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Water Crisis in Dahanu Taluka, Palghar District, Maharashtra, India—A case study of waning Kankradi River Basin

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Introduction

Water is an indispensable component for sustainable development that determines the socio-economic and environmental welfare of a nation. Once considered as a renewable resource, water shortage in recent years has become a serious concern all over the world. The World Water Development Report 2019, 'Leaving No One Behind' ⁽¹⁾, launched in Geneva on 19th March 2019, reinforces the commitments made by the UN member states for Sustainable Development and in recognizing the human rights to safe drinking water and sanitation. This paper delves to unravel the paramount hydrological challenges due to anthropogenic intervention along the Kankradi river basin in the ecologically fragile area of Dahanu taluka, Palghar district of Maharashtra, India.

Objectives of study : The objectives of the study are to examine the factors for salinity intrusion and depletion of groundwater along the Kankradi river basin and to suggest sustainable water management strategies for its potential utilisation.

Geographical background

Palghar district : Palghar district was carved out of the present Thane district, on August 1, 2014, as the 36th district of Maharashtra. Located between the Sahyadri ranges in the east and the Arabian Sea on the west, Palghar district represents three distinct geographical regions. The first region is known as the 'jungalpatti' (the forest-clad hills) area in the east, which comprises the regions of Jawhar, Mokhada and Vikramgad talukas. The second region is the plain land of Wada taluka. The third region is known as the 'bandarpatti' (coastal) area on the west, which includes the talukas of Vasai, Palghar and Dahanu ⁽²⁾.

Dahanu Taluka : Dahanu, the taluka headquarters, lies at 19°58' N latitude and 72°44' E longitude in the North Konkan area of Palghar district. The Surya and Kankradi are major westward flowing rivers that drain into the Arabian Sea. The region lies in the basaltic terrain where groundwater aquifers are determined by fractures, joints and porosity of sub-surface rock beds. The southwest monsoon breaks by the second week of June,

while regular rainy season starts from the third week of June and lasts till the middle of October. The 'regur' or 'black cotton soil' mostly found in this region is useful for paddy cultivation, vegetables as well as fruits like chikoos, coconuts, mangoes, jackfruits, etc. The taluka has been declared as an ecologically fragile zone under the Environment (Protection) Act, 1986. *"In exercise of powers conferred by clause (v) of sub section (2) of section 3 of Environmental (Protection) Act, 1986, the Central Government, in consultation with the Government of Maharashtra, after considering the need for protecting the ecologically sensitive Dahanu taluka, and to ensure that the development activities are consistent with principles of environmental protection and conservation, hereby declare Dahanu taluka, District Thane, Maharashtra as an ecologically fragile area"* ⁽³⁾.

Profile of Study Area – the Kankradi river basin : The Kankradi river has its origin in the Kainad hills (approx. 350 meters above mean sea level), which are located at a distance of approx. 12-15 kms. from the taluka headquarter of Dahanu. The three dams - Nandare, Dongripada and Tankarpada which were built along the river course by the Indian Railways on the Western Railway route to provide water for its steam engines during 1950s, are presently dysfunctional. The Nandare dam which is 106 meters long and 7 meters high, is located about 5 kms east of Dahanu. The Dongripada dam is 50 meters long and 5 meters high and is located about 3.5 kms east of Dahanu and approx. 1.5 kms downstream from Nandare. The Tankarpada dam is 135 meters long and 7 meters high and is located about 2.75 kms. east of Dahanu and 2.25 kms. downstream from Nandare.

After meandering its way downstream, the Kankradi river passes along the villages of Waki, Rai, Kankradi and finally crosses beneath the railway bridge which is 45 meters wide before entering the Dahanu town area. However, barely 300 metres from the Dahanu railway bridge, the river makes a sharp southward turn and then after flowing further 900 metres, it merges into the Dahanu creek and ultimately drains into the Arabian Sea. While the river is a support system for fishing, drinking water supply, horticultural farms, paddy fields and other

Table-1 : Standard Deviation, Mean and the Coefficient of Variation of the 12 Water Samples taken along the Kankradi river basin.

S. No.	Parameters	Standard Deviation	Mean	Coefficient of Variation %
1.	Ph	0.35	7.26	4.83
2.	Electrical Conductivity (EC) (ms/cm)	1.80	2.30	78.26
3.	Sodium (me/lit)	14.19	40.33	35.18
4.	Calcium (me/lit)	2.19	4.95	44.24
5.	Magnesium (me/lit)	0.73	2.39	30.68
6.	Bicarbonate (me/lit)	1.46	8.05	18.10
7.	Chlorides (me/lit)	0.50	3.41	14.63
8.	Sodium Absorption Ratio (SAR) (me/lit)	5.48	19.65	27.87

ms/cm = millisiemens per centimeter# me/lit = milliequivalent per litre

Source: Based on Krishi Vigyan Kendra, Kosbad, Dahanu, laboratory report 2019, of the water samples collected by the researcher.

domestic purposes, its basin area supports habitat for mainly Warli tribes and communities of Bhandaris, Macchis, Vadavals, etc.

Methodology and Database : A preliminary survey was done to understand the sources of water and their potential utilization. The visit revealed serious water problems in the river basin area, which led the researcher to identify four major villages - Nandare, Waki, Rai, Kankradi and the town area of Dahanu for study. The selection of four villages and the town as study areas was also to understand the government intervention in water management of the common water source, the Kankradi river and its basin, flowing through both, the Gram Panchayats and the Municipal Council jurisdictions.

Primary Data at each selected site was collected by Random Sampling method, as though the areas differed geographically and anthropologically, they suffered from similar problems along the common source of water. A site visit to the dams at Nandare, Dongripada and Tankarpada along the Kankradi river was also undertaken. In all 12 water samples, i.e. 6 samples each in pre-monsoon and monsoon period respectively, were collected from the study areas and at both times from the same borewell, hand-pump and the well altogether, to avoid any error in results. Each sample was collected in one-liter sterilised bottle and labelled with respect to the name of the sample collector, source area of the sample and sample number with date. The samples were laboratory tested at Krishi Vigyan Kendra, Kosbad, Dahanu, within 24 hours from the time of collection.

The findings were based on Water Quality Parameters (WQP) like pH value, Electrical Conductivity, Sodium, Calcium, Magnesium, Bicarbonates, Chlorides and Sodium Absorption Ratio and were statistically analysed by the Coefficient of Variation to understand the magnitude of water problem.

Formal interviews with the villagers, gram-sevaks and town-dwellers were conducted and interactions with

the members of the Society for Fast Justice, a local registered NGO in Dahanu, government officials of Groundwater Department, Palghar district, Range Forest Officer and Assistant Conservator of Forests, Dahanu division etc. were undertaken.

References were made to the report of the laboratory test analysis of Maharashtra Pollution Control Board, sub-regional office, regarding the water samples collected near Janata Cooperative Bank (discharged into Kankradi river) and near the estuary (discharged into Dahanu creek) as sent to the Chief Officer, Dahanu Municipal Council and later as submitted in the Court of Chief Judicial Magistrate, Palghar District in 2017 ⁽⁴⁾. Reference was also made to the Memorandum of Application later filed by the Society for Fast Justice, Dahanu, against the Chief Officer and Dahanu Municipal Council, before the National Green Tribunal (NGT), West Zone, Pune ⁽⁵⁾.

Results and Discussion

The WQP analysis indicates that the Coefficient of Variation (CV) in all 12 water samples are primarily high for Electrical Conductivity (EC) 78.26%, followed by Calcium 44.24%, Sodium 35.18%, Magnesium 30.68% and Sodium Absorption Ratio 27.87%. The CV for Bicarbonate 18.10% and Chloride 14.63% indicate that variation in these parameters among its measured values is comparatively low (Table-1).

The pH value ranges from 6.88 - 7.88 for samples collected during pre-monsoon period while it is 6.95 - 7.92 in those collected during monsoon period. This indicates slightly alkalinity in water sources due to ingress of bicarbonates, calcium and sodium into groundwater aquifers through percolation of rainwater.

The Electrical Conductivity was observed higher than permissible limits in borewell water samples of Rai and Kankradi due to excessive ground water withdrawal which is responsible for deterioration of water quality in the region. The well water sample of Dahanu town had

Table-2 : Seasonal variation of content of WQP of the 12 Water Samples taken along the Kankradi river basin.

S. No.	Parameters	Permissible Limits	Nandare			Waki			Rai-1			Rai-2			Kankradi			Dahanu		Testing Method
			1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b						
1.	pH	6.5 – 7.5	7.30	7.00	7.10	7.40	6.88	6.95	7.02	7.02	7.18	7.50	7.88	7.92				7.92		pH Meter
2.	EC	0 – 1	1.16	0.50	2.22	0.70	2.80	2.96	5.28	5.44	2.64	3.24	0.21	0.40				0.21		EC Meter
3.	Sodium	0 – 20	32.00	30.00	44.00	28.00	42.00	46.00	62.00	64.00	54.00	36.00	24.00	22.00				24.00		Flame Photometer
4.	Calcium	0 – 1	3.20	3.40	5.78	3.20	6.20	6.00	8.20	8.60	6.35	3.50	1.80	3.20				1.80		
5.	Magnesium	0 – 1	2.00	2.00	2.60	1.20	2.40	2.20	3.40	3.10	2.78	1.80	3.60	1.60				3.60		
6.	Bicarbonate	0 – 5	7.90	7.30	8.88	7.00	6.20	7.96	10.62	9.80	9.10	8.50	7.80	5.50				7.80		
7.	Chlorides	0 – 4	3.30	3.00	3.80	2.80	3.20	4.20	3.95	3.40	3.45	3.90	3.40	2.50				3.40		
8.	SAR	10 – 18	19.87	11.11	21.56	12.72	20.28	22.77	25.83	26.55	25.35	22.22	13.22	14.28				13.22		SAR = [Na] / SQRT { ([Ca] + [Mg]) / 2 }

Pre-monsoon Samples = 1a, 2a, 3a, 4a, 5a, 6a# Monsoon Samples = 1b, 2b, 3b, 4b, 5b, 6b
 Source : Krishi Vigyan Kendra, Kosbad, Dahanu, laboratory report 2019, of the water samples collected by the researcher.

recorded lowest content of EC and SAR. (Table 2). This is because the well water is extracted from only 25 feet depth unlike 250 feet deep in Rai, Waki and Kankradi from bore wells. *The high SAR indicates that irrigation water will lead to poor permeability of water in soil, adversely affecting crops sustainability* ⁽⁶⁾. Calcium may dissolve readily from carbonate rocks or to be leached from soil ⁽⁷⁾. The Calcium content of Waki, Rai and Kankradi was above permissible limit of 0 - 1 milliequivalent per litre (me/lit). The result shows that the water sources along the river basin are unfit for irrigation purposes and thus also for drinking.

The above data analysis reveals gross negligence in water resource management in an eco-fragile area along the river Kankradi upstream to downstream as follows:

Kainad Hills : They form the major source of the Kankradi river at approx. height of 350 metres above mean sea level. However, in the absence of integrated planning approach like watershed management and building loose boulder structure (LBS) embankment across the river as line of treatment along the Kainad hills to reduce velocity of water runoff, there has been high soil erosion along the river bank at upstream and siltation downstream.

Village Nandare : The Indian Railways have given the permission to the village Gram Panchayat to restore the three dams, without making any structural changes to them, and use the stored water. However, the paucity of funds at village Gram Panchayat level and political unwillingness to reinstate these dysfunctional dams has led to poor recharge of groundwater table, high momentum surface run-off and heavy siltation in river bed.

Village Waki : Borewells in the village of Waki were found with saline water during the pre-monsoon survey. However, during monsoon sampling, the sodium content of the same source reduced drastically from 44.00 me/lit to 28.00 me/litres, but was still higher than the permissible limit. The villagers do not use this water for drinking but only for other domestic purposes.

Village Rai : The situation in the Rai village was found to be severe. Though the reasonable depth to dig borewell is 75-100 feet only, borewells in this village have been dug up to 250 feet deep in absence of any legal supervisory body. There are over 300 borewells in the village as per the village gram-sevak, of which around 20-30 are abandoned due to non-availability of groundwater. People of the village are compelled to drink saline water from their borewells due to absence of any other source of drinking water, including the non-functional overhead village water tank and the dried-up well. Locals also complained of being unable to use this water for cooking. However, both the samples taken, during pre-monsoon and monsoon

period, were found to be unsuitable for irrigation and also unfit for drinking. The ex-headman of Rai village informed the researcher that the illegal prawn farming in the wetlands has forced tidal backwaters to surge into farmlands causing land salinity and also seepage into groundwater resources. The mouth of Kankradi river sees an ingress of the saline water during summers from the Dahanu creek during high tides as it is almost dry in its lower reaches due to which many horticultural and nursery farms in his village had to be closed down.

Village Kankradi : Most of the water sources in Kankradi village are affected by the problem of salinity due to proximity of this village to Dahanu town area. In absence of any scientifically built bulkhead at the estuary of Dahanu, the ingress of sea water contaminates the ground water resources of the village making them unfit for consumption. With high Sodium Absorption Ratio and a higher Sodium content, both the pre-monsoon and monsoon samples were found to be unfit for irrigation and drinking. Locals complained of their clothes getting grey and discolored after wash because of usage of the local borewell water.

Dahanu Town Area (Irani Road) : Many housing societies along the Irani Road in the town area of Dahanu, adjacent to the Kankradi river, had soak pits and drain pipes carrying sewage water into the Kankradi river and the Dahanu creek in absence of Sewage Treatment Plant (STP). It was observed that different government correspondences at different times referred the Kankradi river differently; sometimes as a '*ohal*' meaning a 'small stream' and sometimes as a '*river*' itself, which was allegedly done to allow few builders to manipulate environmental rules and encroach the river bed by land filling, building fencing walls for illegal constructions, etc. and also bypass the Coastal Regulation Zone norms. This has led to narrowing of river width resulting into flooding of this river every monsoon, causing heavy loss to the residents and businessmen of the Dahanu town. Moreover, cutting of big trees along the banks for urban expansion had resulted in heavy soil erosion along river banks posing danger to the stability of the roads that run alongside the river. The housing societies of Irani Road avail piped water supplied by the Dahanu Municipal Council which is mixed with borewell water at individual level for the drinking purpose. Residents preferred piped water along with the use of RO purifiers to further filter the already mixed water as its Total Dissolved Solids value was reported to be very high, sometimes over 3000 ppm, especially during dry season.

"Depletion of groundwater is not simply a case of drawing down a replenishable resource, but potentially one of permanent degradation" ⁽⁸⁾.

Suggestions for Sustainable Water Management Strategies in the study area

Integrated Water Management Programme : Watershed Management in upstream areas should be encouraged to control soil erosion, siltation in river bed and flash floods. Multiple check dams in the middle course along the Kankradi river will enhance water storage for longer duration, aiding groundwater recharge and lessen salinity in water aquifers.

Maintenance of the Dysfunctional Dams : Renovation and future maintenance of the three dysfunctional dams at river upstream is crucial to the solution of the water crisis currently faced by the people in the areas of study. This will help store water to compensate for fluctuations in river flow, considerably increase the groundwater level, raise the storage level of the water and prevent the ingress of tidal creek water upstream.

Community Participation : Encouraging and involving local residents in decision making process based on indigenous principles for sustainable water management should be promoted by the Gram Panchayats and the Dahanu Municipal Council. *"Applying a scientific understanding to drive processes resulting in equitable, efficient and sustainable groundwater management requires strong community participation"* ⁽⁹⁾.

Rainwater Harvesting : Promoting rain water harvesting at community level by creating dug wells, trenches and percolating pits should be encouraged to combat surface run off of rain water in Dahanu taluka which receives heavy rainfall by southwest monsoon. The harvested water can be used for drinking, long-term storage and for groundwater recharge.

Innovative Agriculture Methods : Old and outdated agricultural practices and methods should be replaced by water saving techniques like hydroponics and aquaponics in villages like Waki and Rai where there is less good quality water to promote horticulture and nursery farms by storing rainwater in percolation pits.

Role of Local Self-Help Groups : Local SHGs must be created which will undertake regular testing of water samples of local water sources under legal supervision, launch awareness missions and programmes such as door to door campaigns, discussions at Gram Panchayat levels, stricter implementation of laws against illegal encroachments and exploitation of water sources, etc. Such SHGs should be armed with basic knowledge on soil and water quality and should also have members of local environment groups, judicial representatives, local villagers and town dwellers, students and women members.

Functioning of Defunct National Green Tribunals : It was observed that due to the indifferent approach of the political administration, the Dahanu NGT case filed against the Chief Officer Dahanu Nagarpalika Parishad, is still awaiting its judgment but for the defunct NGT at Pune. The long pending vacancies of judicial and expert members need to be filled-in on urgent basis as the contribution of the NGT to environmental governance cannot be ignored.

Implementation of the Law of Land : Laws pertaining to Environment Protection and Coastal Regulation Zone should be strictly implemented. Preparation of the Town and Regional Plans as per orders of courts and authorities⁽¹⁰⁾, mandatory distance of building structures from high tide limit, river banks, etc. should be maintained by the builders. Scientifically approved dredging of river beds, digging borewell only up to the permissible depth, installation of the sewage treatment plant (STP) are the major areas which require urgent attention of the local government.

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Miracle Grains Millets : Breeding of Smart Food Crop for Nutritional Security

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Abstract

Underutilized groups of cereal grains are Millets. Although there is presence of high nutritional and nutraceuticals components, millets are still considered as food of poor people and not grown in major portion of field. These are considered as rich source of energy, carbohydrate, and protein and are comparable to other cereals. These are found to be rich sources of phytochemicals such as phenolic acids, flavonoids, catechins, phytic acid, and phytosterols. Millets need very little water for their production and grown in marginal lands. It does not demand rich soils for their survival and growth. Hence, for the vast dryland area, they are a boon. Millet do not dependent on the use of synthetic fertilizers, farmyard manures is sufficient for millets growth. Millet are also free from pest attack. Therefore, millets are farmers friend their need for pesticides is close to nil. Therefore, millets are a great boon to the agricultural environment in present climate change scenario. Nutrition content in Millets are also amazing. Each of the millets is three to five times nutritionally superior to the widely promoted rice and wheat in terms of proteins, minerals and vitamins.

Key words : Nutraceuticals, phytochemicals.

Introduction

Millets are grown with limited water resources and usually without application of any fertilizers or other inputs by a multitude of small-holder farmers. Therefore, they are often referred to as “coarse grain” or “poor people’s crop”. Multiple security produce by Millets in today’s climate change era. Millets are climate change compliant crops while single crops such as rice and wheat can succeed in producing food security for India, while millets produce multiple securities. It includes securities of food, nutrition, fibre, fodder, health, livelihood and ecology. Most millets have edible stalks which are the most favoured fodder for cattle. Besides fodder, millets are storehouses of nutrition and hence produce nutrition security. Millets remain our agricultural answer to the climate change crisis that the world is facing. Climate Change is expected to confront us water stress in present situation although millets are grow in water stress situation. Each of the millets is a storehouse of dozens of nutrients in large quantities. They include major and micro nutrients needed by the human body. Hence they can also play main role to keep away malnutrition. Agriculture and climate change are correlated with each other in various aspects, as climate change is the main cause of biotic and abiotic stresses, which have adverse effects on the agriculture of a region. The land and its agriculture are being affected by climate changes Dependence on a few major crops remain a major challenge due to its potential impact and contribution to food security. Higher temperatures, unpredictable rainfall and weather patterns, changes in

growing seasons, increased occurrences of drought and extreme weather events will exert a greater strain on agriculture. Millets and underutilized crops have high nutritional values, forage importance and grown in marginal land without much agricultural inputs. Millets are climate change, compliant crops that resist the challenges. Millets need less water, to grow and can tolerate higher temperatures, crucial for farmers in this era of climate change. Millets and Underutilized crops are a group of grassy plants, short slender culm and small grains possessing remarkable ability to survive under severe drought conditions. These have been food commodities since ancient times. Because of their important nutritional qualities, there is a need to revive their usage in daily diet.

Millets are Climate Change Compliant Crops : Millets are grown in less rain, more heat, reduced water availability and increased malnutrition. All these qualities of millet farming system make them the. Climate change portends. Millets are all-season crops whereas wheat, rice they are season specific crops. In spite of all these extraordinary qualities and capacities of millet farming systems, the area under millet production has been shrinking over the last five decades and rapidly, since the Green Revolution period. Climate change compliant crops cultivated round the year While other major crops wheat and rice might provide only food security, where as millets produce multiple securities (food, fodder, health, nutrition, livelihood and ecological) making them the crops of agricultural security.

Millets are store-houses of nutrition : Millets are good source of food nutrition in this climate change environment. They are miles ahead of rice and wheat in terms of their mineral content, if we compared rice and wheat with minerals. Each one of the millets has more fibre than rice and wheat. Some as much as fifty times that of rice. Finger millet has thirty times more Calcium than rice while every other millet has at least twice the amount of Calcium compared to rice. In their Iron content, foxtail and little millet are so rich that rice is nowhere in the race. The much privileged rice, ironically, has zero quantity of this precious micronutrient. In this fashion, nutrient to nutrient, every single millet is extraordinarily superior to rice and wheat and therefore is the solution for the malnutrition that affects a vast majority of the Indian population.

Millets grow on the poorest of soils or low fertility soils Proso millet, Kodo millet Barnyard millet. In fact, finger millet grows well in saline soils. Millets do not demand chemical fertilizers. Under dry land conditions, millets grow better in the absence of chemical fertilizers. Therefore, most millet farmers grow them using farmyard manure under purely ecofriendly conditions. Growing traditional local landraces and under different ecological conditions, most millets such as foxtail are totally pest free and hence do not need any pesticides. Even in storage conditions, most millets such as foxtail not only not need any fumigants, but also act as antipest agents to store delicate pulses such as green gram.

Phyto-chemicals and antioxidant activity : Phyto-chemicals are naturally present in all the fruits, vegetables, pulses/legumes and grains which are commonly consumed, so it is quite easy to incorporate them in our daily diet. They are the compounds that affect human health. Some of the better-known phyto-chemicals include β -carotene and other carotenoids, ascorbic acid (vitamin C), folic acid, and vitamin E. Some phyto-chemicals may possess antioxidant activity or hormone like actions too. All millet grains, in particular, sorghum, fractions possess high antioxidant activity in vitro relative to other cereals and fruits (Awika *et al.*; 2004). Most sorghum do not contain condensed tannins but all do have phenolic acids. Pigmented sorghum contains unique anthocyanins that could be potential food colorants. The edible component of millet kernel is rich in it having important role in aging and metabolic diseases components (Bravo, 1998).

Health benefits of Millets : Studies have proved that consumption of millets reduces risk of heart disease, protects from diabetes, improves digestive system, lowers the risk of cancer, detoxifies the body, increases immunity in respiratory health and neural systems and are

protective against several degenerative diseases such as metabolic syndrome and Parkinson's disease (Manach *et al.*, 2005; Scalbert *et al.*, 2005; Chandrasekara and Shahidi, 2012). There are several important nutrients present in millets include resistant starch, oligosaccharides, lipids, antioxidants such as phenolic acids, flavonoids, lignans and phytosterols etc. and also hold immense health benefits (Miller, 2001; Edge *et al.*, 2005).

Millets are rich in antioxidants and phenolics and like phytates, phenols and tannins which can contribute to antioxidant activity important in health, metabolic syndrome and aging. Millets fraction and extract have been found to have antimicrobial activity and help in inhibiting the growth of bacteria. Antioxidants significantly prevent tissue damage and stimulate the wound healing process. It is reported good in Finger millet there are antioxidant effects. They are easily digestible for they are alkaline in character. The high level of protein in it makes it very beneficial to vegetarians as the sources of protein from other vegetarian foods might be inadequate.

Finger millet is an extremely nutritious crop that helps maintain overall healthiness. Finger millet is rich in amino acids which are vital in normal functioning of body and are essential for repairing body tissues. However, its high intake could increase quantity of oxalic acid in the body. Therefore, it is not advised for patients having kidney stones. Foxtail millet is a diuretic and a tonic to enhance the strength of the body. Consumption of millets, particularly finger millet, enhances production of milk in lactating mother. Green Ragi is recommended for conditions of blood pressure, liver disorders, asthma, heart weakness and also recommended for lactating mothers who have problems in milk production.

Methionine essential amino acid, not found in most of the cereals. Which is useful in various body processes, helps in eliminating fat from the body, and is main provider of sulphur in body. Sulphur is essential for production of Glutathione - body's natural antioxidant. Millets are the foods which are the least allergic and which are easily digestible and is the best food for gluten sensitive patients. Millets are plenty with essential amino acids, fatty acids and dietary fibre. For the proper functioning of the body, it requires many healthy nutrients and millets have many healthy nutrients. Millets contain vitamins like vitamin-B which helps in easy breakdown of carbohydrate and fats. Millets has amino-acid tryptophan which helps in maintaining the healthy body weight by lowering the appetite. Millets have the high amount of fibre which helps to satiate hunger quickly and helps in preventing overeating millets help in weight management diets. The protein structure present in millets is similar to

wheat but the only difference is that millets are nogluten grains. Millets help in reducing the risk of colon cancer, as they contain both fibres and phytonutrients. Magnesium present in millets helps in relaxes muscles of arterial wall, reducing blood pressure.

Conclusion

Millet crop are intrinsically bio diverse. The monitoring, evaluation and research on millet cultivation must be tailored to this special quality of millet farming system. Millets are beneficial for water saving and it is drought tolerant crops. Therefore they must be viewed as climate change compliant crops. This quality makes them India's food and farming future. Millets will overcome the problem of malnutrition of young children. Water requirement of the crop is very less. Millets can be cultivated without using groundwater or surface irrigation. Their energy requirement from sources such as chemical fertilizers, pesticides, water and power are very less. Their are presence of dietary fiber and phenolic compounds help in the prevention of many diseases such as diabetes, cardiovascular diseases, and cataractogenesis. This can turn out to be a tremendous national gain especially in the ensuing decades of climate crisis. In a future, where water and food crisis stares us in the face, millets can become the food of security.

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Role of Nutritional Ergogenic Foods for Performance and Recovery of Athletes

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Abstracts

Diet is a very significant role for physical performance and mental health of children because it influences the nutritional status later in life. Adolescent taking part in sports activity so as to high demands well balanced nutrients is needed. Proper nutritional counselling is recommended due to increased physical activity such as growth, development and wellness. Due to lack of misinformation about healthy and nutritious foods by the media regarding school going children high chances risk hazards often found related to obesity and undernutrition. The potential ergogenic effect of food for athletes have shown as improved aerobic capacity and strength recovery in all over physical effects. The nutritional needs of athletes person with appropriate type, amount, and timing of intake of food, fluids and supplements for competitive sports performance and training must be required. In general, food showed equal or superior ergogenic activity over supplements. In the field of sports nutrition athletes should be referred to a registered dietitian or Nutritionist for a personalized diet plan.

Key words : Physical activity, nutrition counselling, food and health, ergogenic aid, sports nutrition.

Introduction

Nutritional ergogenic aids are aimed primarily at enhancing performance as increasing lean body mass or muscle mass by stimulation of protein synthesis and at reducing body fat content. Clark and Nancy (2008). Evidence supports a range of dietary strategies in enhancing sports performance. By optimizing intakes of macronutrients, micronutrients, and fluids including their composition and spacing throughout the day. Sports nutrition is a specialization within the field of nutrition that partners closely with the study of the human body and exercise science. Sports Nutrition can be defined as the application of nutrition knowledge to a practical daily eating plan providing the fuel for physical activity, facilitating the repair and building process following hard physical work and achieve athletic performance in competitive events, while also promoting overall health and wellness. Weber S (2004). The basic concept for sports nutrition for athletes requires proper eating strategies and need to have a command of general nutrition as well as exercise science. The second step is to gain the knowledge of how nutrition and exercise science are intertwined, emphasize that physical training and dietary habits are reliant on each other in order to produce optimal performance. The final step is the practical application of sport nutrition knowledge on the individual sports person who is participating in any sport or physical activity, by CM Kerksick (2018).

Importance of sports nutrition : The role of nutrition in

sports performance is very significant. Prior, during and post competition proper nutrition is very important. Nutritional and eating habits have been of specific interest in sports, especially given their impression on athletic performance, given by Meyer NL (2014), American college of Sports Nutrition. General recommendations need to be suggested by sports nutrition experts to accommodate the specific requirements of individual athlete regarding health, sports, nutrient, food choices and body weight and body composition. Nutrition is important for an athlete because it provides energy required to perform the activity. The food they take leaves an impact on strength, training, performance and recovery, by RB Kreider (2010). Not only the type of food is important for sport nutrition but also the time is equally important for what they eat throughout the day. It also has an impact on their performance level and their body ability to recover after workout. The role of nutrition in sports performance is very important. Proper nutrition must be available prior, during and post competition. Greany and Jeukendrup (2011) stated that from fueling to recovery, muscle building weight and making optimal nutrition ensure the best platform for success in any sport. Meals eaten after and before the exercise are the most important in nutrition but we should really be very careful with all that the athlete intake in his body. As a general rule of thumb an athlete should eat about two hours before any exercise and the meal should be high in carbohydrates, low in fat and low to moderate in protein, Bonci L (2010). Carbohydrates are the main source of energy that

provides power to an athlete in exercise regime. Protein is required to develop muscle growth. Wojtyś EM (2015).

Diet strategies employed by athletes :

(1) Maximizing muscle glycogen stores prior to exercise : The main role of carbohydrate to maximize an athlete's muscle glycogen stores prior to endurance exercise.

(2) Carbohydrate intake during the event : Carbohydrates are stored in the body in a form of glycogen, which can be used during physical performance, during sub-maximal exercise, carbohydrates in the body are the major source of fuel. Srilakshmi B (2003).

(3) Protein : The consumption of protein prior to and during endurance enhance rates of muscle protein synthesis (MPS). Burke LM, (2011).

(4) Fat as a fuel during endurance exercise : Fat is primarily used as a fuel during low to moderate intensity exercise for make it easier for process of absorption of fat soluble vitamins. Bonci L (2010).

(5) Fluid and electrolytes : For maintaining hydration and thermoregulation fluid consumption during exercise has most important.

(6) Dietary supplementation : nitrates, beta-alanine, and vitamin D : performance supplements include caffeine, beetroot juice, beta-alanine (BA), creatine, and bicarbonate. Supplementation has increasing exercise efficiency, reduce fatigue, and a oxidative stress. Vitamin D is essential for the maintenance of bone health with muscle strength, regulation of immune system and cardiovascular health.

In this way appropriate selection of foods and fluids, timing of intake and supplement choices are required for optimal health and exercise performance. Fogelholm M (2010).

Healthy diet plan for Athletes person :



Source-lybrate.com

Time	Food items with Amount
Breakfast (8:00-8:30AM)	Mushroom Paratha 2 + Tomato chutney + Scrambled egg (2egg)
Mid-Meal (11:00-11:30AM)	pane Yoghurt with raw vegetables / grilled vegetables -1 cup
Lunch (2:00-2:30PM)	1/2 cup rice + 3 medium chappati + Fish masala 1 cup (fish 180 g Oily fish(Salmon, Mackerel, Troutetc)) + Snake guard subji 1/2 cup.
Evening (4:00-4:30PM)	1 cup boiledchanna+ light tea 1 cup.
Dinner (8:00-8:30PM)	3 Roti/chapatti + 1/2 cup mix veg curry

Source-elivar.com

Meal timing : Meal timing is very important aspect for athletes performance. The timing and content of meals can help achieving training goals. The American College of Sports Medicine (ACSM) also notes that endurance athletes would needs to consume mostly carbohydrates and small amount of protein roughly 1-4 hours before exercise.

Ergogenic Aid : An ergogenic aid is any training techniques, mechanical devices, nutritional practice, pharmacological method or psychological techniques that can improve exercise performance capacity or enhance training adaptations. It helps in individual to tolerate heavy training to a greater degree by helping them recover, faster or help them stay injury free and healthy during intense training. Some studies show that supplement significantly enhances exercise performance e.g. helps athletes run faster, lift more weight or carry out more work during a given exercise task. On other hand it prepares an athlete to perform or enhance recovery from exercise. It has the potential to improve training adjustment and therefore must be considered ergogenic.

The quickest method of increasing muscle creatine stores is by consuming 0.3 grams/kg/day of creatine monohydrate for at least three days followed by 3-5 gram/day thereafter to maintain elevated stores.

Creatine products are readily available as a dietary supplement and are regulated by the US Food and Drug Administration. Specifically, in 1994 US President Bill Clinton signed in to law the dietary supplement Health and Education Act (DSHEA). Which allows manufactures/companies/brands to make structure function claim, the law strictly prohibits disease claims for dietary supplements.

Testosterone also elevates male sex characteristics (e.g., hair, deepvoice, etc). Low level anabolic steroids are often prescribed by doctors to prevent loss of lean weight for people with various diseases and illnesses.

It is widely known that athletes have tested large doses of anabolicsteroids in an effort to enhance training

adjustments, increase muscle mass and/or promote recovery during intense training.

Research has generally shown that use of anabolic steroids and growth hormone during training can promote increase in strength and lean weight. However, a number of potentially life threatening contrary effects of steroid abuse have been reported including liver and hormonal dysfunction, hyper lipidemia (high cholesterol), increased risk to cardiovascular disease and behavioral changes (i.e., steroid rage) and mood swings.

For this cause, anabolic steroids have been banned by most sport organizations and should be avoided unless prescribed by a physician to treat an illness.

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Conclusions

Diet is a key role for performance enhancement of athletes. Person who do not include adequate protein in daily diet may face slower recovery and training adjustments. Athletes must fuel their bodies with the appropriate nutritional foods in sports competition and training. Different types of protein such as whey, casein, soy, milk proteins, colostrums as well as biologically active protein subtypes and peptides (e.g. -lactalbumin, lecto ferrin etc) have varying effects on the physiological, hormonal and immunological responses to training. If these nutritional needs are not met, there is an increased risk of poor performance and health issues. The use of a nutritional supplement is essential for supporting an athlete's general health and their training requirements. Having a good nutrition with suitable diet provides a person enough energy for physical performance.

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Comparative Evaluation of *Desi* Channa Forms Against Mites, *Suidasia nesbitti* Hughes (Acari : Suidasiidae)

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Abstract

During present investigation, whole, broken grains and flour of *Desi* channa were exposed to *Suidasia nesbitti* mites and their population, weight loss were compared during six month study period. Between the three forms, *Desi* channa flour harboured significantly more number of mites (1175.71 mites/g flour) than broken (770.61 mites/g grain) and whole (88.19 mites/g grain) grains. Irrespective of forms, maximum number of mites (2321.55 mites/g channa) was recorded at 180 days which showed significant difference with mite numbers at other durations. At the end of study period, higher percent of mites on flour (58 %) followed by broken grains (38%) and whole grains (4 %) of *Desi* channa were recorded which showed that flour was preferred by mites than other two forms. Similarly, per cent weight loss was significantly more in flour (3.21%) as compared to broken (2.50%) and whole (1.36%) grains. Due to mite feeding, progressive discolouration of whole grains, blackening of broken grains and flour of *Desi* channa was recorded.

Key words : *Desi* channa, flour, mites, *Suidasia nesbitti*

Introduction

Suidasia nesbitti Hughes (Acari: Suidasiidae) is among the most frequently encountered mite species in stored grains and food products responsible for quantitative and qualitative damage (Chhillar *et al.*, 2007; Gad *et al.*, 2020). Stored mites feed on grains with the help of chelicerae which are used for the cutting and piercing. They generally attack scarified/ broken grains and flour and prefer germinal portion of the grains. The choice of food affects the duration of life cycle, fecundity, developmental time and longevity of *S. nesbitti*. Once established, they flourish into large populations causing quantitative losses as stored grains provide water, a food source, shelter and minimal temperature variations to mites. In addition to quantitative and qualitative losses, mite bodies, secretions, excreta and shed skins also act as source of clinically important allergens. These allergens can enter human/ animal body via inhalation of house dust or ingestion of contaminated food and cause damage to human health by direct external contact (conjunctivitis, eczema, Baker's itch, Grocer's itch), inhalation (rhinitis, asthma) and ingestion (anaphylaxis) (Stejskal and Hubert, 2008).

Mites feed on products containing protein, carbohydrates, fats and vitamins (Parkinson, 1990). Contamination with mite was found mostly in flour as this form is preferred by mite, followed by broken and whole grains (Kohli and Mathur, 1994). Susceptibility of pearl millet (Seema, 2020) and cowpea (Dalal, 2020) flour was significantly more as higher number of *S. nesbitti* mites

was recorded from it than on grains. Scanty literature is available on the effect of mite feeding on *Desi* Channa varieties; hence present investigation was carried out under *in vitro* conditions.

Materials and methods

Mites were cultured and maintained in desiccators containing super saturated solution of potassium chloride. Desiccators were placed in BOD at 80-85 percent relative humidity and $27\pm1^{\circ}\text{C}$.

Bengal gram variety, *Desi* was procured from Department of Genetics and Plant Breeding, CCSHAU, Hisar. Whole grains were coarsely grinded to make broken grains and finely grinded, sieved to make flour. Three forms; whole, broken grains and flour were used to estimate quantitative losses occurred due to *S. nesbitti* infestation. For each form, sub sets of different durations *viz.*, 30, 60, 90, 120, 150 and 180 days were prepared under triplicate conditions with 20 mites (10 pairs) of *S. nesbitti* in one g grains or flour. Each form (whole, broken grains and flour) of uninfested material acted as corresponding control. After 30 days of the initiation of the experiment, one sub set was taken out (3 replicates) from the desiccators along with three replicates of control to count the number of mites and symptoms of damage. Mites were counted under stereozoom microscope in square counting dish. After separation of mites through Berlese Funnel method, the weight of whole, broken grains and flour was measured with the help of electronic balance. Similarly, second sub set of each form was removed after 60 days, third sub set after 90 days, fourth

after 120 days, fifth after 150 days and sixth sub set after 180 days was removed and processed as above. Observations were recorded on number of mites in each replicate and weight of grains/ flour was measured individually. The condition of whole, broken grains and flour was also recorded at each observation period. Per cent weight loss in whole, broken grains and flour was also calculated in each sub set with following formulae :

Per cent weight loss

$$\frac{\text{Weight of non infested grains / flour} - \text{Weight of infested grains / flour}}{\text{Weight of non infested grains / flour}} \times 100$$

Results and Discussion

Exposure of *Desi* channa forms, whole, broken grains and flour to *S. nesbitti* population was compared during monthly data analysis (Table-1). Between the three forms, *Desi* channa flour harboured significantly more number of mites (1175.71 mites/g flour) than broken (770.61 mites/g grain) and whole (88.19 mites/g grain) grains (CD= 236.03; p=0.05). Irrespective of forms, maximum number of mites (2321.55 mites/ g channa) was recorded at 180 days which showed significant difference with mite numbers at other durations (CD= 360.55; p=0.05). The number of mites recorded was 38.66, 52.66, 131.00, 376.00 and 1807.33 mites/g channa at 30, 60, 90, 120 and 150 day observation period which were statistically significant at each duration. The interaction between observation period and *Desi* channa forms showed significant difference in the number of mites in whole, broken grains and flour form at each observation period (Table-1). Significant interaction was observed between observation period and *Desi* channa form meaning that statistically lower mite count was recorded in whole grains (CD= 624.502; p=0.05) at all observation periods as compared to broken and flour form.

Due to mite feeding on *Desi* channa, progressive discolouration of whole grains was recorded. During later stages of infestation, fungal growth appeared which completely damaged the grains. Progressive blackening of broken grains and flour of *Desi* channa was witnessed with increase in observation period. All the three forms; whole, broken grains and flour emitted characteristic pungent odour. Broken grain material and flour of *Desi* channa became darker in colour as the population multiplied due to excessive excreta at 150 and 180 days. The graphical representation of *S. nesbitti* population build up at the end of study period on three forms of *Desi* channa showed higher percent of mites on flour (58 %) followed by broken grains (38%) and whole grains (4 %) (Fig.1) which showed that flour was preferred by mites than other two forms. These studies are in conformity with

earlier studies on *S. nesbitti* (Seema, 2020) and *T. putrescentiae* (Anita, 2010) on different commodities as flour provides much larger surface area to mites (Kohli and Mathur, 1994) and act as perfect medium for the mite growth (Mahgoob *et al.*, 2006). Seema (2020) recorded higher susceptibility of pearl millet flour (364.14 mites/ 5g flour) than pearl millet grains (277.28 mites/ 5g grain). On cowpea also, the number of mites thrived on flour (314 mites/5g) was significantly greater than the *S. nesbitti* numbers on broken (231.28 mites/5g) and whole grains (119.19 mites/5g) (Dalal, 2020).

Table-1 : Comparative evaluation of *Desi* channa forms to *Suidasia nesbitti*.

Observation period (days)	Population of <i>Suidasia nesbitti</i> /g <i>Desi</i> channa			Mean
	Whole grains	Broken grains	Flour	
0	20.00	20.00	20.00	20.00
30	14.33	61.33	40.33	38.66
60	23.66	72.00	62.33	52.66
90	32.33	162.33	198.33	131.00
120	73.66	515.33	539.00	376.00
150	193.33	2084.66	3144.00	1807.33
180	260.00	2478.66	4226.00	2321.55
Mean	88.19	770.61	1175.71	

CD (p=0.05) for Observation period = 360.55; SE(m) = 125.89

CD (p=0.05) for *Desi* channa form = 236.03; SE(m) = 82.41

CD (p=0.05) for Observation period x *Desi* channa form = 624.50; SE(m) = 218.04.

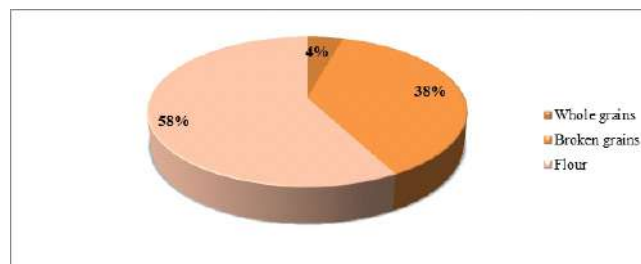


Fig.-1 : Effect of *Desi*channa forms on *Suidasia nesbitti*.

Table-2 : Comparative weight loss in *Desi*channa forms due to *Suidasia nesbitti*.

Observation period (days)	Percent weight loss			Mean
	Whole grains	Broken grains	Flour	
30	0.30	0.70	0.90	0.63
60	0.60	1.13	1.30	1.01
90	0.90	1.86	2.23	1.66
120	1.40	2.80	2.83	2.34
150	2.23	3.60	5.43	3.75
180	2.76	4.93	6.56	4.75
Mean	1.36	2.50	3.21	

CD (p=0.05) for Observation period = 0.10; SE(m) = 0.03

CD (p=0.05) for *Desi*channa form= 0.14; SE(m) = 0.05

CD (p=0.05) for *Desi*channa form x Observation period = 0.25; SE(m) = 0.08

Changes in the weight of three forms of *Desichanna* in terms of per cent weight loss due to *S. nesbitti* infestation are presented in Table-2. The data generated over the period of study exhibited significant increase in weight loss with increase in duration of infestation (CD= 0.10; $p=0.05$). Weight loss was 0.63, 1.01, 1.66, 2.34, 3.75 and 4.75 per cent after 30, 60, 90, 120, 150 and 180 days of observation period. Amongst the three forms of *Desi channa*, per cent weight loss was significantly more in flour (3.21%), corresponding to high population (Table 1) as compared to broken (2.50%) and whole (1.36%) grains (CD= 0.14; $p=0.05$). Statistical analysis done by ANOVA revealed a significant interaction between *Desi channa* form and observation period (CD= 0.25; $p=0.05$). It indicated that at all observation period, mite feeding caused significantly higher loss in flour as compared to broken and grains. Per cent loss was 0.30, 0.60, 0.90, 1.40, 2.23 and 2.76 in whole grains at 30, 60, 90, 120, 150 and 180 days (Table 2). Corresponding values for broken grains were 0.70, 1.13, 1.86, 2.80, 3.60 and 4.93 per cent. In flour form of *Desi channa*, the weight loss was 0.90, 1.30, 2.23, 2.83, 5.43 and 6.56 percent after 30, 60, 90, 120, 150 and 180 days of observation period. In earlier studies, in pearl millet, the weight loss was 2.53 percent in grains and 5.8 percent in flour (Seema, 2020). Similarly, after 180 days of *S. nesbitti* infestation, the weight loss was 4.58, 3.45 and 1.72 percent in whole, broken grains and flour of cowpea (Dalal, 2020).

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Knowledge of Urban Housewives on Terrace gardening

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Abstract

The greener cover of cities is being eaten away by the skyscrapers and concrete paths. This is the high time where the idea of urban greening and terrace cultivation should gain traction. If the housewives are encouraged in terrace cultivation, we can encompass the gender empowerment along with natural conservation. Before deep research on the role of urban housewives in terrace farming, it is essential to have an understanding about their knowledge on terrace cultivation. Here, we are trying to analyse the knowledge level of urban housewives on terrace gardening. The findings of the present study, which is conducted at Pune city, says that 40 per cent of the respondents had medium level of knowledge on terrace cultivation, while 34.44 per cent and 25.55 per cent of the respondents exhibited medium and high knowledge level respectively. Most of the housewives were well aware about the planting time (95.56%), irrigation schedule (95.56%), harvesting index (93.33%) and propagation materials (93.33%). Only a few housewives knew about micro nutrient application (15.56%) and crop varieties suitable (23.33%).

Key words : Terrace gardening; knowledge on terrace cultivation; urban greening; women in agriculture; urban housewives

Introduction

Urban clusters and their resource uses are becoming the main feature of the human presence on earth, intensely changing humanity's relationship to its host planet and its ecosystems. There was lack of space for cultivation of crops. When this condition came, it became an inevitability to utilize the available spaces for cultivation. Hence there was a pressing need for terrace gardens (Panneerselvam *et al*, 2014). A terrace garden is a garden which is established on a roof, patio, or terrace usually in a house or building where there is limited space for gardening. Today around 15 per cent of the world's food is grown in urban areas.

In India, since cultivable land is shrinking, mainly in cities, there is a need of some alternative actions like terrace gardening. It not only provides benefits such as space and time utilization, but also provides organic food, enhanced health, better disposal of household waste, reduction of family expenditure on buying vegetables and a fresh hygienic and eco-friendly atmosphere in the surrounding areas (Agnes *et al*, 2010; Poornima and Suryawanshi, 2020).

Agriculture and women have close association. Agriculture without women can't be imagined (Lohse, 2011). The data shows that slightly less than half of the population of our country is women. In Pune scenario (As per Govt. of India Census, 2011), there are 31 lakhs people are there in the city. Out of these 15 lakhs are females (48.67 per cent). Out of the 12 lakhs people in the

city who are engaged in work or any business activity, only 3 lakhs are females (27.61 per cent among working population and 10.63 per cent among total population). Even though the situation of urban women is quite satisfactory compared to that of rural women, they too need more encouragement to get engaged in some employment or work. There is good scope for empowerment of urban housewives in Pune city through the creation of employment opportunities and income through proper utilization of their time and the space available in the house premises and terraces for cultivation of vegetables (Azaduzzaman, 2011).

In Maharashtra state, Pune is second largest city. The practice of terrace gardening is getting widely accepted in this area. But it is observed that most of the people are not aware of this practice of terrace gardening and importance of consumption of organic food (Poornima *et al.*, 2021). Here, in this study, an attempt has been made to analyse the attitude of urban housewives towards terrace gardening.

Research Methodology

The study was undertaken in Pune city which includes of Pune Municipal Corporation and Pimpri-Chinchwad Municipal Corporation. As women are enthusiastic towards terrace gardening and there is a need for strengthen the gender and giving a space in farming related activities, the respondents selected for the study were housewives in the region. Through random sampling ninety housewives are selected; out of which sixty-two

Table-1 : Distribution of respondents according to their level of knowledge regarding terrace gardening.

Sr. No.	Particulars	Yes		No	
		Frequency	Percentage	Frequency	Percentage
1.	Planting time	86	95.56	04	04.44
2.	Media suitable	70	77.78	20	22.22
3.	Material used for planting	74	82.22	16	17.78
4.	Propagation material used	84	93.33	06	06.67
5.	Different varieties of vegetables and ornamental plants	21	23.33	69	76.67
6.	Intercultural and Horticultural practices	79	87.78	11	12.22
7.	Irrigation schedule	86	95.56	04	04.44
8.	Fertilizer schedule	78	86.67	12	13.33
9.	Use of micronutrients and macronutrients	14	15.56	76	84.44
10.	Compost/ FYM use in the garden	73	81.11	17	18.89
11.	Pest and disease management	58	64.44	32	35.56
12.	Bio pesticides and bio fertilizers	54	60.00	36	40.00
13.	Maturity indices and harvesting schedule	84	93.33	06	06.66

from Pune Municipal Corporation and twenty-eight from Pimpri-Chinchwad Municipal Corporation. The data was collected using pre-structured and structured interview schedule. The collected data was accurately analysed using suitable statistical tests such as mean, frequency, percentage and standard deviation.

The variable knowledge was measured with the help of schedule developed for the study consisting of 13 statements regarding various operations and technology regarding terrace gardening. A two-point continuum was used with 'yes' and 'no' to record the responses with the scores of one and zero, respectively. The total score of each respondent was worked out by summing up scores of all statements. Score '1' was assigned for knowing the expected answer perfectly, score '0' was assigned for lack of knowledge about the expected answer about terrace gardening. According to total score of the respondents, three categories of knowledge (low, medium, and high) has been made on the basis of mean $\pm$ SD value.

Results and Discussion

In this study, knowledge has been operationally defined as the body of information possessed by urban housewives in respect of terrace gardening. Through systematically formed statements regarding various operations in gardening, the details about the level of knowledge are collected. Through scoring technique, the collected information is analysed. The analysed information is presented in the Table-1 and Table-2.

It is understood from Table-1 that, major number of respondents (95.56 per cent) were having adequate knowledge regarding the planting time of various plants cultivated on terrace. Only a very few respondents (04.44 per cent) were lacking adequate knowledge on planting time.

Out of 90 respondents, 70 (77.78 per cent) were knowing about the media which is suitable for gardening viz; soil, cocopeat, FYM etc. The rest of the respondents (22.22 per cent) were not having much knowledge regarding the suitable media for particular crops. This minority were using soil for all the plants in their terrace gardening.

Regarding material used for planting, more than four fifth (82.22 per cent) of the respondent housewives were having good knowledge. They were using earthen pots, pots and bags made of plastic and ceramic materials etc. Other people (17.78 per cent) were only knowing about plastic and earthen planting pots.

It is clear from the table that, majority of the respondents (93.33 per cent) are well aware about the propagation material used for planting. They knew about seeds, cutting, underground parts used as propagation materials and even layering and tissue culture. The rest of respondents (06.67 per cent) were not that familiar with many of the propagation material used for planting in different plants.

Looking through the respondent's knowledge about varieties of different crops, only less than one fourth of the respondents (23.33 per cent) were knowing different varieties of plants. More than three fourth of the respondents (76.67 per cent) did not know about different varieties of plants.

It is revealed in Table 1 that, more than four fifth (87.78 per cent) of the respondents surveyed were well aware of the intercultural and horticultural practices to be done in the terrace gardens. The rest of respondents (12.22 per cent) were not having much knowledge about that.

Almost all the respondents (95.56 per cent) were clearly knowing about the irrigation schedule of the plants

in the garden. While very few (04.44 per cent) did not. Among the total respondents, 86.67 per cent knew about the application schedule of different fertilizers for plant growth. At the same time, the rest of the respondents (13.33 per cent) did not have good knowledge regarding the fertilizer application.

Only less than one fifth of the respondents (15.56 per cent) knew about micronutrients and macronutrients and its use in terrace gardening. Most of the sample population (84.44 per cent) did not know about that.

It is reflected from the table that around four fifth of the respondent gardeners (81.11 per cent) were knowing about compost use in the garden and its schedule. Some were knowing about house hold preparation of compost. Slightly less than one fifth of the sample size were not knowing about composting (18.89 per cent) and its use.

Out of 90 housewives 58 members (64.44 per cent) knew how to do proper plant protection measures. The other 35.56 per cent of the respondents did not have thorough knowledge regarding various plant protection measures.

As one of the main motives behind terrace gardening is production of chemical free eatables, it was necessary to measure their knowledge regarding bio-fertilizers and bio-pesticides. After going through the above table, it is understood that more than half of the respondents (60.00 per cent) were knowing about the use and benefits of bio-fertilizers and bio-pesticides. The remaining respondents (40.00 per cent) were unaware of the use and practice of bio-fertilizers and bio-pesticides.

As far as vegetable gardening is concerned, knowledge of harvesting schedule and maturity indices are very important. It is unveiled in the table that 93.33 per cent of housewives were well versed with harvesting indices and schedules. The rest of the housewives (06.67 per cent) were not familiar with the harvesting schedule and maturity indices.

From Table. 2, it is observed that two fifth (40.00 per cent) of the respondents are having medium level knowledge of various practices and technologies regarding terrace gardening. From the responses of the housewives, it is noticed that they are having moderate connectivity to various information sources such as internet, different training institutes, farm publications etc. This may be the probable reason of them not having high level of knowledge about terrace gardening.

Table-2 : Distribution of respondents according to their level of knowledge regarding terrace gardening.

Sr. No.	Knowledge (score)	Respondents (n = 90)	
		Frequency	Percentage
1.	Low (up to 10)	23	25.55
2.	Medium (10.1 to 12.9)	36	40.00
3.	High (13 and above)	31	34.44
	Total	90	100.00

Conclusions

The findings of the present study, which is conducted at Pune city, elucidates that, most of the housewives were well aware about the planting time, irrigation schedule, harvesting index, and propagation materials. Only a few housewives knew about micro nutrient application and crop varieties suitable for the climate and soil. The result also indicates that most of the farmers have medium to high level of knowledge on terrace gardening. As nearly a quarter of the housewives exhibited low knowledge level it is necessary to impart awareness and knowledge about the practice of terrace cultivation through appropriate tools.

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Dynamic Responses of Organic Wheat under Different Agronomic Alterations Based on Legumes

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Abstract

A field experiment was conducted during Rabi season at the Student research farm, Khalsa College Amritsar. The experiment consisted of 6 treatment combinations grown in three replications in a randomized block design. The experiment was laid out in a randomized block design with three replications. The treatments consisted of T₁ (Flat planting of wheat i.e. control), T₂ (Bed plating of wheat), T₃ (T₂+intercropping gram in center), T₄ (T₂+intercropping lentil in center), T₅ (Paired row of wheat and gram on bed), T₆ (Paired row of wheat and lentil on bed), T₇ (T₅+straw mulching) and T₈ (T₆+straw mulching). Results revealed that the growth (Crop growth rate, tillers) and quality parameters were significantly higher under T₇ treatment.

Key words : Wheat, gram, lentil, intercropping and mulching.

Introduction

In 1960, with the introduction of Green Revolution, the production of wheat and rice crop increased due to the use of High yield varieties which increased area under wheat cultivation and resulted in increase in demand of fertilizers, pesticides and irrigation water. Due to continuous increase in human population, demand of cereal crop increased. Adoption of modern crop production technologies which has considerably raised output but created problem of land degradation, (Gaillard et al.1997) pesticide residue in farm produce, reduction in soil productivity, soil compaction, depletion of water table and atmospheric and water pollution due to the dependence on synthetic fertilizers. The natural resource base is degraded, diminished and quality of the environment sustaining human life is an adversely affected. Higher pressure on soil fertility and water table may aggravate the problem in future (Ryan ,1977). Organic agriculture is an ecological approach to reduce the risks caused by modern agriculture by developing a natural system for the management of nutrients, water, weeds, pests and diseases. Organic agriculture is a comprehensive production management system that promotes and improves the health of the agricultural system, including biodiversity, life history and soil biological activity. Other agronomic innovations that can improve productivity, conserve resources and reduce the threat of weeds, such as bed planting, intercropping of legumes, straw padding, irrigation management, crop geometry, etc. should be explored. Based on the above aspects an experiment was taken up to find out effect of agronomic alterations on wheat.

Materials and Methods

A field experiment was conducted during Rabi season at the Student research farm, Khalsa College Amritsar. The experiment consisted of 8 treatment combinations grown in three replications in a randomized block design. The treatments consisted of T₁ (Flat planting of wheat i.e. control), T₂ (Bed plating of wheat), T₃ (T₂+intercropping gram in center), T₄ (T₂+intercropping lentil in center), T₅ (Paired row of wheat and gram on bed), T₆ (Paired row of wheat and lentil on bed), T₇ (T₅+straw mulching) and T₈ (T₆+straw mulching). Cultivars PBG5 of gram, LL 931for lentil and WH 1105 of wheat were used in this experiment. A rainfall of 0.36 mm was received during the respective cropping seasons. The grain yield was calculated per hectare on the basis of net plot yields.

Results and Discussion

A. Effect of agronomic alteration on growth and yield parameters of wheat

Crop growth rate (CGR) and Tillers (m⁻²) : The improvement in CGR of wheat on bed with legume intercropping and straw mulching was may be due to better environment, nutrient availability, interception absorption and utilization of solar radiation. Dhillon *et al.*(2005) also showed similar results. Treatments T₇,T₈ have significantly more number of tillers than sole wheat (T₂) and at par with wheat intercropped with gram and lentil (T₃,T₄) and paired rows of wheat with gram and lentil without straw mulch (T₅,T₆). The increase in tillers per plant with mulched bed planting in closer sowing may be due to greater weed suppression as lower the competition for resources, regulation of soil temperature, better edaphic environment and due to proper uniform

A. Effect of agronomic alteration on growth and yield parameters of wheat.

Treatments	Crop growth rate (g ⁻² day ⁻¹)	Tillers (m ⁻²)	PAR interception (%)			Canopy temperature (°C)			Straw yield (q ha ⁻¹)	Harvest index (%)	Nitrogen content of grain (%)	Nitrogen content of straw (%)
			At harvest	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS			
T ₁ : Flat planting of Wheat (Control)	0.11	252.5	58.1	70.1	64.5	22.5	17.9	20.9	46.1	38.1	1.62	0.36
T ₂ : Bed planting of Wheat	0.18	262.9	61.0	73.1	67.0	22.4	17.8	20.8	49.1	39.0	1.65	0.40
T ₃ : T ₂ + intercropping gram in center	0.24	271.5	62.4	74.6	68.7	22.3	17.4	20.6	51.3	40.1	1.67	0.54
T ₄ : T ₂ + intercropping lentil in center	0.23	266.6	61.8	74.2	68.6	22.2	17.5	20.7	51.1	40.0	1.66	0.50
T ₅ : Paired row Wheat and gram on bed	0.19	264.9	61.5	73.8	68.6	22.1	17.6	20.7	51.0	40.0	1.65	0.48
T ₆ : Paired row Wheat and lentil on bed	0.22	263.8	61.4	73.6	68.5	22.1	17.7	20.7	50.9	39.9	1.62	0.45
T ₇ : T ₅ + straw mulching	0.25	273.8	62.9	75.6	70.4	21.3	16.3	19.7	52.1	40.2	1.69	0.56
T ₈ : T ₆ + straw mulching	0.22	273.7	62.7	75.5	69.6	21.4	16.6	19.8	51.7	40.1	1.68	0.55
CD		10.2	1.7	2.1	1.9	0.50	0.27	0.38	2.50	NS	NS	NS

B. Effect of agronomic alteration on quality and economics parameters of wheat.

Treatments	Protein content (%)	Hectoliter weight (g lit ⁻¹)	Wheat equivalent yield (q ha ⁻¹)	Economics			B:C
				Total cost	Total income	Net profit	
T ₁ : Flat planting of Wheat(Control)	9.48	860.4	28.4	41500	66360	24860	1.60
T ₂ : Bed planting of Wheat	9.59	861.4	31.5	42750	72638	29888	1.70
T ₃ : T ₂ + intercropping gram in center	10.48	862.7	41.8	46550	89463	42913	1.92
T ₄ : T ₂ + intercropping lentil in center	10.45	862.5	37.4	46350	82591	36241	1.78
T ₅ : Paired row Wheat and gram on bed	10.42	862.2	42.5	46550	90365	43815	1.94
T ₆ : Paired row Wheat and lentil on bed	10.40	861.8	37.8	46350	83133	36783	1.79
T ₇ : T ₅ + straw mulching	10.60	863.5	46.9	47800	97850	50050	2.05
T ₈ : T ₆ + straw mulching	10.56	863.1	39.5	47600	86083	38483	1.81
CD	NS	NS	-	-	-	-	-

distribution of plants. Similarly it was observed by Upadhyay and Tiwari (1996) at that mulched treatments has higher number of tillers over the control.

Photosynthetically Active Radiation Interception (PAR) and canopy temperature : The data in Table 1 indicated that the bed planted wheat has maximum PAR (%) interception than flat sown wheat. At 60 and 90 days intervals, higher PAR (%) recorded in paired rows of wheat and gram + straw mulch (T₇) which was followed by paired rows of wheat and lentil + straw mulch (T₈) and significantly better than sole wheat (T₂) and at par with all other treatments (T₃, T₄, T₅, T₆). Similar trend was found in 120 DAS for PAR (%) interception. The probable reason for the better PAR (%) interception in paired rows of wheat and gram + straw mulch (T₇) might be due to more LAI, more number of tillers, more dry matter accumulation and greater absorption and better utilization of solar radiation by the canopy. Similar results were found by Dhillon *et al.* (2005). Flat sown wheat has higher canopy temperature as compared to all other treatments. It may be attributed due to proper distribution of plants, more LAI and more interception of radiation with in crop canopy. Similar findings are reported by Hobbs *et al.* (1998).

Straw yield and Harvest index : It is cleared from data that higher straw yield 52.1(q ha⁻¹) was recorded in paired

rows of wheat and gram + straw mulch (T₇) which was followed by paired rows of wheat and lentil + straw mulch (T₈). Treatment T₇ and T₈ significantly differ than sole wheat (T₂) but statistically at par with wheat intercropped with gram and lentil (T₃, T₄) and paired rows of wheat with gram and lentil without straw mulch (T₅, T₆). The data represented that maximum harvest index (40.2) was recorded in paired rows of wheat and gram + straw mulch (T₇) whereas minimum (38.1) harvest index was observed in flat planted wheat(T₁).

Nitrogen content of grain and straw : Although the treatment in which paired row of wheat with gram + straw mulch (T₇) have higher nitrogen content than wheat intercropped with gram and lentil in different row ratio with and without straw mulched treatments (T₈, T₃, T₄, T₅, T₆), yet it could not reach the statistical level of significance. Similar results were obtained by Mandal *et al.* (2013).

B. Effect of agronomic alteration on quality and economics parameters of wheat.

Protein content and Hectoliter weight : The maximum protein content 10.60 percent recorded while there is one row plantation on bed with legume crop (T₇) as more nitrogen available to the crop as protein content depends upon the nitrogen content, similar results were obtained

by Mandal *et al.* (2013). Hectoliter weight is also important quality parameter of wheat. It is the mass of wheat grains in gram per liter. The data recorded for the hectoliter weight presented in table 2. Data showed that the different agronomic modification adopted for organic production of wheat nominally affects the hectoliter weight but not get reached at statistical level of significance.

Wheat equivalent yield : The data in Table 4.29 and Figure 4.29 showed that highest wheat equivalent yield was recorded in T₇ (46.9) which are followed by T₈, T₃, T₄, T₅, and T₆. An improvement in wheat equivalent yield in pulse crop association. Similar results were obtained by Mandal *et al.* (2013) from their research experiment.

Economics : In table 2, higher BC ratio observed under bed planted treatments intercropped with pulses in different row ratio has straw mulch than the bed planted wheat without mulch. There higher BC ratio obtained in these treatments due to better returns in yield from gram and lentil crop.

Conclusions

However, grain yield, wheat equivalent yield and other benefits were maximum in bed planted, legume intercropped and straw mulched treatments than sole wheat. Among different intercropping systems, highest

grain yield, straw yield and benefit cost ratio were observed under bed planting, paired rows of wheat and gram + straw mulch.

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A Comprehensive Study of Herbicide Combinations on Weeds Dynamics of Wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during *rabi* seasons of 2018-19 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur to evaluate the effect of herbicides alone or as mixture on broadleaf and narrow leaf weeds in wheat (*Triticum aestivum* L.). Metribuzin alone application were applied as pre-emergence while all other herbicides or mixtures were applied as post-emergence at 35 Days after sowing. Post-emergence application of premix formulation of carfentrazone + sulfosulfuron (20 + 25 g ha⁻¹) proved most effective against *Malva parviflora*, *Chenopodium album*, *Chenopodium murale* and *Phalaris minor*. Maximum reduction in weed density and dry matter accumulation of weeds of wheat were recorded in carfentrazone + sulfosulfuron applied as post-emergence. Therefore, it is concluded that carfentrazone + sulfosulfuron herbicide combination has potential to further explore in wheat crop for further validation at field experiments for weed management practices.

Key words : Wheat, weed dynamics, weed management.

Introduction

Wheat is one in every of the foremost vital crops of India not solely in terms of expanse, however additionally in terms of its skill-fullness for adoption underneath big selection of agro-climatic conditions and crop growing things. It is produced in wide range of climatic environments and geographic regions (Dixon *et al.*, 2009). It provides 21% of the food calories and 20% of macromolecule for quite 4.5 billion folks in 94 developing countries (Braun *et al.*, 2010). In world , wheat ranked second after rice crop in food grain production and it was grown in 220.4 million hectare area with the production of 768.49 million tonnes (FAOSTAT, 2020). In India wheat is grown on 30.55 million hectare area with production of 107.18 million tonnes and productivity 3508 kg ha⁻¹. Rajasthan state takes fifth position in wheat production after Uttar Pradesh, Madhya Pradesh, Punjab and Haryana. In Rajasthan, it is cultivated in 3.20 million hectare area with the production of 10.57 million tonnes and having productivity of 3501 kg ha⁻¹ (IIWBR, 2019-20). The productivity of the wheat depends upon several factors like crop establishment techniques, irrigation, weed management, fertilizers management and other cultural practices. Among these factors, the hidden war with crop starts by weeds and it caused up to 90 percent failure of the crop. Besides the common broad-leaf weeds, difficult to control grassy weeds like

Phalaris minor, *Avena fatua*, *Poa annua* have also been observed to invade wheat field. There is a problem of mimicry weeds growing alongside the crop *i.e.* *Phalaris minor* and *Avena fatua*, which can't be controlled at early growth stage of the crop by mechanical/manual measures. Weeds not only reduce the yield but also make the harvesting and post harvest operations difficult. Chemical weed control method are most ideal, practical, effective, up-to-date, time saving and economical means of reducing early weed competition and crop production losses (Ashiq *et al.*, 2007). Infestation due to complex weed flora in wheat requires a variety of herbicides for effective control of these weeds (Sharma *et al.*, 2015). More recently, herbicide resistance has been reported in *Rumex dentatus* against metsulfuron-methyl (Chhokar *et al.*, 2017) and in *Avena ludoviciana* against clodinafop (Singh *et al.*, 2016). Hence, the herbicides used patterns need to be rationalized in such a way that problem associated with such type of use pattern can be avoided in the future.

Materials and Methods

The present experiment was conducted during *rabi* seasons of 2018-19 laid out at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur which is situated at 24°35' N latitude and 74°42' E longitude at an altitude of 579.5 meter above mean sea level. The weather condition during crop

Table-1 : Effect of weed control treatments on weed density at 45, 60 DAS and harvest of wheat.

Treatments	Weed density (m ⁻²)								
	45 DAS			60 DAS			At harvest		
	Broad leaf weeds	Narrow leaf weeds	Total weeds	Broad leaf weeds	Narrow leaf weeds	Total weeds	Broad leaf weeds	Narrow leaf weeds	Total weeds
Metribuzin 210 g ha ⁻¹	3.76 (13.67)	3.08 (9.00)	4.81 (22.67)	3.34 (10.67)	2.97 (8.33)	4.41 (19.00)	3.13 (9.33)	2.85 (7.67)	4.18 (17.00)
Carfentrazone 20 g ha ⁻¹	3.84 (14.33)	4.42 (19.00)	5.81 (33.33)	3.44 (11.33)	4.18 (17.00)	5.37 (28.33)	3.34 (10.67)	4.06 (16.00)	5.21 (26.67)
Metsulfuron-methyl 04 g ha ⁻¹	3.88 (14.67)	4.34 (18.33)	5.78 (33.00)	3.58 (12.33)	4.14 (16.67)	5.43 (29.00)	3.14 (11.33)	3.98 (15.33)	5.21 (26.67)
Carfentrazon + sulfosulfuron 20 + 25 g ha ⁻¹	3.11 (9.33)	3.13 (9.33)	4.36 (18.67)	2.80 (7.33)	2.67 (6.67)	3.80 (14.00)	2.55 (6.00)	2.48 (5.67)	3.49 (11.67)
Pinoxaden + metsulfuron 50 + 04 g ha ⁻¹	3.53 (12.00)	3.24 (10.00)	4.74 (22.00)	3.39 (11.00)	3.02 (8.67)	4.49 (19.67)	2.97 (8.33)	2.92 (8.00)	4.10 (16.33)
Mesosulfuron + iodosulfuron 12 + 2.4 g ha ⁻¹	3.27 (10.33)	3.19 (9.67)	4.52 (20.00)	2.85 (7.67)	2.92 (8.00)	4.02 (15.67)	2.67 (6.67)	2.85 (7.67)	3.84 (14.33)
Two hand weeding at 30 and 45 DAS	2.47 (5.67)	2.97 (8.33)	3.80 (14.00)	3.02 (8.67)	2.97 (8.33)	4.18 (17.00)	2.92 (8.00)	2.80 (7.33)	3.98 (15.33)
Weedy check	6.99 (48.33)	4.60 (20.67)	8.33 (69.00)	7.51 (56.00)	5.15 (26.00)	9.08 (82.00)	8.49 (71.67)	5.43 (29.00)	10.05 (100.67)
SEm ±	0.19	0.08	0.18	0.05	0.042	0.04	0.052	0.06	0.059
CD(P=0.05)	0.56	0.23	0.52	0.14	0.12	0.11	0.15	0.17	0.17

* $\sqrt{x}$ 0.5Transformed values and Data in parenthesis are original values.

season indicate that the crop faced low temperature at early stage of crop growth while there was slowly increase in average maximum and minimum temperature at reproductive stage. Wheat variety Raj.-4079 was used as a test crop. The experiment consisted of 8 treatment combinations and these were replicated three times in Randomized block design. The experiment comprised of total eight treatments viz. Metribuzin 210g ha⁻¹; Carfentrazone 20 g ha⁻¹; Metsulfuron-methyl 04 g ha⁻¹; Carfentrazone + sulfosulfuron 20 g + 25 g ha⁻¹; Pinoxaden + metsulfuron 50 g + 04 g ha⁻¹; Mesosulfuron + iodosulfuron 12 g + 2.4 g ha⁻¹; Two Hand Weeding at 30 and 45DAS and weedy check. The experimental field was prepared by ploughing with tractor drawn disc plough followed by cross harrowing and planking to obtain well pulverized soil tilth. As per recommendation, 120 kg N + 60 kg P₂O₅ + 40 kg K₂O ha⁻¹ was applied. Urea, DAP and MOP were used as a source of nitrogen, phosphorus and potassium, respectively. The total quantity of phosphorus and potassium and half dose of nitrogen were drilled in furrows before sowing. The remaining half dose of nitrogen was applied through urea as top dressing in two equal splits at the time of first and second irrigation. Herbicides were applied as post-emergence at 35 days after sowing (DAS) with the help of knapsack sprayer fitted with flat-fan nozzle using 500 liter of water/ha.

Weed studies : In order to ascertain dominant weed species in experimental field, weed flora was surveyed from two spot in each plot using 0.25m² quadrat before weeding (i.e. 30 DAS). The dominant weed species were

as follows: *Anagallis arvensis* L., *Chenopodium album* L., *Chenopodium murale* L., *Malva parviflora* L., *Coronopus didymus* (L.) Sm., *Fumaria parviflora*, *Convolvulus arvensis* L., *Rumex obtusifolius*, *Melilotus indica* (L.), *Phalaris minor* Retz., *Spergulla arvensis* L.

Weed density : The number of individual weed species were counted at 30, 45 (before hand weeding) 60 DAS and at harvest from two spots selected randomly in each plot by using 0.25 m² quadrat. Average number of broad and narrow leaf weeds was computed from each experimental unit which were counted as total weed and expressed as number per meter square area. The data were subjected to square root transformation to normalize their distribution (Gomez and Gomez, 1984).

Weed dry matter : All the broad and narrow leaf weed were collected separately at 30, 45 (before hand weeding), 60 DAS and at harvest from two spots in 0.25m area from each plot as explained above. The samples were chopped and filled in perforated paper bags separately and sun dried for two days. Finally these samples were kept in an oven at 70°C to obtain a constant weight. These were weighed and expressed in g m⁻²

Weed control efficiency (WCE) : Weed control efficiency was calculated by using the following formula (Maniet *et al.*, 1973).

$$WCE (\%) = \frac{\text{Dry matter of weeds in control plot}}{\text{Dry matter treated plots}} \times 100$$

The experimental data was statistically analyzed by

Table-2 : Effect of weed control treatments on weed dry matter at 45, 60 DAS and harvest of wheat.

Treatments	Weed dry matter (m^{-2})								
	45 DAS			60 DAS			At harvest		
	Broad leaf weeds	Narrow leaf weeds	Total weeds	Broad leaf weeds	Narrow leaf weeds	Total weeds	Broad leaf weeds	Narrow leaf weeds	Total weeds
Metribuzin 210 g ha^{-1}	5.87	5.13	11.00	4.38	4.79	9.17	4.13	4.22	8.35
Carfentrazone 20 g ha^{-1}	4.96	9.97	14.93	4.24	9.63	13.87	3.98	7.13	11.11
Metsulfuron-methyl 04 g ha^{-1}	5.18	10.08	15.26	4.26	9.85	14.11	4.03	8.21	12.24
Carfentrazone + sulfosulfuron 20 + 25 g ha^{-1}	4.11	1.64	5.75	3.38	1.47	4.85	2.98	1.33	4.31
Pinoxaden + metsulfuron 50 + 04 g ha^{-1}	4.60	2.06	6.66	4.37	1.85	6.22	4.01	1.74	5.75
Mesosulfuron + iodosulfuron 12 + 2.4 g ha^{-1}	4.19	1.78	5.97	3.86	1.63	5.49	3.70	1.49	5.19
Two hand weeding at 30 and 45 DAS	3.95	1.31	5.26	4.20	1.95	6.15	4.06	1.79	5.85
Weedy check	39.87	10.47	50.34	42.77	12.63	55.40	38.44	9.40	47.84
SEm $\pm$	0.22	0.16	0.38	0.28	0.17	0.45	0.24	0.19	0.43
CD(P=0.05)	0.66	0.48	1.12	0.83	0.50	1.33	0.72	0.56	1.28

the methods of analysis of variance (ANOVA) as described by Panse and Sukhatme (1985).

Results and Discussion

Effect of herbicide treatments on weeds flora : The experimental field was infested with natural population of *Malva parviflora* (26.0 %) *Chenopodium album* (18.0 %) *Chenopodium murale* (19.0 %) and others are *melilotus Indica*, *Fumaria parviflora* and *Convolvulus arvensis* whereas *Phalaris minor* (31.0 %) was only narrow leaf weeds. Herbicide treatments showed differences in weed control during the period of experimentation in wheat crop. Data (Table 1) reflect that compared to weedy check, different weed management practices significantly reduced the density of broad leaf, narrow leaf and total weeds at 45, 60 DAS and harvest. Minimum density of broad leaf weeds were noticed under two hand weeding in broad leaf (5.67 m^{-2}), narrow leaf (8.33 m^{-2}) and total weed (14.00 m^{-2}) at 45 DAS. Whereas, at 60 DAS and harvest the application of carfentrazone + sulfosulfuron recorded minimum weed density in broad leaf (7.33 ; 6.67 m^{-2}), narrow leaf (6.67 ; 5.67 m^{-2}) and total weed (14.00 ; 11.67 m^{-2}), respectively followed by mesosulfuron + iodosulfuron as compared to two hand weeding and weedy check. The data on effect of various weed management treatments on accumulation of dry matter by weeds at 45, 60 DAS and harvest are presented in Table-2. The different weed management treatments significantly reduced dry matter accumulation of broad leaf, narrow leaf and total weeds of 45 DAS. In all treatments, two hand weeding accumulated minimum in dry matter of broad leaf (3.95 g m^{-2}), narrow leaf (1.31 g m^{-2}) and total weeds (5.26 g m^{-2}) followed by carfentrazone + sulfosulfuron and mesosulfuron + iodosulfuron. At 60 DAS and harvest the maximum reduction in weed dry

matter by the application of carfentrazone + sulfosulfuron in broad leaf (3.38 ; 2.98 g m^{-2}), narrow leaf (1.47 ; 1.33 g m^{-2}) and total weeds (4.85 ; 4.31 g m^{-2}) followed by mesosulfuron + iodosulfuron as compared to rest of treatments. Sulfosulfuron, sulfonyl urea herbicides usually do not influence grain germination but root and shoot growth of sensitive seedlings are severely inhibited. The principal mechanism of action of this compound on weeds is the inhibition of cell division and growth by inhibiting plant enzyme acetolactase synthase, thereby, blocking branches chain of amino acid biosynthesis and hence the plant suffers (Kumar *et al.*, 2018). A contact, non-residual, translocated herbicide carfentrazone of aryl triazolinone family have been found effective to control broad-leaf weeds in wheat by inhibiting activity of protoporphyrinogen oxidase in chlorophyll biosynthetic pathway against broad-leaf weeds while sulfosulfuron provides excellent control of narrow leaf weeds and up to some extent of broad leaf weeds in winter cereals (Baghestani *et al.*, 2007; Curran *et al.*, 2011). Carfentrazone and sulfosulfuron is degraded in the soil by microorganism and by acid hydrolysis at low pH of soil and has a field half-life of 14 to 75 days depending upon the climate and soil (Walia *et al.*, 2010). The results obtained with sulfosulfuron in this study are in well accordance with findings of Yadav *et al.*, (2009), Bhullar *et al.*, (2012), Nanher and Singh, (2015) and Chauhan *et al.*, (2017).

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Performance of Different Varieties of Soybean (*Glycine max* L.) under Different Date of Sowing in South-East Rajasthan

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Abstract

An experiment entitled "Performance of different varieties of soybean (*Glycine max* L.) under different date of sowing in south-east Rajasthan" was conducted during the *kharif* season of 2019 at Career Point University, Kota (Rajasthan). Experiment was frame out in split plot design with four replications. In main plot, date of sowing with D¹ (25th June), D² (5th July), and D³ (15th July) and under sub plot treatments consisted of four varieties viz., JS 20-29, JS 20-34, JS 95-60 and JS 93-05. Results reveals that all varieties produced significantly higher seed yield (JS 20-34 1903 kg/ha) of soybean was recorded under D¹ (25th June) in comparison to late sowing D² (5th July), and D³ (15 July). Similarly, highest net return and benefit cost ratio were also recorded under this date of sowing. Similarly, highest net return, BCR was also obtained under these varieties. Further, under interaction effect sowing of soybean on 25th June with JS 20-34 Variety was found superior all over the varieties and gave higher seed yield (1903 kg ha⁻¹) which was 86.75 percent higher in comparison to sowing on 15 July with JS 93-05 variety (1019 kg ha⁻¹).

Introduction

Soybean is a native plant of East Asia and has been used as a Oil seed and pulses crop for thousands of years by Bhatia, V.B., Tiwari, S.P. and Joshi, O.P. (1999). It has a greater potential to substitute different oilseeds and pulses to overcome the shortage of edible oils and protein rich food. Soybean is an important source of vegetable protein and photochemicals in many developed countries. Soybean meal is mainly used as a source of protein in livestock and poultry feed, whereas soybean oil is used for human consumption and industrial purposes. Soybean being leguminous crop able to fix atmospheric nitrogen in soil to an extent of 65 to 100 kg ha⁻¹ depending on the soil type and climatic condition through rhizoidal symbiosis by Khare, *et al.*, (1998). Total area under soybean in the world as a whole is increasing about a 3 percent increase per annum. With respect to production, the increase is about a seven percent increase per annum. It continues to rank first among various oilseed crops globally contributing approximately 25 per cent to the total oil and fat production. In India, it ranks as number one oilseed crop with an area of 11.39 M. ha and production of 13.50 mt. Despite the numerous contributions soybeans continue to make in improving the world economy, its poor storability remains a great challenge in soybean production worldwide. The germination and vigor potential of soybean is short lived as compared to other grain crops and it is often reduced prior to planting time (Nkang, A. and Umoh, E.O. 1996.).

The sowing of soybean varieties of high yield

potential at optimum sowing time is considered as a hopeful approach to increase soybean production. Generally, the sowing date varies depending on the climatic condition of the region and the varieties to be grown. Different varieties of soybean are sensitive to change in environmental conditions where the crop is being sown. Therefore, it is also necessary to study the genotype × environment interaction to identify the varieties which are stable in different environments (Calvino *et al.*, 2003a). Sowing dates influence soybean growth stages, due to variation in photoperiod (Han *et al.*, 2006; Kumudini *et al.*, 2007), air temperature (Chen and Wiatrak, 2010), and rainfall distribution and amount during the crop cycle (Hu and Wiatrak, 2012). Sowing date is the variable with the largest effect on crop yield (Calvino *et al.*, 2003b). Environmental conditions associated with late sowing affect crop features related to the capture of radiation and portioning of crop resources as soybean is a dicotyledonous photoperiod sensitive crop (short day) and faces thermo-sensitivity in nature. These include less vegetative growth, shorter stems lower reproductive nodes and shortening of the reproductive phases (Kantolic and Slafer, 2001). Delayed sowing generally shifts reproductive growth into less favorable conditions with shorter days and lower radiation and temperature (Egli and Bruening, 2000).

Materials and Methods

The experiment was carried out on Soybean during *Kharif* 2019 at Career Point University, Kota (Rajasthan) to test the Performance of different varieties of soybean with

Table-1 : Effect of different varieties of soybean and different date of sowing on germination.

Treatments	Germination % of soybean at harvest	Germination % of soybean at 30 DAS
A. Main plot (Date of Sowing)		
D1 (25 th June)	87.5	87.5
D2 (5 th July)	85.6	85.6
D3 (15 th July)	83.1	83.1
S.Em±	90.9	0.54
C.D. at 5%	89.2	1.86
B. Sub plot (Variety)		
JS 20-29	88.6	85.1
JS 20-34	90.7	87.2
JS 95-60	88.4	84.9
JS 93-05	88.2	84.4
S.Em±	0.61	0.54
C.D. at 5%	NS	1.59

different date of sowing, in south east Rajasthan. The experiment was frame in split-plot design by allocating dates of sowing to main plots and the varieties to sub plots and it was replicated thrice. Date of sowing for experiment was D¹ (25th June), D² (5th July), and D³ (15th July). The treatments consisted of four varieties viz., JS 20-29, JS 20-34, JS 95-60 and JS 93-05 and the plant geometry is 45 cm X 5 cm. Hence, the present investigation is planned with objectives to find out the best sowing window to suggest a suitable variety of soybean for the region in South East Rajasthan.

Results and Discussion

Effect on Germination and maturity : Early sowing of soybean on 20th June had the highest number of plants (38.5 per m²), while the least number of plants (36.0 per m²) was obtained with 10th July sowing due to continuous rainfall received in 28th to 30th standard meteorological week (SMW) which had influenced the initial plant stand of soybean. Among the varieties, JS 20-34 had maximum plants (37.7 per m²) followed by variety JS 20-29 (37.3 per m²), JS 95-60 (37.0 per m²) and JS 93-05 (36.3 per m²). Further, sowing of 25th June took more days to mature which might be due to favorable temperature prevailed leading to more vegetative growth and drymatter accumulation resulting in prolonged of delayed maturity. Among varieties, the highest number of days was taken by JS 93-05, which was at par with JS 20-29 and showed superiority to JS 95-60 and JS 20-34. A gradual reduction in the total duration of crop with delayed planting, might be due to unfavorable climatic condition and reduced day length during the crop period similar results were reported by Pramila Rani and Kodandaramaiah (1999), Ramesh and Gopala Swamy (1992) and Sarma (1994) also observed similar reduction in number of days to maturity with delay in date of sowing. Among the varieties, JS

93-05 and JS 20-29 took the maximum days to maturity with early sowing which might be the varietal character. Similarly finding with different varieties were reported by, Halvankar *et al.* (2001).

