect on leaf area and chlorophyll content of leaves. The maximum leaf area (871.00 cm²) and maximum value of chlorophyll (1.46 mg g⁻¹) content was recorded with 60 kg S ha⁻¹ which was statistically at par with 40 kg S ha⁻¹. The mean minimum leaf area and chlorophyll content of leaves was recorded in S₀ (control). The mean increase in

leaf area and chlorophyll content of leaves under S₂ treatment was found to be 24.07, 8.78 and 31.43 and 10.40 per cent over S₀ and S₁, respectively.

Application of sulphur has been reported to help in lowering soil pH resulting in increased availability of several nutrients or might be due to the activation of a number of enzymes, energy transformation, chlorophyll formation and also in carbohydrate metabolism (Tandon, 1986). Due to sulphur fertilization, xylem and collenchymas fiber are also reported to be thickened resulting into more pronounced growth of plant (Biswas *et al.*, 1995). Increasing vegetative growth of cauliflower due to sulphur fertilization in the present investigation are in close conformity with the finding of Yadav and Paliwal (1990), Shekhawat (1992), Dhar *et al.* (1999), Meena (2004) and Bhagavatagoudra and Rokhade (2001). Sulphur also plays an important role in the production of chlorophyll. It was found that the sulphur increased the chemical and biological activation of iron in the leaves resulting in increased chlorophyll content. Chhipa (2005).

Effect of sulphur on yield attributes : A perusal of data given in Table-2 reveals that the application of 40 kg S ha⁻¹ significantly increased yield attributes viz., average weight of curd (g), total curd yield per plot (kg), total curd yield per ha (q) and volume of curd (CC) as compared to control and 20 kg sulphur but remained statistically at par with 60 kg sulphur per ha. The maximum average weight of curd (372.08 g) and volume of curd (266.30 CC) was recorded with 60 kg ha⁻¹ which was statistically at par with 40 kg ha⁻¹ whereas minimum was recorded under control. The critical analysis of data also presented in same Table reveals that the different sulphur doses significantly influenced the curd yield per plot and per ha. The maximum curd yield per plot (5.95 kg) and per ha (105.77 q ha⁻¹) was recorded with 60 kg S ha⁻¹, which was statistically at par with 40 kg S ha⁻¹. While minimum was recorded under control.

The increase in yield and yield attributes might be due to the important role of sulphur in lowering the pH of saline-alkaline soil resulting in increased availability of

many nutrients (Hossan and Olsen, 1966) or might to be the activation of a number of enzymes and also in carbohydrate metabolism (Tandon, 1986) which in turn might have favoured better development of curd and resulted in increased growth and ultimately higher yield. The results are in close conformity with those of Hara *et al.* (1981), Bijania and Dixit (1996), Bhagavatagoudra and Rokhade (2001) and Gautam (2012).

The increase in yield attributes was probably due to source and sink relationship. The increase in yield attributes can be attributed to increase the size of source and consequently the enhanced partitioning of photosynthates towards sink. The results revealed that application of 60 kg sulphur ha⁻¹ significantly increased the curd yields ha⁻¹ of cauliflower as compared to control and 20 kg sulphur per ha, which were found statistically at par with 60 kg S ha⁻¹. These finding corroborates with the findings of Dhar *et al.* (1999), Jamre *et al.* (2010) and Talukder *et al.* (2013).

Interactive effect (F×S) : The perusal of data on combined effect of different fertility levels and sulphur doses has been presented in Table 3. The maximum average weight of curd (449.84 g), curd yield per plot (7.20 kg) and curd yield per ha (222.14 q ha⁻¹) were recorded under the treatment combination F₃S₃, which was a significantly superior over to control and other treatment combination. However F₃S₃ was statistically at par with F₂S₂, F₃S₂ and F₂S₃, while minimum curd weight (148.98 g), curd yield per plot (2.38 kg) and curd yield per ha (73.57 q ha⁻¹) was recorded with F₀S₀ treatment combination. The application of sulphur has been reported to help in lowering soil pH and improve not only the availability of sulphur but of other nutrient too, which resulted in increased consequently the yield. Sulphur plays a vital role in the activation of number of enzymes and carbohydrate metabolism in plant. The results are conformity with the finding of Kumhar (2004), Jamre *et al.* (2010), Abd el-All and EL- Shabrawy (2013) and Bairwa (2015).