Effect on growth : At 30 DAS, plant height of soybean was not influenced either by the sowing dates nor by the varieties or by their interaction. Further, at 60 DAS soybean plant height was obtained significantly higher (50.4 cm) when sown on 25th June but found at par with sown on 05th July. However there was significant decreased in the plant height with delay in sowing. Among the varieties, maximum plant height was recorded with JS-93-05 (52.90 cm) which was significantly superior to the other three varieties JS 20-29 (46.87 cm), JS 95-60 (44.23 cm) and JS 20-34 (43.9 cm). Similarly, at harvest plant height was not influenced by sowing dates but it was influenced by varieties only and it was significantly superior with variety JS 93-05 (55.2 cm) compared to JS 20-29 (49.7 cm), JS 95-60 (45.9) and JS 20-34 (45.9 cm) varieties of soybean. Further, at 30 DAS highest dry matter production was recorded with 25th June sowing of soybean which was at par with 05th July sowing and significantly superior over 15th July sowing. Among the varieties, the highest dry matter accumulation (546 kg ha⁻¹) was recorded with variety JS 93-05 which was significantly superior to the other three varieties tested. However, at 60 DAS, the maximum dry matter production (2578 kg ha⁻¹) was recorded with 25th June sowing of soybean which was significantly superior to other dates of sowing. Among the varieties, the highest dry matter accumulation (2595 kg ha⁻¹) was recorded with variety JS 93-05, which was on a par with variety JS 20-29 (2423 kg ha⁻¹) and significantly superior to JS 95-60 and JS 20-34 soybean variety. Similarly, at harvest, the highest dry matter accumulation (3633 kg ha⁻¹) was recorded with 25th June sowing of soybean which was on a par 05th July sowing. Among the varieties tested, the highest dry matter accumulation (3507 kg ha⁻¹) was recorded with variety JS 20-34, which was significantly superior to other three varieties JS 20-29 (3460 kg ha⁻¹), JS 95-60 (3413 kg ha⁻¹) and JS 93-05 (3381 kg ha⁻¹). Maximum dry matter accumulation in the early sown crop was perhaps due to more plant height, higher leaf area index and vigorous vegetative growth. The decrease in dry matter accumulation with delay in sowing might be due to decrease in plant height coupled with less vegetative growth. These results are in conformity with the results of Hanumantharao *et al.* (1990), Sahoo *et al.* (1991), Pramilarani and Kodandaramaiah (1999) and Halvankar *et al.* (2001).

Effect on yield and yield attributing characters : Data presented in Table-3. Results reveals that highest number of pods plant⁻¹ (31.9) was observed with 25th June sowing

Table-2 : Effect of different varieties of soybean and different date of sowing on plant height and dry matter accumulation.

Treatments	Plant height (cm) at 30 DAS	Plant height (cm) at 60 DAS	Plant height (cm) at harvest	Dry matter Production (kg ha ⁻¹) at 30 DAS	Dry matter Production (kg ha ⁻¹) at 60 DAS	Dry matter Production (kg ha ⁻¹) at harvest
A. Main plot (Date of Sowing)						
D ₁ (25 th June)	34.85	49.10	51.1	543	2570	3633
D ₂ (5 th July)	33.80	47.80	49.6	518	2475	3461
D ₃ (15 th July)	33.20	43.28	46.9	483	2223	3228
S.Em±	0.62	0.98	1.44	16.4	76.0	113.9
C.D. at 5%	NS	3.38	NS	56.9	263.2	394.4
B. Sub plot (Variety)						
JS 20-29	33.87	46.87	49.7	510	2423	3460
JS 20-34	33.53	43.9	45.9	498	2367	3507
JS 95-60	33.73	44.23	45.9	503	2389	3413
JS 93-05	34.67	51.90	55.2	546	2595	3382
S.Em±	0.76	1.29	0.75	15.7	67.9	83.3
C.D. at 5%	NS	3.77	2.20	45.9	198.4	243.2

Table-3 : Effect of different varieties of soybean and different date of sowing on yield and yield attributing characters.

Treatments	No. of pods plant ⁻¹	No. of seed pod ⁻¹	1000-grain weight (g)	Seed yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	H.I.(%)
A. Main plot (Date of Sowing)						
D ₁ (25 th June)	31.9	2.9	123.2	1667	3065	34.9
D ₂ (5 th July)	29.1	2.7	120.8	1458	2761	34.2
D ₃ (15 th July)	25.1	2.5	119.2	1235	2362	34.0
S.Em±	0.44	0.03	1.50	42.0	40.8	1.26
C.D. at 5%	1.53	0.12	5.18	145.5	141.2	NS
B. Sub plot (Variety)						
JS 20-29	28.4	2.7	119.5	1474	2718	35.1
JS 20-34	34.7	2.8	124.2	1707	2965	35.5
JS 95-60	26.8	2.6	118.6	1422	2705	34.4
JS 93-05	24.9	2.5	121.6	1211	2530	32.3
S.Em±	0.35	0.03	1.55	35.0	40.4	1.03
C.D. at 5%	1.03	0.10	4.52	102.4	117.9	NS

of soybean which was significantly superior to other dates of sowing. Among the varieties, the maximum number of pods plant⁻¹ (34.7) was recorded with JS 20-34 which was significantly superior to the other three varieties JS 20-29 (28.4), JS 95-60 (26.8) and JS 93-05 (24.9). Kushwaha (1990) and Singh and Bajpai (1992) reported that higher number of pods plant⁻¹ were recorded with early sowings. These results were corroborates the findings of Singh and Arya (1994), Karmakar and Bhatnagar (1995), Billore *et al.* (2000) and Halvankar *et al.* (2001).

A significant decrease in seeds pod⁻¹ of soybean was observed with delay in sowing from 25th June (2.9) to 15th July (2.5). The highest (2.9) number of seeds pod⁻¹ was recorded with 25th June sowing of soybean which was significantly superior to other dates of sowing. Among the varieties, the maximum numbers of seeds per pod (2.8) were recorded with JS 20-34 which was significantly superior to the other three varieties tested. The highest number of seeds pod⁻¹ of soybean was recorded with 25th June sowing with variety JS 20-34 which was significantly superior to other three varieties at same date of sowing. Higher number of seeds per pod observed with early sowing on 25th June might be due to

good seed set and translocation of photosynthetic due to congenial weather prevailed, which is in agreement with the findings of Hundal *et al.* (2003). In case of varieties, the maximum seeds per pod recorded with variety JS-93-05 might be due to varietal character, high dry matter. Similar results were found by Karmakar and Bhatnagar (1995), Billore *et al.* (2000) and Halvankar *et al.* (2001).

The maximum 1000 grain weight of soybean (123.2 g) was recorded with 25th June sowing which was significantly superior to over other dates of sowing. Among the varieties, 1000-seed weight recorded was maximum with JS 0-34 (124.2 g) which was at par with JS 20-29 variety (119.5 g). Higher 1000-grain weight recorded with early sowing might be due to favorable weather conditions coupled with more number of growing days during reproductive stage which might have helped in translocation of more assimilates into grains and subsequently develop to bold grain during early sowing. Results obtained are in consonance with Billore *et al.* (2000), Halvankar *et al.* (2001) and Asewar *et al.* (2015).

Early sowing of soybean in 25th June recorded

Table-4 : Effect of different varieties of soybean and different date of sowing on yield and economics.

Treatments	Seed yield (kg ha ⁻¹)	Gross returns (Rs. ha ⁻¹)	Cost of cultivation (Rs. ha ⁻¹)	Net returns (Rs. ha ⁻¹)	B:C ratio
25 th June JS 20-29	1694	62847	27350	35497	1.30
25 th June JS 20-34	1903	70601	27350	43251	1.58
25 th June JS 95-60	1669	61920	27350	34570	1.26
25 th June JS 93-05	1401	51977	28356	23621	0.83
05 th July JS 20-29	1486	55131	28356	26775	0.94
05 th July JS 20-34	1709	63404	28356	35048	1.24
05 th July JS 95-60	1426	52905	28550	24355	0.85
05 th July JS 93-05	1212	44965	28550	16415	0.57
15 th July JS 20-29	1241	46041	28550	17491	0.61
15 th July JS 20-34	1509	55984	27450	28534	1.04
15 th July JS 95-60	1172	43481	27450	16031	0.58
15 th July JS 93-05	1019	37805	27450	10355	0.38

significantly higher grain yield when compared to delay sowing. The yield reduction with delay in sowings of soybean might be due to a shortened vegetative period with decrease in plant height and dry matter accumulation leading to decrease in yield attributes and yield. The reduction in yield during rainy season July 05th and July 05th sowing can also be attributed to continuous heavy rainfall during initial crop establishment and plant suffer due to water stress at maturity which prevailed leading to low biomass accumulation and low yield. Results are also in accordance with Babalad et al (1996), Madhavi et al. (1997), Pramilarani (1997) and Radhakrishna Murthy et al. (2001). The highest grain yield recorded with JS-335, is due to higher number of pods per plant, number of seeds per pod and also test weight which resulted in maximum pod yield. These results are in accordance with those reported by Kausale et al. (2004), Kaushik et al. (2014) and Tariq Shah et al. (2017). Similarly Jaybhay and Varghese (2015) concluded that in western region of Maharashtra state, the highest seed yields of soybean can be obtained by sowing the crop at the onset of monsoon rain i.e. up to 15th June. Similar trend were also observed with haulm yield with early sown soybean crop which was significantly superior to delayed sowing of soybean. Similar findings was reported by Radhakrishna Murthy et al. (2001) and Amarajyothi and Pulla Rao (2002). In respect of varieties, maximum haulm yield was recorded with JS 20-34 which was due to cumulative effect of taller plants, and more dry matter production. These results are in conformity with the findings of Barik and Sahoo (1989), Chavan et al. (1998) and Ramesh Naidu (2017).

Effect on economics : Sowing of soybean on 25th June with variety JS 20-34 obtained highest gross return (Rs. 70601/- ha⁻¹), net return (Rs. 43251/- ha⁻¹) and B:C ratio (1.58) followed by under D1V1 obtained net return (Rs. 35497/- ha⁻¹) and B:C ratio (1.30) in comparison late

sowing on dated 15th July with variety JS93-05 the net return (Rs.10355) and B:C ratio (0.38), respectively.

Conclusions

Soybean crop sown on 25th June was found the optimum sowing time for getting higher seed yield (1903 kg ha⁻¹) which was 86.75 percent higher in comparison to sowing on 15th July (1019 kg ha⁻¹). However, data show that among the varieties, JS 20-34 was found superior over all rest of the varieties viz., JS 20-29, JS 95-60 and JS 93-05. Further, variety JS 20-34 gave significantly higher seed yield (1707 kg ha⁻¹) which was 40.95 percent higher in comparison to variety JS 93-05 (1211 kg ha⁻¹). Similarly, highest net return (Rs. 43251/- ha⁻¹) and B:C ratio (1.58) was obtained under sowing of soybean on 25th June with JS 20-34 variety.

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Importance of Boron for crops : A Review

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Abstract

Boron (B) is a micronutrient that is required by higher plants. It is, nevertheless, toxic in large quantities. In many soils, the concentration range between B deficiency and toxicity is narrow and varies by crop. Both of these variables have a substantial influence on crop yield and quality. While B toxicity is more difficult to handle agronomically, it can be minimised by the use of B-tolerant crop varieties. Chlorotic and/or necrotic patches commonly develop on the edges and tips of older leaves, indicating B poisoning. Several essential cellular functions appear to be vulnerable to B toxicity, according to data. The molecular mechanisms, on the other hand, are still a mystery. Generally, the capacity to sustain a low B content in shoots is connected to B tolerance. B-tolerant cultivars, on the other hand, differ from sensitive types in that they are better at excluding B from roots and translocating it less to shoots.

Key words : *Boron, boron tolerance, boron tolerant, boron toxicity, germination and growth, micronutrient, physiological and biochemical.*

Introduction

Boron is a critical element for plants that is mostly taken through the roots in the form of boric acid. It is critical for plant metabolism because it stabilises molecules containing cis-diol groups. This element is found in the cell wall and helps to maintain the structure and function of the membrane. It also takes part in a variety of ion, metabolite, and hormone transport processes. In terms of boron requirements, plant species and genotypes within species differ substantially. Available soil boron may have hazardous consequences on another crop if it is inadequate for one. Genetic variability (Interspecies) in boron utilisation efficiency and toxicity tolerance, combined with an understanding of boron physiological traits, should result in the development of efficacious and tolerant varieties capable of providing a long-term sustainable solution to the problem of insufficient or excess boron supply (Dadrwal, 2018).

Boron (B) deficiency is a mutual concern in humid climates around the world. Certain crops cannot grow in soils with 5-8 mg B kg⁻¹. Fertilization may correct the deficit, and other treatments can lessen soil boron toxicity; but, these procedures are expensive and time-consuming, and typically have only a temporary impact. Boron is a difficult chemical to regulate due to its high permeability and the fact that it exists at physiological pH as an uncharged molecule. Boron is very soluble and can readily be washed away after severe rains, causing in plant shortages. The contrary is often true in low-rainfall areas: it is not fully leached and hence accumulates to a level in the leaves that is harmful to plant growth and

metabolism (Reid, 2007). Boron can also build up in the topsoil as a result of crops being irrigated with boron-rich groundwater. Agronomic methods to lower B concentrations in soil are neither practicable nor feasible. In the majority of situations, the only practical approach to sustain yields on high-B soils is to choose or create crop cultivars with a high tolerance for boron. Numerous processes may contribute to elevated B levels in soil solution (Leyshon and Jame, 1993). In dry regions, the two most common explanations are (i) soils naturally rich in B, such as those formed by marine deposits or volcanic activity, and (ii) supply of irrigation water obtained from deep wells naturally rich in B. In other places, accidental applications of excess B in the treatment of B deficiency, the application or disposal of fossil combustion wastes such as coal fly ash, and the application or disposal of B-containing waste materials such as wastewater are other plausible sources of B toxicity. Underground irrigation water in arid or semi-arid Indian areas such as Rajasthan, Haryana, Uttar Pradesh, Punjab, and Gujarat has fatal levels of B.

Despite its relevance in agriculture, our knowledge of B toxicity is fragmented and limited. Boron is also involved in sugar transport, carbohydrate and RNA metabolism, cell wall construction, synthesis and lignification of the cell wall, respiration, membrane activities, DNA synthesis, and the control of metal activated enzymes (Dordas and Brown, 2005). The gap between B doses necessary for plant development and those that are harmful is negligible. In general, elevated B concentrations are seen in salty soils and irrigation water in arid and semi-arid parts of the globe. According to

some sources, B toxicity reduces photosynthetic efficiency, leaf development, and fruit set, resulting in decreased agricultural yield. When plants are poisoned with B, their root development is reduced in comparison to when B is treated optimally (Gunes *et al.*, 2006). Boron poisoning impairs the cell division process in the meristematic segments of roots, resulting in malformations (Liu *et al.*, 2000).

Plants need macro and micronutrients to grow and develop properly. Inadequate nutrient supply has a detrimental impact on plant growth and production. The purpose of this study is to determine the influence of boron, a micronutrient, on germination and growth of crops.

Micronutrient Boron

Boron is an essential micronutrient for higher plants :

Boron (B) is a chemical element that has both metallic and nonmetallic characteristics. It is a member of the group 13 of the periodic table. III-A (CAS), III-B (IUPAC). It is absorbed mostly by plant roots in the form of uncharged boric acid molecules that easily pass through the phospholipid bilayer of the cell wall (Brown *et al.*, 2002). Boron is a micronutrient for plants, which means that it is needed at concentrations as low as 1/g – 1 mg/g for optimum growth and development.

Boron is a well-known element found in plants. Its presence in a range of plant species, including wheat, has been experimentally proven, however no claim has been made that the element is necessary. As a consequence, is often credited with establishing the element's significance in plant metabolism. Boron is necessary for the development of a broad variety of monocotyledonous and dicotyledonous species, as well as conifers, ferns and phytoplankton species. The element's widespread use for agricultural plants was early recognised. Boron has an effect on the metabolism of macrominerals such as calcium, magnesium, and potassium, as well as triglycerides, glucose, amino acids, proteins, reactive oxygen species, and steroid hormones, making it a necessary or particularly beneficial micronutrient for mammals. The recommended daily intake for humans is between 1 to 13 mg, with the primary sources being fruits, vegetables, nuts, and legumes (Nielsen, 2011; Khaliq *et al.*, 2018).

Roles of boron in plant metabolism : Boron is a needed micronutrient, although its physiological function in plants is mainly unclear (Lewis, 2019; Wimmer *et al.*, 2019). The element's primary function is to help in the production of cell walls and to keep them structurally and functionally intact. Boron content in the wall is determined by the kind of plant, organ, and source of boron (Goldbach, 2000).

Plants absorb boron mostly as uncharged boric acid molecules (about 96 percent) and to a considerably lesser proportion as borate anions. Both compounds readily form complexes with molecules that are cis-hydroxylated. Borate contributes to the architecture and function of the cell wall by establishing ester connections between rhamnogalacturonan II (RGII) monomers' apiose residues. Monocotyledonous plants have less pectin in their cell walls than dicotyledonous plants, and thus have lower boron requirements and a lower tolerance for excess boron.

Boron's major role in plant metabolism, may be in the stability of cis-diol-containing compounds, independent of their function. Boron preserves the structure of the plasma membrane by forming cis-diol complexes with glycoproteins and glycolipids. Because it is involved in the metabolism and function of membranes, it participates in enzyme processes as well as the transport of ions, metabolites, and hormones (Blevins and Lukaszewski, 1998; Goldbach and Wimmer, 2007). It participates in the transfer of sugar across the membrane, the creation of lignin and flavonoids, and the metabolism of auxins, nitrogen compounds, and phenols; it stimulates, inhibits, or stabilizes enzymes (Huang *et al.* 2014; Seth and Aery, 2017).

When boron supply is inadequate, the reduction of DNA synthesis induced by pyrimidine base deficiency results in the termination of root growth (Blevins and Lukaszewski, 1998). This element has been shown to have an effect on cell division tissue vegetative growth and differentiation (Cakmak and Römheld, 1997), translation and transcription (Dzondo-Gadet *et al.*, 2002), and nitrogen fixation in legumes and mycorrhiza (Dzondo-Gadet *et al.*, 2002; Sonmez *et al.*, 2009).

Due to the fact that a shortage in boron leads in a range of biochemical, physiological, and anatomical alterations, it is particularly difficult to distinguish the primary and secondary effects of the deficiency. The most noticeable consequence is a disruption of cell division in the apical meristem, which results in root growth being reduced or completely halted. Boron deficiency reduces male fertility by decreasing microsporogenesis, seed germination, and pollen tube elongation (Cheng and Rerkasem, 1993). Following fertilization, the feeding condition impairs development, resulting in the loss of seeds or the production of defective or incomplete embryos (Rerkasem and Jamjod, 2004; Rerkasem *et al.*, 2019).

Boron and root system : Aquea *et al.* (2012) recently released a paper elucidating the molecular mechanisms behind B toxicity-induced root growth inhibition in Arabidopsis. According to the researchers, B poisoning

boosted the expression of genes involved in abscisic acid signalling, abscisic acid response, and cell-wall changes. Additionally, B poisoning lowered the expression of genes producing water transporters, showing that B toxicity induced a water-stress response that inhibited root growth. Given the root system's involvement in the B-excess response, genotypic variation in root elongation has been often exploited as a measure of B tolerance (Hayes and Reid, 2004; Choi *et al.*, 2006). Choi *et al.* (2007) observed that B tolerance in barley is connected with root morphological changes such as increased branching and finer root growth, which permits enhanced soil utilization through osmotic adjustment. Princi *et al.* (2013) recently shown that a short B-excess treatment has a substantial influence on several root morphological traits. Particularly in the presence of excess B, the root system of the tolerant tomato was longer and thinner than that of the sensitive tomato.

Boron and photosynthesis process : Although the cause of harm is unknown, elevated B concentrations inhibited photosynthesis. When exposed to high levels of B (Fang, 2001), the leaf's edge died, reducing photosynthetic area, chlorophyll concentration, and hence photosynthetic rate (Han *et al.*, 2009; Chen *et al.*, 2013). Only in barley leaves was a unique outcome seen, with photosynthesis being unaffected by excess B at 50 mM and hardly inhibited (23% inhibition) at a 100 mM B concentration (Reid *et al.*, 2004). According to Landi *et al.* (2013), increasing B resulted in a reduction in the chlorophyll a/b ratio and a decrease in the photosystem II photochemical efficiency in cucurbits (*Cucumis sativus* L. and *Cucurbita pepo* L.). The B excess lowered the Fv/Fm ratio (maximum quantum yield of chlorophyll fluorescence) in various species, suggesting that leaves were photoinhibited, perhaps resulting in ROS formation (Velez Ramirez *et al.*, 2011). This might explain the drop in chlorophyll content (Han *et al.*, 2009; Chen *et al.*, 2012). Additionally, lower activity of many enzymes involved in CO₂ assimilation (carboxylase/oxygenase, ribulose-1,5-bisphosphate, and fructose-1,6-bisphosphate phosphatase) was related with a drop in electron transport rate, indicating decreased NADPH and ATP use (Han *et al.*, 2009). Chen *et al.* (2013) investigated protein patterns in Arabidopsis leaves in response to B overload using a proteomic technique. Surprisingly, B excess had an impact on proteins involved in both the light and CO₂ fixation processes of photosynthesis prior to the onset of apparent symptoms in leaves such as chlorophyll deficiency, total cell protein deficiency, or growth deficiency.

Boron uptake : Boron uptake has long been a point of debate owing to the diversity of plant species, very high boron concentrations, and a variety of experimental

approaches. Boron is mostly taken by plants as boric acid via their roots. It is a tiny, soluble, undissociated, uncharged molecule that glides across lipid bilayers readily. Boron is the sole element in the soil that does not enter as an ion. When there is an enough supply of the element, it is transported passively, without the necessity of protein catalysis or energy. Passive diffusion was long assumed to be the only mechanism of transmission due to the cell's high boron permeability, unique flux patterns throughout the transpiration stream, and buildup towards the leaf tips (Nable, 1988). Increases in boron tissue content in response to increased external boron (Nable *et al.*, 1990), as well as the lack of effect of metabolic inhibitors and both low and high temperatures (2-42°C) on accumulation seem to confirm this stance. The element is thought to enter the cell in two ways: passively through the lipid bilayer and actively via Hg-sensitive protein channels, aquaporins, or other channels.

Boron is unusual among nutrients in that its mobility varies greatly across plant species. Boron is strongly phloem-mobile in species that primarily photosynthesize polyols (e.g., sorbitol, mannitol and dulcitol). The mobility is a result of boron's polyol complexation. *Prunus*, *Malus* and *Pyrus* (pears, apples, cherries, almonds, plums, peaches, and apricots) are examples of such species, as are onion, celery, carrot, olive, bean, pea, cauliflower, cabbage, and asparagus. On the other hand, boron has been shown to impair phloem mobility in plants that depend significantly on sucrose for photosynthetic energy. These species (which include wheat, barley, and walnut) account for the overwhelming bulk of the population. Boron builds near the stream's terminus as it passes. As a result, the element is concentrated much greater in the leaf tips and margins than it is throughout the leaf. On the other hand, the concentration of boron in the leaves of phloem-mobile plants is stable. Boron concentrations in older leaves are generally higher and are associated with lower phloem mobility. Phloem concentrations in early leaves and fruits are higher, indicating phloem migration (Stangoulis *et al.*, 2010; Choudhary *et al.*, 2021).

Boric acid is a water-soluble molecule that is easily washed away by rain, which explains why boron shortage is so prevalent in humid areas. Boron deficiency is most dangerous in southwestern China, northwestern India, Nepal, Japan, Bangladesh, and Brazil; but, at least 80 countries globally, including Zambia, Nigeria, the Philippines, Thailand, Korea, and northern European countries, are anticipated to get the disease (Rehman *et al.*, 2014; Rerkasem *et al.*, 2019). Unlike boron deficiency, soil boron toxicity is rare and occurs only in dry and semi-arid regions. Soil boron levels were discovered to be high in Australia, the United States, Russia, Turkey,

Mexico, Israel, Iraq, Egypt, Syria, Morocco, Jordan, Libya, India, Pakistan, Malaysia, Peru, Chile, Hungary, Serbia, and Italy (Dadarwal *et al.*, 2018; Landi *et al.*, 2019).

Alleviation of the effects of boron deficiency and toxicity : Boron fertilisers are frequently used to treat boron deficiencies. Soil fertilization is the most popular method, but foliar treatment and seed priming are other viable options. The effects of boron deficiency on plants can be mitigated to varying degrees depending on the treatment approach, the time of administration, other soil factors such as temperature and humidity, and the species and genotype efficiency of boron absorption and usage. Boron fertilisers increased the production, quality, and several physiological features of a wide range of agricultural plants, most notably yield, but also water management and chlorophyll content. The amount of added boron should be carefully handled for each application, given the small range between deficiency and toxicity (Duran *et al.*, 2018; Sapkota *et al.*, 2018; Fujiyama *et al.*, 2019).

Leaching, amending with different substances, or producing boron-tolerant plants all contribute to the improvement of soils that contain an excess of boron. After successfully reclaiming salty soils, leaching with boron-deficient water is employed, such as river water. The method must be customized to the soil's physical and chemical properties. Boron leaching is hampered by its slower rate of removal than salt, the possibility of migration into deeper soil layers and subsequent root zone contamination, the risk of leaching other nutrients, and the risk of spontaneous boron regeneration (Dhassi *et al.*, 2019). The interactions between boron and other elements, such as calcium, sulphur, zinc, silicon, and aluminium, have been exploited to develop soil supplements with the goal of improving soil quality or alleviating adverse effects on plants (Hossain *et al.*, 2005; Inal *et al.*, 2009; Turan *et al.*, 2009). To compensate for excess boron, organic matter and a variety of plant growth modulators were applied (Esteban *et al.*, 2016). If cost-effective methods for removing boron from irrigation water could be discovered and implemented, the most common source of pollution produced by people would be eliminated (Hilal *et al.*, 2011; Shaffer *et al.*, 2012; Wolska and Bryjak, 2013).

Agricultural Plants and Boron

Boron deficiency : Boron deficiency has a greater impact on root development than on shoot growth. Root elongation is hindered when boron deficiency prevents cell proliferation in the apical meristem. Acute shortage causes the root cap to vanish, growth to stall, and root tips to die. Increased shoot/root ratios make plants more sensitive to drought and nutrient deficiencies. Snowball

and Robson (1983) observed longitudinal breaks in the major vein of early leaves in wheat, as well as deformed leaf margins, however these symptoms are uncommon in the field (Rerkasem and Jamjod, 2004). In severe and chronic shortages, internodes are reduced and necrotic areas appear on leaves.

Boron needs are often increased during a plant's reproductive phase. As a consequence, yields might be severely lowered under field circumstances without evident evidence of insufficiency. The required level of boron deficiency in wheat flag leaves during the vegetative phase is 1 ppm; however, unlike toxicity, leaf boron concentration does not always correspond to boron use efficiency (Asad *et al.*, 2001; Wongmo *et al.*, 2004). A concentration of 7-8 parts per million (ppm) in anthers and 5-6 parts per million (ppm) in carpels causes wheat sterility. Male sterility is the most common unfavorable result of insufficient reproductive capacity. Seeds may be aborted if fertilisation occurs. As a result, boron deficit in wheat, for example, results in a reduction in the quantity of seeds per spike and in extreme cases, yield may be decreased by as much as 100% owing to nutrition difficulties. Boron use is believed to be more effective in genotypes with steady output in conditions when other genotypes' yields are reduced.

Due to their capacity for internal boron retranslocation, phloem-mobile species seldom experience insufficiency. As a consequence, boosting polyol synthesis may be an efficient strategy to increase boron use. This may be done by genetic modification (e.g., tobacco, rice) or by choosing genotypes with a high polyol yield.

Two different loci have been identified that influence boron efficiency in wheat. Dominant loci (Bod1, Bod2) indicate high efficiency, and hence the following locus combinations are considered to be the gold standard for utilisation efficiency: Bod1 Bod1, Bod2 Bod2 (Fang 60-efficient cultivars), bod1bod1 bod2bod2 (Bonza-inefficient cultivars), and bod1bod1 Bod2 Bod2 (SW 41-moderately efficient cultivars).

The efficiency of boron usage is influenced by the capacity of boron transport from roots to aboveground plant organs (Huang *et al.*, 2001; Nachiangmai *et al.*, 2004). The Arabidopsis thaliana membrane protein BOR1, which is involved in boron loading in the xylem and defective translocation, was discovered for the first time by Takano *et al.* (2002). The bicarbonate transporter in animals is the same protein. It was possible to create a boron-deficiency-resistant Arabidopsis strain (Miwa *et al.*, 2006). This was accomplished by increasing BOR1 production, which resulted in more boron being transferred from roots to aboveground organs. The

transgenic plants were cultivated under inadequate conditions, which resulted in a 100 percent reduction in wild-type yield, and they showed no enhanced sensitivity to excess boron. Future study targeted at breeding or producing boron-efficient cultivars will be based on the transporters discovered in major agricultural plants (Kato *et al.*, 2009; Miwa and Fujiwara, 2010; Yoshinari, 2017).

Transgenic tomato lines (cv. Micro-Tom) have been produced to improve growth in boron-deficient environments. Boron absorption, transport, and usage, for example, all contribute to the efficiency of *Brassica napus*. Using a previously created high-density genetic map, several quantitative trait loci (QTL) connected to boron utilization efficiency have been discovered. In order to identify beneficial genotypes, breeders might profit from the discovery of molecular markers linked with QTLs. More study is needed, however, to translate our existing understanding of boron consumption efficiency physiology and genetics into boron-efficient plant varieties with improved growth, quality, and yield. The transformation was initiated by *Agrobacterium*. Tomatoes are widely used as a model for plants that produce fruit. Due to the high expression of AtBOR1, the lines are boron-efficient (*Arabidopsis thaliana* BOR1). Transgenic plants cultivated under inadequate circumstances showed a greater shoot dry weight and boron concentrations in the shoot and fruit, compared to non-transgenic plants. Transgenic crops may provide a long-term solution for boron-deficient regions, according to the research. Another possibility is to use marker-assisted selective breeding to improve boron use efficiency. The feature is polygenic in the majority of crop plants. Boron absorption, transport, and usage, for example, all contribute to the efficiency of *Brassica napus*. Using a previously created high-density genetic map, several quantitative trait loci (QTL) connected to boron utilization efficiency have been discovered. In order to identify beneficial genotypes, breeders might profit from the discovery of molecular markers linked with QTLs. More study is needed, however, to translate our existing understanding of boron consumption efficiency physiology and genetics into boron-efficient plant varieties with improved growth, quality, and yield (Zhang *et al.*, 2014; Zhang *et al.*, 2014; Hua *et al.*, 2016; Yuan *et al.*, 2017; Pommerrenig *et al.*, 2018).

Boron toxicity : Boron toxicity manifests differently depending on whether phloem movement is limited or considerable. In species with stationary phloem, boron diffuses through the xylem and accumulates at the end of the transpiration stream. Chlorosis and necrosis that extend from the leaf tips, as well as brown lesions that begin at the leaf margins and spread across the leaf surface, are foliar symptoms in barley and wheat. The

illness first affects the plant's oldest leaves and subsequently extends to the plant's crown. Brown lesions on leaf sheaths, stems, spikes, and awns have been seen in severe cases. Stem height, dry matter weight, 1000-kernel weight, spike number per plant, and yield all decreased, as did emergence and foliation duration (Nable, 1988; Rehman *et al.*, 2006). Barley symptoms are often more severe and appear sooner than wheat symptoms. When the soil's boron content rises with depth, symptoms appear later and the yield is reduced less. Boron excess has no effect on the area, width, or length of the leaves. In hydroponically produced wheat and barley, we discovered overall root weakening and decreased lateral root growth (Nable, 1988). The intensity of all boron poisoning symptoms varies by genotype; for example, certain genotypes have a lower, equal, or greater dry matter weight when exposed to boron (Torun *et al.*, 2006). Wheat and barley yields were lowered, and genotypes differed significantly in terms of yield reduction and visual indicators of boron toxicity (Yau and Ryan, 2008). Additionally, despite acute poisoning symptoms and elevated shoot boron concentrations, genotypes with steady yields exist in environments with elevated soil boron.

Excess amount of boron hinders the emergence of maize, tomato, carrot, and alfalfa. In phloem-mobile *Prunus*, *Malus*, and *Pyrus* species, young shoot tip cessation, leaf axil gumming, brown corky lesions along stems and petioles, and bud abscission have all been seen. Boron toxicity in celery appears as an uneven stem shape and juvenile leaves that are malformed.

As a species with restricted phloem mobility, barley's leaf tips have a much higher boron content (10-50 times) than the leaf base, implying that leaf concentration is proportional to the percentage of tip to remaining leaf sections. Boron buildup is affected by transpiration; as water consumption increases, so does boron accumulation and concentration in leaf tips (Nable *et al.*, 1990). In *Arabidopsis*, excessive external boron reduces water transport and transpiration, which may be a boron tolerance mechanism (Macho-Rivero *et al.*, 2018). Additionally, rain rapidly depletes the boron content in leaves (Reid and Fitzpatrick, 2009). As a result, defining universal critical boron concentrations is almost impossible.

Despite of the kind of research or boron concentrations in the soil or nutrient solution, it is widely accepted that tolerant barley and wheat cultivars have lower boron levels in all organs (Rehman *et al.*, 2006; Ghaffari *et al.*, 2015). The shoot boron contents of boron-tolerant barley, bread, and durum wheat genotypes were found to be variable. As a consequence, certain

genotypes absorb or translocate less boron, while others can tolerate greater boron levels in the tissue. For example, 70 durum wheat genotypes were analysed, and it was observed that tolerant and sensitive genotypes with high and low shoot boron contents exist (Torun *et al.*, 2006). No link between tolerance characteristics and plant boron levels was discovered in a laboratory study using 40 bread wheat genotypes tested for boron tolerance at the seedling stage. The tolerant genotypes, on the other hand, exhibited a larger boron level, which was explained by the sensitive genotypes' lower nutrient absorption, including boron.

The disparity in B tolerance between genotypes of different origins might be explained by an edaphic adaptation or by inadvertent selection for boron tolerance in breeding centers situated in areas with an excess soil boron issue. Numerous instances support this position. For decades, the region's agricultural area has been irrigated with boron-rich saline water. In those conditions, local cultivars produced significantly more than expected. Boron tolerance was studied in field-grown wheat's from a variety of nations and it was found that indigenous cultivars (from Turkey and Serbia, respectively) were better adapted to the nutrition issue. The researchers looked at two Syrian indigenous populations, one from a semi-arid region prone to boron toxicity and the other from a more humid one. The first was resistant to excess boron, but the second was susceptible (Yau, 2002).

Effect of boron on carbohydrate metabolism in plants

: The level of sucrose fluctuate often in response to a variety of environmental stresses, including B stress (Rosa *et al.*, 2009). B has a varying effect on the production of plant glycosides, primarily sucrose, according to several studies. Boron also prevented sugar from being converted to starch. A spike in reducing sugars (RS) was seen in the root tip when too much B was present in the soil (McDonald *et al.*, 2003). Under conditions of B toxicity, tolerant barley demonstrated an increase in invertase activity, as well as increases in RS, glucose, and fructose content. This change in carbohydrate metabolism would be beneficial for root development and plant growth in the presence of B toxicity (Choi *et al.*, 2007). A segregant population was recently employed to discover genomic regions (quantitative trait loci (QTL)) associated with RS concentration in barley cultivars that were hybridised between B-susceptible and B-tolerant barley cultivars (Huynh *et al.*, 2009). The association between B tolerance and a high level of RS in the root tip in the presence of excess B might support the idea that RS contributes to B tolerance.

Effect of boron on amino acid content in plants : Proteins are composed of amino acids that perform a

range of functions. They are critical because their absence leads in a decrease in protein synthesis (Xiao, 2011). The largest concentration of total free amino acids was found in the rhizomes of *Phragmites australis* (Cav.), followed by the leaves, and finally the roots. When salinity was raised from 0% to 10%, the amino acid content almost quadrupled.

Effect of boron on proline content in plants : Chiang and Dandekar (1995) examined the composition of proline in total free amino acids and determined that between 1 and 3% of proline was found in vegetative tissues. Proline has a role in the floral induction process. Proline was shown to be overproduced in transgenic plants, and enhanced free proline levels were revealed to be directly associated with flower formation.

Because proline increases more rapidly than other amino acids under drought conditions, it is often used as an assessment criteria for irrigation scheduling and selection of drought-tolerant varieties. Severe water stress in plants results in a range of metabolic problems. Due to the passage of proline from leaves to flowers, M bean's research revealed that free proline accumulation in leaves is crucial for the formation of generative organs.

Changes in external osmotic pressure cause the accumulation of compatible solutes such proline and sugar, which is important for maintaining the balance of ions in vacuoles and cytoplasm within the cell, therefore safeguarding the cell structure and permitting continuous water ingress (Parida and Das, 2005).

Effect of boron on melondialdehyde (MDA) content in plants

: Boron stress was applied at doses of 5mM and 10 mM to barley (*Hordeum vulgare*) and lentil (*Lens clunar*) plants. Where Boron stress decreased the relative growth rate (percentage) and total chlorophyll content (mg/ g). MDA, H₂O₂, and proline concentrations rose as a result of boron poisoning. Additionally, it was advocated that NH₄⁺-containing fertilisers be extensively recommended for farmlands contaminated with boron (Tepe *et al.*, 2011).

The accumulation of NADPH in leaf mesophyll tissues as a result of a decrease in CO₂ concentration. When NADPH is decreased, oxygen serves as a convenient elector acceptor, causing superoxide radicals to develop. Boron treatment decreased growth and elevated levels of H₂O₂ and malondialdehyde in shoot and root tissues of wheat (Gunes *et al.*, 2007).

Suggestion for Future

When compared to nontolerant cultivars, tolerance to B toxicity was related with lower B accumulation in both root and shoot tissues. Active B efflux from root cells via ion transporters has been connected to the basis for B tolerance, at least in part.

It was recently discovered that overexpressing the tonoplast channel (AtTIP5;1) in *Arabidopsis* improved B tolerance. As a result, more attention should be paid to the involvement of vacuolar and tonoplast boron transporters in avoiding B accumulation in the cytoplasm and, as a result, decreasing Boron toxicity and transcript levels in wheat, demonstrating the high complexity of this quantitative feature.

In summary, future B tolerance research should adopt a multidisciplinary approach, integrating physiological dissection of B-tolerant characteristics as well as genetic and genomics techniques. Additionally, identifying and exploiting new variety exhibiting varying degrees of tolerance to elevated B concentrations in the soil is crucial for diversifying the sources of B excess tolerance accessible to breeders.

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Intercropping in *Bambusa balcooa* in Agroforestry System

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Abstract

Bamboo (*Bambusa balcooa*) based agroforestry provides higher economic return to the farmers, improve the soil, and provide raw material to the industry as well as for domestic use of the rural community. Because of the use of various intercrops, products are obtained even in the early stages of plantation and the income would be much higher than any other system. Maximum plant height (13.2 m) and spread (1.0 m) of *B. balcooa* was recorded in the intercrop plot with banana while average culms (7.8 no.) was the highest in bamboo intercropped with turmeric in 3 years after plantation. Pineapple as intercrop with *B. balcooa* registered fruit yield of 75.37 t/ha at 4.0 m away from the base of *B. balcooa* clump in comparison with 3.0, 2.0, 1.0 and 0.5 m. distances and decreased gradually towards the base of bamboo. Statistical analysis showed that fruit yield of banana was significantly higher (15.08 t/ha) in 4.0 m away from the base of bamboo clump in comparison to 3.0, 2.0 and 1.0 m distance. Turmeric as intercrop yielded 14.86 t/ha at 4.0 m away from the base of *B. balcooa*. Organic matter and soil nutrients build up was observed due to the intercrops.

Introduction

Bamboo is basically a household plant species grown in homestead, on farmlands and other available places of farm holding. It is grown in homestead as every part of the bamboo finds one use or another in daily life of a farmer. Jaysanker and Muralidharan (2000) found that advantage of bamboo over other perennial cash crops as low gestation period, fast growth, diversified uses and easier marketability; all ensuring its potential as an excellent agroforestry crop.

Among the cultivated species of bamboo, *B. balcooa* occupies the second position in acreage and productivity in the commercial cultivation. *B. balcooa* is an evergreen or deciduous gregarious bamboo, 7-23 m in height, 5-10 cm in diameter and used extensively for house construction, farm fencing, production of pulp and paper, making agricultural implements, mats, screen, wall plate, basket and food grain container. Bamboo being C₄ plant contributes a lot for cleaning the environment.

Intercropping in bamboo is another option to enhance farm income further. Fu Maoyi and Banik (2001) have reviewed different bamboo based agroforestry models in INBAR technical bulletin no.8 and suggested three groups i.e. bamboo-agriculture model, bamboo-fishery model and special purpose model. Bamboo based agroforestry models provide higher economic returns to the farmers improve the soil, help fill the gap of required national forest cover (33%) and provide raw material to the industry as well as for domestic use of the rural community. Because of the use of various intercrops, products are obtained even in the early stages of plantation and the income would be much higher than any other system. Bamboo can be harvested

every year from fourth year onwards and hence regular income starts much earlier compared to any other woody component (Seshadri, 1985).

Keeping all in view, a field experiment on *B. balcooa* was planned to evaluate production potential, economics, soil health and impact of bamboo based agroforestry on nutritional resource base.

Materials and Methods

One year old Bamboo rhizomes with one meter culm length having at least 2 – 3 internodes were selected as planting materials for *B. balcooa* (Bhaluka). Rhizomes were planted in pits at 45° angle inclined towards North and the base were tempered in the month of March-August, 2016. Gap filling was done twice in the month of May, 2016 and June, 2016. Three different intercrops viz. Pineapple (var. Kew), banana (var. Chenichampa) and turmeric (cv. Tall Clone) were selected. Pineapple suckers and banana suckers were planted in the month of September, 2017. Turmeric was sown in April months of 2016, 2017 and 2018.

Yield data of bamboo and intercrops for three years have been recorded. During third year, yield and yield attributing characters of pineapple and turmeric as intercrop at 0.5 m, 1.0 m, 2.0 m, 3.0 m and 4.0 m away from the base of bamboo have been collected whereas for banana similar data have been recorded at 1.0 m, 2.0 m, 3.0 m and 4.0 m distance from the base of bamboo.

Data generated with regards to growth and yield of *B. balcooa*, intercrops and soil parameters were compiled and statistically analysed under randomized block design (Gomez & Gomez, 1984).

Initial soil samples during 2016 were collected from

Table-1 : Growth performance of *B. balcooa*.

Treatments	Clump height (m)	Clump diam. (m)	New culms (no.)	Total culms (no.)	Length of 3 rd Internode (cm)	Diam. of 3 rd internode (mm)	Canopy dia. (m)
Bamboo (Sole)	8.9	0.7	3.5	9.1	20.5	20.1	6.8
Bamboo + Pineapple	9.2	0.6	2.8	8.6	18.7	19.6	6.7
Bamboo + Banana	13.2	0.9	3.6	9.6	18.8	23.2	5.9
Bamboo + Turmeric	8.5	0.9	3.0	9.2	18.3	22.1	5.5

Table-2 : Effect of *B. balcooa* on growth and yield of pineapple.

Distance from bamboo (m)	Plant height (m)	Canopy spread (m)	Leaves per plant (no.)	Fruit length (cm)	Fruit girth (cm)	Fruit yield (cm)	Plant weight (kg)	Fruit yield (t/ha)	Plant yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
0.5	1.1	1.0	32.0	15.5	33.1	0.9	5.1	30.19	322.6	332.2	2.8
1.0	1.1	0.8	30.5	17.3	29.2	1.2	5.0	42.75	263.0	271.0	2.9
2.0	1.3	0.8	32.2	16.4	35.2	1.3	3.8	53.12	405.1	414.7	2.3
3.0	1.2	1.0	33.0	15.2	30.1	1.5	3.8	64.97	300.0	308.6	2.7
4.0	1.1	1.0	32.9	17.3	35.5	1.8	4.3	75.37	336.6	347.2	3.0
S. Ed.	0.11	0.15	1.83	0.68	1.81	0.17	0.40	2.24	7.47	18.94	0.32
C. D. (5%)	NS	0.33	NS	1.48	3.95	0.36	0.87	4.52	16.28	41.29	NS

Table-3 : Effect of *B. balcooa* on growth and yield of banana.

Distance from bamboo (m)	Plant height (m)	Suckers per plant (m)	Leaves per plant (no.)	Plant girth (cm)	Hands per bunch (no)	Fingers per hand (no)	Fruit length (cm)	Fruit girth (cm)	Hand weight (kg)	Fruit yield per plant (kg)	Total fruit yield (t/ha)	Plant weight (kg)	Total plant weight (t/ha)	Biological yield (t/ha)	Harvest Index (%)
1.0	3.23	3.03	12.0	49.2	8.05	17.2	13.2	11.7	2.70	12.4	8.47	42.6	340.8	349.2	2.42
2.0	3.14	3.30	5.6	38.6	8.25	15.3	13.5	11.2	2.85	11.1	10.72	45.2	361.6	372.3	2.88
3.0	3.00	3.40	5.6	55.3	7.20	18.2	14.0	11.0	3.20	13.2	14.85	45.3	362.4	377.2	3.93
4.0	3.45	3.63	10.1	62.0	8.55	19.0	14.5	12.0	3.55	13.5	15.08	46.6	372.8	387.8	3.88
S. Ed.	0.25	0.12	.088	3.30	0.58	0.95	1.0	1.07	0.18	0.53	0.24	2.12	6.01	16.25	0.08
CD (5%)	.054	0.26	1.92	7.18	NS	NS	NS	2.33	.39	1.15	0.51	NS	13.1	NS	0.17

Table-4 : Effect of *B. balcooa* on growth and yield of turmeric.

Distance from bamboo (m)	Plant height (m)	Leaves per plant (no.)	Rhizome yield (kg/plant)	Plant weight (kg)	Total rhizome yield (t/ha)	Total plant yield (t/ha)	Total biological yield (t/ha)	Harvest Index (%)
0.5	0.98	6.3	1.2	0.2	10.12	49.54	59.66	16.9
1.0	1.11	7.3	2.0	0.2	11.78	56.83	68.61	17.1
2.0	1.01	9.9	2.3	0.3	12.69	72.03	84.72	14.9
3.0	1.05	11.6	2.4	0.4	13.05	75.53	88.58	14.7
4.0	1.30	12.0	2.4	0.4	14.86	76.50	91.36	16.2
S. Ed.	0.04	0.61	0.21	0.03	0.79	2.52	3.87	0.66
C. D. (5%)	0.09	1.34	0.46	0.06	1.66	5.49	9.43	1.44

the depth of 0-30 cm and analyzed adopting routine procedures. During 2019 soil samples were collected from the experimental plots for final estimation.

Results and Discussion

Growth parameters of *B. balcooa* in agroforestry system after three years are presented in Table 1. Maximum plant height (13.2 m) and clump spread (0.9 m) of *B. balcooa* was recorded in the intercrop plot with banana while average culms (9.6 nos.) was the highest in bamboo intercropped with banana in 3 years after plantation. Length and diameter of third internode of bamboo was 18.8 cm and 23.2 mm in the intercrop plot with banana. Canopy diameter of bamboo was the highest (6.7 m) in the intercrop plot with pineapple. Maximum number of

new culms (3.6) of bamboo in the third year was observed in the system with banana.

Pineapple as intercrop with *B. balcooa* registered maximum fruit yield of 75.37 t/ha at 4.0 m away from the base of *B. balcooa* clump (Table 2) in comparison with 3.0, 2.0, 1.0 and 0.5 m. which was decreased gradually to the base of bamboo. Most of the growth parameters and fruit characters studied was in conformity with the yield variation. This might be due to the competition between bamboo and intercrop.

Banana as intercrop in *B. balcooa* registered maximum plant height of 3.45 m and recorded 15.05 t/ha as maximum fruit yield after three years of plantation (Table 3). Statistical analysis showed that fruit yield of banana was significantly higher (15.05 t/ha) in 4.0 m away

Table-5 : Status of soil OM as affected by *B. balcooa* (0-30 cm).

Distance from bamboo (m)	Initial (%)	Final (%)	Increase over initial (%)	Increase over sole bamboo (%)
Bamboo (Sole)	1.32	1.62	22.72	-
Bamboo + pineapple	1.35	1.68	24.44	3.70
Bamboo + banana	1.27	1.72	35.43	6.17
Bamboo + turmeric	1.30	1.78	36.92	9.88
Pineapple (Sole)	1.25	1.62	29.60	-
Banana (Sole)	1.33	1.68	26.31	-
Turmeric (Sole)	1.28	1.75	36.71	-
S. Ed.	0.04	0.059	-	-
CD (5%)	NS	0.12	-	-

Table-6 : Status of available N as affected by *B. balcooa* (0-30 cm).

Distance from bamboo (m)	Initial (kg/ha)	Final (kg/ha)	Increase over initial (%)	Increase over sole bamboo (%)
Bamboo (Sole)	252.7	270.2	6.92	-
Bamboo + pineapple	246.3	292.6	18.79	8.29
Bamboo + banana	245.9	286.4	16.47	6.00
Bamboo + turmeric	240.3	292.4	21.68	8.21
Pineapple (Sole)	243.5	285.1	17.08	-
Banana (Sole)	245.3	290.4	18.38	-
Turmeric (Sole)	255.7	300.5	17.52	-
S. Ed.	4.38	4.42	-	-
CD (5%)	NS	9.63	-	-

Table-7 : Status of available P_2O_5 as affected by *B. balcooa* (0-30 cm).

Distance from bamboo (m)	Initial (kg/ha)	Final (kg/ha)	Increase/Decrease over initial (%)	Increase over sole bamboo (%)
Bamboo (Sole)	32.7	25.4	(-) 27.73	-
Bamboo + pineapple	28.9	32.4	12.11	27.55
Bamboo + banana	27.2	31.4	15.44	23.62
Bamboo + turmeric	30.5	35.6	16.72	40.15
Pineapple (Sole)	30.9	35.4	14.56	-
Banana (Sole)	31.7	33.6	5.99	-
Turmeric (Sole)	33.0	39.2	18.78	-
S. Ed.	2.90	3.11	-	-
CD (5%)	NS	6.79	-	-

Table-8 : Status of available K_2O as affected by *B. balcooa* (0-30 cm).

Treatment	Initial (kg/ha)	Final (kg/ha)	Increase over initial (%)	Increase/Decrease over sole bamboo (%)
Bamboo (Sole)	132.6	142.7	7.61	
Bamboo + pineapple	126.7	140.6	10.97	(-) 1.47
Bamboo + banana	130.4	144.5	10.81	1.26
Bamboo + turmeric	129.5	150.2	15.98	5.25
Pineapple (Sole)	135.3	143.6	6.13	-
Banana (Sole)	134.5	150.2	11.67	-
Turmeric (Sole)	132.9	165.9	24.83	-
S. Ed.	3.86	4.79	-	-
CD (5%)	NS	10.43	-	-

from the base of bamboo clump in comparison to 2.0 m and 1.0 m whereas it was at par with 3.0 m (14.85 t/ha). This was 77.7 per cent increase of banana yield in comparison to 1 m distance from the base of bamboo. The yield reduction of banana nearer to the bamboo clump might be due to competition between main crop and intercrop.

Turmeric as intercrop yielded 14.86 t/ha at 4.0 m away from the base of *B. balcooa* (Table 4). This was significantly superior to all other treatments. However, no statistical difference was observed in yield of turmeric at 1.0 m, 2.0 m and 3.0 m distance from the base bamboo. With the increasing distance from the base of bamboo all

Table-9 : Production economics of bamboo intercrops.

Treatment	Yield of bamboo(nos.) and intercrops (t/ha)				Gross income (Rs.)				Cost of production (Rs.)				Net income (Rs.)	B:C ratio
	1 st yr	2 nd yr	3 rd yr	Total	1 st yr	2 nd yr	3 rd yr	Total	1 st yr	2 nd yr	3 rd yr	Total		
Bamboo (Sole)	-	-	466.7	466.7	-	-	70005	70005	15000	7500	7500	30000	40005	2.33
Bamboo + pineapple	-	-	483.3	483.3	-	-	72,495	117179	15000	-	-	220754	951041	5.30
	-	56.65	53.28	109.93	-	566500	532800	5	126184	39785	39785			
Bamboo + banana	-	-	498.7	498.7	-	-	74805	384105	15000	-	-	162739	221366	2.36
	-	18.65	12.28	30.93	-	186500	122800		73939	36900	36900			
Bamboo + turmeric	-	-	517.9	517.9	-	-	77685	568165	15000	-	-	245874	322291	2.31
	28.57	20.24	12.50	66.31	228560	161920	100000		76958	76958	76958			
Pineapple (Sole)	-	59.07	61.40	120.47	-	590700	614000	120470	157731	49731	49731	257193	947507	4.68
Banana (Sole)	-	18.76	19.96	38.72	-	187600	199600	387200	105627	52714	52714	211055	176145	2.20
Turmeric (Sole)	28.98	27.29	22.09	78.36	231840	218320	176720	626880	102610	102610	102610	307830	319050	2.04

Price of mature bamboo: Rs 150/-per culm, pineapple Rs 10/-per kg, banana Rs 10/- per kg, turmeric Rs 8/- per kg
 Planting material costs: bamboo 60/- per rhizome, pineapple Rs 2.00 per sucker, banana Rs 10/- per sucker, turmeric Rs20/- per kg

the growth and yield parameters of turmeric were recorded higher significantly.

Economic analyses of cumulative data revealed that net return and B:C ratio was higher in intercrops under bamboo in comparison to sole crops (Table 9). Maximum net return (Rs. 951041.00) was recorded in pineapple as intercrop. Among intercrops maximum B:C ratio (5.30) was observed in pineapple followed by banana (2.36).

Soil status of the experimental site has been shown in the Table 5-8. Organic matter and major nutrient build up has been observed due to bamboo plantation and intercrops therein. Singh (2000) reported that bamboo is an efficient conserver of NPK. Maximum increase of organic matter (36.92 per cent) over initial is due to turmeric as an intercrop in bamboo, followed by turmeric as sole crop (36.71 per cent) and banana as intercrop (35.43 per cent). This may be due to high accumulation of biomass of bamboo as well as intercrops especially turmeric.

Maximum increase of available soil N (21.68 per cent) was recorded in turmeric as intercrop followed by pineapple (18.79 per cent) as intercrop and sole banana (18.38 per cent). Build up of soil N during three year may be due to application of fertilizers to the intercrops.

Maximum available P₂O₅ (39.2 kg/ha) was recorded in sole turmeric plot. Maximum increase of available P₂O₅ over initial status was found in sole turmeric (18.78 per cent) followed by turmeric (16.72 per cent) and banana (15.44 per cent) as intercrops in bamboo. In sole bamboo plot the decrease of available P₂O₅ might be due to utilization of inherent available P₂O₅ by bamboo clump and non addition of fertilizer.

After three year experimentation, maximum available K₂O (165.9 kg/ha) was recorded in sole turmeric plot which was significantly higher over all other treatments. Maximum increase of available K₂O (24.83 per cent) over initial status was observed in sole turmeric followed by turmeric as intercrop (15.98 per cent). This may be due to high accumulation of biomass and their rapid decomposition.

Conclusions

Marketable yield of bamboo (B. balcooa) has been obtained during third year after plantation. Pineapple, banana and turmeric as intercrop can be grown successfully upto three years after plantation of bamboo. However, yield of intercrops decreased gradually with the increase of canopy of bamboo. Among the intercrops pineapple is the most profitable crop. Build up of major nutrients and organic matter has been observed due to bamboo plantation and intercrops therein.

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Adoption Behaviour of White Grub Management Practices by Sugarcane Growers in Western Maharashtra

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Abstract

The extension research was conducted in college development block of Agriculture College, Kolhapur in the year 2015. From this study it was indicated that majority of respondents were aware of all technologies recommended by MPKV, Rahuri with respect to white grub management. More than 80 per cent of respondents were adopted cultural measures like deep ploughing and avoiding late plantation of sugarcane. Very few respondents were adopted seed treatments with insecticides and biological measures due to the facing constraints like lack of technical knowledge regarding white grub management, high prices of chemical insecticides and unavailability of insect pathogenic fungi *Metarhizium* in adequate quantities for effective white grub management. Moreover the respondents suggested for the need of *Metarhizium* to be made easily available on subsidized rates, need of technical knowledge regarding white grub management, Sugar factories, Government to take initiative to provide for insecticides on subsidized rates.

Key words : sugarcane, white grub, knowledge and adoption.

Introduction

Sugarcane is one of the major cash crops of the state and considered as economic backbone of rural Maharashtra and Kolhapur is the major sugarcane growing district from Western Maharashtra. More than 200 species of insects and a few species of non-insect pests have been recorded on sugarcane and a dozen of them, including stem borers, sap feeders and defoliators, and subterranean pests such as root borer, white grubs, termites and rats assume major pest status in a given geographical area (Srikanth et al. 2012). Among them white grubs, borer pests, sap feeding pests and rodents cause damage to sugarcane commonly in Maharashtra. A decade ago sugarcane crop suffered with heavy infestation of White wooly aphid and in recent years growing infestation of White grub is observed in this crop. White grub has become the serious pest of the area in banks of Kumbhi-Kasari, Panchganga, Warana, Tulashi rivers of Kolhapur district.

The subterranean White Grub has potential to cause 80-100 % damage to sugarcane crop. The yield loss due to white grubs was reported to be as high as 100 percent in Tamil Nadu (Thamarai Selvi et al, 2010). Thus, there is ample scope for improvement of cane and sugar productivity in this state. Several techniques have been adopted for the management of white grubs including cultural, mechanical, biological, chemical and integrated methods suggested by various workers (Sahayaraj and Borgio, 2009; Srikanth and Singaravelu, 2011). Integrated pest management (IPM) is a systematic approach to crop protection that uses increased information and improved

decision-making paradigms to reduce purchased inputs and improve economic, social, and environmental conditions on the farm and in society. Moreover, the concept emphasizes the integration of pest suppression technologies that include biological, chemical, legal, and cultural controls (Allen and Rajotte, 1990). Rajula Shanthy et al. (2019) reported that adopting IPM practices facilitated to get more yield and thereby increase in net profit. It is therefore necessary to know the extent of knowledge, adoption and constraints faced by sugarcane growers regarding integrated white grub management practices in the area.

Materials and Methods

The study was conducted in Hatkanangle, Bhudharghar and Radhanagari tahsils of College Development Block of College of Agriculture, Kolhapur during the year 2015. Ten villages from these tahsils and 10 farmers from each village were selected randomly. Thus in all 100 farmers were selected randomly. The farmers were interviewed with the help of structured interview schedule personally. The Knowledge and Adoption of White Grub management practices followed by farmers were studied. The constraints in adoption of these practices and suggestions of farmers were derived. The Ex-post facto design was used. The data was tabulated and processed through the primary and secondary tables. The statistical tools like frequency, percentages, and means of the averages was used for interpreting the data and inferences are drawn.

Results and Discussion

Knowledge : The data regarding the knowledge of

Table-1 : Distribution of respondents according to their extent of knowledge.

Sr. No.	Technologies	Knowledge (n=100)	
		No. of respondents	Per cent
(A)	Cultural measures		
i.	Deep Ploughing (Early Morning or Evening hours)	100	100.00
ii.	Avoid ratoon crop in infested field	98	98.00
iii.	Crop rotation with sunflower/ paddy transplanted	97	97.00
iv.	Through cultivation with Rotavator in the month of April, May or June	100	100.00
v.	Avoiding late plantation	100	100.00
vi.	Host plants of White grub adults:Neem Babhul, Ber	95	95.00
vii.	Collection of white grub adults and destruction using Kerosine+ Water	96	96.00
(B)	Chemical Measures		
(a)	White Grub Infested fields		
	Furrow application of one of following recommended insecticides		
	Fipronil 0.3 GR @ 20 kg /ha or	58	58.00
	Phorate 10 G @25 kg /ha or	100	100.00
	Carbofuran 3G@ 30kg /ha or	74	74.00
	Methyl Parathion 2% @ 25 kg/ha	80	80.00
	Furrow applin. mixed with Chemical fertilizer and light Irrigation	100	100.00
(b)	Drenching of one of the following recommended insecticide at sugarcane Stool/Clump		
	Use of Padegaon crow bar after second earthling up for application of fertilizers and Insecticides together	73	73.00
	First application at one side of ridge at 1ft distance 15-20 cm deep holes	74	74.00
	Second application on other side after 45 days	30	30.00
	i. . Flubendamide 480 SC, @ 200 ml. /100 lit. Water or	64	64.00
	ii. Fipronil 5 SC. @200 ml/100 lit. Water	63	63.00
	iii. Clothynidin 50 WDG, @ 250gm/ 100 lit water or	64	64.00
	iv.. Thiomethoxam 25 WG,@ 250 gm/100 lit. water or	64	64.00
	v. Emidachloprid1200 S.L., @ 250 ml./100 lit. water or	71	71.00
	vi. Chloropyriphos 20 EC.@ 400 ml./100 lit water or	95	95.00
	vii. Emidachloprid 40 EC + Fipronil 40EC 80 WG@ 45gm/100 lit.	42	42.00
(c)	Seed Treatment		
	Dipping sets in one of following recommended insecticides for ten minutes @10 lit water		
i.	Emidachloprid17 S.L., 5 ml. or	65	65.00
ii	Thiomethoxam 25 WG, 5 gm or	61	61.00
iii.	Malthion 35 EC., 20 ml. or	81	81.00
iv.	Clothynidin 50 WDG, 5gm or	55	55.00
v.	. Rinaxapire 20 SC., 4 ml or	58	58.00
vi	Flubendamide 480 SC, 5 ml. or	52	52.00
vii.	Mythyl dematon 25 EC, 20ml. or	66	66.00
viii	Chloropyriphos 20 EC. 20 ml.	92	92.00
(C)	Biological Measures		
i.	Soil application crushed Neem cake 2 MT/ ha	93	93.00
ii.	Insect pathogenic fungi <i>Metarhizium anisopliae</i> and <i>Beauveria Basiana</i>	81	81.00
iii.	Soil Application of fungi @ 25 kg / ha incubated in FYM for 3-4 days	78	78.00
iv.	Drenching of <i>Metarhizium</i> fungi @ 50gm/10 lit water	79	79.00
v.	Use of Padegaon Crow bar for Drenching	78	78.00

farmers various white grub Management practices is presented in Table 1 indicates that almost all the respondents were having complete knowledge about cultural practices like deep ploughing in early morning or evening hours, avoiding ratoon crop in infested fields, avoiding late planting and through cultivation with rotavator. Ninety five percent of the farmers had

knowledge about host plants of white grub adults i.e. *Neem*, *babhul* and *Ber* and their destruction method. In respect to chemical measures, all the farmers having knowledge about furrow application of Phorate granules @ 25 kg/ha mixed with FYM or chemical fertilizers and seed treatments for effective white grub management majority (92.00 per cent) of respondents with

Table-2 : Distribution of respondents according to their Adoption.

Sr. No.	Technologies	Adoption (n=100)		
		Complete	Partial	No
(A)	Cultural Measures			
	Deep Ploughing (Early Morning or Evening hrs)	100(100.00)	00	00
	Avoid ratoon crop in infested field	27(27.00)	11(11.00)	62(62.00)
	Crop rotation with sunflower / paddy transplanted	18(18.00)	00	82(82.00)
	Through cultivation with Rotavater in the month of April, May or June	55(55.00)	00	45(45.00)
	Avoiding late plantation	82(82.00)	00	18(18.00)
	Collection of white grub adults from host plants and destruction using Kerosine+ Water	17(17.00)	00	83(83.00)
(B)	Chemical measures			
(a)	White Grub Infested fields			
	Furrow application of one of the following recommended insecticide			
	Fipronil 0.3 GR @ 20 kg /ha or	27(27.00)	03(03.00)	70(70.00)
	Phorate 10 G @25 kg /ha or	22(22.00)	68(68.00)	10(10.00)
	Carbofuran 3G@ 30kg /ha or	08(08.00)	04(04.00)	88(88.00)
	Methyl Parathion 2% @ 25 kg/ha	04(04.00)	16(16.00)	80(80.00)
	Application by mixing with FYM/ Chemical fertilizer and light Irrigation	74(74.00)	17(17.00)	09(09.00)
(b)	Seed Treatment			
	Dipping sets in insecticides for ten minutes in one of the following recommended insecticides @ 10 lit water			
	Emidachloprid 17 S.L., 5 ml. or	05(05.00)	00	95(95.00)
	Thiomethoxam 25 WG, 5 gm or	02(02.00)	00	98(98.00)
	Malthion 35 EC., 20 ml. or	26(26.00)	00	74(74.00)
	Clothynidin 50 WDG, 5gm or	01(01.00)	00	99(99.00)
	Rinaxapire 20 SC., 4 ml or	01(01.00)	00	99(99.00)
	Flubendamide 480 SC, 5 ml. or	00	00	100(100.00)
	Mythyl dematon 25 EC, 20ml. or	16(16.00)	00	84(84.00)
	Chloropyriphos 20 EC. 20 ml.	49(49.00)	00	51(51.00)
(C)	Biological Measures			
	Soil application crushed Neem cake 2 MT/ ha	04(04.00)	47(47.00)	49(49.00)
	Soil Application of <i>Metarhizium anisopliae</i> fungi @ 25 kg / ha incubated in FYM for 3-4 days	05(05.00)	38(38.00)	57(57.00)

*Figures in parenthesis indicate percentages.

Chloropyriphos. Regarding biological measures of white grub management 93.00 per cent of farmers had knowledge about soil application of crushed Neem cake. Seventy Nine per cent of respondents had knowledge about drenching of insect pathogenic fungi *Metarhizium Anisopliae* and 78.00 per cent had knowledge about soil application of fungi @ 25 kg/ha incubated for 3-4 days in FYM for control of white grub. Rajula Shanthi *et al.* (2019) also reported that around 65.0% of the respondents were not having much knowledge about biological measures.

Adoption : The table-2 regarding adoption behavior of respondents indicates almost all the farmers adopted the cultural measures like deep ploughing to that only 55.00 per cent of farmers cultivated their land thoroughly with rotavator. Among the chemical measures, majority of respondents (74.00 per cent) used furrow application of reported insecticides in table-2 by mixing with FYM/ Chemical fertilizer and seed treatment with chloropyriphos was used by 49 per cent of farmers followed by 26.00 percent of farmers using Malathion for

seed treatment. In respect to biological measures, it is strange that very few respondents adopted this concept mentioned in table-2

Constraints : It is revealed from Table-3 that almost all the respondents faced the constraints like Lack of Technical knowledge regarding white grub management, high prices of chemical insecticides and unavailability of insect pathogenic fungi *Metarhizium* in adequate quantities for effective white grub management. Ahmed *et al.* (2016) revealed that non-availability of labours during peak period ranked as prime constraint in Assam. Availability of plant protection chemicals in the market is not at all a constraint to the respondents. Rajula Shanthi *et al.* (2019) in his study mentioned that due to the advancement in scientific approach towards agriculture, many new technologies are available for adoption. It is not the dearth of technology that haunts Indian agriculture today, but the non-availability of adequate knowledge about the technologies to the indented clients.

Table-3 : Distribution of respondents according to their constraints faced by them.

Sl.	Particulars	Frequency (n = 100)	Percent
1.	Lack of Technical knowledge regarding white grub management	78	78.00
2.	High prices of chemical insecticides	84	84.00
3.	Unavailability of insect pathogenic fungi <i>Metarhizium</i> in adequate quantities	90	90.00
4.	Lack of effective control measures on White grub	95	95.00

Table-4 : Distribution of farmers according to suggestions made by them.

Sl.	Particulars	Frequency (n = 100)	Per cent
1.	Needs technical knowledge regarding white grub management	95	95.00
2.	<i>Metarhizium</i> should be made easily available in adequate quantities on subsidized rates	100	100.00
3.	Need of effective insecticides for white grub control.	100	100.00
4.	Sugar factories, Government should take initiative to provide insecticides on subsidized rates.	100	100.00

Suggestions

All the respondents suggested for the need of *Metarhizium* to be made easily available on subsidized rates, need of technical knowledge regarding white grub management, Sugar factories, Government to take initiative to provide for insecticides on subsidized rates and effective control measure on white grub.

Conclusions

Majority of the respondents had knowledge about cultural practices, chemical measures and biological measures but adoption behavior was less be due to the lack of technical knowledge regarding white grub management, high prices of chemical insecticides and unavailability of insect pathogenic fungi *Metarhizium* in adequate quantities for effective white grub management. All the farmers suggested for the need of *Metarhizium* to be made easily available on subsidized rates, need of technical knowledge regarding white grub management, Sugar actories, Government to take initiative to provide for insecticides on subsidized rates.

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Rhizospheric Microbial Diversity Associated with Different Agricultural Land Use

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Abstract

We tested the hypothesis that crops and land use changes alter soil microbial community composition and biomass. The aim of our experiment was to study the below ground microbial diversity in different agricultural land use patterns like field crops, mono and multi varietal mango orchards, and pristine forest soils of Chittoor district of Andhra Pradesh. The results showed that culturable microbial populations varied with crops and land use systems. The forest soils had the highest total Bacterial (7.8×10^6 CFU/ g soil) and Actinobacterial (15.0×10^4 CFU / g soil) population whereas highest Fungal population (4.20×10^4 CFU / g soil) was observed in field crop Jowar (*Sorghum bicolor*). The maximum population of beneficial microorganisms like Nitrogen fixers (8.5×10^4 cfu/ g soil), Phosphate solubilizers (1.85×10^4 CFU / g soil) and Zn solubilizers (ZnCO_3) (37.0×10^4 CFU / g soil) were found in multi varietal mango orchards dominated by variety Totapuri. Soil enzyme activities were also observed highest under multivarietal orchards and showed differences with varietal dominance. Highest Shannon index value for culturable microbial diversity was recorded in multi varietal mango orchard dominated by Naati variety (0.060).

Key words : Mango, soil enzymes, culturable microbial diversity, chittoor

Introduction

Chittoor district in Andhra Pradesh, India is one of the main mango growing belts in South India under semi-arid monsoonic climate with distinct summer, winter and rainy season. Since from decades farming system in this area were growing water intensive crops like Sugarcane, Paddy and Ragi (irrigated) but later due to decrease in water table slowly shifted towards less water intake crop like mango with multiple varieties within the orchards. The multi-varietal orchard is a locally innovated system for mango, widely practiced in this district. However, in the later part with establishment of processing units in the district there has been a shift from multi-varietal orchards to monocropped orchards.

A multi-varietal orchard is defined as an orchard that includes more than the average number of varieties in that area. Thus, in a system of mango orchards with an average richness of 4.7, more than four varieties are grown. Moreover, a multi-varietal orchard often includes few traditional varieties such as Naati, Imampasand, Atimadhuram and Lalbaba that flower profusely over an extended period from November to March and improve the fruit setting of the commercial varieties, robustness against adverse weather conditions (dry monsoon, unexpected heat or sudden rains during flowering) and also resistance against pests or diseases (Mango hopper, Anthracnose) apart from wider scope for marketing over an extended period and choice of varieties. This practice is said to improve yields by 10% to 25%. Thus the aboveground plant diversity of mango orchards in

Chittoor district is very well established. Such changes in land use from agriculture to multiple variety orchards to monocropped orchards has led to changes in the soil microbial diversity within these systems. However, the effect of agricultural land use change on soil microbial community composition and biomass remains a widely debated topic. Lauber *et al.* (2008) showed that land use, edaphic properties, soil pH and nutrient availabilities influence the bacterial and fungal community structures and diversity in soil. In addition, soil microorganisms, form symbiotic relationships with plants to help improve aboveground plant production (Ferguson and Mathesius, 2003) and management systems. Measurement of soil biodiversity is an important indicator of healthy soil, with greater the species diversity indicates a healthy environment. The microbial diversity and population data can help us identify effects of such a shift from multi varietal mango orchard practices to monocropped orchards on hosting desirable microbial life to enhance a seemingly “good-quality” soil (Delgado-Baquerizo *et al.* 2016). Therefore assessment of microbial diversity under such changed land uses helps us in understanding their contribution to soil health. Such information is completely lacking. We assessed the culturable microbial diversity from different agricultural land uses like field crop, mono varietal and multi- varietal mango orchards and from pristine forest soil.

Materials and Methods

Selection of orchards : Based on the diversity of mango varieties 10 farmer's orchards were selected consisting of

Table-1 : Details of the multi and mono varietal mango orchards selected for studies in Chittoor District.

S. No.	Mandal	Area (ha)	Variety
Multiple variety mango orchards			
1.	Puthalapattu	18	Totapuri, Kadhar, Pulura, Bernisha, Malgova, Rumani, Neelam, Dilipasand, Kalepadu, Himamipasand and Naati varieties
2.	Puthalapattu	10	Imampasand, Kadhar, Pulura, Bernisha, Malgova, Rumani, Neelam, Reddypasand, Kalepadu, Gadhamar and 3 Naati varieties
3..	Puthalapattu	15	Kadhar, Pulura, Bernisha, Malgova, Rumani, Neelam, Dilipasand, , Kalepadu, Rajapasand, Gadiyaram, Mallika, Royalpasand
4.	Puthalapattu	4	Bernisha, Chekeraguttulu, Malgova, Rumani, Kalepadu, Pulura,
5.	Bangarupalyam	25	Lalbaba, , Pulura, Dilipasand, Kudadath, Mittagiri, Athimaduram, Malgova, Rumani, Kalepadu, Gadhamar
6.	Puthalapattu	15	Neelam, Pulura, Bernisha, Malgova, Rumani, Dilipasand, , Kalepadu, Rajapasand, Gadiyaram, Mallika, Royalpasand
7.	Puthalapattu	4	Naati varieties, Rumani, Kalepadu, Bernisha
Monocropped mango orchards			
1.	Puthalapattu	2	Thotapuri
2.	Bangarupalyam	4	Thotapuri
3.	Puthalapattu	6	Thotapuri

7 multiple variety and 3 monocropped orchards for the study purpose. The orchard size varied from 4 ha. to 30 ha. The multiple variety orchards contained minimum 4 varieties and maximum 19 varieties. Three Totapuri orchards were selected for monocropped orchards. The details of the orchards selected for the study are presented in Table 1. Since the area under each farmer and under each type varied, we earmarked uniformly 2 ha. area under each category for sampling based on tree uniformity and even distribution of varieties.

Site and soil samples : Seven soil samples (0-15 cm) were collected from farmer's orchard under multivarietal mango (one composite sample in each orchards with a dominance of variety-Totapuri, Imampasand, Khadar, Benishan, lalbaba, Neelum, Naati), one composite sample each under mono varietal mango orchard (Totapuri), from adjacent field crop (Jowar) and from Pristine soil (an adjacent forest site) samples for comparison. The fresh soil samples were analysed for microbiological parameters and diversity studies, further samples were air dried and analyzed for physico chemical properties. The soil samples were analysed for pH, organic C, available N, P and K, and free CaCO₃ following methods described by Page et al. 1983. In the field at the time of sampling soil moisture was estimated by gravimetric method and the bulk density by the core sampling. All determinations were performed in triplicate, and the results expressed on the basis of oven-dried weight.

Culturable microbial populations and diversity indices : The soil samples were serially diluted in ten- fold and plated on Nutrient agar (NA), Martein Rose Bengal agar (MRBA), Kusters agar (KA) for the enumeration of total bacteria, fungi and Actinobacteria. Phosphate

solubilizers were enumerated using Pikovskaya's medium, nitrogen fixers on Jensen's medium, Zinc solubilizers on mineral salts medium supplemented with insoluble zinc sources (zinc phosphate, zinc sulphate and zinc carbonate at 1%). The culturable microbial diversity index was calculated using Simpson's and Shannon index and proportional abundance was calculated based on total bacteria, fungi and Actinobacteria present in soil samples.

Soil enzyme activities : The dehydrogenase activity(DHA) of the soil samples was determined by following the triphenyl tetrazolium reduction test (Casida *et al.* 1964). Phosphatase activity of soil samples was determined by following the procedure of Tabatabai and Bremner (1969).

Diversity indices

Simpson index :

$$1 \sum_{i=1}^n P_i^2$$

$P_i = n_i/N$, where n_i = number of individuals of i^{th} species, N = total number of individuals aggregating all the species.

The Shannon and Weaver diversity index

$$H' = - \sum (P_i \ln P_i)$$

P_i = Fraction of individuals belonging to i^{th} species (Pielou 1969; Saeki et al. 2008).

Evenness (E) is a measure of proportion of individuals among species $E = H/H_{max}$

Where, E = Evenness, H = diversity, H_{max} = maximum diversity possible

Statistical analyses : All the parameters were

Table-2 : General and beneficial microbial populations in multi and mono varietal mango orchards, field crop and pristine soil samples.

Land use	Sample no.	Bacteria cfuX10 ⁶ /g dry soil	Fungi cfuX10 ⁴ /g dry soil	Actinobacteria cfuX10 ⁴ /g dry soil	Free-N Fixers cfuX10 ⁴ /g dry soil	P-Solubilizers cfuX10 ⁵ /g dry soil	Zinc Solubilizers cfuX10 ⁴ /g dry soil		
							ZnPO ₄	ZnSO ₄	ZnCO ₃
Multi varietal mango orchards	S1	2.80 ^f	1.80 ^d	4.83 ^{cd}	8.50 ^a	1.85 ^a	5.50 ^c	2.50 ^b	37.00 ^a
	S2	6.50 ^b	2.60 ^c	8.50 ^b	4.00 ^b	0.75 ^c	11.00 ^b	2.00 ^b	35.50 ^a
	S3	4.50 ^c	3.50 ^b	5.00 ^{cd}	1.50 ^c	0.45 ^d	11.00 ^b	0.00 ^c	6.00 ^d
	S4	4.60 ^c	1.60 ^d	8.50 ^b	4.83 ^b	1.10 ^b	14.50 ^a	5.00 ^a	15.50 ^b
	S5	2.50 ^g	2.60 ^c	1.50 ^{ef}	1.33 ^c	0.10 ^e	9.00 ^b	1.50 ^{bc}	5.50 ^{de}
	S6	3.70 ^d	0.50 ^e	4.00 ^{de}	1.33 ^c	0.10 ^e	0.50 ^d	0.00 ^c	1.00 ^f
	S7	3.30 ^e	3.20 ^b	4.83 ^{cd}	4.00 ^b	0.48 ^d	13.50 ^a	1.50 ^{bc}	13.50 ^c
	Mean	4.17	2.4	5.30	3.64	0.69	9.28	1.78	16.28
Monovarietal mango orchard	S8	2.60 ^{fg}	0.40 ^e	7.00 ^{bc}	3.40 ^b	0.44 ^e	7.22 ^d	0.64 ^c	7.53 ^f
Field crop (Sorghum)	S9	3.60 ^d	4.20 ^a	0.50 ^f	2.83 ^b	0.17 ^e	9.00 ^b	2.00 ^b	4.00 ^e
Pristine	S10	7.80 ^a	4.10 ^a	15.00 ^a	3.80 ^{bc}	0.86 ^e	9.50 ^b	1.50 ^{bc}	18.15 ^f
	LSD at 1%	2.32	3.81	2.64	2.39	2.03	2.11	1.60	1.94

* S1 (Totapuri, Kadhar, Pulura, Bernisha, Malgova, Ruman, Neelam, Dilipasand, Kalepadu, Himamipasand and Naati varieties with Totapuri as dominant variety); S2 (Imampasand, Kadhar, Pulura, Bernisha, Malgova, Ruman, Neelam, Reddypasand, Kalepadu, Gadhamar and 3 Naati varieties with Imampasand as dominant variety); S3 (Kadhar, Pulura, Bernisha, Malgova, Ruman, Neelam, Dilipasand, Kalepadu, Rajapasand, Gadiyaram, Mallika, Royapasand varieties with Khadar as dominant variety); S4 (Bernisha, Chekeraguttulu, Malgova, Ruman, Kalepadu, Pulura varieties with Banshan as dominant variety); S5 (Lalbaba, , Pulura, Dilipasand, Kudadath, Mittagiri, Athimaduram, Malgova, Ruman, Kalepadu, Gadhamar varieties with Lalbaba as dominant variety); S6 (Neelam, Pulura, Bernisha, Malgova, Ruman, Dilipasand, Kalepadu, Rajapasand, Gadiyaram, Mallika, Royapasand varieties with Neelam as dominant variety); S7 (Naati varieties, Ruman, Kalepadu, Bernisha varieties with Naati as dominant variety); S8 (Only Totapuri); S9 (Jowar); S10 (Forest).

Table-3 : Physical and chemical properties of soil samples.

Variety	pH	Org C (%)	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	CaCO ₃	Moisture %	BD
S1	7.55	0.44	148	9.44	188	4.6	34	1.361
S2	7.52	0.43	144	10.40	182	4.1	35	1.358
S3	7.40	0.42	148	10.72	192	4.8	34	1.366
S4	7.65	0.42	144	10.70	186	4.6	34	1.403
S5	7.54	0.41	151	10.52	176	4.4	34	1.382
S6	7.59	0.42	160	11.21	170	4.7	33	1.388
S7	7.60	0.43	160	10.2	182	4.4	34	1.402
Mean	7.55	0.42	150.71	10.46	182.29	4.51	34	1.38
Monocropped orchards								
S8	7.72	0.41	156	11.08	196	3.9	29	1.411
Agriculture soil								
S9	7.44	0.36	168	14.88	196	4.6	26	1.436
Pristine soil								
S10	7.31	0.48	190	9.27	144	4.4	38	1.289

* S1 (Totapuri, Kadhar, Pulura, Bernisha, Malgova, Ruman, Neelam, Dilipasand, Kalepadu, Himamipasand and Naati varieties with Totapuri as dominant variety); S2 (Imampasand, Kadhar, Pulura, Bernisha, Malgova, Ruman, Neelam, Reddypasand, Kalepadu, Gadhamar and 3 Naati varieties with Imampasand as dominant variety); S3 (Kadhar, Pulura, Bernisha, Malgova, Ruman, Neelam, Dilipasand, Kalepadu, Rajapasand, Gadiyaram, Mallika, Royapasand varieties with Khadar as dominant variety); S4 (Bernisha, Chekeraguttulu, Malgova, Ruman, Kalepadu, Pulura varieties with Banshan as dominant variety); S5 (Lalbaba, , Pulura, Dilipasand, Kudadath, Mittagiri, Athimaduram, Malgova, Ruman, Kalepadu, Gadhamar varieties with Lalbaba as dominant variety); S6 (Neelam, Pulura, Bernisha, Malgova, Ruman, Dilipasand, Kalepadu, Rajapasand, Gadiyaram, Mallika, Royapasand varieties with Neelam as dominant variety); S7 (Naati varieties, Ruman, Kalepadu, Bernisha varieties with Naati as dominant variety); S8 (Only Totapuri); S9 (Jowar); S10 (Forest)

Table-4 : Proportional abundance and microbial diversity indices.

Samples	Proportional abundance			Microbial diversity	
	P _{bacteria}	P _{fungi}	P _{actinomycetes}	Simpson index	Shannon index
S1	0.978	0.006	0.015	0.043	0.051
S2	0.986	0.003	0.010	0.028	0.035
S3	0.981	0.007	0.010	0.036	0.045
S4	0.978	0.003	0.018	0.042	0.049
S5	0.983	0.010	0.005	0.032	0.041
S6	0.988	0.001	0.010	0.023	0.030
S7	0.974	0.012	0.013	0.051	0.060
Mean	0.981	0.006	0.011	0.036	0.044
S8	0.972	0.001	0.025	0.053	0.057
S9	0.991	0.008	0.001	0.017	0.020
S10	0.971	0.006	0.022	0.056	0.063

* S1 (Totapuri, Kadhar, Pulura, Bernisha, Malgova, Rumani, Neelam, Dilipasand, Kalepadu, Himamipasand and Naati varieties with Totapuri as dominant variety); S2 (Imampasand, Kadhar, Pulura, Bernisha, Malgova, Rumani, Neelam, Reddypasand, Kalepadu, Gadhamar and 3 Naati varieties with Imampasand as dominant variety); S3 (Kadhar, Pulura, Bernisha, Malgova, Rumani, Neelam, Dilipasand, Kalepadu, Rajapasand, Gadiyaram, Mallika, Royalpasand varieties with Khadar as dominant variety); S4 (Bernisha, Chekeraguttulu, Malgova, Rumani, Kalepadu, Pulura varieties with Banshan as dominant variety); S5 (Lalbaba, , Pulura, Dilipasand, Kudadath, Mithagiri, Athimaduram, Malgova, Rumani, Kalepadu, Gadhamar varieties with Lalbaba as dominant variety); S6 (Neelam, Pulura, Bernisha, Malgova, Rumani, Dilipasand, , Kalepadu, Rajapasand, Gadiyaram, Mallika, Royalpasand varieties with Neelam as dominant variety); S7 (Naati varieties, Rumani, Kalepadu, Bernisha varieties with Naati as dominant variety); S8 (Only Totapuri); S9 (Jowar); S10 (Forest)

Table-5 : Soil Enzyme activities in Multi and mono varietal mango orchards, field crop and pristine soil samples.

Sample No.	Dehydrogenase (μ g TPF/g/day)	Acid Phosphatase (μ g <i>p</i> -nitrophenol/g of soil/hr)	Alkaline Phosphatase (μ g <i>p</i> -nitrophenol/g of soil/hr)
S1	97.29 ^e	133.12 ^a	162.56 ^b
S2	120.59 ^b	97.58 ^d	152.82 ^c
S3	110.97 ^c	103.24 ^c	162.56 ^b
S4	108.43 ^d	98.71 ^d	134.71 ^e
S5	148.46 ^a	118.41 ^b	139.46 ^d
S6	62.83 ^h	48.00 ^f	112.75 ^f
S7	69.42 ^g	73.35 ^e	175.23 ^a
Mean	102.57	93.201	148.58
S8	88.17 ^f	23.55 ^h	93.96 ^h
S9	62.32 ^h	28.07 ^g	101.65 ^g
S10	14.19 ⁱ	119.77 ^b	39.39 ⁱ
LSD at 1%	2.32	2.32	2.32

* S1 (Totapuri, Kadhar, Pulura, Bernisha, Malgova, Rumani, Neelam, Dilipasand, Kalepadu, Himamipasand and Naati varieties with Totapuri as dominant variety); S2 (Imampasand, Kadhar, Pulura, Bernisha, Malgova, Rumani, Neelam, Reddypasand, Kalepadu, Gadhamar and 3 Naati varieties with Imampasand as dominant variety); S3 (Kadhar, Pulura, Bernisha, Malgova, Rumani, Neelam, Dilipasand, Kalepadu, Rajapasand, Gadiyaram, Mallika, Royalpasand varieties with Khadar as dominant variety); S4 (Bernisha, Chekeraguttulu, Malgova, Rumani, Kalepadu, Pulura varieties with Banshan as dominant variety); S5 (Lalbaba, , Pulura, Dilipasand, Kudadath, Mithagiri, Athimaduram, Malgova, Rumani, Kalepadu, Gadhamar varieties with Lalbaba as dominant variety); S6 (Neelam, Pulura, Bernisha, Malgova, Rumani, Dilipasand, , Kalepadu, Rajapasand, Gadiyaram, Mallika, Royalpasand varieties with Neelam as dominant variety); S7 (Naati varieties, Rumani, Kalepadu, Bernisha varieties with Naati as dominant variety); S8 (Only Totapuri); S9 (Jowar); S10 (Forest).

statistically analyzed using online software developed by IASRI. Duncan's multiple range test (DMRT) was used to compare the treatment means.

Results and Discussion

Culturable microbial populations : Plant and soil are the two main drivers of soil microbial community structures. They exert their function in a complex manner.

Soil microbes are critical to the maintenance of soil function in both natural and managed agricultural soils because of their involvement in such key processes as decomposition of organic matter; cycling of C,N,P,S, formation of soil structure and removal of toxins. Microbes further promote plant growth and support suppression of soil borne diseases. They sometimes aid in changes in vegetation structure of the ecosystem. In this study soil

type was kept constant and the plant type was varied to study the effects on microbial diversity and abundance as a function of plant types and land use. We selected the land use from pristine forest soils on one end and the agriculture system (field crops) on the other side sandwiching multivarietal and monocropped mango orchards. From these land uses we collected soil samples and analyzed for the culturable microbial populations.

Culturable microbial populations varied with the land use systems. Generally the populations of microbes were more in multiple variety orchards than monocropped orchards (Table 2). However, the forest soils had the highest and the agricultural soils the lowest. Within the multiple variety orchards, the highest total bacterial count (6.5×10^6 cfu/ g) was observed in orchards with dominance of variety Imampasnd, fungi (3.20×10^4 cfu/ g) in orchards with dominance of variety Naati. Whereas Actinobacterial (8.5×10^4 cfu/ g) counts were found highest in orchards dominant in Imampasand and Benishan. Forest soils contained higher organic carbon (0.48%) and nitrogen (190 kg/ha) and hence supported more bacteria and actinobacterial populations followed by multiple variety orchards and mono cropped orchards. The least was in agricultural soils (0.36% organic carbon) because of a greater loss of organic carbon under this system (Table 3). Generally Actinobacteria make up 10-15% of the total microbial population in both forest and cultivated soils. In alkaline soils, especially when dry, the relative abundance is spectacularly high. However, in comparison with true bacteria, Actinobacteria are less common in wet than in dry soils. The population is likewise greater in grassland and pastured soil than in cultivated fields (Alexander, 1961).

Similarly highest fungal population was observed in field crop (sorghum) compared to forest soil and mono and multivarietal mango orchards. VIEIRA and NAHAS (2005), also found similar results and reported higher numbers of Fungal colony-forming units (CFU) in sorghum cultivated soils and of spore-forming and gram-negative bacteria, Actinobacteria in forest soils.

The highest populations of beneficial micro-organisms like N fixers were found in forest soils and the least in field crops soil. In mango orchards, the maximum population of N fixers (8.5×10^4 cfu/ g), P solubilizers (1.85×10^4 cfu/ g) and Zn solubilizers (ZnCO_3) (37.0×10^4 cfu/ g) were found in soils of multiple variety mango orchards and particularly in orchards with dominance of Totapuri and Benishan. Whereas in pure stand of Totapuri recorded less number of fungi (0.40×10^4 cfu/ g) and beneficial micro organisms like P and Zn solubilizers (Table 3). It has been reported that the population of microorganisms in the soil and their diversity depend on

both biotic and abiotic factors (Schlegel, 2000; Saadoun and Gha- Raibeh, 2003) and on the rhizo-deposition of nutrients by plant roots that supports increased microbial growth (Kumar, *et al.* 2013). In general multivarietal orchards recorded more microbial populations compared to mono varietal orchards reinforcing the concept that, in the same soil type, different plant species have an effect on the size and composition of the microbial populations. Similar to our results, Gopal and Kurein (2015) found that nutrient solubilising microbes (*Bacillus* sp. and *Streptomyces spp*s) were the most predominant group of micro organisms associated with the horticultural crops like mango.

Proportional abundance and culturable microbial diversity : Relative abundance refers to the per cent composition of an organism to the total number of organisms in the area. When we compare proportional abundance of bacteria, fungi and Actinobacteria as a function of land use we found that bacterial abundance is in the order of field crop > multivarietal mango orchards > mono varietal mango orchards > pristine, where as fungal abundance is in the order of field crop > multivarietal mango orchards > pristine soil > mono varietal mango orchards. Actinobacterial abundance is in the order of Mono varietal mango orchards > pristine soil > multi varietal mango orchards > field crop.

To calculate the diversity indices, it is imperative to ensure that the groups of organisms considered for calculation be discreet, non-overlapping and all inclusive. Among the total culturable bacteria, agriculturally important organisms (AIMs) were also cultured in specific media. Apart from these AIMs, there is a multitude of other organisms under total culturable bacteria that may be agriculturally important but we are not growing, as well as other bacteria which may not be directly important in agriculture. The composition of this remaining unit of total culturable bacteria is difficult to find out and difficult to include into the calculation as a specific unit due to possible complications in interpretation. Hence, for simplification, only total culturable bacteria, total culturable fungi and total culturable Actinobacteria were included in the calculation of diversity indices (Table 4). The highest Shannon index and Simpson's index of culturable microbial diversity was recorded in pristine soil (0.063, 0.053) whereas the lowest value was recorded in field crop (0.020, 0.017). In mango orchards the highest Shannon index value was recorded in multivarietal orchard dominated by Naati variety (0.060), whereas highest Simpson's index value was recorded in mono varietal Totapuri orchard (0.053). Obviously when we consider both the indices, the diversity value of both the indices varied, therefore it is vital to understand the difference between Shannon-Wiener index and

Simpson's index. Both the indices reflect biodiversity. However, Simpson's index is more weighted on the dominant species compared to Shannon-Wiener index. Shannon-Wiener index is a better measure for species richness as well as evenness (Heip *et al.* 1998). So it is seen that mango orchard dominated by Naati variety recorded highest Shannon-Wiener index. This means the multi varietal orchard dominated by Naati variety shows a higher level of species richness, diversity and evenness. This is in accordance with the normal expectations from the study as the Naati is a traditional variety of Chittoor region and it can tolerate against adverse weather conditions like dry monsoon, unexpected heat or sudden rains during flowering and resistance against pests or diseases (mango hopper, anthracnose). So the micro organisms which are present in the rhizosphere of this traditional variety maintained its species richness, diversity and evenness without much alteration to external environment.

Soil enzyme activities : Enzyme activities were also observed highest under multivarietal orchards (Table 5). Dehydrogenase activity was highest in multivarietal orchard dominated by Lalbaba variety (148.46 µg TPF/ g/ day), acid phosphatase in multi varietal orchard dominated by Totapuri (133.12 µg p-nitrophenol/ g of soil/ hr) and alkaline phosphatase in multivarietal orchard dominated by Naati variety (175.23 µg p-nitrophenol/ g of soil/ hr). The higher enzyme activities under multi varietal orchards may be due to the presence of higher population of general and beneficial microbes in multi varietal orchards. Chendrayan *et al.* (1980) correlated microbial population to enzyme activity in soil and found similar results that plant species diversity in ecosystem encourages accumulation of organic material in soil, which in turn increases the general level of microbial activity in soil (Ratnadass *et al.* 2012).

Conclusions

This study demonstrated the variation in microbial community diversity in rhizosphere soil under different land use systems as well as different crops. Forest soil recorded maximum population of total bacteria and Actinobacteria, whereas field crop (Jowar) recorded maximum fungal population. Multi varietal cropping system induce an increase of culturable beneficial microbial population *i.e.*, P and Zn solubilizers, N fixers. Correspondingly the activities of soil enzymes enhanced suggesting a potential relationship between yield increase in multi varietal mango orchards and presence of microbes when compared with their mono varietal mango orchards. Our study highlighted that the mono varietal mango orchards significantly reduced the culturable microbes distribution, further studies are required to know

the role of uncultured rhizosphere microbes and their interaction with crop and land uses.

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Response of Late Sown Wheat (*Triticum aestivum* L.) to Nitrogen Levels Under Different Application Methods

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Abstract

A field experiment was conducted during the rabi season of 2019-20 at Agriculture Research Farm of School of Agriculture Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab to study the response of late sown wheat (*Triticum aestivum* L.) to nitrogen levels under different application methods. The experiment was laid out in a randomized complete block design (RCBD) in three replications. The treatments comprised of two application methods viz. nitrogen applied before irrigation and nitrogen applied after irrigation: and four nitrogen levels viz. control, 100, 125, 150% of recommended dose of nitrogen (RDN). All the growth and yield attributing characters significantly increased in nitrogen applied before irrigation over nitrogen applied after irrigation. The grain yield was significantly higher when nitrogen applied before irrigation (51.11 q/ha) over nitrogen applied after irrigation (42.57 q/ha). Straw yield also followed the same trend but harvest index was not influenced significantly by application methods. The application of 150, 125 and 100% of recommended dose of nitrogen recorded significantly higher growth and yield attributes except ear length over control. The 150% of recommended dose of nitrogen recorded significantly higher grain yield (53.77 q/ha) over 100% (46.31 q/ha) and control (40.0 q/ha) but was par with 125% of recommended dose of nitrogen (43.37 q/ha). Straw yield also followed the same trend but harvest index was not influenced significantly by nitrogen levels. Interaction between application methods and nitrogen levels was found non-significant in all the parameters.

Introduction

Wheat (*Triticum aestivum* L.) has the highest importance among all the crops grown for the grain purpose worldwide. In India wheat alone covers about 25% of the total area covered by cereal crops. Wheat flour mostly, used for making chapati and bread (Singh et al.2007).Wheat is major cereal crop in Punjab. Presently, in Punjab wheat crop occupies 35.20 lakh hectares during 2020-21 with the production of 176.2 lakh tones and average yield of 50.04 quintal per hectares (Anonymous, 2021). There were various factors involved in low production of wheat including application of nitrogen fertilizer in improper amount, edaphic properties, method of sowing, quality of irrigation water, prevailing climate condition and management of field operation by the farmer due to lack of knowledge and awareness. Nitrogen is main component and major constitute of plants for formation of living tissues. It is necessary to apply nitrogen fertilizer in the soil for bumper yield of wheat (Ullah et al. 2018).

Materials and Methods

The experiment was carried out during the rabi season2019-20 at the Agricultural Research Farm, RIMT University, Mandi Gobindgarh, Punjab. The experimental field is located at 30.6642°N latitude and 76.2914°E longitude at an altitude of 268 meters above mean sea level. The site was low in organic carbon (0.38%) and available nitrogen (144.6 kg N ha⁻¹), medium

in available phosphorus (17.3 P₂O₅ ha⁻¹) and potassium (168 kg K₂O ha⁻¹). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of two methods of N application viz. Before irrigation and after irrigation and four nitrogen levels viz. control, 100, 125 and 150% of recommended dose of nitrogen. The seed at the rate of 112.5 kg was used irrespective. The nitrogen in the form of urea (46% N) was applied as per the treatments. The gross plot size was 4.5 m × 3.5 m and net plot size was 4.0 m × 3.0 m. The crop was sown on December 11, 2019 and harvested on May 15, 2020. All the other practices were applied uniformly to the treatments.

Results and Discussion

Growth Parameter : The plant height of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). Among different application methods, the significantly higher plant height was observed when nitrogen was applied before irrigation (92.31 cm) over the nitrogen applied after irrigation (67.22 cm). The nitrogen level of 150% of recommended dose of nitrogen recorded significantly higher plant height (84.71 cm) over 100% of recommended dose of nitrogen (80.86 cm) and control (75.56 cm) but was par with 125% of recommended dose of nitrogen (82.93 cm). The interaction between nitrogen levels and application methods was found to be non-significant. Yousaf, M. (2015) Plant height was significantly affected by different nitrogen levels and irrigation methods maximum plant

Table-1 : Effect of Nitrogen levels and its application methods in wheat (*Triticum aestivum* L.).

Treatments	Plant height (cm)	Ear length (cm)	Test weight	No. of tiller/m row length	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Nitrogen levels (kg N/ha)							
Control	75.56	6.00	31.13	82.11	40.0	75.2	42.40
100	80.86	7.00	32.28	84.12	46.31	80.7	43.06
125	82.93	7.83	33.60	87.11	47.37	86.4	43.53
150	84.71	8.83	36.18	90.66	53.77	92.7	44.80
SEM	2.82	0.51	1.15	2.86	0.235	0.45	0.44
CD 5%	6.11	1.11	2.50	5.93	4.52	10.88	0.677
Methods of application							
Before irrigation	92.31	8.66	37.01	111.8	51.11	89.6	44.33
After irrigation	67.22	6.16	29.58	83.22	42.57	77.7	42.06
CD 5%	4.32	0.78	1.76	5.93	3.2	7.69	0.957
CD for interaction	NS	NS	NS	NS	NS	NS	NS
CV (%)	6.1	11.9	6.0	6.7	7.59	10.8	1.7

height (96.60 cm) was recorded from 150kg N/ha and irrigated 30 days after germination treatments as compare with other treatments. The results of nitrogen doses of 120 kg/ha were applied and irrigated 20 days after germination were statistically at par with those treatments where 150 kg nitrogen was applied and 30 days after germination.

Yield Attributes : The ear length of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). The nitrogen applied before irrigation recorded significantly higher ear length (8.66 cm) over nitrogen applied after irrigation (6.16 cm). The application of 150% of recommended dose of nitrogen (8.83 cm) was significantly higher over 100% of recommended dose of nitrogen (7.00 cm) and control (6.00 cm) but was par with 125% of recommended dose of nitrogen (7.83 cm). The interaction between nitrogen levels and application methods was found non significant. Patel and Upadhyay (1993) observed that the application of 120 kg N ha⁻¹ increased ear length significantly over 90 kg N ha⁻¹ and further increase of nitrogen levels 150 kg N ha⁻¹ did not influence the ear length significantly.

Test weight of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). Among different application methods, the significantly higher test weight was observed where nitrogen was applied before irrigation (37.01 g) over nitrogen applied after irrigation (29.58 g). The application 150% of recommended dose of nitrogen recorded significantly higher test weight (36.18 g) over 100% of recommended dose of nitrogen (32.28 g) and control (31.13 g) but was par with 125% of recommended dose of nitrogen (33.60 g). Non-significant interaction effect was noticed between nitrogen levels and application methods. Parihar and Tripathi (1990) also revealed that test weight increased significantly with increasing nitrogen rates up to 100 kg N/ha and further increase in nitrogen to 150 kg/ha did not show considerable increase in grain weight.

Number of tillers/m row length of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). The significantly higher number of tillers was observed when nitrogen applied before irrigation (111.88) over nitrogen applied after irrigation (83.22). The application of 150% of recommended dose of nitrogen (90.66) recorded significantly higher number of tillers over 100% of recommended dose of nitrogen (84.12) and control treatments (82.11) but was par with 125% of recommended dose of nitrogen (87.11). Non-significant interaction effect was noticed between nitrogen levels and application methods. Yousaf. M. (2015) number of tillers were significantly affected by nitrogen levels and irrigation application. All the treatments receiving nitrogen produced a significantly more total number of tillers/m row length after those treatments where no nitrogen was applied. where nitrogen was applied at the rate of 150 kg/ha and irrigated 20 and 25 days after germination .

Yield Parameter : Grain yield of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). The nitrogen applied before irrigation recorded significantly higher grain yield (51.11 q/ha) over nitrogen applied after irrigation (42.57 q/ha). The magnitude of increase in grain yield was 20.06 percent. The application of 150% of recommended dose of nitrogen recorded significantly higher grain yield (53.77 q/ha) over 100% of recommended dose of nitrogen (46.31 q/ha) and control (40.0 q/ha) but was par with 125% of recommended dose of nitrogen (43.37 q/ha). Interaction between nitrogen levels and application methods was found to be non-significant. Beheraa and Rautaray (2010) reported the higher grain yield obtained with increased nitrogen levels up to (165kg N ha⁻¹) which was might be due to its favourable effect on yield attributing characters.

Straw yield of late sown wheat was influenced by nitrogen levels and application methods (Table-1). The

nitrogen applied before irrigation (89.6 q/ha) recorded significantly higher straw yield than the nitrogen applied after irrigation (77.7 q/ha) by margin of 15.31 per cent higher respectively. The highest straw yield (92.7 q/ha) was observed with 150% of recommended dose of nitrogen which was significantly higher over 100% of recommended dose of nitrogen (80.7 q/ha) and control (75.2 q/ha) but was par with 125% of recommended dose of nitrogen (86.4 q/ha). Non-significant interaction between nitrogen levels and application methods was observed. However, nitrogen levels and application methods failed to affect the harvest index of late sown wheat. Ghobadi *et al.* (2010) also observed the taller plants, greater number of tiller per unit and total dry matter which collectively resulted in higher straw yield. However, nitrogen levels and application methods failed to affect the harvest index of late sown wheat.

Conclusions

It may be concluded that 150% of recommended dose of nitrogen (53.77 q/ha) should be applied to wheat before irrigation to get the higher yield (51.11 q/ha).

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Performance of New Wheat Genotypes at Different Dates of Sowing under Irrigated Conditions

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Abstract

A field experiment entitled “Performance of new wheat genotypes at different dates of sowing under irrigated conditions” was conducted at Instructional Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Sarkanda, Bilaspur during Rabi 2020-21. It was laid out in split plot design with three replications. The treatment consisting of two dates of sowing as main plot viz, D₁ (15th November) and D₂ (9th December) with five genotypes as subplot viz (GW322(C), HI1544(C), HI8713 (d) (C), GW513 and HI1636) were laid out in split plot design with three replications. The crop sown as per treatments using 100 kg seeds ha⁻¹ at 20 cm row apart. The soil of the experimental site was neutral in reaction (6.9) and clay in texture, the soil was slightly alkaline in reaction medium in organic carbon (0.60%) low in available nitrogen (138 kg ha⁻¹) medium in phosphorus (12.8 kg ha⁻¹) and potash (186.14 kg ha⁻¹). A recommended fertilizer dose of 120:60:40 NPK kg ha⁻¹. The result revealed that maximum values of plant population, growth parameters i.e., plant height, number of tillers, dry matter accumulation (g plant⁻¹) and yield attributes viz. ear length (cm), number of grain ear⁻¹ head, weight of grain ear⁻¹ head, test weight (g), grain yield (q ha⁻¹), straw yield (q ha⁻¹) and harvest index (%) was observed under sowing date 15th November (D₁) and lowest value was recorded under sowing date 9th October (D₁) most of the parameters. Among the genotypes, maximum growth and yield attributing parameters viz. Number of tillers (m⁻²), dry matter production (g plant⁻¹), grain yield and straw yield were recorded higher in genotype (V₁) GW322(C) which was at par with (V₃) GW513 while the minimum was recorded with the genotype HI8713 (d) (C). Maximum gross return (93,473 Rs ha⁻¹) and net return (62,781 Rs ha⁻¹) and B:C ratio (2.04) were found under the genotype (V₁) GW322(C) followed by V₃) GW513 (91,534.5, 60842.5 Rs ha⁻¹) and B:C ratio (1.98).

Key words : Wheat, sowing dates, genotypes, yield.

Introduction

Wheat (*Triticum aestivum* L.) is the first important and strategic cereal crop for the majority of world's populations. It is the second most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur, 1995). It exceeds in acreage and production every other cereal crop (including rice, maize, etc.) and is therefore, the most important cereal crop of the world, which is cultivated over a wide range of climatic conditions

There are many factors, which are responsible for low average yield of wheat in this tract. Therefore, some efforts have been made to increase the yield by introduction of high yielding varieties, balanced fertilizer application and efficient use of irrigation facilities. But, still there are certain factors on which attention have not been given to increase the per hectare yield of wheat. One of such environmental factor is date of sowing. This factor affects the yield of wheat crop considerably. Recently developed new varieties of wheat have potential to replace the old established varieties of the command area. Sowing time significantly influenced the growth,

yield attributes, grain and straw yields. There are still many factors, which are responsible for low average yield of wheat in this tract. One of such environmental factors is untimely planting and it affects yield of wheat crop considerably (Saini *et al.*, 1988). Growing of a suitable variety at an appropriate time is crucial for ensuring optimum productivity. For getting maximum yield under good management and optimum input conditions, the choice of appropriate variety plays a very important role. In the absence of a right variety, proper production technology cannot be applied effectively. Sowing time is an important non monetary input that affects the productivity. Sowing time needs to be adjusted so that the crop grows well under suitable climatic conditions and utilizes the soil moisture stored in the profile efficiently for initial growth and development. Variation in seeding date influences crop growth, development and yield of wheat.

Selection of proper sowing date is vital to obtain high yield due to variation among the weather conditions. Proper sowing date and varietal selection could be responsible for high crop production. Wheat is grown in winter season. It requires definite temperature and light for optimum growth definite temperature and light for optimum growth the optimum could also produce poor plants. At optimum temperature, early sowing enhances

Table-1 : Plant populations, plant height (cm), number of tillers (m⁻²) and Dry matter production (g) of wheat as influenced by sowing dates and genotypes.

Treatment	Plant population (m ⁻²)	Plant height (cm)	Tillers m ⁻²	Dry matter production (g)
Sowing dates				
D1 (15 th November)	94.97	95.28	379.27	16.87
D2 (9 th December)	89.37	92.07	372.78	13.30
SEm±	0.20	0.13	0.85	0.17
C.D. (P=0.05)	1.20	0.80	5.19	1.03
Genotypes				
GW322 (C)	93.50	95.64	391.17	16.67
HI1544 (C)	92.51	93.68	369.17	15.67
HI8713(d) (C)	90.50	91.56	365.78	15.17
GW513	93.19	94.34	386.50	14.28
HI1636	91.17	93.17	367.50	13.63
SEm±	0.77	0.70	0.70	0.29
C.D. (P=0.05)	2.32	2.09	2.10	0.87
Interaction				
SEm±	1.09	0.99	0.99	0.41
C.D. (P=0.05)	NS	NS	NS	NS

Table-2 : Ear length (cm), grains per ear head, test weight and Biological yield (ha⁻¹) of wheat as influenced by sowing dates and genotypes.

Treatment	Ear length (cm)	Grains per ear heads	1000 seed weight (g)	Biological yield (q ha ⁻¹)
A. Sowing dates				
D1 (15 th November)	7.40	30.07	43.58	92.49
D2 (9 th December)	7.13	29.67	41.32	84.03
SEm±	0.04	0.48	0.17	0.87
C.D. (P=0.05)	0.24	2.92	1.04	5.32
Genotypes				
GW 322 (C)	7.72	28.66	44.23	95.15
HI 1544 (C)	7.40	29.62	43.00	87.64
HI 8713 (d) (C)	6.56	30.48	40.92	82.22
GW 513	7.62	28.76	43.67	93.36
HI 1636	7.02	31.85	40.42	82.93
SEm±	0.10	1.04	1.00	1.77
C.D.(P=0.05)	0.31	NS	NS	5.32
Interaction				
SEm±	0.15	1.47	1.42	2.51
C.D.(P=0.05)	NS	NS	NS	NS

the wheat growth and nutrient uptake. Whereas delay in crop sowing cause reduction in yield. The intensity of winter season become increased that causes the reduction in production (Muhammad *et al.*, 2015).

Materials and Methods

A field experiment entitled “Performance of new wheat genotypes at different dates of sowing under irrigated conditions” was conducted at Instructional Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Sarkanda, Bilaspur during *Rabi* 2020-21

The treatment consisting of two dates of sowing as main plot *viz*, D₁ (15th November) and D₂ (9th December) with five genotypes as subplot *viz* (GW322(C), HI1544(C),

HI8713 (d) (C), GW513 and HI1636) were laid out in split plot design with three replications. The crop sown as per treatments using 100 kg seeds ha⁻¹ at 20 cm row apart. The soil of the experimental site was neutral in reaction (6.9) and clay in texture, the soil was slightly alkaline in reaction medium in organic carbon (0.60%) low in available nitrogen (138 kg ha⁻¹) medium in phosphorus (12.8 kg ha⁻¹) and potash (186.14 kg ha⁻¹). A recommended fertilizer dose of 120:60:40 NPK kg ha⁻¹ was applied through urea, single super phosphate and murate of potash respectively. 33% nitrogen with full dose P & K was applied as basal dose at sowing time and remaining nitrogen was applied in two equal split. *e.* 1/4 at after first irrigation (CRI) and second at second irrigation in all the treatments.

Table-3 : Grain yield (q ha⁻¹), straw yield (q ha⁻¹) and Harvest Index (%) of wheat as influenced by sowing dates and genotypes.

Treatment	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Harvest index (%)
A. Sowing dates			
D1 (15 th November)	44.62	53.12	49.38
D2 (9 th December)	38.32	42.77	45.83
SEm±	0.65	0.30	1.06
C.D. (P=0.05)	3.95	1.80	NS
B. Genotypes			
GW 322 (C)	44.62	52.19	47.70
HI 1544 (C)	41.91	47.33	47.49
HI 8713(d) (C)	38.56	44.97	48.28
GW 513	43.68	48.65	47.79
HI 1636	38.60	46.58	46.77
SEm±	0.78	0.73	0.92
C.D.(P=0.05)	2.34	2.19	NS
Interaction			
SEm±	1.10	1.03	1.29
C.D.(P=0.05)	NS	NS	NS

Table-4 : Cost incurred, Rs. ha⁻¹, Gross realization Rs. ha⁻¹, Net realization Rs. ha⁻¹ and Benefit cost ratio (B:C) of wheat as influenced by sowing dates and genotypes.

Treatment	Cost incurred (Rs. ha ⁻¹)	Gross realization (Rs. ha ⁻¹)	Net realization (Rs. ha ⁻¹)	B:C Ratio
Sowing dates				
D1 (15 th November)	30,692	93,066.5	62,374.5	2.03
D2 (9 th December)	30,692	80,615	49,923	1.62
A. Genotypes				
GW 322 (C)	30,692	93,473	62,781	2.04
HI 1544 (C)	30,692	87,536.25	56,844	1.85
HI 8713 (d) (C)	30,692	80,741	50,049	1.63
GW 513	30,692	91,534.5	60,842.5	1.98
HI 1636	30,692	81,154	50,462	1.64

Results and Discussion

Effect on growth parameter : Maximum plant population and growth characters viz, plant height (cm), number of tillers (m⁻²), total dry matter production (g plant⁻¹), Crop growth rate (g plant⁻¹ day⁻¹) and relative growth rate (g g⁻¹ day⁻¹) were recorded on 15th November (D₁) and Lower value were observed under sowing on 9th December (D₂) in most of the growth parameter. Amongst different genotype (V₁) GW322(C) was found maximum in crop growth parameter viz, number of tillers (m⁻²), total dry matter production (g plant⁻¹), Crop growth rate (g plant⁻¹ day⁻¹) and relative growth rate (g g⁻¹ day⁻¹), which was at par with (V₃) GW513 while the minimum was recorded with the genotype HI8713 (d) (C).

Effect on yield parameter : The yield attributing character viz, ear length (cm), grains per ear heads, 1000 seed weight, biological yield and Harvest index were also recorded higher in 15th November (D₁) and Lower value were observed under sowing on 9th December (D₂).

Wheat crop sown in 15th November (D₁) gave highest grains and straw yield (44.62, 53.12 qha⁻¹) while the lowest grain yield and straw yield was recorded in plant sown on 9th December (D₂).

Economics : Highest Gross return (93,066.5 Rs ha⁻¹), Net return (62,374.5 Rs ha⁻¹) and B:C ratio (2.03) were recorded higher in 15th November (D₁) and Lower while lower Gross return (80,615 Rs ha⁻¹), Net return (49,923 Rs ha⁻¹) and B:C ratio (1.62) value were observed under sowing on 9th December (D₂).

Conclusions

From the findings of this research, the following crucial conclusion concluded from the study that 15th November is the best sowing time for wheat crop for getting higher yields and economic return. Amongst the genotypes GW322 was found superior in crop growth parameters, yields and economic returns followed by HI8713(d) (C). Maximum gross, net realization and B:C ratio (85,893.5, 55,198.5 Rs ha⁻¹ and 1.79 respectively) were also found under GW322 genotype followed by HI8713(d) (C).

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Effect of Film Thickness on Quality Characteristics of Tomato Under Modified Atmosphere Packaging (MAP) System

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Abstract

The effect of a modified atmosphere packaging (MAP) with different thicknesses of low density polyethylene film (LDPE) films on the physical properties, sensory qualities, and shelf life of tomato (*Lycopersicum esculentum*) was investigated. LDPE films were taken at 25, 37.5, and 50 microns. Tomatoes were stored in modified atmospheric packaging (MAP) at low temperatures ($10\pm1^{\circ}\text{C}$) and ambient temperatures ($22\text{--}26^{\circ}\text{C}$), with relative humidity levels of 90 ± 3 percent and 61 ± 4 percent, respectively. After 6 days of storage, the PLW was changed by 15.40% at ambient temperature, whereas less than 6% weight loss was found in all samples at $10\pm1^{\circ}\text{C}$ temperature up to 21 days of storage. Firmness was good at low temperatures up to 21 days, while firmness loss was highest at ambient storage up to 6 days. The study resulted in the best quality of tomato being found up to 21 days under MAP conditions with a 25 micron thickness of LDPE film at a low temperature.

Key words : Tomato; modified atmosphere packaging, film thickness; quality characteristics.

Introduction

India is the second largest producer of vegetables in the world after China & accounts for about 15% of the world's production of vegetables. According to the National Horticultural Board, during 2018-2019, India produced 189.464 million metric tonnes of vegetables. The area under cultivation of vegetables stood at 10.31 million hectares (1). The differing agro climatic zones of India make it conceivable to grow all variety of horticultural crops. Only 2.2 % of the total production is processed in our country. India is behind the other countries like USA (65%), China (23%) and Philippines (78%) in value addition, enhancing the shelf life and reducing the wastage of the farm products (2, 3).

Vegetables are rich sources of essential nutrients. Tomato (*Lycopersicum esculentum*) are the most important, popular and versatile vegetable crops because of wide range of uses in raw form as salad, home-cooked food and from digestive aids to beauty products (4). Tomato is consumed as juice, paste, sauce etc. These are the most preferred vegetables grown under protected conditions in the world, constituting an important part of human diet. Demand of tomato is comparatively regular throughout the year because of their versatile use. In India, tomato is cultivated in 8.13 lakh ha area with the average annual production of 21.19 lakh tonnes (1). India is the world's fifth largest tomato producer, accounting for 6.0 percent of global production. After potato and sweet potato, it is the world's largest vegetable crop. Tomatoes were the first crop to be cultivated in a greenhouse, out of

all the vegetable crops. Odisha, Andhra Pradesh, and Karnataka are the fastest-growing states in India. Tomatoes (*Lycopersicon esculentum*) are known as the "poor man's orange" and universally treated as "Protective Foods" (5).

Packaging is the technologies which reducing or extending the physicochemical and microbiological changes that comes in fresh commodity after harvesting, thus diminishing the loss of quality and enhance the acceptability during marketing and distribution. To avoid condensation inside the package, the design and configuration of suitable packaging systems for perishable fresh produce with high transpiration rates, should take into account the removal of moisture produced by the packaged produce (6). A packaging system with inadequate moisture removal ability, either by permeation or adsorption by an adsorbent material, will result in a higher rate of degradation and quality loss.

In case of packaging alternatives, modified atmosphere packaging (MAP) is a well known technique used for increasing the shelf-life of freshly harvested produce. MAP, in combination with low-temperature storage, aids in the preservation of fruits and vegetables by prolonging the shelf-life and maintaining the quality of perishable food by creating an adequate gaseous environment around produce packed in polymeric films (7). By adjusting the gas composition (O_2 supply, application of an increased level of CO_2 , and balancing of N_2) inside the headspace of a package, MAP slows down the metabolic activity of a product and the microorganisms present, both spoilage and harmful.

Modified atmosphere packaging (MAP) has proved to be an effective method of regulating respiration to delaying the changes (8). This modified atmosphere aids prolong product shelf life by slowing the rate of product respiration, which delays senescence and degradation (9). The MAP is used for different kind of produce, where the composition of gases in the package depends on the packaging materials, product type and storage temperature.

It's also crucial to choose a packaging film substance whose gas permeability corresponds to the rate of respiration. To date, the trial-and-error method has been widely used in use. Fresh produce is wrapped and stored in a variety of packaging film materials, and then appropriate materials are chosen based on the gas composition in the container and the consistency of the produce after packaging and storage.

Materials and Methods

Fresh tomato was obtained from a local farmer of Hisar, Haryana and brought to Agro Processing Centre, department of Processing and Food Engineering, CSS Haryana Agricultural University, Hisar. The tomatoes were manually sorted, cleaned, washed, and weighed and packed for the experimental purpose. During the above mentioned unit operations, tomato was properly handled to avoid any mechanical injury.

Package headspace analysis : The package headspace gas concentrations (O_2 and CO_2) were analyzed at three days interval by using a portable headspace gas analyzer (Make: Systech Illinois; Model: GS6600 O_2 & CO_2 Headspace Analyzer).

Physiological loss in weight (PLW, %) : Initial weight of the sample was taken at the time of sample storage. The change in sample weight was observed at regular interval of three days. Weighing was done on a digital balance with a minimum count of 0.01g. The weight reduction was computed as a percentage of the starting weight. For this trait, a maximum weight loss of 6% was deemed a quality limit. (10). The PLW at each interval was calculated as :

$$PLW \% = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100 \quad \dots(1)$$

Total Colour Difference : The color of tomato was measured with the help of Hunter Lab colorimeter (Make: Hunter Lab Colorimeter; Model : PCM) (11). The color values of tomato were expressed as Hunter color 'L' value ('100 L' and '0 L' show white and black), 'a' value ('-a' and '+a' values show greenness and redness) and 'b' value ('-b' and '+b' values show blue and yellow). For color analysis of each sample, the reflectance spectra were measured at three different points on the surface of

sample and then the mean value was obtained. Total colour change was measured three days interval by equation (2) given by (12).

$$\text{Colour change} = (L-L_0)^2 + (a-a_0)^2 + (b-b_0)^2$$

$$TCD (E) = (L)^2 + (a)^2 + (b)^2 \quad \dots(2)$$

Firmness : Market value of tomato is affected by its firmness during storage and transport. So texture of tomato (fresh and stored) was tested in terms of firmness (N) by using Texture Analyzer (Make: Food Technology Corporate, Model: TMS Touch) as per the method of (13). Compression probe (P-5) having 5 mm in diameter and test speed of 5 mm/s was used to measure firmness of the tomato. The firmness was expressed in newton. Measurements were made at three locations (top, middle and bottom) of each sample with peel.

Sensory evaluation : The samples packed in different films and stored at selected environmental conditions were examined on 3 days interval for the purpose of sensory evaluation. The samples were required to be evaluated immediately when opened. Taste panel members were analyzed the sensory on the basis of visual appearance and odour. The quality characteristics of the samples were examined by using the 7 point hedonic scales proposed by (14), value 7 is like extremely and 1 is moderate dislike.

Statistical Analysis : The data was statistically analyzed to determine the differences between treatments during the storage study. The experiments were conducted in triplicate. Analysis of variance (ANOVA) and significant difference of data at $p < 0.05$ was carried out using a statistical package (SPSS, trial version).

Results and Discussion

Headspace partial pressures of O_2 and CO_2 : The headspace O_2 and CO_2 levels in all the packages were found to be in unsteady state until the first few days of storage and they arrived at steady state thereafter. Fig. 1 and 2 shows that samples in 25 micron LDPE was slightly higher O_2 headspace partial pressure than 37.5 and 50 micron LDPE while in case of CO_2 lower partial pressure of headspace in 25 and 37.5 micron than in 50 micron LDPE. This may be due to permeability of LDPE films. Similar results were found during the storage cucumber (15). After 21 days tomatoes packed in LDPE showed a rapid decrease in O_2 concentration in relation to 50 microm thickness films (4.50kPa) flowed by 37.5 (4.79kPa) and 25 μ m thickness (5.03kPa), respectively at 10°C . Changes in gas composition in a MAP system are mainly rely on storage temperature, ratio of mass product / package film surface, film permeability and product respiration rate (16). Concentration of O_2 and CO_2 at

ambient temperature was same as standard atmosphere 21.16 and 0.03 kPa. Gas concentration was statistically significant at 95% confidence level with p-value < 0.05 which indicate the changes in gas concentration in different thickness of LDPE during storage (Table-1).

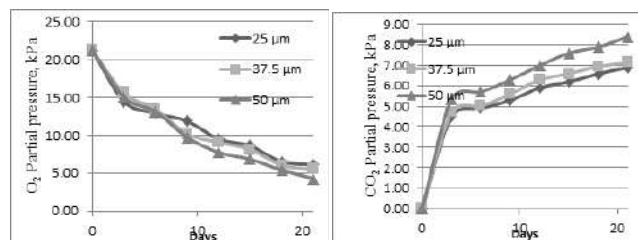


Fig-1 and 2 : In-pack gas concentration of stored tomato under MAP with different thickness of film.

Physiological loss in weight (PLW) : In fresh fruits and vegetables, weight loss (WL) is one of the main parameters that cause a reduction in shelf life and loss in commercial value (17). PLW of tomato in passive modified atmosphere packaging was less as compared to control samples that lost 15.40 % of their initial weight. Similar results was found in the report of (18) passive modified atmosphere packaging conditions for shelf life extension of ready-to-eat cherry tomatoes. Fig. 3 indicates an average weight loss of 4.50 to 5.03% at the end of storage period (21 days) with different treatments (packed with different thickness). Highest weight loss was found in sample packed with 25 µm thickness followed by 37.5 and 50 micron thickness. MAP significantly decreased WL, allowing reducing product dehydration during storage. Similar results were found by (16) in sanitized cherry tomatoes. Positive effect on weight loss shown by MAP technology is mainly due to LDPE film imposing a barrier to water vapor loss, which limits its transfer from product to outside atmosphere. Therefore, atmosphere inside package becomes saturated and dehydration is significantly reduced (9). In addition, modification of atmosphere can retard metabolic activity and, consequently, vegetable transpiration.

Total colour difference (TCD) : One of the most essential quality characteristics in determining customer approval is colour. A slightly significant difference was found in TCD value at different storage temperatures. TCD values increased with increase in temperature. TCD was found to be highest at ambient temperature as compare to MAP package. After 6 days of storage at ambient temperature, the highest TCD was found to be 23.50. TCD levels increased as the temperature rose. Fig.4 shows that there was very slight significant effect of film thickness on TCD. TCD was lowest in samples held at low temperature with a 25 micron thickness (17.97), followed by 37.5 micron (18.10), and 50 micron thickness

(18.52) during a 21-day period. There was slight difference in TCD values at 10°C but difference increases considerably with storage period as at ambient temperature. Retardation of colour changes in packaged samples may be due to high CO₂ and/or Low O₂ levels in the package environment. These results are quite comparable with (19) wherein low O₂ and high CO₂ environment inhibit yellowing of cut broccoli at low temperatures.

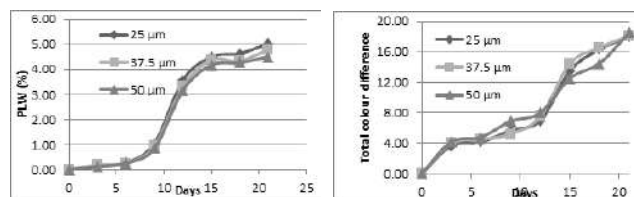


Fig-3 and 4 : PLW (%) and TCD of stored tomato under MAP with different thickness of film.

Firmness : Texture of fresh tomato was measured in terms of hardness (firmness) by compression test. Hardness is the force required to deform the product to a given percentage of strain. The storability and marketability of fruits and vegetables are greatly affected by hardness during its storage and transport. The firmness of fresh tomato decreased as the storage period progressed irrespective of the treatments. The findings revealed that fruit firmness decreased as storage time progressed (Fig. 5). Control sample showed steep trend throughout the storage period as compared to packaged samples. This may be attributed to rapid water loss and comparatively higher rates of respiration by control samples. Better texture was maintained at 10°C as compared to control samples. The average tomato hardness at the start of the trials was 11.5 N. Firmness slightly changes during initial days and rapidly decreases during later days of storage. Similarly (20) found that there was no significant difference in firmness of tomatoes upto red stages of fruit maturity after that decreased with high rate. Fruit firmness was highest in sample with 25 micron thickness (5.70 N) followed by 37.5 micron (5.40 N) and 50 micron thickness (5.00 N) of LDPE at 10±1°C temperature up to 21 days of storage. The firmness of unpacked sample was examined 3.2 N after 6 days at ambient temperature. This may be due to shriveling of tomato by loss of more moisture content. Firmness loss in fruits and vegetables is the principal cause of pectin depolymerization. MAP decreases O₂ levels while raising CO₂ levels in the surrounding environment of fruits, which, according to (21), lowers pectinesterase activity and permits fruit firmness to be retained.

Sensory analysis : With a three-day interval, a panel

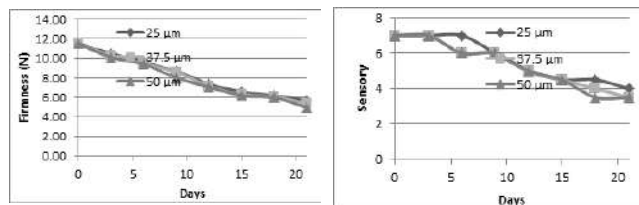


Fig.-5 and 6 : Firmness and sensory of stored tomato under MAP with different thickness of film.

Table-1 : ANOVA indicating the effect of thickness of packaging material on quality parameters.

		Sum of Squares	df	Mean Square	F	Sig.
Oxygen	Between Groups	7.154	2	3.577	.136	.874
	Within Groups	552.800	21	26.324		
	Total	559.955	23			
Carbondioxide	Between Groups	4.280	2	2.140	.375	.692
	Within Groups	119.743	21	5.702		
	Total	124.023	23			
PLW	Between Groups	.025	2	.012	.003	.997
	Within Groups	97.379	21	4.637		
	Total	97.404	23			
TCD	Between Groups	2.132	2	1.066	.024	.976
	Within Groups	924.991	21	44.047		
	Total	927.122	23			
Firmness	Between Groups	.503	2	.251	.052	.949
	Within Groups	101.459	21	4.831		
	Total	101.962	23			

analysed the samples of various packaging conditions on the basis of visual appearance and odour. On the basis of sensory evaluation of tomato, the visual appearance of tomato was good and odour was neutral up to 21 days at 10 °C while in case of control sample up to 6 days (at ambient temperature). Fig. 6 shows the thickness with 100 gauge LDPE film was acceptable for better appearance and freshness up to 21 days. Similar research was reported by (22, 23). After 21 days at 10°C temperature samples were occurred decaying (black dots created on surface of tomato). In case of 150 and 200 thickness sensory was not acceptable because sensory score was 3.5. This may be due to decay and off-odour. Whereas in control sample at ambient was shriveled and ripened (got red colour) after 6 days. Similar result was reported by (24) during evaluation the effect of MAP and storage condition on quality of cucumber.

Conclusions

The impact of modified atmosphere packaging (MAP) on tomato quality metrics were shown to be considerable. At low temperatures, modified atmosphere packaging (MAP) with 25 micron thickness LDPE preserved the atmosphere in the package, which was advantageous to the physical qualities of tomato. The PLW was 6.50 percent on the

third day, and the colour was satisfactory, therefore the experiment was kept at room temperature for sensory evaluation. Thickness of LDPE plays a vital role in prolonging the shelf life of tomato during storage period. The bags with 25 micron thickness at $10\pm1^{\circ}\text{C}$ temperature and $90\pm3\%$ RH maintained all the qualities such as minimum loss of weight, colour and greatest firmness and sensory score of stored tomato and increasing the shelf life up to 21 days.

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Effect of Sowing Methods and Seed Rates on The Grain Yield of Wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during the *rabi* season of 2019-20 at Agriculture Research Farm of School of Agriculture Science and Technology, RIMT University, Mandi Gobindgarh, Punjab to study the effect of sowing methods and seed rates on grain yield of wheat. The experiment was laid out in a randomized complete block design (RCBD) in three replications. The treatments comprised of three methods of sowing i.e. uni-directional (N-S), uni-directional (E-W) and bi-directional (N-S & E-W); and three seed rates viz. 75, 100 and 125% of recommended. All the growth and yield attributing characters significantly increased in bi-directional (N-S & E-W) sowing method over uni-directional (E-W) sowing method but was par with uni-directional (N-S) sowing method. The grain yield was significantly higher in bi-directional (N-S & E-W) sowing methods (48.8 q/ha) over uni-directional (E-W) sowing method (42.57 q/ha) but was par with uni-directional (N-S) sowing method (42.9 q/ha). Straw yield also followed the same trend but harvest index was not influenced significantly by seed rates. The 125% and 100% recommended seed rates recorded significantly higher growth and yield attributes over 75% of recommended seed rates. The 125% of recommended seed rate recorded significantly higher grain yield (46.1 q/ha) over 75% of recommended seed rate (40.0 q/ha) but was par with 100% of recommended seed rate (43.7 q/ha). The application of 125% recommended seed rate recorded 5.49 percent and 9.25 percent higher grain yield of late sown wheat over 100 and 75% of recommended seed rate respectively. Straw yield also followed the same trend but harvest index was not influenced significantly by seed rates. Interaction between sowing methods and seed rates was found non-significant in all the parameters.

Introduction

Wheat (*Triticum aestivum* L.) has the highest importance among all the crops grown for the grain purpose worldwide. In India wheat alone covers about 25% of the total area covered by cereal crops. Wheat flour mostly used for making chapati and bread Singh *et al.* (2007). Wheat is major cereal crop in Punjab and occupied 35.20 lakh hectares during 2019-20 with the production of 176.2 lakh tones and average yield of 50.04 quintal per hectares (Anonymous, 2021). Wheat is generally sown in straight uni-directional row i.e., line sowing (22.5 cm apart) where in plants are usually over crowded. They suffer from mutual shading and lower leaves do not get full sunlight. Thus, the plant does not make sufficient use of resources for photosynthesis. However in the recent past, research have indicated superiority of bi-directional sowing compared to present recommendation of uni-directional one. It has been reported that even distribution of plants over cropped area through bi-directional sowing at appropriate geometry facilitate greater availability of growth input particularly light and nutrients with least competition which result in realization of higher productivity over conventional/unidirectional sowing in row 22.5 cm apart (Singh, 1993).

Seed rate plays a vital role for optimum plant densities which is a pre-requisite for increased seed yield. It influences the yield attributes and yield of wheat. Seed rate depends on seeding method. The broadcasting

method requires more seeds than line sowing. Higher seed rate produces more plants in unit area resulting in less intra-crop competition here by affecting the yield and production cost. On the other hand, lower seed rate may reduce the yield drastically (Singh and Singh, 1987).

Materials and Methods

The experiment was carried out during *rabi* season of 2019-20 at Agricultural Research Farm of School of Agriculture Science and Technology, RIMT University, Mandi Gobindgarh, Punjab. The experimental field is located at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters above mean sea level. The site was low in organic carbon (0.38%) and available nitrogen (144.6 kg N ha⁻¹), medium in available phosphorus (17.3 P₂O₅ ha⁻¹) and potassium (168 kg K₂O ha⁻¹). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of three methods of sowing i.e. uni-directional (N-S), uni-directional (E-W) and bi-directional (N-S & E-W); and three seed rates viz. 75, 100 and 125% of recommended. The nitrogen in the form of urea (46% N) was applied in 2 splits i.e. half at sowing and half at 30 day after sowing. The gross plot size was 4.5 m × 3.5 m and net plot size was 4.0 m × 3.0 m. The crop was sown on December 11, 2019 and harvested on May 15, 2020. All the other practices were applied uniformly to all the treatments.

Table-1 : Effect of sowing methods and seed rates on the grain yield of wheat (*Triticum aestivum* L.).

Treatments	Plant height (cm)	Ear length (cm)	Test Weight	No of tillers/m row length	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Sowing methods							
Uni-directional (E-W)	88.2	5.6	26.3	64.7	38.0	55.3	41.8
Uni-directional (N-S)	92.8	7.7	29.5	83.2	42.9	62.5	43.5
Bi-directional	98.7	9.5	33.4	111.8	48.8	77.0	45.2
CD 5%	0.8	0.8	2.20	5.93	2.57	2.96	0.632
Seed rates							
75 % of recommended	91.7	7.2	28.7	82.1	40.0	61.5	43.2
100 % of recommended	93.5	7.4	29.0	87.1	43.7	64.1	43.4
125 % of recommended	94.5	8.3	31.5	90.6	46.1	67.2	44.0
SEM	3.358	0.720	1.262	3.399	0.336	0.462	0.209
CD 5%	0.8	0.8	2.20	5.93	2.57	2.97	0.632
CD for interaction	NS	NS	NS	NS	NS	NS	NS
CV (%)	6.2	11.5	6.0	6.7	9.5	11	1.4

Results and Discussion

Growth Parameter : The plant height of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). Among different sowing methods, the significantly higher plant height was observed in bi-directional (N-S & E-W) sowing method (98.3 cm) over uni-directional (E-W) sowing method (88.2 cm) but was par with uni-directional (N-S) sowing methods (92.8 cm). Dhingra *et al.* (1986) reported that the higher plant height in bi-directional due to uniform distribution of the plants per unit area and better establishment of seedling. The 125% of recommended seed rate recorded significantly higher plant height (94.5 cm) over 75% of recommended seed rate (91.7 cm) but was par with 100% of recommended seed rate (93.5 cm). But the difference between 125% of recommended seed rate and 100% of recommended seed rate was non significant. The interaction between sowing methods and seed rates was found to be non-significant. Pandey *et al.* (2004) also reported higher plant height under 125% seed rate might be due to more number of plants which would have struggled for sunlight and grew in upward direction resulting increase in plant height.

Yield Attributes : The ear length of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). The bi-directional (N-S & E-W) sowing method recorded significantly higher ear length (9.55 cm) over uni-directional (E-W) sowing method (5.66 cm) but was par with uni-directional (N-S) sowing method (7.77 cm). Panda *et al.* (1996) reported maximum ear length under bi-directional due to more or less equal-distance among the plant which in better light interception and air circulation around the lower canopies and probably carried their conducive effect on the photosynthetic activity of the crop to remarkable degree and helped in

increased ear length. The 125% of recommended seed rate produced significantly higher ear length (8.33 cm) over 75% of recommended seed rate (7.22 cm) but was par with 100% of recommended seed rate (7.44 cm). The interaction between sowing methods and seed rates was found non significant.

Test weight of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). Among different sowing methods, the significantly higher test weight was observed in bi-directional (N-S & E-W) sowing method (33.4 g) over uni-directional (E-W) sowing method (26.3 g) but was par with uni-directional (N-S) sowing method (29.5 g). Jain *et al.* (1991) also reported that maximum test weight under bi-directional was probably due to better growth and development of crop which increased uptake of nutrient and better nourishment of grains resulting in bold size of grain, ultimately increase in test weight. The 125% of recommended seed rate recorded significantly higher test weight (31.5 g) over 75% of recommended seed rate (28.7 g) but was par with 100% of recommended seed rate (29.0 g). Non-significant interaction effect was noticed between sowing methods and seed rates.

Number of tillers/m row length of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). The significantly higher number of tillers was observed in bi-directional (N-S & E-W) sowing methods (111.8) over uni-directional (E-W) sowing method (64.7) but was par with uni-directional (N-S) sowing method (83.2). The 125% of recommended seed rate recorded significantly higher number of tillers (90.66) over 75% of recommended seed rate (82.11) but was par with 100% of recommended seed rate (87.11). Non-significant interaction effect was noticed between sowing methods and seed rates. Iqbal *et al.* (2010)

reported that increasing seed rate increased the fertile tillers and total tillers significantly.

Yield Parameter : Grain yield of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). The bi-directional (N-S & E-W) sowing methods recorded significantly higher grain yield (48.8 q/ha) over uni-directional (E-W) sowing method (42.57 q/ha) but was par with uni-directional (N-S) sowing method (42.9 q/ha). Singh *et al.* (1994) and Singh (1996) reported bi-directional sowing in increase grain and straw yield could be attributed to the fact that bi-directional had the advantage of more or less equal-distance among plants, better utilization of moisture and nutrients as well as solar radiation due to better orientation of the leaves. The 125% of recommended seed rate recorded significantly higher grain yield (46.1 q/ha) over 75% of recommended seed rate (40.0 q/ha) but was par with 100% of recommended seed rate (43.7 q/ha). The interaction between sowing methods and seed rates was found non-significant. Hameed *et al.* (2003) reported that grain yield increased as seed rate increased. Sandhu *et al.* (2010) also reported that increasing trend in grain yield of wheat with increasing in seed rates.

Straw yield of late sown wheat was influenced by sowing methods and seed rates (Table-1). The bi-directional (N-S & E-W) sowing method recorded significantly higher straw yield (77.0 q/ha) over uni-directional (E-W) sowing method (55.3 q/ha) but was par with uni-directional (N-S) sowing methods (62.5 q/ha). The highest straw yield (67.2 q/ha) was observed with 125% of recommended seed rate which was significantly higher over 75% of recommended seed rate (61.5 q/ha) but was par with 100% of recommended seed rate (64.1 q/ha). Non-significant interaction between sowing methods and seed rates was recorded. Pandey I.B *et al.* (1999) also reported that increased straw yield with increased seed rates kg/ha. However, sowing methods and seed rates failed to affect the harvest index of late sown wheat.

Conclusions

It may be concluded that wheat should be sown by bi-directional (N-S & E-W) and uni-directional (N-S) methods with a seed rate of 100% of the recommended seed.

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Impact of Krishi Vigyan Kendra on Adoption of Rice Production Technologies by the Farmers of Keonjhar District of Odisha

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Abstract

The study was carried out in Keonjhar district of Odisha, India in 2019 to study the impact of Krishi Vigyan Kendra (KVK) on the adoption of rice production technologies by the farmers. A sample of 120 farmers cultivating rice was selected on a multistage random sampling technique to select from the study area. The study reveals that the majority (60 percent) of the farmers had a medium level of adoption of rice production technologies. Land preparation and nursery bed raising were most adopted by the rice farmers with an average mean score of 2.85 while proper seed variety was least adopted by the rice farmers with an average mean score of 2.01. Better interventions including training and demonstrations are needed for improving the adoption of production technologies in the region.

Key words : Adoption, KVK, management, rice and technology.

Introduction

Rice is central to the lives of billions of people around the world. India is the second largest producer of rice in the world. Agriculture in Odisha to a considerable extent means growing rice. Rice covers about 86% of the total cultivated area under rice. It is the primary meal of practically the entire population of Odisha, hence increases in rice production and productivity have a direct impact on the state's economy. Odisha was a key rice-producing state in the country in the 1950s, and it used to send a significant amount of rice grain to the country's central food stockpile. However, throughout the last 35 years, the state's rice area has remained stable at roughly 4 million hectares, or around 10% of the country's total rice area. Odisha's proportion of the country's rice production peaked at more than 11% in 2005-06, but fell to 7.9% in 2008-09. Rice is now farmed on 4.4 million hectares in Odisha, accounting for 91 percent of the state's cereal land and contributing roughly 94 percent of total grain production (Das, 2012). In this state, rice is cultivated in almost 65% of cropping area. Odisha ranks 5th position with the production of 8.29 million tonnes in 2014-15.

Keonjhar is also the major rice growing district among the 30 district of Odisha state, where rice is grown in 175.37'000ha with average yield of 1450 kg/ha. the productivity of rice in the district is low as compared to the average yield of state level. In Keonjhar district majority of the farmers are having small and medium land holding size. For the purpose of increasing rice production KVK scientist give various training on recommendations rice practices to the farmers to increase their yield and

productivity. Whether the rice growers are actually implementing these recommendations, need a thorough investigation. As per previous investigations, the knowledge level of the farmers cultivating rice in SRI method had insufficient knowledge on proper cultivation practices (Prusty *et al.*, 2020). Therefore, the present study was an attempt to know the impact of KVK training on adoption of rice production technologies by the farmers of four blocks of Keonjhar district.

Research Methodology

The study was conducted during 2019 with use of Ex-post facto research design. The district Keonjhar is one of the major rice growing district in Odisha. Moreover, Krishi Vigyan Kendra, Keonjhar is the first KVK established in Odisha during 1993. Therefore, district Keonjhar was selected purposively. The focus of the study was to assess the various management practices adopted on rice by the farmers trained at KVK. Both purposive and random sampling techniques were followed to select the respondents for the study. The district Keonjhar was selected purposively. Proportionate random sampling technique was followed to select blocks, villages and respondents. Discussion was made at length with the scientists and senior scientist and head of the KVK about training programmes conducted in different blocks of the district during the last five years. more training programmes organized and better participation of the farmers in training programmes. Hence, out of 13 blocks in the district, four blocks namely Keonjhar Sadar, Champua, Harichandanpur and Patna blocks selected randomly for the study. Names of the farmers from each selected villages undertaken training on rice production

Table-1 : Distribution of the respondents based on their extent of adoption about recommended practices of rice crop (n=120).

Sl. No.	Categories	Adoption Score	Frequency	Percent
1.	Low	below 21.64	18	15
2.	Medium	between 21.16 to 26.16	72	60
3.	High	above 26.16	30	25
	Total		120	100

Mean-23.9 S.D.-2.26.

Table-2 : Average mean score and rank of different components of extent of adoption.

Sl. No.	Components	Average Mean Score	Rank
1.	Land preparation	2.85	I
2.	Nursery raising	2.85	I
3.	Adoption of Variety	2.01	VIII
4.	Transplanting	2.74	III
5.	Fertilizer and Manure	2.51	V
6.	Water Management	2.48	VI
7.	Pest and Disease Management	2.78	II
8.	Cultural Management	2.38	VII
9.	Harvest and Post-harvest Management	2.57	IV

technology were collected from the training register of KVK. Among the list around 15 percent of the farmers were selected randomly for the study. The total sample size selected for the study became 120. The name of the block, gram panchayat, village and respondents selected for the study has been reflected in table below.

Prior to selection of the variables and preparation of interview schedule, the researcher made visit to the study area. Discussions and interaction were made with the farmers undergone training on rice production technology by KVK, Keonjhar. Discussions were also made with the scientists of KVK, extension officials of the Department of Agriculture as well as influential persons of the locality. On the basis of variables selected statements were framed under each variable with the experience gained during pilot study, consultation with experts and referring related literature. In the course of development of interview schedule, many proposed statements were discarded, new statement added after judging each item with their possible linkage with the objective set for the study. Repeated verification and proper measures were taken to avoid vague and ambiguous response that may distort the information flow. Close ended questions were put in the schedule to get appropriate and easy response. Interview schedule was broadly divided into three parts based on the four objectives of the study. The data were collected through personal interview methods with the help of structured pre-tested schedule for this study. The respondents were contacted at their work place or dwelling place for the collection of information.

Results and Discussion

Extent of adoption of various management practices in rice cultivation by the respondents : The data

regarding the extent of adoption of respondents about recommended practices in rice crop were collected. As discussed in the methodology, the adoption of recommended practices of rice was divided into 9 different practices. A comprehensive list of all the practices adopted by farmers under sub-heads was prepared. The farmers were asked about the practices they followed on their farm. Their responses were recorded in the schedule. The responses obtained from respondents were analyzed. The mean and S.D were calculated. The respondents were classified into three categories on the basis of mean and S.D.

Low adoption = Mean – S.D (below 21.64)

Medium adoption = Mean +- S.D (between 21.16 to 26.16) High adoption = Mean + S.D (above 26.16)

The data presented in table-1 revealed that more than half (60 per cent) of the respondents had medium level of adoption about recommended practices of rice production technology, followed by 25.00 per cent of them had high level of adoption and 15.00 per cent had low level of adoption. Concluding the findings that the majority of the respondents were in medium extent of adoption of the recommended practices of rice crop, followed by high and low group respectively. This might be due to the fact that the majority of the respondents had medium level of knowledge regarding recommended practices of rice crops. Similar results were reported by Singh and Varshney (2010) where majority of the farmers showed medium level of overall adoption of recommended technology. Meena *et al.*, (2012) reported that majority of farmers were in medium adoption group followed by low and high adoption groups. Singh and Yadav (2014) reported that the majority of respondents had a medium level of adoption gap regarding recommended rice production technology, followed by a low level of adoption gap and high level of adoption gap of recommended rice production technology.

Comparative Analysis of Extent of Adoption on recommended practices in rice : The second objective of the study is to assess the extent of adoption of different rice production technologies under various broad concepts like land preparation, nursery preparation, variety of adoption, transplanting, fertilizer application, water management, pest and disease management, cultural management and harvest and post-harvest

management were also studied and the findings of the study are presented below in table-2.

The data presented in table-2 revealed that out of nine broad components which further consists of different specific technology component while the preference of the respondent farmers found to be linked with land preparation and nursery raising as their first choice. This is simply because of the fact that these two activities are considered the most essential pre-requisite for furthering of the rice production activities in the field. Hence, the farmers found to be more serious with these two activities and they promptly accept and adopt in the form of farm advices given to them in the context of rice production technology without having any doubt, queries, anxiety and questions in the context. Similar results were found by Prusty *et al.* (2021) where majority of the farmers cultivating rice in SRI method adopted recommended land preparation practices.

Out of the 9 different specific technologies pest and disease management was given second rank as the respondents perceived the volume / extent of damage caused by pest and diseases to their rice crop was huge. Accordingly, they don't hesitate to protect rice crop from the attack of pest and diseases by adopting the recommendation made by the plant protection specialist functioning in their locality.

Out of the 9 different specific technologies transplanting was given third rank as the raising seedling in nursery bed by adopting all the recommendation of the farm scientist will go in vain unless the raised seedling is transplanted in the main field in proper manner with regard time of transplanting, method of transplanting, appropriate age of seedling for transplanting etc. Therefore, transplanting was ranked third among the various component of rice production technology with regard to their extent of adoption. Similar results were found by Padhy *et al.*, (2021) in a study on adoption of crop cultivation practices of cotton by tribal farmers of Odisha.

Rank fourth was given to harvest and post-harvest technique. This might be due to the fact that when the crop is ready for harvest and even after harvesting certain cares should be taken by the rice growers because any careless approach will might the risk of harvest and post-harvest damage to the crop. Therefore, the technology pertaining to harvest and post-harvest management are always accepted on the basis of its importance as per the assessment of the rice growers.

Out of the 9 different specific technologies fertilizer and manure was given fifth rank as the farmers after being concerned with land preparation, nursery raising, pest and disease management and harvest and

post-harvest management aspect realize the importance and effect of importance of application of manure and fertilizer in domain of package of practices of rice. However, cultural management, water management and variety of adoption are in the lower rank of the preference sown by the farmers as per their assessment. Variety hardly showed any mark differences with regard to the related yield and water management as well as cultural management not considered so seriously as the seriousness shown with land preparation and nursery raising.

Conclusions

It can be concluded from the study that there was medium level (60 percent) adoption of recommended practices of rice production followed by higher level (25 percent) and lower level (15 percent) of adoption of recommended practices of rice production as prescribed by KVK scientists. Land preparation and nursery bed raising were most adopted by the rice farmers with an average mean score of 2.85 while proper seed variety was least adopted by the rice farmers with an average mean score of 2.01. The medium level of adoption indicates the requirement of more training and demonstrations on the techniques for improving the understanding of farmers in the region.

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Evaluation of Organic and Inorganic Fungicides Against Wilt in Castor

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Abstract

Wilt incited by *Fusarium oxysporum t.sp. ricini* is an economically important and major disease at present in castor growing areas. To investigate the efficacy of organic and inorganic fungicides an experimental trail was carried out on evaluation of organic and inorganic fungicides against wilt in castor during *Kharif* 2019 and 2020. Two years pooled data indicated that all the organic and inorganic fungicides were significantly superior in reducing disease incidence over control and recorded very good germination percentage. In inorganic, seed treatment with tebuconazole + trifloxystrobin 75% @ 0.4g/kg registered minimum 1.0 per cent of wilt incidence and maximum (4127kg/h) seed yield with 3.3 B: C ratio while in organic, seed treatment with *Trichoderma harzianum* @ 10 g/kg + soil application of neem cake @ 1.8 t/ha registered 1.10 per cent of wilt incidence.

Key words : Castor, wilt, *Fusarium oxysporum t.sp. ricini*, organic, inorganic.

Introduction

Castor (*Ricinus communis* L.) occupies an important position in the Indian agriculture economy. It is an ancient non-edible oilseed crop which belongs to family *Euphorbiaceae*. It is an important crop among oilseed crops and generally cultivated under diversified agro-ecological situation. Castor seed contains approximately 50% non-edible oil which has a high level of demands in the world due to its numerous uses in agriculture, paper industry, plastics engineering, textile industry, rubber, pharmaceuticals. Its oil contains around 90% fatty acid known as "ricinoleic" acid in abundance which is used in biodiesel productions and industrial lubricant. Castor and its products have an importance in cosmetic, due to its renewal nature, biodegradability and eco-friendliness. India is known as the world's largest country in castor production followed by China and Brazil and has 7.6 lakh ha area and 12.2 lakh tone production. In India, it is predominantly grown in the states of Gujarat, Rajasthan, Andhra Pradesh, Tamil Nadu, Orissa, Maharashtra, Karnataka etc. These States together shared more than 80-90 per cent of total production. Gujarat is the first state in castor seeds production in India followed by Rajasthan. Both Gujarat and Rajasthan contributed 87% of the total castor area in the country under irrigated conditions while 13% area under rainfed conditions (Anonymous, 2020-21). Castor cultivation is usually efficient and profitable for tiny and marginal farmers in Nation. Its attacks by various biotic factors that liable for low productivity of castor, among them fungal diseases (phytophthora seedling blight, alternaria leaf spot, cercospora leaf spot, anthracnose, powdery mildew, root rot, and fusarium wilt) are major considerations. But, wilt (*Fusarium oxysporum f.sp. ricini*) is that the most

devastating soil borne disease of castor. It seems the least at seedling growth stages but lots of conspicuous throughout flowering and spike formation stage. Wilt disease causes significant yield losses up to 80% (Prasad, 2019). At flowering stage - 77%, at 90 days after sowing - 63% and in later stages on secondary branches of plants - 39% yield losses reported (Pushpawathi, et al., 1998). Castor growing states are more endemic to fusarium wilt. Application of organic (biocides) and inorganic (fungicides) in soil as well as on seed provides an effective control of the disease. Keeping in view, this investigation was administrated to search out the effective organic and inorganic practice to manage this problem.

Materials and Methods

To test the efficacy of organic and inorganic fungicides an experimental trial was raised out on evaluation of organic and inorganic fungicides against wilt of castor at Agricultural Research Station (Agriculture University, Jodhpur), Mandor during *Kharif* 2018 to 2020. The crop was sown in randomized blocked design (RBD) with susceptible castor cultivar (JI-35) in the last week of August during both seasons. The plot size was 6.0 x 4.5 m². Seven treatments (Table-1) including one check were exploited in three replications. The organic treatments were applied as soil and seed treatment and inorganic were applied as seed treatment only. The per cent wilt incidence was calculated by remarking the infected plants from total number of plants from sowing to harvest. Per cent disease incidence was calculated by using formula given below. Seed yield (kg/h) and B : C ratio also calculated and analyzed statistically.

Table-1 : Details of treatment applied against wilt disease in castor.

Treatment	Treatment detail
T ₁	Seed treatment with <i>Trichoderma harzianum</i> , @10g/kg and soil application (1kg mixed with 100 kg FYM incubated for a week and applied while seed dibbling)
T ₂	Seed treatment with <i>T. harzianum</i> @10g/kg and soil application of neem cake @ 1.8 t/ha one week of before sowing
T ₃	Seed treatment with <i>T. harzianum</i> @10g/kg and soil application of vermicompost @ 3 t/ha one week of before sowing
T ₄	Seed treatment with tebuconazole + trifloxystrobin 75% WP @ 0.4g/kg
T ₅	Seed treatment with carboxin 37.5% + thiram 37.5% @ 2g/kg seed
T ₆	Seed treatment with carbendazim @ 2g/kg seed
T ₇	Untreated (Control)

Table-2 : Evaluation of organic and inorganic management practices against wilt and seed yield (kg/h) of castor.

Treatment	Germination (%) Pooled	Wilt PDI			Seed Yield (kg/h)			B:C ratio
	2019-20	2019	2020	Pooled	2019	2020	Pooled	
T ₁	89.00 (70.63)	1.58 (7.22)	3.0 (9.9)	2.30 (8.72)	4192	3710	3951	3.2
T ₂	89.00 (70.63)	0.70 (4.80)	2.7 (9.4)	1.70 (7.49)	4196	3760	3978	1.1
T ₃	89.00 (70.63)	1.55 (7.15)	5.0 (12.9)	3.27 (10.42)	4037	3550	3794	2.0
T ₄	89.00 (70.63)	0.00 (0.00)	2.1 (8.3)	1.00 (5.74)	4285	3710	3998	3.3
T ₅	89.00 (70.63)	0.79 (5.10)	5.6 (13.6)	3.20 (10.30)	4170	3590	3880	3.1
T ₆	89.00 (70.63)	0.99 (5.17)	3.9 (11.3)	2.40 (8.91)	4242	3410	3826	3.1
T ₇	89.00 (70.63)	2.50 (9.10)	23.1 (28.7)	12.90 (21.05)	3884	2870	3377	2.6
SEm+	1.41	0.02	0.19	0.11	82.77	54.11	54.37	-
CD at 5%	4.23	0.07	0.57	0.32	255.06	162.33	162.90	-
CV	3.54	4.35	6.58	6.27	3.57	9.0	3.45	-

Percent disease incidence

$$= \frac{\text{Total number of plant infected}}{\text{Total number of plant observed}} \times 100$$

Results and Discussion

Two years pooled result of organic and inorganic fungicides indicated that all the treatments were recorded very good germination percentage and found significantly superior in reducing per cent wilt disease incidence of castor over control. The pooled results of inorganic fungicides, minimum per cent of wilt disease incidence (1.0%) was registered in seed treatment with tebuconazole + trifloxystrobin 75% @ 0.4g/kg with maximum (3998 kg/h) seed yield followed by seed treatment with carbendazim @ 2g/kg seed registered 2.40 per cent wilt incidence and 3826 kg/ha seed yield. In organic, seed treatment with *Trichoderma harzianum* @ 10 g/kg + soil application of neem cake @ 1.8 t/ha registered 1.70 per cent wilt disease incidence and 3978 kg/ha seed yield followed by seed treatment with *Trichoderma harzianum* @ 10g/kg and soil application of *Trichoderma harzianum* @ 1.0 kg mixed with 100 kg FYM registered 2.30 per cent wilt incidence and 3951 kg/ha seed yield. Seed treatment with carboxin 37.5% + thiram 37.5% @ 2g/kg seed and seed treatment with *T.*

harzianum @ 10 g/kg and soil application of vermicompost @ 3.0 t/ha (one week of before sowing) registered 3.20 and 3.27 per cent wilt incidence respectively. Maximum 12.90 per cent wilt incidence and minimum 3377 kg/ha seed yield were registered in control. Our observations are in conformity with several workers and reported that seed treatment with thiram @ 3g/kg or bavistin @ 2g/kg of seed + seed (10 g/kg) and soil application (1.0 kg/100 kg FYM) of *Trichoderma viride* reduced the wilt incidence (Bhat *et al.*, 2019) *Trichoderma harzianum* and *T. viride* significantly inhibited the mycelial growth of *Fusarium oxysporum* (Vahunia *et al.* 2017 and Meghwal *et al.*, 2014). Neem oil cake was found most effective in reducing wilt incidence (Jat, *et al.*, 2017, Kimaru *et al.*, 2004 and Yelmame *et al.*, 2010).

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Wilt Disease Scenario of Castor (*Ricinus communis* L.) in Zone-IA of Rajasthan

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Abstract

Castor wilt is a major emerging problem and causes huge losses to castor crop in Rajasthan, Gujarat, Tamil Nadu and other castor growing areas. A random survey was carried out to investigate the per cent disease incidence (PDI) of castor wilt caused by *Fusarium oxysporum* f.sp. *ricini* from major castor growing farmer's fields of Jodhpur zone of Rajasthan during Kharif 2019 and 2020. Two years mean data revealed that per cent incidence of wilt disease was high in Jodhpur zone and was varied from 0 to 18.50% in the surveyed areas during both the year.

Key words : Castor, wilt, incidence, *Fusarium oxysporum* f.sp. *ricini*

Introduction

Castor is scientifically known as *Ricinus communis* L. is a valuable non-edible industrial oilseed crop which belongs to family *Euphorbiaceae*. It is one of the ancient cultivated crop and mainly grown in tropical and sub-tropical climate of India, China and Brazil. Castor seed contains approximately 50% non-edible oil, which is used as domestic, medicinal and industrial purposes. India is the top most castor producing country in the world with 7.6 lakh ha area and 12.2 lakh tone production. The major castor producing States in India are Gujarat, Rajasthan, Andhra Pradesh, Tamil Nadu and Orissa. These States accounted more than 90 per cent of total castor seed production. In India, Gujarat is the leading state in castor seeds production followed by Rajasthan. Gujarat and Rajasthan both shared 87% of the total castor area in the country [1]. Rajasthan has 140571 hector areas with 207584 productions. Sirohi, Jalor, Jodhpur, Barmer are major castor growing districts of Rajasthan [2]. Wilt, root rot, gray mold, seedling blight, alternaria blight and bacterial blight are the major fungal and bacterial diseases of castor plant. But, wilt caused by *Fusarium oxysporum* f.sp. *ricini* is a most important soil-borne disease and found in severe form at all castor growing regions. It was first recorded from Morocco [3]. In India, it was first time noticed from Udaipur, Rajasthan [4]. It appears at all crop growth stages but more conspicuous during flowering and spike formation stage.

Materials and Methods

Collection of sample : A survey was carried out from major castor growing areas of Jodhpur, Jalor and Nagaur districts of Rajasthan during Kharif 2019 and 2020. Samples of wilted plant were collected randomly from the farmer's fields of different locations of the above

mentioned districts. The collection of diseased samples was started from first week of October during both the years. Three fields of each village of each district were surveyed to record the incidence of wilt disease. In each field, 10 meters rows were marked randomly. A total of 20 villages of 3 different districts of Rajasthan were surveyed during the year. In each row, total number of plants and number of diseased plants were counted and expressed in terms of percentage. The per cent disease incidence (PDI) was recorded as per the formula given below.

Per cent disease incidence

$$= \frac{\text{Total number of plant infected}}{\text{Total number of plant observed}} \times 100$$

Further the collected wilted samples of castor were used for isolation, pathogenicity and identification of pathogen.

Isolation : The wilted samples of castor plant brought to the laboratory, washed with tap water to remove the adhering soil particles and cut the wilted roots aseptically into small pieces. The root pieces were surface sterilized with 1% sodium hypochloride solution for 1-2 minute with three consecutive washing in sterilized distilled water and dried the root pieces by using sterilized blotter paper to remove excess moisture. Placed a cut piece of root on the middle of Petri plate containing 20 ml sterilized solid potato dextrose agar under aseptic condition. After inoculation, Petri plates were incubated at $28 \pm 2^{\circ}\text{C}$ in BOD for seven days. After incubation, the isolated culture was purified by hyphal tip method. The cultured fungus was identified by colony characters and examined with the help of microscope. The fungal culture was maintained in deep freeze on potato dextrose agar (PDA) medium.

Pathogenicity : The pathogenicity of the isolated fungus was tested under pot house conditions. The pots were

Table-1 : Per cent wilt disease incidence in castor at Zone Ia of Rajasthan.

S. No.	Location	District	Previous crop	90-150 DAS Wilt PDI*		Mean PDI
				2019	2020	2019-20
1.	ARS, Mandor	Jodhpur	Wheat	13.0	17.0	15.00
2.	Anwana	Jodhpur	Cumin	16.0	21.0	18.50
3.	Osian	Jodhpur	Isabgol	3.0	7.0	5.00
4.	Thob	Jodhpur	Bajara	4.0	5.0	4.50
5.	Nevra Road	Jodhpur	Moongbean	9.0	13.0	11.00
6.	Narwa	Jodhpur	Bajara	5.0	11.0	8.00
7.	Baori	Jodhpur	Sesame	2.0	11.0	6.50
8.	Soyla	Jodhpur	Moongbean	6.0	7.0	6.50
9.	Tiwari	Jodhpur	Cotton	0.0	6.0	3.00
10.	Chadi	Jodhpur	Moongbean	2.0	3.0	2.50
11.	Begaria	Jodhpur	Cumin	3.0	0.0	1.50
12.	Jeloo	Jodhpur	Cumin	0.0	0.0	0.00
13.	Bagara	Jalor	Cumin	3.0	11.0	7.00
14.	Sayla	Jalor	Mustard	4.0	7.0	5.50
15.	Bhinmal	Jalor	Isabgol	5.0	3.0	4.00
16.	Chittlawala	Jalor	Sesame	7.0	5.0	6.00
17.	Sanchor	Jalor	Cumin	6.0	9.0	7.50
18.	Bhawari	Jalor	Isabgol	2.0	4.0	3.00
19.	Ahor	Jalor	Cumin	2.0	6.0	4.00
20.	Kheenvsar	Nagaur	Mothbean	2.0	4.0	3.00

*Average of three fields per village (PDI = Per cent Disease Incidence)

sterilized before filling with 5% sodium hypochloride solution for 30 minutes and filled with a mixture of sterilized soil: sand: organic matter (2:1:1) before dibbling of the castor seed, 20g of 10 days old autoclaved sorghum seed containing fungus culture was mixed in each pot. Five seeds were dibbled in each pot. The pots were moistened thrice a week regularly. A non-inoculated pot served as control. The pots were monitored regularly and per cent wilt incidence was recorded after 15 days of seed dibbling. Re-isolation was done after one month from infected plants showing disease symptoms like yellowing, wilting etc and the isolated fungus was compared with the original culture used.

Cultural and morphological characters of the pathogen : The pathogen of castor wilt is a soil borne in nature and it was identified as *Fusarium oxysporum f. sp. ricini* (Nanda and Prasad). After soil inoculation, young seedling of castor plant showed discolouration and loss of turgidity with or without change in colour at when plant was two-three leaf stage under pot condition. The isolated fungal mycelium mat on PDA was cottony/fluffy white to greyish-white in colour which turned pinkish when incubated. The fungal mycelium is hyaline, branched, septet. The conidiophore is hyaline, simple and branched. It produces three types of asexual spores viz., Microconidia, Macroconidia and chlamydospores (These are resting spores which survive in adverse conditions). Chlamydospores are formed in old cultures with smooth

or rough walled, terminal and intercalary and may form singly or in pairs or in chain.

Results and Discussion

A random survey was carried out from Jodhpur, Jalor and Nagaur districts of Rajasthan and surveyed twenty villages of mentioned districts. The mean results indicated that wilt incidence of castor was varied from 0.0 to 18.50 per cent. The maximum 18.50 per cent disease incidence was recorded from Anwana village of Jodhpur followed by 15.0 per cent from Agricultural Research Station, Mandor, Jodhpur and 11.0 per cent from Nevra Road. Minimum (1.50 and 2.50 %) wilt disease incidence was recorded from Begaria and Chaddi village of Jodhpur. The village Jeloo was free from disease incidence (0.0 per cent). Twenty three major castor growing villages of Nagarkurnool, Wanaparthi and Jogulamba Gadwal districts of Southern Telangana zone were randomly surveyed during *Kharif* 2020 and *Rabi* 2020-21 and recorded 50 per cent seedling blight during vegetative stage and 5 per cent wilt incidence were from farmer fields during *Kharif* [1]. A random survey was conducted in Junagadh, Amreli and Gir Somnath districts and 15 castor growing fields were covered with 0.0 to 8.0 per cent wilt diseases incidence [1]. About 85 per cent wilt incidence recorded from North Gujarat condition [5]. Reduction in castor seed production was recorded from 10 to 40 % in yield, 8-14% in seed weight and 1-2 % in oil content [6]. During the survey on disease scenario in Gujarat, 1.0 to

35.0% wilt incidence was recorded on different castor hybrids [7].