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Study on Correlation and Regression Analysis under Pearl Millet Based Cowpea and Cluster Bean Cropping System

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Abstract

A field experimentation was carried out at New Delhi, India for two years (2020-21) under rainfed semi-arid conditions to assess the effect of two tillage practice and with two level of residue management and two planting ration permutation on productivity, economics and soil health under pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] + Cowpea and pearl millet + clusterbean intercropping system. In current study, the cowpea grain yield under with pearl millet was at par with ZT based 1:1 ratio cowpea and clusterbean with ZT (2:2) kharif residue treatment. Under P+CL intercropping, inclusion of clusterbean led to significant reduction in clusterbean yield compared to its cowpea with same permutation of tillage and plant population. However, additive series of PCIS may bring more net economic gains over their sole stands in semi-arid ecology of India. The coarse cereal-legume interactions under PCIS have also led to improved quality and seed size in Zero tillage compare to CT practice. Study revealed that growth parameter like CGR, RGR, DMA at 50 DAS is positively correlated with grain yield and final output. Regression analysis show negative trend of these parameter with test weight, seed per pod and number of pods per plant. Treatment with ZT(2:2) P+CW and ZT (2:2) P+CL show highest value for yield and resource use efficiency over the remaining treatment. Hence inclusion of grain legumes under zero tillage could be breakthrough for achieving higher productivity as well profitability of system in addition to provide nutrition-based diets and food security targets.

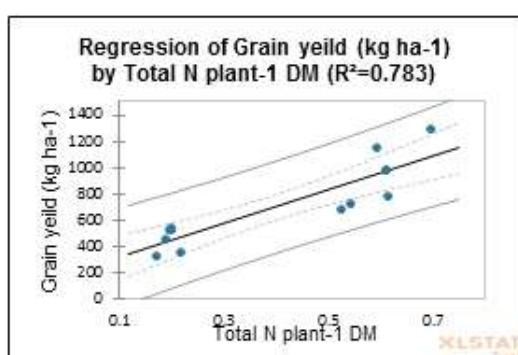
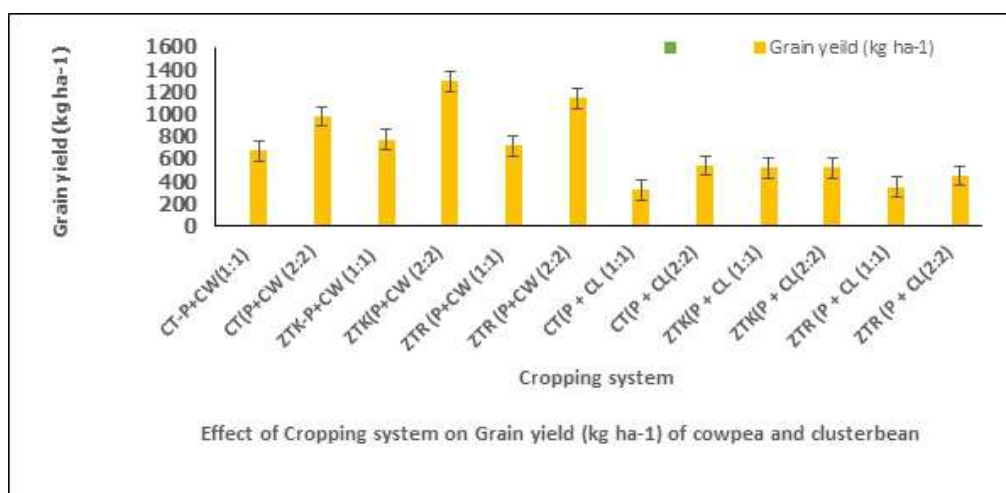
Introduction

In rainfed drylands of India, pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] with clusterbean [*Cyamopsis tetragonaloba* (L.) Taub] and Cowpea [*Vigna unguiculata*] are two major cropping system occupying prestigious place in the rural economy of these regions. Intercropping is an important crop production strategy for smallholder farmers, as it can lead to productivity improvements per unit of land when compared with those of sole cropping systems. Explanations for the benefits of intercrop systems are typically related to at least one of the following three factors (Brooker *et al.*, 2015): First, complementary use of resource niches, especially in terms of the different rooting behaviour of crops. As an example, intercropping has been found to enhance root length density in subsoil (Schröder and Köpke, 2012). Secondly, the combination of different crops can result in better system protection against pests and diseases. intercropping leads to the development of a more complex canopy structure that can help to generate a more favourable micro-climate, which could potentially reduce soil moisture evaporation (Tsubo *et al.*, 2004). grain legumes with a short growing cycle such as lablab, common bean, green grams, or cowpea are sown as cover crops during the short rains. Permanent ground cover through mulching contributes to increased cereal yields in seasons when soil moisture is limiting (Mupangwa *et al.*, 2012) by acting as a buffer against large bare ground evapotranspiration due to