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Study on Utilization of Information and Communication Technology tools by KVK Staff and Farmer's in Central Uttar Pradesh

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Abstract

The study was conducted in Central Uttar Pradesh to assess the knowledge level of KVK staff and farmers towards utilization of ICT tools in farm communication and to find out the relationship with socio-economic characteristics of KVK staff and farmers using these ICT tools. Kanpur Dehat, Unnao, Lucknow, Rae Bareilly and Pratapgarh districts were selected purposively because these districts are nearer to Lucknow. The respondents selected for the study include 37 KVK staff from 5 KVKs and 175 farmers from 5 villages of 5 districts. The findings of the study revealed that nearly 80 per cent of the KVK Staff and 70 per cent farmers had medium to high level of knowledge about ICT tools. Variables such as types of training, work experience, and social participation had positive and significant relationship with knowledge of KVK staff and farmers about ICT tools at one per cent level of significance whereas; education and annual income had positive and significant relationship at five per cent level of significance. As the study revealed, most of the farmers had knowledge about the utility of ICT tools for farm communication, only limitation is the availability. The arrangement for availability of ICT tools could make huge difference in the agriculture sector of the country. The Information and Communication Technology (ICT) is an emerging field and can play a central role in facilitating the exposure of farmers to a variety of information. It involves application of innovative ways to use ICT in the rural domain. Increasing penetration of mobile phones and mobile-enabled information services, and computers in rural India can complement the role of extension services.

Key word : Knowledge level, ICT, KVK, training.

Introduction

Information and Communication Technology (ICT) in Agriculture is emerging field focusing on the enhancement of agricultural and other development in India. The Agriculture sector is gearing itself to make optimal use of the new information and communication technologies. The diffusion of ICTs has contributed enormously to the growth of economies in developed nations and developing nations and is earnestly facilitating policy framework to ensure an equitable diffusion of new technologies. The information and communication support during last 50 years has mainly been conventional method. Earlier the extension personnel used to disseminate the technology/ message to farmers orally/ manually (Manty, 2011). In practical sense communication is the essence of extension services. Extension services, both people and approaches, seek to provide rural people with knowledge and information (Banerjee, 2014). ICT covers any product that will store, retrieve, manipulate, transmit or receive information electronically in a digital form. For example, personal computers, digital television, email, mobile etc. As ICT's diffusion started to grow in many developing countries, the application of ICT to agricultural and rural development began to receive the attention of researchers and policy makers. A number of studies have suggested that ICT could play an important role in

agricultural development. Majority (83.87%) of the respondents used T.V. as source of information followed by radio (78.71%) and tape recorder (7.74%) (Kumar, 2000). Majority of tribal farmers received information from RAO's followed by friends; neighbour and progressive farmers of the region, radio and T.V. combination were recorded of about 39.46 per cent as communication sources (Sharma *et al.*, 2000). Majority (82.00%) of the respondents had perceived medium credibility of radio followed by 10.67 percent and 73 percent of the respondents who perceived high and low credibility. The collaboration of extension activities with ICT in recent decade like television, mobile phone, computers, digital networks had led unavoidable capacity for dissemination of information and knowledge gaining of the farmers. Some of the ICT tools have played a major role in promoting agricultural related information which includes tele-centers, web portals, call centers, mobile apps, community radio, digital photography, GIS, audio and video conferencing and social media such as facebook, twitter, youtube and whatsapp (Jyoti and Mishra, 2018).

Statement of Problem : ICTs play an important role in disseminating the information, especially in agriculture sector. With the emergence of these ICTs almost all the information is brought to the farmers and staff with the single press. No doubt the progress has been achieved as

a result of using various ICT tools; however, its benefits have remained confined primarily to the urban areas. Rural communities have not been able to gain to the same extent from ICTs. Krishi Vigyan Kendras (KVKs) are the main institutions responsible for disseminating agricultural information among farmers. Various ICT initiatives have been adopted by KVKs. As a means of technology transfer, its utilization was not reaching the target people. Hence, this study has been designed to study the Utilization of ICT tools by KVK staff and Farmers in Central Uttar Pradesh with the following *research questions* :

What is the role of ICTs in Information dissemination in Agricultural sector?

To what extent the major ICT tools are used by KVK staff and farmers?

Scope of Study : India has made great strides in the growth and development of ICT tools, ICTs provide opportunity to the KVK staff and Farmers to gain information through the integration of these technologies the communication becomes more seamless. Usefulness of ICTs can be gauged by way of its usage now in various countries as one of the basic thing to make transfer of information between KVK staff and farmers. At the same time ICTs also provide challenge to KVK staff and farmers in terms of subject specific ICT resources for each other's understanding with various kinds of activities. Information and Communication Technologies provide more interactive and less didactic approach, where the KVK staff and farmer can interact through the ability to capture, combine and manipulate information from a variety of sources. It is very essential to know the awareness, knowledge, extent of use and problem faced during the uses of ICT tools.

Objectives of Research

To study the knowledge level of KVK staff and farmers regarding ICT tools.

To study the relationship of knowledge and utilization level of ICT tools users with the socio-economic variables.

Research Methodology

Locale of the Study

Selection of the State : The study was conducted in purposively selected state Uttar Pradesh (UP) as it is the largest state of India in terms of population and number of Krishi Vigyan Kendras. There are 75 KVKs in UP. Geographically Uttar Pradesh has been divided into five parts namely Eastern UP, Western UP, Central UP, Bundelkhand and Ruhelkhand region. Out of five regions Central UP was selected purposively for conducting this study. Reasons for selecting central UP are as follows :

It has reasonably large number of KVKs. There are 16 KVKs located in central UP.

All types of KVKs (i.e. KVKs of SAUs, KVKs of ICAR Institutes and KVKs of NGOs) are functional in this area.

Research worker is very well acquainted with language and culture of the area.

Selection of the districts : There are 15 districts in central UP. Out of 15 districts five districts viz. Kanpur Dehat, Unnao, Lucknow, Rae Bareilly and Pratapgarh were purposively selected for the present study. These districts are close to the capital of UP and different types of KVKs are present in these districts. Convenient of research worker for data collection was also a reason.

Selection of Krishi Vigyan Kendras and respondents

Selection of KVKs : Five KVKs were selected for the purpose of study. One KVK from each selected district was considered for this study. From the district Kanpur Dehat, KVK Daleep Nagar which is working under Chandra Shekhar Azad University of Agriculture and Technology, Kanpur was selected. Virendra Kumar Singh KVK Hasanganj working under Kunwar Ram Baksh Educational Society (NGO) from district Unnao was selected. KVK ICAR-IISR from district Lucknow was the third KVK selected for study. From district Raebareilly KVK Dariapur which is working under Chandra Shekhar Azad University of Agriculture and Technology, Kanpur was selected. Fifth KVK selected for the study was Raja Dinesh Singh KVK Kalakankar under Raja Avadhesh Singh Memorial Educational Society (NGO) from district Pratapgarh. Thus 5 KVKs were selected for the purpose of Research.

Selection of KVK staff as respondents : All the Senior Scientist cum Head, Subject Matter Specialists (SMS), Programme Assistant, Farm Manager and Computer Programmer of the selected 05 KVKs formed the respondents of this study. There were 05 Senior Scientist cum Head, 26 SMS, 01 Programme Assistant, 01 Farm manager, and 04 Computer Programmer were working in selected KVKs. Thus a total of 37 KVK staff was selected as respondents on census basis.

Selection of Farmers as Respondents : During preliminary visit to selected 05 KVKs data related to number of registered farmers with KVK and how many of them have been using ICT tools was obtained. It was decided to select 5% farmers from each KVK who were using ICT tools. Thus a total of 175 farmers were selected as respondents using proportionate to the size random sampling technique. A brief account of registered farmers, farmers using ICT tools and selected farmers from 5 selected KVKs is given below :

Name of KVK	No. of registered farmers	No. of farmers using ICT tools	5% selected farmers
KVK Kanpur Dehat	2500	500	25
Virendra Kumar Singh KVK Unnao	5000	500	25
ICAR-IISR KVK Lucknow	1000	500	25
KVK Rae Bareli	5000	1000	50
Raja Dinesh Singh KVK Pratapgarh	5600	1000	50
Total	19100	3500	175

Research Design : An Ex-Post Facto Research Design' was used for the Research.

Dependent Variable

Knowledge Level : It refers to the fact or condition of knowing something with familiarity gained through experience or association. It also relates to the fact or condition of being aware of something. Thus, it is the fact or condition of having information about something. It was measured with the help of a knowledge test specially developed for this study. The test constituted 16 knowledge questions for KVK Staff and 10 knowledge questions for farmers which were provided with 3 alternative answers including correct answer. The knowledge test was administered to the respondents and they were asked to tick mark to the correct answer. Quantification of knowledge item answers was made by giving one score for correct and zero score for wrong answers. The scores of all the individual items were summed to get knowledge score of the respondent. The summation of scores for a particular respondent indicated his knowledge level about ICT tools. The maximum score that one can get was 16 for KVK Staff and 10 for Farmer and the minimum was zero. Based on the total score, the respondents were classified into three categories namely, 'low', 'medium' and 'high' knowledge level by using mean $\pm$ standard deviation.

Method of Data Collection and Tools Preparation : Structured interview schedule and questionnaire were prepared as per the objectives of the study in consultation with the experts in this field for necessary data collection.

Statistical Analysis of the data : Collected data were tabulated and analyzed in the light of the objectives set forth for the study. The statistical methods used in the present study include:

Percentage : For making sample comparisons, the percentage values were calculated by dividing the frequency of a particular cell by total number of respondents in a particular category and multiplying by 100.

The data have been presented in the result and discussion chapter.

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

Where,

n = frequency of a particular cell

N = Total number of respondents in that particular category

P = Percentage

Frequency : It was calculated to find out the number of respondents in a particular cell.

Mean : The arithmetic average of a set of data needs to be computed during the analysis of data. Mean scores for each category was worked out separately which was calculated by the following formula :

$$\bar{X} = \frac{\sum x_i}{N}$$

Where,

$\bar{X}$ = Mean score

$\sum x_i$ = Sum of each of the individual comparisons

N = Total number of respondents.

Standard Deviation : Standard deviation was computed for the purpose of analysis and further categorization of data. The standard deviation was calculated by using following formula.

$$\frac{\sum (X_i - \bar{X})^2}{n}$$

Where

= Standard deviation

X_i = Value of individual variables

$\bar{X}$ = Arithmetic mean

n = Total number of items

Co-Efficient Of Correlation : It was used to find out the relationship between independent and dependent variables. The coefficient of correlation was worked out by applying following formula.

$$r = \frac{\text{Cov}(x_1, x_2)}{\sqrt{\text{Var } x_1 \cdot \text{Var } x_2}}$$

$$\text{Cov } (X_1 X_2) = \frac{\sum (x_1 - \bar{x}_1)(x_2 - \bar{x}_2)}{n}$$

Where,

$$\text{Var } (X_1) = \frac{\sum (x_1 - \bar{x}_1)^2}{n}$$

$$\text{Var } (X_2) = \frac{\sum (x_2 - \bar{x}_2)^2}{n}$$

X_1 and X_2 are the two variables

r = correlation co-efficient between X_1 and X_2 .

Results and Discussion

To study the knowledge level of KVK staff and farmers regarding ICT tools :

The objective was divided in following sub-heads :

Knowledge level of KVK staff regarding ICT tools

Knowledge level of farmers regarding ICT tools

Results is presented as follows :

Knowledge level of KVK staff regarding ICT tools

Table-1 : Distribution of KVK Staff according to their knowledge level about ICT Tools.

S. No.	Knowledge Level	Respondents (N=37)	
		Frequency	Percentage
1.	Low Knowledge (up to 9)	7	19
2.	Medium Knowledge (10 to 13)	17	46
3.	High Knowledge (Above 13)	13	35
	Total	37	100

Mean=11 SD=2 Range of Score : 0 - 16

It is revealed from the table-1 that majority of respondents (46%) had medium level of knowledge. 35 per cent of KVK staff were having high level of knowledge regarding ICT tools. It is also clear from the table that only 19 per cent of KVK staff were having low level of knowledge, where the mean score was 11.

Knowledge level of farmers regarding ICT tools

Table-2 : Distribution of respondents according to knowledge level about ICT tools.

S. No.	Category	Respondents (N=175)	
		Frequency	Percentage
1.	Low (up to 3)	48	27
2.	Medium (4 to 7)	70	40
3.	High (8 & Above)	57	33
	Total	175	100

Mean=5.86 SD=2.63 Range of Score: 0 - 10

It is revealed from the table 2 that in case of farmers, majority of respondents (40%) had medium level of knowledge, followed by high and medium level, 33 and 27 per cent, respectively.

Relationship of selected independent variables with Knowledge Level of KVK staff

Table-3 : Relationship of selected independent variables with Knowledge Level of KVK staff. N = 37

S.N.	Selected independent variables	Value of Correlation coefficient (r)
1.	Age	0.73**
2.	Education	0.68**
3.	Social Participation	0.81**
4.	Income	0.76**
5.	Work experience	0.80**
6.	Types of training	0.77**

Significant at 0.01 level of probability

NS = Non significant

It is evident from the table 3 that age, education, social participation, income, work experience and types of training were positively and significantly related with the

knowledge level of KVK staff about various ICT tools. The above observation shows that selected variables exerted their influence over knowledge of the KVK staff.

Relationship of selected independent variables with Knowledge Level of Farmers

Table-4 : Relationship of selected independent variables with Knowledge Level of Farmers. N=175

S.N.	Selected independent variables	Value of Correlation coefficient (r)
1.	Age	-0.43*
2.	Education	0.73**
3.	Income	0.81**
4.	Social Participation	-0.38*
5.	Land holding	0.80**

**Significant at 0.01 level of probability

*Significant at 0.05 level of probability

NS = Non significant

In case of farmers, table-4 reveals that the variables age and social participation are negatively correlated with the knowledge level of farmers about ICT tools. Age creates negative effect on knowledge level of farmers. Variables education, income and land holding were positively correlated with the knowledge level of farmers.

Conclusions

Agriculture information resources should be significantly organised and processed to disseminate right information to the right user at the right time. The study revealed that nearly 80 per cent of the KVK Staff and 70 per cent farmers had medium to high level of knowledge about ICT tools. This means extension through ICT tools could be a feasible option for the extension service providers. Most of the KVK staff and farmers depended on TV, Radio, mobile and newspaper for getting wide range of information because of its accessibility. Dissemination of information like marketing information, package of practices through mobile and the television could create a positive impact on the production system of the country.

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Studies on Genetic Variability and Heritability in Bread Wheat in Relation to Grain Yield and its Ingredient Trait (*Triticum aestivum* L.)

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Abstract

Genetic variation is of prime importance for any systematic varietal development programmes. Genetic parameters of variation provide information about expected response to selection and helps in developing suitable breeding procedure for their improvement by making selection of better plant types. The present investigation entitled "Studies on Genetic variability and heritability in Bread wheat in relation to grain yield and its ingredient trait (*Triticum aestivum* L.)" was carried out during 2018-19 and 2019-20 at the research farm of Motherhood University, Roorkee, Uttarakhand. Fifty-two genotypes of wheat were used to estimate the genetic variability, heritability, and genetic advance. These genotypes were planted in a randomized complete block design with three replications. Data were recorded on days to 75% flowering, plant height, peduncle length, number of productive tillers/plant, days to maturity, spike length, number of spikelet's/spike, number of grains/spike, 1000-grain weight, biological yield/plant, grain yield/plant, harvest index, and two quality trait such as gluten content and protein content. The results showed highly significant variation among the genotypes for all characters ($p < 0.05$). Days to 75 percent flowering, plant height, number of spikelet's/spike, number of grains/spike, 1000 grain weight, biological yield/plant, and grain yield/plant all showed high heritability combined with high genetic advance, indicating that these characters were under the control of additive gene action, which will be more useful in predicting the gain under selection than heritability alone. The high heritability of the traits like peduncle length and harvest index, together with poor genetic progress, showed a preponderance of non-additive gene action, and hence direct selection for such characters would lead to an unexpected result. As a result, it was found that there is sufficient genetic variation enabling the selection of superior genotypes form a breeding programmes.

Introduction

Wheat (*Triticum aestivum* L.) is a common staple meal in many people's diets all over the world. It is the most significant grain in terms of agronomy and nutrition, and it is critical for food security, poverty alleviation, and improved livelihoods. In India, three types of wheat are grown commercially: (*Triticum aestivum* L.) (bread wheat), *Triticum durum* (macaroni wheat), and *Triticum dicoccum* (emmer wheat). Wheat is grown on an estimated 224.49 million hectares worldwide, yielding 792.40 million tonnes of grain (Anonymous, 2021). Wheat has played a critical role in stabilising the country's food grain supply in recent years. After China, India is the world's second-largest wheat producer. It covers roughly 31.61 million hectares and produces 109.52 million tonnes of produce and 3464 kg/ha of productivity (Anonymous, 2021). The largest wheat-producing states in India include Uttar Pradesh, Punjab, Madhya Pradesh, Haryana, Rajasthan, and Bihar. The six states indicated above account for almost 92 percent of total wheat production. Uttar Pradesh has the biggest area and production of wheat, whereas Panjab has the highest productivity. Rajasthan was India's fourth-largest state by land, fifth-largest by production, and third-largest by productivity. Wheat is grown on 3.00 million hectares in

Rajasthan, with a yield of 11.03 million tonnes and a productivity of 3676 kg/h.

Understanding heritability and genetic progress (as a percentage of the mean) is necessary for effective selection. The most beneficial condition in breeding programmes is thought to have high heritability combined with strong genetic advance estimates for a specific trait. According to Panse and Sukhatme (1969), high heritability combined with high genetic advance indicates additive gene effects, but high heritability combined with low genetic advance indicated dominance and epistatic effects. With this in mind, the current study was undertaken with the objective to evaluate 52 wheat genotypes for nature and magnitude of variability, heritability and expected genetic advance.

Materials and Methods

During rabi 2018-19, the experimental materials, which included 52 genotypes of wheat, were grown in a randomized block design with three replications at Motherhood University's research farm. The experiment was carried out on a 5 meter long plot with 5 rows in two consecutive season viz. November 2018-2019 & November 2019-20. The space between rows and plants was kept at 22.5 cm and 10 cm, respectively. To counteract the border effect, the border rows were also

Table-1 : Analysis of variance (ANOVA) for 14 characters in bread wheat.

Source of variation	DF	Days to 75%flowering	Plant height (cm)	Peduncle length	No. of productive tiller/plant	Days to maturity	Spike length (cm)	No. Of spikelets/spike
Replication	2	5.81	34.38	3.21	0.15	0.03	0.30	7.14
Treatment	51	11.39**	79.97**	13.57**	0.21**	10.98**	1.53**	3.67**
Error	102	2.60	1.77	1.72	0.06	1.92	0.11	0.45
Source of variation	DF	No. of grains/spike	1000 grain weight	Biological yield/plant (gm)	Grain yield/plant (gm)	Harvest index/plant (%)	Gluten content (%)	Protein content (%)
Replication	2	2.41	2.77	0.17	0.02	0.27	0.03	0.14
Treatment	51	399.77**	25.94**	74.09**	11.16**	0.60**	0.57**	0.86**
Error	102	1.10	0.19	0.39	0.06	0.15	0.05	0.06

planted. For a good wheat crop and competitive crop stand, the prescribed agronomic procedures were followed. Days to 75 percent flowering, plant height (cm), peduncle length (cm), number of productive tillers per plant, days to maturity, spike length (cm), number of spikelet's per spike, number of grains per spike, 1000-grain weight (g), biological yield per plant (g), grain yield per plant (g), harvest index (percent) were all observed on five randomly selected competitive plants from each genotype in each replication. On the basis of Panse and Sukhatme's model (1969), the treatment means for all characteristics were used to compute the analysis of variance.

Heritability estimates : In a wide sense, heritability [Allard (1960)] estimated H^2 (b) as a ratio of genotypic (V_G) to phenotypic variance (V_P). Given as :

$$\text{Broad-sense heritability} = H^2 = \frac{V_G}{V_P} = \frac{V_G}{V_G + V_E}$$

Here V_E stands for environmental variation.

Thus, heritability is the proportion of the total variance that is due to genetic variance, thereby it helps in selection. Heritability estimates provide information about genetic.

Genetic advance : Plant breeders can use heritability estimates to forecast gain if accompanied with estimates of genetic advance.

Genetic advance was calculated according to Allard's (1964) by the following formula;

$$\text{Genetic advance (GA)} = i H^2 \sqrt{V_P}$$

Where,

i = selection intensity; H^2 = heritability for a trait; $\sqrt{V_P}$ = square root of the phenotypic variance of a trait. Selection intensity at 5% will be 2.06.'

Results and Discussion

The analysis of variance was found highly significant for all of the traits studied, indicating that there was enough

variation among the genotypes (Table-1). This suggests that there is enough scope for selecting superior genotypes to improve genetic yield potential. High heritability and genetic progress are more useful than heritability estimates alone in predicting the gain under selection as high heritability does not always indicate a high genetic gain; hence heritability is recommended to be considered in association with genetic advance to predict the effect of selection (Johnson *et al.*, 1995).

Days to 75% flowering : For this trait, the analysis of variance indicated highly significant variation among the genotypes (Table-1), indicating the presence of genetic variability and providing considerable room for improvement (Anwaret *et al.*, 2009) The data's mean values ranged from 82.50 (1003) to 91.83 (1006) days, with an average of 88.15 days (Table 2). The genetic variance was found to be 2.93. Heritability (53.02) and a significant number of genotypes tested (Table 3). Moderate heritability coupled with low genetic advance indicating that this trait was mainly controlled by non-additive type of genes hence selection in early generation would not be effective. Chandrashekhar and Kerketta (2004, 2005) reported similar findings.

Plant height : The plant height represented enough variation across the genotypes. The average plant height was 88.59 cm. with a range of 74.61 (10001) to 100.61 (8043) (Table 2). The character had high heritability (93.64) and moderate genetic progress (11.48) when genetic variance was assessed at 0.05. (Table-3). The results for this feature are consistent with Moshref *et al.*, report's (2000).

Peduncle length (cm) : The variance for this trait is highly significant ($p < 0.01$) (Table 1). The data mean values ranged from 28.93 [1019] to 37.53 (2059), with a 35.50 cm. average (Table 2). The genetic variance was found to be 3.95. The examined genotypes (Table 3) showed high heritability (69.65) and modest genetic progress (10.18), indicating that there is room for improvement through simple selection. Gollen *et al.* (2011) obtained the same results.

Table-2 : Mean performance.

S. No.	Genotypes	Days to 75% flowering	Plant height (cm)	Peduncle length	No. of productive tiller/plant	Days to maturity	Spike length (cm)	No. Of spikelet/s/spike	No. Of grains/s/pike	1000 grain weight	Biological yield/plant (gm)	Grain yield/plant (gm)	Harvest index/plant (%)	Gluten content (%)	Protein content (%)
1.	1001	84.50	88.28	30.77	4.70	115.17	9.21	16.10	53.47	39.00	22.75	8.93	39.33	7.18	11.57
2.	1003	82.50	92.66	32.37	4.73	117.50	8.74	16.52	60.93	39.17	28.61	11.13	38.92	8.00	11.33
3.	1006	91.83	93.73	31.53	4.73	115.50	11.02	17.47	59.57	42.93	25.84	10.02	38.80	8.13	11.37
4.	1013	86.83	87.36	31.17	4.70	115.00	10.61	16.27	60.13	36.03	22.66	8.93	39.54	7.10	12.58
5.	1019	88.83	86.98	28.93	4.40	118.67	9.40	15.80	60.43	37.83	27.46	10.82	39.39	7.38	12.13
6.	1022	90.67	89.85	32.02	4.28	117.50	11.29	17.50	51.50	41.42	24.56	9.57	38.95	8.55	11.43
7.	NADI 1026	89.00	93.04	32.53	4.13	115.00	9.59	16.40	51.47	37.58	22.09	8.70	39.38	7.72	11.32
8.	CHIPAK 1033	87.17	92.63	32.10	4.83	116.00	10.36	16.40	60.07	37.75	27.23	10.67	39.21	7.25	12.08
9.	1036	89.33	93.08	32.40	4.70	118.67	10.55	16.93	55.37	42.62	19.43	7.82	40.22	7.47	13.25
10.	GS 1039	85.17	86.16	31.37	4.73	118.83	9.89	18.13	41.47	41.25	20.23	7.95	39.28	8.20	12.08
11.	1040	87.33	84.04	31.60	4.23	118.67	8.28	16.07	58.83	38.53	25.11	9.93	39.53	8.57	11.45
12.	1043	84.17	91.06	34.13	4.27	118.50	10.54	16.47	57.57	49.42	18.25	7.22	39.51	7.28	11.98
13.	1051	86.67	85.43	31.50	4.53	117.83	9.45	16.07	59.87	38.00	23.04	9.05	39.27	7.50	11.50
14.	1052	85.33	98.68	32.60	4.03	119.33	10.76	17.73	42.23	38.17	12.34	4.88	39.44	7.40	12.50
15.	2003	87.50	85.91	37.07	4.23	119.00	10.39	16.73	32.93	41.10	12.00	4.73	38.83	8.65	11.45
16.	2019	86.33	85.13	31.50	4.40	119.33	9.58	17.40	81.07	39.33	29.92	11.65	38.97	7.27	12.55
17.	2020	90.67	90.81	35.23	4.37	114.17	9.72	16.60	43.03	43.38	14.49	5.65	39.00	7.22	12.23
18.	2021	89.50	92.51	36.27	4.67	116.83	9.46	15.93	56.73	35.42	22.31	8.65	38.81	7.92	11.43
19.	2027	90.33	86.31	31.23	4.40	119.33	9.41	16.00	70.63	48.33	27.38	10.67	38.97	7.47	11.67
20.	2040	89.33	91.96	37.45	4.37	115.17	10.08	15.60	66.03	39.80	26.05	10.23	39.29	7.23	13.15
21.	2059	87.67	88.08	37.53	4.93	117.83	9.89	17.73	59.77	38.75	24.83	9.72	39.14	8.07	11.97
22.	HD 2733	91.00	75.91	34.13	4.93	118.50	8.63	19.20	52.03	41.75	24.57	9.68	39.39	7.32	12.57
23.	3009	87.50	88.84	32.50	4.57	117.33	9.83	16.07	67.20	37.13	27.90	10.78	38.68	7.90	11.70
24.	3016	91.00	98.59	32.78	4.67	118.00	9.60	15.53	58.63	38.67	26.08	10.22	39.18	7.95	12.05
25.	4007	89.67	84.16	31.70	4.80	115.50	9.95	15.80	58.47	42.30	24.57	9.67	39.33	7.45	11.75
26.	4018	89.33	92.03	31.23	4.80	115.67	10.14	15.80	48.90	29.65	23.30	9.22	39.57	8.47	12.53
27.	4032	89.33	81.91	30.13	4.50	114.00	9.88	15.67	55.67	43.57	24.56	9.63	39.22	8.28	11.88
28.	4058	88.67	85.50	36.38	4.93	117.33	10.23	16.20	38.17	39.67	14.68	5.72	38.95	7.68	12.28
29.	5006	86.83	83.74	33.37	4.87	117.67	8.88	15.67	55.93	39.38	24.28	9.48	39.06	7.92	12.45
30.	5040	87.33	80.51	31.63	4.37	119.83	9.67	15.87	59.60	40.17	24.24	9.45	38.97	7.68	12.65
31.	6013	86.33	84.31	31.10	4.80	119.00	10.49	16.87	97.47	41.02	39.46	15.52	39.35	7.30	11.72
32.	PBW6512 X PASTON 6017	87.33	87.84	35.38	4.93	119.67	8.20	15.87	62.17	39.92	24.10	9.73	40.38	8.63	12.62

Table-2 : Contd....

S. No.	Genotypes	Days to 75% flowering	Plant height (cm)	Peduncle length	No. of productive tiller/plant	Days to maturity	Spike length (cm)	No. Of spikelets/s/ spike	No. Of grains/s/ pike	1000 grain weight	Biological yield/plant (gm)	Grain yield/plant (gm)	Harvest index/plant (%)	Gluten content (%)	Protein content (%)
33.	6047	87.00	91.95	36.12	4.67	118.50	8.72	16.40	80.67	41.08	28.74	11.17	38.80	7.93	12.18
34.	6059	89.67	86.81	34.48	5.25	119.00	8.96	15.20	59.00	39.58	24.09	9.53	39.57	7.28	12.70
35.	8010	86.67	90.93	34.65	4.77	115.50	10.60	17.47	56.53	39.23	23.11	9.08	39.30	7.68	11.33
36.	8028	89.17	88.18	34.95	5.00	118.83	10.82	19.40	63.10	37.92	25.83	10.17	39.35	7.25	12.25
37.	8031	87.67	88.25	36.87	4.60	117.83	10.28	16.27	59.97	39.92	24.54	9.65	39.31	7.40	11.38
38.	8043	87.83	100.62	34.75	5.20	119.83	9.65	16.60	68.97	39.50	25.44	10.00	39.30	7.52	11.60
39.	8050	90.33	91.88	37.03	5.07	119.67	9.76	17.67	63.33	42.93	24.31	9.60	39.46	7.33	12.00
40.	8054	85.67	85.47	35.08	4.80	118.50	10.40	18.53	47.37	41.00	23.96	9.42	39.55	7.83	12.80
41.	8056	89.17	90.84	34.67	4.57	113.83	11.00	17.10	60.23	40.50	24.16	9.58	39.65	7.50	12.42
42.	9016	91.50	95.79	35.10	4.70	114.17	9.77	17.67	42.57	39.15	14.68	5.90	40.14	7.95	11.43
43.	9050	87.83	90.12	36.02	4.93	114.50	9.62	17.13	39.63	38.35	14.24	5.65	40.02	8.42	13.12
44.	9051	89.00	85.94	34.57	4.47	119.00	9.57	15.73	63.23	41.83	24.73	9.78	39.81	7.95	12.27
45.	9053	87.67	84.60	35.18	4.50	117.67	10.46	15.87	41.13	39.18	14.42	5.75	39.90	7.73	11.38
46.	10001	88.17	74.61	32.97	4.80	120.83	8.84	19.67	38.80	41.75	15.01	5.90	39.29	7.75	12.50
47.	10006	88.33	88.41	33.97	4.77	120.00	8.95	16.80	49.03	41.52	21.11	8.55	40.50	7.68	12.02
48.	10008	89.83	87.18	34.53	4.53	118.83	10.32	18.10	58.07	39.35	22.82	9.12	39.94	7.22	12.07
49.	10013	87.50	84.23	32.90	4.43	120.50	9.30	18.87	68.57	40.42	25.97	10.05	38.59	7.77	11.48
50.	10014	90.50	86.05	31.20	4.90	119.67	9.35	18.80	58.47	41.93	24.18	9.58	39.62	8.43	11.65
51.	10020	88.17	88.77	35.61	4.70	119.83	10.12	17.80	54.73	42.42	22.83	8.70	38.22	7.50	12.74
52.	10021	87.33	99.03	34.07	4.47	118.33	10.22	17.73	67.43	42.85	25.23	9.98	39.54	7.43	11.60
	Mean	88.15	88.59	33.58	4.65	117.71	9.82	16.87	57.27	40.18	23.15	9.10	39.34	7.73	12.04
	Max	82.50	74.61	28.93	4.03	113.83	8.20	15.20	32.93	29.65	12.00	4.73	38.22	7.10	11.32
	Min	91.83	100.62	37.53	5.25	120.83	11.29	19.67	97.47	49.42	39.46	15.52	40.50	8.65	13.25
	SE(d)	1.32	1.09	1.07	0.19	1.13	0.28	0.55	0.86	0.36	0.51	0.20	0.32	0.19	0.20
	C.D. at 5%	2.61	2.16	2.13	0.39	2.25	0.55	1.09	1.70	0.71	1.02	0.39	0.63	0.37	0.40
	C.V. (%)	1.83	1.50	3.91	5.12	1.18	3.44	3.97	1.83	1.09	2.71	2.65	0.99	2.96	2.03

Table-3 : Estimation of heritability and genetic advance for different characters of wheat genotypes.

Genotypes	Variance (g)	Heritability (%)	GA% mean	GA% mean
Days to 75% flowering	2.93	53.02	2.91	2.91
Plant height (cm)	26.07	93.64	11.49	11.49
Peduncle length	3.95	69.65	10.18	10.18
No. of productive tiller/plant	0.05	47.53	6.93	6.93
Days to maturity	3.02	61.16	2.38	2.38
Spike length (cm)	0.47	80.58	12.94	12.94
No. of spikelets/spike	1.07	70.59	10.64	10.64
No. of grains/spike	132.89	99.18	41.29	41.29
1000 grain weight	8.58	97.80	14.85	14.85
Biological yield/plant (gm)	24.56	98.42	43.76	43.76
Grain yield/plant (gm)	3.70	98.46	43.21	43.21
Harvest index/plant (%)	0.15	49.55	1.43	1.43
Gluten content (%)	0.17	76.63	9.66	9.66
Protein content (%)	0.27	81.66	7.97	7.97

Number of productive tillers per plant

For this trait, the analysis of variance indicated extremely significant differences among the genotypes (Table-1), indicating that there is adequate diversity among the genotypes and ample room for improvement. Tazeen and Naqvi (2009) found similar findings. Tillers/plant mean values ranged from 4.03 (1052) to 5.25 (6059), with an average of 4.65 (Table 2). The genotypes that were tested had moderate heritability (47.63) and modest genetic progress (6.93) (Table-3). Zhang made a similar observation (1987). This suggests that the environment has a strong influence on the character, and that genetic improvement through selection will be difficult due to the environmental influence.

Days to maturity : Significant differences ($p < 0.05$) were found for this trait (Table-1), implying that there is enough variability among genotypes to allow for further improvement. With an average of 117.71 days, mean values ranged from 120.83 10001 to 113.83 (8056) (Table-2). The genetic variance was calculated to be 3.02. The trait had a high heritability (61.16) but a low genetic progress (2.38%). (Table-3). The finding for this trait is consistent with Moshref, *et al.*, (2000).

Spike length : Spike length plays an important effect on seed germination and yield. The results for all genotypes were very significant ($p < 0.05$) (Table-1). The length of the spikes varied from 8.20 to 11.28 cm. The genotype (PBW6512 X PASTON 6017) had the longest spike length (10.22), while the genotype (PBW6512 X PASTON 6017) had the shortest spike length (9.82 cm) (Table 2). The genetic variance was 0.47. This variable had a high heritability (80.58) and moderate genetic progress (12.94) (Table-3), indicating additive gene action and the possibility of selection. Gollenet *et al.*, (2011) found similar results.

Number of spikelet's per spike : For this trait, the analysis of variance indicated very significant differences among genotypes (Table-1), indicating that there is enough diversity among genotypes to allow for further improvement (Mekbib, 2003; Parvizet *al.*, 2015). The data's mean values ranged from 15.20 (6059) to 19.67 (10001) days, with an average of 16.87 days (Table-2). 1.07 was the genetic variance. The genotypes studied had a high heritability of 70.99 and a moderate genetic advance of 10.64 (Table-3).

1000-grain weight : Grain weight is an important yield determinant since it has a big influence on a genotype's yield potential. For 1000-grain weight, the analysis of variance revealed highly significant differences (Table-1). As a result, there is significant variety among the genotypes, indicating that there is room for improvement. The grain weight recoded ranged from 29.65 to 49.42 g, with an average of 40.18 gm. The minimal and highest ranges were found in genotypes 4018 and 1043, respectively (Table-2). The genetic variance was calculated to be 8.58. High heritability (97.80) and moderate genetic progress (14.85). (Table-3). Similar findings were found by Jagshoran *et al.* (2005), Khokhar *et al.* (2015), and Maan and Yadav (2010), demonstrating that direct selection may be efficient due to the presence of additive gene effects.

Biological yield per plant : For all of the features tested, the analysis of variance indicated extremely significant differences across the genotypes (Table-1), indicating that there is enough variety among the genotypes to allow for further improvement. The data's mean values ranged from 12.00 (2003) to 39.46 (6013), with an average of 23.15 g. (Table 2). The genetic variance was found to be 24.56. High heritability (98.42) and genetic advancement (43.76) (Table 3). Saxena *et al.* (2007), Maan and Yadav (2010), and Kauland Singh (2010) have previously found

significant heritability along with high genetic progress for this feature (2011). This shows that additive genetic diversity has a significant role in the expression of the feature.

Grain yield per plant : Plant breeders' ultimate goal is to increase grain output. Grain yield data revealed significant variations ($p < 0.01$) (Table-1), implying that there is adequate diversity among genotypes and room for further development. In this study, (6013) had the maximum grain yield (15.52), while (2003) had the lowest grain yield range (4.73), with an average of 9.10 g. (Table-2). The genetic variance was found to be 3.76. The examined genotypes (Table 3) had a high heritability (98.46) and a high genetic advance (43.21), indicating the likelihood of a big response to selection and increased opportunities for wheat improvement. Bhoiteet al. (2008), Nagireddy and Jyothula (2009), Khokhar *et al.* (2010), and Maan and Yadav (2010) found similar results.

Harvest index (%) : For this attribute, analysis of variance indicated extremely significant differences ($p < 0.01$) (Table 1), showing that there is adequate variety among genotypes and plenty of room for improvement. The mean values ranged from 38.22 (10020) to 40.50 (10006), with a 39.34 percent average (Table-2). The genetic variance was 0.15, with a moderate heritability of 49.55 and a low genetic advance of 1.43. (Table-3). The prevalence of non-additive gene action was revealed by modest heritability combined with low genetic progress for harvest index, implying that direct selection for such features might mislead the predicted outcomes.

Gluten content (%) : For this trait, the analysis of variance indicated very significant variations between genotypes ($p < 0.05$) (Table-1), indicating that there is enough diversity among genotypes to allow for further improvement. The average was 7.73 percent, with mean values ranging from 7.10 (1013) to 8.65(2003) (Table-2). The genetic variance was 0.17, with a high heritability (76.63) and a modest genetic advance of 9.66 (Table-3). Gluten content has a high heritability and a moderate genetic advance, indicating that dominance and epistatic effects are important in the inheritance of this character, and therefore selection for this character would be less successful. These findings contradicted those of Yadav *et al.*, (2014).

Protein content (%) : For this trait, the analysis of variance indicated very significant variations between genotypes ($p < 0.05$) (Table-1), indicating that there is enough diversity among genotypes to allow for further improvement. The mean values ranged from 11.32 percent (NADI 1026) to 13.25 percent (NADI 1036), with a 12.04 percent average (Table 2). The genetic variance was found to be 0.27. With a high heritability of 81.66%

and a low genetic progress of 7.97%, (Table-3). Gluten content has a high heritability and a moderate genetic advance, indicating that dominance and epistatic effects are important in the inheritance of this character, and therefore selection for this character would be less successful. These findings contradicted those of Yadav *et al.*, (2014).

Conclusions

In the genotypes investigated, there was a significant proportion of genetic variation, indicating that there was a lot of room for selection. Plant height, peduncle length, days to maturity, spike length, number of spikelets per spike, number of grains per spike, 1000-grain weight, biological yield per plant, grain yield per plant, protein content, and gluten content all showed a high heritability. For number of grains/spike, biological yield/plant and grain yield/plant, have shown high heritability and genetic advance were observed. Characters having high heritability and high genetic advance as per cent of mean indicates the predominance of additive gene action and selection for such traits is being effective. Hence in a breeding program a proper weightage should be given to those components of yield which recorded high heritability estimate followed by high genetic advance and less weightage should be given to those component traits of yield which had recorded low to medium heritability estimates coupled with low genetic advance.

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Effect of Fine Rice Genotypes to Different Levels of Major Nutrients

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Abstract

A field experiment was conducted in *Kharif* season during the year 2017 and 2018. The experiment was laid down in Randomized Block Design with four fine rice genotypes viz. *OR-2329-03*, *OR-2380-02*, *OR-2542-12* and *MTU-7029 (Swarna)* and three doses of major nutrients viz. N:P₂O₅:K₂O :: 80::40:40 kg/ ha, N:P₂O₅:K₂O :: 100::50:50 kg/ ha and N:P₂O₅:K₂O :: 120::60:60 kg/ ha which were replicated thrice. The soil of the experiment was clay loam in texture with P^H 5.9, Organic Carbon 0.62 % and available N, P₂O₅, K₂O was 265.25, 38.85 and 215.40 kg/ ha respectively. The two years pool data shows that, these twelve (12) treatments expressed significant difference on plant height, dry matter, LAI and tiller production. The number of tiller was highest in *MTU-7029 (Swarna)* with application of N:P₂O₅:K₂O:: 120::60:60 kg/ ha (T₃). The treatment having variety *OR-2329-3* and application of N:P₂O₅:K₂O:: 120::60:60 kg/ ha was also produced highest grain yield 3.69 ton /ha which was at par with the variety *OR-2542-12* with N:P₂O₅:K₂O:: 120::60:60 kg/ ha. The lowest straw yield 3.15 ton/ha was observed from the genotype *OR-2380-02* with N:P₂O₅:K₂O :: 80::40:40 kg/ ha. The highest gross return (Rs. 62,049/-) , net return (Rs.22,804/-) and BC ratio (1.58) were observed in the T₁₂ treatment having variety *OR-2329-3* and application of N:P₂O₅:K₂O:: 120::60:60 kg/ha.

Key words : Fine rice genotypes, NPK nutrients, grain yield, harvest index, BC ratio.

Introduction

The increasing land use intensity without adequate and balanced use of chemical fertilizers with little or no use of organic manure have caused severe fertility deterioration of the soil resulting in stagnating or even declining crop productivity. There is growing concern about the sustainability of the rice production system due to stagnation or decline in yield in some states of India. (*Shekara and Nagarajushreedhara, 2010*). The application of fertilizer in proper amount must be done to boost up the rice production to an economically desirable level. An experiment was conducted with the objective to determine an economically optimum dose of nutrients at which fine rice genotypes gave maximum yield (*Dwivedi and Thakur, 2000*).

Materials and Methods

A field experiment was carried out during kharif 2017 and 2018 at Central Research Farm, OUAT, Bhubaneswar. The experiment was laid out in randomized block design with three replications, keeping four fine rice genotypes with three nutrient levels. The soil of the site was clay loam in texture with P^H (5.9), Organic Carbon (0.62%) available N (265.25 kg/ha), P₂O₅ (38.85 kg/ha) and K₂O (215.40 kg/ha). The biometric observations like plant height, no. of tillers , dry matter accumulation were taken at a regular interval of 30th, 60th and 90th days after transplant (DAT) and at harvest. Yield attributes and productivity were recorded before and after harvesting as per the

investigation required. The leaf area index (LAI) was measured by using portable digital plant canopy analyser. The Crop Growth Rate (CGR) calculated by using standard formula. The Fertile spikelet as well as sterile spikelet per panicle was estimated by manual counting. The Test weight (1000 grain weight) were taken from the grain samples after proper threshing and cleaning the final grain. The Harvest Index was also calculated by using formula, HI = Economical Yield x 100 / Biological Yield. The cost of cultivation was work out by taking into consideration of all the expenses incurred. The gross return was worked out by multiplying grain and straw yield with its prevailing market price and expressed in Rupees per Hectare. The fine rice genotypes were transplanted in mid August and harvested in mid December. The need based plant protection measures and irrigations applied to the crop during experimentation. The data collected from the experiment during both the years were subject to statistical analysis to draw valid conclusion (*Gomez and Gomez, 1976*).

Results and Discussion

The levels NPK brought significant effect on all the growth parameters viz. plant height, number of tillers, dry matter accumulation, leaf area index at different growth stages. These parameters were progressively enhanced from lower to higher dose of nutrients (Table-1). The plant height of all the four fine rice genotypes from 60 DAT (Days After Transplant) was highest followed by a reduced rate of growth then onwards till harvest. It was

Table-1 : Effect of fine rice genotypes and different levels of nutrients on plant growth parameters (Pool data of 2017 & 2018).

Treatment	Details of the combination of genotype & nutrient level	Plant Height (cm)		No. of tillers per plant		LAI (Leaf Area Index)		Dry matter accumulation per hill (g)	
		60 DAT	At harvest	60 DAT	At harvest	60 DAT	At harvest	60 DAT	At harvest
T ₁	OR-2329-3 X N:P ₂ O ₅ :K ₂ O :: 80::40:40 kg/ ha	73.23	86.47	15.60	13.60	6.58	2.55	25.10	36.92
T ₂	OR-2380-02 X N:P ₂ O ₅ :K ₂ O :: 100::50:50 kg/ha	95.50	109.63	15.20	14.77	6.62	1.75	38.11	50.55
T ₃	MTU-7029 (Swarna) X N:P ₂ O ₅ :K ₂ O:: 120::60:60 kg/ha	55.50	69.10	18.20	16.20	6.28	1.41	27.04	35.75
T ₄	MTU-7029 (Swarna) X N:P ₂ O ₅ :K ₂ O:: 80::40:40 kg/ha	59.50	73.43	14.63	11.97	6.29	1.78	36.69	30.63
T ₅	OR-2542-12 X N:P ₂ O ₅ :K ₂ O :: 80::40:40 kg/ha	83.70	91.83	16.87	14.87	7.33	2.09	42.60	52.77
T ₆	OR-2329-3 X N:P ₂ O ₅ :K ₂ O:: 100::50:50 kg/ha	94.27	103.77	16.10	13.53	7.38	2.49	49.18	62.36
T ₇	OR-2542-12 X N:P ₂ O ₅ :K ₂ O:: 120::60:60 kg/ ha	98.10	109.73	15.83	13.60	7.43	1.86	50.15	63.44
T ₈	OR-2380-02 X N:P ₂ O ₅ :K ₂ O:: 120::60:60 kg/ha	97.13	108.23	19.90	16.20	7.20	2.17	67.44	79.33
T ₉	OR-2380-02 X N:P ₂ O ₅ :K ₂ O:: 80::40:40 kg/ ha	97.37	106.87	12.37	9.73	6.69	1.69	48.14	54.66
T ₁₀	MTU-7029 (Swarna) X N:P ₂ O ₅ :K ₂ O:: 100::50:50 kg/ha	61.63	77.7	15.73	12.80	6.56	2.45	21.98	31.64
T ₁₁	OR-2542-12 X N:P ₂ O ₅ :K ₂ O:: 100::50:50 kg/ ha	98.43	109.77	14.40	13.20	6.53	2.33	41.16	48.97
T ₁₂	OR-2329-3 X N:P ₂ O ₅ :K ₂ O:: 120::60:60 kg/ ha	99.77	114.20	15.33	12.83	7.53	1.24	51.35	61.87
CD (P= 0.05)		5.95	2.44	1.67	3.5	1.32	0.79	1.08	4.04

DAT-Days After Transplant

found that, plant height was highest (114.20 cm) at T₁₂ followed by T₁₁ and T₇ at the time of harvesting. This reveals that, Nitrogen was instrumental in controlling the height of the plant in these new genotypes as compared to the Swarna (MTU-7029), (Murthy *et al.* 2012). It was observed from the present experiment that tillering continued till 60 DAT, and then it decreased up to harvesting. Decline in tiller number would have occurred due to mortality of the late formed tillers. The number of tillers was highest (16.20) in T₃ and T₈, however it was at par with T₁, T₂, T₅, T₆, T₁₀, T₁₁, T₁₂. It might be due to the treatment T₃ and T₈, were most suitable for the optimum expression of the above physiological condition. The minimum numbers of tillers were formed in T₉ (9.73) where comparatively low dose of fertilizer was provided thus it was observed that application of nutrient is more important. The leaf area index (LAI) was the efficiency of photosynthetic process and revealed the extent of photosynthetic surface of the crop. The LAI was highest in T₁₂ (7.53) at 60 DAT, where uppermost level of chemical fertilizers was applied which was followed by T₅ and at par with T₆, T₇ and T₈. The rate of crop dry matter accumulation was the product of total incident of solar

radiation, the dry matter was the absorptance of incident solar radiation by the crop canopy. The dry matter accumulation per hill increased progressively with age till maturity of the rice plants. It was observed highest in T₈ (66.44 gm) at 60 DAT followed by T₁₂. Similar trend also observed at the time of harvest. This shows that high application of nutrients produced higher amount of dry matters (Table-1). The CGR measure the efficiency of the production of total crop in unit time over a given land area. 90 DAT to harvest CGR was highest to T₁₂ (2.47 g/day/m²) where all the nutrients given to its upper most dose and found to be significant T₃, T₄ and T₁₀ were remain at par with each other (Banerjee and Pal, 2012). The lucid effect of NPK level was also observed on yield and yield attributing characters such as panicles per meter square, number of filled grain per panicles and grain test weight (Table-2). The fertile spikelet per panicle was maximum in T₁₂ (450.21) and minimum in T₂ (300.69). The fertility percentage was maximum in T₁₂ (98.46 %) followed by T₈ (96.82 %) and lowest in T₁ (78.78 %) where lowest dose of nutrient was given. The thousand grain weight (Test weight) is an important yield determining component and genetic characteristic of the variety least

Table-2 : Effect of fine rice genotypes and different levels of nutrients on CGR, Fertility percentage, Test weight, Grain yield, Straw yield and Harvest index (Pool data of 2017 & 2018).

Treat- ment	Details of the combination of genotype & nutrient level	CGR (Crop Growth Rate) g/day/m ²		Fertile spikelet per panicle	Fertility (%)	Test weight (g)	Grain yield (t/ha)	Harvest Index	Gross return (Rs/ha)	Benefit Cost Ratio
		30 to 60 DAT	90 to Harvest							
T ₁	OR-2329-3 X N:P ₂ O ₅ :K ₂ O :: 80::40:40 kg/ ha	4.94	1.43	408.59	78.78	20.84	3.30	0.41	55,770	1.49
T ₂	OR-2380-02 X N:P ₂ O ₅ :K ₂ O :: 100::50:50 kg/ ha	6.27	1.82	300.69	82.98	21.35	2.35	0.36	56,260	1.47
T ₃	MTU-7029 (Swarna) X N:P ₂ O ₅ :K ₂ O:: 120::60:60 kg/ ha	5.48	1.12	408.59	83.97	20.44	2.35	0.41	39,635	1.19
T ₄	MTU-7029 (Swarna) X N:P ₂ O ₅ :K ₂ O:: 80::40:40 kg/ ha	5.35	1.04	352.98	88.10	19.86	2.18	0.40	37,038	1.12
T ₅	OR-2542-12 X N:P ₂ O ₅ :K ₂ O :: 80::40:40 kg/ ha	6.24	2.10	445.55	93.29	22.20	2.63	0.32	48,083	1.29
T ₆	OR-2329-3 X N:P ₂ O ₅ :K ₂ O:: 100::50:50 kg/ ha	5.46	2.12	390.60	79.08	22.13	2.74	0.33	49,714	1.30
T ₇	OR-2542-12 X N:P ₂ O ₅ :K ₂ O:: 120::60:60 kg/ ha	5.14	2.05	324.10	86.96	22.34	3.54	0.39	59,045	1.50
T ₈	OR-2380-02 X N:P ₂ O ₅ :K ₂ O:: 120::60:60 kg/ ha	6.24	2.45	448.55	96.82	21.86	3.53	0.37	61,353	1.56
T ₉	OR-2380-02 X N:P ₂ O ₅ :K ₂ O:: 80::40:40 kg/ ha	5.29	1.76	317.34	93.52	21.84	2.39	0.31	44,039	1.18
T ₁₀	MTU-7029 (Swarna) X N:P ₂ O ₅ :K ₂ O:: 100::50:50 kg/ ha	5.12	1.08	304.02	92.40	20.86	2.27	0.39	39,078	1.17
T ₁₁	OR-2542-12 X N:P ₂ O ₅ :K ₂ O:: 100::50:50 kg/ ha	5.59	2.15	415.91	94.11	22.64	2.55	0.37	44,435	1.16
T ₁₂	OR-2329-3 X N:P ₂ O ₅ :K ₂ O:: 120::60:60 kg/ ha	6.31	2.47	450.21	98.46	22.42	3.69	0.42	62,049	1.58
CD	—	0.12	0.08	2.98	NS	NS	0.13	0.19	—	—

(P=0.05)

DAT-Days After Transplant

influenced by the environment. The test weight was highest in T₁₁ (22.64 g) and lowest in T₄ (19.86 g). The treatment T₁₂ which comprises top dose of the fertilizer applied to the genotype OR-2329-03 performed the best 3.69 t/ ha and it was at par with T₈ and T₇. The grain yield was lowest in T₄ (2.18 t/ha) followed by T₁₀ (2.27 t/ha) where less amount of nutrient applied to Swarna (MTU-7029). The harvest index of the fine rice genotypes was highest in T₁₂ (0.42) which was followed by T₃ (0.41) and T₁, T₂, T₄, T₈, T₇, T₁₀ and T₁₁ which were remain at par,

(Singh and Jain, 2000). The higher NPK levels observed at par with each other regarding different yield attributes, however in respect of grain yield it differed significantly (Table-2). Increasing levels of NPK from 80:40:40 kg/ha to 120:60:60 kg/ha had markedly enhanced the gross return and net return (Zaidi and Tripathi, 2007). The maximum gross return (Rs.62, 049 per ha.), net return (Rs.22,804 per ha.) and highest benefit cost ratio (1.58) was obtained with N:P:K::120:60:60 kg/ha (Siddiq *et al.* 2011). Based on two years result, it may be concluded that fine rice genotype 'OR-2329-03' responded favourably to the N:P:K::120:60:60 kg/ha for achieving maximum grain yield at Bhubaneswar region.

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Four Decades of Research on Safflower at AICRP on Safflower Solapur

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All India Coordinated Research Project on Safflower, ZARS, Solapur (MPKV, Rahuri),

Abstract

The research efforts were made to evolve superior genotypes of Safflower. The earlier Varieties were Late, Low yielding, Low oil content not wider adaptable, Susceptible to Pest and Diseases. The research work was carried out since establishment of the project 1980 to work and to solve the problems rain fed safflower by developing varieties of safflower Early types, High seed, High seed oil content, Resistant/tolerant to Alter, Tolerant Aphids and responsiveness to Fertilizer. Eleven Varieties were identified and released for cultivation for State and Nation viz., Bhima (S4), Girna (JLSF 88), Phule Kusuma (JLSF 414), SSF 658 (Non Spiny), SSF 708, SSF 733 (Phule Kardi), Phule Chandrabhaga (SSF748), Phule Nira (SSF 12-40), Phule Bhivara (SSF 13-71) SSF 15-62 (High Oil) and SSF 16-02. Eleven varieties with High Oil content (33-35 %), Four Bold Capitula (3-4 cm dia), Appressed types (4), Vegetable types (3) and Early, dwarf type with high oil content, Alternaria tolerant & Wilt Resistant: (01) Resistant/Tolerance source identified: Aphid tolerant: 22 Alternaria tolerance: 06, Wilt resistant 10, Moderately resistant: 15, Fusarium wilt : Immune : 11 Moderate : 25, Resistant : 20 Recommendations: Agronomy: 05, Plant Pathology: 06 and Entomology: 03.

Key words : Safflower, phule, SSF, varieties, spiny and non spiny, wilt, resistant, tolerant

Introduction

Safflower (*Carthamus tinctorius* L.) is an important rabi oilseed crop of the country. The area under safflower in India was 0.81 lakh ha, having 0.55 lakh ton production and productivity of 679 kg/ha (Anonymous 2017-18). In Maharashtra it is grown over an area of 0.39 lakh ha with production 0.21 lakh ha and average yield of 548 kg/ha. The numbers of high yielding spiny varieties are released for commercial cultivation. From 1976 to 2010 "The area under this crop is declining due to several reasons. The availability of seed of high yielding varieties and resistant/tolerant to Pests and diseases. Considering these constraints research work was carried out and varieties were identified and released to solve the problems of rain fed Safflower.

Materials and Methods

Economic Importance and its uses : Safflower has been grown in India since ancient times. It is used for :

- (i) Orange red dye extracted from its glittering florets but also for its seed oil. For textile industries.
- (ii) **Edible oil :** Safflower produces oil rich in polyunsaturated fatty acids (Linolic acid 78%) which play an important role in reducing blood cholesterol level and is considered as a healthy cooking medium. Oil is also used for illuminating and as hair oil.
- (iii) Drying oil in the preparation of paints, varnishes and surface coatings.

(iv) The oil is an effective non-allergenic dispersing agent for injects able medications.

(v) Dried red and orange flowers are sold as substitutes for saffron in markets, Flowers are also used in the preparation of cosmetics.

(vi) Dried flowers are useful to prepare infusions that are helpful in the treatment of many problems of the circulatory systems for inflammation and muscular fatigue.

(vii) The safflower plant also makes an acceptable livestock forage in times of scarcity, if cut at or just after bloom stage. It can also be used.

Considering these importance constraints of rain fed conditions of the crop Safflower the research work was carried since from establishment the varieties were narrated here.

Safflower Uses



Seed



Oil



Paint



Saffron



Safflower Tea

Review of Research

These Varieties were developed by The Research center, All India Coordinated Research Project on Safflower ZARS, MPKV, Solapur is summarized.

Sr. No.	Name of the Variety	Year of Release	Photo	Specific Characters
1.	Bhima (S 4)	1982 for Maharashtra		i) Average yield 13-15 q/ha ii) Duration 120 to 130 DAS iii) Oil Content 29-30 % iv) Moderately tolerant Pests and Diseases v) Flower Colour at Bloom Creamy White at fading stage dirty white with pink Spots
2.	Girna (JLSF-88)	1990 for Maharashtra		i. Average yield: 13-14 q/ha ii. Oil content: 28-29 % iii. Duration-130-135 days iv. Tolerant to aphid v. Moderately resistant to wilt vi. Flower colour at bloom stage –Yellow vii. Flower colour at fading stage-Orange
3.	Phule Kusuma (JLSF 414)	2003 for rainfed as well as irrigated areas, Maharashtra, Andra Pradesh and Madhya pradesh		i Average yield: Rainfed-12-15 q/ha, Irrigated-20-22 q/ha ii Oil content-29% iii Moderately tolerant to aphids iv Duration-125-140 days v Flower colour at bloom stage- Dark yellow vi Flower colour at fading stage- Red
4.	SSF-658 (Non spiny)	2006 Safflower growing areas of India for rainfed as well as irrigated Situations		i. Average seed yield – 12-13 q/ha ii. Oil content-27% iii. Days to maturity- 120-125 days. iv. Moderately tolerant to aphid. v. Tolerant to wilt. vi. Petal yield-90-110 kg/ha
5.	SSF-708	2010 Cultivation under rainfed and irrigated conditions of Maharashtra state.		Average seed yield Rainfed-14-16 q/ha, Irrigated-20-25 q/ha ii. Highest yield potential 31.57 q/ha. iii. Higher oil content (30-31%). iv. Moderately tolerant to aphid. v. Early, Maturity 116-122 days.

Sr. No.	Name of the Variety	Year of Release	Photo	Specific Characters
6.	Phule Karadai SSF7 33	2011, Cultivation under rainfed safflower growing areas of the country		i. Average seed yield – Rainfed-13-15 q/ha ii. Oil content of is 28-29 % iii. Early, maturity Days 120-125 iv. Flower colour at bloom stage- white v. Flower colour at fading stage- dull white vi. Higher volume weight vii. Responsive to fertilizer application. viii. Moderately tolerant to aphid.
7.	Phule Chandrabhaga SSF 748	2012 Cultivation under rainfed and irrigated conditions of India		i.i. Average seed yield- Rainfed-14-16 q/ha, Irrigated-22-25 q/ha ii.ii. Oil content is 28-29% iii.iii. Days to Maturity - 130-140 days iv. Higher harvest index- 28.0 % v. 1000 seed weight- 57 g vi. Moderately tolerant to aphid. iv. v.
8.	Phule Nira (SSF-12-40)	2019 Cultivation under rainfed and Irrigated conditions Safflower growing area of Zone I India	 	i. Average seed yield: 1713 kg/ha, Rainfed: 1476 kg/ha, Irrigated: 2065 kg/ha ii. Average oil yield: 565 kg/ha, Rainfed: 479 kg/ha, Irrigated: 680 kg/ha iii. Oil content is 32.9% iv. Maturity – 123-125 days v. Harvest Index -25.6% vi. 1000 seed weight - 53.5 g vii. Moderately resistant to wilt
9	Phule Bhivara SSF-13-71	2019 Cultivation under rainfed and irrigated conditions of India	 	i. Average seed yield: 1999 kg/ha, Rainfed: 1621 kg/ha, Irrigated: 2575 kg/ha ii. Average oil yield: 591 kg/ha, Rainfed: 484 kg/ha, Irrigated: 717 kg/ha iii. Oil content is 29.2%. iv. Days to maturity 125 days v. Harvest Index -24.0 % vi. 1000 seed weight - 54.5 g
10.	SSF-15-65 (High oil)	2020 Cultivation under rainfed and irrigated conditions of India (Zone I)	 	i. Average seed yield: 1665 kg/ha ii. Average oil yield: 575 kg/ha iii. Oil content is 34.60% iv. Days to maturity: 122 days v. Harvest Index: 21.5 vi. 100 seed weight: 4.50 g vii. Hull content: 41.9% viii. Moderately resistant to wilt
11.	SSF-16-02	2020 Cultivation under rainfed and irrigated conditions of India	 	i. Average seed yield: 2058 kg/ha ii. Average oil yield: 632 kg/ha iii. Oil content is 30.5%. iv. Days to maturity - 132 days v. Harvest Index -22.1 vi. 1000 seed weight - 49.0 g vii. Hull content: 43.2% viii. Moderately tolerant to aphid

Achievements : The research achievements of different disciplines

Breeding :

(i) **High oil content lines (33-35%):** SAF-11-81, SAF-11-82, SAF-11-83, SAF-12-05, SAF-12-06, SAF-12-18, SAF-1244, SAF-13-49, SAF-13-59, SAF-12-40, SAF-14-39

(ii) **Bold Capitula (3-4 cm dia) :** SSF-09-1-5, SSF-09-3-4, SSF-661, and SSF-15-07 (high oil).

(iii) **Appressed type :** GMU-4912, GMU-6831, GMU-6833, And GMU 6872, GMU-6878 4.

(iv) **Vegetable purpose :** MS-105-3-1, MS-105-6 and MS-105-7-8.

(v) **Early, dwarf type with high oil content, Alternaria tolerant & Wilt Resistant :** SSF-674.

Agronomy :

Recommendations :

(A) The seed treatment with Azospirillum (@ 25 gm/kg seed under scarcity zone could effectively substitute 50% of recommended N, hence the seed treatment is recommended.

(B) For higher seed yield and net monetary returns of chickpea-safflower year to year crop rotation, the application of 50 kg P₂O₅+25 kg N /ha to chickpea and 25 kg P₂O₅+50 kg N/ha to safflower is recommended for medium deep soil of scarcity zone of Maharashtra.

(C) For higher yield with higher economic returns from Safflower–Gram year to year crop rotation, the application of 100 % N (25 kg N ha⁻¹) + 50 % P (25 kg P₂O₅ ha⁻¹) + PSB to gram crop and 50 % NP (25 kg N and 12.5 kg P₂O₅ ha⁻¹) + *Azotobacter* + PSB to safflower is recommended for medium to deep soils of scarcity zone of Maharashtra.

(D) The foliar application of Magnesium Sulphate (MgSO₄) to safflower @ 500 ppm (5 g in 10 liter water) at bud initiation stage (60-65 DAS) and at flower initiation (75-80 DAS) for higher seed yield and net monetary returns is recommended under scarcity zone of Maharashtra.

(E) An application of fertilizer dose of 60:30:00 kg NPK ha⁻¹ is recommended for higher yield of safflower in scarcity zone of Maharashtra.

(F) The application of 100 per cent N and 50 per cent P to black gram and 50 per cent NP to safflower is recommended for higher economic returns from black gram-safflower crop sequence under scarcity zone of Maharashtra.

(G) For higher safflower equivalent yield and higher net returns from safflower, non- spiny safflower variety NH-1

for seeds and petal collection and chickpea+ Safflower (3:1) for intercropping system is recommended for scarcity zone of Maharashtra.

(H) Safflower variety SSF-708 sown at 45 x 20 cm apart and drip irrigated with 100 per cent of CPE at rosette termination (30-35 DAS), flower initiation (55-60 DAS) and at 50 per cent flowering (72-75 DAS) is recommended for higher seed yield and economical benefit.

(I) For higher seed and oil yield, sowing of SSF-708 or SSF-748 variety of safflower in first fortnight of September is recommended for scarcity zone of Maharashtra.

Pathology :

(A) The first spray of carbendazim (60 g) + mancozeb (475 g) in 500 L water per hectare immediately after disease appearance followed by second spray at 15 days (need based) under congenial climatic conditions (intermittent rains with 25-30°C temperature and RH-I above 80%) is recommended for effective and economical management of *Alternaria* leaf blight of safflower

(B) It is recommended to treat the safflower seed before sowing with Cymoxanil 8% + Mancozeb 64% @ 2 g/kg or captan 50% WP @ 3 g/kg seed or *Trichoderma harzianum* Th4d SC @ 1 ml/kg for effective and economical management of *Phytophthora* seedling blight of safflower and getting higher seed yield under scarce rainfall zone of Maharashtra

(C) For effective and economical management of the seed/soil borne diseases of safflower like *Alternaria* leaf spot, *Fusarium* wilt and *Phytophthora* damping-off and seedling blight and getting higher seed yield, it is recommended to treat the safflower seed before sowing with cymoxanil 8% + mancozeb 64% @ 2 g/kg or carbendazim 12% + mancozeb 63% @ 2 g/kg or *Trichoderma harzianum* Th4d SC @ 2 ml/kg or captan 50 WP @ 3 g/kg.

(D) linear regression equations for short term forewarning (prior to one week) the *Alternaria* leaf spot incidence of safflower based on weather parameters are recommended in scarcity zone of Maharashtra

(1) Early sowing : $PDI = 104.28 - 6.72^* T_{min} + 2.19^* RH-I - 1.81^* RH-II - 0.37^* RF$ (2nd fortnight of August)

(2) Normal sowing : $PDI = 440.91 - 7.97^* T_{max} - 1.17^* T_{min} - 1.67^* RH-I$ (2nd fortnight of September)

(3) Late sowing : $PDI = 295.03 - 6.23^* T_{max} - 1.23^* T_{min} - 0.729^* RH-I$ (2nd fortnight of October)

[Where, PDI=Percent disease index, T_{min}=Minimum temperature, T_{max}=Maximum temperature, RH-I=Morning relative humidity, RH-II=Evening relative humidity and RF=Rainfall].

(E) The need based 2 to 3 sprays of combi-fungicides of Carbendazim 12% + Mancozeb 63% **or** Iprodione 25% + Carbendazim 25% @ 2 g/litre water at 15 days interval starting from first disease appearance is recommended for effective and economical management of *Alternaria* leaf spot of safflower in the scarcity zone of Maharashtra

(F) Seed biopriming with *Trichoderma harzianum* Th4d WP @ 10g/litre water for 12 hrs **or** seed treatment with *Trichoderma harzianum* Th4d WP @ 10g/kg seed 1hr before sowing is recommended for effective and economical management of Phytophthora seedling blight, Fusarium wilt and Macrophomina root rot of safflower and getting higher seed yield under dryland condition.

Entomology :

(A) It is recommended to undertake need based one or two sprays of 0.05 % dimethoate i. e. 825 ml in 500 liter of water/ha immediately after first incidence for the control of safflower aphid.

(B) Two sprayings of 75 SPacephate @ 16 g or 50 WDG clothianidin @ 1 g per 10 liters of water at 40-45 DAS (Fourth week of November) and second spray 55-60 DAS (Second week of December) are recommended for the control of safflower aphid.

(C) Seed treatment of safflower with either thiamethoxam 30 FS @ 10 ml/kg or imidachloprid 48 FS @ 8 ml/kg and foliar spray with Pymetrozine 50 WG @ 300 g/ha effectively reduces aphid population and results in higher seed yield in scarce rainfall zone of Maharashtra.

The varieties were released for cultivation in the country due their better performance and specific characters.

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Diversification through Multiple Cropping : An Economic Analysis of Mango with Vegetable Intercropping at Kolar District, Karnataka

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Abstract

Mango was grown as an important rainfed perennial-fruit crop in the study area. During the initial period of mango cultivation which takes a gestation period of around 6 years for its first bearing, farmers used the mango orchards for cultivation of short duration vegetable crops like tomato both high yielding varieties and hybrids under irrigation. Some of the farmers had leased in mango orchards for its maintenance and were growing intercrops mainly tomatoes and other short duration vegetables under irrigation in all the three seasons. The present study was conducted at Srinivaspura taluk, Kolar District of Karnataka where a sample of 50 farmers growing horticultural crops were selected through simple random sampling and interviewed. The primary data was collected for the agriculture year 2014-15. An average area found under mango cultivation was 5.16 acres. The cost and return analysis of mango showed that the total establishment cost of the mango orchard was Rs. 54154 per acre whose amortized cost for an economic life span of around 30 years was Rs. 6452 per year. The total cost of cultivation of mango was Rs 88865 per acre and gross returns was Rs. 105806 per ac with return per rupee expenditure was 1.19. The profitable vegetable crops grown along with mango were cauliflower, carrot, tomato, beans, capsicum and potato.

Key words : Mango, vegetable crops, cost of cultivation, returns, area, farmer

Introduction

Around 60 per cent of the agricultural land is under rainfed condition, witnessing a continuous decrease in average farm size over the years. On the other hand, growing population, urbanization and increase in per capita income of people are demanding quality agricultural output. Food, nutritional, livelihood security and health care have become crucial to human and socio-economic development of the country. Hence, the government of India is focusing its vision towards sustainable agriculture by doubling the farm income by 2022 (Economic survey 2015-16). Increase in health consciousness and purchasing power of people have spurred the demand for more nutritious and healthy diet including fruits and vegetables. Thus, cultivation and utilization of horticultural crops stand to play a key role in raising prosperity of the nation and in turn on health and happiness of people.

Horticulture is a prominent sector under agriculture and is a fastest growing subsector. It has ensured income diversification, employment generation and increased earnings for the farmers. Diversification of enterprises helped in reducing the income risks in farming. It is the most popular on-farm strategy used by the farmers (Maharjan, 2002). India is the second largest producer of fruits and vegetables in the world after China. Horticultural crops comprising fruits, vegetables, flowers, medicinal and aromatic plants and mushrooms play an important role in meeting the livelihood, nutritional security and

socio-economic development of farmers. As a result of research, technology and policy initiatives, horticulture in India today has become a sustainable and viable avocation for small and marginal farmers. With this background, the present study was taken up with an objective to analyze the cost and returns from different horticultural crops being cultivated in inter-cropping system/diversified cropping in the study area.

Materials and Methods

The study area selected for the study was Srinivaspura taluk of Kolar district, Karnataka. It comprises of the geographical area of 860 sq. km consisting of 347 villages. The literacy rate is about 71.29 per cent. The net area irrigated in the taluk is 2249 ha and net area sown is 38561 ha. Apart from cereals and pulses, the major horticultural crops cultivated are potato, tomato, onion, beans, green chilies, cabbage, cauliflower, carrot, radish, beetroot, mango, banana, guava, sapota, grapes, marigold, jasmine, chrysanthemum and rose.

A sample of 50 farmers growing different horticultural crops was randomly selected. The primary data was collected for the agriculture year 2014-15. The data from both primary and secondary sources were collected and used in the study. Total costs and economic returns were calculated for each crop separately grown by the farmers in the study area. Amortized cost which is the establishment cost in the case of perennial crops like

Mango, were amortized over the total life span of the crop using the formula,

$$\text{Amortized cost} = I * [i * (1+i)^n] / [(1+i)^n - 1]$$

Where, I is initial establishment cost

i is the interest/discount rate

n is the number of years of duration of the crop

Returns per rupee of expenditure was worked out by taking the ratio of net return to total cost

$$\text{Return per rupee of expenditure} = \frac{\text{Gross returns}}{\text{Total cost}}$$

Results and Discussion

Agriculture was the main occupation in the study area where-in farmers was growing a variety of crops. Farmers were growing different crops across all the three seasons. The major source of irrigation in the study area was bore wells. An average area found under mango cultivation was 5.16 acres. It was one of the major fruit crops grown in the study area with lot of export and domestic demand. The season of mango coincided with the tomato harvesting season for summer crop, during which the demand for labourers and transportation vehicles was usually higher leading to higher wages.

The perennial fruit crop, mango was cultivated in 5.16 acres with return per rupee expenditure of 1.19. The total initial establishment cost of mango orchard was Rs.54154 per acre and after amortization, it was Rs.6452 per year. The total cost of cultivation was Rs. 88865 per acre of which major component was total variable/input cost of Rs. 55629 (62.6 %) followed by total fixed cost of Rs. 33236 (37.4%). Average yield obtained was around 2.3 tons per acre which fetched an average wholesale price of Rs. 45995 per ton. The gross return obtained was Rs. 105806, net returns of Rs. 16941 with 1.19 returns per rupee expenditure (Table-1). These results were in support with the a study which showed that, Net present worth of Rs. 155607 per acre was estimated for the sampled respondents which indicated that mango cultivation fetches higher returns whereas benefit cost ratio was reasonably higher and it was estimated to be 2.61, these results indicated that investing in mango orchard would bring huge returns to the farmers Baksh *et al.* (2006).

Mango was major fruit crop grown in rainfed conditions in the study area. Farmers having access to irrigation water with bore wells were growing vegetables as a diversified income source. During the initial period of mango cultivation which takes a gestation period of around 6 years for its first bearing, farmers used the mango orchards for cultivation of short duration vegetable

Table-1 : Economics of cultivation of Mango (Rs/ac.).

Particulars	Value
Average area (acres)	5.16
Establishment cost	
Land preparation + digging pits	6866
Manure	15250
Fertilizers	10858
Planting materials	1650
Fencing	12040
Irrigation	2775
Labour	4716
Total establishment cost	54154
Amortization	
Amortized cost	6452
Irrigation	2775
Growth regulators	9160
fertilizers	14850
Plant protection chemicals	15625
Labour	2646
Interest on working capital	4121
Total variable cost	55629
Fixed costs	
Rental value of land	20000
Land revenue	25
Interest on fixed capital	11494
Depreciation	1717
Total fixed cost	33236
Total cost	88865
Returns	
Average yield (tons/ac)	2.3
Average price (Rs/ton)	45995
Gross returns	105806
Net returns	16941
Return per rupee expenditure	1.19

crops like tomato both high yielding varieties and hybrids under irrigation. Some of the farmers had leased in mango orchards for its maintenance and were growing intercrops mainly tomatoes and other short duration vegetables under irrigation in all the three seasons. Along with the mango crop, around 48% of the sample farmers were growing intercrops of different vegetables and rest of the farmers grown multiple cropping whose costs and returns are discussed below, Cost of cultivation per acre of beans as a relay crop was Rs. 65004 per ac in Srinivaspura taluk as the cost of growing a relay crop depends on inputs used in the previous crop which was HYVs/Hybrids of tomato in this case. Beans (Rs. 83505 per ac), carrot (Rs. 60149 per ac) and mango (Rs. 88865 per ac) were grown with lowest cost of cultivation per acre, as these crops were more specialized and well suited to the study regions. Srinivaspura taluk was a major mango growing belt as reported by Srikanth *et al.* (2015) along with cauliflower and beans grown as a relay crop after tomato. Around 54 per cent of the sample

Table-2 : Costs and returns analysis of different vegetable grown along with mango under diversified farming system (Rs./ac.).

Crops/Economic parameters	Total cost of cultivation	Gross returns	Net returns	Return per rupee of expenditure	Average area (ac)
Mango (Rainfed)	88865	105806	16941	1.19	5.16
Tomato	168130	276271	108141	1.64	3.1
Beans	83505	87988	4483	1.05	2.25
Beans as a relay crop	65004	87954	22950	1.35	1.83
Potato	150248	152251	2003	1.01	1.94
Cabbage	108418	131180	22762	1.21	1.75
Cauliflower	111357	195360	84003	1.75	1.00
Carrot	60149	100000	39851	1.66	2.02
Capsicum	166934	199879	32945	1.20	1.00

farmers cultivated both hybrids and HYVs of tomato, whereas, about 26 per cent of farmers cultivated HYVs and 20 per cent of them were growing hybrids of tomato. The total cost of cultivation of tomato was Rs. 168130 per acre with a net return and return per rupee expenditure of Rs. 108141 and 1.64 respectively. Almost all farmers sold the vegetables at Kolar market and very few sold it in Srinivasapura APMC market as it was mainly dealing with marketing of mango.

Potato was grown as a major *rabi* crop in an average area of 1.94 acres with Return per rupee expenditure of 1.01. Cabbage was grown on 1.75 acres with the cost of cultivation per acre of Rs. 108418 and return per rupee of expenditure at 1.21. Cauliflower was grown with cost of cultivation per acre at Rs. 111357 and RRE at 1.75. Carrot was grown by around 12 per cent of farmers in 2.02 acres with a cost of cultivation per acre at Rs. 60149. Similarly, Capsicum crop was grown with cost of cultivation per acre at Rs. 166934 with net returns and returns per rupee expenditure of Rs. 32945 and 1.20, respectively (Table-2). With the given diversified cropping system of vegetables, cauliflower was found more profitable at 1.75 returns per rupee expenditure followed by carrot (1.66), tomato (1.64), beans as relay crop (1.35), cabbage (1.21), capsicum (1.20), beans (1.05) and potato (1.01).

Conclusions

Mango was major fruit crop grown in rainfed conditions in the study area. The net return was Rs. 16941 per acre with 1.19 returns per rupee expenditure. Farmers having access to irrigation water with bore wells were growing

vegetables as a diversified income source. During the initial period of mango cultivation which takes a gestation period of around 6 years for its first bearing, farmers used the mango orchards for cultivation of short duration vegetable crops. Analyzing diversified cropping system of vegetables, cauliflower was found more profitable at 1.75 returns per rupee expenditure followed by carrot (1.66), tomato (1.64), beans as relay crop (1.35), cabbage (1.21), capsicum (1.20), beans (1.05) and potato (1.01).

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Income Generation for Farm Women through Value Added Product Aonla Candy

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Abstract

The present investigation was undertaken on aonla candy a value added product in Badri and Fategarh adopted villages of KVK Mandsaur; under On Farm Testing (OFT) & Front line demonstration (FLD) program. Total 15 farm women were selected purposely for assess the income generation of farm women through value added product aonla candy. Various parameter's were measured viz., demographic & Socio-Economic Sensory parameters taste, colour, texture, flavour overall acceptability and storage ability. The result revealed that net return for improved practice Rs 15920 per unit production higher as compare to Rs 1040 in traditional practice through aonla candy. Maximum benefit cost: ratio (1.412.10), high sensory evaluation score and high nutritional quality, with more storage ability was found in improved method as compare to traditional method.

Key words : Income generation, value addition, aonla candy, overall acceptability, sensory parameter.

Introduction

Aonla, (*Emblica Officinalis Gaertn.*), the king of arid fruits belongs to *Euphorbiaceae*, is popularly referred as "Indian gooseberry" could be is a small-sized minor subtropical fruit grown widely in North India (Yadav *et al.*, 2017) [12]. India ranks first with in the area under production and productivity of aonla or Indian gooseberry (*Emblica officinalis Gaertn.*). It's well-known Indian fruit for its medicinal and therapeutic properties from the traditional time in India. The chemical composition of fresh fruit in relevancy to energy 170/40 kJ/Kg, moisture (84.35%), protein (0.88%), Vitamin C (571.60 mg/100g), Total sugar (3.11%), Fibre (3.2 gm) Reducing sugars (2.37%), minerals has been reported by lot a of researchers (Goyal *et al.*, 2008) [3]. Amalaki (*Emblica officinalis*) i.e. Aonla and its preparations is employed in any style of unhealthiness. It's universally used in piles, fracture, constipation, vomiting, nausea, diseases associated with vision and eye, hick up, fever, jaundice, liver disease, disease of the skin, diabetes (Kavita, 2013)[4]. Its importance lies in its high richness of ascorbic acid. It's the second highest source of vitamin C among fruits next only to Barbados cherry. It's prolific and seasonal bearer. Its annual production accounts around 2 lakh metric ton in India (Goyal *et al.*, 2008) [3]. It's commercially cultivated in many districts of Madhya Pradesh viz. Mandsaur, Neemach, Ratlam, Jabalpur, Betul, Dewas, Hoshangabad, Chindwara, Sheopur, Tikamgarh, Rewa, etc. Fruits of aonla are highly perishable with limited storage period. The fresh fruits are generally not

consumed because it is extremely acidic and astringent; therefore it's not so popular table fruit. But, it's has got great potential in processed forms since, 17% or more of the produced fruit are lost during transport, storage and marketing (Singh *et al.*, 1993) [9]. Therefore, modern technologies are needed to cut back the losses. A study was conducted to gauge the impact of valuable addition and economics of preparation of candy and also the overall acceptability for income generation of farm women in district Mandsaur (M.P.).

Materials and Methods

The study was conducted in Mandsaur district of M.P. Two villages i.e. Badri and Fategarh were selected for conducting the On Farm Testing (OFT) and Front Line Demonstration (FLD) for preparation of Aonla candy (whole) product. Both the villages are situated within the periphery of 25 and 12 Km from Krishi Vigyan Kendra, Mandsaur. Aonla growers were identified 15 farm women were selected randomly. The chosen group represented the marginal and small land holding farm women. The interview schedule and questionnaire was developed to review demographic parameter's and extensive review of the training of respondent of villages. Demonstration useful value added product of Aonla (candy) has been prepared as per norm of FPO specifications. The subsequent equipments and other materials were used for preparing Aonla candy product. Items used are stainless steel fork for pricking of Aonla fruits. Cooking utensils, hand refractometer, measuring cylinder,

Table-1 : Demographic profile of the Villages family.

S. No.	Census Parameter	Village Census Data	
		Badri Block-Malhargarh	Fategarh Block-Mandsaur
1.	Total Population	724	2340
2.	Total No of Houses	149	516
3.	Female Population %	49.7% (360)	47.8% (1118)
4.	Total Literacy rate %	55.8% (404)	62.1% (1454)
5.	Female Literacy rate	20.9% (151)	24.7% (578)
6.	Scheduled Tribes Population %	6.4% (46)	6.8% (160)
7.	Scheduled Caste Population %	4.0% (29)	20.3% (475)
8.	Working Population %	42.5%	55.9%
9.	Child (0-6) Population by 2011	99	337
10.	Girl Child (0-6) Population % by 2011	47.5% (47)	41.2% (139)

Source : Census data village Badri & Fategarh.

Table-2 : Ingredient used for preparation of Aonla Candy.

S. No.	Ingredients / Particular	Quantity
1.	Aonla (Narendra-7)	45.000 kg
2.	Sugar	67.500 kg
3.	Salt White	01.000 kg
4.	Alum	00.500 kg
5.	Citric acid	45.000 gm
6.	Cardamom	90.000 gm
7.	Sodium Benzoate @ per kg product	50.00 PPM
8.	Glass /pet Jar	As per need
9.	Utensils	As per need
10.	Labour	As per need
11.	Fuel	As per need
12.	Dehydration	As per need
13.	Labels	As per need

Table-3 : Economic parameters of processed product of Aonla Candy.

Particular	FWP	IP
No. of trials	15.00	15.00
No. of farm family involved	15.00	15.00
Cost of input in Rs.	735.00	7555.00
Output of Production kg/day	55.00	77.50
Cost of produce/kg in (Rs.)	13.36	97.48
Gross profit in Rs.	1040.00	15920.00
Net return in Rs.	305.00	8365.00
Income increase (%)	41.49	110.72
Benefit Cost Ratio (BCR)	1.41	2.10

balance, muslin cloth, pet Jar, sugar, acid, alum, cardamom, salt white and chemical preservative- II Benzoate etc. Preparation of Aonla candy from fully mature Aonla (Narendra-7). Product was evaluated for Sensory parameters viz; taste, colour, texture, flavour overall acceptability and storage ability As per Ranganna, S. (1978) [7]. Data were analyzed and simple mean percentage were calculated as formula is given below

(1) Benefit Cost Ratio = Total benefit in Rs / Total cost in Rs.

(2) Income increases (%) : Output – Input/ Input × 100

(3) Additional income (%)

$$= \frac{\text{Higher income} - \text{lower income}}{\text{Lower income}} \times 100$$

Results and Discussion

Demographic Profile of family It absolutely was (Table-1) clearly evident that literacy rate (55.8 %) & (62.1 %) and feminine population (49.7%) & (47.8%) respectively in both the villages of the participants . Similar results are reported by Roy *et al.*, (2013) [8]. It had been (Table 3) Cost of input per kg was Rs. 735 in traditional practice and Rs.7555 in improved practice. Improved practice increases production per unit 110.72 %. The net return for improved practice Rs 8365.00 per unit production over traditional practice. The benefit cost ratio was found in improved practice (2.10) and (1.41) in traditional practice. Similar results also conformity Kumar and Pathak (2020) [5] in enriched Aonla Candy, Tripathi et al. (2020) [10]. The information depicted in (Table 4) revealed that sensory parameters viz., colour, texture, flavor, taste and overall acceptability were found superior in improved practice method as compared to the traditional method. Similar findings were reported by Tripathi et al. (1988) [11], Patel et al. (2014)[6] in aonla product, Durrani and Verma (2011)[2] in honey Aonla murabba and Kumar and Pathak (2020) [5] in enriched Aonla Candy.

(1) BC Ratio = Gross profit /Cost of Input

$$FP = 1040 / 735 = 1.41$$

$$IP = 1592 / 7555 = 2.10$$

(2) Income increases % - (Gross Profit – Cost of Input/ Cost of input) × 100

$$FP - (1040 - 735) / 735 \times 100 = 41.49 \%$$

$$IP - (15920 - 7555) / 7555 \times 100 = 110.72 \%$$

Table-4 : Organoleptic evaluation of the processed product of Aonla Candy.

Product	Sensory Attributes					
	Colour	Texture	Flavour	Taste	Overall acceptability	Shelf life (days)
(Farmers Practice)	5.60	5.70	5.80	6.10	5.70	-
(Improved Practice)	6.70	6.80	6.70	7.70	7.00	12 months

Conclusions

Value added product of Aonla candy may increase the income of farm women and it might be a take off for cottage scale entrepreneur for geographical area. The benefit cost ratio was (2.10) found in improved practice and (1.41) in traditional practice, where additional net income was increased by 110.72 % to match with traditional method. Farm women earn the money by value addition of aonla candy. The processing may be helpful to manage market price fluctuation and losses of aonla fruits through value addition.

Acknowledgments

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Advanced Design Using Animal Power in Rotary Mode Operation for Pulses Polisher Machine

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Abstract

Livestock have been used in agriculture for thousands of years supplying energy for crop production in terms of draught power and organic manure. Bullocks are the main source of power in Indian agriculture. Use of bullocks for agricultural work is limited to tillage, sowing and transportation in the state of Maharashtra, India. But due to mechanization in agriculture, the role of animals in crop production became less relevant. But in a country like India where 78% of farmers have less than 2 ha of area for cultivation, the question whether the use of tractors and tillers are economical put forward the importance of draught animals in agriculture. It is assumed that one pair of draught animals develop approximately 750 watts of power. The total annual use of bullocks is less than 300 hours. But the potential use of bullocks in a year is nearly 800 hours. To enhance the utilization of bullock in the state, there is the need of a modified machine design and draught animal in rotary mode operation with stationary machines requiring around 1 hp (0.8 kW) power for doing various post-harvest operations like chaff cutting, seed cleaning and grading, flour milling and pulses polishing etc. This would ultimately reduce the economic burden of owning a pair of bullocks and also to decrease the use of non-renewable energies in agricultural post-harvest operations. With this aim, a study was conducted for operating a pulses polisher machine with the help of a rotary gear complex driven by bullock power. The mechanical power is transmitted to the pulses polisher with the help of belt pulley arrangement with the provision of stepping up or stepping down the speed ratio as per requirement. The experiment was conducted continuously for 1.5 hours with the measurement of physiological responses like respiration rate, heart rate, body temperature etc. The pulses polisher was run with a pair of bullocks in rotary mode of operation and two persons were employed for polishing and collecting polished dal. The output capacity in rotary mode pulses polisher was observed to be 263.3 kg of polished pulses/hour, whereas 330 kg/hour in electrically operated pulses polisher. The cost of operation in rotary mode of operation through bullocks, in electrically operated pulses polisher was observed to be Rs.36.25 and Rs.11.23 per 100 kg of polished pulses respectively. Due to fluctuation of speed in rotary mode, the performance of the pulses polisher machine was lower in a rotary power transmission system than that of in the electrically operations.

Key words : *Pulses Polisher, Rotary mode operation, Agricultural implements, Renewable energy, Bullock energy, Sustainable energy, rural livelihood, draft, pulse rate.*

Introduction

The agriculture of Maharashtra state is characterized by small fragmented land with small and marginal farmers, hill agriculture, mix cropping and inter cropping more than 55per cent of total cultivated area is still being managed by using draught animals supplied 17per cent of total farm power in Maharashtra state. In spite of large scale application of tractor and electrical power in agriculture still animal power plays an important role in India for small and marginal farmers.

The cost of utilization is therefore very high as the bullock are to be fed throughout the year whether they are in use or not and thus to reduce the economic burden of owning a pair of bullock is to increase the rotary mode of power to operate different agro-processing machine (Srivastava and Yadav 1987) by using bullock pair in rotary mode operation the surplus idle animal power available after tillage sowing and other field operation can be utilized efficiently for different agro processing operation.

As per the last 17th livestock census the state of Maharashtra had 8.8per cent of cattle population in the country. In Maharashtra the cross breed cattle have increased by 12.9 per cent but indigenous cattle decreased by 13.4 per cent during the period 16 and 17th census. This study aims at use of animal energy particularly during idle period so that their annual use will be increased and ultimately the cost benefit ratio will be improved besides providing useful information on the suitability of animals in rotary mode of operations.

Agricultural Implements Available For Draft Animals :

Draught animals are generally used for various agricultural operations like ploughing, puddling, leveling, harrowing, bund forming and ridging, seeding, planting, weeding, threshing and carting. The different implements and tools presently available are plough, leveller, puddler, harrow, cultivator, bund former, ridger, seed drill, planter, interculture plough, weeder, tool carrier and cart. These implements are mostly of indigenous designs and are being manufactured by local artisans and small-scale



Plate No. 1. Gear box unit for mechanical power in rotary mode.

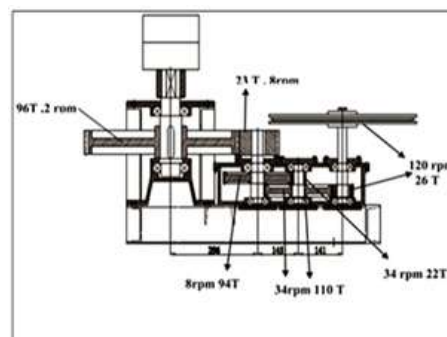


Plate No. 2, 3. Pulses polisher in rotary mode operation.

industries. Implements are generally made up of locally available materials.

Utilization of Bullock Power through Mechanical Rotary Gear System : The rotary gear unit was installed in the premises of College of Agricultural Engineering and Technology, at the site of the AICRP on UAE, CAET, V.N.M.K.V., and Parbhani. India. The experiment was conducted during 2013-14 in the College of Agricultural Engineering and Technology, V.N.M.K.V., Parbhani. India.

Rotary gear Unit

Box : In the gear box different part are assembled it is made up of 6mm thick cast iron plate frame shape of box is rectangular having dimension 860mm X 750mm X 75mm

Spur gear : A set of spur gear of power transmission between two parallel shafts. The spur gear are made up of heat treated alloy steel having module 3.0 mm the spur gear has 96 T Teeth while the spur pinion has 23T teeth. The speed ratio is 1: 4.1 speed step-up obtained.

Bevel gears : A set of bevel gear transmitted the power of 900 they are spiral tooth. The material of the bevel gear is heat treated alloy steel. The speed ratio is 1: 4. Combination of bevel and spur gear can produce the speed ratio of 1: 4

Shafts : The first shaft of spur gear is held in vertical position having diameter of 500mm at bottom side and top side respectively. The second shaft of the spur 94T teeth link with third shaft of idler gear 22T has 250 mm with ratio 1: 4 speed step-up and idler gear 110T teeth link with pinion 31T teeth has dia 250 mm. The fourth shaft of pinion fixed by belt-pulley transmission system dia 18" Drive pulley transmit the power to dia 10" pulley of bevel gear which is transmit vertical motion to horizontal 900 motion to the underground shaft of rotary mode system.

Bearings : One ball bearing 90 x 50 x 24 mm size is fitted on the 50mm shaft and another ball bearing of 72 x 30 x 20 mm size are fitted at the top of the same. One thrust bearing 60 x 38 x 20 mm size is fitted at outer end of pinion shaft. For underground shaft four pedestal bearings 300 x 80 x 50 mm size is fitted.

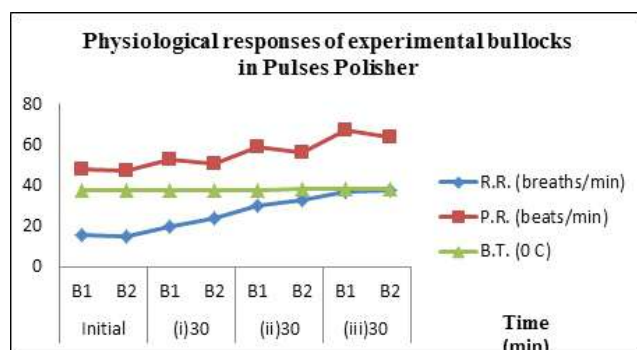
Belt pulley transmission unit : The two transmission shaft are mounted in this rotary mode system first shaft is underground shaft which is connected to output of gear box that first drive shaft was coupled with another 16 feet size shaft for increasing length. One pulley of 12" was mounted on the first drive shaft and counter shaft has pulley of 16" and other pulleys of various sizes. The pulley of 12" was connected to 16" size pulley in counter shaft with the help of v belt thereby stepping down in the ratio 1:0.75

For the Pulse Polisher operation 30 cm v pulley mounted on the counter shaft was connected through v-belt with polisher unit having 30.48 cm pulley with stepping same ratio 1:1 from polisher unit main shaft another pulley 35.56 cm was connected through v- belt to blower shaft having 7.5 cm pulley with the speed ratio 1: 4.7.

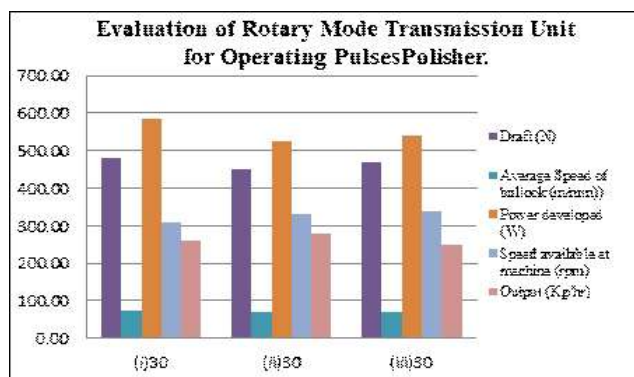
Table-1 : Salient specifications of the Pulses polisher.

Sr. No.	Overall Dimensions	
1.	Length (cm)	229
2.	Width (cm)	97
3.	Height (cm)	120
4.	Weight (kg)	150-170
5.	Polishing efficiency (per cent)	85.1-89.4
6.	Power requirement (kw) :	4.3-5.7
7.	Capacity (kg/h) : (depending upon the pulses)	280-350

Evaluation of Pulses polisher : The pulses polisher was run with the bullocks in rotary mode of operation and two persons were employed for polishing machine. It consists of single screw auger, hopper, oil and water tank, blower, cyclone separator. The structure of pulses polisher screw is like auger arranged horizontally placed wrap with nylon rope or Lather. It consists of hopper having 50 Kg capacity at a time. When the material fall in screw chamber applies the polishing material like oil and water by circular motion the screw will be rub the material in between nylon rope with low speed. Creating suction with blower the husk and light weight unwanted material will separate by cyclone separator. The following parameters were studied during the experiment. Standard techniques were used for measurement of the different parameters. The experiment was conducted for 1.5 hours and the observations were taken at half hour interval. Rotary gear parameters; power requirement at load, bullock parameters at load condition; speed of bullocks, average draft, power output, physiological responses, fatigue score and machine parameters (polisher); polishing efficiency, output capacity, cost of operation etc.



Graph-1 : Physiological responses of bullocks in operation of pulses polisher



Graph-2 : Evaluation of pulses polisher machine in rotary mode operation.

Results and Discussion

The pulses polisher machine was operated and the data on evaluation of the polisher machine in rotary mode has been presented in Table-4. The draft requirement varied 480.2 N in the beginning to 470.4 N at the end. The mean draft was 467.1 N which was 5.4 % of the bodyweight of the bullocks. The increase in pulse rate and respiration rate as usual decreased with duration and varied between 47 to 67 and 15 to 38 within one an half hours respectively. The corresponding mean values were 75 and 33. There was not much variation in the body temperature. Half hourly RPM of the bullocks were between 64 to 60 and gradually deceased with duration so also the linear speed. The mean linear speed of the bullocks was 1.18 km/h and the corresponding polisher velocity was 5.88 m/s. The mean RPM of the polishing shaft was observed to be 395.6. Polishing efficiency varied between 85.1 to 89.4 % with a mean of 87.25 %. The output of the polisher gradually decreased with duration; may be due to decrease in the peripheral velocity of the polishing shaft. The mean output was found to be 263.3 kg/h. The power output was found to be 0.55 kW which indicated that the bullocks could easily do the threshing operation and their utilization could be enhanced. The bullocks could sustain the duration of polishing without getting fatigue as the average fatigue score was 16.33 The bullock becomes fatigue when it attains a fatigue score of 20 (Upadhyay, R.C., & Madan, M.L. 1985) and is required to relieve it from work.

The cost of operation of the pulses polisher in rotary mode was Rs.36.25 /100kg whereas it was Rs.11.23 /100kg in case of pulses polisher being operated by electric motor as mentioned. The cost of polisher in rotary mode it shows that threshing through rotary mode of operation is more and economically viable than the idle period of draught animals can be efficiently utilised. The above operation through rotary mode was found to be within the draftability of the bullock.

Table-2 : Physiological responses of bullocks and performance of pulses polisher in rotary mode of operation.

Parameters	Duration, h								Mean	
	In		0.5		1.0		1.5		B1	B2
	B1	B2	B1	B2	B1	B2	B1	B2		
Respiration rate, bpm	16	15	20	24	30	33	37	38	25.75	27.5
Opulse rate, bpm	48	47	53	51	59	56	67	64	56.75	54.5
Body temp, °C	37.5	37.8	37.9	38.0	38.0	38.1	38.2	38.3	37.9	38.05
Draft, kg	—	—	49	—	46	—	48	—	47.66	—
Percentage body weight	—	—	5.56	—	5.22	—	5.45	—	5.41	—
Draft, N	—	—	480.2	—	450.8	—	470.4	—	467.1	—
rpm of bullocks/0.5h	—	—	64	—	61	—	60	—	61.66	—
Speed, m/s	—	—	1.22	—	1.17	—	1.15	—	1.18	—
Speed, km/h	—	—	4.42	—	4.21	—	4.14	—	4.25	—
rpm at machine shaft	—	—	395	—	400	—	392	—	395.6	—
rpm at Blower	—	—	1618	—	1639	—	1627	—	1628	—
rpm at Auger	—	—	80	—	95	—	90	—	88.33	—
Power output of Bullock (kW)	—	—	0.585	—	0.527	—	0.540	—	0.550	—
Output(Kg/h)	—	—	260	—	280	—	250	—	263.3	—
Fatigue score	—	—	15	—	17	—	18	—	16.66	—

Conclusions

The following conclusions are made from the study :

(i) The operation for draft requirements of the polisher was found to be 5.4 % in term of percentage of body weight. So the bullocks could sustain the draft for half hours of continuous operation.

(ii) The operation of polisher through rotary mode was not economical compared to be operated with electric motor. However, polishing of pulses through rotary mode was marginally more but actual cost of operation of the system comes out to be low as the idle work capacities of animals get utilized.

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Trends in Area, Production and Productivity of *Kharif* Groundnut in Maharashtra

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Abstract

The present study "Regional disparities in oilseeds production in Maharashtra" was carried out to estimate the trends in area, production and productivity of *kharif* groundnut in Maharashtra over the period of 26 years beginning from 1990-91 to 2015-16. This study was based on secondary data obtained from <http://krishi.maharashtra.gov.in> and Government publications. The exponential, linear, logarithmic, polynomial and power functions were computed and best fit was judged based on coefficient of determination (R^2) values. During overall period, fitness of trends (R^2) value in area, (0.32, 0.92, 0.97, 0.99 & 0.97) and production (0.30, 0.73, 0.67, 0.92 & 0.82) of *kharif* groundnut were estimated, in Konkan, Western Maharashtra, Marathwada, Vidarbha region and Maharashtra state respectively. Polynomial functional form was the best fit to the trend for *kharif* groundnut due to the highest coefficient of determination (R^2) value. The rest of the study revealed that, the highest coefficient of determination (R^2) value in the polynomial functional forms for area and production during overall period was positive and significant for the *kharif* groundnut in Konkan, Western Maharashtra, Marathwada, Vidarbha regions and Maharashtra. During overall period for productivity of *kharif* groundnut the coefficient of determination value (R^2) of the estimated functions was low. Therefore, none of the function was fit for productivity in Konkan, Western Maharashtra, Marathwada, Vidarbha region and overall Maharashtra.

Key words : Trend, area, production and productivity, groundnut.

Introduction

Importance of oilseed : Oilseeds and edible oils are two of the most sensitive essential commodities. India is one of the largest producers of oilseeds in the world. India contributes about 6-7 per cent of the world oilseeds production; this sector occupies an important position in the agricultural economy. The oil extracted from oilseeds form an important item of our diet. Extracted oil is used as raw material for manufacturing paints, varnishes, soaps, perfumes, lubricants, etc. Oil cake is a byproduct obtained after the extraction of oil from oilseeds and an excellent cattle feed. Oil cakes are also used as fertilizers.

Groundnut : The groundnut (*Arachis hypogea*) also known as the peanut or monkey-nut. It is a member of family *Papilionaceae*. Gujarat is the leading state in groundnut production. Groundnut kernels are rich in proteins, fat and vitamins. It is used for manufacture of soap, candles and artificial leather. Groundnut is used for extraction of edible oil. It is also called as the poor man's cashew-nut. It is used as an important rotation crops as it helps in increasing soil fertility by fixing atmospheric nitrogen through the root nodules bacteria and an efficient cover crop of lands exposed to soil erosion. Groundnut has about 45 per cent of oil and 26 per cent of protein

content. Edible oil is used in many part of world and its oil cake derived after extracting oil is used as cattle feed.

The main uses of groundnut are for making butter, candy, salted, shelled nuts, roasted nuts, etc. Salted groundnuts are usually roasted in oil and packed in retail size, transparent plastic bags and hermetically sealed cans. Dry roasted, salted groundnuts are also marketed in significant quantities. The primary use of groundnut butter is in the home, but large quantities are also used in the commercial manufacture of sandwiches, candy, and bakery products. Low grade or culled groundnuts not suitable for the edible market, it is utilized in the production of groundnut oil, seed and feed. Paint, varnish, lubricating oil, leather dressings, furniture polish, insecticides and nitroglycerin, etc. are made from groundnut oil. Soap is made from saponified oil, and many cosmetics contain groundnut oil and its derivatives. The protein portion of the oil is utilized in the manufacture of some textile fibers. Groundnut shells are put to use in the manufacture of plastic, wallboard, abrasives and fuel. They are also used to make cellulose (used in rayon and paper) and mucilage (glue). Groundnut plant tops are used to make hay. The protein cake (oilcake meal) residue from oil processing is utilized as an animal feed and as a soil fertilizer.

Research Methodology

Selection of the study area : Maharashtra State comprises four regions viz; Konkan, Western Maharashtra, Marathwada and Vidarbha and overall Maharashtra.

Specification of time periods : To facilitate proper understanding of regionwise disparities in the state with regard to increase in area, production and productivity of *kharif* groundnut oilseed crop. The periods from 1990-91 to 2015-16 i.e. total 26 years period was selected, this 26 years period was divided in to two sub periods and one overall period as indicated below.

Period - I : 1990-91 to 2001-02

Period - II : 2002-03 to 2015-16

Overall period : 1990-91 to 2015-16

Data requirement and sources of data : The present study was based on secondary data the data in respect of area, production and productivity of *kharif* groundnut, crop for the overall period (i.e. 1990-91 to 2015-16) were obtained from the <http://Krishi.maharashtra.gov.in>. Epitomes, districts statistical abstract and Economic survey of Maharashtra.

Trends in area, production and productivity of oilseed crops : In order to assess the trends in area, production and productivity of selected oilseed crops, the linear, linear function and non-linear exponential function, logarithmic function, polynomial (quadratic) function and power function trend curves (functions) were fitted and the one yielding the highest coefficient of determination (R^2) were finally chosen for examining the year to year variations.

Suitable linear and non-linear trend equations were fitted as follow :

(i) Exponential function : The exponential function of the following form was employed,

$$Y = a.b^x$$

Where,

Y = Dependent variable

a, b = Parameter of exponential curve

x = Independent variable (Time period)

(ii) Linear function : The linear function of the following form was used for the estimation of trends in area, production and productivity of oilseeds.

$$Y = a + bx$$

Where,

Y = Dependent variables for which growth rate was estimated,

a = Intercept (constant)

b = Regression coefficient

x = Independent variable (Time period)

(iii) Logarithmic function : The logarithmic equation of the following form was employed,

$$Y = a + b(x)$$

Where,

Y = Dependent variable

a = Constant

b = Regression coefficient of Y on and in (x)

x = Independent variable (Time period)

(iv) Polynomial (Quadratic) function : The polynomial function of the following form was analyzed,

$$Y = a + bx + cx^2$$

Where,

Y = Dependent variable

a = Constant

b, c = Partial regression coefficient of x_1 and x_2

x = Independent variable (Time period)

(v) Power function : Power function of the following form was used,

$$Y = a_0 ax^2$$

Where,

Y = Dependent variable

a_0 = Constant

= 3.14

a = Parameter of the power curve

x = Independent variable (Time period)

Results and Discussion

Trends in area, production and productivity of *kharif* groundnut in Maharashtra : In order to assess the trends in area, production and productivity of selected oilseed crops, the linear, linear function and non-linear, exponential function, logarithmic function, polynomial (quadratic) function and power function trend curves (functions) were fitted and the one yielding the highest coefficient of determination (R^2) were finally chosen for examining the year to year variations.

The coefficients of determination (R^2) values for the period-I, period-II and overall period were employed to fit

Table-1 : Trends in area, production and productivity of *Kharif* groundnut in Konkan.

Sr. No.	Dependent equation	Coefficient of determination (R ²)								
		Period-I			Period-II			Overall Period		
		A	P	Y	A	P	Y	A	P	Y
1.	Exponential	0.24	0.01	0.09	0.04	0.00	0.09	0.13	0.20	0.14
2.	Linear	0.23	0.01	0.08	0.01	0.04	0.10	0.20	0.27	0.15
3.	Logarithmic	0.21	0.00	0.06	0.01	0.08	0.08	0.21	0.20	0.08
4.	Polynomial	0.26	0.10	0.14	0.17	0.28	0.10	0.32	0.30	0.19
5.	Power	0.22	0.01	0.06	0.00	0.02	0.06	0.16	0.16	0.07

Table-2 : Trends in area, production and productivity of *Kharif* groundnut in Western Maharashtra.

Sr. No.	Dependent equation	Coefficient of determination								
		Period-I (1990-91 to 2001-02)			Period-II (2002-03 to 2015-16)			Overall Period (1990-91 to 2015-16)		
		A	P	Y	A	P	Y	A	P	Y
1.	Exponential	0.88	0.30	0.18	0.80	0.29	0.08	0.92	0.73	0.00
2.	Linear	0.85	0.29	0.16	0.80	0.31	0.08	0.89	0.72	0.00
3.	Logarithmic	0.90	0.29	0.20	0.68	0.32	0.03	0.92	0.65	0.01
4.	Polynomial	0.91	0.30	0.23	0.80	0.32	0.09	0.92	0.73	0.00
5.	Power	0.89	0.27	0.21	0.67	0.31	0.03	0.87	0.63	0.01

Table-3 : Trends in area, production and productivity of *Kharif* groundnut in Marathwada.

Sr. No.	Dependent equation	Coefficient of determination								
		Period-I (1990-91 to 201-02)			Period-II (2002-03 to 2015-16)			Overall Period (1990-91 to 2015-16)		
		A	P	Y	A	P	Y	A	P	Y
1.	Exponential	0.92	0.35	0.00	0.66	0.41	0.05	0.93	0.66	0.00
2.	Linear	0.92	0.38	0.01	0.69	0.39	0.01	0.88	0.65	0.01
3.	Logarithmic	0.90	0.27	0.22	0.74	0.23	0.22	0.95	0.61	0.02
4.	Polynomial	0.94	0.43	0.03	0.84	0.56	0.40	0.97	0.67	0.04
5.	Power	0.84	0.24	0.03	0.68	0.23	0.03	0.86	0.52	0.00

the trends for area, production and productivity of oilseeds in Maharashtra.

(1) Trends in area, production and productivity of *kharif* groundnut in Konkan : The linear and non-linear trend lines were fitted to area, production and productivity of *Kharif* groundnut for period-I, period-II and overall period. The coefficient of determination for the trends lines in Konkan region of *kharif* groundnut in Maharashtra are depicted in Table-1.

The exponential, linear, logarithmic, polynomial and power functions based were employed and best fit was judged based on the value of coefficient of determination.

During period-I and period-II for area of *kharif* groundnut the value of R² of the estimated functions was low. Therefore, it indicates that the function does not fit in area of *kharif* groundnut respectively, in Konkan region.

During overall period for area of *kharif* groundnut, the R² value of polynomial function was the highest i.e. 0.32 and it was best fit for area in Konkan region.

For production of *kharif* groundnut during period-I and period-II the value of R² of the estimated functions was low. Therefore, it indicates that the function does not

fit in production of *kharif* groundnut respectively, in Konkan region.

During overall period for production of *kharif* groundnut the R² value of polynomial function was the highest i.e. 0.30 and it was best fit for production in Konkan region.

For productivity of *kharif* groundnut during period-I, period-II and overall period the value of R² of the estimated functions was low in Konkan region. Therefore, it indicates that the function does not fit in productivity of *kharif* groundnut respectively, in Konkan.

During overall period for productivity of *kharif* groundnut the value of R² of the estimated functions was low in Konkan region. Therefore, it indicates that the function does not fit in productivity of *kharif* groundnut respectively, in Konkan region.

(1) Trends in area, production and productivity of *kharif* groundnut in Western Maharashtra : The linear and non-linear trend lines were fitted to area, production and productivity of *Kharif* groundnut for period-I, period-II and overall period. The coefficient of determination for the

Table-4 : Trends in area, production and productivity of *Kharif* groundnut in Vidarbha.

Sr. No.	Dependent equation	Coefficient of determination								
		Period-I (1990-91 to 2001-02)			Period-II (2002-03 to 2015-16)			Overall Period (1990-91 to 2015-16)		
		A	P	Y	A	P	Y	A	P	Y
1.	Exponential	0.99	0.66	0.04	0.86	0.75	0.01	0.97	0.92	0.01
2.	Linear	0.98	0.64	0.02	0.89	0.76	0.00	0.84	0.78	0.01
3.	Logarithmic	0.93	0.47	0.09	0.86	0.62	0.01	0.96	0.78	0.03
4.	Polynomial	0.99	0.72	0.47	0.92	0.76	0.13	0.99	0.86	0.05
5.	Power	0.84	0.44	0.11	0.76	0.57	0.00	0.85	0.76	0.04

Table-5 : Trends in area, production and productivity of *Kharif* groundnut in Maharashtra.

Sr. No.	Dependent equation	Coefficient of determination								
		Period-I (1990-91 to 2001 02)			Period-II (2002-03 to 2015-16)			Overall Period (1990-91 to 2015-16)		
		A	P	Y	A	P	Y	A	P	Y
1.	Exponential	0.95	0.45	0.22	0.85	0.41	0.09	0.96	0.81	0.08
2.	Linear	0.92	0.43	0.21	0.84	0.42	0.10	0.90	0.78	0.07
3.	Logarithmic	0.94	0.36	0.26	0.74	0.41	0.07	0.96	0.73	0.12
4.	Polynomial	0.96	0.45	0.32	0.85	0.42	0.11	0.97	0.82	0.12
5.	Power	0.92	0.36	0.27	0.73	0.40	0.06	0.91	0.71	0.12

trends lines in Western Maharashtra region of *kharif* groundnut in Maharashtra are presented in Table-2.

The exponential, linear, logarithmic, polynomial & power functions based were employed and best fit was judged based on the value of coefficient of determination.

For area of *kharif* groundnut during period-I, the R^2 value of polynomial function was the highest i.e. 0.91 and it was best fit for area in Western Maharashtra region. For area of *kharif* groundnut during period-II, the R^2 value of exponential, linear and polynomial functions was the highest i.e. 0.80, 0.80 and 0.80, respectively and it was best fit for area in Western Maharashtra region.

During overall period, for area of *kharif* groundnut the R^2 value of exponential, logarithmic and polynomial functions was the highest i.e. 0.92, 0.92 and 0.92, respectively and it was best fit for area in Western Maharashtra.

During period-I, for production of *kharif* groundnut the R^2 value of exponential and polynomial functions was the highest i.e. 0.30 and 0.30, respectively and it was best fit for production in Western Maharashtra region.

For production of *kharif* groundnut during period-II, the R^2 value of logarithmic and polynomial functions was the highest i.e. 0.32 and 0.32, respectively and it was best fit for production in Western Maharashtra.

During overall period, for production of *kharif* groundnut the R^2 value of exponential and polynomial functions was the highest i.e. 0.73 and 0.73, respectively and it was best fit for production in Western Maharashtra region.

For productivity of *kharif* groundnut during period-I, period-II and overall period the value of R^2 of the estimated functions was low in Western Maharashtra region. Therefore, none of the function was fit in productivity of *kharif* groundnut respectively, in Western Maharashtra region.

(1) Trends in area, production and productivity of *kharif* groundnut in Marathwada : The linear and non-linear trend lines were fitted to area, production and productivity of *Kharif* groundnut for period-I, period-II and overall period. The coefficient of determination for the trends lines in Marathwada region are presented in Table-3.

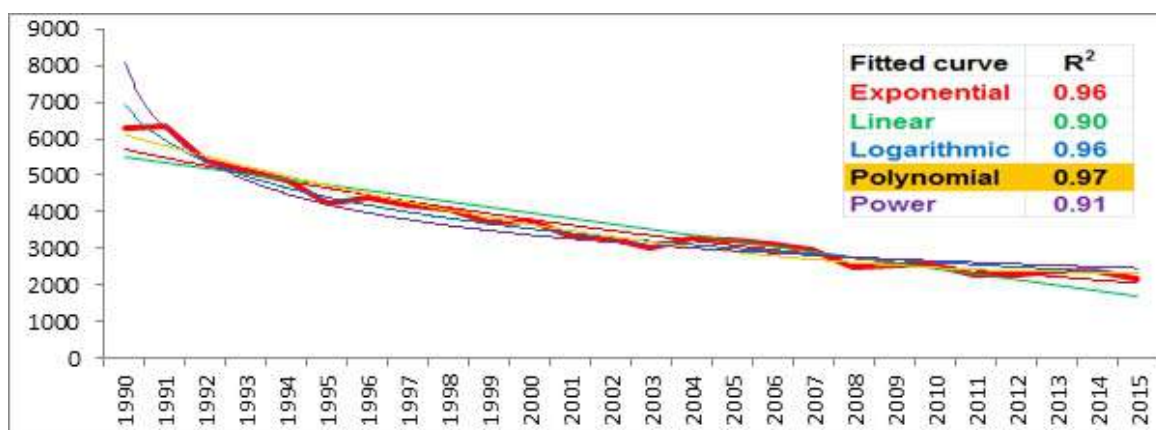
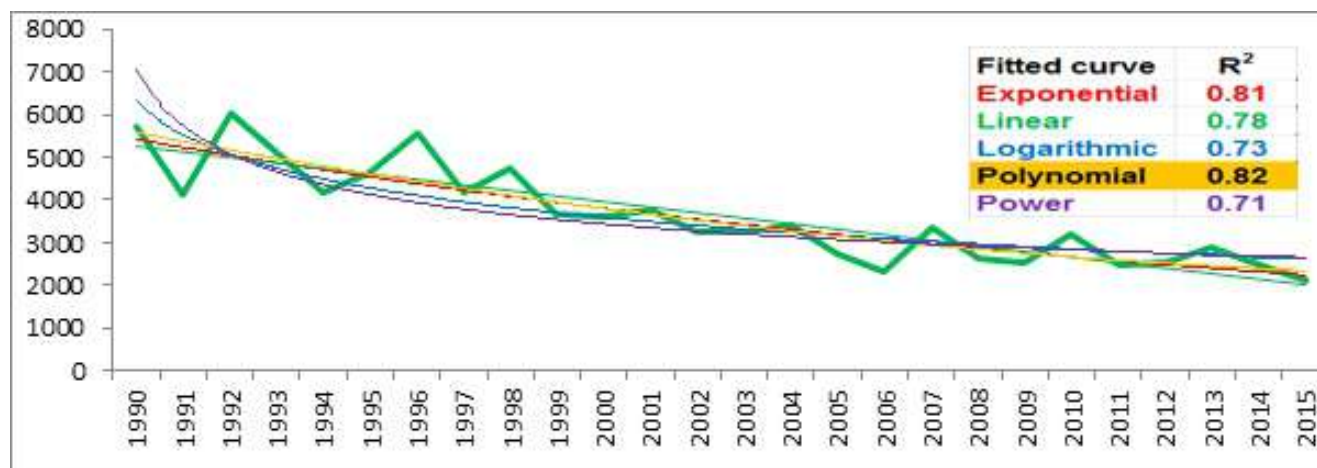
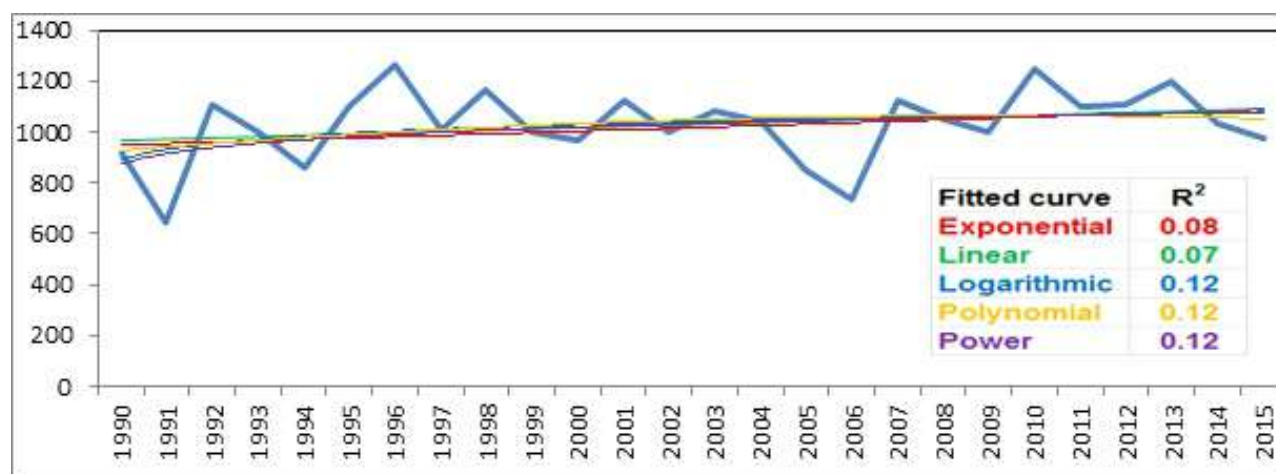
The exponential, linear, logarithmic, polynomial & power functions based were employed and best fit was judged based on the value of coefficient of determination.

During period-I and period-II for area of *kharif* groundnut the R^2 value of polynomial function was the highest i.e. 0.94 and 0.84, respectively and it was best fit for area in Marathwada region.

During overall period, for area of *kharif* groundnut the R^2 value of polynomial function was the highest i.e. 0.97 and it was best fit for area in Marathwada region.

For production of *kharif* groundnut during period-I and period-II, the R^2 value of polynomial function was the highest i.e. 0.43 and 0.56, respectively and it was best fit for production in Marathwada.

During overall period, for production of *kharif* groundnut the R^2 value of polynomial function was the

Fig-1 : Trends in area of *Kharif* groundnut for the overall period in MaharashtraFig-2 : Trends in production of *Kharif* groundnut for the overall period in Maharashtra.Fig-3 : Trends in productivity of *Kharif* groundnut for the overall period in Maharashtra.

highest i.e. 0.67 and it was best fit for production in Marathwada region.

During period-I and overall period for productivity of *kharif* groundnut the coefficient of determination value (R^2) of the estimated functions was low in Marathwada region. Therefore, none of the function was fit for productivity of *kharif* groundnut in Marathwada.

For productivity of *kharif* groundnut during period-II, the R^2 value of polynomial function was the highest i.e. 0.40 and it was best fit for production in Marathwada region.

(1) Trends in area, production and productivity of *kharif* groundnut in Vidarbha : The linear and non-linear trend lines were fitted to area, production and productivity

of *Kharif* groundnut for period-I, period-II and overall period. The coefficient of determination for the trends lines in Vidarbha region are depicted in Table-4.

The exponential, linear, logarithmic, polynomial & power functions based were employed and best fit was judged based on the value of coefficient of determination.

For area of *kharif* groundnut during period-I, the R^2 value of exponential and polynomial functions was the highest i.e. 0.99 and 0.99, respectively and it was best fit for area in Vidarbha region. For area of *kharif* groundnut during period-II, the R^2 value of polynomial function was the highest i.e. 0.92 and it was best fit for area in Vidarbha region.

During overall period, for area of *kharif* groundnut the R^2 value of polynomial function was the highest i.e. 0.99 and it was best fit for area in Vidarbha region.

For production of *kharif* groundnut during period-I, the R^2 value of polynomial function was the highest i.e. 0.72 and it was best fit for production in Vidarbha region. For production of *kharif* groundnut during period-II, the R^2 value of linear and polynomial functions was the highest i.e. 0.76 and 0.76, respectively and it was best fit for production in Vidarbha region.

During overall period, for production of *kharif* groundnut the R^2 value of exponential function was the highest i.e. 0.92 and it was best fit for production in Vidarbha region.

For productivity of *kharif* groundnut during period-I the R^2 value of polynomial function was the highest i.e. 0.47 and it was best fit for productivity in Vidarbha region.

During period-II and overall period for productivity of *kharif* groundnut the value of R^2 of the estimated functions was low in in Vidarbha region. Therefore, none of the function was fit in productivity of *kharif* groundnut respectively, in Vidarbha region.

(1) Trends in area, production and productivity of *kharif* groundnut in Maharashtra : The linear and non-linear trend lines were fitted to area, production and productivity of

Kharif groundnut for period-I, period-II and overall period. The coefficient of determination for the trends lines in Maharashtra State are presented in Table-5.

The exponential, linear, logarithmic, polynomial & power functions based were employed and best fit was judged based on the value of coefficient of determination.

For area of *kharif* groundnut during period-I, the R^2 value of polynomial function was the highest i.e. 0.96 and it was best fit for area in Maharashtra state. For area of *kharif* groundnut during period-II, the R^2 value of

exponential and polynomial functions was the highest i.e. 0.85 and 0.85, respectively and it was best fit for area in Maharashtra state.

During overall period, for area of *kharif* groundnut the R^2 value of polynomial function was the highest i.e. 0.97 and it was best fit for area in Maharashtra state.

For production of *kharif* groundnut during period-I, the R^2 value of exponential and polynomial functions was the highest i.e. 0.45 and 0.45, respectively and it was best fit for production in Maharashtra state. For production of *kharif* groundnut during period-II, the R^2 value of linear and polynomial functions was the highest i.e. 0.42 & 0.42, respectively, it was best fit for production in Maharashtra state.

During overall period, for production of *kharif* groundnut the R^2 value of polynomial function was the highest i.e. 0.82 and it was best fit for production in Maharashtra state.

For productivity of *kharif* groundnut during period-I the R^2 value of polynomial function was the highest i.e. 0.32 and it was best fit for productivity in Maharashtra state.

During period-II and overall period for productivity of *kharif* groundnut the value of R^2 of the estimated functions was low in Maharashtra state. Therefore, none of the functions was fit in productivity of *kharif* groundnut respectively, in Maharashtra state.

This implies the declined in area, production and productivity of *kharif* groundnut viz; *Kharif* groundnut in Maharashtra State. The growth of area, production and productivity of *Kharif* groundnut were declined over the period. The exponential, linear, logarithmic and polynomial functions R^2 value in area and production were mostly negative impact on *kharif* groundnut in the State over the periods-I, period-II and even overall period, these assumptions seemed to be positive. These results are in accordance with finding of Mishra (2017) and Sharma (2018).

Conclusions

Trends fitness during overall period in area, (0.32, 0.92, 0.97, 0.99 & 0.97) and production was (0.30, 0.73, 0.67, 0.92 & 0.82) of *kharif* groundnut was in Konkan, Western Maharashtra, Marathwada, Vidarbha region and Maharashtra state respectively. Polynomial functional form was to best fit the trends for *kharif* groundnut due to the highest value.

The results of the study revealed that, the value in the polynomial functional forms for area and production during overall period was positive and significant for the *kharif* groundnut in Konkan, Western Maharashtra,

Marathwada, Vidarbha region and Maharashtra state respectively.

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Trends in area, production and productivity of soybean (oilseed) in Maharashtra

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Abstract

The present study "Regional disparities in oilseeds production in Maharashtra" was carried out to estimate the trends in area, production and productivity of soybean in Maharashtra over the period of 26 years beginning from 1990-91 to 2015-16. This study was based on secondary data obtained from <http://krishi.maharashtra.gov.in> and Government publications. The exponential, linear, logarithmic, polynomial and power functions were computed and best fit was judged based on coefficient of determination (R^2) values. Fitness of trends (R^2) value in area (0.96, 0.97, 0.94 & 0.96) and production (0.93, 0.84, 0.80 & 0.86) of soybean, were estimated for Western Maharashtra, Marathwada, Vidarbha region and Maharashtra. Power functional form was best fit to the trend for soybean due to the highest (R^2) value. The rest of the study revealed that, the highest co-efficient of determination (R^2) value in the power functional forms for area and production during overall period in soybean was positive and significant in Western Maharashtra, Marathwada, Vidarbha region and overall Maharashtra. During overall period for productivity of soybean the coefficient of determination value (R^2) of the estimated functions was low. Therefore, none of the function was fit for productivity in Western Maharashtra Marathwada, Vidarbha region and overall Maharashtra.

Key words : Trends, area, production and productivity, soybean.

Introduction

Importance of oilseed : Oilseeds and edible oils are two of the most sensitive essential commodities. India is one of the largest producers of oilseeds in the world. India contributes about 6-7 per cent of the world oilseeds production; this sector occupies an important position in the agricultural economy. The oil extracted from oilseeds form an important item of our diet. Extracted oil is used as raw material for manufacturing paints, varnishes, soaps, perfumes, lubricants, etc. Oil cake is a byproduct obtained after the extraction of oil from oilseeds and an excellent cattle feed. Oil cakes are also used as fertilizers.

Soybean : Soybean (*Glycine max*) belongs to the family *fabaceae* or *leguminasae* (legume), which also includes peanuts, chickpea, other beans and pulses. Soybean themselves are hard and rounded and range in colour from black to pale yellow. Although, classified as a bean, a soybean is actually an oilseed like the peanut. Because of their high oil and protein content, soybeans are particularly useful for a variety of purposes.

Most of the early introductions planted in these areas were obtained from China, Japan, India, Manchuria, Korea, and Taiwan. It is the second important oilseed crops grown in different parts of India after groundnut. Due to its unique qualities it is known with the name of miracle crop also. It has 18-20 per cent edible oil,

45 per cent protein with high level of amino acid such as methionine and cysteine (Agarwal and Singh, 2015).

The majority of the soybean is processed into oil and meal. Soybean is also used in industrial paint, varnishes, caulking compounds, linoleum, printing inks and other products. Development efforts in recent years have resulted in several soya oil-based lubricant and fuel products that replace non-renewable petroleum products. Lecithin, a product extracted from soybean oil, is a lubricant used in many foods, commercial and industrial applications.

Soybean the 'golden bean' or 'miracle bean' is one of the most important oilseed crops in the world. Soybean rank first in oil production in world; almost 50 per cent production of oilseeds contributed by soybean. It is the most valuable crop as it contains 20 per cent oil, 45 per cent proteins, 4 per cent minerals and 2 per cent phospholipids. It is also known as gold of 20th century due to easy cultivation, high benefit cost ratio, less requirement of nitrogenous fertilizers etc. It is called 'poor man meal' due to its high nutritive value and due to that soybean is also called as vegetarian's meat. Maharashtra rank second after Madhya Pradesh in India for soybean production. Soybean was looked upon not merely as a means to supply food for humans and animals, but also at the same time to serve as a means for improving the soil though their ability to fix atmospheric nitrogen. As a

legume, it is ideal component of sound agricultural system. The protein of soybean is called a complete protein, because it supplies sufficient amounts of the kinds of amino acids required by the body for building and repair of tissues. It's food value in heart diseases and diabetes is well known. It is significant that using soybean milk in place of cow's milk is practically free from rickets. Total area under soybean cultivation was 0.03 million hectares and production was 0.01 million tonnes (1970-71).

The area, production and yield of soybean in Maharashtra during the year 2016-17 was 3841.00, ("000"ha.), 4587.00, ("000"MT) and 1194.00, Kg/ha. (Source: Economic Survey of Maharashtra 2017-18).

Research Methodology

Selection of the study area : Maharashtra State comprises four regions viz; Western Maharashtra, Marathwada, Vidarbha and overall Maharashtra.

Specification of time periods : To facilitate proper understanding of regionwise disparities in the state with regard to increase in area, production and productivity of soybean oilseed crop. The periods from 1990-91 to 2015-16 i.e. total 26 years period was selected, this 26 years period was divided in to two sub periods and one overall period as indicated below.

Period - I : 1990-91 to 2001-02

Period - II : 2002-03 to 2015-16

Overall period : 1990-91 to 2015-16

Data requirement and sources of data : The present study was based on secondary data the data in respect of area, production and productivity of *kharif* groundnut, crop for the overall period (i.e. 1990-91 to 2015-16) were obtained from the <http://Krishi.maharashtra.gov.in>. Epitomes, districts statistical abstract and Economic survey of Maharashtra.

Trends in area, production and productivity of oilseed crops : In order to assess the trends in area, production and productivity of selected oilseed crops, the linear, linear function and non-linear exponential function, logarithmic function, polynomial (quadratic) function and power function trend curves (functions) were fitted and the one yielding the highest coefficient of determination (R^2) were finally chosen for examining the year to year variations.

Suitable linear and non-linear trend equations were fitted as follow :

(i) Exponential function : The exponential function of the following form was employed,

$$Y = a.b^x$$

Where,

Y = Dependent variable

a, b = Parameter of exponential curve

x = Independent variable (Time period)

(ii) Linear function : The linear function of the following form was used for the estimation of trends in area, production and productivity of oilseeds.

$$Y = a + bx$$

Where,

Y = Dependent variables for which growth rate was estimated,

a = Intercept (constant)

b = Regression coefficient

x = Independent variable (Time period)

(iii) Logarithmic function : The logarithmic equation of the following form was employed,

$$Y = a + b(x)$$

Where,

Y = Dependent variable

a = Constant

b = Regression coefficient of Y on and in (x)

x = Independent variable (Time period)

(iv) Polynomial (Quadratic) function : The polynomial function of the following form was analyzed,

$$Y = a + bx + cx^2$$

Where,

Y = Dependent variable

a = Constant

b, c = Partial regression coefficient of x_1 and x_2

x = Independent variable (Time period)

(v) Power function : Power function of the following form was used,

$$Y = a_0 a x^2$$

Where,

Y = Dependent variable

a_0 = Constant

= 3.14

a = Parameter of the power curve

x = Independent variable (Time period)

Table-1 : Trends in area, production and productivity of soybean in Western Maharashtra.

Sr. No.	Dependent equation	Coefficient of determination (R^2)								
		Period-I (1990-91 to 2001-02)			Period-II (2002-03 to 2015-16)			Overall Period (1990-91 to 2015-16)		
		A	P	Y	A	P	Y	A	P	Y
1.	Exponential	0.80	0.76	0.33	0.75	0.54	0.00	0.88	0.77	0.02
2.	Linear	0.90	0.80	0.34	0.83	0.50	0.00	0.96	0.86	0.01
3.	Logarithmic	0.95	0.78	0.37	0.91	0.59	0.00	0.83	0.79	0.08
4.	Polynomial	0.96	0.81	0.36	0.90	0.68	0.00	0.96	0.87	0.20
5.	Power	0.96	0.89	0.37	0.91	0.66	0.00	0.96	0.93	0.10

Table-2 : Trends in area, production and productivity of soybean in Marathwada.

Sr. No.	Dependent Equation	Coefficient of determination (R^2)								
		Period-I (1990-91 to 2001-02)			Period-II (2002-03 to 2015-16)			Overall Period (1990-91 to 2015-16)		
		A	P	Y	A	P	Y	A	P	Y
1.	Exponential	0.70	0.70	0.39	0.78	0.17	0.14	0.92	0.83	0.03
2.	Linear	0.69	0.76	0.34	0.95	0.17	0.04	0.89	0.55	0.00
3.	Logarithmic	0.67	0.74	0.48	0.89	0.24	0.04	0.59	0.39	0.02
4.	Polynomial	0.69	0.76	0.53	0.95	0.35	0.09	0.97	0.55	0.12
5.	Power	0.85	0.88	0.55	0.94	0.29	0.10	0.84	0.84	0.00

Results and Discussion

Trends in area, production and productivity of soybean in Maharashtra : In order to assess the trends in area, production and productivity of selected oilseed crops, the linear, linear function and non-linear, exponential function, logarithmic function, polynomial (quadratic) function and power function trend curves (functions) were fitted and the one yielding the highest coefficient of determination (R^2) were finally chosen for examining the year to year variations.

The coefficients of determination (R^2) values for the period-I, period-II and overall period were employed to fit the trends for area, production & productivity of oilseeds in Maharashtra.

The exponential, linear, logarithmic, polynomial and power functions were employed and best fit was judged based on the value of coefficient of determination.

(1) Trends in area, production and productivity of soybean in Western Maharashtra : The linear and non-linear trend lines were fitted to area, production and productivity of soybean for period-I, period-II and overall period. The coefficient of determination for the trends lines in Western Maharashtra are depicted in Table-1.

For area of soybean during period-I, the R^2 value of linear, polynomial and power functions was the highest i.e. 0.96, 0.96 and 0.96, respectively and it was best fit for area in Western Maharashtra region. For area of soybean during period-II, the R^2 value of logarithmic and power functions was the highest i.e. 0.91 and 0.91, respectively and it was best fit for area in Western Maharashtra.

During overall period, for area of soybean the R^2 value of linear, polynomial and power functions was the highest i.e. 0.96 and it was best fit for area in Western Maharashtra region.

For production of soybean during period-I, the R^2 value of power function was the highest i.e. 0.89 and it was best fit for production in Western Maharashtra region. For production of soybean during period-II, the R^2 value of polynomial function was the highest i.e. 0.68 and it was best fit for production in Western Maharashtra region.

During overall period, for production of soybean the R^2 value of power function was the highest i.e. 0.93 and it was best fit for production in Western Maharashtra region.

For productivity of soybean during period-I, the R^2 value of power and logarithmic function was the highest i.e. 0.37 and 0.37, it was best fit for productivity in Western Maharashtra region.

During period-II and overall period for productivity of soybean the value of R^2 of the estimated functions was low in Western Maharashtra region. Therefore, it indicates that the

function does not fit in productivity of soybean respectively, in Western Maharashtra region.

(1) Trends in area, production and productivity of soybean in Marathwada : The linear and non-linear trend lines were fitted to area, production and productivity of soybean for period-I, period-II and overall period. The coefficient of determination for the trends lines in Marathwada region are presented in Table-2.

The exponential, linear, logarithmic, polynomial and

Table-3 : Trends in area, production and productivity of soybean in Vidarbha.

Sr. No.	Dependent Equation	Coefficient of determination (R ²)								
		Period-I (1990-91 to 2001-02)			Period-II (2002-03 to 2015-16)			Overall Period (1990-91 to 2015-16)		
		A	P	Y	A	P	Y	A	P	Y
1.	Exponential	0.92	0.87	0.27	0.71	0.45	0.25	0.92	0.66	0.03
2.	Linear	0.91	0.86	0.25	0.72	0.40	0.18	0.94	0.54	0.00
3.	Logarithmic	0.83	0.78	0.27	0.82	0.47	0.11	0.79	0.54	0.01
4.	Polynomial	0.92	0.86	0.28	0.81	0.41	0.27	0.94	0.62	0.23
5.	Power	0.93	0.88	0.29	0.86	0.65	0.16	0.94	0.80	0.00

Table-4 : Trends in area, production and productivity of soybean in Maharashtra.

Sr. No.	Dependent equation	Coefficient of determination (R ²)								
		Period-I (1990-91 to 2001-02)			Period-II (2002-03 to 2015-16)			Overall Period (1990-91 to 2015-16)		
		A	P	Y	A	P	Y	A	P	Y
1.	Exponential	0.92	0.86	0.34	0.82	0.79	0.20	0.95	0.77	0.04
2.	Linear	0.94	0.88	0.32	0.89	0.75	0.13	0.95	0.65	0.01
3.	Logarithmic	0.88	0.82	0.37	0.93	0.70	0.08	0.74	0.58	0.01
4.	Polynomial	0.95	0.86	0.37	0.92	0.76	0.22	0.96	0.67	0.21
5.	Power	0.97	0.91	0.38	0.96	0.89	0.22	0.96	0.86	0.20

power functions were employed and best fit was judged based on the value of coefficient of determination.

During period-I, for area of soybean the R² value of power function was the highest i.e. 0.85 and it was best fit for area in Marathwada region. For area of soybean during period-II the R² value of linear and polynomial function was the highest i.e. 0.95 and 0.95, it was best fit for area in Marathwada region.

During overall period, for area of soybean the R² value of polynomial function was the highest i.e. 0.97 and it was best fit for area in Marathwada region.

During period-I and period-II for production of soybean the R² value of power and polynomial function was the highest i.e. 0.88 and 0.35 respectively and it was best fit for production in Marathwada.

During overall period, for production of soybean the R² value of power function was the highest i.e. 0.84 and it was best fit for production in Marathwada region.

During period-I, for productivity of soybean the R² value of power function was the highest i.e. 0.55 and it was best fit for productivity in Marathwada region.

For productivity of soybean during period-II and overall period the value of R² of the estimated functions was low in Western Maharashtra region. Therefore none of the function was fit in productivity of soybean respectively, in Marathwada region.

(3) Trends in area, production and productivity of soybean in Vidarbha : The linear and non-linear trend lines were fitted to area, production and productivity of soybean for period-I, period-II and overall period. The

coefficient of determination for the trends lines in Vidarbha region are depicted in Table-3.

The exponential, linear, logarithmic, polynomial and power functions were employed and best fit was judged based on the value of coefficient of determination.

For area of soybean during period-I, the R² value of power function was the highest i.e. 0.93 and it was best fit for area in Vidarbha region. For area of soybean during period-II, the R² value of power function was the highest i.e. 0.86 and it was best fit for area in Vidarbha region.

The exponential, linear, logarithmic, polynomial and power functions were employed and best fit was judged based on the value of coefficient of determination.

For area of soybean during period-I, the R² value of power function was the highest i.e. 0.93 and it was best fit for area in Vidarbha region. For area of soybean during period-II, the R² value of power function was the highest i.e. 0.86 and it was best fit for area in

(4) Trends in area, production and productivity of soybean in Maharashtra : The linear and non-linear trend lines were fitted to area, production and productivity of soybean for period-I, period-II and overall period. The coefficient of the linear and non-linear trend lines were fitted to area, production and productivity of soybean for period-I, period-II and overall period. The coefficient of determination for the trends lines in Maharashtra State are presented in Table-4.

For area of soybean during period-I, the R² value of power function was the highest i.e. 0.97 and it was best fit for area in Maharashtra state. For area of soybean during

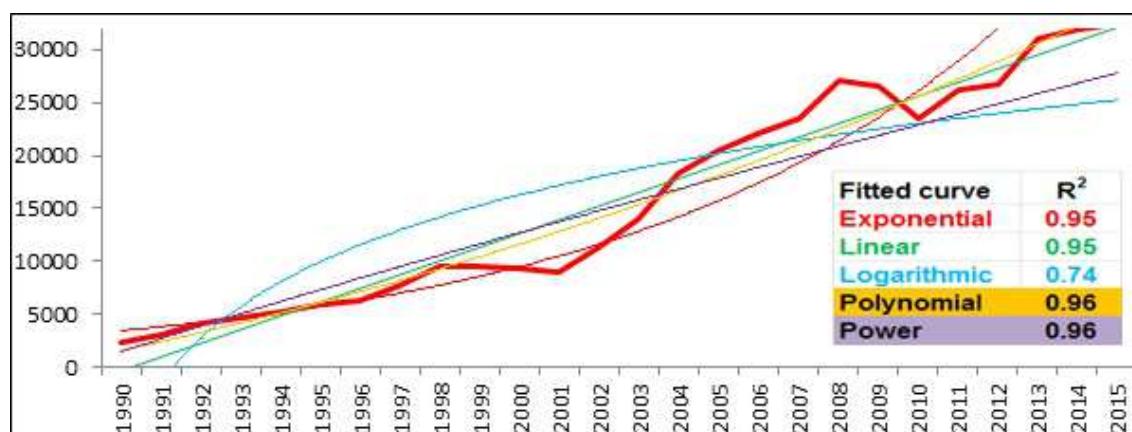


Fig-1 : Trends in area of soybean for the overall period in Maharashtra.

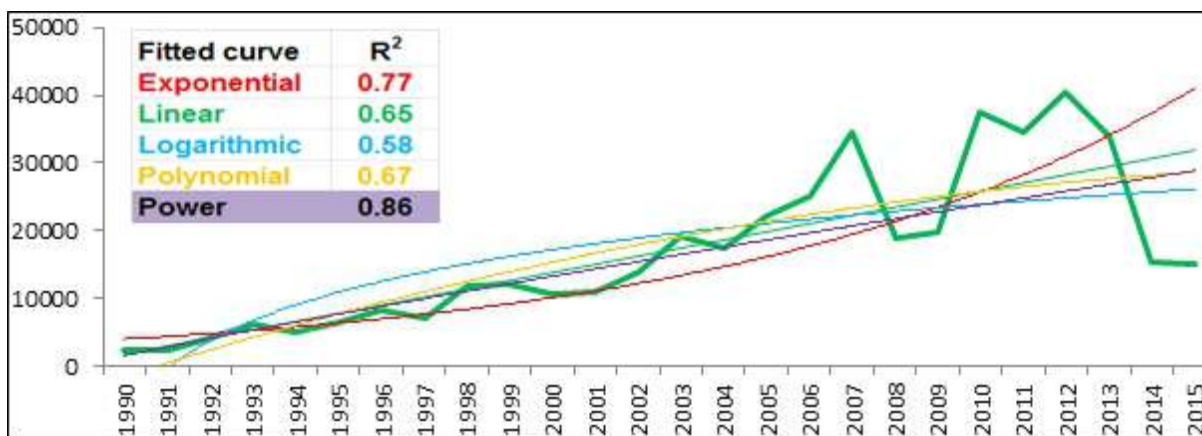


Fig-2 : Trends in production of soybean for the overall period in Maharashtra.

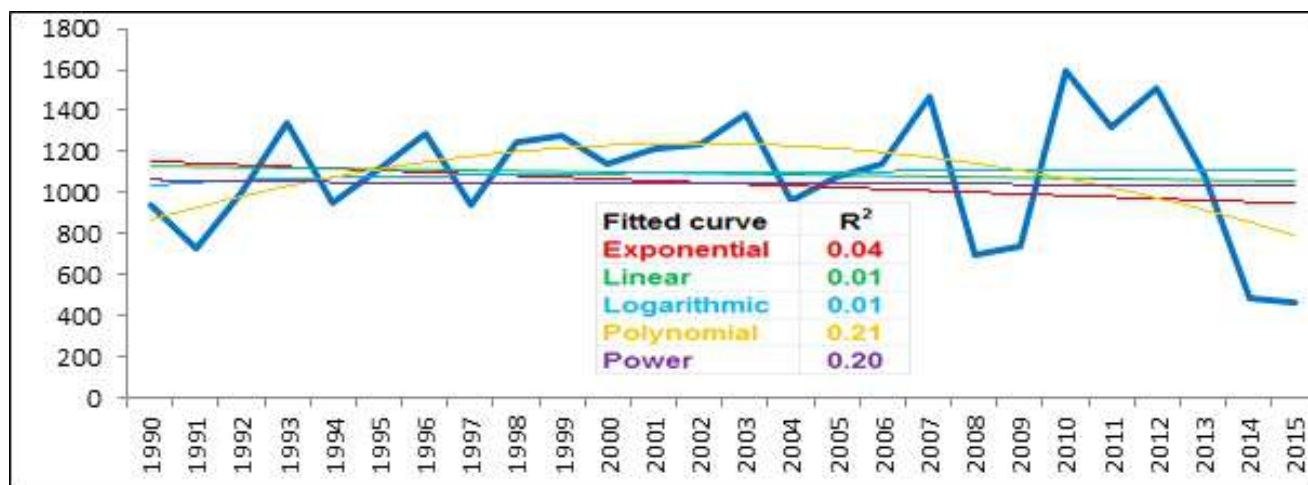


Fig-3 : Trends in productivity of soybean for the overall period in Maharashtra.

period-II, the R^2 value of power function was the highest i.e. 0.96 and it was best fit for area in Maharashtra state.

During overall period, for area of soybean the R^2 value of polynomial and power functions was the highest i.e. 0.96 and 0.96, respectively and it was best fit for area in Maharashtra state

For production of soybean during period-I, the R^2 value of power function was the highest i.e. 0.91 and it was best fit for production in Maharashtra state. For production of soybean during period-II, the R^2 value of power function was the highest i.e. 0.89 and it was best fit for production in Maharashtra state.

During overall period, for production of soybean the R^2 value of power function was the highest i.e. 0.86 and it was best fit for production Maharashtra state.

For productivity of soybean during period-I, the R^2 value of power function was the highest i.e. 0.38 and it was best fit for production Maharashtra state.

During period-II and overall period for productivity of soybean the value of R^2 of the estimated functions was low in Maharashtra state Therefore; none of the function was fit in productivity of soybean respectively, in Maharashtra state.

This implies the acceleration of increased in area, and production of oilseed viz; soybean. The growth of area, production and productivity of soybean were increased over the period's reveals that, the assumption seemed to be positive. The results of the study revealed that the highest co-efficient of determination value in the power functional forms for area, production and productivity during overall period in soybean was positive and significant in Maharashtra.

It was reveals that the exponential, linear, logarithmic and polynomial functions R^2 value in area and production were mostly positive impact on soybean oilseed in Maharashtra, during periods-I, period-II and even overall period. These results are confirmatory with the finding of Mishra (2017) and Sharma (2018).

Conclusions

Trends fitness during overall period in area was (0.96,

0.97, 0.94 & 0.96) and production was (0.93, 0.84, 0.80 & 0.86) of soybean in Western Maharashtra, Marathwada, Vidarbha regions and Maharashtra respectively. Power functional form was computed to best fit the trends for soybean due to the highest (R^2) value. The results of the study revealed that, the highest coefficient of determination value in the power functional forms for area, production and productivity during overall period in soybean was positive and significant in Western Maharashtra, Marathwada, Vidarbha region and Maharashtra state respectively.

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A Study on Impact of Time Spent in Watching Television Per Day on Food Habits of Adolescents

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Mass media, particularly television, plays a crucial role in socializing our Adolescents. Globally, television (TV)—still considered the most used form of media for marketing food and beverages, especially those with high levels of sugars, fats, and salt—plays an influential role in food choices (Cairns *et.al.*, 2013). Thus, exposure time to TV can be considered a risk factor for the higher consumption of foods and beverages of low nutritional quality through the influence of advertisements on food preferences (Boyland *et al.*, 2011) and the consumption of unhealthy snacks in front of the TV, especially when the public comprises children and adolescents (Oliveira *et al.*, 2016). Therefore, television is supposed to influence adolescents lifestyle directly or indirectly. Television is also a major source of information about food with all media platforms flooded with advertisements promoting different edible stuff and in post covid era immunity boosters. A 2003 national survey of children, sponsored by the Kaiser Family Foundation, indicated that the average child between the ages of 8 and 18 watches 3 hours of TV a day, and the averages are even higher among younger age groups (8- to 14- year-olds watched an average of 3 hours and 16 minutes). Total in-home screen time increased to 4 hours and 15 minutes when videos on DVDs are included. The addition of computers/tabs/mobiles and videogames increased total exposure to more than 6 hours (Roberts *et.al.*, 2005), that caused lowering of BMI (body mass index) among the children. So, this study was focused on the effect of advertisement on eating habits among teenagers and the rise of obesity level in them due to lack of physical activity; because of spending most of their time in front of the mass media. The study also attempts to find out of the similarities and variation in the our finding and previous studies.

Helsper (2010) emphasised on the impact of media on children and predicted that it varies from age to age and assumed that younger children tend to be more influenced by television as compared to older ones and strong correlation was found in television viewing habits and poor diet, poor health and obesity among both children adults. Living & Helsper (2011) noted that very few experiments have been conducted on teenagers,

making it difficult to go beyond the observation that television exposure is associated with unhealthy diets or obesity for this age group. There is strong evidence that exposure to television advertising is associated with adiposity in adolescence age 6 to 19 but that the causal relations involved not have been determined. The television advertising influences the food and beverages beliefs of adolescence and that it influences the usual dietary intake of adolescence aged, with weaker evidences for 8 – 18 years old.

National Research found that on over 4000 adolescence aged 11-19 has shown that these who watch more television have more body fat and a greater BMI than lower viewer. Eating in front of the television is associated with eating more, for teenage girls and with a higher fat diet while reducing television viewing is followed by reduced weight gain. A cohort study of over 10,000 10-18 year olds in India found that those who spent more time with TV/video games showed large BMI increase a year later these effects were stronger for those who are already over weight, suggesting a cumulative effect over times. Lytle and colleagues (2011) found that the transition to adolescence, where young people experience an increased need for autonomy and a desire to express themselves, influence young people's food choices. Furthermore, youth experience peer pressure which significantly influence their food choices. In comparison to younger children, teens might also be exposed to more unhealthy food choice in their environment.

Research Methodology

The main objective of the study was to assess the impact of television or other electronic gadgets on food habits of adolescents and to know about how much time adolescents spend for watching T.V. a day. Data for this study was collected by mean of questionnaire, which was filled by the students themselves. Questions were explained to the students whenever required. The students of 10th and 11th class girls and boys were selected "simple Random Sampling". Sample was collected from 50 girls and 50 boy's student of FAIZABAD PUBLIC SCHOOL. Specific information included

Table-1 : Distribution of time spend by respondents in watching television in a day.

Watching T.V	Male	Percentage	Female	Percentage
2-4 Hours	31	62%	15	30%
4-6 Hours	19	38%	35	70%
Total	50	100%	50	100%
Tabulated Value		df	Calculated Value	
	0.00393	1	0.016137	

Table-2 : Distribution of Respondent according to their view about the best example of a nutritious breakfast after watching food related advertisement.

Their thinking about Nutritious Diet	Male	Percentage	Female	Percentage
A glass of orange juice and a bowl of cereal	31	62%	32	64%
Three pancakes and three pieces of toast.	7	14%	6	12%
A glass of apple juice and two pieces of toast.	12	24%	12	24%
Total	50	100%	50	100%

information about impact of Television on food habits of Adolescents and how much time spends by adolescents in watching T.V in a day.

Statistical Analysis : Representation of statistical data by diagrams, graphs and charts or pictures are more effective than tabular representation, being easily intelligible to layman.

Data Processing and analysis : Data were analyzed using pearson chi square tests to investigate the relationship between variables of internet.

$$\chi^2 = \sum_{i=1}^n \frac{(O_i - E_i)^2}{E_i}$$

Results and Discussion

Questionnaire was used for collection of data. Adolescents in the age group of 16-18 year were selected from Faizabad public school of faizabad city using simple random sampling and purposive sampling. The total sample of 100 adolescents comprising 50% boys and 50% girls were selected for the present study. The data collected was than analyzed to draw appropriate inferences by application of suitable statistical Techniques. The statistical method used was percentage and chi square test.

Analysis of data collected revealed that maximum 62% Male Respondent spend 2-4 hours in watching T.V, while 70% female Respondents spend 4-6 hours in watching T.V. A significant difference between male and female was recorded on time spend on watching Television (Table-1). Maximum of 62% male respondent were of the view that a glass of orange juice and an bowl of cereals is the best example of nutritious breakfast after watching T.V, while 70% of Female respondents said a glass of orange and bowl cereals is the best example (Table-2). Youngsters admitted that watching television influence their food preferences in lunch especially

influencing the type of food they ate in lunch. Fast food was preferred by 12% males in comparison to 16% females. Balanced diet was preferred by 40% females whereas only 28% males opted for balanced food (Table-3). Majority of male respondents (66%) thought television to have a negative impact on food habits in comparison to 72% of females who also considered television to have a negative impact. A significant difference was recorded between male and female about television's positive or negative impact upon her /his personality and food habits (Table-4).

Conclusions

Media also plays a big role influencing what teens eat. Half of the advertisements aimed at children are food ads, most of which are unhealthy choices and none that the mass media, particularly television, play a crucial role in socializing our adolescents. Adolescents spend more time in front of the television than any other activity except for sleep. Therefore, television presents to the adolescent's considerable information about how one should look, behave, succeed in life, be popular, and so forth. Television is also is major source of information about food and bodyweight. Adolescents have many factors influencing their eating choices. Eating out often is a big one. With a busy lifestyle and limited incomes or allowances, fast food restaurants are a popular choice. The number of these restaurants has doubled since 1972. Findings confirm that eating this type of food increases the saturated fat and sugar intake but limits dietary fiber intake as opposed to eating other types. The relationship between TV and inadequate eating habits is already well established, especially when it refers to the effective influence of marketing on the eating behaviors of children and adolescents, which contributes to an increase in the rates of overweight and obesity in these age groups(Boyland & Halford, 2013; Jenkin, Madhvani, Signal, & Bowers, 2014; Lobstein & Dobb, 2005).

Table-3 : Distribution of Respondent according to the influence of advertisements on food preferences in lunch.

Lunch Preference	Male	Percentage	Female	Percentage
Fast Food	6	12%	8	16%
Balanced Diet	14	28%	20	40%
Both	30	60%	22	44%
Total	50	100%	50	100%

Table-4 : Distribution of Respondent who feel that T.V has created on his/her food habits.

Category	Male	Percentage	Female	Percentage
Positive	17	34%	14	28%
Negative	33	66%	36	72%
Total	50	100%	50	100%
Tabulated Value	df		Calculated Value	
	0.00393	1	0.935922	

It can be concluded, we articulate that the adolescents are the direct targets of the Television advertising. It is observed from exploratory analysis that the foods advertising are mostly show products contains high level of fat and sugar. So the food advertisement effect on eating habits of the adolescents and evoking their desire to eat fatty and high value sugar contain products, it's found that more than half 54% of the things the adolescents asked for were snack/dessert food candy, chips, fast foods. Such eating habits leads to obesity and other health problems in adolescents.

Chapman *et. al.*, (2014) suggested that different TV programs elicit different levels of concurrent food intake, and that the degree to which a program is engaging (or alternately, boring) is related to that intake. Additionally, they suggest that emotional content (e.g. boring vs. engaging) may be more associated than modality (e.g. TV vs. text) with concurrent intake.

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Soil Organic Carbon Stock in Selected JFMC Areas of Khurdha Forest Division, Odisha

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Abstract

Soil physical and chemical properties were quantified to assess soil organic carbon (SOC) density (t ha^{-1}) and SOC CO_2 mitigation (t ha^{-1}) under JFMC managed forests of Khurdha Forest division. Bulk density of the soil was ranged from 1.21 Mg m^{-3} to 1.33 Mg m^{-3} at Dimiria and Dhani (S) Panchamauja VSS managed forest. Particle density of the soil was 2.65 Mg m^{-3} at all VSS managed forest. Water holding capacity of the soils varied from 33.87% (Grigobardhan VSS) to 39.88% (Dimiria VSS). Coarse fragment % ranged from 14.26% (Dhani (S) Panchamauja VSS and Maa Khorakhai VSS) to 24.32% (Rameswar VSS). Soil pH varied 5.23 to 6.14 at Dimiria VSS and Maa Asurakumari VSS managed forest respectively. Electrical conductivity of the soil was ranged from 0.04 dSm^{-1} (Maa Khorakhai VSS) to 0.064 dSm^{-1} (Dimiria VSS). Organic carbon varied from 4.31 g kg^{-1} at Rameswar VSS to 10.29 g kg^{-1} at Maa Asurakumari VSS managed forest. SOC density in 0-30 cm depth of 32.88 t ha^{-1} was observed in Maa Khorakhai VSS managed forest and the least 12.44 t ha^{-1} for Rameswar VSS managed forest.

Key words : Soil organic carbon, CO_2 mitigation, joint forest management committee, forest.

Introduction

Forest are the most important component in reducing atmospheric carbon (C) by storing C in various pools (IPCC 2006) like above ground biomass, below ground biomass, soil, litter and deadwood. Soil has also prominent role in mitigating climate change and assumed to be secured in carbon storage capacity (IPCC 2003, 2006). The world's forests store large quantities of C, with an estimated C of 330 Gt in live and dead in the form of above and below-ground vegetation, and 660 Gt in mineral soil plus organic (O) horizon (Watson et al. 1996). SOC is one of the standard options to mitigate atmospheric CO_2 (IPCC 2000; Lal and Kimble 2000) and the role of SOC in greenhouse effect has been significant (Bouwman 1990; Lal 2004).

Monitoring system of soil Organic carbon will enable developing countries to improve reporting in national communications to be submitted every 4 years to the United Nations Framework Convention on Climate Change (UNFCCC). India has already agreed under Bali Action Plan to all the elements of REDD + (Reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest C stocks in 13th meeting of the Conference of parties (COP 13) at Bali. For the REDD+ context SOC estimates in the present study are significantly important for India in view of huge data gaps for this region which pose a great challenge to collect information on C forestry. Very little data is available regarding (SOC) density in Khurdha Forest Division, Odisha, India although some works on SOC%

estimation have been carried out as a part of soil physical and chemical properties (Mishra *et al.* 2013 for Khurdha district of Odisha).

The objective of this study was: 1) to quantify soil physical properties (coarse fraction, bulk density, particle density), soil chemical properties (pH, Electrical conductivity and SOC %) and SOC density within (O) horizon (0–30 cm) under JFMC managed forest of Khurdha Forest Division, Odisha. 2) to evaluate variability in SOC density and subsequently SOC CO_2 mitigation potential.

Materials and Methods

Study Area : Khordha Forest Division is situated in the eastern part of Odisha between $19^{\circ} 27' \text{ N}$ to $20^{\circ} 26' \text{ N}$ latitude and $84^{\circ} 59' \text{ E}$ to $86^{\circ} 56' \text{ E}$ longitude. Khordha Forest Division is nearer to the state capital Bhubaneswar. The total geographical area under the jurisdiction of this Division is 3,588.50 sq. km. and the forest area is 674.66 sq. km., which is 18.79% of the total geographical area of this Division. The Khordha Forest Division consists of 6 forest ranges namely Khordha, Ranpur, Tangi, Balugaon, Balipatna and Delanga. There are 108 no of VSSs, covering 155no. of revenue villages and 16409 no. of families (members) which are managing 15600.08 ha of forest area. The forest area assigned to VSS are of 9450.48 ha RF, 5604.6 ha PRF/ DPF and 545 ha others forest. Among the total no. of families 1834 are SC, 1660 are ST and 12915 are general category. Due to increase in population the forest areas are converted to other purposes.

The soil is very fertile and having thick profile. The soil is slightly acidic to neutral in nature (Das, 2012). Climate of

the area is highly humid and remains throughout the year because the area lies close to the sea.

Soil Analysis : A total of 30 soil samples comprising of 0 to 30 cm layers from six Vana Surakhya Samiti managed forests of Khordha forest division were collected to study their physico-chemical characteristics. For analysis of soil carbon a pit of 30cm x30cm x30m was dug at the centre of the 1m x1m x 1m plot and a sample of soil weighing 200gm was kept for analysis. These soil samples were dried under shed, grinded in wooden hammer, passed through 2mm sieve and preserved in polyethylene bags for laboratory study.

Physical Characteristics

(a) Coarse fragments : Highest coarse fraction >2 mm masses were separated and the amount of coarse fragments per sample was weighed and deducted from the respective samples to get correct weight bulk density (BD) and particle density(PD). SOC was determined on soil masses <2 mm assuming that the fraction of SOC in coarse fraction with fast turnover rate doesn't contribute to SOC significantly (Schrumpf *et al.* 2011, Wani *et al.* 2013).

(b) Soil texture : Fifty gram of soil was taken in a beaker; 15 ml of sodium hexa metaphosphate (15 %) and 200ml of tap water was added and then stirred for 20 minutes in a 500 ml long neck beaker with a mechanical stirrer. The contents were transferred to 1000 ml measuring cylinders and then shaken well after making up of the volume up to one liter mark. After 5 minutes and 5 hours, temperature and bouyoucos hydrometer readings were recorded. Percentage of sand, silt and clay were determined with the help of Bouyoucos hydrometer (Piper, 1950). The textural classes were determined by the help of textural diagram (International system).

(c) Bulk density and particle density : Bulk density and particle density was determined by cylinder method. The soil samples were collected by means of a special metal core (cylinder) of known volume from 0 to 30cm without disturbing the natural structure.

$$BD \text{ (g/cm}^3\text{)} = \frac{\text{Mass of oven dired soil}}{\text{Total volume of soil}}$$

$$PD \text{ (g/cm}^3\text{)} = \frac{\text{Mass of oven dired soil}}{\text{Mass of solids (including pore space)}}$$

(d) Water holding capacity : Water holding capacity of soil was determined by using the formula given by Piper (1950).

$$\text{Water holding capacity (\%)} = \frac{W_2 - W_3 - W_4}{W_3 - W_1} \times 100$$

(Where, W_1 = weight of sieve + filter paper, W_2 = weight of sieve+ filter paper + saturated soil, W_3 = weight of sieve +

filter paper + oven dried soil, W_4 = weight of water absorbed by filter paper).

Chemical Characteristics

(a) Soil pH : The pH of the soil sample was determined in 1:2.5 soil-water suspensions after equilibration for half an hour with intermittent stirring using the glass electrode pH meter (Model M K VI).

(b) Electrical conductivity (EC) : The soluble salts content (EC) of soil sample was determined in 1:2.5 soil: water suspension after equilibration for half an hour with intermittent stirring using the conductivity bride (Model: Systronics 306) and the unit was expressed as dSm^{-1} .

(c) Organic carbon : The organic carbon content of the soil was determined by Wet digestion procedure by rapid titration method of Walkley and Black (1934). One gram of soil was added with 10 ml of 1N $\text{K}_2\text{Cr}_2\text{O}_7$ and 20ml of conc. H_2SO_4 . After half an hour of reaction, 200ml of water, 5 drops of ferroin indicator were added and titrated against standard FAS (Ferrous ammonium sulphate) to maroon or wine red end point. The unit expressed in g kg^{-1} soil.

The soils having organic carbon content <5.0 g C kg^{-1} soil is rated as low, 5.0 to 7.5 g C kg^{-1} soil as medium and > 7.5 g C kg^{-1} as high.

SOC density and SOC CO_2 mitigation : From the results found from the soil analysis on CF, BD and SOC% from the collected samples the SOC density (t ha^{-1}) was calculated by using the following equation proposed by IPCC good practice guidance (IPCC 2003, 2006) for Land use, Land-use change and Forestry (LULUCF).

$$\text{SOC density} = \frac{\text{Horizon } n}{\text{Horizon } 1} \{(\text{SOC}) * \text{Bulk density} * \text{depth} * (1 - \text{C frag.})/100\} \text{ horizon}$$

Where, SOC = Representative soil organic carbon content for tonnes (t) C ha^{-1} , SOC = Soil organic carbon content for a constituent soil horizon, t C ha^{-1} , (SOC) = Concentration of SOC in a given soil mass obtained from analysis, $\text{g C (kg soil)}^{-1}$, Bulk Density = Soil mass per sample volume, tonnes soil m^{-3} (equivalent to Mg m^{-3}), Depth = Horizon depth or thickness of soil layer (m), C fragments = % volume of coarse fragments/100.

The SOC density calculated for each JFMC was converted to SOC CO_2 mitigation after multiplication by with a factor of 3.67 (C equivalent of CO_2). The values obtained represent the amount of CO_2 mitigated by soil under each VSS.

Results and Discussion

A total of 30 soil samples comprising of 0 to 30 cm layers from six Vana Surakhya Samiti managed forests of

Table-1 : Physical properties of the soil of different VSS of Khurda Forest Division.

Sl. No.	Parameter	Rameswar	Girigobardhan	Dhani (S) Pancha Mauja	Maa khorakhai	Dimiria	Maa Asurakumari
1.	CF (%)	24.32±4.62	14.26±1.30	14.70±1.59	14.32±1.46	16.45±1.67	13.45±1.46
2.	Texture	Sandy loam	Sandy loam	Loamy sand	Sandy	Loamy sand	Loamy sand
3.	Sand (%)	78.5±2.79	71.6±1.26	85.66±0.43	86.44±0.64	74.56±6.45	82.8±3.61
4.	Silt (%)	7.18±2.24	12.6±0.06	4.58±0.02	4.14±0.45	12.88±5.02	6.2±2.135
5.	Clay (%)	14.32±0.93	15.8±1.24	9.76±0.44	9.42±0.26	12.56±1.99	11±1.495
6.	BD (Mgm ⁻³)	1.27±0.04	1.33±0.04	1.31±0.01	1.30±0.01	1.214±0.05	1.256±0.03
7.	PD (Mgm ⁻³)	2.65±0.005	2.652±0.004	2.652±0.002	2.646±0.003	2.65±0.004	2.654±0.003
8.	WHC% (w/w)	38.34±1.03	33.87±2.16	34.66±1.09	35.5±0.86	39.88±2.89	37.36±1.99

Table-2 : Chemical properties of the soils at Different VSS of Khurda Forest Division.

Sl. No.	Parameters	Rameswar	Girigobardhan	Dhani (S)	Maa khorakhai	Dimiria	Maa Asurakumari
1.	pH (1:2.5)	5.28±0.18	5.57±0.19	5.50±0.28	5.28±0.19	5.23±0.08	6.14±0.05
2.	EC (dSm ⁻¹)	0.045±0.002	0.044±0.005	0.049±0.008	0.040±0.002	0.064±0.010	0.060±0.009
3.	OC (gKg ⁻¹)	4.31±0.88	6.54±0.49	6.09±0.34	7.61±.72	7.20±1.42	10.29±1.56

Khurda forest division were collected are studied. The results are as follows

Physical Properties of Soil

Coarse fragment (CF)% : The coarse fragment was separated by sieving the soil sample by 2 mm sieve and shown in the table-1. Perusal of the data in table-1 showed coarse fragment% was varied from 13.25% to 37.36% with a mean value 24.32% at Rameswar VSS, 10.21% to 17.25% with mean value 14.26% at Giri Gobardhan VSS, 9.81% to 18.53% with mean 14.70%, at Dhani (S) Panchamauja VSS, 9.61 to 18.25 with a mean value 14.31 at Maa Khorakhai VSS, 10.25% to 20.02% with mean 16.45% at Dimiria VSS and 10.21% to 18.20% with mean value 13.45 at Maa Asura Kumari VSS.