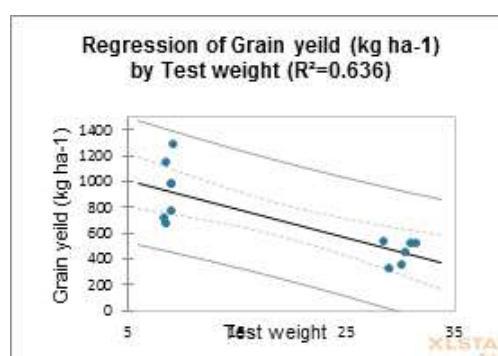
intense solar radiation while inhibiting the conditions for weed appearance (Mgolozeli *et al.*, 2020). Mulches also provide the initial decomposing material upon which fungi, bacteria, and abiotic processes act upon to transform complex organic material into inorganic molecules (Miki *et al.*, 2010). Mixing of cereal mulching with more readily decomposable residues or mineral fertilizers can therefore be a viable strategy to improve stable soil organic matter (SOM) content and plant's N availability (Gentile *et al.*, 2008). A fundamental aim of the experiment was to identify cropping system adaptation strategies for harsher climate conditions than those of the current key cropping seasons.

Materials and Methods

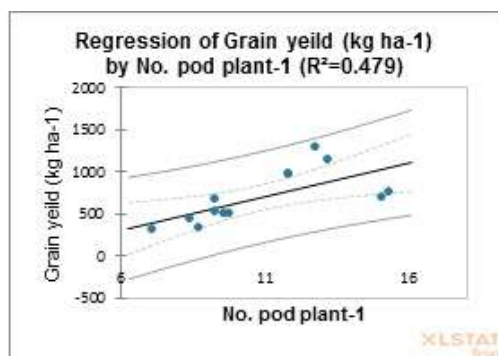
Study site : Indian Agricultural Research Institute (IARI), New Delhi [28-40' N latitude; 77-12' E longitude; 228.6 m altitude; characterized with semi-arid and sub-tropical climate, hot dry summers and severe cold winters] during *kharif* (rainy) seasons of 2020 to 2021 under rainfed semi-arid conditions. The mean annual rainfall is about 664 mm, of which nearly 80% is received during south-west monsoon (July to September) and the rest during October to May. The mean daily US Weather Bureau Class 'A' annual pan evaporation is about 850 mm. The rainfall for the cropping seasons was recorded at meteorological observatory of IARI, New Delhi showing that total rainfall during the *kharif* seasons of 2020 and 2021 was 691 mm and 664 mm, respectively. Soil was sandy loam with pH 7.6 and BD value 1.49. The experiment was laid-out in Randomized complete block



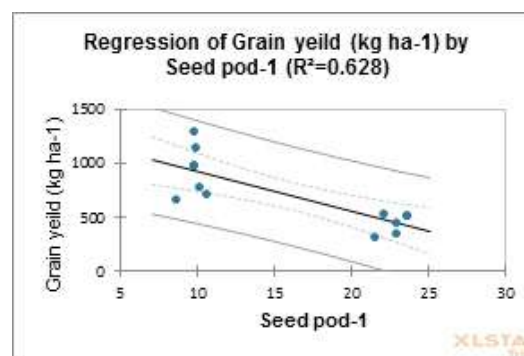
(a)



(b)



(c)



(d)

design and replicated thrice. Pearl millet Pusa composite 443 and clusterbean RGC-936 and Cowpea (kasi Kanchan) were planted in intercropping systems under three residue level, viz. Kharif season residues (ZTK), Rabi residue retention (ZTR) and conventional tillage residue. Two levels of planting ratio (1:1) and (2:2) were used under intercropping system. The plot size was 5×4 m. Pearl millet cowpea and cluster bean were sown using seed @ 4 kg/ha, 12 kg/ha and 20 kg/ha, respectively. Planting of pearl millet was done at a row-to-row distance of 50 cm. Data on eighteen quantitative traits were recorded on five randomly selected plants in each plot and mean values were calculated for statistical analysis. Data

obtained from current field experimentation were statistically analyzed, using the F-test as per the procedure given by Gomez and Gomez (1984). Tukey's honestly significant difference test was used as a post-hoc mean separation test ($P < 0.05$) using SAS 9.1 (SAS Institute, Cary, NC). The Tukey procedure was used where the ANOVA was significant.