The average coarse fraction in this study was found to be 16.53% which is comparatively more than the values in a similar study by (Gupta and Sharma 2011). Coarse fraction of 14 % was reported in coniferous plantation forests in northern Taiwan (Tsai et al. 2009). The SOC density varies within different strata is related to varying proportion of coarse fragments (Liski and Westman 1997; IPCC 2003).

Soil texture : Soil texture is the relative portion of the sand, silt clay in soil. It is the fundamental properties of soil which affects plant growth by controlling the other character like water holding capacity of the soil and nutrient supply shown in the table 1. Soil texture at Rameswar VSS managed Forest and Grigobardhan VSS managed Forest, of Tangi Range was found to be sandy loam. Where as at Dhani(S) panchamauja VSS, Dimiria VSS and Maa Asurakumari VSS managed forest Ranpur range was found to be Lomy sand and at Maa khorakhai VSS managed forest Ranpur range was found to be Sandy.

Sand : Sand % of the soil ranged from 84.6% to 70% with mean value of 78.5% at Rameswar VSS managed forest of Tangi range. Whereas at Girigobardhan VSS ranged from 68.6% to 74.6% with mean value of 71.6%, at Dhani (S) Panchamauja VSS managed forest of Tangi range it was ranged from 84.6% to 86.6% with mean value of 85.66%. Sand % of the soil ranged from 84.8% to 88.6% with mean value of 86.44% at Maa Khorakhai VSS of Ranapur range. Whereas it was found to be ranged from 54.6% to 86.6% with mean value of 74.56% at Dimiria VSS managed forest, and at Maa Asurakumari VSS managed forest it was ranged from 68.6% to 88.6% with mean value of 82.8%. (Table-1)

Silt : Data in table-1 showed that silt % of the soil ranged from 2.6% to 12.7% with a mean value of 7.18% at Rameswar VSS managed forest of Tangi range, at Grigobardhan VSS managed forest it ranged from 12.4% to 12.8% with a mean value of 12.6%, at Dhani (S) Panchamauja VSS managed forest ranged from 4.5% to 4.6% with a mean value of 4.58%. Whereas it was ranged from 2.6% to 4.6% with a mean value of 4.14% at Maa Khorakhai VSS of Ranapur range, at Dimiria VSS managed forest it was ranged from 4.6% to 31.00% with a mean value of 12.88% and at Maa Asurakumari VSS managed forest ranged from 2.6% to 14.6% with a mean value of 6.2%.

Clay : Clay cotaint % of the soil was ranged from 12.8% to 17.5% with a mean value of 14.32 % at Rameswar VSS managed forest of Tangi range, whereas at Grigobardhan VSS managed forest it ranged from 12.8% to 18.6% with a mean value of 15.8 % and was ranged from 8.8% to 10.8% with a mean value of 9.76 % at Dhani (S) Panchamauja VSS managed forest of Tangi range. Clay cotaint % of the soil was ranged from 8.8% to 10% with a mean value of 9.42 % at Maa Khorakhai VSS of Ranapur

Table-3 : SOC density (t ha^{-1}) and CO_2 mitigation density (t ha^{-1}) of the soils at different VSS of Khurdha Forest Division.

Name of VSS	Mean of SOC density (t ha^{-1})	CO_2 mitigation density (t ha^{-1})
Rameswar	12.44 $\pm$ 2.65	45.64 $\pm$ 9.74
Grigobardhan	22.19 $\pm$ 1.13	81.39 $\pm$ 4.15
Dhani (S) Panchamauija	20.46 $\pm$ 1.51	88.00 $\pm$ 16.46
Maa Khorakhai	25.57 $\pm$ 2.80	93.84 $\pm$ 10.27
Dimiria	21.07 $\pm$ 3.14	77.32 $\pm$ 11.54
Maa Asurakumari	32.88 $\pm$ 3.99	120.65 $\pm$ 14.64
Mean	22.43 $\pm$ 1.52	84.47 $\pm$ 9.96

Table-4 : Coorrelation Analysis.

Parameters	Sand	Silt	Clay	BD (Mgm^{-3})	PD (Mgm^{-3})	EC (dSm^{-1})	OC (g/kg)	pHw (1:2.5)	WHC (%)
Sand	1								
Silt	-.955**	1							
Clay	-.849**	.654**	1						
BD (Mgm^{-3})	.191	-.190	-.149	1					
PD (Mgm^{-3})	.129	-.123	-.109	.142	1				
EC (dSm^{-1})	-.135	.184	.017	-.600**	-.075	1			
OC (g/kg soil)	-.080	.167	-.093	-.429*	-.081	.536**	1		
pHw (1:2.5)	.066	-.110	.026	.028	.164	.064	.234	1	
WHC (%)	-.276	.289	.189	-.858**	-.058	.526**	.461*	-.126	1

** . Correlation is significant at the 0.01 level (2-tailed). * . Correlation is significant at the 0.05 level (2-tailed).

range, it was ranged from 8.8% to 19.4% with a mean value of 12.56 % at Dimiria VSS managed forest Ranpur range. and ranged from 8.8% to 16.8% with a mean value of 11.00 % at Maa Asurakumari VSS managed forest of Ranpur range.(Table-1)

Vishnu *et al.* (2017) studied Physico – Chemical Properties of Forest Soils in Kerala and found the sand fractions in the forest soils varied from 78 % (moist deciduous forests) to 92 % (shola forests), silt from 4 % (shola forest) to 11 % (Evergreen forest) and clay from 4% (shola forest) to 12 % (moist deciduous forest). The texture of the soils varied from sandy to loam which was close to the findings of the present study.

Bulk density (BD) : Bulk density is the mass of unit volume of soil including pore space and influenced by addition of organic matter. By addition of soil organic matter the pore space changed and influenced on bulk density. Soil samples were collected from different sites were analysed and presented in table-1.

Bulk density of the soil was ranged from 1.19 to 1.38 Mgm^{-3} with a mean value 1.27 Mgm^{-3} at Rameswar VSS managed forest where as itl was ranged from 1.18 to 1.43 Mgm^{-3} with a mean value 1.33 Mgm^{-3} at Grigobardhan VSS, 1.29 to 2.34 Mgm^{-3} with a mean value 1.31 Mgm^{-3} at Dhani (S) Panchamauija VSS managed forest of Tangi range.Bulk density of the soil was ranged from 1.29 to 1.33 Mgm^{-3} with a mean value 1.30 Mgm^{-3} at Maa Khorakhai VSS managed forest, 1.08 to 1.34 Mgm^{-3} with a mean value 1.21 Mgm^{-3} at Dimiria VSS managed forest

and 1.18 to 1.33 Mgm^{-3} with a mean value 1.26 Mgm^{-3} at Maa Asurakumari VSS managed forest of Ranpur range.The bulk density is highly correlated to the organic carbon content (Morisada et al. 2004, Liefeld et al. 2005, Bhandari & Bamm 2013).

Particle density (PD) : Particle density is the mass of unit volume of soil excluding pore space. It depends on the mineral composition of the soil shown in the table-1.

Particle density of the soil was ranged from 2.64 to 2.67 Mgm^{-3} with a mean value 2.65 Mgm^{-3} at Rameswar VSS managed forest, 2.64 to 2.66 Mgm^{-3} with a mean value 2.65 Mgm^{-3} at Grigobardhan VSS managed forest, and 2.65 to 2.66 Mgm^{-3} with a mean value 2.65 Mgm^{-3} at Dhani (S) Panchamauija VSS managed forest of Tangi range. Particle density of the soil was ranged from 2.64 to 2.65 Mgm^{-3} with a mean value 2.65 Mgm^{-3} at Maa Khorakhai VSS managed forest, 2.64 to 2.65 Mgm^{-3} with a mean value 2.65 Mgm^{-3} at Dimiria VSS managed forest and 2.65 to 2.66 Mgm^{-3} with a mean value 2.65 Mgm^{-3} at Maa Asurakumari VSS managed forest of Ranpur range.

Water holding capacity (WHC) : Soil water holding capacity is the ability of soil to hold the amount of water which can be store for plant use. The soil samples collected, analysed and presented in table-1.

Water holding capacity of the soils varied from 35.25% to 41.3% with a mean value 38.345% at Rameswar VSS managed forest, 29% to 40% with a mean value 33.87% at Grigobardhan VSS managed

forest and 32.5% to 43.6% with a mean value 34.66% at Dhani (S) Panchamauja VSS managed forest of Tangi range. It was varied from 33.0% to 46.75% with a mean value 39.88% at Dimiria VSS managed forest, 32.5% to 42.2% with a mean value 39.88% at Dimiria VSS managed forest and 32.8% to 36.1% with a mean value 35.5% at Maa Khorakhai VSS managed forest of Ranpur range .

Mahapatra (2015) studied some forest soil profiles under natural Sal forest and teak plantation in Korian area of Dhenkanal forest division and found the Water holding capacity of the soils varied from 32.4 to 42.8% in 0-30 cm depth of soil which is similar to the result of present study.

Chemical Properties

pH : The negative logarithm of hydrogen ion activity is pH and it is the most important and fundamental character of the soil. The soil samples collected, analysed and presented in table 2.

Soil pH varied between 4.89 to 5.73 with a mean value of 5.28 at Rameswar VSS, 5.11 to 5.73 with a mean value of 5.21 at Grigobardhan VSS and 4.76 to 6.1 with a mean value of 5.85 at Dhani (S) Panchamauja VSS of Tangi range. It varied between 4.86 to 5.35 with a mean value of 5.28 at Maa Khorakhai VSS managed forest, 4.95 to 5.43 with a mean value of 5.23 at Dimiria VSS managed forest and 5.99 to 6.28 with a mean value of 6.14 at Maa Asurakumari VSS managed forest of Ranpur Range.

The maximum pH was found in 6.14 in Maa Asurakumari VSS and the minimum was 5.23 in Dimiria VSS. In the present study the soil pH varies from 5.23 to 6.14 and acidic in nature which is in the same range observed by Vishnu *et al.* (2017) in their study Physico – Chemical Properties of Forest Soils in Kerala was found to be acidic in different forest types and it ranged from 5.1 to 6.5.

Mishra *et al.* (2013) studied soils of different blocks of Khordha district of Odisha Bolagarh, Jatni, Begunia, Tangi, Balipatna, Bhubaneswar, Banpur, Chilika, Khurda and balipatna block were found pH to be 5.63, 5.29, 5.36, 5.18, 5.21, 5.42, 5.81, 6.00, 5.32 and 5.22 respectively are acidic in nature and which was close to the finding of the present study. Vishnu *et al.* (2017) studied Physico–Chemical Properties of Forest Soils in Kerala and found the soil reaction was found to be acidic in different forest types and it ranged from 5.1 to 6.5 which was close to the result found in the present study.

Electrical conductivity (EC) : The electrical conductivity of the soil is the soluble salt concentration in the soil and influences the plant growth by affecting the soil water

balance. The soil samples analyzed for electrical conductivity were presented in table-2.

Electrical conductivity of the soils was ranged from 0.04 dSm⁻¹ to 0.05 dSm⁻¹ with a mean value of 0.045 dSm⁻¹ at Rameswar VSS, 0.03 dSm⁻¹ to 0.06 dSm⁻¹ with a mean value 0.044 dSm⁻¹ at Grigobardhan VSS and 0.035 dSm⁻¹ to 0.08 dSm⁻¹ with a mean value 0.049 dSm⁻¹ at Dhani (S) Panchamauja VSS of Tangi range. It was ranged from 0.035 dSm⁻¹ to 0.045 dSm⁻¹ with a mean value 0.04 dSm⁻¹ Maa Khorakhai VSS managed forest, 0.04 dSm⁻¹ to 0.09 dSm⁻¹ with a mean value 0.064 dSm⁻¹ Dimiria VSS managed forest and 0.04 dSm⁻¹ to 0.08 dSm⁻¹ with a mean value 0.06 dSm⁻¹ at Maa Asurakumari VSS managed forest of Ranpur range

Mishra *et al.* (2013) studied soils of different blocks of Khordha district of Odisha Bolagarh, Jatni, Begunia, Tangi, Balipatna, Bhubaneswar, Banpur, Chilika, Khurda and balipatna block and found EC 0.043 dSm⁻¹, 0.038 dSm⁻¹, 0.021 dSm⁻¹, 0.046 dSm⁻¹, 0.072 dSm⁻¹, 0.046 dSm⁻¹, 0.078 dSm⁻¹, 0.125 dSm⁻¹, 0.091 dSm⁻¹ and 0.077 dSm⁻¹ respectively which are close to the present study. The result of study of Mishra *et al.* (2014) studied the soils of different blocks of Dhenkanal district in Odisha. They studied soils of Dhenkanal sadar, Kankadahad, Bhuban, Kamakhyanagar, Parjang, Odapada, Hindol and Gondia the EC found were 0.117 dSm⁻¹, 0.082 dSm⁻¹, 0.088 dSm⁻¹, 0.080 dSm⁻¹, 0.098 dSm⁻¹, 0.182 dSm⁻¹, and 0.094 dSm⁻¹ and 0.09 dSm⁻¹ respectively also close to the present study.

Organic Carbon (OC) : Soil organic carbon is the major component of soil fertility. By releasing nutrients it helps in plant growth, promotes the structure, biological and physical health of soil, and it protect against harmful substances. It is one of the most important indicators of soil health. SOC is one of the most important constituents of the soil due to its capacity to affect plant growth as both a source of energy and a trigger for nutrient availability through mineralization. The soil samples are analysed for SOC presented in the table-2.

Organic carbon varied from 2.11 to 6.54 g kg⁻¹ with mean value of 4.31 g kg⁻¹ at Rameswar VSS, from 5.03 to 7.94 g kg⁻¹ with mean value of 6.54 g kg⁻¹ at Girigobardhan VSS, 5.29 to 7.16 g kg⁻¹ with mean value of 6.09 g kg⁻¹ at Dhani (S) Panchamauja VSS, 5.96 to 7.40 g kg⁻¹ with mean value of 7.60 g kg⁻¹ at Dhani Maa Khorakhai VSS, 4.11 to 11.07 g kg⁻¹ with mean value of 7.20 g kg⁻¹ at Dimiria VSS managed forest and 6.44 to 14.35 g kg⁻¹ with mean value of 10.29 g kg⁻¹ at Maa Asurakumari VSS managed forest. Soil organic carbon is low in Rameswar VSS , medium in Girigobardhan VSS, Dhani (S) pancha mauja VSS and Dimiria VSS and high in Maa khorakhai and Maa Asurakumari VSS. The SOC

content ranged from 4.31 to 10.29 g kg⁻¹ which is close to the similar study of the SOC content ranged from 5.2 to 17.1 gm/kg by Pattanayak et al.(2020) in secondary tropical deciduous forests of Odisha, India.

The soil organic carbon % varied from 0.43% to 1.03% in Rameswar and Maa asurakumari VSS managed forest of Khurda Forest Division. Mishra *et al.*(2013) studied soils of different blocks of Khordha district of Odisha Bolagarh, Jatni, Begunia, Tangi, Balipatna, Bhubaneswar, Banpur, Chilika, Khurda and balipatna block and found organic carbon to be 0.322 %, 0.524 %, 0.370%, 0.399 %, 0.655 %, 0.306 %, 0.63 %, 0.831 %, 0.419(%) and 0.766 % respectively which was close to the finding of the present study. Mishra *et al.* (2014) studied the soils of different blocks of Dhenkanal district in Odisha. They studied soils of Dhenkanal sadar, Kankadahad, Bhuban, Kamakhyanager, Parjang, Odapada, Hindol and Gondia the organic carbon to be 0.640 %, 0.837 %, 0.685 %, 0.724 %, 0.751%, 0.822%, 0.707% and 0.756% respectively which was close to the finding of the present study.

SOC density and CO₂ mitigation density : The soil organic carbon pool is the formed by C inputs from litter fall, rhizo-deposition and released by decomposition (Jandl *et al.* 2007). The SOC density was estimated by SOC%, BD and CF in the soil as per IPCC equation (IPCC, 2006). In the present study highest SOC density in 0-30 cm depth 32.88±3.99 t ha⁻¹ was observed in Maa Khorakhai VSS managed forest and the least 12.44±2.65 t ha⁻¹ for Rameswar VSS managed forest.as shown in table-3.

Patil *et al* (2014) in a study of changes in soil organic carbon stock as an effect of land use system in Gondia district of Maharashtra found that the SOC density was ranged from 13.5- 50.2 t ha⁻¹ in tropical dry forest. This was closed to the findings of the present study.

Gandhi *et al.* (2017) in their study on Soil carbon stock assessment in the tropical dry deciduous forest of the Sathanur reserve forest of Eastern Ghats, India found that the SOC stock 16.92 to 44.65 Mg/ha which is also close to the present study. Gandhiv Cafle (2019) in his study on tropical community forest found to be 34.35 Mg/ha is also close to the result of the present study.

Gupta and Sharma (2014) in their study on sequestered organic carbon in soil in tropical dry forest of Haryana found that in 0-30 cm horizon the organic carbon was 40.92 t/ha in sal forest which was higher than the present study as the research under taken in the area were under wild life sanctuary, national park and conservation reserves and the present study was in the degraded forests which were protected for last 10 to 15

years. The SOC increases with age from young age stands to mature stands (Chen and Shrestha 2012).

CO₂ mitigation density values estimated on the basis of SOC density for different JFMC managed forest (Table-3). The analysis revealed highest CO₂ mitigation density of 120.65±14.64 t ha⁻¹ for Maa asurakumari VSS and lowest value of 45.64±9.74 t ha⁻¹ for Rameswar VSS managed forest.

Sand was found to be negatively correlated with silt (-0.955**) and clay (-0.849**). As sand % increased the silt% and clay% was decreased because silt and clay leached down and sand % increased in upper layer. Silt was positively correlated with clay (0.654**). Bulk density was negatively correlated with EC (-0.600**), organic carbon (-0.429*) and WHC% (-0.858**). EC was positively correlated with OC (0.536**) and WHC% (0.526**) where as organic carbon was positively correlated with WHC% (0.461). As organic carbon increased due to decomposition of plant derbies the soil become lose so the electric conductivity and water holding capacity increased and bulk density decreased.

Conclusions

The results of this study recommend that factors such as quality and density of vegetation, soil physical and chemical properties influence SOC density. The values of SOC density were varying considerably among different JFMC managed forests. The JFMC managed forests showed variation in SOC density per hectare also reflect site quality and coarse fraction of the soil. The following recommendations could be made from the study :

The Indian forest management system should focus on forest SOC which is one of the strongest and long term CO₂ mitigation options to achieve the REDD + need.

The soil monitoring system needs to be strengthened at regional and local level to address uncertainty and improve reporting of SOC.

Strategies to increase forest SOC includes immediate protection of degraded forest sites by allowing natural growth and planting trees in vacated area and local species should be promoted. Soil and water conservation mechanisms should be adopted.

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Role of Different Concentrations Gibberellic Acid (GA₃) on Seed Germination and Seedling Quality of *Saraca asoca* (Roxb.) De Wilde

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Abstract

During July and August 2015, study was carried out at the Shade net house, Nursery of Biotechnology-cum-Tissue Culture Centre, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, evaluated the "Effect of Gibberellic Acid (GA₃) different concentrations on seed germination and seedling growth of *Saraca asoca* (Roxb.) De Wilde." With three replications, the experiment was set up in a completely randomized design. Gibberellic acid was used to pre-treat the seeds (100, 200, 300, 400 ppm, and a control). The highest germination percentage (56.67) was found at T₃ (GA₃ 200 ppm), with a mean daily germination of (0.94), a maximum peak value (1.21), and a maximum germination value (1.46) in 200 ppm GA₃. Under T₃ (200 ppm GA₃) at 60, 90, and 120 DAS, maximum plant heights of 22.67, 28.33, and 30.33 cm were reported. In 60, 90, and 120 days, the largest number of leaves (17.00, 20.67, and 22.67 leaves per seedling) was reported. At 120 days, the maximum number of branches per seedling (4.67) was reported. At 120 days, the maximum root length (22.00 cm) was reported under treatment T₃ (GA₃ 200 ppm). Under comparable conditions, the seedling's maximum fresh weight (14.77 g) and dry weight (4.19 g) were recorded. As a result, it's possible to infer that GA₃ at 200 ppm has a substantial impact on Ashoka seed germination and seedling growth, and that it should be suggested to growers for faster seed germination and better seedling growth.

Key words : Ashoka, germination, peak value, root, seedling.

Introduction

Forests would not be complete without trees. Trees are inexhaustible sources of nutritious food, lumber, and medicines used in everyday life. As a result, natural and artificial pressures are exerted on these resources. Plants are used for a variety of purposes, including Ayurvedic, Unani, Siddha, Homeopathy, Allopathy, and other uses such as people pharmaceuticals, family unit treatments, and naturopathy. The WHO estimates that the present market for medicinal plants is worth roughly \$14 billion per year (Sharma, 2004). Deforestation for agriculture, fodder, shelter, and grazing, as well as the diversion of important trees for development purposes, have all had a negative impact on forest resources, putting them in jeopardy.

Saraca asoca (Roxb.) De Wilde syn. *Saraca indica* has a place with family Fabaceae is a medium understory evergreen tree growing to 9m high, with various spreading and hanging glabrous branches. Leaves are pinnate, 30-60cm long, having 2-3 sets of lanceolate flyers. Flowers are orange or orange-yellow, masterminded in thick corymbs and exceptionally fragrant. Fruits are flat black pods, leathery and compressed with 4-8 seed/pod. Seeds are ellipsoid oblong and compressed. The bark is dim dark, coloured

to dim or dark with a warty surface. The thickness differs from 5mm to 10mm. The tree is found nearly all through India, with the exception of North-Western India, Up to 750 m. It is likewise found in Andaman Islands.

Saraca asoca (Roxb.) De Wilde grows well in areas with well-distributed rainfall and in slightly shady areas. It requires soil reach in organic matter and moisture. *Saraca asoca* (Roxb.) De Wilde posses therapeutic uses. The bark is helpful in dyspepsia, fever, consuming sensation, ulcers, leucorrhoea and pimples. The leaf juice blended with cumin seeds are utilized for treating stomachalagia. The blooms are thought to be uterine tonic and looseness of the bowels. The outstanding Ayurvedic preparation is "Ashokarishta" is recommended in Leucorrhoea and different ailments of female (Nudrat, *et al.* 2005). Producing commercially valuable Ashoka with high levels of medicinal properties requires *Saraca asoca* (Roxb.) De Wilde trees to be a minimum of 15 years old the age at which they will be harvested *Saraca asoca* (Roxb.) De Wilde is expensive compared to other types of woods; therefore, to maximize the profit of bark is harvested by removing from the tree (Rout *et al.* 2017).

Saraca asoca (Roxb.) De Wilde can be propagated through seeds and cuttings. It is mostly propagated by seeds (Prachi, 2016).The viability of *Saraca asoca*

(Roxb.) De Wilde seeds is up to two months and under cold condition seed may retain viability up to six months if carefully stored (Dent, 1948). It is propagated through seeds either by coordinate sowing in nursery bed or polybags. A nursery blend of prolific soil, sand, and FYM, in 2:1:1 proportion, is discovered best and practical for generating higher quality seeding. Seeds can likewise been specifically sown in the plantation field. Pretreatments of seeds with growth hormone before sowing also improve seeds' germination (Raynor, 1940). GA₃ is essential to plant growth regulators for multiple plant development processes, including seed germination and flowering induction. GA₃ is the plant growth regulator having numerous applications in Agriculture and forestry, its having positive effects demonstrated in various crops (Urbanova *et al.* 2018). These study methods are a possible way to shorten the germination and quality of seedlings of Ashoka Species. Therefore the objective of this study was to determine the effects of GA₃ application on seed germination, plant development, and optimizing the concentration of the GA₃ plant growth regulator. Keeping in view the importance of the study, an attempt has been made to evaluate the effect of Gibberellic Acid (GA₃) different concentrations on seed germination and seedling growth and quality seedling of *Saraca asoca* (Roxb.) De Wilde

Materials and Methods

The present investigation was undertaken during the year 2015-17. The experiment was carried out in the Shade net house, Nursery of Biotechnology-cum-Tissue Culture Centre, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar. Seeds were collected from candidate plus trees identified in Bhubaneswar from July to August 2015. The Seed then was sown polypots in nursery bed prepared with soil, sand and FYM planting mixture of ratio 2:1:1 respectively for each treatments condition. The preparation of GA₃ solutions (100, 200, 300 and 400 ppm concentration) of 100 mg, 200 mg, 300 mg and 400 mg of GA₃ respectively were taken and each of dissolved separately in 5-10 ml of ethyl alcohol and then the volume was made to 1000 ml by adding distilled water. The extracted 10 seeds/replication were soaked for 24 hours in GA₃ solutions of each concentration and distilled water (Control). Intermittent hand weeding was done as when needed. Observation recorded i.e. Number of seed germinated, plant height, number of leaves, fresh weight, dry weight. Based on the number of seeds germinated, the different parameters, i.e. Germination percentage, were calculated as number of seed sown and number of seeds germinated express in percentage. Mean daily germination was calculated as the

average daily germination (ADG) or per day germination and was calculated by the formula (Czeabatore, 1962).

Peak value was calculated as the maximum MDG reached at any time during the period of the test (Czeabatore, 1962). Germination value is an index combining speed and completeness of seed germination. Daily germination counts were recorded and G V was calculated as per (Czeabatore, 1962). Height was measured from ground level to the tip of opened leaf (60, 90 and 120 days). The total number of leaves per seedling was counted and the average was calculated. Matured leaves were taken into account. The following observations were recorded at 120 days after sowing. Randomly selected three plants were tagged for following observations. The total number of leaves per seedling was counted and the average was calculated. Matured leaves were taken into account a) Fresh Biomass (g), b) Dry Biomass (g) For determining the dry matter production three plants were removed from polybags and roots were washed. After recording the fresh weight, the samples were at 60°C for 36 hrs (till constant weight) s. The dry weight of total plant was recorded accordingly. Various parameters were analyzed statistically wherever necessary using the methods suggested by Gomez and Gomez (1984) in Completely Randomized Design (CRD). The analysis of variance (ANOVA) table was prepared. The treatment effects were tested by 'F' test at 5% level of significance. The critical difference at 5% level was calculated for comparing the treatment means.

Results and Discussion

In this investigation the mature seed were collected and pre treated as per treatment details (100, 200, 300, 400 ppm, and a control). The seeds (10 numbers) under each replication of the above treatments were sown in the poly pots in the nursery and number of seeds germinated was recorded up to 60 days based on these observations, mean daily germination, peak value and germination value were carried out. The effect of different treatment i.e. various concentration of GA₃ on germination percent, mean daily germination, peak value, and germination value in seeds of *Saraca asoca* (Roxb.) De Wilde was found highly significant and is given in table 1, 2 and 3.

Germination Percentage : Seed germination percentage was worked out and presented in table 1 and fig 1. The data revealed that the maximum percentage of germination 56.67 was noted at T₃ (200 ppm). Whereas the minimum seed germination of 13.33 percent was under T₁ (Control).

These findings may be due to the effect of GA₃, which would have triggered the activity of specific enzymes that promoted early germination, such as

Table-1 : Effect of different concentrations of Gibberellic acid (GA₃) on germination of seeds of *Saraca asoca* (Roxb.) De Wilde.

Treatments	Germination %	Mean Daily germination	Peak Value	Germination Value
T ₁ -Control	13.33	0.22	0.34	0.08
T ₂ -100 ppm GA ₃	46.67	0.77	1.18	0.92
T ₃ -200 ppm GA ₃	56.67	0.94	1.21	1.46
T ₄ -300 ppm GA ₃	33.33	0.55	0.83	0.46
T ₅ -400 ppm GA ₃	23.33	0.39	0.60	0.24
SE(m)±	3.17	0.05	0.18	0.09
CD at 5%	8.80	0.14	0.51	0.27

Table-2 : Effect of different concentration of Gibberellic acid (GA₃) on vegetative growth parameters of *Saraca asoca* (Roxb.) De Wilde.

Treatments	Plant height 60 DAS	Plant height 90 DAS	Plant height 120 DAS	No. of leaf 60 DAS	No. of leaf 90 DAS	No. of leaf 120 DAS
T ₁ -Control	11.33	13.00	15.67	3.67	6.33	7.67
T ₂ -100 ppm GA ₃	17.33	17.00	20.67	4.33	8.33	11.00
T ₃ -200 ppm GA ₃	22.67	28.33	30.33	17.00	20.67	22.67
T ₄ -300 ppm GA ₃	19.33	21.67	25.33	13.33	15.33	17.33
T ₅ -400 ppm GA ₃	13.33	15.33	23.33	10.33	12.67	14.00
SE(m)±	0.84	1.12	1.29	0.66	0.87	0.73
CD at 5%	2.33	3.12	3.58	1.84	2.42	1.31

Table-3 : Effect of different concentrations of Gibberellic acid (GA₃) on biomass production of *Saraca asoca* (Roxb.) De Wilde.

Treatments	No. of Branches 120 DAS	Root length (cm) 120 DAS	Fresh weight (g)	Dry weight (g)
T ₁ -Control	2.67	11.67	6.34	2.06
T ₂ -100 ppm GA ₃	3.67	17.67	13.08	3.84
T ₃ -200 ppm GA ₃	4.67	22.00	14.77	4.19
T ₄ -300 ppm GA ₃	4.00	21.00	12.36	3.91
T ₅ -400 ppm GA ₃	3.33	14.00	12.25	4.62
SE(m)±	0.28	0.87	1.36	0.47
CD at 5%	0.78	2.42	3.77	1.31

-amylase, which have increased the availability of starch assimilation.

The enhanced germinability of GA₃ treated seeds may be due to an increase in gibberellin content in the seeds after treatment (Koyuncu, 2005). In recent years, research has revealed that gibberellin is an excellent germination promoter in a variety of plant species (Dewir *et al.*, 2011; Bhan and Sharma, 2011).

Mean Daily Germination : The value of mean daily germination of seed was found maximum in seed treated with 200 ppm GA₃ (0.94) which was followed by with mean daily germinating seed treated with 100 ppm GA₃ (0.77) (Table-1 and Fig-2).

Peak Value : The value of peak value of seed was found maximum in seeds treated with 200 ppm GA₃ (1.21), which was followed by T₂ (200 ppm GA₃). However, the lowest peak value (0.34) was recorded in seeds at T₁ (Control) (Table-1 and Fig-1).

Germination value : The value of germination value of seed was found maximum in seed treated with 200 ppm GA₃ (1.46), followed by T₂ (100 ppm GA₃). However the

lowest germination value (0.08) was recorded in seeds at T₁ (Control).

Height of Plant (cm) : Gibberellic acid concentration had shown a significant effect on the height of plants at 60, 90 and 120 days after sowing was recorded and presented in Table-2 and Fig-2. Data showed that the gibberellic acid concentration significantly affected plant height at 60, 90 and 120 days. The maximum plant height of 22.67, 28.33 and 30.33 cm noted under T₃ (200 ppm GA₃) at 60, 90 and 120 DAS, respectively and it was significantly superior over rest of the treatments. The minimum plant height of 11.33, 13.00 and 15.07 cm was recorded under T₁ (Control) at 60, 90 and 120 days after seed sowing, respectively.

It was due to additional GA₃, activated -amylase which digested the available carbohydrate into simple sugar so that energy and nutrition were easily available to faster-growing seedlings. Increase in plant height due to GA₃ has also been reported by Shant and Rao (1973). This finding is also supported by Wanyama *et al.* (2006) and Mostafa (2002) in *Balanites aegyptiaca*.

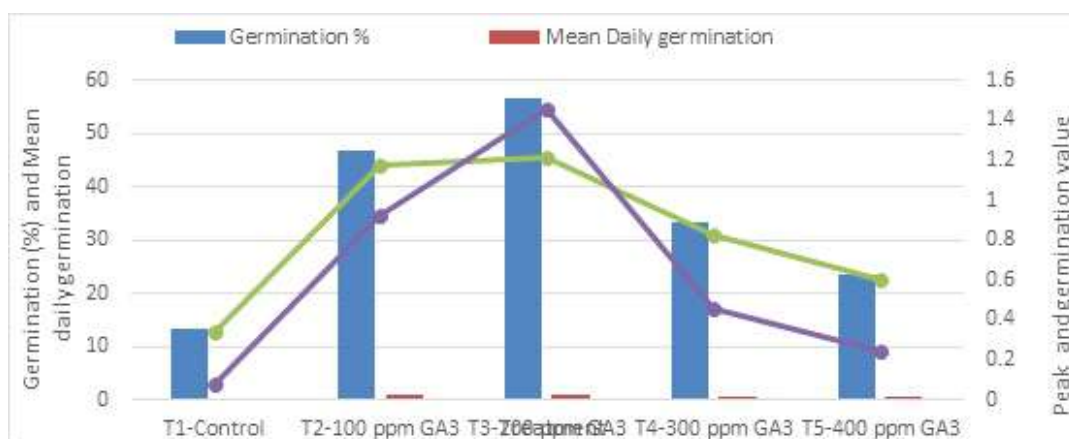


Fig-1 : Effect of different concentration of Gibberellic acid (GA₃) on germination of seeds of *Saraca asoca* (Roxb.) De Wilde.

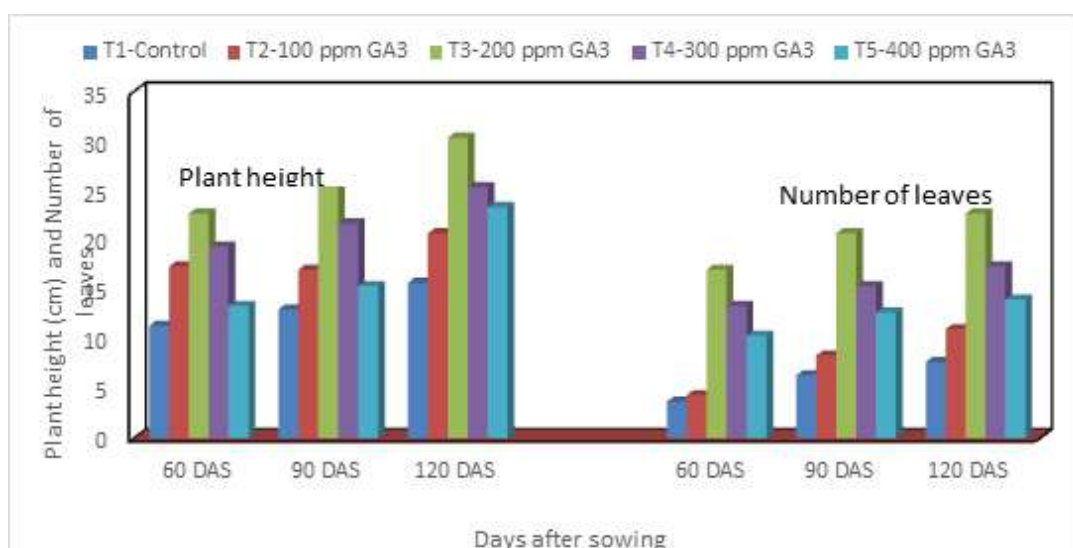


Fig-2 : Effect of different concentration of Gibberellic acid (GA₃) on vegetative growth parameters of *Saraca asoca* (Roxb.) De Wilde.

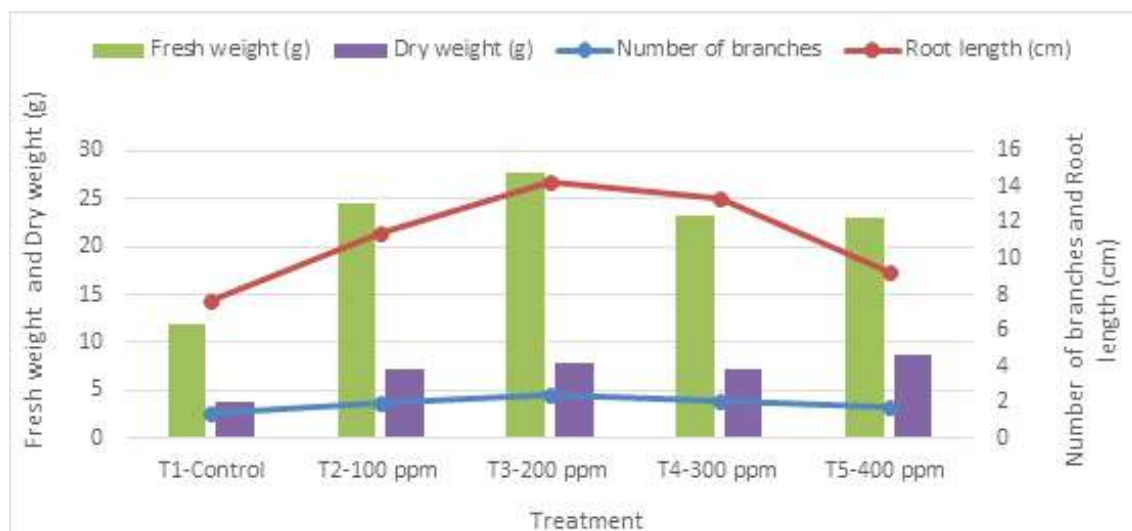


Fig-3 : Effect of different concentration of Gibberellic acid (GA₃) on biomass production of *Saraca asoca* (Roxb.) De Wilde.

Number of leaves per seedling : The data pertaining to number of leaves per seedling at 60, 90 and 120 days after sowing was recorded and presented in table-2 and Fig-2. Data revealed that the maximum number of leaves (17.00, 20.67 and 22.67 leaves per seedling) was recorded respectively when seed pre soaked with GA₃ 200 ppm (T₃) and showed significant superiority over rest of the treatment at 60, 90 and 120 days after seed sowing. However, the minimum number of leaves (3.67, 6.33 and 7.67) per seedling was recorded under T₁ (Control) at 60, 90 and 120 days after seed sowing, respectively. Brijwal and Kumar, (2013) supported the result of higher number of leaf is due to GA₃, suitable soil moisture and temperature. The results are in alignment with the findings of Shaban (2010).

Number of branches per seedling : The data pertaining to number of branches per seedling at 120 days after sowing was recorded and presented in table-3 and Fig-3. Data revealed that the maximum number of branches (4.67) branches per seedling) was recorded respectively when seed pre soaked with GA₃ 200 ppm (T₃) and showed significant superiority over rest of the treatment at 120 days after seed sowing. However, the minimum number of leaves (2.67) per seedling was recorded under T₁ (Control) at 120 days after seed sowing, respectively.

The maximum number of branches observed under the treatment may be due to it have absorbed more food material and might be increased the physiological activities of seedlings, essential for cell division or cell enlargement or both, because growth of the plant occurs by two processes i.e. cell division by mitosis which add new cells and elongation of already existing cells by enlargement of the vacuoles. The findings are supported by Ozguven *et al.* (1995), Wagh *et al.* (1998), Swamy *et al.* (1999) and Kalabandi *et al.* (2003).

Root length (cm) at 120 days after sowing : It is evident from table-3 and fig-3 that GA₃ different concentrations significantly influenced the root length of seedling and the maximum root length (22.00 cm) was recorded under treatment T₃ (GA₃ 200 ppm), which was significantly superior over rest of the treatments and minimum fresh weight of seedling (11.67 cm) was noted under treatment T₁ (Control) at 120 days after seed sowing, respectively.

Exogenous application of GA₃ induced the activity of gluconeogenic enzymes during early stages of seed germination. This could be the reason for improved germination and vigour characteristics reflected in the increase in root length (Rout *et al.* 2016).

Fresh weight of shoots (g) at 120 days after sowing : It is evident from table-3 and fig-3 that GA₃ different concentrations significantly influenced the fresh weight of seedling and the maximum fresh weight (14.77 g) was

recorded under treatment T₃ (GA₃ 200 ppm) and stood at par with T₂ (100 ppm GA₃) (13.08) which was significantly superior over rest of the treatments and minimum fresh weight of seedling (6.34 g) was noted under treatment T₁ (Control) at 120 days after seed sowing, respectively.

Increase in fresh weight of plant is due to the influence of GA₃ on different plant parts, which could be due to its effect in stimulating cell division, cell elongation, auxin metabolism, cell wall plasticity and permeability of cell membrane leading to enhanced growth. Increase in the dry weight of different plant parts due to improved mobilization of nutrients due to the application of GA₃, which promotes plant growth and development.

Dry weight of shoots (g) at 120 days after sowing : It is clear table-3 and fig-3 that GA₃ different concentrations significantly influenced dry weight of shoots at 120 days after sowing. Maximum dry weight of seedling (4.19 g) was recorded under treatment T₃ (GA₃ 200 ppm) which was found to be significantly superior over rest of the treatments and minimum dry weight of seedling (2.06 g) was noted in treatment T₁ (Control) at 120 days after seed sowing, respectively.

This may be due to its effect in stimulating cell division, cell elongation, auxin metabolism, cell wall plasticity and permeability of cell membrane leading to enhanced growth. Increase in the dry weight of different plant parts due to improved mobilization of nutrients due to the application of GA₃, which promotes plant growth and development. The findings are agreement with the findings of Rahemi and Baninasab (2000); Rout *et al.* (2020).

Conclusions

It was concluded from this study on the investigation of germination parameters and seedling growth performance, the GA₃ concentration is 200 ppm is the optimum and may be recommended to grower and researcher for the quality seeding production of *Saraca asoca* (Roxb.) De Wilde.

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Performance of Willow Clones in Climatic Condition of U.P.

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Abstract

A field experiment entitled "Performance of willow Clones in Climatic Condition of U.P." was conducted at Soil Conservation and Water Management Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The results showed much better growth of clone PN-731 in terms of plant height and girth (289 cm and 9.2 cm during 2009-10 and 325 cm & 12.1 cm during 2010-11) followed by PN – 227 and GBP selection during experimentation years. Clone 795, PN 272, SE-69002 and SI-63-007 were also attained better height and girth as compared to remaining clones.

Introduction

Short rotation forestry is the need of the hour because of forest area decreasing day by day and short duration tree species attract farmers to incorporate in agricultural system. Agroforestry is practiced in both irrigated and rainfed conditions where it produces food, fuel, fodder, timber, fertilizer and fibre , contributes to food, nutritional and ecological security, sustains livelihoods, alleviates poverty and promotes productive and resilient cropping and farming environments. Agroforestry also has the potential to enhance ecosystem services through carbon storage, prevention biodiversity and soil / water conservation. In addition, when strategically applied on a large scale, with appropriate mix of species, agroforestry enables agricultural land to tolerate extreme weather events, such as floods and droughts, and climate change. Agroforestry has significant potential to provide employment to rural and urban population through production, industrial application and value addition ventures. Current estimates show that about 65 % of the country's timber requirement is met from the trees grown on farms. It is also recognized that agroforestry is perhaps the only alternative to meeting the target of increasing forest or tree cover to 33 per cent from the present level of less than 25 per cent, as envisaged in the National Forest Policy (1988). Agroforestry species are known to sequester as much carbon in below ground biomass as the primary forests, and far greater than the crop and grass systems. *Salix alba* (white willow) is a species of Willow native to Europe and Western and Central Asia . It is a medium-sized to large deciduous tree growing up to 10–30 m tall, with a trunk up to 1 m diameter and an irregular, often-leaning crown. The bark is grey-brown, and deeply fissured in older trees.

The cultivation of *Salix alba* (Willow) has a long history for its variety of benefit to mankind, which is grown in many area of the world for bioenergy and bioproducts,

agroforestry and phyto-remedation (Volk *et al.* 2006). *Salix alba* commonly known as the white willow or English willow is an introduced willow species. It grows upon 2100 m above m.s. l. and has the character of a height of about 30 m and girth from 1 to 2 m. This tree species is most favored account of its fast growth, multipurpose utility, high adaptability and short duration, thereby ensuring quick return to the farmers. Due to its short duration, *Salix alba* is a great boost to the rural economy (Heaton *et al.* 1999). The wood of willow is used for making fruit boxes (Apples) in Kashmir valley. The other local and international use of *Salix alba* construction material for wide array of items likes; sweet lodges, furniture, baskets, splint of match boxes and agricultural implements, etc.

Materials and Methods

A field experiment entitled "Performance of willow Clones in Climatic Condition of U.P." was conducted at Soil Conservation and Water Management Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during 2009-10 to 2011- 2012 with the objectives that to screen out suitable willow clones for waterlogged soil. The experimental site is situated at an elevation of 125.9 metre above mean sea level and lies between 25° 26' and 26° 58' North latitude and 79° 31' and 80° 34' East longitude. Kanpur falls in central U.P. and sub-tropical zone having average annual rainfall 800 mm and alluvial soil with neutral pH. Treatment comprises of 22 willow clones used to raise nursery which were collected from Dr. Y.S. Parmar University of Horticulture and Forestry, Solan (Himanchal Pradesh) and one clone collected from G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar (Uttanchal). Another second experiment entitled "Effect of weed management and irrigation interval on plant height of willow in nursery" planned at Kanpur at same location. Cuttings of willow were transplanted in second week of February in each experimental year at 50 cm row to row and 20 cm plant to

Table-1 : Performance of Willow clones under nursery condition at Kanpur.

Willow Clones	Plant height (cm)		Plant girth (cm)	
		2010-11	2009-10	2010-11
NZ-1002	118	192	4.20	6.10
Clone-795	153	221	4.20	7.40
PN-227	162	235	5.30	9.10
Clone-84/21	62	92	2.20	2.30
SE-69002	72	110	2.20	2.40
SI-63-007	80	96	2.10	2.40
MB-368	66	90	2.10	2.20
PN-731	289	325	9.20	12.10
SE-750-001	50	80	1.90	2.10
SE-63-016	76	100	2.20	2.40
Clone-212/03	56	80	1.80	2.10
Clone-V.99	48	90	1.90	2.20
SI-62-96	56	76	1.80	2.20
Kashmiri	76	90	1.90	2.30
Local-M	66	80	1.90	2.30
Clone-84/11	68	83	1.80	2.20
NZ-1140	80	98	2.00	2.40
Clone-1793-A	78	96	2.20	2.50
SI-64-017	62	70	1.80	2.10
Local-F	50	66	1.90	2.10
PN-272	54	68	1.90	2.20
GBP-selection	148	242	5.10	8.20
S.E. (d)	18	17	0.20	1.51
C.D. (P=0.05)	36	35	0.41	3.06

Table-2 : Effect of weed management and irrigation intervals on plant height of willow in nursery.

Treatments	Plant height (cm) at Days after planting (DAP)			
	80	160	240	320
Weed management practices				
Control	39	82	166	218
Two weeding and hoeing	48	105	235	305
Spraying of Paraquat @ 3.5 l/ha before 25 days of planting followed by two weeding and hoeings	54	135	249	337
Spraying of Glyphosate @ 3.5 l/ha before 30 days of planting followed by two weeding and hoeings	63	145	265	355
S.E. (d)	3.3	5.6	12.9	17.7
C.D. (P=0.05)	7.1	11.9	27.6	37.9
Irrigation intervals				
4 days	58.7	131.2	245.2	328.7
8 days	43.2	102.2	212.2	278.7
S.E. (d)	2.3	3.9	9.1	12.5
C.D. (P=0.05)	4.9	8.4	19.5	26.8

plant spacing in nursery. Experimental field was highly infested with broad leaved weed and grassy weed plants specially *Barru* grass (*Sorghum helpense*) and having medium soil fertility with sandy loam texture. Treatment comprises of four weed management practices viz. (i) control (ii) two weeding and hoeing (iii) spraying of Paraquat @ 3.5 l/ha before 25 days of planting followed by two weeding and hoeing (iv) spraying of Glyphosate @ 3.5 l/ha before 30 days of planting followed by two weeding and hoeing as well as two irrigation intervals viz. (i) at four

days interval and (ii) at eight days interval upto first week of July were tested.

Result and Discussion

The results showed much better growth of clone PN-731 in terms of plant height and girth (289 cm and 9.2 cm during 2009-10 and 325 cm & 12.1 cm during 2010-11) followed by PN-227 and GBP selection during three experimentation years. Clone 795, PN 272, SE-69002

and SI-63-007 were also attained better height and girth as compared to remaining clones (Table-1).

It is apparent from Table-2 that the plant height of willow in nursery was significantly affected by weed management practices. Spraying of Glyphosate followed by two weeding and hoeing treatment was observed the highest plant height (63, 145, 265 and 355 cm) at 80, 160, 240 and 320 days after planting, respectively. Irrigation intervals also affects height of willow plant in nursery. Maximum plant height (58.7 131.25, 245.2 and 328.7 cm) was observed at 80, 160, 240 and 320 days after planting under plots where field irrigated at 4 days interval.

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Performance of Mango with Pineapple Based Agrihorti System with Nutrient and Irrigation Management in Odisha

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Abstract

Introduction of fruit trees into agroforestry system proves remunerative to the farmers and that impart stability to the income. Farmers have natural preference for horticulture based agroforestry system. A study was conducted at the experimental site of All India Co-ordinated Research Project on Agroforestry, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India, during July, 2018 to June, 2019 to evaluate irrigation and nutrient management of Mango (*Mangifera indica*) + Pineapple (*Ananas comosus*) agrihorti system. The experiment consisted three main plots and four sub-plots including three irrigation systems such as sprinkler, drip and ridge-furrow irrigation systems and four nutrient managements i.e., STD (50%) + FYM, STD (75%) + FYM, STD (100%) + FYM, organic [FYM + dry leaf mulch + biofertilizer (Azot: Azosp: PSB in 1:1:1) {4 kg each/ha}]. Maximum pineapple yield of 10,276 kg ha⁻¹ was obtained with STD (100%) + FYM fertilization under drip irrigation whereas the lowest pineapple production of 5359 kg ha⁻¹ was recorded with organic fertilization under ridge-furrow irrigation. Also STD (100%) + FYM fertilization with drip irrigation registered the maximum mango equivalent yield (27363 kg ha⁻¹), net return (Rs. 5,81,990 per ha) and BC ratio (3.44). The maximum Water Use Efficiency (WUE) of pineapple (205.7 kg ha⁻¹ cm⁻¹) was attained under drip irrigation system in combination with STD (100%) + FYM fertilization whereas the minimum water efficiency was resulted with organic fertilization under ridge-furrow irrigation system.

Key words : irrigation and nutrient management, agrihorti system, mango, pineapple and soil test based dose.

Introduction

Fruit based agri-horticulture system is a self sustainable system in which solar energy is harvested at different height and also provide higher economic return even under stressed growing conditions than annual crops. The system is also helpful in generating employment especially during off-season when crops are not in cultivation. Fruit crops by the virtue of their perennial nature of woody framework (Nutrients locked therein), extended physiological stages of growth, differential root distribution pattern (root volume distribution), growth stages from the point of view of nutrient requirement and preferential requirement of some nutrients by specific fruit crop, collectively make them nutritionally more efficient than the annual crops. Mango (*Mangifera indica* L.) is an indigenous fruit of India and also known as national fruit of the country because of its wide edaphic and climatic adaptability, high nutritive value, attractive appearance and popularity among growers. Moreover, the foliage of mango is sparse, which permits required light for the under storey intercrops and makes more compatible for inter cultivation. It is a multipurpose fruit tree suitable for agroforestry, which yields fruits, timber, fuels, etc. (Musvoto and Campbell, 1995). The fruits are also considered, protective food as it contains anti-oxidants, essential vitamins, minerals and enzymes, which are required for better functioning and maintaining resistance

power against many diseases of human beings (Chattopadhyay 2001). Pineapple (*Ananas comosus* L. Merr.) is an important tropical fruit of world under the Bromeliaceae family and one of the most internationalized fruit traded globally after bananas and citrus. It is the most suitable intercrop in mango based agroforestry system due to its shade loving nature apart from that the infestation of disease and pest very low and requirement of less water for its survival. Development of a profitable mango based production system with income from the first year onwards can help in alluring the farmers to take up mango orcharding. Intercultural operations in annual crops positively influence the vegetative growth of fruit plants at initial stage (Saroj, 2003). Economic advantages of mango based agri horticultural systems have been reported by number of workers (Pawar and Sarwade, 2006, Ramaswamy, 1997, Singh *et al.* 1996, Ratha and Swain, 2006). Thus, present study aiming to develop a sustainable model to maximise the utilisation of nutrient and irrigation water by the mango and pineapple based agrihorti system.

Materials and Methods

This experiment was conducted at the experimental site of All India Co-ordinated Research Project on Agroforestry, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India, during July, 2018 to June, 2019 to evaluate irrigation and nutrient management of

Table-1 : Crop yield and economics of the Mango and pineapple based agrihorti system (2018-19).

Treatment	Mango Yield (kg/ha)	Pineapple yield (kg/ha)	Mango equivalent Yield (kg/ha)	Gross return per year (Rs./ha)	Net return per year (Rs./ha)	BCR
Sprinkler irrigation						
STD (50%)+FYM	4738	7946	21158	634740	415590	2.90
STD (75%)+FYM	4991	8879	23644	709320	485295	3.17
STD (100%)+FYM	5389	9728	25905	777150	548250	3.40
Organic (FYM+ leaf mulch + biofertilizer)	4383	5911	15738	472140	247740	2.15
Drip irrigation						
STD (50%)+FYM	4978	8611	16431	492930	263780	2.15
STD (75%)+FYM	5371	9490	17992	539760	305735	2.31
STD (100%)+FYM	5722	10276	27363	820890	581990	3.44
Organic (FYM+ leaf mulch + biofertilizer)	4699	6378	16976	509280	274880	2.17
Ridge and furrow						
STD (50%)+FYM	4460	7292	19415	582450	373300	2.80
STD (75%)+FYM	4656	8163	21737	652110	438091	3.04
STD (100%)+FYM	4967	8828	23507	705210	486309	3.22
Organic (FYM+ leaf mulch+ biofertilizer)	4108	5359	14268	428040	213640	2.00

Table-2 : Fertility status of the soil (2018-19).

Treatment	pH	Organic carbon (%)	Available N (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)
Sprinkler irrigation					
STD (50%) + FYM	5.72	0.59	298.6	33.4	192.4
STD (75%) + FYM	5.70	0.60	303.1	34.2	194.7
STD (100%) + FYM	5.75	0.61	310.2	37.8	196.8
Organic (FYM+ leaf mulch+ biofertilizer)	5.73	0.59	291.5	32.2	190.6
Drip irrigation					
STD (50%) + FYM	5.67	0.61	300.7	33.8	196.4
STD (75%) + FYM	5.74	0.62	303.4	35.4	197.6
STD (100%) + FYM	5.69	0.62	312.1	37.2	198.8
Organic (FYM+ leaf mulch+ biofertilizer)	5.73	0.60	293.8	32.6	192.7
Ridge and furrow irrigation					
STD (50%) + FYM	5.69	0.58	294.3	31.5	190.3
STD (75%) + FYM	5.72	0.59	301.4	32.8	191.8
STD (100%) + FYM	5.58	0.60	305.8	34.1	193.4
Organic (FYM+ leaf mulch+ biofertilizer)	5.67	0.58	290.6	32.2	190.1
Initial soil status (2015)	5.51	0.55	287.8	31.3	189.3

Soil Tested Dose (STD) for pineapple : 10:06:10 :: N : P₂O₅ : K₂O g/plant as against
 Recommended Dose of Fertilizer (RDF) : 10:08:10 :: N : P₂O₅ : K₂O g/plant

Mango (*Mangifera indica*) + Pineapple (*Ananas comosus*) agrihorti system. The experimental site is situated inside the Horticultural Research Station of O.U.A.T., Bhubaneswar which is located at 20°15' N longitude and 85° 52' East latitude with an altitude of 25.9 meter above mean sea level. The study area has a warm and moist climate characterized by humid summer and mild winter. The normal average rainfall of the station is 1227.6 mm with 93 rainy days in a year which is mostly received from the south-west monsoon. The experimental field is fairly levelled and well drained. Soil is sandy loam in texture. It is rich in oxides of iron and aluminium, but poor in di- basic cations and soluble salts. Soil samples were taken before

conducting the experiment from a depth of 0-15 cm, taking all possible precautions prescribed for soil sampling. The experiment was laid out in the split plot design with three replications. The experiment was consisted of three main plots and four sub plots. There were three irrigation systems (drip irrigation, sprinkler irrigation, and ridge-furrow irrigation) along with combination of four types of nutrient management [STD 50% + FYM, STD 75% + FYM, STD 100% + FYM and organic (FYM + dry leaf mulch + biofertilizer)]. 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 (row to row and plant to plant distance) were

Table-3 : Water use efficiency of Mango and pineapple based agrihorti system (2018-19).

Treatment	Effective rainfall (cm)	Irrigation water (cm)	Total water used (cm)	Field water use efficiency (kg/ha-cm)
STD (50%) + FYM	89	50	139	152.2
STD (75%) + FYM	89	50	139	170.1
STD (100%) + FYM	89	50	139	186.4
Organic (FYM + leaf mulch + biofertilizer)	89	50	139	113.2
STD (50%) + FYM	89	44	133	123.5
STD (75%) + FYM	89	44	133	135.3
STD (100%) + FYM	89	44	133	205.7
Organic (FYM + leaf mulch + biofertilizer)	89	44	133	127.6
STD (50%) + FYM	89	80	169	114.9
STD (75%) + FYM	89	80	169	128.6
STD (100%) + FYM	89	80	169	139.1
Organic (FYM + leaf mulch + biofertilizer)	89	80	169	84.4

intercropped with a ten year old established mango orchard. At the time of final land preparation, well decomposed FYM was applied @ 5 t ha⁻¹. A dose of N - P₂O₅ - K₂O - 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, soil samples were collected from 0-15, 15-30 cm, 45 cm and 90 cm depth 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. In drip irrigation system, the main and sub main lines were laid underground at a depth of 60cm from the ground surface. Different sub main pipes were laid to cater to the irrigation needs of trees and fruit crops. The inline lateral pipes were laid on the ground at different spacing. Pineapple crops are irrigated by individual lateral line. The average water emission from each dripper varies from 1.0-1.5 litres/hour. The micro sprinklers are placed at line to line 5.0-10m and sprinkler to sprinkler 2.5-5m are mounted at a height of 60 cm and each micro sprinkler discharge about 150-200 litres/hour. The surface irrigation provided to the plant in furrows in 2-3 days interval during summer and 6-7 days interval in winter season and no irrigation provided during the rainy season. Water use efficiency (WUE) was calculated as the ratio of yield and total water used. Total water used was obtained by adding depth of water applied and effective rainfall (50%) of total rainfall. 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. The cost involved in production of different treatments was estimated and converted to per hectare value, then the return obtained from each treatment were evaluated

and the net return (Rs ha⁻¹) was worked out by subtracting the cost of cultivation from the gross return obtained.

Results and Discussion

The highest mango equivalent yield was observed in the treatments having drip irrigation system viz STD (100%)+ FYM 5t/ha (27363 kg/ha) followed by STD (75%)+ FYM 5t/ha (17992 kg/ha) and STD (50%)+ FYM 5t/ha (16431 kg/ha). The maximum average net return of Rs. 5,81,990 and BCR of 3.44 recorded with STD (100%)+ FYM 5t/ha with drip irrigation followed by STD (100%)+ FYM 5t/ha with sprinkler irrigation (Rs. 5,48,250 & BCR 3.40) compared to STD 100% with FYM 5t/ha with ridge and furrow irrigation (net return of Rs. 4,86,309/ ha & BCR 3.22) per year. The organic treatment recorded lowest fruit yield, net return and BCR irrespective of irrigation method. Similar findings also reported by Darnaudery *et al.* (2018).

In mango + pineapple based agri-horticultural system at the end of the cropping season, highest values of available N (312.1 kg ha⁻¹), P₂O₅ (37.2 kg ha⁻¹) and K₂O (198.8 kg ha⁻¹) were noticed with STD (100%) + FYM followed by STD (75%) + FYM, STD (50%) + FYM and organic treatment in drip system. Similar trend also observed in sprinkler and furrow irrigation system. The lowest available N (290.6 kg ha⁻¹) & K (190.1 kg ha⁻¹) was recorded with organic mulch in ridge & furrow irrigation system. Similar findings were also reported by Kaur *et al.* (2000) and Subba *et al.* (2017).

In mango + pineapple agri-horticultural system irrigation water used was highest (80 cm) under ridge and furrow system followed by sprinkler (50 cm) and lowest with drip system (44 cm) in addition to effective rainfall of 89 cm. The field water use efficiency was higher under drip irrigation system followed by sprinkler and furrow irrigation system irrespective of nutrient management practices. The highest field water use efficiency (205.7 kg/ha-cm) was with

STD (100%)+ FYM 5t/ha followed by STD (75%)+ FYM 5t/ha (135.3 kg/ha-cm) and STD (50%)+ FYM 5t/ha (123.5 kg/ha-cm) in drip irrigation system. Similar pattern was also observed in sprinkler & furrow irrigation system. Singh *et al.* (2013) also reported that under automated irrigation in mango orchard the fruit yield was increased by 17.6-23.1% in comparison to conventional system so the drip irrigation system proved to be superior to sprinkler and ridge-furrow irrigation system.

Conclusions

Among the four different nutrient and three irrigation management system STD (100%)+ FYM with drip irrigation system was recorded the highest yield (10,276 kg/ha) , BCR (3.44) and maximum field water use efficiency (205.7 kg/ha^{-cm}).

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Development of E-Book on Nutrition for Women and its Evaluation by the Experts

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Abstract

The study was planned to develop an e-book on nutrition for women and conduct assessment by experts. In line with this purpose, collected subject matter information and e-book was developed by researcher. The e-book was evaluated by a panel of ten experts from Food Science and Nutrition and Extension Education and Communication Management areas on a five point continuum from 'excellent' to 'poor' with scores 5 to 1, respectively. Results reveal that the mean scores of the e-book ranges between 4.04 to 4.34 out of maximum score 5, which indicate that e-book was judged good to excellent for all the criteria.

Key words : e-book, nutrition, women

Introduction

Health and nutrition are the most important contributory factors for human resource development in the country. A proper diet is essential from the very early stages of life for proper growth, development and to remain active. Women are the key to food and nutrition security. They play an important role as producers of food, as managers of natural resources, as providers of care for their families and in income generation. Yet, women often continue to have limited access to information, education and credit. They are thus impaired in fulfilling their potential socio economic roles in food and nutrition security and in ensuring care, health and hygiene for themselves and their families. This is aggravated by the fact that women themselves are often more vulnerable or more affected by hunger and malnutrition than men, especially by iron deficiency and undernourishment during pregnancy and lactation (National Institute of Agricultural Extension Management, 2014).

Poor diet places women at a higher risk of unhealthy gestational weight gain, which can negatively impact mothers' and babies' health, causing a range of poor maternal and infant outcomes. Exposure of the unborn baby to maternal obesity, diabetes and excessive gestational weight gain can increase his/her risk of developing childhood obesity and chronic diseases later in life. An analysis of underlying and basic determinants of under nutrition reveals that the health problems are rampant in rural areas, not merely because of lack of medical facility but because of general poverty, low level of education, lack of balanced and nutritious diet, lack of knowledge regarding nutrition and their age at marriage are crucial factors influencing the overall nutrition outcomes. A study by Gupta (2017) found that only 22 per cent of the women had good knowledge about nutrition

during pregnancy and 82 per cent show willingness to acquire more information about maternal nutrition. Source of information for most pregnant women was immediate family members (41%).

Information and Communication Technologies (ICTs) in Community Science are capable of providing extended access to information that is capable to support and drive sharing of knowledge. Today women are increasingly taking advantages of ICT in all spheres of life, thus confirming that they can be a tool to generate awareness. Communicating with people in rural areas is a difficult and challenging task. Therefore, mode of communication approach is needed which impact the mind of target group. To bring effective teaching and learning, information communication material has been used as a good communication tool. The most important requirement for effective and efficient communication is effective teaching. The use of information material in teaching, makes teaching more productive and lasting. Thus, the present study "Development of e-book on nutrition for women and its evaluation by experts" has been undertaken.

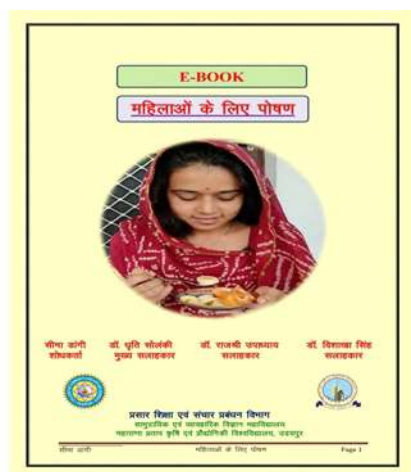
Research Methodology

For designing of e-book on nutrition for women, detailed content was gathered and outline was prepared. Subject matter was organized in accordance with content outline. Appropriate illustrations were selected and captured in natural conditions by the investigator. Finally, the e-book was prepared with the help of computer. The designed e-book was evaluated by a panel of 10 experts from Food Science and Nutrition and Extension Education and Communication Management areas. The assessment of e-book was carried out in terms of 10 criteria relevance to topic, subject matter coverage, layout, subtitle, continuity, accuracy, language, illustrations and overall presentation.

The e-book was evaluated on the basis of these criteria on a five point continuum i.e. excellent, very good, good, fair and poor with scores 5, 4, 3, 2 and 1, respectively.

Results and Discussion

1. Designing of e-book : The e-book entitled nutrition for women was designed after collecting appropriate content from available literature. The collected content was approved by the subject matter specialists. The language chosen for content was Hindi as the target group for the study was rural women. After collection, the content was organized in appropriate layout and e-book was designed with the help of computer.



2. Evaluation of e-book : The e-book was subjected to evaluation by a panel of ten experts from Food Science and Nutrition and Extension Education areas. The e-book was evaluated on a five point continuum from 'excellent' to 'poor' for relevance to topic, subject matter coverage, layout, subtitle, continuity, accuracy, language, illustrations and overall presentation.

Overall evaluation of e-book

Table-1 : Overall Evaluation of e-book by the experts.

S. No.	Criteria	Mean weighted scores
1.	Relevance to topic	4.34
2.	Layout	4.24
3.	Sub title	4.26
4.	Subject matter coverage	4.24
5.	Continuity and Sequence	4.12
6.	Language	4.08
7.	Accuracy of language	4.2
8.	Illustration	4.12
9.	Over all presentation	4.28

Perusal of Table-1 and Fig.-1 reveals that the mean scores of the e-book ranges between 4.04 to 4.34 out of maximum score 5, which indicate that e-book was judged good to excellent for all the criteria. Solanki (2009) revealed that the developed booklet on female foeticide

was judged as highly effective with an equal mean score of 4.93, followed by clarity of message, subject matter coverage, relevance of topic and illustration with an equal mean score of 4.90. An e-booklet on female foeticide developed by Aishwarya and Singh (2013), reported that the fog index value of e-booklet was 6.14 and 3.58 for rural and urban respondents, respectively, indicating that the e-booklet had high readability.

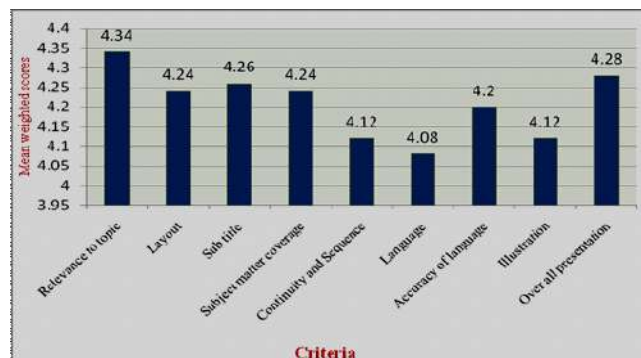


Fig.-1 : Overall evaluation of e-book by the experts.

Component wise evaluation of e-book

Component wise evaluation of different aspects of e-book by the experts shown in Table-2 indicate that all the aspects of e-book were rated good by experts in terms of relevance to topic, layout, sub title, subject matter coverage, continuity and sequence, language, accuracy of language, illustration and overall presentation. The mean scores ranges between 4.0 to 4.5 in all the components. A study on women issues in media: content analysis and development of media package was conducted by Goswami (2009). The results revealed that majority of the respondents (80% of website and 86% of booklet) understood the content of website and booklet and about 90-100 per cent respondents understood all the illustrations of website and booklet. Majority of the respondents were having good perception (96 % website and 90% of booklet).

Component of 'Nutrition for women (NP/NL)' received the highest overall MWS (4.26) followed by 'Balanced diet' (4.18), 'Major nutritional problems (Normal and pregnant women)' (4.17), 'Nutrition during pregnancy' (4.16) and 'Nutrition for lactating mother' (4.14). Further, Table-2 indicates that for all the aspects various criteria were rated as good to excellent as the mean weighted score for all criteria ranges between 3.9 to 4.5. None of the criterion was rated as fair or poor. The reason for such findings might be that the e-book was prepared under the constant guidance of experts and suggestions were incorporated during development of e-book. Majority of the experts appreciated the e-book and assigned scores ranging from 4-5. Few suggestions in language and

Table-2 : Component wise evaluation of designed e-book by the experts.

S. No.	Different aspects of e-book			Mean weighted score (MWS)										Over-all MWS	
				Relevance to topic	Layout	Sub title	Subject matter coverage	Continuity and Sequence	Language*			Accuracy of language	Illustration		Overall presentation
1.	Balanced	Diet		4.5	4.2	4.3	4.2	4.1	4.1	4	4	4.1	4.2	4.3	4.18
2.	Nutrition (NP/NL)	for Women		4.2	4.4	4.4	4.4	4.2	4.1	4.2	4.2	4.3	4.1	4.4	4.26
3.	Nutrition	during Pregnancy		4.3	4.1	4.2	4.2	4.1	4.2	4.1	4	4.3	4	4.3	4.16
4.	Nutrition	for Lactating Mother		4.4	4.2	4.3	4.1	4	4.1	3.9	4.1	4.1	4.2	4.2	4.14
5.	Major Problems	Nutritional (Normal and pregnant women)		4.3	4.3	4.1	4.3	4.2	4.2	4	4	4.2	4.1	4.2	4.17

*Language-A : Clarity, B : Selection of words, C : Sentence structure

illustrations of different components of e-book were recommended by them which were incorporated by the investigator before field testing. The findings are in line with Bala (2019) who in a study on development of instructional material for rural women on 'nutrition for children (0-3years)' concluded that the flipbook was rated as good by the experts for different aspects like clarity of visuals, subject matter, organization and continuity etc. Kaur and Rathore (2012) published a study on development of an e-booklet on *dairy evam pashudhan vikas*. The developed e-booklet was standardized on the quality parameters which were perceived quite high by majority of the judges.

Conclusions

On the basis of findings, it could be asserted that the e-book on 'nutrition for women' was perfectly developed. The developed e-book can be used by Home Scientist and Extension Personnel of KVKs and other agencies/organizations for knowledge management of rural women on the subject of nutrition for women.

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Study on Differentiation Between Sustainable Agriculture and Conventional Agricultural Research

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Abstract

Sustainable agriculture consists of environment friendly methods of farming that allow the production of crops or livestock without damage to human or natural systems. The different criteria of sustainability may conflict and can be seen from different viewpoints: those of the farmer, the community, the nation and the world. There may be conflicts between present and future needs; between satisfying immediate needs and conserving the resource base. The conventional Agricultural research and extension organizations has contributed to the non- sustainability of current world agriculture and neglecting the needs of the farmers. In developed countries, the conventional experiment station-based agricultural research system generally has served farmers well. In developing countries, however, the same model has had less success in addressing needs of many farmers, particularly those operating diversified farming systems in resource- poor and risk prone environments. The relative lack of success of the conventional station-based agricultural research in many low income countries (i.e. developing countries) led to the evolution of a farmers based research approach popularly known as 'farming system research and extension'.

Key words : Sustainable agriculture, conventional agricultural research, extension organization, farming system research, diversified farming, environmental degradation.

Introduction

It is true that sustainability must need the expanding food, feed, fiber and fuel needs of a continually increasing population, getting achievable yield of high yielding cultivars or say maximum economic yield goals by minimizing the yield gaps between on research station and on farm to possible extent. This will help achieving goal of agricultural sustainability, food and nutrition security, alleviate drudgery and human sufferings, improving living standard of farming community and provide a respectable way of life for a majority of the population.

Recent concerns about increased cost and reduced availability of fossil fuels, improved human nutrition and environmental degradation have prompted agricultural researchers and planners to re-evaluate the current agricultural practices and investigate alternate agricultural production methods. The intensification of agriculture using high-yielding crop varieties, fertilizers, irrigation and pesticides has increased the agricultural production globally but overstretched the resource use. During this process, the second generation problems like soil fertility depletion, production fatigue, emergence of noxious weeds and resistant to insects-pests have come up. These problems have threatened the very base of agricultural production systems. Therefore, to enhance the production of ever growing population corrective measures have to be taken immediately. The urgent goal

is to increase the production while conserving environmental resources in a sustainable basis.

Agriculture Sustainability : The word 'sustainability' is now widely used in development circles. What does it really mean. According to a dictionary definition, 'sustainability' refers to 'keeping an effort going continuously, the ability to last out and keep from falling'. In the contest of agriculture 'sustainability' basically refers to the capacity to remain productive while maintaining the resource base. According to Gips 1986, sustainable agriculture is widely defined as :

Ecologically sound : which means the quality of natural resources is maintained and the vitality of the entire agri eco system- from humans, crops and animals to social organisms is enhanced. This is best ensured a when the soil is managed and the health of crops, animals and people is maintained through biological processes (self-regulation). Local resources are used in a way that minimizes losses of nutrients, biomass and energy, and avoids pollution. Emphasis is on the use of renewable resources.

Economically viable : which means that farmers can produce enough for self-sufficiency and/or income, and gain sufficient returns to warrant the labour and costs involved. Economic viability is measured not only in terms of direct farm produce (yield) but also in terms of functions such as conserving resources and minimizing risks.

Socially just : which means that resources and

power are distributed in such a way that the basic needs of all members of society are met and their rights to land use, adequate capital, technical assistance and market opportunities are assured. All people have the opportunity to participate in decision making, in the field and in the society. Social unrest can threaten the entire social system, including its agriculture.

Humane : which means that all forms of life (plant, animal, human) are respected. The fundamental dignity of all human beings is recognized, and relationships and institutions incorporate such basic human values as trust, honesty, self-respect, cooperation and compassion. The cultural and spiritual integrity of the society is preserved and nurtured.

Adaptable : This means that rural communities are capable of adjusting to the constantly changing conditions for farming: population growth, policies, market demands etc. This involves not only the development of new appropriate technologies but also innovations in social and cultural terms.

Why sustainable Agriculture : Because we are alert to many claims which indicate that the survival of our generation and our children has been threatened by the present system or practices in agricultural production, including the production of crops, animals, fisheries and forestry. Sustainable agriculture provides guidelines for research and development which will allow successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources.

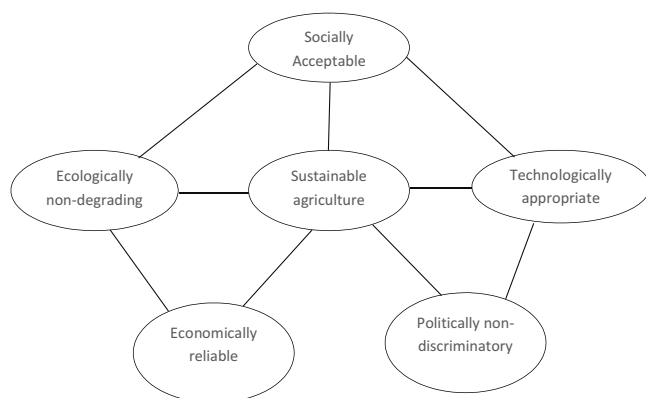


Fig.-1 : Dimensions of Sustainable agriculture.

Conventional Agricultural Research and Extension : In agricultural development, raising production is often given primary attention. But there is an upper limit to the productivity of ecosystem. If this is exceeded, an

ecosystem will be able to survive on the remaining resources than before. This implies that, when the limits on the supply side are reached, something has to be brought into balance on an ecologically sustainable level. Although sustainability must be seen as a dynamic concept which allows for the changing needs of an increasing global population (TAC/CGIAR, 2010).

The conventional agricultural research as taught at agriculture universities and practiced in official agricultural research and extension organization has contributed to the non-sustainability of current world agriculture by neglecting the needs of the farmers. Conventional agricultural research tends to serve resource rich farmers, which results to bias technology development in their favour (Rolling 1988).

Problems with the present use of resources

(i) Soil : It has been generally accepted that no single resource is more important to the achievement of a sustainable agriculture than the soil which contains the nutrients and stores the water essential for plant growth. According to FAO the loss of productive cropland due to soil erosion and degradation is estimated to be 6 – 7 million hectares annually in the world.

Some of the other soil problems are related to soil acidity, alkalinity, salinity, low water holding capacity, water logging, loss of soil fertility due to repeated cropping and desertification.

(ii) Water : Irrigation and rainfall are the two major sources of water for agriculture. Today, the 17 percent of the world's cropland that is irrigated supplies about 1/3 of the agricultural production. Various problems arise due to poor irrigation management in agriculture. Poor irrigation practices result in severe problems of land degradation through water-logging and salinization.

Under rainfed conditions agricultural productivity depends greatly on the amount, distribution and reliability of rainfall. These are many problems related to rainfall, water run-off and soil erosion which are very serious problems, especially on slope land of over 2 percent gradient. Crop management including the use of fertilizers or other inputs is subject to high degrees of risk. Hence, most farmers tend to practice traditional farming systems, i.e., no external input or low external inputs (Poungsomlee, A. 1995 and David, W. Norman et al. 1994).

(iii) Atmosphere : Agriculture to a lesser degree, as well as other human activities, for instance, the combustion of fossil fuel and smelting of metallic ores, release harmful gaseous elements into the air. The two alarming terms, most often heard of during past decades are acid rain and the greenhouse effect. Acid rain is related to the

contamination of sulphur and nitrogen oxides in the atmosphere, while the greenhouse gases – Carbon dioxide (CO₂), methane (CH₄), Nitrous Oxide (N₂O), chlorofluorocarbon (CFC 11 and 12), Ozone in the troposphere.

(iv) Energy : Energy efficiency is the amount of energy harvested in edible form, divided by the amount of energy dissipated for its production. Some agricultural systems for example integrated farming system in which the waste or by – products from one commodity can be useful for the other are more efficient than others, for instance a monoculture system of agriculture. The use of Draught Animal Power (DAP) can reduce air pollution, soil compaction and costs of production. DAP use is a very common practice by small farmers in developing countries.

(v) Chemicals : The use of pesticides in agriculture is increasing at very high rates, both in developed and developing countries. There are many problems concerning the use of pesticides: some of these are (i) Excessive use and misuse of pesticides (ii) Direct poisoning and deaths (iii) Destruction of the environment (iv) Contamination of agricultural products and water.

(vi) Other resources : Obviously, one of our major concerns at the present is deforestation. Besides, depletion of forest resources, there are several factors which influence genetic erosion or destruction of the gene treasures. Deforestation like expansion of agricultural land, encroachment by development projects viz. roads, hydroelectricity, mining etc. crops breeding and breeding of indigenous animal species as well as hunting of wildlife (Gelia T. Castillo 1992).

Drawbacks of conventional agricultural research and extension : Conventional agricultural research with its bias toward high potential areas, exports crops and better-off farmers has produced results which are out of reach of most farmers and inappropriate. The drawback of conventional agricultural research and extension were summarized with the following points (Reijntjes, *et al.* 1992).

- Focus on single commodity
- Primarily market orientation and associated nutrient drain
- Disregard of environmental effects
- Neglect of rain-fed areas and local resources
- Gender bias
- Neglect of local farmers knowledge
- Emphasis on station-based research
- Extension of incomplete products
- Application of chemical fertilizers

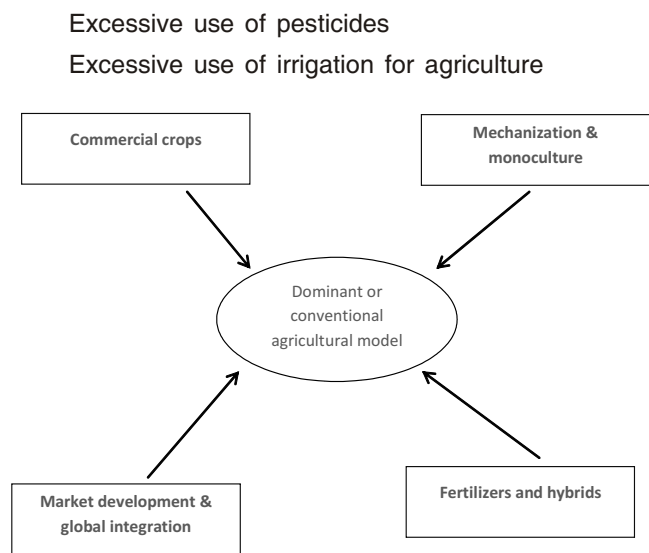


Fig-2 : Schematic representation of conventional agricultural research.

(i) Focus on single commodity : The emphasis has been on maximizing production of particular commodities and not total farm production. Plants which are complete with the desired crops for water, nutrients and light are regarded as weeds. Technology development has concentrated on reducing this competition. This has hindered the study and enhancement of positive interactions between different plants, animals and man.

(ii) Primarily market orientation and associated nutrients drain : integration of farms into national or international markets results in a net nutrients drain, if extracted nutrients cannot be replenished. Very few technologies have been developed for returning nutrients from consumer to producer areas.

(iii) Disregard of environmental effect : Driven by research procedures and political pressures to focus on short-term environmental effects to the future or the other sectors. Given the focus on the crop field and at best farm level, the long-term effects on soil fertility, the regenerative capacity of natural vegetation and fauna, human health etc have not usually been given sufficient consideration.

(iv) Neglect of rain fed areas and local resources : Until recently, conventional research largely neglected the rainfed and marginal areas where farmers live and the local crops and animals which provide their livelihood. Research content and design has had little relevance to the major concerns and methods of farmers.

(v) Gender bias : Agricultural research has given little attention to solving the problems of female farmers and in the design of new technologies, often disregards

important questions of women's influence on decision making and labour allocation.

(vi) Neglect of local farmers knowledge : The conventional top-down approach to technology development within agricultural research institutions gave scientists like opportunity to become well acquitted with the conditions, objectives and knowledge of farmers. The situation was not improved by the widespread attitude of extensionists and researchers, instilled already in school and university that the formal system is the ultimate source of innovations and that information can come only from above.

(vii) Emphasis on station-based research : The production condition research institutes and experiment stations do not resemble those farmers and cannot possible represent the highly variable conditions in rain fed agriculture. As a result, technology tested on-station often does not work under farmers conditions while the good qualities of local varieties, which are adapted to local conditions, are not recognized under station conditions (Biggs 1984).

(viii) Extension of incomplete products : Conventional technology developed tends to be organized in terms of discipline, and not according to the aggregate level of the farm. As a result, the 'products' delivered for extension are often incomplete. They represent merely the answer to disciplinary technical problems, without taking account for, for example, production aims, labour allocation between various crops, risk spreading, access to and affordability of external inputs, and other aspects of the socio-economic context.

Much more serious is the lack of sufficient extension staff. Supplies and technical support for extension system has been the lack of appropriate information and technologies that they could make available to small holders. Other major problems in many rain-fed farming systems, the available science – based technology simply does not apply. Interventions have been introduced in ignorance of the realities of existing farming practices and systems.

(ix) Application of chemical : Farmers and scientists begin to recognize some of the limitations of chemical fertilizers.

Dryland tropical crops lose upto 40–50% of applied nitrogen. In irrigated rice, losses are seldom less than 60–70% (Greenwood et al. 1980 and FAO 1990).

They may disturb soil life and soil balance. They increase decomposition of organic matter, leading to degradation of soil structure, higher vulnerability to drought and lower effectiveness in producing yields.

Fertilizers used in developed and developing countries contributes to global risks arising from the release of nitrous oxide (N_2O) to the atmosphere. In the stratosphere, N_2O depletes the ozone layer and by absorbing certain wave lengths of infra-red light, increases global temperature (greenhouse effect) and destabilizes climates.

(x) Excessive use of pesticides : In 1985 roughly 2,300 million kg of chemical pesticides were used worldwide. About 30% of all insecticides is used in the third world countries, where it is regarded as an early way of raise production. However, some disadvantages and dangers of using pesticides are gradually becoming clearer.

Yearly, thousands of people are poisoned by pesticides, about half of them in the third world. For example in 1983 a total of about 2 million people suffered from pesticides poisoning and 40,000 of the cases were fatal (Schoubroeck et al. 1990).

Over time, pests build up resistance to pesticides which must then be used in ever higher doses to have effects. Pest resistance builds up more rapidly in tropical than in temperate climates, as biological processes are more rapid at higher temperatures.

Pesticides kill not only organisms that cause damage to crops but also useful organisms such as natural enemies of pests.

Only a small proportion of the pesticides applied in fields reach the organism that is support to be controlled. The major part reaches the air, soil or water, where it has a damaging effect on living organism (partially aquatic organisms which are sensitive to pesticides).

(xi) Excessive use of irrigation for agriculture :

The area of land under irrigation has increased considerably during the last decades. However, the increase in stagnating, partly because the water reserves in many countries are used almost to the maximum resulting declining water tables and other ecological problems. In the case of rain-fed farming, water conservation measures like water harvesting pond (WHP) and organic matter management is of greater importance, but the farmers capacity for investment is very limited (Sesenlo Kath and Kanagasabapathi, 2020).

Conclusions

The impact of agricultural activity has become a major concern throughout the world, particularly in areas with a high population density. A critical problem confronting both developing and industrial nations is the rapid deterioration of soil and water resources as a result of non-sustainable agricultural practices. The farmers have been forced to apply increasing doses of fertilizers to

maintain the crop yields. But crop yields have failed to show much improvement owing to the acute deterioration in the soil fertility. To make the situation even worse, pest problems have amounted over time requiring increasing application of chemical pesticides, which has further escalated soil and water quality known as bioterrorism. Although technologies for conservation and management are well documented, farmers and local communities in many developing nations have few or no resources for conservation measures. Thus, National and International assistance is needed to restore, manage and consume for the benefit of both upstream and downstream human communities, as well as the natural ecosystem. Agricultural scientist should place emphasis on their ethical responsibility for sustainable food production and environmental security; otherwise it could become a major threat to human and environmental security in the near future.

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Vulnerability of Horticultural Crops Towards Climate Change in Different Districts of Bastar Plateau Zone of Chhattisgarh

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Abstract

This study comprises the vulnerability assessment of some selected horticultural crops towards climate change in Bastar Plateau Zone of Chhattisgarh. It was performed at Department of Agrometeorology, College of Agriculture, IGKV, Raipur, Chhattisgarh throughout 2020-2021. The area and production data of horticultural crops from 2004-2020 was collected from Directorate of Horticulture and Farm Forestry, Chhattisgarh (Dept. of Agriculture, Government of Chhattisgarh). For climate change vulnerability assessment, five indicators: demographic, climatic, agricultural, occupational and geographical were used. Vulnerability was assessed for 6 districts of Bastar Plateau Zone with the help of five indicators i.e., demographic, climatic, agricultural, occupational and geographical. Based on the value of indices, all the six districts are ranked accordingly. In this research Narayanpur district is ranked one indicating the most vulnerable and Bastar district has assigned the highest rank i.e., six specifying the least vulnerable among all the districts of Bastar Plateau Zone while all the remaining districts showed intermediate vulnerability. In order to create and disseminate climate-smart technology, it is necessary to first assess agriculture's sensitivity to climate change. These findings give important information that can be used to support future climate and agriculture policy, as well as sustainable planting patterns among farmers in Bastar Plateau Zone.

Key words : Vulnerability, demographic, sustainable, climate-smart, sensitivity.

Introduction

The state of Chhattisgarh, with Raipur as its capital, was formed on November 1, 2000, when 16 districts of the Chhattisgarh area were separated from Madhya Pradesh. With a population of about 20 million people, Chhattisgarh is located between 23.70 N latitude and 80.40-83.380 E longitude in the central eastern section of India. The state's entire geographical area is 136.03 thousand square kilometres. The Climate is the key factor in regulating the growth of plants. It refers to the average atmospheric condition over a period of time, where the current and temporary atmospheric conditions are defined by the term weather. Indian region is highly vulnerable to climate change. Agriculture sector is most susceptible sector as 1.2 billion people are directly depended on it. Various climate components such as temperature, humidity, wind, solar radiation, precipitation, hail and frost are responsible for efficient growth of horticultural crops. Almost every aspect of the climate has an impact on horticulture crops. All of them are intertwined. The impact of each is influenced by the impact of others.

Horticultural crops serve a distinctive function in India's economy, increasing rural people's income. Thus, horticulture crop production is critical to a country's development and is intimately tied to people's health and pleasure. India ranks 2nd position in production of vegetables after China. The production of fruits is

approximately 44.04 million tons from an area of 3.72 million hectares (Bhati *et al.*, 2018). Next to China, India is the world's second largest producer of vegetable, accounting for around 15% of global vegetable production. Area of 6.2 million hectares produces over 90 million tones (Bhati *et al.*, 2018). In the year 2019-20, the total area under fruit crops in Chhattisgarh was 2,58,630 ha with the production of 25,48,930 MT. Mango, guava, lime, litchi, cashew-nut, cheeku, and other fruits are among the principal fruit crops farmed in the state. Minor fruits such as sitafal, bael, ber, and anola are also grown. Agro-climatically, mango may be produced across the state, whereas cashew nuts grow in the Bastar and Raigarh districts' Plateau regions. Cashew requires an average temperature of 16°C to 25°C, as well as rainfall ranging from 50 to 350 cm. It may be cultivated on poor rocky soils with ease. It may be cultivated on poor rocky soils with ease.

In climate research and policy, vulnerability is a new notion. Efforts to measure climate change vulnerability have sparked a process of theory development and assessment practise, which is represented in the Intergovernmental Panel on Climate Change's reports (IPCC) (Fussel and Klein, 2006). Climate change vulnerability assessments are used to help policymakers establish policies that mitigate the hazards associated with climate change. Recognizing the importance of these characterizations for climate change assessments, the

present paper extends the ranking of the districts according to their vulnerability. Further Garret's ranking is done to show the severity of the climate change response.

Data sources for estimation of Climatic Vulnerability Index (CVI) :

Census of India
Agricultural census
Census of India, Chhattisgarh: Exp CG
DACNET- District wise Crop Production Statistics
Directorate of Economics and Statistics,
Government of Chhattisgarh

Materials and Methods

The assessment of Climate Vulnerability Index (CVI) will be done by constructing a 'Vulnerability Index' as proposed by Patnaik and Narayanan (2005) and later used by Hiremanth and Shiyani (2013). For the estimation of Climate Vulnerability Index, the following formula will be used :

$$\text{Vulnerability Index} = \left[\prod_{i=1}^n (\text{AI}_i) \right]^{1/n} / n$$

Where,

AI = Average index

n = number of sources of Vulnerability and = n

Steps for calculation of the Vulnerability Index : To calculate climate vulnerability, we used five types of indices which are described below :

In step i, we will calculate the geometric mean of demographic, climatic, agricultural, occupational and geographical indicators through the dimension index. Two type of functional relationship was possible i.e., ? functional relationship and ? functional relationship. Dimension index scores will lie between 0 and 1. The value 1 will correspond to that region with maximum value and 0 will correspond to the region with minimum value.

In this case we say that the variables have ? functional relationship with vulnerability and the normalization is done using the formula- X_i

$$\text{Dimension index} = \frac{(\text{Actual } X_i - \text{Minimum } X_i)}{(\text{Maximum } X_i - \text{Minimum } X_i)}$$

Where,

Actual X_i = District wise actual value of respective component

Minimum X_i = District wise minimum value of respective component

Maximum X_i = District wise maximum value of respective component

All climatic indicators and one demographic indicator like population density both are calculated through this formula.

In this case we say that the variables have ? functional relationship with vulnerability and the normalization is done using the formula :

Where,

Actual X_i = District wise actual value of respective component

Minimum X_i = District wise minimum value of respective component

Maximum X_i = District wise maximum value of respective component

All agricultural indicators and one demographic indicator like literacy rate both are calculated through this formula.

This method of normalization that takes into account the functional relationship between the variable and vulnerability is important in the construction of the indices. If the functional relation is ignored and if the variables are normalized simply by applying formula (1), the resulting index will be misleading.

In step ii, the value of geometric mean of demographic, climatic and agricultural indicators obtained from step 1 will be calculated through the average index.

$$\text{Average Index } i = [\text{Indicator}_1 + \dots + \text{Indicator}_j] / J$$

Where,

Indicator $_1$ = Geometric mean of Indicator $_1$

Indicator $_j$ = Geometric mean of Indicator $_j$

J = number of indicators in each source of vulnerability

In step iii, after calculation of average index (AI) for demographic, climatic and agricultural indicators, we have to work out climate vulnerability index which is computed with the help of following formula:

$$\text{Vulnerability Index} = \left[\prod_{i=1}^n (\text{AI}_i) \right]^{1/n} / n$$

Where,

AI = Average index

n = number of sources of Vulnerability and
= n

In step iv, Garrett's Ranking Technique :

Outcome of step three will be ranked as per degree of vulnerability. The assigned rank was converted into

Table-1 : Functional relationship of indicators with vulnerability to climate change.

Sr. No.	Component	Indicator	Functional relationship
1.	Demographic	i. Population Density (person per sq. km) ii. Literacy rate (%)	
2.	Climatic	i. Annual rainfall (mm) ii. Seasonal rainfall	
3.	Agricultural	i. Area, production and productivity of selected crop ii. Cropping intensity (%) iii. Irrigation intensity (%)	
4.	Occupational	i. Total main workers ii. Agricultural labor iii. Non workers iv. Manufacturing labor	
5.	Geographic	i. Forest area	

Table-2 : Vulnerability indices for climate change of Bastar plateau ACZ.

Sr. No.	Districts	DV	CV	AV	OV	GV
1.	Bastar	0.45	0.50	0.29	0.02	0.36
2.	Dantewada	0.56	0.34	0.82	0.87	0.51
3.	Narayanpur	0.09	0.38	0.72	1.00	1.00
4.	Bijapur	0.57	0.62	0.66	0.69	0.07
5.	Kondagaon	0.64	0.24	0.11	0.32	0.99
6.	Sukma	0.57	0.60	0.76	0.71	0.00

percentage position which was subsequently transferred into Garrett score using Garrett's table. For each constraint, scores of individual respondents were added together and then divided by total number of respondents. Thus, mean score for each constraint was ranked by arranging them in descending order.

$$\text{Percentage position} = \frac{100 (R_{ij} - 0.50)}{N_j}$$

Where,

R = Rank given for the i item by the j individual and

N = Number of items ranked by the j individual.

1. To find out the most vulnerable districts based on vulnerability index.

2. Strategic plan will be prepared on the basis of outcome of study.

Results and Discussion

Climate change vulnerability assessments are emerging tools that is used as an initial step in the adaptation planning processes. It focuses on species, habitats or system of interest, and helps identify the greatest risks to them from climate change impacts. Climate change vulnerability (also known as climate vulnerability or climate risk vulnerability) is a measure of societal vulnerability to climate change that is used in discussions about society's response to climate change, as well as in processes such as climate change adaptation, risk assessments, and determining climate justice concerns.

The analysis is carried out at district level. After the values of the index are calculated for all the districts a ranking of these districts is carried out to identify the most vulnerable districts in terms of the indicators used for measurement. This analysis is done from yearly data of different districts of Bastar plateau ACZ in order to see the vulnerability index against climate change. The following table shows the values of the vulnerability index of districts and their corresponding ranks. In the table a rank of one shows the maximum vulnerable district and the vulnerability decreases as the rank increases.

In the above table-1. the values of all the indicators are given along with the districts of Bastar plateau ACZ. In demographic vulnerability the value for Kondagaon (0.64) is highest from which we interpret that it is more vulnerable to climate change. The value is highest due to lower population and higher literacy rate. If any change occurs due to vulnerability, the people living there will easily adopt any preventive measures and policy making decisions will be wisely followed due to higher literacy rate. In contrary to this, Narayanpur (0.09) district has larger population density and also lower literacy rate which is enough to give out lower value of demographic vulnerability. This district has the lowest value among all the districts of Bastar plateau ACZ.

In climatic vulnerability Bijapur (0.62) has the highest value followed by Sukma (0.60). Maximum annual and seasonal rainfall in the district make the value of climatic vulnerability larger whereas the least value is for

Table-3 : Cumulative Vulnerability Index and Ranks for different districts of Bastar plateau ACZ.

Sr. No.	Districts	CVI	Rank
1.	Bastar	0.32	6 (less vulnerable)
2.	Dantewada	0.62	2
3.	Narayanpur	0.64	1 (more vulnerable)
4.	Bijapur	0.52	4
5.	Kondagaon	0.46	5
6.	Sukma	0.53	3

Table-4 : Garret's ranking for the following districts of Bastar plateau ACZ.

Sr. No.	Districts	Rank	Garret's Ranking	Garret's ranking by G.R. conversion table
1.	Bastar	6 (less vulnerable)	91.7	23
2.	Dantewada	2	25.0	63
3.	Narayanpur	1 (more vulnerable)	8.3	77
4.	Bijapur	3	41.7	54
5.	Kondagaon	5	75.0	37
6.	Sukma	4	58.3	46

Kondagaon district (0.24) followed by Dantewada (0.34). The remaining district Narayanpur (0.38) and Bastar (0.50) show intermediate value among total districts of Bastar plateau ACZ. Lowest value of climatic vulnerability is Kondagaon is due to lower annual and seasonal rainfall.

The agricultural vulnerability of all the districts of Bastar plateau ACZ is shown in table 4.21. in which Dantewada (0.82) has been assigned the highest value followed by Sukma (0.76) while the lowest value is assigned to Kondagaon (0.11) followed by Bastar (0.29). The highest value of Dantewada is due to larger area under cultivation along with higher cropping intensity and irrigation intensity. But Kondagaon has lower area of cultivation, less cropping intensity and irrigation intensity. The remaining districts Narayanpur (0.72) and Bijapur (0.66) shows intermediate values of agricultural vulnerability.

From the table-1, it is clear that the value of occupational vulnerability in Bastar (0.02) is lowest followed by Kondagaon (0.32) while Narayanpur (1.00) has the highest value followed by Dantewada (0.87). This value depicts the involvement of people in employment sector in that particular district. The reason behind showing highest value of occupational data by Narayanpur is that it has lowest number of total employing people generating overall less income while in case of Bastar, highest population are engaged in employment sector, thus generating higher income. So, more vulnerable district, Bastar has higher risk bearing capacity than Narayanpur because Bastar secure more income. The remaining districts like Sukma (0.71) and Bijapur (0.69) show intermediate value so they have medium risk bearing capacity towards occupational vulnerability.

From the above table-3. it is clear that Narayanpur

(1.00) has the highest value while Sukma (00) has the lowest value of geographical vulnerability. Therefore, Narayanpur with highest value shows more vulnerability towards climate change while Sukma with lowest value shows less vulnerability. The reason behind the lower susceptibility of Sukma is that, maximum forest area is attributed by the district. As a result, the forest area keeps the district stable in the face of climate change. In contrary to this Narayanpur is most vulnerable among all the districts of Bastar plateau ACZ because of lowest forest covering area by the district. As per the above analysis Kondagaon (0.99) has lower value than Narayanpur, so it is less vulnerable than Narayanpur. Since Bijapur (0.07) has higher value than Sukma district so, Bijapur is more vulnerable than Sukma. Similarly, Bastar (0.36) and Dantewada (0.51) have intermediate values exhibiting medium susceptibility among all the districts.

From the above table it is clear that Narayanpur has assigned rank one because it has highest value of Cumulative Vulnerability index (0.64) which is the most vulnerable districts among the other districts of Bastar region followed by Dantewada. This shows that the climate and weather of Narayanpur is more susceptible to climate change and it will more affect the life of people living there. Bastar received the highest rank with least value of CVI (0.32) resulting least vulnerable for climate change. Bijapur (0.52) and Sukma (0.53) can be allocated as moderately vulnerable. This may be due to the fact that these two districts have sufficient forest area. Kondagaon has higher value of CVI (0.46) than Bastar so, Kondagaon is more vulnerable than Bastar. In the same way Dantewada has less value of CVI (0.62) than Narayanpur so it is less vulnerable than Narayanpur. Vulnerability index is important for policy making as it helps in taking precautions in most vulnerable areas. The adoption of

precautionary measures also depends on the literacy and poverty of that area. The cropping pattern are decided on the basis of the climate and its vulnerability. The adaptive capacity of the people in these regions become less as for the past many seasons they have been vulnerable and this drains out their resources for adaptation at future time periods. Bastar and Kondagaon are less vulnerable areas as their climatic pattern and rainfall is not highly variable. The less vulnerable districts will be not be much affected by climate change mainly rainfall and temperature. There is no need to take precautionary measures in these districts as the agriculture is not much affected by climate change. Higher literacy rate results more awareness among people towards climate change. Bastar and Kondagaon have higher literacy rate, so it is also one of the reasons behind less vulnerability of these two districts and risk bearing capacity is also high in this case.

The following table shows Garret's ranking along with their district and The Garret's ranking technique facilitates the preferential ordering of districts according to their vulnerability which will in turn throw light on the decision-making perspectives by the people for that particular area.

After considering the vulnerability indices of the various district, any deviation in climatic variables such as rainfall, temperature should be assumed to increase vulnerability as such deviations necessitate adaptation of the economic activity to the emerging scenario. However, given the nature of agriculture in majority of regions in the district, it is more difficult to adapt to decreasing rainfall and rising temperature than to increasing rainfall and decreasing temperature. Sensitivity of crops to heat (temperature) stress is evident and irrigation is one of the key desired management responses. Therefore, we assumed that rising temperature and decreasing rainfall have adverse impacts on agriculture. However, increase in extreme rainfall and temperature related events are assumed be undesirable and hazardous.

Prasanna (2017) did similar work for the analysis of vulnerability indices in various agro-climatic zones of Andhra Pradesh, primarily to study agriculture's vulnerability to climate change, source-wise contributions to overall climate change vulnerability over time, and classification of districts under different degrees of vulnerability. During the three years under study, the data pertaining to overall climate change sensitivity revealed that Anantapuram, which is located in the Scarce Rainfall Zone, remained the most vulnerable district. Nellore, S.P.S. In the year 1994, the district from the Southern zone was the least vulnerable.

The results of vulnerability indices analysis for districts of Bastar plateau zone of Chhattisgarh revealed

that Narayanpur (0.64) district is the most vulnerable among the other districts of Bastar region followed by Dantewada. Bastar received the highest rank with least value of CVI (0.32) resulting least vulnerable for climate change. Bijapur (0.52) and Sukma (0.53) have been allocated as moderately vulnerable. This may be due to the fact that these two districts have sufficient forest area. Kondagaon has higher value of CVI (0.46) than Bastar so, Kondagaon is more vulnerable than Bastar. In the same way Dantewada has less value of CVI (0.62) than Narayanpur so it is less vulnerable than Narayanpur. The geographical and occupational indicators are the major contributors in vulnerability, so Narayanpur is more vulnerable due to comparatively minimum forest cover among other districts of Bastar zone.

Conclusions

Only district Dantewada showed non significantly negative trend for rainfall whereas districts Jagdalpur and Bijapur showed significant increasing trend and the remaining districts of Bastar plateau ACZ showed non-significantly positive trend for rainfall while in case of area and production trend, most of the districts of Bastar plateau ACZ showed significantly increasing trend for fruit crops while only few districts showed significantly increasing trend for vegetable crops.

The production of fruit crops like mango, papaya and cashew nut showed positive correlation with rainfall while for productivity not a single fruit crop showed positive correlation, whereas in case of vegetable crops all districts showed non-significant correlation for production and productivity with rainfall.

In Bastar plateau ACZ of Chhattisgarh, Narayanpur was found more vulnerable to climate change based on the overall vulnerability index and garrets ranking, whereas Bastar was the least vulnerable.

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Disease Response of Indigenous and Exotic Apple Cultivars Grafted on Clonal Rootstocks under Temperate Conditions of India

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Abstract

Commercial apple cultivars are highly subjected to major fungal foliar diseases (Scab and Alternaria leaf blotch), leading to huge economic losses in apple production throughout the world. Locating the host plant resistance is effective and durable way to manage these diseases viz-a-viz easy way to reduce pesticide application and other input costs. An extensive research was carried out to find out the disease response of twenty four cultivars grafted on clonal rootstocks was assessed under natural epiphytotic conditions of Kashmir from the cropping year 2013 to 2020. Experiments were established according to completely randomized block design with three replicates. During the evaluation, no fungicide application was done and the plants were kept unsprayed during the experimental years. Disease status of the cultivars under high density revealed the significant variation among the cultivars in terms of their response to major fungal foliar diseases (Scab and Alternaria leaf blotch). Out of 24 tested high density apple cultivars, five cultivars viz., Shalimar Apple-1, Shalimar Apple-2, Firdous, Shireen, Sunhari showed resistant reaction against both scab and Alternaria leaf blotch diseases, seven cultivars (Akbar, Shalimar Apple-1, Shalimar Apple-2, Firdous, Shireen, Sunhari and Chamurao) against scab and five (Shalimar Apple-1, Shalimar Apple-2, Firdous, Shireen, Sunhari) against Alternaria leaf blotch. Rest of the sixteen tested cultivars proved moderately susceptible to highly susceptible to both scab and Alternaria blotch diseases.

Key words : Scab, Alternaria leaf blotch, cultivars, resistance, high density, reaction, susceptibility

Introduction

Apple (*Malus domestica* Bork.) is the premier table fruit of the world and is most widely cultivated in temperate regions of both northern and southern hemispheres for its high economic value. Globally, apple is grown over an area of 4,933.841 thousand hectares with an annual production of 83,139.326 thousand metric tonnes (Anonymous, 2019). The major apple producing countries of the world are China, United States, Poland, Turkey and India. In India, apple is cultivated over an area of 307.0 thousand hectares with an annual production of 2371.0 thousand metric tonnes (Anonymous, 2018). In India, it is predominantly grown in Jammu and Kashmir (J&K), Himachal Pradesh (H.P), Uttarakhand (U.K), Arunachal Pradesh (A.P) and Nagaland. In J&K, it is grown over an area of 164.742 thousand hectares with a production of 1882.319 metric tonnes (Anonymous, 2018a). Apple is the host of wide range of diseases and pests, many of which are present in all apple producing regions in the world (Way *et. al.*, 1990). Among them, fungal diseases significantly affect its production and degrade its quality leading to great economic losses. In Kashmir, the most predominant and destructive diseases are apple scab

caused by *Venturia inaequalis* (Cooke) Winter and Alternaria leaf blotch (*Alternaria mali* Roberts). Apple scab has been endemic to almost all apple producing countries of the world and causes huge economic losses up to 70 per cent of quality apple production and accounts for an average of 70 per cent of total plant protection measures in conventional fruit growing (Biggs, 1990; MacHardy, 1996). It leads to weakening and unproductiveness of tree due to mid-summer defoliation and reduces the market value of fruit due to devaluation in fruit grade. High cost of fungicide and increasing resistance to systemic fungicides has developed great interest in using scab-resistant or less susceptible cultivars (Merwin *et. al.*, 1994). Therefore, accurate and reliable knowledge of scab susceptibility of apple cultivars is a key component for establishing an orchard. Studies on the varietal behaviour in response to scab have been carried out in some areas and tolerant genotypes have been selected (Corbaz *et. al.*, 1991; Buscaroli *et. al.*, 1996; Quadretti *et. al.*, 1996). Alternaria leaf blotch is the second most important disease of apple in Kashmir causing huge economic losses due to premature defoliation thereby weakens the host resulting in an overall yield decline (Puttoo, 1987). *A. mali* resistant varieties have been actively targeted for

Asian breeding programs for some time, using traditional techniques of crossing from resistant varieties (Saito and Takeda, 1984) but no such resistant varieties have been released into the world market from these programs till date. The introduction and the adoption of this new approach has generated a model shift from conventional orchard system to high density, however, it may results in change in microclimatic conditions within the orchard system which may lead to increased risk and vulnerability to many fungal and bacterial diseases. Moreover, the demands of fruit market have encouraged widespread plantings of new varieties such as Gala, Fuji, Granny Smith, Silver spur, Vance delicious and Red Chief which reportedly are very susceptible to many diseases (Marini, 2014). Since the high density apple orchard system has been recently introduced in Kashmir valley, there is need to assess the disease status under high density orchard system under Kashmir conditions.

Materials and Methods

Selection of orchard : The experiment was conducted in high density apple experimental orchard, Division of Fruit Science, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K) Shalimar. The experimental site is located at an elevation of 1685 m MSL with 34° 9' 22" N latitude, 74° 52' 55" E longitude. The site is characterized by very cold temperature during December to March, minimum temperature of about 7°C occurs in January and maximum temperature of around 35°C in July. The month of April and May remain cold and mild, while, June to August comparatively warm and mild in September. Besides, the month of October and November are cold and generally dry. The experiment was conducted from first year of plantation in 2013 up to eight years of age of plantation attained in the year 2020 season. The orchards blocks having exotic apple cultivars viz., Mollies Delicious, Gala Mast, Early Red One, Starkrimson, Oregon Spur, Vance Delicious, Top Red, Wells Spur, Royal Delicious, Golden Delicious, Red Delicious, Red Velox, Fuji Zehn Aztec, American Apirouge, Super Chief Sandidge, Gala Redlum and indigenous cultivars viz., Chamurrae, Firdous, Shalimar Apple-1, Shalimar Apple-2, Akbar, Lal Ambri and Shireen grafted on clonal rootstocks each planted line wise at a spacing of 1.5 x 3m, installed with 4-wire trellis system. The cultivars were assessed with regard to disease incidence and severity of major foliar diseases (Scab and ALB). Five plants of each cultivar were maintained as unsprayed for recording the disease response.

Disease incidence and intensity : Disease incidence and severity was recorded by randomly selecting four trees of each cultivar and four branches from each

selected tree representing all the four directions. One hundred leaves were examined randomly from each tree for recording the incidence and intensity of leaf scab and Alternaria leaf blotch (ALB), while as for recording the fruit scab, fifty fruits were randomly examined from each selected tree. The per cent disease incidence of leaf scab and Alternaria leaf blotch was calculated by using the following formula :

Per cent Disease Incidence (PDI)

$$= \frac{\text{Number of leaves infected}}{\text{Total no. of leaves observed}} \times 100$$

The leaf scab intensity was recorded as per the slightly modified 0-5 scale given by Croxall *et al.*, 1953 where, 0 = No infection on leaves; 1 = 5% of leaf area infected; 2 = 5.1 - 10% of leaf area infected; 3 = 10.1- 25% of leaf area infected; 4 = 25.1 - 50 of leaf area infected; 5 = >50% of leaf area infected. Similarly, fruit scab intensity was also recorded as per the slightly modified 0-5 scale given by Croxall *et al.*, 1953 where, 0 = Free from infection; 1 = Upto 1% of area infected; 2 = 1.1-5.0% of area infected; 3 = 5.1-20% of area infected; 4 = 20.1-50% of area infected; 5 = >50% of area infected

Alternaria leaf blotch intensity was recorded as per the slightly modified 0-5 scale adopted by Filajdic and Sutton (1991), where 0 = Free from infection; 1 = 0.1-3.0% area infected; 2 = 3.1- 6.0 % area infected; 3 = 6.1-12% area infected; 4 = 12.1-25 area infected; 5 = >25% area infected. The per cent disease intensity (PDI) was calculated as per the formula :

$$PSD = \frac{\sum (n \times v)}{N \times G} \times 100$$

Where, $\sum$ = Summation, n = Number of diseased leaves, v = Numerical value of the category, N = Total Number of leaves examined, G = Highest grade value

Disease reaction : On the basis of PDI, the test cultivars were categorized into different reaction groups according to disease rating scale of McKinney (1923) for scab where, 1 = 0 - 5.0 % intensity; Resistant (R); 2 = 5.1- 10.0 % intensity; Moderately resistant (MR); 3 = 10.1-25.0% intensity; Moderately susceptible (MS); 4 = 25.1-50.0% intensity; Susceptible (S); 5 = >50.0% intensity; Highly susceptible (HS) and scale adopted by Shahzad (2008) for Alternaria leaf blotch, where, 1 = 0.1-1.0 % intensity; Highly Resistant (HR); 2 = 1.1- 5.0 % intensity; Resistant (R); 3 = 5.1-10.0% intensity; Moderately resistant (MR); 4 = 10.1- 20.0% intensity; Susceptible (S); 5 = >20.0% intensity; Highly susceptible (HS).

Data analysis : The data obtained from field experiments in randomized block design was subjected to arc sine

Table-1 : Status of leaf and fruit scab incidence and intensity on different apple cultivars under high density orchard system.

Cultivars	Leaf scab (%)*			Fruit scab (%)*			Overall (%)	
	Incidence	Intensity	Reaction**	Incidence	Intensity	Reaction**	Intensity	Reaction**
Red chief	92.3 (74.04)ab	52.40 (46.40)b	HS	82.67 (65.43)c	50.13 (45.06)a	HS	51.26 (45.70)ab	HS
Oregon Spur	84.00 (66.60)de	37.60 (37.85)cde	S	58.00 (49.60)e	30.13 (33.28)c	S	33.80 (35.55)d	S
Wells Spur	89.33 (70.99)bcd	43.67 (41.34)c	S	48.00 (43.87)f	26.00 (30.61)c	S	34.83 (36.15)d	S
Mollies Delicious	48.00 (43.93)g	23.47 (28.95)g	MS	25.33 (30.80)h	7.87 (16.14)e	MR	15.67 (23.30)h	MS
Top Red	81.00 (64.43)e	27.40 (31.64)fg	S	48.67 (44.22)f	25.47 (30.26)c	S	26.43 (30.91)e	S
Golden Delicious	79.67 (63.53)e	33.53 (35.33)ef	S	27.00 (30.20)h	12.53 (20.61)d	MS	23.03 (28.60)ef	MS
Red Delicious	93.33 (75.10)ab	56.40 (48.77)ab	HS	88.00 (69.75)ab	51.60 (45.90)a	HS	54.00 (47.28)a	HS
Akbar	0.00 (0.60)i	0.00 (0.60)i	R	0.00 (0.60)j	0.00 (0.60)g	R	0 (0.00)j	R
Lal Ambri	63.67 (52.90)f	26.67 (31.10)g	S	36.67 (37.22)g	14.53 (22.36)d	MS	20.55 (26.97)fg	MS
American Apirouge	65.67 (54.20)f	24.27 (29.47)g	MS	26.67 (30.90)h	10.67 (18.91)de	MS	17.47 (24.65)gh	MS
Sunhari	0.00 (0.60)i	0.00 (0.60)i	R	0.00 (0.60)j	0.00 (0.60)g	R	0 (0.00)j	R
Royal Delicious	90.67 (72.50)abc	51.33 (45.75)b	HS	70.00 (56.83)d	39.73 (39.10)b	S	45.53 (42.41)c	S
Chamurao	15.33 (22.956)h	6.00 (14.14)h	MR	10.00 (18.40)i	2.80 (9.34)f	R	4.40 (12.08)i	R
Firdous	0.00 (0.60)i	0.00 (0.60)i	R	0.00 (0.60)j	0.00 (0.60)g	R	0 (0.00)j	R
Shireen	0.00 (0.60)i	0.00 (0.60)i	R	0.00 (0.60)j	0.00 (0.60)g	R	0 (0.00)j	R
Shalimar Apple-1	0.00 (0.60)i	0.00 (0.60)i	R	0.00 (0.60)j	0.00 (0.60)g	R	0 (0.00)j	R
Shalimar Apple-2	0.00 (0.60)i	0.00 (0.60)i	R	0.00 (0.60)j	0.00 (0.60)g	R	0 (0.00)j	R
Gala Mast	94.33 (76.30)a	53.73 (47.13)b	HS	82.00 (65.80)c	36.93 (37.40)b	MS	45.33 (42.29)c	S
Early Red One	64.33 (53.39)f	35.33 (36.40)de	S	26.00 (30.60)h	11.07 (19.24)de	MR	23.20 (28.76)ef	MS
Starkrimson	86.00 (68.10)cde	40.73 (39.70)cd	S	56.00 (48.46)ef	26.40 (30.88)c	S	33.56 (35.38)d	S
Red Velox	94.00 (75.993)ab	52.07 (46.17)b	HS	85.33 (67.53)bc	50.53 (45.30)a	HS	51.32 (45.72)ab	HS
Super Chief Sandidge	91.33 (73.10)abc	51.73 (45.98)b	HS	88.00 (69.75)ab	41.87 (40.31)b	S	46.80 (43.13)bc	S
Fuji Zehn Aztec	94.00 (75.90)ab	60.73 (51.21)a	HS	85.67 (67.87)abc	42.80 (40.83)b	S	51.76 (45.99)a	HS
Gala Redlum	92.00 (73.80)ab	51.60 (45.90)b	HS	90.67 (72.45)a	51.07 (45.60)a	HS	51.33 (45.74)ab	HS
CD (P=0.05)	5.20	3.92		4.65	3.76		2.81	

*Figures in parentheses are arc sine transformed values;** HS = Highly susceptible; S = Susceptible; MS = Moderately susceptible; MR= Moderately Resistant; R = Resista.

transformation using Statistical Analysis System (SAS) version 16. 0 (Gomes and Gomes, 1984).

Results and Discussion

Leaf scab : Perusal of data (Table-1) revealed that the extent of leaf scab incidence and intensity on test cultivars

varied ranging from zero to 94.33 and zero to 60.73 per cent, respectively. The maximum leaf scab incidence 94.33 per cent was recorded in cultivar Gala Mast followed by Red Velox (94.00%) and Fuji Zehn Aztec (94.00%). Maximum leaf scab intensity of 60.73 per cent was noticed in cultivar Fuji Zehn Aztec followed by Red

Table-2 : Categorization of apple cultivars on the basis of reaction response to scab disease.

Category	Reaction Type	Disease Intensity (%)	Cultivars
Resistant	R	0-5.0	Akbar, Chamurae, Sunhari, Firdous, Shireen, Shalimar Apple-1, Shalimar Apple-2
Moderately resistant	MR	5.1-10.0	-
Moderately susceptible	MS	10.1-25.0	Mollies Delicious, Golden Delicious, Lal Ambri, American Apirouge, Early Red One
Susceptible	S	25.1-50.0	Oregon Spur, Well Spur, Top Red, Gala Mast, Starkrimson, Super Chief Sandidge, Royal Delicious
Highly susceptible	HS	> 50	Red Chief, Red Delicious, Red Velox, Fuji Zehn Aztec, Gala Redlum

Delicious (56.40%), Gala Mast (53.73%) and Red Chief (52.40%). However, cultivars viz., Akbar, Sunhari, Firdous, Shireen, Shalimar Apple-1 and Shalimar Apple-2 exhibited no incidence of disease and were categorized as resistant to scab. Accordingly, on the basis of per cent leaf scab intensity (Table 1), Chamurae was categorized as moderately resistant, while as Mollies Delicious and American Apirouge as moderately susceptible and rest of the test cultivars as susceptible to highly susceptible.

Fruit scab : The fruit scab incidence and intensity also varied among test cultivars and ranged from zero to 90.67 and zero to 51.60 per cent, respectively. The maximum fruit scab incidence of 90.67 per cent was recorded in cv. Gala Redlum followed by cv. Super Chief Sandidge (88.00%) and Red Delicious (88.00%). It was observed that fruit scab intensity was maximum in Red Delicious (51.60%) followed by Gala Redlum (51.07%), Red Velox (50.53%) and Red Chief (50.13%) cultivars. The fruits of Akbar, Sunhari, Firdous, Shireen, Shalimar Apple-1 and Shalimar Apple-2 cultivars were free from any scab disease and were categorized as resistant to fruit scab. The categorization of the test cultivars on the basis of fruit scab intensity revealed that two cultivars (Mollies Delicious and Early Red One) were moderately resistant while rest of the cultivars were grouped as moderately susceptible to highly susceptible.

Overall leaf and fruit scab intensity : The overall leaf and fruit scab intensity varied from zero to 54.00 per cent with highest disease intensity of 54.00 per cent in case of cv. Red Delicious followed by Fuji Zehn Aztec (51.76%), Gala Redlum (51.33%), Red Velox (51.32%) and Red Chief (51.26%), whereas no disease was recorded in cultivars viz., Akbar, Sunhari, Firdous, Shireen, Shalimar Apple-1 and Shalimar Apple-2 (Table 1). The cultivars were categorized (Table-2) into different reaction groups on the basis of overall scab per cent intensity (Table-2). Of the total 24 test cultivars screened, seven cultivars viz., Akbar, Sunhari, Firdous, Shireen, Shalimar Apple-1 and Shalimar Apple-2 with disease intensity of 0.00 per cent and Chamurae (4.40 per cent PDI), were grouped as resistant, and seven other cultivars viz., Oregon Spur, Well Spur, Top Red, Gala Mast, Starkrimson, Super Chief

Sandidge and Royal Delicious with disease intensity ranging from 26.43 to 46.80 per cent, were categorized as susceptible. Five cultivars (Mollies Delicious, Golden Delicious, Lal Ambri, American Apirouge and Early Red One) exhibited disease intensity of 15.67 to 23.20 per cent and were categorized as moderately susceptible, while as four cultivars viz., Red Velox, Fuji Zehn Aztec and Gala Redlum exhibited highly susceptible reaction.

Alternaria leaf blotch incidence and intensity : The data of Alternaria leaf blotch of test cultivars are presented in table 3 and 4. Perusal of the data indicated that all the test cultivars varied with respect to extent of Alternaria leaf blotch. The disease incidence varied from zero to 89.00 per cent with maximum disease incidence recorded on Red Chief followed by Akbar (77.67%), Chamurae (75.00%) and Fuji Zehn Aztec (66.33%). Two cultivars viz., Shireen and Sunhari did not record any disease and were followed by Shalimar Apple-1, Shalimar Apple-2, and Firdous by exhibiting minimum disease incidence of 1.00, 4.00, and 11.00 per cent, respectively. Alternaria leaf blotch intensity also varied among the test cultivars with maximum recorded on Red Chief (31.20%) and lowest (0.00%) on Shireen, Shalimar Apple-1 and Sunhari. On the basis of PDI recorded in 24 test cultivars (Table 4), three cultivars viz., Sunhari, Shireen and Shalimar Apple-1 were categorized as highly resistant, two cultivars (Firdous and Shalimar Apple-2) as resistant, four cultivars (American Apirouge, Gala Mast, Starkrimson and Early Red One) as moderately resistant (Table-4). Rest of the test cultivars showed susceptible to highly susceptible reaction.

Among the test cultivars, six cultivars viz., Akbar, Shalimar Apple-1, Shalimar Apple-2, Firdous, Shireen and Sunhari without any scab symptom and Chamurae with overall leaf and fruit scab intensity 4.40 per cent, were categorized as resistant. Amongst them, three cultivars viz., Shalimar Apple-1, Firdous, and Shireen, have been developed and released by SKUAST-K as scab resistant cultivars. Resistance of these cultivars can be attributed to their resistant parental background viz., Shalimar Apple-1 (Sunhari × Prima), Firdous (Golden Delicious × Rome Beauty × Malus floribunda), Shireen

Table-3 : Status of *Alternaria* leaf blotch incidence and intensity on different apple cultivars under high density orchard system.

Cultivars	Alternaria leaf blotch (%)*		
	Incidence	Intensity	Reaction**
Red chief	89.00 (70.88)a	31.20 (33.85)a	HS
Oregon Spur	32.67 (34.80)i	12.13 (20.30)fgh	S
Well Spur	57.00 (49.10)def	20.40 (26.64)cde	HS
Mollies Delicious	39.00 (38.60)hi	17.20 (24.42)def	S
Top Red	65.00 (53.73)cd	14.47 (22.34)efg	S
Golden Delicious	52.00 (46.14)efg	20.87 (27.11)cde	HS
Red Delicious	63.00 (52.53)de	26.13 (30.56)abc	HS
Akbar	77.67 (62.01)b	23.60 (28.94)abcd	HS
Lal Ambri	18.67 (25.56)jk	10.13 (18.45)ghi	S
American Apirouge	14.00 (21.93)jk	5.13 (13.05)j	MR
Sunhari	0.00 (0.60)m	0.00 (0.60)l	HR
Royal Delicious	37.00 (37.20)i	12.93 (20.82)fgh	S
Chamurae	75.00 (60.00)bc	21.87 (27.81)bcd	HS
Firdous	11.00 (19.35)k	4.07 (11.52)j	R
Shireen	0.00 (0.60)m	0.00 (0.60)l	HR
Shalimar Apple-1	1.00 (4.81)lm	0.40 (3.11)kl	HR
Shalimar Apple-2	4.00 (9.31)l	1.73 (6.26)k	R
Gala Mast	18.00 (24.90)jk	6.80 (14.94)ij	MR
Early Red One	16.00 (23.51)jk	5.20 (12.91)j	MR
Starkrimson	22.00 (27.91)j	8.13 (16.53)hij	MR
Red Velox	35.00 (36.12)j	12.20 (20.23)fgh	S
Super Chief Sandidge	50.33 (45.17)fgh	20.27 (26.24)cde	HS
Fuji Zehn Aztec	66.33 (54.62)cd	28.67 (32.30)ab	HS
Gala Redlum	41.00 (39.79)ghi	16.73 (24.11)def	S
CD (P=0.05)	6.80	5.19	

*Figures in parentheses are arc sine transformed values

** HS = Highly susceptible; S = Susceptible; MR = Moderately Resistant; R = Resistant; HR = Highly Resistant

(Lord Lambourne × Melba × R-12740-7A). The resistance of cultivar Chamurae can be attributed to its leaf morphology as the leaves of the cultivar possess more hair density on adaxial surface which might be hampering the pre-penetration host pathogen interaction and

subsequent disease development. Earlier, Yoon and Lee (1987) have also confirmed through artificial inoculation tests that removal of leaf hairs of resistant cultivars make them susceptible to the disease and concluded that resistant apple cultivars possessed higher leaf hair

Table-4 : Categorization of apple cultivars on the basis of reaction response to *Alternaria* leaf blotch disease.

Category	Reaction type	Disease intensity (%)	Cultivars
Highly Resistant	HR	0.1-1.0	Sunhari, Shireen, ShalimarApple-1
Resistant	R	1.1-5.0	Firdous, Shalimar Apple-2
Moderately	MR	5.1-10	Gala Mast, American Apirouge, Early Red One, Starkrimson
Susceptible	S	10.1-20	Oregon Spur, Top Red, Gala Redlum, Red Velox, Royal Delicious, Lal Ambri, Mollies Delicious
Highly susceptible	HS	> 20	Red Chief, Well Spur, Red Delicious, Golden Delicious, Chamurrae, Akbar, Super Chief Sandidge, Fuji Zehn Aztec, Gala Redlum

density on the under surface as against the lesser leaf hair density in susceptible cultivars. Cultivars viz., Mollies Delicious, Golden Delicious, Lal Ambri, American Apirouge, Early Red One, Oregon Spur, Well Spur, Top Red, Gala Mast, Starkrimson, Super Chief Sandidge, Royal Delicious, Red Chief, Red Delicious, Red Velox, Fuji Zehn Aztec and Gala Redlum with overall scab intensity ranging from 15.67 to 54.00 per cent were categorized as moderately to highly susceptible. The susceptibility to scab in various apple cultivars has been also reported by Rosenberger (2003) and Biggs *et al.* (2010). The varying reaction response of apple cultivars with identical genetic background, as observed in present study, has been also reported by Balint *et al.* (2013). However, resistance in apple cultivars necessitates validation through genetical and physiological background studies (Holb, 2009).

The test cultivars also showed varied reaction against *Alternaria* leaf blotch disease. Amongst them, Shalimar Apple-1, Shalimar Apple-2, Firdous, Shireen, Sunhari, Gala Mast, American Apirouge, Early Red One and Starkrimson with disease intensity ranging from 0.00 to 8.13 per cent, showed moderately resistant to highly resistant reaction, whereas rest of the cultivars exhibited susceptible to highly susceptible reaction. The present findings are in accordance with Li *et al.* (2012) evaluated 25 apple cultivars, found most of the apple cultivars highly susceptible and only three cultivars as resistant against *Alternaria* leaf blotch disease under field conditions as well as similar findings were reported by Sasnauskas *et al.* (2006).

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Yield Forecast Models of Potato Using Discriminant Function Analysis for Barabanki District of Uttar Pradesh

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Abstract

The time series data on yield of potato and weekly data from 40th SMW of the previous year to 6th SMW of the following year on five weather variables viz., Minimum Temperature, Maximum Temperature, Relative humidity 08.30hrs, Relative humidity 17.30hrs, and Wind-Velocity covering the period from 1990-91 to 2011-12 have been utilized for development of pre-harvest forecast model. Statistical methodologies using discriminant functions analysis for developing pre-harvest forecast model have been described. In all, 6 models have been developed based on discriminant functions analysis. On the basis of $\text{adj}R^2$, RMSE percent deviation and %SE, the best two models obtained by the application of weekly weather data are Model- II and model- V_{th}. These models can be used to get the reliable forecast of potato yield two and half months before the harvest.

Key words : pre-harvest forecast statistical model, crop yield, weather variables, discriminant function.

Introduction

Potato (*Solanum tuberosum* L.) is the most important vegetable crop of the India and known as “The king of vegetable”. It is most important cash crop of Uttar Pradesh. Being a short duration crop, it produces more quantity of dry matter, edible energy and edible protein in lesser duration of time compared to cereals like rice and wheat. It is a native of tropical South America. India produced about 453.44 lakh tones of potato from 19.92 lakh hectares in the year 2012-13. The bulk of the produce come from state of Uttar Pradesh, West Bengal, Bihar and Punjab contributing 32, 26, 15 and 5% respectively in the year 2012-13. The area, production and potato yield at the national level increased during the period 1979-80 to 2010-11 by 172, 408 and 87% respectively. The heat sensitive potato crop is mostly confined to Indo-Gangetic plains under irrigated conditions due to climate constraints. Small scattered area as rainfed crop are grown in hill during summers and in kharif season in plateau region, whereas winter season crop in the plateau region is irrigated. Usually the pre-harvest estimate of crop yield is obtained on the basis of visual observation which is not objective. There are two major objective approaches for forecasting crop yields, one by using weather variables and the other by using weather variables and agriculture inputs jointly. These approaches can be used individually or in combination to give a composite model. Weather is one of the most important factors influencing crop growth. It may influence production directly through affecting the growth structural characteristics of crop such as plant population, numbers

of tillers, leaf area etc., and indirectly through its effect on incidence of pest and diseases. The effect of weather parameter at different stages of growth of crop may help in understanding their response in term of final yield and also provide a forecast of crop yields in advance before the harvest. The extent of weather influence on crop yields depends only on magnitude of weather parameters but also on their frequency distribution. Therefore, the knowledge of the frequency distribution of weather parameter is also essential while developing the pre-harvest model. Several studies have been carried out in past both in India and abroad on the crop weather relationship and forecasting crop yield. Fisher (1924) made first attempt to develop crop-weather relationship. Hendrics and Scholl (1943) modified the Fisher's technique. Agarwal et al (1980) further modified the technique of Hendrics and Scholl (1943) by developing forecast model using weather indices for rice crop in Raipur district of Chhatisgarh. Such technique of Agarwal et al (1980) has been used by various author in the past for developing forecast yield of various crops in different region of the country. Agrawal et al (2012), Sisodia et al (2014), Azfar et al (2014), Azfar et al (2015) and Yadav et al (2016) have applied discriminant function analysis for developing forecast models for some crops. The present study is envisaged to develop forecast models for potato yield using weather variables by applying discriminant function analysis.

Materials and Methods

The material used and the methodology employed for developing forecast models are presented below :

Description of the Study Area : Barabanki is situated between 27° 19' and 26° 30' north latitude, and 80° 05' and 81° 51' east longitude; it runs in a south-easterly direction, confined by the nearly parallel streams of the Ghaghara and Gomti. The extreme length of the district from east to west may be taken at 57 miles (92 km), and the extreme breadth at 58 miles (93 km); the total area is about 1,504 sq miles (3,900 km²): its population amounts to 2,673,581 being at the rate of 686.50 per square kilometre (1,778/sq miles). The Barabanki city is the district headquarters. It stretches out in a level plain interspersed with numerous jhils or marshes. In the upper part of the district, the soil is sandy, while in the lower part it is clayey and produces finer crops.[2] The district is well fed by rivers Ghaghra (forming the northern boundary), Gomti (flowing through the middle of the district) and Kalyani and their tributaries, for the major part of the year. In 2011, Barabanki had population of 3,260,699 of which male and female were 1,707,073 and 1,553,626 respectively. In 2001 census, Barabanki had a population of 2,673,581 of which males were 1,416,921 and remaining 1,256,660 were females. There was change of 21.96 per cent in the population compared to population as per 2001. In the previous census of India 2001, Barabanki District recorded an increase of 26.54 per cent to its population compared to 1991.

Yield data : Time series data on yield of potato of Barabanki district of Uttar Pradesh for 22 years (1990-91 to 2011-12) have been collected from the Bulletins of Directorate of Agricultural Statistics and Crop Insurance, Govt. of Uttar Pradesh.

Weather data : Weekly weather data for the same period on five weather variables viz., Minimum Temperature, Maximum Temperature, Relative Humidity at 8.30 and 17.30 hrs and Wind-Velocity have been used in the study. The weekly data on these weather variables have been obtained from the Department of meteorological center, Amausi Airport Lucknow. U.P. India.

Statistical Tools Used in the Analysis : Keeping in view the objectives set out for the study, following statistical tools and methods have been used. The data are analyzed by using software like SPSS, and MS-EXCEL.

Statistical methodology : The technique of discriminant function analysis provides an appropriate function that discriminates two or more groups and classifies the future observations into one of the previously defined groups. Consider that observations are classified into k non-overlapping groups on the basis p variables. The technique identifies linear functions where the coefficients of the variables are determined in such a way that the variation between the groups gets maximized relative to

the variation within the groups. The maximum number of discriminant functions that can be obtained is equal to minimum of $(k-1)$ and p . These functions are used to calculate discriminant scores, which are used to classify the observations into different groups.

Agrawal *et al* (2012) were first to develop forecast models for wheat yield in Kanpur district of Uttar Pradesh using discriminant function analysis technique that provided reliable yield forecast about two months before harvest. This paper applies this technique used by them along with a few modifications for the development of suitable models for pre-harvest forecast of potato yield in Barabanki district of Uttar Pradesh.

In order to apply discriminant function analysis for modeling yield using weather variables, crop years have been divided into three groups namely congenial, normal and adverse on the basis of crop yield adjusted for trend effect. Data on weather variables in these three groups were used to develop linear discriminant functions and the discriminant scores were obtained for each year. These scores were used along with year as regressors and crop yield as regressand in developing the forecast models. In the present study the number of groups is three and number of weather variables is five, therefore, only two discriminant functions are sufficient for discriminating a crop year into either of the three groups.

Three groups of crop years, viz. adverse, normal and congenial have been obtained as follows: Let y and s be the mean and standard deviation of the adjusted crop yields of n years. The adjusted crop yields less than or equal to $y - s$ would form adverse group, the adjusted crop yields between $y - s$ and $y + s$ would form normal group and adjusted crop yields above or equal to $y + s$ would form congenial group.

It is, however, known that weather variables affect the crop differently during different phases of crop development. Its effect depends not only on its magnitude but also on its distribution pattern over the crop season. Therefore, using weekly weather data as such in developing the model poses a problem as no. of independent variables in the regression model would increase enormously. To solve this problem, following weather indices have been developed using the procedure of Agrawal *et al* (1983, 1986).

where Z_{ij} is un-weighted (for $j=0$) and weighted (for $j=1$) weather indices for i th weather variable and is the unweighted (for $j=0$) and weighted (for $j=1$) weather indices for interaction between i th and i' th weather variables. X_{iw} is the value of the i th weather variable in w th week, $r_{iw}/r_{ii'w}$ is correlation coefficient of yield adjusted for trend effect with i th weather variable/product

Table-1 : Comparison between actual and forecasted yield of different years of Barabanki District.

Model	Year	Actual yield	Forecast yield	Percent Deviation	RMSE	% SE	R ²	R ² adj.
I	2009-10	19.58	15.56	20.53	3.21	10.25	61.19	53.43
	2010-11	20.34	19.29	5.17		12.31		
	2011-12	26.07	22.37	14.19		10.61		
II	2009-10	19.58	17.92	8.45	1.29	6.83	83.33	80
	2010-11	20.34	19.06	6.29		7.05		
	2011-12	26.07	25.27	3.05		6.27		
III	2009-10	19.58	14.15	27.72	3.33	7.72	85.32	82.37
	2010-11	20.34	18.42	9.46		7.69		
	2011-12	26.07	25.93	0.53		6.25		
IV	2009-10	19.58	15.74	19.58	2.24	6.16	89.17	87
	2010-11	20.34	19.93	2.02		6.77		
	2011-12	26.07	25.68	1.49		4.98		
V	2009-10	19.58	15.03	23.2	2.85	8.27	79	74.81
	2010-11	20.34	18.87	7.23		8.35		
	2011-12	26.07	24.8	4.85		7.04		
VI	2009-10	19.58	14.69	24.95	2.87	10.91	84.92	81.9
	2010-11	20.34	19.46	4.32		12.64		
	2011-12	26.07	25.85	0.82		13.65		

of i th and i 'th weathervariable in w th week, n is the number of weeks considered in developing the indices and p is number of weather variables. Here, $p=5$ and $n=15$, i.e. 15 weeks' data from 44th week to 52nd week of a year and 1st week to 6th week of the next year have been utilized for constructing weighted and un-weighted weather indices of weather variables along with their interactions. In all 30 indices (15 weighted and 15 un-weighted) consisting of 5 weighted weather indices and 10 weighted interaction indices, and 5 un-weighted and 10 un-weighted interaction indices have been constructed. Besides, some more suitable strategies have been suggested. In all, six possible models are attempted. First two are the best models reported by Agrawal *et al.* (2012) and last four are newly proposed. Models are developed using regression analysis. Only the first 18 years data from 1991 to 2008 have been utilized for modeling the yield and remaining two years yield data of 2009 and 2010 have been used for validation of the models.

Development of forecast model using discriminant Function Analysis.

Procedure-1 : This utilizes the complete data over 19 weeks and also considers relative importance of weather variables in different weeks. Using five weighted weather indices of five weather variables as discriminating variables, discriminant function analysis has been carried out and two discriminant functions have been obtained. Two sets of discriminant scores for the years under consideration from these two discriminant functions were

obtained. For developing forecast these two sets of discriminant scores along with the trend variable were utilized as the regressors and the yield as the regressand. The form of considered is as follows :

$$y = \alpha_0 + \alpha_1 ds_1 + \alpha_2 ds_2 + \alpha_3 T + \epsilon$$

where y = crop yield,

α_0 = intercept,

α_i 's ($i=1,2,3$) = the regression coefficients

ds_1 and ds_2 are the two discriminant scores, T is the trend variable and ϵ is error $\sim N(0, \sigma^2)$.

Procedure-2 : This is 4th of Agrawal *et al.* (2012). Two discriminant functions and there from two sets of discriminant scores have been obtained using the first week data (40th SMW) on five weather variables. Next, two sets of discriminant scores obtained from first week data and second week (41th SMW) data on five weather variables have been used as discriminating variables. So in all there were 7 discriminating variables and based on these 7 discriminating variables, the discriminant function analysis has been done and therefore, two sets of discriminant scores have been obtained. This process is repeated up to the last week till the time of forecast (6th SMW or 19th week) and finally two sets of discriminant scores have been obtained. Based on these two sets of discriminant scores, the forecasting taking yield as the regressand and the discriminant scores and the trend variable (T) as the regressor variables has been fitted. The form of this model is similar to the model giving in equation no. (2).

Procedure-3 : In this model, 5 weighted and 5 un-weighted weather indices have been used as discriminating variables. Now, based on these 10 indices, the discriminant function analysis has been done and two sets of scores have been obtained. On the basis of these two sets of scores, the regression has been fitted taking the yield as the regressand and the two sets of scores and the trend variable (T) as the regressors. The form of this model is similar to the model giving in equation no. (2).

Procedure-4 : In this, all 30 indices (weighted and un-weighted including interaction indices) have been used as discriminating variables in discriminant function analysis and two sets of discriminant scores from two discriminant functions have been obtained. Forecasting has been fitted taking un-trended yield as the regressand variable and the two sets of discriminant scores and the trend variable (T) as the regressor variables. The form of this model is similar as in equation no. (2) has been fitted.

Procedure-5 : In this, discriminant function analysis has been carried out using weekly data of the first weather variable spread over 19 weeks as discriminating variable. Using two sets of discriminant scores obtained from two estimated discriminant functions based on data of the first weather variable and 19 weeks' data of the second variable, discriminant function analysis has been again performed and two sets of discriminant scores are obtained (here the discriminating variables will now become 21). Using these two sets of discriminant scores and 19 weeks' data of third weather variable have been again used to carry out discriminant analysis and subsequently two sets of discriminant scores have been obtained. This process is continued up to five weather variable, and ultimately we got two sets of discriminant scores ds_1 and ds_2 . These two sets of scores and the trend variable (T) as the regressor variables and crop-yield as the regressand are utilized to develop forecast by fitting the similar model as in equation no. (2).

Procedure-6 : In this, discriminant function analysis has been carried out using the un-weighted and weighted averages (weather indices) for the first weather variable (here discriminating factors will be only two). Using the two sets of discriminant scores obtained on the basis of first weather variable, and un-weighted and weighted averages (weather indices) for the second weather variable, discriminant function analysis has been further carried out (here, the discriminating factors will be four). This process is continued up to fifth weather variable, and finally we got two sets of discriminant scores ds_1 and ds_2 . Using crop-yield as regressand and discriminant scores ds_1 and ds_2 and the time trend variable (T) as regressor are utilized to develop forecast by fitting the similar model as in equation no. (2).

Results and Discussion

Various pre-harvest forecast models based on the procedures as described in the preceding section have been developed. The results and findings and relevant discussion are presented as follows.

Forecast Mode I-I	$Y = 20.63 + 2.54ds_1 - 0.39ds_2 - 0.22T$
Forecast Mode I-II	$Y = 18.023 + 0.078ds_1 - 0.697ds_2 + 0.023T$
Forecast Mode I-III	$Y = 17.588 - 1.831ds_1 - 0.022ds_2 + 0.046T$
Forecast Mode I-IV	$Y = 17.869 + 1.307ds_1 + 0.399ds_2 + 0.033T$
Forecast Mode I-V	$Y = 17.574 + 0.218ds_1 + 1.244ds_2 + 0.048T$
6 Forecast Mode I-VI	$Y = 17.852 - 1.902ds_1 - 0.229ds_2 + 0.029T$

In all six models have been develop based on six procedurs. Sowing of potato starts generally from the first week of October in Barabanki district. Therefore, weekly data on the weather variables have been considered from pre-sowing the 40nd SMW of crop which fall during the first week of October. It has been proposed to make pre-harvest forecast of the potato yield at the stage of milking / dough, about two months before the harvest. Milking and dough stages generally start after about 130 days of sowing. Therefore, 6th SMW of the next year (Feb.5-Feb.11) has been considered the week of pre-harvest forecast. Thus, in all 19 weeks' data on the weather variables (40th SMW of the previous year to 6th SMW of the next year) have been utilized to develop the statistical models. In all six models are developed based on aforesaid six procedures. The models obtained are given below

Comparison of the model : Based on these six forecast models, the forecast yields for the 2009-10, 2010-11 and 2011-12 have been computed and result are presented in Table-1 The values of R^2_{adj} , percent deviation of forecast from actual yield, RMSE and %SE (CV) have also been computed for each model and are also presented below.

It is evident from the results of the Table-1 that coefficient of determination (R^2) has been found to be 83.3% with minimum RMSE, less percent S.E. and minimum percent deviation for the Model-II followed by model-IV have R^2 89.17 with 2.24 RMSE and lesser percent deviation with minimum percent S.E. followed. While rest of the models namely I, III, V, and VI are not comparable with the above models as they have more RMSE. On the basis of the overall results of the Table- 1 it can be concluded that the Model - II and Model - IV are the most suitable models among all the models to forecast potato yield in Barabanki district of Eastern Uttar Pradesh. Hence, a reliable forecast of potato yield about two and half months before the harvest can be obtained from the Model-II and Model-IV.

Conclusion

Discriminant function analysis technique has been applied to develop forecast model for potato yield in Barabanki district of UP using weekly data on five weather variables. In all six models have developed. The model II and IV have been found best among all based on the criteria of RMSE, percent deviation and percent SE including coefficient of determination, These two models can provide reliable forecast of potato yield about two and half months before the harvest.

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Export Structure of Cereals (HS Code : 10) from Asia Pacific Region

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Abstract

The present study assessed the export structure of Cereals (HS Code: 10) from Asia Pacific region. Lorenz curve and Gini coefficient are used for the purpose of analysis. The Gini coefficient values are 0.8818, 0.8607 and 0.8492 for the years 2000, 2009 and 2018 respectively. Gini coefficient values of Cereals (HS Code: 10) are high for all the years studied as major portion of export is contributed by only two countries which in turn implies high degree of export market concentration but it shows a gradual decrease over the years. All the Lorenz curves for the years 2000, 2009 and 2018 are distant from the equality line and are moving towards perfect inequality. The results of the study on export structure of Cereals (HS Code:10) among partners of Asia Pacific shows that the contribution of export is cornered by few countries. Hence, the reduction in the trade barriers between countries in the form of delicensing and liberal international trade reforms can correct this type of inequality among countries and can change the export structure of Cereals (HS Code:10) in the region.

Key words : *Export structure, cereals, gini coefficient, lorenz curve, market concentration.*

Introduction

Asia Pacific region is an important region player in the world with a quarter of the world GDP and trade originating in this region. The region consists of several economies of various types and structures. Two of the world's largest economies namely China and Japan and many smaller economies consist in the region. The economy mostly includes emerging economies from East and Southeast Asia. The region has witnessed enormous changes in the last 2-3 decades in the agricultural trade with agricultural mechanization, modern production systems replacing traditional agriculture.

The heterogeneity of Asia-Pacific countries is also reflected in the business indicators which serve as the benchmark for the countries approach to trade performance. The countries like Singapore and Lao's people democratic republic have represented the diverse structure in their economies which have led to provision of resources and plenty of opportunities for growth making many economies in the region are transforming, diversifying and opening up the trade barriers for smoother integration into the regional and world economies, cross border trade, investment and technology.

The Asia Pacific region consists of large number of countries but small in size have wide diversity in agricultural trade. The study is an attempt to analyze the structure of exports of Cereals(HS Code:10) from Asia Pacific region and suggest policies for smooth international trade in the Asia Pacific region.

Vivine (2011) assessed market structure of India's coffee exports using Lorenz curve and Gini coefficient. Gini coefficient values were 0.65, 0.70 and 0.71 for the years 2000-01, 2005-06 and 2009-10 respectively which implied high degree of market concentration for coffee exports from India. Results also revealed that market concentration shifting towards perfect inequality distribution.

Burange and Karnik (2014) conducted a study on concentration of bilateral merchandise trade between India and SAARC. Hirschman Index (HI) was used for analyzing data from 1990-1991 to 2013-14. Results revealed that HI for exports varied between 8 and 16 per cent for almost all the years. For imports HI ranged between 10 and 40 per cent. HI was low for both imports and exports which implied concentration of products was found to be high between India and SAARC.

Ani *et al.* (2017) carried out a study to analyse the structure of soyabean markets in Benue and Enugu states of Nigeria using descriptive statistics, regression model, Herfindahl Hirschman Index, Gini coefficient and Lorenz curve. Herfindahl Hirschman Index (2017.18 and 1081.97) and Gini coefficient values (0.84 and 0.81) were high for both wholesalers and retailers which in turn implied high degree of market concentration for soyabean.

Erkalo (2017) examined the structure of honey market in Chena district kaffa zone of Southern Ethiopia. Data were analysed using Gini coefficient and descriptive statistics. The results revealed that market concentration

Table-1 : Analysis of export structure of Cereals (HS Code:10) from Asia Pacific region for the year 2000.

Annual exports (Thousand Metric Tonnes)	Frequency	Proportion of countries(X)	Cumulative proportion of countries	Total exports (Thousand Metric Tonnes)	Proportion of total exports	Cumulative proportion of exports(Y)
1000	18	0.7500	0.7500	795.31	0.0145	0.0145
1001-2500	2	0.0833	0.8333	3808.69	0.0695	0.0840
2501-5000	1	0.0417	0.8750	3480.93	0.0635	0.1475
5001-7500	1	0.0417	0.9167	6193.110	0.1130	0.2605
>7500	2	0.0833	1.0000	40537.71	0.7395	1.0000
Sum	24			54815.76		

Gini Coefficient (1- XY) = 0.8818

Table-2 : Analysis of export structure of Cereals (HS Code:10) from Asia Pacific region for the year 2009.

Annual exports (Thousand Metric Tonnes)	Frequency	Proportion of countries(X)	Cumulative proportion of countries	Total exports (Thousand Metric Tonnes)	Proportion of total exports	Cumulative proportion of exports(Y)
1000	17	0.7083	0.7083	768.41	0.0142	0.0142
1001-2500	1	0.0417	0.7500	1082.96	0.0201	0.0343
2501-5000	2	0.0833	0.8333	7060.14	0.1308	0.1651
5001-7500	2	0.0833	0.9167	11000.79	0.2038	0.3690
>7500	2	0.0833	1.0000	34057.23	0.6310	1.0000
Sum	24			53969.53		

Gini Coefficient (1- XY) = 0.8607

Table-3 : Analysis of export structure of Cereals (HS Code:10) from Asia Pacific region for the year 2018.

Annual exports (Thousand Metric Tonnes)	Frequency	Proportion of countries(X)	Cumulative proportion of countries	Total exports (Thousand Metric Tonnes)	Proportion of total exports	Cumulative proportion of exports(Y)
1000	17	0.7083	0.7083	1959.91	0.0285	0.0285
1001-2500	1	0.0417	0.7500	2206.66	0.0321	0.0607
2501-5000	1	0.0417	0.7917	3158.68	0.0460	0.1067
5001-7500	1	0.0417	0.8333	5591.47	0.0814	0.1882
7501-10000	1	0.0417	0.8750	8120.99	0.1183	0.3064
10001-12500	1	0.0417	0.9167	11331.48	0.1651	0.4715
>12500	2	0.0833	1.0000	36280.90	0.5285	1.0000
Sum	24			68650.09		

Gini Coefficient (1- XY) = 0.8492

was marginally observed to be high (Gini coefficient = 0.33) for traders in honey market.

Mohandas *et al.* (2018) analyzed dynamics of contribution of individual group of vegetables in the basket of vegetable exports from India. The Gini coefficient value for vegetables has decreased from 50.61 during the period 1988 to 1999 to 42.32 during the period from 2000 to 2016. The decrease in Gini coefficient value implied decrease in commodity concentration for vegetables.

Materials and Methods

Description of study area : Asia Pacific region is the part of the world close to the Western Pacific Ocean. Asia-Pacific region generally includes all the countries in

East Asia, Southeast Asia, South Asia, Australia, and Oceania.

Sources of data : The entire study is based on secondary sources of data. The required Harmonized System coding (HS 1992) data procured from UNCOMTRADE data accessed through the World Bank's World Integrated Trade Solution (WITS) software. Cereals (HS Code:10) is purposively selected for the study as it one of the top three exports from Asia Pacific region.

Gini Concentration Ratio : The Gini concentration ratio, proposed by Italian Statistician Corrado Gini is a measure of inequality among values of a frequency distribution. The Gini concentration ratio varies from 0 to 1. The value one indicates perfect inequality distribution while the value

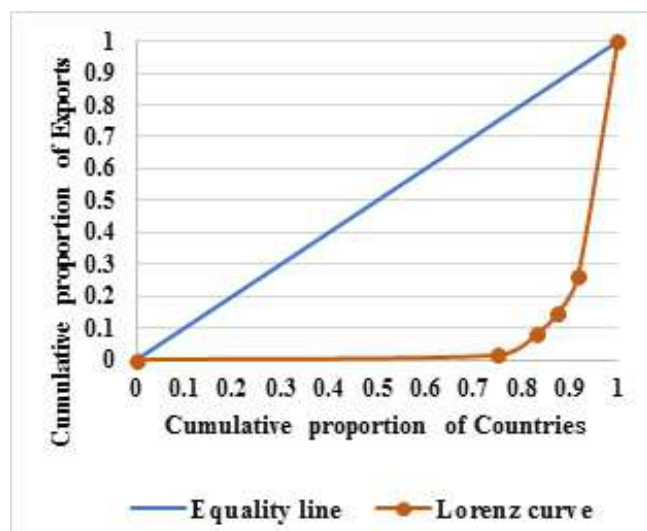


Fig-1 : Lorenz curve for the export of Cereals (HS Code:10) from Asia Pacific region for the year 2000.

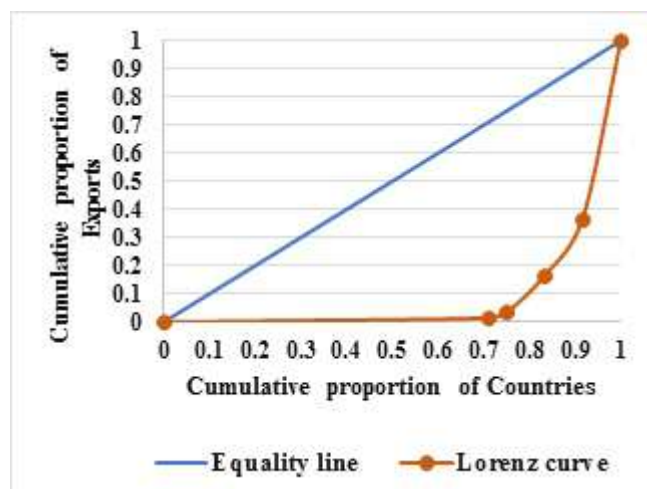


Fig-2: Lorenz curve for the export of Cereals (HS Code:10) from Asia Pacific region for the year 2009.

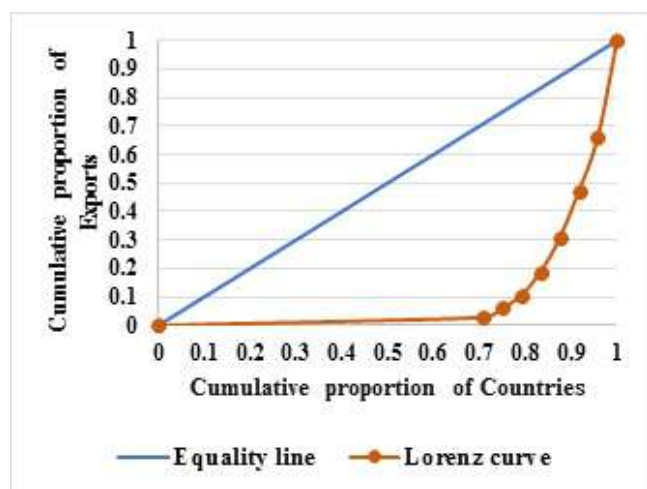


Fig-3: Lorenz curve for the export of Cereals (HS Code:10) from Asia Pacific region for the year 2018.

zero indicates perfect equality. This tool was used to analyse the structure of selected major agricultural commodities exported from Asia Pacific region. Gini concentration ratio is calculated for three years 2000, 2009 and 2018. The Gini concentration ratio was calculated as a ratio of the areas on the Lorenz curve diagram.

Lorenz Curve : The Lorenz curve was used to analyze the market power and concentration of trade among exporters of a market. The Lorenz curve is a graphical representation of concentration among countries of an export market. The line at the 45° angle shows perfectly equal distribution of quantity exported while the other line shows the actual distribution of quantity exported. The farther away from the diagonal, the more unequal the size of distribution of quantity exported.

Results and Discussion

The results of the analysis of export structure of Cereals (HS Code:10) from Asia Pacific region for the year 2000, 2009 and 2018 are presented in Table 1, 2 and 3 respectively. In total, 24 countries were considered for analysing export structure of cereals which accounted for 93 to 99 per cent of total cereals export from Asia Pacific region.

Out of 24, the top 2 countries contribute 73.95, 63.10 and 52.85 per cent to the total cereals export during the years 2000, 2009 and 2018 respectively. The Gini coefficient values computed for the years 2000, 2009 and 2018 are 0.8818, 0.8607 and 0.8492 respectively which showed a gradual decrease over the years. Gini coefficient for Cereals is high for all the years as major portion of export is contributed by only two countries which in turn implies high degree of export market concentration. Though the export market concentration is high for Cereals (HS Code:10) in Asia Pacific region, over the years market concentration is decreasing.

The Lorenz curve for the export of cereals for the years 2000, 2009 and 2018 are presented in Fig.1, Fig.2 and Fig.3 respectively. All the Lorenz curves are distant from the equality line. The Lorenz curves are moving towards perfect inequality.

Conclusions

The results revealed that Gini coefficient values are high for export of Cereals (HS Code:10) from Asia Pacific region. All the Lorenz curves are distant from the equality line. The results of the study on export structure of Cereals(HS Code:10) among partners of Asia Pacific shows that the contribution of export is cornered by few countries. The countries which contribute major share in export of Cereals (HS Code:10) from Asia Pacific region

are Australia, China, Thailand and India. Hence, the reduction in the trade barriers between countries in the form of delicensing and liberal international trade reforms can correct this type of inequality among countries and can change the export structure of Cereals in the region.

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Changing Pattern of Agricultural Trade in India

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Abstract

India occupies a leading position in the global trade of agricultural products. However, its total agricultural export basket accounts for a little over 2.15 per cent of the world agricultural trade. The paper attempts to quantify the changing patterns of Indian agricultural exports and imports. Data for the analysis was considered for a period of 27 years from 1992 to 2018. Compound Annual growth rate (CAGR) was used for analyzing the growth in quantity and value of agricultural exports and imports over the years. The Compound annual growth rate for exports and imports of agricultural commodities in terms of value for India are 9.52 and 12.92 per cent respectively. The Compound annual growth rate of agricultural commodities in terms of quantity is 7.12 per cent for exports and 10.25 per cent for imports of India. Efforts are needed to give increased focus on exploring global markets for agricultural commodities to give an additional source of market for the surplus of agricultural produce.

Key words : *Compound annual growth rate, exports, imports, trade, trends.*

Introduction

India is the eighth largest exporter of agricultural commodities in the world. In the last 15 years, India showed an increase in export of almost all the agricultural commodities. India has emerged as a significant Agri-exporter in a few crops viz. rice, cotton, sugarcane, cashew nut, castor seed and groundnut. As per the WTO statistics, in the year 2018, India exported animal products worth USD 10.63 billion, food products worth USD 6.80 billion and vegetable products worth USD 18.05 billion. The shares of animal, vegetable and food products are 3.30, 5.6 and 2.11 per cent of total exports by India respectively.

India is the second-most populous country. By 2024 it may surpass China and become the most populous country. Agricultural imports of India mainly consist of vegetable oils, pulses, fresh fruits, cashew nuts, spices, sugar, cocoa, cotton, etc. During the year 2018, India imported animal products worth USD 0.24 billion, food products worth USD 3.40 billion and vegetable products worth USD 21.54 billion which accounted for about 0.04, 0.55 and 3.49 per cent of the total India's imports respectively.

The present study was conducted to analyse growth in agricultural exports and imports in India. Some of the reviews related to the study are presented as follows:

Thomas and Sheik (2012) analyzed the growth and performance of agricultural exports from India during the post-reform era. The compound growth rate for India's agricultural exports during the period 1991-92 to 2008-09

grew 9.2 per cent per year. Cereals and cereal preparations, fruits, pulses, spices, tobacco, cotton, meat and its preparations, dairy and poultry products showed a higher compound annual growth rate than that of India's total agricultural exports.

Gupta (2014) analyzed trends in imports and exports of India during the period 1970 to 2011. The growth rates of both imports and exports showed fluctuations during the entire study period. The growth of export showed a sharp decrease in 1990-91 and the highest growth in 2010-11. The growth rate of imports showed a sharp decrease during 2008-10 due to the global financial crisis during 2008.

Sahni (2014) conducted a comparative study on India's exports in pre and post-reform periods. The study analyzed the effect of economic reforms of 1991 on its exports during 1980-81 to 2010-11. The study period was categorized into two periods i.e., from 1980-81 to 1991-92 as pre-reform period and from 1992-93 to 2010-11 as post-reform period. The results showed that the compound annual growth rate of India's export during post-reform period (14.8 per cent) increased by two-fold when compared to compound annual growth rate during pre-reform period (7.9 per cent).

Kamble and Vijay (2016) analyzed the agricultural export performance of India. The entire study period was divided into two periods i.e., the pre-reform era (1980-81 to 1990-91) and the post-reform era (1991-92 to 2014-15). During the pre-reform era agricultural exports have grown at the rate of 7.44 percent per annum and total exports grew at the rate of 16.14 per cent per annum

Table-1 : Trends in Agricultural exports and imports in terms of value for India.

Year	Exports in Million USD	Imports in Million USD
1992	5341.99	1391.40
1993	5794.30	1153.86
1994	6701.20	2360.23
1995	8886.51	2231.03
1996	10070.53	2360.89
1997	9964.90	2758.19
1998	8783.90	4007.71
1999	8588.90	4148.06
2000	8872.99	3179.20
2001	9312.11	3692.53
2002	9901.12	4269.11
2003	10097.53	5274.48
2004	12090.58	5720.77
2005	13633.09	6544.81
2006	15975.25	6756.66
2007	20104.85	8869.08
2008	25065.40	9674.42
2009	19139.33	12218.66
2010	27882.89	14531.10
2011	39753.30	17811.97
2012	48248.74	20470.05
2013	54768.37	19434.14
2014	50110.83	22220.37
2015	41001.51	23430.02
2016	38497.04	25105.79
2017	44286.53	28530.56
2018	45037.31	28073.08
Average	22144.85	10600.67
C.V. (%)	74.08	85.56
CAGR (%)	9.52**	12.92**

Note : **represents significant at one percent
 *represents significant at one percent

whereas in the post-reform era growth rate of agricultural exports almost doubled i.e., 14.75 per cent per annum and growth rate of total exports was 18 per cent per annum. In the post-reform era the growth rate was found to be significant.

Materials and Methods

The research study is completely based upon secondary sources of data. The required data was procured from UNCOMTRADE data accessed through the World Bank's World Integrated Trade Solution (WITS) software, FAO trade year book and other related published sources.

Data related to the composition of trade were based on Harmonized System coding (HS 1992) and HS two-digit level of classification was considered for a period of 27 years i.e., from 1992 to 2018.

Table-2 : Trends in Agricultural exports and imports in terms of quantity for India.

Year	Exports in Million MT	Imports in Million MT
1992	7.03	2.57
1993	8.90	1.81
1994	7.89	3.61
1995	14.46	2.56
1996	15.18	3.87
1997	11.58	5.51
1998	15.88	7.58
1999	8.72	9.33
2000	9.53	6.26
2001	13.93	8.59
2002	18.18	8.71
2003	17.62	9.48
2004	18.99	9.44
2005	18.52	10.52
2006	22.60	10.82
2007	28.66	15.32
2008	32.00	12.62
2009	19.90	16.93
2010	24.15	15.61
2011	34.65	14.51
2012	45.21	18.39
2013	49.02	19.37
2014	43.54	22.35
2015	34.25	27.19
2016	31.94	30.23
2017	42.60	36.26
2018	45.55	31.68
Average	23.72	13.38
C.V. (%)	55.40	70.38
CAGR(%)	7.12**	10.25**

Note : **represents significant at five percent
 *represents significant at one percent

Compound Annual Growth Rate : The Compound Annual Growth Rate (CAGR) is a useful measure of growth over multiple time periods. In the present study, the CAGR was used to analyse the trends in agricultural exports and imports both in terms of value and quantity during the period 1992 to 2018.