Results and Discussion

There was significant difference between the treatment used under studied and response was highly positive for residue level as well as tillage configuration effect. Highest grain yield was observed under the zero tillage kharif

Table-1 : Correlation matrix among different variables with effect of tillage and residue levels.

Variables	SPAD50	DMA50	CGR50	RGR50	RGRHv	WP	S-WUE	PLER	TLER	GY	PB	PN	SP	TW	TN
SPAD50	1	-0.390	-0.410	-0.342	-0.412	-0.164	0.080	-0.040	0.139	-0.172	0.300	-0.225	0.422	0.435	-0.445
DMA50		1	0.996	0.997	0.987	0.845	0.649	0.705	0.580	0.853	-0.657	0.771	-0.970	-0.967	0.976
CGR50			1	0.992	0.973	0.827	0.610	0.699	0.549	0.836	-0.618	0.740	-0.961	-0.960	0.961
RGR50				1	0.984	0.836	0.646	0.701	0.578	0.842	-0.649	0.779	-0.970	-0.966	0.967
RGRHv					1	0.848	0.662	0.684	0.576	0.852	-0.676	0.814	-0.985	-0.980	0.994
WP						1	0.890	0.933	0.878	0.999	-0.539	0.657	-0.794	-0.786	0.873
S-WUE							1	0.814	0.971	0.887	-0.426	0.634	-0.552	-0.531	0.681
PLER								1	0.884	0.933	-0.389	0.557	-0.646	-0.636	0.716
TLER									1	0.876	-0.371	0.550	-0.475	-0.452	0.604
GY										1	-0.524	0.657	-0.797	-0.788	0.875
PB											1	-0.494	0.689	0.683	-0.698
PN												1	-0.785	-0.765	0.800
SP													1	0.998	-0.977
TW														1	-0.971
TN															1

DMA: dry matter accumulation, CGR: crop growth rate, RGR: relative growth rate, WP: water productivity; LER: land equivalent ratio; GY: grain yield (kg/ha); PN: No. of pod/plant; TW: test weight (g); TN: total Nitrogen per plant (%).

residue with 2:2 planting ratio followed by ZTR(P+CW) [1:1] ratio. Lowest Grain yield was observed under CT(P+CL1:1). The increase in yield under zero tillage with residue could be due to increase nutrient and moisture availability over a period of total season as well complementary shading of cowpea by pearl millet. The interspace between 2:2 planting pattern proved an aided advantage specially under moisture limited scenario as under present study which was performed without irrigation and under rainfed dryland condition. Yield increment also assign to favourable rainfall distribution during in both the year.

Present study was intuitive to know the effect of different permutation of tillage, residue and planting ration on grain yield. With all grain yield is a dependent variable on growth and yield attributing characters. Regression analysis showed a stronger correlation ($R^2 = 0.783$) while moderator correlation (Figure 2a) area expansion was observed with no. of seed pod⁻¹ with ($R^2 = 0.628$) and test weight of seed ($R^2 = 0.636$). number of pods per plant showed low correlation effect over final grain yield for both the grain legumes (Figure 2c).

Correlation matrix data as presented the relation matrix among the all variables used under study. The Blue colour represent the strongly significant relation between the variables while the pink colour fill of value represent the significant negative relationship among variables. (Table-1).

Figure-2. Regression relationship with R^2 value in grain yield (kg ha⁻¹) and between (a) total nitrogen plant⁻¹, (b) test weight (g), (c) number of pod plant⁻¹, (d) seed pod⁻¹

The dry matter accumulation at 50 DAS shown an positive correlated with CGR RGR at 50 DAS. On the other way, seed pod, branches per plant as well test weight is negatively and significant correlate with CGR, RGR and DMA at 52 DAS variables. (Table-1).

Conclusions

The climate change, moisture scarcity, resource inefficiency cause a strong urge for development of new alternatives as well technologies for successful crop production. This is more urgent in rainfed dryland area of the country. Zero tillage with residue retention proved a efficient permutation for such regions. In aided, intercropping provided an extra edge for such area where due to climate vagaries, one crop could be failed or produce less of potential. Further research on such alternative serve the purpose better and result into strengthen the marginalized section of rainfed dryland ecologies over the regions. Cowpea with zero tillage and 2:2 planting ration pave the best result under present study.

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