The Compound Annual growth rate (CAGR) is estimated by fitting a semi-log trend equation of the following form :

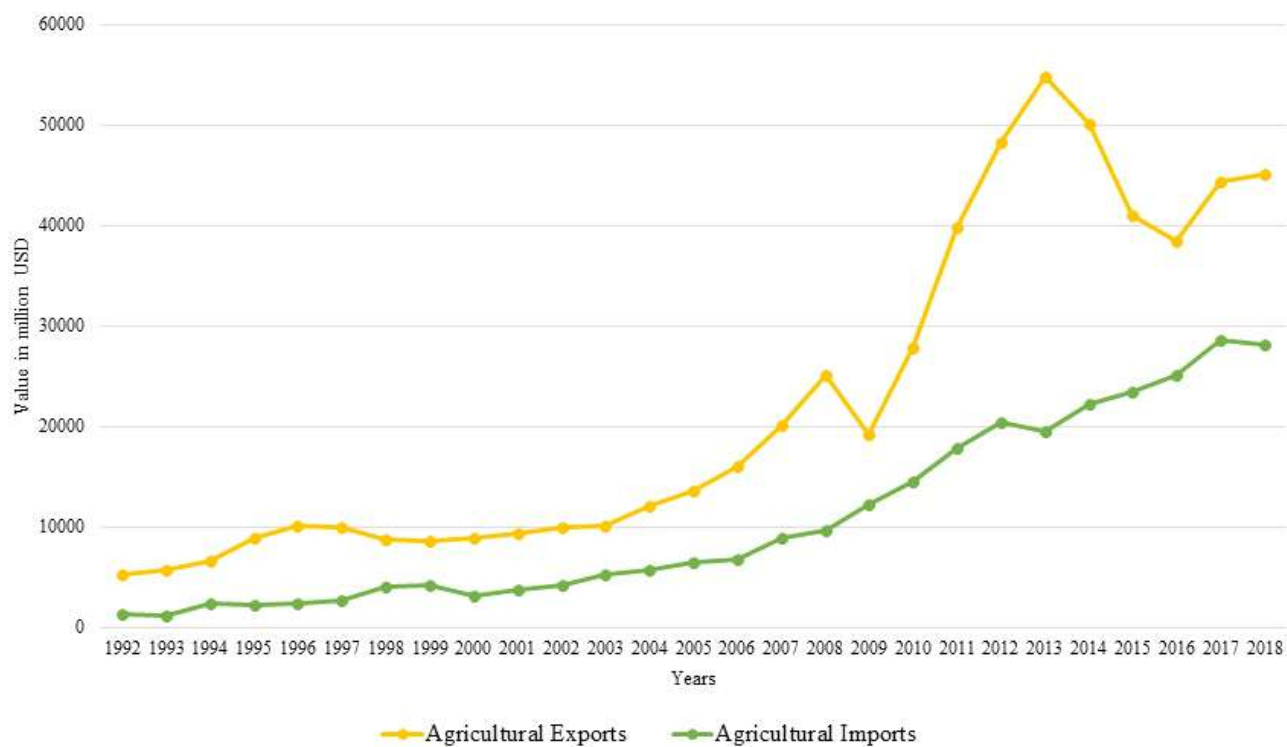
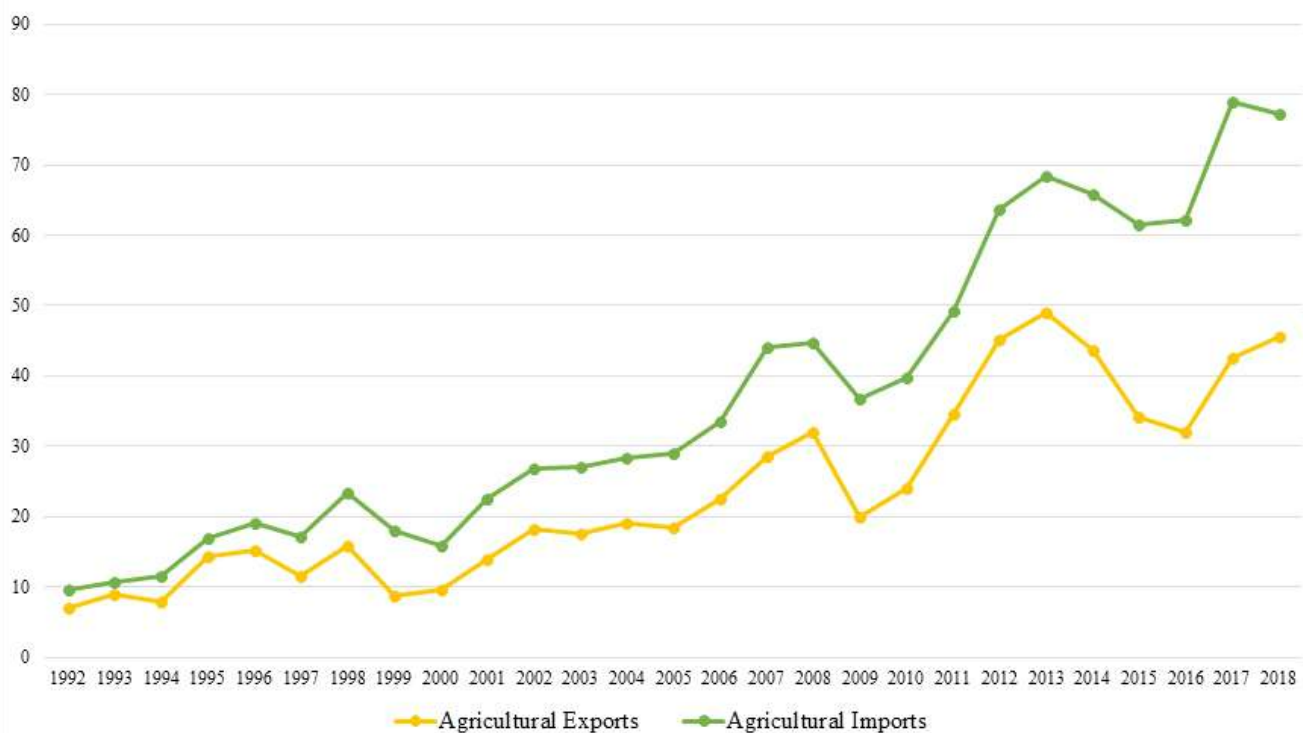
$$Y_t = AB^t u_t \quad \dots(1)$$

Where,

Y_t = Export or Import during time t

A = Constant

t = Time period

Fig.1 Trends in agricultural commodity trade of India in terms of value**Fig.2 Trends in agricultural commodity trade of India in terms of quantity**

u_t = Error term

$B = (1+g)$, where g = growth rate

By taking the logarithm, equation (1) was reduced to the following form.

$$\text{Log } Y_t = \text{Log } A + t (\text{Log } B) + \text{Log } u_t$$

Where $\log A$ and $\log B$ were the parameters of the function obtained by ordinary least square (OLS) method. Once the above equation is estimated, g can be computed as :

$$g = [\text{Antilog } (b)-1] \times 100$$

Results and Discussion

The trends in agricultural commodity exports and imports in terms of value for India are presented in Table 1. During the study period i.e., from 1992 to 2018, the agricultural commodity exports for India increased from 5341.99 to 45037.31 million USD with an average of 22144.85 million USD. The agricultural commodity imports ranged between 1153.86 and 28530.56 million USD with an average of 10600.67 million USD. Compound annual growth rate for exports and imports of agricultural commodities in terms of value for India are 9.52 and 12.92 per cent respectively which are found to be significant at one per cent. The Coefficient of Variation (C.V) of agricultural commodity exports and imports of India in terms of value are 74.08 per cent and 85.56 per cent respectively. Fig.-1 depicts the trends in the agricultural commodity trade of India in terms of value. Both Agricultural exports and imports show a positive growth rate. Agricultural imports show higher growth than that of agricultural exports in value terms.

The results for trends in agricultural commodity exports and imports of India in terms of quantity are presented in Table-2. The average agricultural commodity exports and imports of India are 23.72 million MT and 13.38 million MT respectively. The agricultural commodity exports and imports showed significant

growth at an increasing rate of 12.92 and 10.25 per cent per annum respectively. The results showed that the coefficient of variation in terms of quantity for agricultural commodity exports is 55.40 per cent whereas for agricultural commodity imports is 70.38 per cent. Fig.2 portrays trends in the agricultural commodity trade of India in terms of quantity. From the graph, we can observe that both agricultural exports and imports show positive growth and are similar. Agricultural imports show higher growth than that of agricultural exports in quantity terms.

Conclusions

India occupies a leading position in the global trade of agricultural products. However, its total agricultural export basket accounts for a little over 2.15 per cent of the world agricultural trade. Indian agricultural trade performance from 1992 to 2018 showed an increase in agricultural exports and imports due to globalization and liberalization. The findings of the studies show that the Indian agriculture imports show higher growth than that of exports both in value terms and quantity terms. Efforts are needed to give increased focus on exploring global markets for agricultural commodities to give an additional source of market for the surplus of agricultural produce.

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A Regression Analysis of Epidemiological Factors for Rice Brown Spot Disease Severity

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Abstract

Rice brown spot disease (RBS) caused by *Bipolaris oryzae* is mainly spread and impacts all times of rice cropping. A study on RBS disease severity measured by Percent Disease Index (PDI) was undertaken in Thiruvallur District (13°7'48"N 79°46'30"E) during two seasons Kharif (April-July 2019) and Rabi (August-December 2019). A higher PDI was observed in the Rabi season (PDI= 46.35) compared to the Kharif season (PDI=26.36). In the both seasons, the PDI increased in the second month of the crop which coincides with their transplanting age. The PDI reached its maximum at Correlation analyses of different weather parameters, including temperature, relative humidity, precipitation and wind speed on the whole season, along with the PDI showed that the relative humidity and precipitation were positively correlated (Rvalue =0.773&0.587 for RH and Precipitation) whereas, the temperature (Rvalue = -0.864) was negatively correlated and wind speed (Rvalue = -0.366) was meagerly affecting the PDI in negative correlation.. A step down Regression analysis done and the study reported that the PDI was aggravated by temperature ($R^2 = 0.747$), and Relative humidity ($R^2 = 0.597$) whereas, windspeed and precipitation did not affect the disease severity.

Key words : *Bipolaris oryzae*, RBS (Rice Brown Spot), PDI (Percent Disease Index), correlation and regression analysis.

Introduction

In rice cultivation, rice brown spot (RBS) is a chronic, persistent, and potentially deadly disease that affects the entire stages of the rice plants, from seed to grain. This disease was associated with India's two major epidemics (during 1918-19 in Krishna-Godavari delta and 1942 in undivided Bengal) (Chakrabarti, 2001). RBS caused by *Bipolaris oryzae* spreads primarily through seeds and seriously spreads through the air and it is a polycyclic pathogen, causing secondary infection in the nursery and the main field. As of now, it represents one of the strongest yield reducers among rice crop diseases. The symptoms appear during the seedling stage of the crop in the nursery to harvest when the effects are maximum on the milky stage in the main field. Sara Franco Ortega *et al.* 2020 reported that the *B.oryzae* spores after germination entered into the coleoptile and released new spores formed during rice growth causes secondary infections and, therefore, characteristic leaf spots. These spores can infect leaves, panicles, and later the grains, thus opening the next life cycle. Pampa Chakraborty *et al.*2020 reported that conidia of *Bipolaris oryzae* were found throughout the year in the air and seemed to be totally independent of the meteorological factors. As reported by Nimyola and Irabanta Singh, 2016, they found the methodology of disease forecasting made great use of the airborne fungal spores of the RBS pathogen and the correlation with the meteorological parameters. In 1993, Pinnschmidt reported that accurate measures of inoculum are crucial to developing forecasting systems. Therefore, it is

important to validate the research regarding the airborne presence of pathogens in order to reduce their chronic consequences and to check and predict their boom and bust cycles. Inadequacies in the available data about RBS airborne nature severely hinder the management strategies. This situation prompted this investigation aimed at air monitoring of RBS pathogens in Thiruvallur district, Tamilnadu for two seasons (Kharif and Rabi) of the year 2019 as well as disease progression measurements.

Materials and Methods

Field Layout : During the field study in Thiruvallur district (13°7'48"N 79°46'30"E), 20 × 20 m² plot area was selected as the study area. This study area was cultivated with ASD 16 variety of paddy during Kharif season (April 5/2019 to July 20/2019) and Co 43 variety of paddy during Rabi season (August 10/2019 to December 23/2019), because these varieties are prone to RBS disease. There was rice cultivation on both north and south sides of the study area, and coconut plantations, palm trees, and mango trees on both east and west sides. Standard crop management practices followed without foliar application of fungicides or pesticides and need-based irrigation.

Meteorological data collection : Weather parameters such as Temperature, Relative humidity, Precipitation, and Wind speed were collected monthly from online sources "Weather Atlas" during the study period (January 2019-December 2019).

Computation of Percent disease index (PDI) : The experimental plots included 10 plants with disease scoring tags in the four corners and the center of the plots. Based on the standard disease rating scale of IRRI (2002), the PDI (percent disease index) was determined.

Disease rating scale (IRRI, 2002)

SCALE	(Affected leaf area)
1	No incidence
2	Less than 1%
3	1-3%
4	4-5%
5	11-15%
6	16-25%
7	26-50%
8	51-75%
9	76-100%

step-down regression analysis was performed to evaluate the effects of different meteorological factors on the PDI calculations.

Results and Discussion

Analysis of impact of weather parameters on *B. oryzae* conidial concentration in the airspora of Paddy field : The PDI of the Rabi season was comparatively greater than that of the Kharif season in the present study. As a result of the weather conditions prevailing from August to December such as the low temperature, high relative humidity, and rain patterns, the RBS pathogen is more likely to establish and infect the rice crop than during the Kharif (April-July) season. At the time of maximum tillering stage, an increase in microbe populations in the air was observed in Kharif (April-July) and Rabi (August-December). Fig.1 depicted that the

Table-1 : Correlation analysis of weather parameters on PDI (Rice Brown spot disease).

S. No.	Months	Average Temperature (°C)	Relative humidity (%)	Average Precipitation (mm)	Average Wind speed (Km/Hr)	PDI	Mean PDI
1.	(Kharif) April 5/2019 to April	30.3	61	18	11.2	10.45 ^{bc}	26.36
2.	July 20/2019	32.1	53	55	11.7	23.57 ^c	
3.							
4.							
5.	August 10 to December	29.2	62	113	11.9	30.62 ^c	46.35
6.	23/2019	28.5	67	127	9.3	38.64 ^d	
7.		26.8	75	177	8.1	45.26 ^b	
8.		24.7	78	136	10.0	58.45 ^a	
9.		23.3	76	67	10.8	58.82 ^a	

Values in the column followed by same letters not differ significantly by DMRT(p=0.05)

Table-2 : Regression analysis of weather parameters, and the effect on the PDI of RBS disease on the whole season.

	Temperature on PDI	Relative humidity on PDI	Precipitation on PDI	Wind speed on PDI
MSS	8.56	90.85	225.75	3.03
R2	0.747	0.597	0.344	0.134
R	-0.864	0.773	0.587	-0.366
Regression equation (weather factor Vs PDI)	PDI=-4.59407(T) + 167.99589	PDI=1.26089(RH) - 44.3441	PDI = 0.1921(Ppt) + 18.7757	PDI=-3.27323(Wsd) + 73.69704

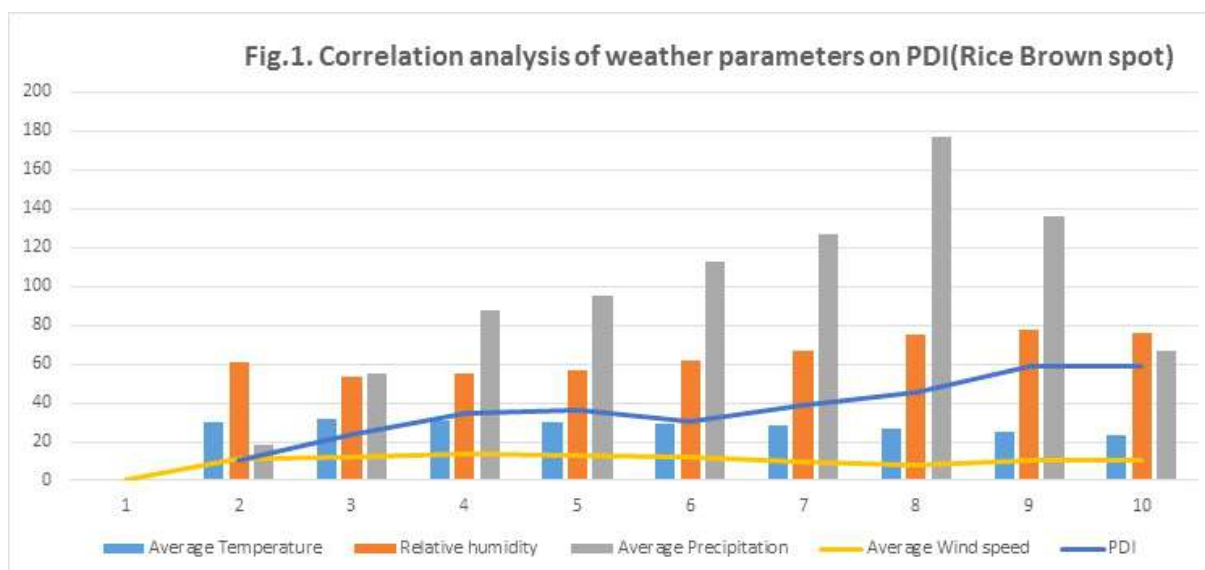
The percent disease index (PDI) was calculated by using Mckenny's formula (1927). The PDI was calculated on 20th date of every month for Kharif and Rabi seasons.

$$PDI = \frac{\text{Sum of numerical ratings}}{\text{Total numbers of plants observed maximum disease scale}} \times 100$$

Statistical analyses : The data entry and processing were done in MS Excel 10. For the analysis, Randomized Block Design was used. Analyses were conducted at 1% & 5% levels of significance (Gomez and Gomez, 1984). A

weather parameters like temperature and Relative humidity were The findings of Michel Almaguer et al. 2013 which indicated that the prevalence of microbe populations was higher during the dry season from November to April are supported in this study. In Havana, Cuba, the highest level was registered on 31 January 2011 with 2034 CFU/m³ and 1700 CFU/m³ were detected on 25 February, 10 July, and 28 October.

Regression analysis of weather parameters, and the effect on the PDI of RBS disease: Correlation analyses of different weather parameters, including temperature,



relative humidity, precipitation and wind speed, along with the PDI showed that the relative humidity and precipitation were positively correlated ($R_{\text{value}} = 0.773$ and 0.587 for RH and Precipitation) whereas, the temperature and wind speed were negatively correlated ($R_{\text{value}} = -0.864$ & -0.366 for temperature & relative humidity). A Regression study reported that the PDI was aggravated by temperature ($R^2 = 0.747$), and Relative humidity ($R^2 = 0.597$) whereas, precipitation and wind speed were not at all aggravating the PDI comparatively. Dhaliwal et al. 2019 developed a regression model for rice brown spot disease with meteorological parameters and then validated it with 2014 data on disease severity.

Conclusions

Rice Brown spot is a polycyclic disease poses a persistent threat to rice farmers due to its secondary spread through airborne inoculum. Additionally, the *B.oryzae* pathogen is insensitive to weather conditions, making it able to flourish in any climate. Among the IDM practices, managing the aerial spread of the disease is a critical component, and the focus should be on constructing a forecasting model based on epidemiological factors to deal with it. If RBS

can be predicted in advance, it is not a threatening disease. Control measures employing either chemicals or botanicals will be more effective when their application is protective. This study, based on its findings, shows that a forecasting model would greatly benefit the agricultural sector. Despite the fact that more data were available in common, this study is specific to the Thiruvallangadu location in Thiruvallur district, Tamilnadu.

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Weed Management Practices for Control of Complex Weed Flora in Kodo Millet under Eastern Dry Zone of Karnataka

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Abstract

A field experiment was carried out during *Kharif* 2018 at Zonal Agricultural Research Station, University of Agricultural Sciences, GKV, Bengaluru (Eastern Dry Zone, Karnataka) The experiment was scheduled to study the effect of various weed management practices on weed density, weed dry weight, yield and economics of Kodo millet. The experiment consists of twelve treatments replicated thrice in a randomized complete block design. Among the various treatments, weed free check recorded significantly higher grain (2107 Kg/ha) and straw (4200Kg/ha) yield and it was found at par with Bensulfuron methyl 0.6 % G + Pretilachlor 6.0 % G @ 165 g a. i ha⁻¹ as pre-emergent herbicide *fb* post emergent application of Bispyribac sodium 10 % SC @ 10 g a. i ha⁻¹ (1958 Kg/ha and 4063 Kg/ha, respectively). Again the treatment was marked with higher net return (Rs. 46,812/ha) and benefit:cost ratio (3.06) proving its advantage over other treatments imposed.

Key words : Oxadiargyl, bensulfuron methyl + pretilachlor, pendimethalin, bispyribac sodium, ethoxysulfuron. yield, weeds.

Introduction

Kodo millet (*Paspalum scrobiculatum* L.) is one of the important food crops of the world and it is an important staple food grain in semi-arid areas, where hardly any cereal crop can be grown. In India, Kodo millets grows in an area of 0.62 m.ha with a production of 0.44 m.t. and a productivity of 714 kg/ha. This crop is cultivated in Indonesia, Vietnam, Thailand, West Africa and India and mainly cultivated for human consumption. The main states for its cultivation are Madhya Pradesh, Chhattisgarh, Maharashtra, Tamil Nadu and Karnataka mainly under rainfed areas.

Kodo millet growth and yield are considerably less and have failed to keep up with population growth, leading to shortages and higher prices that have adversely affected the poor. Clearly, food security remains somewhat tenuous despite the rapid economic growth experienced in many parts of the world (7). Kodo millet cultivation has become uneconomical due to escalating labour costs and non-availability of timely labour coupled with lesser productivity of the crop due to non-timely agricultural operations. To overcome these problems especially scarcity of human labour at critical operations practices, researchers as well as farmers are looking for the better options to reduce cost of cultivation.

Weed management in kodo millet can be accomplished by mechanical, cultural and chemical methods. Mechanical method of weed control consisting of repeated weeding and intercultivation which is effective, but it's labour intensive and reduces the benefit:cost ratio. Hence, for kodo millet, the chemical

method of weed management is a good option (6). Weeds in kodo millet emerges early when compared to other millets due to the slow germination and slow growth during initial stages of crop establishment. And hence, weeds start competing with crop right from very beginning. Kodo millet being a crop of long duration as compared to other millets, and hence weed management by herbicide is crucial. Keeping this in mind, an experiment was conducted with an objective to find the best weed management practice to control weeds effectively in kodo millet.

Materials and Methods

A field experiment was conducted during *kharif* 2018 to know the bio-efficiency of combination of herbicides against complex weed flora, and their effect on growth and yield of kodo millet. The field study was conducted at Zonal Agriculture Research Station, GKV, Bengaluru (Eastern dry Zone, Karnataka) under the jurisdiction of the University of Agricultural Sciences, Bengaluru. The soil type was red sandy loam. The treatment combinations tested were T₁: Oxadiargyl 80 % WP @ 150 g a. i. ha⁻¹ at 3 DAS, T₂: Bensulfuron methyl 0.6 % G + Pretilachlor 6.0 % G @ 165 g a. i ha⁻¹ at 3 DAS, T₃: Pendimethalin 38.7 % CS @ 450 g a. i ha⁻¹ at 3 DAS, T₄: Oxadiargyl 80 % WP @ 150 g a. i ha⁻¹ at 3 DAS *fb* Bispyribac sodium 10 % SC @ 10 g a. i ha⁻¹ at 15 DAS, T₅: Bensulfuron methyl 0.6 % G + Pretilachlor 6.0 % G @ 165 g a. i ha⁻¹ at 3 DAS *fb* Bispyribac sodium 10 % SC @ 10 g a. i ha⁻¹ at 15 DAS, T₆: Pendimethalin 38.7 % CS @ 450 g a. i ha⁻¹ at 3 DAS *fb* Bispyribac sodium 10 % SC @ 10 g a. i ha⁻¹ at 15 DAS, T₇: Oxadiargyl 80 % WP @ 150 g a. i ha⁻¹ at 3 DAS *fb*

Table-1 : Weed density in kodo millet category wise (Sedges, grasses and broad leaf weeds, number m⁻²) at 30 and 60 DAS as influenced by different weed management practices.

Treatments	Weed density							Weed index (%)	Weed control efficiency (%)	
	30 DAS				60 DAS					
	Sedges	Grasses	BLWs	Total	Sedges	Grasses	BLWs			Total
T ₁ : Oxadiargyl 80 % WP @150 g a.i. ha ⁻¹	2.37 (4.67)	4.79 (22.00)	5.00 (24.00)	7.18 (50.67)	2.56 (5.67)	5.03 (24.3)	5.22 (26.33)	7.57 (56.33)	53.33	70.42
T ₂ : Bensulfuron methyl 0.6 % G + Pretilachlor 6.0 %G @ 165 g a.i. ha ⁻¹	2.69 (6.33)	4.14 (16.30)	4.15 (16.33)	6.31 (39.00)	2.69 (6.33)	4.45 (19.00)	4.34 (18.00)	6.65 (43.33)	43.33	71.36
T ₃ : Pendimethalin 38.7 % CS @ 450 g a.i. ha ⁻¹	2.77 (6.67)	4.61 (20.33)	4.71 (21.33)	7.02 (48.33)	2.77 (6.67)	4.82 (22.30)	4.96 (23.66)	7.32 (52.66)	50.00	73.65
T ₄ : Oxadiargyl 80 % WP @ 150 g a. i. ha ⁻¹ fb Bispyribac sodium 10 SC @10 g a.i. ha ⁻¹	1.99 (3.00)	4.47 (19.30)	3.71 (13.33)	6.04 (35.67)	2.06 (3.33)	4.80 (22.30)	4.00 (15.66)	6.49 (41.33)	13.33	75.98
T ₅ : Bensulfuron methyl 0.6 G + Pretilachlor 6.0 G @ 165 g a. i. ha ⁻¹ fb Bispyribac sodium 10 SC @ 10 g a. i. ha ⁻¹	2.70 (6.33)	2.81 (7.00)	2.80 (7.00)	4.59 (20.33)	2.70 (6.33)	3.04 (8.30)	3.14 (9.00)	4.95 (23.66)	6.67	94.63
T ₆ : Pendimethalin 38.7 CS @ 450 g a.i. ha ⁻¹ fb Bispyribac sodium 10 SC @ 10 g a. i. ha ⁻¹	2.76 (6.67)	3.96 (14.70)	3.21 (9.33)	5.62 (30.67)	2.76 (6.67)	3.65 (12.30)	3.36 (10.33)	5.51 (29.33)	10.00	83.44
T ₇ : Oxadiargyl 80 WP @ 150 g a. i. ha ⁻¹ fb Ethoxysulfuron 15 WG @ 12 g a. i. ha ⁻¹	2.31 (4.33)	4.38 (18.70)	4.04 (15.33)	6.25 (38.33)	2.38 (4.67)	4.71 (21.70)	4.24 (17.00)	6.64 (43.33)	30.00	81.96
T ₈ : Bensulfuron methyl 0.6 G + Pretilachlor 6.0 G @ 165 g a. i. ha ⁻¹ fb Ethoxysulfuron 15WG @ 12 g a. i. ha ⁻¹	2.64 (6.00)	2.56 (5.70)	2.74 (6.66)	4.38 (18.33)	2.58 (5.67)	3.05 (8.30)	2.95 (8.00)	4.78(22.00)	10.00	86.87
T ₉ : Pendimethalin 38.7 CS @ 450 g a. i. ha ⁻¹ fb Ethoxysulfuron 15 WG @ 12 g a. i. ha ⁻¹	2.54 (5.67)	4.19 (16.70)	3.65 (12.33)	5.97 (34.67)	2.54 (5.67)	4.46 (19.00)	3.91 (14.33)	6.32 (39.00)	26.67	79.93
T ₁₀ : Two intercultivation + hand weeding	1.63 (1.67)	1.90 (2.70)	2.67 (6.33)	3.40 (10.67)	1.52 (1.33)	2.37 (4.70)	3.03 (8.33)	3.91 (14.33)	3.33	96.31
T ₁₁ : Un weeded check	3.46 (11.00)	5.65 (31.000)	6.85 (46.00)	9.43 (88.00)	3.04 (8.33)	5.68 (31.3)	6.87 (46.33)	9.32 (86.00)	66.67	100
T ₁₂ : Weed free check	1.00 (0.00)	1.00 (0.0)	1.00 (0.0)	1.00(0.0)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	0.00	0.00
S.Em±	0.16	0.26	0.25	0.25	0.17	0.22	0.28	0.24	-	-
C. D. at 5%	0.47	0.769(0.0)	0.76	0.75	0.51	0.32	0.82	0.70	-	-

Data analysed using Square root of (x+1) transformation, () = Data given in parenthesis are original values, DAS= Days after sowing

Table-2 : Yield and economics of kodo millet as influenced by weed management practices.

Treatment	No of ear head plant ⁻¹	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Gross returns (Rs. ha ⁻¹)	Cost of cultivation (Rs. ha ⁻¹)	Net returns (Rs. ha ⁻¹)	B:C ratio
T ₁ : Oxadiargyl 80% WP @ 150 g a.i. ha ⁻¹	4.02	956	3055	33950	20485	13465	1.66
T ₂ : Bensulfuron methyl 0.6% G + Pretilachlor 6.0% G @ 165 g a.i. ha ⁻¹	4.33	1173	3525	41653	22093	19561	1.89
T ₃ : Pendimethalin 38.7% CS @ 450 g a.i. ha ⁻¹	4.07	1046	3246	37145	22155	14990	1.68
T ₄ : Oxadiargyl 80% WP @ 150 g a.i. ha ⁻¹ fb Bispyribac sodium 10 SC @ 10 g a.i. ha ⁻¹	5.09	1859	3896	66006	22778	43229	2.90
T ₅ : Bensulfuron methyl 0.6 G + Pretilachlor 6.0 G @ 165 g a.i. ha ⁻¹ fb Bispyribac sodium 10 SC @ 10 g a.i. ha ⁻¹	6.15	1958	4063	69509	22698	46812	3.06
T ₆ : Pendimethalin 38.7 CS @ 450 g a.i. ha ⁻¹ fb Bispyribac sodium 10 SC @ 10 g a.i. ha ⁻¹	5.36	1909	4012	67770	22758	45012	2.98
T ₇ : Oxadiargyl 80 WP @ 150 g a.i. ha ⁻¹ fb Ethoxysulfuron 15 WG @ 12 g a.i. ha ⁻¹	4.93	1504	3633	53404	22780	30624	2.34
T ₈ : Bensulfuron methyl 0.6 G + Pretilachlor 6.0 G @ 165 g a.i. ha ⁻¹ fb Ethoxysulfuron 15 WG @ 12 g a.i. ha ⁻¹	5.64	1940	4037	68870	22700	46170	3.03
T ₉ : Pendimethalin 38.7 CS @ 450 g a.i. ha ⁻¹ fb Ethoxysulfuron 15 WG @ 12 g a.i. ha ⁻¹	5.22	1607	3737	57049	22763	34286	2.51
T ₁₀ : Two intercultivation + hand weeding	6.17	2034	4101	72195	26715	45480	2.70
T ₁₁ : Un weeded check	3.48	717	2038	25442	17575	7867	1.45
T ₁₂ : Weed free check	6.24	2107	4200	74799	27840	46959	2.69
S.E.m±	0.46	64.95	77.31	-	-	-	-
C. D. at 5%	1.34	190.53	226.78	-	-	-	-

Ethoxysulfuron 15 % WG @ 12 g a. i ha⁻¹ at 15 DAS, T₈: Bensulfuron methyl 0.6 % G + Pretilachlor 6.0 % G @ 165 g a. i ha⁻¹ at 3 DAS fb Ethoxysulfuron 15 % WG @ 12 g a. i ha⁻¹ at 15 DAS, T₉: Pendimethalin 38.7 % CS @ 450 g a. i ha⁻¹ at 3 DAS fb Ethoxysulfuron 15 % WG @ 12 g a. i ha⁻¹ at 15 DAS, T₁₀: two intercultivation + hand weeding @ 20 and 40 DAS, T₁₁: un weeded check and T₁₂: weed free check. These treatment combinations were replicated thrice in randomized complete block design.

Kodo millet variety 'RBK-155' was sown at a spacing of 30 cm x 10 cm with fertilizer at a dose of 40 kg N and 20 kg P₂O₅/ha. The gross and net plot sizes were 4.5m x 4.0 m and 3.3 x 3.6 m, respectively. The herbicides were applied using spray volume of 500 L/ha and 375 L/ha with knapsack sprayer having flood jet nozzle. The data on species wise weed count in a quadrat of 50cm x 50 cm were collected on 15, 30, 45, 60, 90 DAS (days after sowing) and at harvest. From this, density of major weed species/m² (sedges, grass and broad-leaf weeds) was also worked out. In addition, dry weight of weeds category – sedges, grass and broad-leaf weeds (g/m²) was also collected at 15, 30, 45, 60, 90 DAS and at harvest. The data on weeds' density and dry weight were analyzed using transformation of square root of (x + 2) and also data on weed index and weed control efficiency were analysed.

At harvest, the data on kodo millet yield, straw yield and number of ear head per plant were collected. In addition, the economics of weed management practices were also calculated based on the prevalent market prices of the inputs used. The data collected on different traits was statistically analyzed using the standard procedure and the results were tested at five per cent level of significance (1).

Results and Discussion

Weed flora and weed density : Major weed flora observed in the experimental plots were *Cyperus rotundus* (sedge), *Digitaria marginata*, *Echinochloa colona* (among grasses); whereas among broad-leaf weeds, *Borreria articularis*, *Spilanthes acmella*, *Commelinabenghalensis*, *Ageratum conyzoides*, *Euphorbiageniculata* and *Euphorbia hirta* were dominant. Among the weed species, the densities of *Cyperus rotundus*, *Digitaria marginata*, *Echinochloa colona*, *Spilanthes acmella*, *Euphorbia geniculata* and *Ageratum conyzoides* were more than other weed species indicating their dominance and competitiveness with the kodo millet.

Among different category of weeds, density and dry weight of broad-leaf weeds was higher in unweeded check followed by grasses and sedges at 60 days after sowing (DAS) (Table 1). However, weed free check

recorded significantly the lowest total weed density and it was found at par with two intercultivation + hand weeding @ 20 and 40 DAS, Bensulfuron methyl 0.6% G + Pretilachlor 6.0 % G @ 165 g a.i ha⁻¹ as pre-emergent herbicide *fb* post emergent application of bispyribac sodium 10 % SC @ 10 g a. i ha⁻¹ and Bensulfuron methyl 0.6 % G + Pretilachlor 6.0 % G @ 165 g a. i ha⁻¹ pre-emergent herbicide *fb* Ethoxysulfuron 15 % WG @ 12 g a. i ha⁻¹ as post emergent have effectively reduced the density and dry-weight of weeds compared to other treatments. However, all these herbicide treatments were significantly lowered the weed density as compared to unweeded (5).

Grain, straw yield and economics : The data pertaining to number of ear head per plant, grain yield, straw yield and weed index are presented in Table 3. Weed free check recorded significantly higher grain (2107 kg/ha) and straw yield (4200 kg/ha) as compared to rest of the treatments, and was found at par with Bensulfuron methyl 0.6% G + Pretilachlor 6.0% G @ 165 g a. i ha⁻¹ *fb* Bispyribac sodium 10% SC @ 10 g a. i ha⁻¹ (1958 kg/ha and 4063 kg/ha, respectively) and Bensulfuron methyl 0.6 % G + Pretilachlor 6.0% G @ 165 g a. i ha⁻¹ *fb* Ethoxysulfuron 15 % WG @ 12 g a. i ha⁻¹ (1940 kg/ha and 4037 kg/ha, respectively). Un weeded check resulted in the lowest grain and straw yields (717 kg/ha and 2038 kg/ha, respectively). The increase in grain yield over un weeded check due to different treatments was attributed to the reduced density and biomass of weeds at all stages of crop growth, which resulted in increased dry matter of kodo millet, number of ear head per plant ultimately resulting to higher yield of crop. These results were in accordance with previous researchers (3).

Among different weed management practices, higher net returns of Rs.46,812/ha was recorded in Bensulfuron methyl 0.6 % G + Pretilachlor 6.0 % G @ 165 g a. i ha⁻¹ *fb* Bispyribac sodium 10 % SC @ 10 g a. i ha⁻¹ along with higher benefit: cost ratio of 3.06 (Table 2). This result was obtained due to effective weed management at critical stages by integration of effective pre and post-emergence herbicides along with

intercultivation practices followed, which resulted in higher grain yield with reduced cost of cultivation. Similar, findings have been also reported previously (2 & 4).

Conclusions

It was concluded that integrated weed management consisting of pre-emergence application of Bensulfuron methyl 0.6 % G + Pretilachlor 6.0 % G @ 165 g a. i ha⁻¹ *fb* post-emergence application of Bispyribac sodium 10 % SC @ 10 g a. i ha⁻¹ with one intercultivation at 20 DAS in kodo millet was found most remunerative under Eastern dry zone of Karnataka.

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Assessing Changes in Physical and Biological Properties in Soil by Soil Test Crop Response Approach

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Abstract

A field experiment was conducted during 2018 at Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan 334001, India with five treatments consist General recommended dose, STCR based nutrient recommendation 20 q ha⁻¹ and STCR based nutrient recommendation 15 q ha⁻¹ with IPNS, STCR based nutrient recommendation 20 q ha⁻¹ and STCR based nutrient recommendation 15 q ha⁻¹ with fertilizer in a randomized block design (RBD). Our results demonstrated that application of STCR based nutrient recommendation 20 q ha⁻¹ with IPNS recorded significantly highest porosity (43.96% and 42.09% 0-7.5 cm and 7.5-15 cm soil depth respectively), water storage (7.71% and 9.03% 0-7.5 cm and 7.5-15 cm soil depth respectively) lowest particle density highest microbial population (i.e. Fungi 5x 10⁻⁴ c.f.u. g⁻¹, Actinomycetes 5.8 x 10⁻⁴ c.f.u. g⁻¹ and Bactria 5.78 x 10⁻⁶ c.f.u. g⁻¹ 0-15 cm soil depth).

Key word : STCR, porosity, water storage, particle density and microbial population

Introduction

An inappropriate manner of fertilizer application without proper nutrient management going to decline crop productivity over the period of time. After the green revolution, due to the continuous application of inorganic fertilizer to soil going to deteriorate soil quality and soil health. Hence, an integrated use of organic and inorganic fertilizers into the soil will help to regenerate soil fertility and soil health. Consequently, this will improve soil productivity. It is previously explained by various soil scientists that use an organic source of nutrients will enhance soil microbial qualities (Collins *et al.*, 1992).

After introduction of high yielding varieties and hybrid crops, the need for systematic soil test crop response research (STCR) in different soil agro-climatic regions become evident. ICAR established the AICRP on STCR in 1967 and the STCR concept was developed by Ramamoorthy, in 1987. STCR provides the relationship between a soil test value and crop yield.

STCR approach is aiming at obtaining a basis for precise quantitative adjustment of fertilizer doses under varying soil test values and response conditions of the farmers and for targeted levels of crop production. The recommendation of plant nutrients is equally important in sustaining soil quality and productivity. Use of inorganic fertilizers alone could not sustain the productivity under continuous intensive cropping system, whereas integration of organic manures improves physico-chemical properties and fertility of soil and crop yields (Swarup, 1991 and Mandai *et al.*, 2003). Prescribing

fertilizer dose needs due consideration for improving soil quality. Among different methods of formulating fertilizer recommendations the concept of soil test crop response correlation (STCR) has been found quantitative, precise and meaningful (Truog, 1960 and Ramamoorthy *et al.*, 1967) which consider the soil test values for the targeted yields (Randhawa and Velayutham, 1982; Singh, 1986).

Soil microbial populations play an influential role in the biological management of soil fertility and productivity. They are harnessed and processed in a way to hook the beneficial effects on the soil and structure the soil-biological relation in an ameliorating manner. Today's farmers are interested in using soil and plant microbial inoculants to maintain the microbial equilibrium to enhance soil fertility and promote agro-crop production. Microbes increase plant growth promotion and enhance resistance against phytopathogens, etc., which in turn influence the agro-production efficiency as all are closely linked. Until now, increasing agro-productivity was not correlated with sustainability or ecofriendly behavior, but recent agro-trends have pointed to the efficient use of soil microflora that yield enhanced growth, productivity, and agriculture quality. The mechanisms involved in enhancing agro-productivity include nitrogen fixation, hormonal homeostasis, siderophore and phytohormone production, phytopathogen resistivity, nutrient availability, promotion of mycorrhizal functioning, and decreasing pollutant toxicity (Glick *et al.*, 1999). The interactive nature of plants and microbes works in either direct or indirect stimulatory processes. The direct stimulatory processes include the phytohormones (auxin, gibberellin,

and cytokinin), siderophores, and enzyme production along with elicitation of systemic resistance while indirect stimulation comprises antibiotic and extracellular enzyme production for further survival processes (Zahir *et al.*, 2004). There were many reports which investigate the processes by which microbes can enhance the plant growth. Dey *et al.* (2004) reports the production of 1-aminocyclopropane-1-carboxylate (ACC) deaminase, which reduces the level of ethylene in the roots of developing plants. Narula *et al.* (2006), Saleem *et al.* (2007), Ortýz-Castro *et al.* (2008), and Mishra *et al.* (2010) reported the production of phytohormones such as gibberellic acid, ethylene, cytokinin, and indole-acetic acid, respectively. Pathma *et al.* (2011) reported pathogen resistivity by the production of siderophores, -1, 3-glucanase, chitinases, antibiotics, fluorescent pigment, and cyanide.

Particle density focuses on just the soil particles and not the total volume that the soil particles and pore spaces occupy in the soil. Particle density differs from bulk density because bulk density includes the volume of the solid (mineral and organic) portion of the soil along with the spaces where air and water are found. The density of soil particles is a result of the chemical composition and structure of the minerals in the soil. Organic matter has the capacity to absorb and retain water equivalent to up to 90% of its weight. Most of the water held by the organic matter is absorbed by the plants whereas water absorbed by clay is unavailable for the plants.

Soil porosity is the ratio of nonsolid volume to the total volume of soil. In crop production, soil porosity is important to conduct water, air, and nutrients into the soil (Indoria *et al.*, 2017). Pore-size distribution provides the ability to soil to store root zone water and air necessary for plant growth (Reynolds *et al.*, 2002). The porosity and pore size distribution in the soil directly influenced the various soil hydraulic properties such as hydraulic conductivity, water retention, infiltration, and available water capacity (Luxmoore, 1981; Kutýlek and Jendele, 2008; Pagliai and Vignozzi, 2002). Largely, saturated hydraulic conductivity of soil is a function of pore size; coarse-textured soils have larger pores and higher saturated conductivity than fine-textured soils. Reynolds *et al.* (2002 and 2009) reported that soil porosity and water release characteristics directly influence a range of soil indices including soil aeration capacity, plant available water capacity, and relative field capacity. The soil's biological activity and plant root growth depend upon the soil porosity characteristics.

Materials and Methods

Soil moisture depletion pattern : To assess the change in soil water status with the time after initially saturated

soil. The soil moisture content measured continuously for seven days after initially saturated soil and moisture determined by using the gravimetric method.

Particle density : Particle density of soil samples were determined by measuring mass of oven dried the soil solid and their volume. The volume of soil solids is determined by immersion (Black, 1963).

Total porosity : Total porosity of soil calculated by using formula as follows :

$$\text{Total porosity} = 1 - \frac{\text{bulk density}}{\text{particle density}} \times 100$$

Total fungi, total actinomycetes and total bacteria population : The soil samples were serially diluted, and aliquots of selected dilution were inoculated in potato dextrose agar media for fungi, kenknight and munaier's media for actinomycetes and nutrient agar media for bacteria taken in sterilized Petriplate. Each colony, developed in the culture media, were assumed to have grown from one viable unit (Dhingra and Sinclair, 1993).

Statistical analysis : Statistical analysis was done by using SPSS (Statistical Package for the Social Science).

Results and Discussion

Moisture depletion pattern : Data presented in table and shows that the moisture depletion pattern of soil for seven days after irrigation of crop at 0-7.5 and 7.5-15 cm soil depths. The maximum moisture retention of soil water irrigation was registered with treatment T₅ (*i.e.* Target yield 20 q ha⁻¹ with IPNS) compare to other treatments followed by T₃, T₁, T₄ and lowest moisture retention of soil water irrigation was registered with treatment T₂ (*i.e.* Target yield 15 q ha⁻¹). The value indicates that moisture depletion rate decrease with increase IPNS. The water retention in soil by application of organic manures showed little variation at particular suction possibly due to light texture of soil. This is explained by the fact that water retention at lower tension depends primarily upon the pore size distribution. The increase in water retention as a result of organic manure is expected from the aggregation resulting in favourable pore geometry of soil (Barzegar *et al.* 2002; and Acharya *et al.*, 1988).

Particle density : Data presented in table-4 revealed that application of fertilizer using STCR approach with and without IPNS did not show any significant change the particle density of the soil at 0-7.5 cm and 7.5-15 cm soil depths after the harvest of clusterbean (Kharif, 2018). Highest particle density (2.668 g cm⁻³ at 0-7.5 cm soil depth and 2.690 g cm⁻³ at 7.5-15 cm soil depth) was observed under treatment T₂ and T₁ (*i.e.* STCR recommended for 15 qt ha⁻¹ of clusterbean yield target and general recommended dose, respectively) and lowest

Table-1 : Details of treatments with their symbols.

Treatment symbols	Treatment details
T ₁ -General recommended dose	: General recommended dose (20 Kg Nitrogen ha ⁻¹ 32 Kg P ₂ O ₅ ha ⁻¹)
T ₂ -Target yield 15 q ha ⁻¹	: Soil test crop response recommendation dose for target 15 q ha ⁻¹
T ₃ -Target yield 15 q ha ⁻¹ with IPNS	: Soil test crop response recommendation under integrated plant nutrient system dose for target 15 q ha ⁻¹
T ₄ -Target yield 20 q ha ⁻¹	: Soil test crop response recommendation dose for target 20 q ha ⁻¹
T ₅ -Target yield 20 q ha ⁻¹ with IPNS	: Soil test crop response recommendation under integrated plant nutrient system dose for target 20 q ha ⁻¹

These STCR requirements were calculated following the equation.

For Nitrogen = $6.70 T^* - 0.37 N^{**} - 0.65 O^{***}N$

For Phosphorus = $9.90 T^* - 2.15 P_2O_5^{**} - 2.05 X 50 O^{***} P_2O_5$

For Potassium = $6.78 T^* - 0.23 K_2O^{**} - 0.62 O^{***} K_2O$

*Target yield ** Amount of available nutrient present in soil ***Nutrient per cent in IPNS

Table-2 : Effect of STCR approach on soil moisture depletion pattern at 0-7.5 cm soil depth (%).

Treatments	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7
T ₁	6.8	6.63	5.63	4.39	3.71	3.12	2.88
T ₂	6.79	6.28	5.54	4.02	3.46	2.98	2.66
T ₃	7.12	7.01	5.78	5.28	4.07	3.17	2.91
T ₄	6.79	6.35	5.56	4.28	3.63	3.05	2.87
T ₅	7.71	7.48	6.35	5.44	4.14	3.56	3.25

Table-3 : Effect of STCR approach on soil moisture depletion pattern at 7.5-15 cm soil depth (%).

Treatments	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7
T ₁	8.75	8.53	7.51	6.29	5.63	4.91	4.77
T ₂	8.58	8.17	7.42	5.91	5.24	4.87	4.49
T ₃	8.78	8.53	7.64	7.18	5.93	5.41	4.84
T ₄	8.69	8.24	7.45	6.17	5.55	4.89	4.68
T ₅	9.03	8.89	8.25	7.33	5.98	5.94	5.12

Table-4 : Effect of STCR approach on soil bulk density (Mg m⁻³), particle density (Mg m⁻³) and total porosity (%).

Treatments	0-7.5 cm soil depth		7.5-15 cm soil depth	
	PD	Porosity	PD	Porosity
T ₁ -General recommended dose	2.665	43.26	2.685	39.76
T ₂ -Target yield 15 q ha ⁻¹	2.668	41.15	2.690	39.41
T ₃ -Target yield 15 q ha ⁻¹ with IPNS	2.660	43.23	2.668	41.80
T ₄ -Target yield 20 q ha ⁻¹	2.668	41.33	2.688	39.49
T ₅ -Target yield 20 q ha ⁻¹ with IPNS	2.650	43.96	2.660	42.09
SEm+	0.011	0.91	0.016	0.59
Cd (P = 0.05)	NS	2.81	NS	1.80

soil particle density (2.650 g cm⁻³ 0-7.5 cm soil depth and 2.660 g cm⁻³ 7.5-15 cm soil depth respectively) was observed under treatment T₅ (i.e. Target yield 15 q ha⁻¹ with IPNS).

Soil porosity : A perusal of data in table-4 revealed that application of fertilizer using STCR approach with and without IPNS significantly affected porosity of 7.5-15 cm soil depth after the harvest of clusterbean. Highest porosity was observed under treatment T₅ (i.e. Target yield 20 q ha⁻¹ with IPNS) followed by T₃, T₁, T₄ and lowest porosity was found in treatment T₂ (i.e. Target yield 15 q ha⁻¹). Application of FYM in to the soil was significantly improved some soil physical properties such as soil

porosity. The findings corroborate with the results of other scientists (Boix-Fayos *et al.*, 2001; Barzegar *et al.*, 2002; Haghighi *et al.*, 2010; and Singh *et al.*, 2015).

Total fungi, total actinomycetes and total bacteria population : A perusal of data in table-5 revealed that application of fertilizer using STCR approach with and without IPNS significantly altered the microbial population of the soil. Data pertaining to fungi population at 0-7.5 cm soil depth were significantly affected the fungi, actinomycetes and bacteria population of the soil. Highest fungi, actinomycetes and bacteria population (5×10^4 c.f.u.g⁻¹, 5.8×10^4 c.f.u.g⁻¹ and 5.7×10^6 c.f.u.g⁻¹

Table-5 : Effect of STCR approach on soil microbial population.

Treatments	Bacteria (c.f.u.10 ⁶ g ⁻¹)	Actinomycetes (c.f.u. 10 ⁴ g ⁻¹)	Fungi (c.f.u. 10 ⁴ g ⁻¹)
T ₁ -General recommended dose	4.13	5.0	4.00
T ₂ -Target yield 15 q ha ⁻¹	3.88	4.0	3.50
T ₃ -Target yield 15 q ha ⁻¹ with IPNS	5.63	5.0	4.50
T ₄ -Target yield 20 q ha ⁻¹	4.10	4.8	3.75
T ₅ -Target yield 20 q ha ⁻¹ with IPNS	5.78	5.8	5.00
SEm+	3.90	0.28	0.36
Cd (P = 0.05)	12.01	0.87	1.10

*c.f.u. – colony forming unit.

respectively) were observed under treatment T₅ (i.e. Target yield 20 q ha⁻¹ with IPNS) followed by T₃, T₁, T₄ and lowest fungi population (3.5×10⁴ c.f.u.g⁻¹) were found under treatment T₂ (i.e. Target yield 15 q ha⁻¹). Application of IPNSs in loamy sand soil increase the microbial population (fungi, bacteria and actinomycetes) in the treatment T₅ (table-5) clearly showed. Same result were found the study by different researcher like (Schloter *et al.*, 2003; Arancon *et al.*, 2006; Chu *et al.*, 2007; Lliang *et al.*, 2014; Bowles *et al.*, 2014; Nagar *et al.*, 2016; Srinivasarao *et al.*, 2018 and Stamenov *et al.*, 2018).

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Seasonal Incidence of Jasmine Leaf Webworm, *Palpita unionalis* (Pyralidae : Lepidoptera)

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Abstract

The seasonal incidence of *P. unionalis* was studied under *in situ* and in light trap collections. Under *in situ*, the seasonal incidence of jasmine leaf webworm, *P. unionalis* was recorded at weekly intervals based on per cent leaf and bud damage respectively from February 2012 to January 2013. The damage by *P. unionalis* was higher during January 2013 (18.08%) and lower per cent damage was recorded during May 2012 (1.13%). The multiple regression coefficient of weather parameters under *in situ* against the incidence of leaf webworm, *P. unionalis* in terms of per cent leaf damage showed a positive correlation with morning relative humidity, bright sunshine hours and a negative correlation with the maximum and minimum temperature, evening relative humidity and rainfall. In the light trap collections of leaf webworm, *P. unionalis* moths, a positive correlation was observed with the evening relative humidity, bright sunshine hours and a negative correlation with the weather parameters viz., maximum and minimum temperature, morning relative humidity and rainfall.

Key words : Seasonal incidence, *in situ* and light trap collections, *Jasminum sambac*, *Palpita unionalis*.

Introduction

India is the home for many species of jasmine and three of jasmine species i.e., *Jasminum sambac* Aiton, *Jasminum auriculatum* (Vahle.) and *Jasminum grandiflorum* L. which have been mentioned in ancient Tamil literature way back to 500 B.C. to 200 A.D. In India, jasmine is cultivated throughout the country. The term jasmine is derived from the Arabic Persian word "Yasmin" with a meaning of "gift from god".

It is generally a woody shrub, climber or a trailer with two hundred species mostly from Asia, Europe and Africa. It is native to tropical and warm temperate regions. In India the cultivation of jasmine is done majorly in the states like Tamil Nadu, Karnataka and Andhra Pradesh (Venkataraman, 2000). In Tamil Nadu, *J. sambac* is cultivated in the districts of Madurai, Ramanathapuram, Kanyakumari, Tirunelveli, Dindugal, Coimbatore and Salem (Jayachandran, 2001). It was stated that the commercially important species grown for cut flowers and perfumery industry are *J. sambac*, *J. grandiflorum* and *J. auriculatum* (Rimando, 2003).

Jasmine prefers full sun to partial shade and a warm site. Jasmine can be grown on all soil types, well in moist, well drained, sandy loam to clayey garden soil with moderate level of fertility. Well drained sandy loams and red loams are ideally suited for its cultivation. They give

good yield in low rainfall conditions (Choudhary and Mehta, 2011).

Materials and Methods

To study the seasonal incidence of the bud worm, *P. unionalis*, a supervised field experiment was conducted in the established plants of jasmine during February to January at Eastern farm of PAJANCOA and RI, Department of Horticulture, Karaikal, U. T. of Puducherry. The experiment was conducted in an area of 24.60 × 8.50 square meter with a spacing of 1.25 × 1.25 m and the variety used was *J. sambac* (Gundumalli single mogra). The population of the *H. duplifascialis* was collected in the light trap daily and the incidence of pests *in situ* on ten randomly selected bushes was recorded at weekly intervals.

The recommended dose of fertilizer 60:120:120 g/plant of N:P:K and FYM @ 10 kg/plant were applied twice once after pruning and again during June–July.

Results and Discussion

Occurrence of *Palpita unionalis* - *in situ* : The seasonal incidence of jasmine leaf webworm, *P. unionalis* was worked out based on the per cent leaf damage and are presented in Table-1. It was found that the per cent leaf damage ranged from 1.13 to 18.08 per cent from the month of February 2012 to January 2013. The per cent leaf damage was higher during January 2013 (18.08%)

Table-1 : Seasonal incidence of *Palpita unionalis* in jasmine-*in situ*.

Sl. No.	Month and Year	Percentage of incidence (Mean of ten plants)
		Leaf webworm, <i>Palpita unionalis</i> (% leaf damage)
1.	February 2012	17.04
2.	March 2012	8.52
3.	April 2012	2.68
4.	May 2012	1.13
5.	June 2012	2.36
6.	July 2012	2.65
7.	August 2012	2.80
8.	September 2012	3.93
9.	October 2012	7.92
10.	November 2012	15.26
11.	December 2012	15.66
12.	January 2013	18.08

was regressed against the respective average weekly and monthly weather parameters.

The regression equations of the incidence of jasmine leaf webworm, *P. unionalis* on *J. sambac* based on per cent damage, weekly and monthly average weather parameters showed a good and statistically significant R^2 value of 0.807 and 0.943 respectively. It was found that, among the weather parameters a positive correlation was observed with the morning relative humidity, bright sunshine hours and a negative correlation with the weather parameters *viz.*, maximum and minimum temperature, evening relative humidity and rainfall.

Occurrence of jasmine leaf webworm, *Palpita unionalis* (Hubner) in light trap collections : The result on the occurrence of jasmine leaf webworm, *P. unionalis* in terms of light trap catches of adult moths are presented in Table-3. The light trap collections was recorded daily

Table-2 : Multiple regression coefficient of weather parameters against the incidence of jasmine leaf webworm, *P. unionalis* on *jasmine* during February 2012–January 2013 -*in situ*.

Sl. No.	Source	Pests	Regression equation	R^2
1.	Weekly count	Leaf webworm, <i>P. unionalis</i>	$Y=70.808-0.891 X_1-0.115 X_2+0.048 X_3-0.149 X_4+0.065 X_5-0.134X_6$	0.807**
2.	Monthly count	Leaf webworm, <i>P. unionalis</i>	$Y=112.100-1.044 X_1-0.244 X_2-0.237 X_3-0.103 X_4-0.089 X_5-0.053 X_6$	0.943**

** = Significant at $P = 0.01$

X_1 = Maximum temperature

X_2 = Minimum temperature

X_3 = Morning relative humidity

X_4 = Evening relative humidity

X_5 = Bright sunshine hours

X_6 = Rainfall

Table-3 : Multiple regression coefficient for the jasmine leaf webworm, *Palpita unionalis* in light trap catches from February 2012–January 2013.

Sl. No.	Source	Pests	Regression equation	R^2
1.	Weekly count	Leaf webworm, <i>P. unionalis</i>	$Y=10.605-0.414 X_1-0.458 X_2-0.757 X_3+0.752 X_4-0.149 X_5-0.349X_6$	0.662**
2.	Monthly count	Leaf webworm, <i>P. unionalis</i>	$Y= 25.585-0.987 X_1-0.001 X_2-0.428 X_3-0.282 X_4+0.234 X_5-0.020X_6$	0.908**

** = Significant at $P=0.01$

X_1 = Maximum temperature

X_2 = Minimum temperature

X_3 = Morning relative humidity

X_4 = Evening relative humidity

X_5 = Bright sunshine hours

X_6 = Rainfall

followed by February 2012 (17.04%), December 2012 (15.66%) and November 2012 (15.26%). A lower per cent leaf damage was recorded during May 2012 (1.13%) and similar trend was continued upto September 2012. It was found that the per cent leaf damage by *P. unionalis* was low during April 2012 to September 2012.

Influence of weather factors on the seasonal incidence of jasmine leaf webworm, *Palpita unionalis* - *in situ* : The results on the multiple regression coefficient of weather parameters against the incidence of leaf webworm, *P. unionalis* are furnished in Table-2. The *in situ* count of *P. unionalis* under field conditions was recorded at weekly intervals from February 2012 to January 2013 and average monthly incidence of pests

from February 2012 to January 2013 and average weekly and monthly incidence of pests was regressed against the average weekly and monthly weather parameters.

It was found that the regression equations of the average number of jasmine leaf webworm, *P. unionalis* collected in the light trap based on weekly and monthly average weather parameters showed a good and statistically significant R^2 value of 0.662 and 0.908 respectively. It was found that, a positive correlation was obtained with the evening relative humidity, bright sunshine hours and a negative correlation with the weather parameters *viz.*, maximum and minimum temperature, morning relative humidity and rainfall.

The seasonal incidence of leaf webworm, *P. unionalis* and budworm, *H. duplifascialis* under *in situ* were recorded at weekly intervals based on per cent leaf damage from February 2012 to January 2013.

It was found that the damage by leaf webworm, *P. unionalis* was higher during January 2013 (18.08%) and lower per cent damage was recorded during May 2012 (1.13%). The correlation between per cent damage of leaf webworm, *P. unionalis* with weather parameters showed a positive correlation with morning relative humidity, bright sunshine hours and a negative correlation with the maximum and minimum temperature, evening relative humidity and rainfall.

In the light trap collections of leaf webworm, *P. unionalis*, the regression equation against the weather parameters showed a significant R^2 values of 0.662 and 0.908 based on weekly and monthly observations respectively. It was also found that a positive correlation was obtained with the evening relative humidity and bright sunshine hours while a negative correlation was observed with the weather parameters *viz.*, maximum and minimum temperature, morning relative humidity and rainfall.

In the present study, it was found that the incidence of leaf webworm, *P. unionalis* was higher during February 2012 (17.04 and 19.45%) and the incidence was in a decreasing trend upto August 2012. The percentage

incidence of *P. unionalis* was increasing trend from September 2012 to January 2013. A higher per cent damage was recorded during February 2012, November 2012 to January 2013. It was concluded that the percentage incidence of *P. unionalis* was higher during the month of November to February.

Vanitha (2001) stated that the incidence of leaf webworm, *P. unionalis* was found to increase gradually from the month of June to December. The present findings are in conformity with the above research findings.

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Production Potential of Twenty Year Old *Bambusa Vulgaris* Schrad. Plantation Raised through Double Noded Culm Cutting

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Abstract

The present study entitled "Production potential of 20 year old *Bambusa vulgaris* Schrad plantation raised through double noded culm cutting". The observations were recorded from the Instructional Livestock Farm of OUAT. The growth parameters like height, diameter at breast height, clump circumference, no. of nodes, number of nods below 1st branching, no. of culms of randomly selected clumps were measured. The average height of the clump was found to be 12.60 m, the average clump circumference was 6.24 m, the average no. of 1-year, 2-year and >3-year culms/clump were found to be 5.73, 17.64 and 1.64 respectively. However, the average number of damaged culms/clump were found out to be 8.82. The cut stumps and fresh cut stumps (edible purpose) were found to be an average of 15.55 and 2.82 nos/clump respectively. The no. of 1-year culm/ha is 1719.0 nos, 2-year culm/ha is 5292.0 nos, 3-year culm/ha is 492.0 nos, damaged culm is 2646.0 nos/ha and the nos of cut stumps and fresh cut stumps (cut for edible purpose) are 4665.0 and 846.0 nos per ha. The total value for 1ha taking into consideration, all above categories of bamboo culms came out to be Rs. 6,26,400/-. From the study, it was concluded that plantation of *Bambusa vulgaris* Schrad. raised through culm cutting is commercially viable for farmers and the data compiled will be helpful for research programmes.

Key words : *Bambusa vulgaris*, culm cutting, growth parameters, value

Introduction

Bambusa vulgaris, common bamboo belongs to family "Poaceae" is an open-clump type bamboo species. It is native to Indochina and to the province of Yunnan in southern China, but it has been widely cultivated in many other places and has become naturalized in several regions. *B. vulgaris* is a species of the large genus *Bambusa* of the clumping bamboo tribe *Bambuseae*, which are found largely in tropical and subtropical areas of Asia, especially in the wet tropics. Among bamboo species, it is one of the largest and most easily recognized. Bamboos are some of the fastest growing plants in the world.

Bambusa vulgaris forms moderately loose clumps and has no thorns. It has lemon-yellow culms (stems) and dark green leaves. Stems are not straight, not easy to split, inflexible, thick-walled, and initially strong. The densely tufted culms grow 10–20 m (30–70 ft) high and 4–10 cm (2–4 in) thick. Culms are basally straight or flexuose (bent alternately in different directions), drooping at the tips. Culm walls are slightly thick. Nodes are slightly inflated. Internodes are 20–45 cm (7.9–17.7 in). Several branches develop from mid-culm nodes and above.

Flowering is not common, and there are no seeds. Fruits are rare due to low pollen viability caused by irregular meiosis. At the interval of several decades, the whole population of an area blooms at once and individual

stems bear a large number of flowers. Vegetation propagates through clump division, by rhizome, stem and branch cutting, layering, and marcotting. The easiest cultivation method is culm or branch cutting. In the Philippines, the best results were obtained from one-node cuttings from the lower parts of six-month-old culms. When a stem dies, the clump usually survives. A clump can grow out of stem used for poles, fences, props, stakes, or posts. Its rhizomes extend up to 80 cm before turning upward to create open, fast-spreading clumps. The easy propagation of *B. vulgaris* explains its seemingly wild occurrence.

Common bamboo is the most widely grown bamboo throughout the tropics and subtropics. *B. vulgaris* grows mostly on river banks, road sides, wastelands, and open ground, generally in the low altitudes. It is a preferred species for erosion control. It grows best under humid conditions but can tolerate unfavourable conditions like low temperatures and drought. Though adaptable to a wide range of soils, common bamboo grows more vigorously on moist soils. It can tolerate frost down to -3 °C (27 °F) and can grow on ground up to 1,500 m (4,900 ft) above sea level, though in higher altitudes stems grow shorter and thinner. In extreme droughts, it may defoliate completely.

Common bamboo has a wide variety of uses, including the stems used as fuel and the leaves used as fodder, though a large amount of ingestion of leaves is

known to cause neurological disorder among horses. The worldwide production and trade of *B. vulgaris* is considerable, though no statistics are available. It also has some disadvantages. Working and machining properties of the stems are poor, as they are not straight, not easy to split, and not flexible, but they are thick-walled and initially strong. Because of high carbohydrate content, stems are susceptible to attacks from fungi and insects such as powder post beetles. Protection from biological threats is essential for long-term use. The stems or culms of *B. vulgaris* are used for fencing and construction, especially of small, temporary shelters, including flooring, roof tiles, paneling, and walls made with culms or split stems. The culm is used to make many parts of boats including masts, rudders, outriggers, and boating poles. It also is used to make furniture, basketry, windbreakers, flutes, fishing rods, tool handles, stakes, weapons, bows for fishing nets, smoking pipes, irrigation pipes, distillation pipes, and more. It is used as raw material for paper pulp, especially in India. Paper made from *B. vulgaris* has exceptional tear strength, comparable to paper made of softwood. It can also be used to make particle boards and flexible packaging grade paper.

Bamboo is a group of tall arborescent grasses, play an important role in the economy of the world. In the areas of their preponderance, bamboo is intimately linked with the socio-economic development of the rural communities. The importance of Bamboo as an Eco-friendly raw material capable of meeting multifarious needs of the people at large is gaining global acceptance. From a raw material known as the poor man's timber, bamboo is currently being elevated to the status of the timber of the 21st century and from poor man timber to common man timber. Emamverdian *et al.* (2020) reported that Bamboo has many uses, mainly in construction (flooring, roofing designing, and scaffolding), furniture, food, biofuel, fabrics, cloth, paper, pulp, charcoal, ornamental garden planting, and environmental characteristics, such as a large carbon sink and good phytoremediation option, improving soil structure and soil erosion. It has utility in environment protection, as a nutrient food, high-value construction material and also in about 1,500 other listed applications. Experts working in the field of bamboo are of the opinion that the full potential of this raw material still remains to be understood or tapped.

Bambusa vulgaris is a plant with potential anti-osteoporotic effects, due to its phytoestrogenic, anti-oxidative and anti-inflammatory properties (Watcho *et al.*, 2019). *Bambusa vulgaris* leaves have wound healing effect (Davane, Nagoba 2016). Bamboo shoot has a number of healing properties. Bamboo leaves

correct irregular menstruation, expectorant to relieve nasal congestion, used as antibiotic and anti-inflammatory, induces labor, meant for acid digestion, anti-venomous, diuretic for stool elimination, anti diabetic, treat aphrodisiac etc.

From its all-pervading dominance in the agrarian economies of the East during the middle ages and the subsequent oblivion in the 19th and 20th centuries, bamboo is once again emerging as a much sought-after material in the hi-tech world of the 21st century. Manandhar and Kim (2019) reported Bamboo is a natural building material that can be found in the tropical to mild temperate regions. It has been used from ancient times for its natural strength and flexibility. Many bamboo-based building materials have also been developed which is more suitable for the modern construction needs. Bamboo has many environmental benefits which has made it a favourite green building material.

It is estimated that about 2.5 billion people use bamboo in one form or the other at the global level. The annual turnover is estimated around US \$ 10 billion (Rs.50,000 crores) and this was estimated to shoot up to USD 20 billion by in 2015. Advanced research activities are conducted to utilize bamboo for efficient fuel generating system. Networks like the International Network for Bamboo and rattan (INBAR) are functioning at the international level. The Govt. of India is a signatory to this network. At the global level, primary processing and product manufacturing is shifting to a highly mechanized mode.

India, having about 136 species, has the world's richest resources of bamboos. The North East India holds the largest stock and diversity of bamboos. Next to the N.E., the Western Ghats area has the second largest diversity of bamboos. Though India has the largest area under bamboo which is estimated around 9.6 million hectares, the yield per ha is estimated around 0.4 tonnes, which is very low in comparison to other countries like China, Malaysia, Costa Rica etc. Bamboo has been associated with people since ancient times. Being a natural gift to the mankind, bamboo is very popular due to its multipurpose use, fast growth, easy propagation, soil binding properties and short gestation period as compared to trees. Every part of bamboo is utilized in one-way or the other. It has a high calorific value of 4600 to 5400 cal/kg., which makes it an energy crop. Rural and urban people use it for a variety of purposes. Bamboo provides basic necessities of life i.e. fuel, food, shelter and clothing, particularly to the rural people and is also a source of raw material for cottage, small and medium scale industries. Keeping in view its versatile uses, the potential of bamboo can be harnessed for the service of

Table-1 : Growth parameters of clumps of *Bambusa vulgaris* raised from culm cutting.

	Height (m)	DBH (cm)	Internodal length (cm)	Clump circumference (m)	No. of nodes	No. of nodes below 1 st branching
CLUMP-1	12.2	6.04	22.0	6.36	57.0	15.0
CLUMP-2	13.25	7.0	24.5	6.95	62.0	9.0
CLUMP-3	12.0	6.68	24.5	7.12	55.0	9.0
CLUMP-4	14.0	7.0	20.0	7.33	70.0	16.0
CLUMP-5	12.3	7.0	20.1	8.2	60.0	23.0
CLUMP-6	12.1	5.72	21.0	5.84	53.0	7.0
CLUMP-7	10.8	4.61	25.0	6.75	40.0	6.0
CLUMP-8	11.5	6.04	19.0	4.07	54.0	9.0
CLUMP-9	14.5	6.36	21.0	4.47	53.0	15.0
CLUMP-10	14.8	7.0	20.0	5.64	58.0	10.0
CLUMP-11	11.2	5.72	22.0	5.95	42.0	12.0
Mean	12.60	6.29	21.65	6.24	54.91	11.91
S.E. (m)	0.405	0.229	0.593	0.369	2.549	1.498

Table-2 : Growth parameters of clumps of *Bambusa vulgaris* raised from culm cutting.

Clump no.	No. of 1 year old culm	No. of 2 year old culm	No. of 3 year and more old culm	Total no. of culms/clump	No. of damaged culm	Total no. of cut stumps	Fresh cut stump (consumption)
CLUMP-1	7.0	19.0	0	26.0	0	16.0	10.0
CLUMP-2	8.0	21.0	0	29.0	5.0	15.0	5.0
CLUMP-3	4.0	15.0	0	19.0	11.0	17.0	3.0
CLUMP-4	12.0	29.0	1.0	42.0	25.0	21.0	0.0
CLUMP-5	4.0	21.0	0	25.0	4.0	11.0	2.0
CLUMP-6	4.0	13.0	7.0	24.0	4.0	16.0	7.0
CLUMP-7	4.0	16.0	2.0	22.0	3.0	22.0	1.0
CLUMP-8	3.0	10.0	2.0	15.0	4.0	5.0	3.0
CLUMP-9	5.0	15.0	0	20.0	18.0	10.0	0
CLUMP-10	6.0	14.0	2.0	22.0	14.0	21.0	0
CLUMP-11	6.0	21.0	4.0	31.0	9.0	17.0	0
Mean	5.73	17.64	1.64	25.0	8.82	15.55	2.82
S.E.(m)	0.775	1.579	0.664	2.178	2.283	1.563	0.998

the poor and for eradication of poverty. Cultivation of bamboo can reduce pressure of fuel, fodder and small timber from forest areas. Bhol and Nayak (2008) said that the common bamboo (*Bambusa vulgaris* Schrad. ex Wendl.) is an important cultivated bamboo species grown in many parts of world. It is a very fast-growing bamboo species and promising species for commercial cultivation.

It is estimated that 8 million bamboo artisans are depended on this craft for their livelihood. The annual turnover of the bamboo sector in India is estimated to be around Rs. 2400 crores. By and large, this is a totally unorganized sector and bamboo has always been considered from the craft point of view and if otherwise for pulp making only. This craft has been practiced by the North Eastern States for centuries as their prime income source and, in the process, the weaving skills of the artisans had evolved to levels comparable with the craftsman from more affluent societies like Japan,

China etc. though the product diversity still remains undeveloped.

Odisha has 9% of the Country's total bamboo forest cover and 7% of total growing stock of Bamboo. The bamboo in forest areas of Odisha grows as mixed crop associated with Sal & other species. The mixed bamboo forest area is spread over about 17,795 Sq. Km. and pure bamboo forest (occurring mostly as bamboo brakes) is about 375 Sq.Km. There are about 13 species of bamboo available in Odisha of which most commonly found are *Dendrocalamus strictus* (80%), and *Bambusa bambos* (10%). Cultivated species are *Bambusa vulgaris* and *Bambusa nutans*. *Bambusa tulda*, *Dendrocalamus lorgispathus*, *Schizostachyum pergracile*, *Thyrostachys oliveri* and *Gigantachloa rostrata* are occurring in localized area in different parts of State. Others (*Thyrostachys regia*, *Dendroclamus giganteous*, *Bambusa striata*, *Bambusa wamin*) are occurring in Silvicultural &

Table-3 : Economics of bamboo clumps raised from bamboo cuttings per hectare.

Age of culm	Average no. culms / Clump	No. of culms/ha (Mortality @25%)	Value (Rupees)/ha (Rs.40/ culm)
1 Year	5.73	1719.0	68,760/-
2 Year	17.64	5292.0	2,11,680/-
3 year & more	1.64	492.0	19,680/-
Damaged culms	8.82	2646.0	1,05,840/-
Total cut stumps	15.55	4665.0	1,86,600/-
Fresh cut stumps (consumption)	2.82	846.0	33,840/-
TOTAL VALUE			6,26,400/-

other bambusetum as representative plantation. *Bambusa vulgaris* has the potential for commercial cultivation in the farmer's field owing to the multifarious utility and demand. The limiting factor is the availability of sufficient number of quality planting material of *B. vulgaris* owing to the long gestation period of flowering and seed production. Vegetative propagules through rhizome planting and offset planting marked with insufficient availability of planting material, labour intensive and cost prohibitive. The culm cutting method is an alternative method for production of sufficient amount planting material required for commercial cultivation, but very less data are available on growth parameters and productivity of bamboo clumps raised in culm cutting method. So, the present study was undertaken with the following objective :

To study the production potential of 20 years *Bambusa vulgaris* plantation raised through double noded culm cutting.

Materials and Methods

Study area : The present study was conducted during September 2021 in Instructional Livestock Farm, OUAT, Bhubaneswar, Odisha. The details of materials used, techniques adopted, and observations noted during the course of this study are presented in this chapter. The Instructional Livestock Farm lies between north latitude 20°16'54" and east longitude of 85°47'8".

Planting method : The plantations of *Bambusa vulgaris* were done in the year 2000, with a spacing of 5m x 5m. Double noded culm cuttings were prepared from two year old bamboo culms collected from phenotypically superior bamboo clumps. A hole was made in the internode of double noded cuttings to fill up water and was covered with a tape. The planting material was directly planted in the field at 5x5m spacing in the month of March. A total no. of 312 clumps were planted in the year 2000, which was grown into a plantation of *B. vulgaris* plantation. The plantation was studied to assess its production potential.

Observations to be recorded :

Height of the clumps : The heights of the leading

shoots of each clump were measured by a tape after felling.

DBH : The diameters were measured with a measuring tape at the breast height of 1.37m. from base of culm of the leading shoot.

Internodal length : The internodal lengths were measured at the 5th inter node of the leading shoot.

No. of nodes : The total no. of nodes was counted along with the nodes below first branching of the dominant shoot.

Circumference of the clump : The circumferences of the clumps were measured with a measuring tape.

Identification of the Bamboo Culms :

1-year old culm : The total no. of one-year culms were recorded by observing the culms, their colour (vibrant, emerald green colour with outer sheaths just beginning to fall off), no presence of lichen yet and minimal branching at the top looking fresh and clean.

2-year-old culm : The two-year culms were observed by a little bit darker colour, formation of white spots on the culm, indicating the growth of lichen.

More than 3-year-old culm : The three and more-year culms were observed by their thickest inner walls, clearly visible lichens and dull yellowish colour.

Damaged culms : The damaged culms were overmatured stumps which were not extracted and are marked by bending and broken pieces.

Fresh cut culm (for consumption) : The local people cut off the freshly harvestable bamboo culms for edible purpose which was also clearly observable.

Total cut stumps : A good no. of cut off stumps were observed either harvested, damaged or cut off for consumption earlier. It does not reflect the exact number of culms harvested earlier as some of the

cut stumps might have been decayed completely by white ants or other decaying agents. It includes the fresh cut stumps along with previous year cut stumps.

Method of data collection : The clumps were selected randomly from various rows and columns and sampling was done and observations were recorded. For ease of observation and re-study, the randomly sampled clumps were spotted with white paint.

Mortality Study : The mortality percentage was calculated by counting no. of clumps died in the population.

$$\text{Mortality (\%)} = (\text{No. of clumps died} / \text{Total no. of clumps}) \times 100$$

Results and Discussion

Growth parameters of *Bambusa vulgaris* : From perusal of the data in Table-1, the average height recorded was 12.60 m with the range of heights from 10.8m to 14.8 m. Similarly, the DBH varied from 4.61 cms to 7.0 cms with average diameter of 6.29 cms. The internodal length varied from 19.0 cms to 25.0 cms with average of 21.65 cm. The total no. of nodes varied from 40.0 to 70.0 nos with average of 54.91 nodes and the no. of nodes below first branching varied from 6.0 to 23.0 nos with average of 11.91 nodes below the first branching. The clump circumference varied from 4.07 m. to 8.2 m with average circumference of 6.24 m per clump. Islam *et al.* (2015) reported seedling survival, culm height, culm diameter, culms production etc. were in *B. Vulgaris* Schrad. plantation in coastal Bangladesh. The result revealed that significantly greater culm height was 16.30m, culm diameter was 5.29cm from Rangabali site but greater number of culms/clump was 21.20 at Char Kukri-Mukri site at the age of 4.0 years old plantation.

From perusal of the data Table-2, the no. of one-year culms varied from 3.0 to 12.0 no. of culms per clump with an average of 5.73 culms per clump. The two-year culms found to vary from 10.0 to 29.0 culms per clump with an average of 17.64 culms per clump. The three and more than three-year culms varied from 0 to 7.0 no. of culms per clump with an average of 1.64 culms per clump. The total no. of culms per clump varied from 15.0 to 42.0 nos with the average 25.0 nos. culms per clump were recorded. The damaged culms showed variation from 0 to 25.0 culms per clump with an average of 8.82 culms per clump. Maximum damage was found to be because of the super cyclone Fani and a few damages were found due to the encroachment of wild boars into the farm. Total no. of cut stumps varied from 5.0 to 22.0 cut stumps per clump with an average of 15.55 stumps per clump. The fresh cut stumps were also observed i.e. for consumption purpose and that varied from 0 to 10.0 with

average per clump was found to be 2.82stumps/clump. Thapa *et al.* (1995) reported in a 4.5 years plantation of *Bambusa nutans* sub sp. cupulata raised in Nepal from survival percentage was 86%, 15.5 no. of total culms/clump which increased to 23.25 no. of culms in 5.5 years and 5.8 nos of new culms/clump.

Mortality percent:

No. of rows of plants=24

No. of lines of plants=13

Spacing=5x5 m²

Total no. of plants=312

Area=7800 sq. m

Two rows were randomly selected, and observation on mortality /death of the clumps were observed. Out of 48 plants in two rows 12 clumps were died.

$$\text{Mortality \%} = (12/48) \times 100 = 25(\%)$$

$$\text{Survival \%} = 100 - \text{mortality (\%)} \\ = 100 - 25(\%)$$

$$= 75(\%)$$

No. of clumps/ha at (5x5) m. spacing= (No. of clumps/ha.)x Survival(%)

$$= (400 \times 75)/100 \\ = 300$$

The data in the Table-3, depicted about the economy of the 20-year bamboo clumps per ha raised from bamboo cuttings in Instructional Livestock Farm, OUAT. From the perusal of the data in Table-3, it was recorded that the mortality rate was 25.0%. The no. of 1-year old culms/ha. was 1719.0 nos valued at Rs. 68,760/-, whereas the 2-year old culms (5292.0 nos) worth Rs. 2,11,680/- but with least density of the 3-year old and more culms(492.0 nos) generated less revenue of Rs. 19,680/-.Whereas the damaged culms(2646.0 nos) created a total revenue of Rs. 1,05,840/-, the total cut stumps(4665.0 nos) were valued at Rs. 1,86,600/- and the fresh cut stumps(846.0 nos) have generated a revenue of Rs. 33,840/-.The total value of the bamboo clumps/ha comes around Rs. 6,99,480/- taking into consideration the total cut stumps, damaged culms, fresh cut stumps for consumption and 1year, 2 year and three and more than three year old bamboo culms present in the plantation.

Conclusions

The present investigation was undertaken to study the production potential of 20 years old *Bambusa vulgaris* Schrad. plantation raised through culm cutting methods. Bamboo has sown tremendous potential for its multifarious

use. It could replace the use of wood in various utility. Bamboo grown in non forest areas has been removed from the definition of tree in recent past by Govt. of India facilitating its felling and movement for economic use. Now a days commercial cultivation by farmers promoted through Bamboo mission programme requires production of large number of planting material through culm cutting. The present study on *Bambusa vulgaris* plantation raised through culm cuttings revealed it could be a potential and economically viable enterprise at farmer's field.

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Study on *Alternaria* Leaf Spot Disease of Bell Pepper (*Capsicum annum*) Caused by *Alternaria alternata* (Fr.) Keissler

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Abstract

The present investigation was undertaken to study the management of leaf spot disease (*Alternaria alternata*) of Bell pepper through different botanicals *in vitro* and *in vivo*. Field experiment was conducted during *Kharif* season 2021 at Bhimtal, Uttarakhand with seven botanical treatments along with control against *Alternaria alternata*. Randomized Complete Block Design was followed in this experiment. Seven different botanicals namely – Onion, Garlic, Ginger, Clove, Tulsi, Turmeric, Marigold with a control will be tested on different per cent concentration like 5%, 10% and 15 % by food poison technique and radial growth will be recorded at different concentration after 7 days of interval. *In vitro*, the data revealed that among the seven botanicals Garlic clove extract was found most effective inhibiting (34.66mm) of the pathogen *Alternaria alternata* followed by Ginger rhizome (43.83mm), Turmeric (43.66mm), Tulsi (49.33mm), Onion (49.50mm), Clove (51.16mm), Marigold (52.33mm). In present investigation *in vivo* condition minimum disease index was recorded in Garlic, (40.11%) followed by Ginger, (43.25%) Turmeric, (44.58%) while maximum was observed in Marigold, (55.39%) on 60, 75 and 90 days.

Botanicals gave good results and managed disease effectively and eco-friendly for the betterment of end users. In *in vitro* evaluation, Among the botanicals, maximum per cent inhibition of mycelial growth was recorded in Garlic (54.68mm) followed by Ginger (42.70mm) at 15% concentration. In case of field condition @15% of botanicals, minimum per cent disease index (40.11%) was recorded in Garlic followed by Ginger (43.25%) and Turmeric (44.58%). All the results of experiments through botanicals concluded that spray of Garlic at 15% resulted minimum percent disease index (40.11%) and maximum yield (289.30q/ha).

Key words : Garlic, Marigold, Bell pepper, *Alternaria alternata*, food poisoned technique, California wander.

Introduction

Bell pepper (*Capsicum annum*) a member of the Solanaceae family, is regarded as one of the most popular and nutritious vegetable, commonly known as sweet pepper or capsicum or Shimla mirch. China is the world's largest producer of bell pepper followed by Mexico, Turkey, Indonesia and United states of America. It is native to tropical South America, especially originating from Brazil, and is widely cultivated in Peru. According to the Food and Agriculture organization (FAO) of the United Nations the United states ranked 4th in pepper production in 2005.

In India, it is commercially cultivated in Tamil Nadu, Karnataka, Himanchal Pradesh, and in some parts of Uttar Pradesh. It was introduced by Britishers in the 19th century in Shimla hills. While they are fruit- botanically classified as berries. India export bell peppers and their products of various countries Abudhabi, Australia, Canada, Japan, USA and UK with around 25000 Tonnes costing about Rs. 76 crores. They are commonly used vegetable ingredient.

Bell pepper is grown on partially all types of soil accept salty land provided the soil is well drained and well aerated where the seasons are shorts, sandy and sandy loams are preferred. Acidic and alkaline soils are not suitable for capsicum growing. North India, it is commonly known as “Shimla Mirch” and is an important summer vegetable..It is not only rich in nutrients but also added as a natural colorant in food preparations. It is a rich source of vit A,B,C and is useful in snakebite (Jadon *et al.*, 2016).

The bell pepper is a plant of tropical and subtropical regions requiring a warm humid climate. The crop can tolerate extremes of climate better than tomato and brinjal. It also can not with stand long frost and dies at freezing temperature. In general the bell pepper require a temperature of 20-25° unfavourable temperature and water supply are the basic reasons for bud, blossom and fruit drops. It thrives in area having a moderate rainfall with in range of 60-120cm. Excessive rainfall however bring defoliation and rotting of the

plants. Higher night temperature was found to be responsible for higher capsaicin contents.

The bell pepper is the only member of the genus *Capsicum* that does not produce Capsaicin, a lipophilic chemical that can cause a strong burning sensation when it comes in contact with mucous membranes. They are thus scored in the lowest level of the Scoville scale. The absence of capsaicin is due to a recessive form of a gene that eliminated the compound and consequently the hot taste usually associated with the rest of the genus *Capsicum*.

It is affected by 750 pathogens of different origin which have been reported in different part of world, but only few cause considerable damage. Among the fungal diseases affecting pepper, *Alternaria alternata* (Fries) Keissler is one of the most economically important; it is responsible for both pre and post harvest crop losses and consequently affects both yield and quality. The distinct fruit rot can cause substantial economic losses, since diseased fruit become unmarketable (Hassan, 2021)

Alternaria alternata is the most common cause of internal rot in capsicums. Infection usually occurs at the flowering stage, mainly through the stigma and the style of the flower, but it can occur up to 21 days after fruit set. *A. alternata* is a common fungus in the environment that can live on decaying plant material. It is favoured by warm and moist weather conditions when it produces masses of spores that are carried to flowers by wind, air currents or in water splash. Once infection occurs, the fungus remains latent in the developing fruit until the fruit ripens and softens, and the internal symptoms develop. An alternative infection pathway is after flowering, through a small gap under the calyx where *A. alternata* can establish a superficial infection and then develop into the fruit. Temperature required for the growth of the pathogen is 24-28%.

Symptoms are small light brown circular spots, becoming irregular, dark brown, surrounded by a chlorotic halo, mainly at the leaf margin were observed. Lesions progressively enlarged from 3 to 8 cm in diameter to encompass the entire leaf surface, and severely affected plants were partially defoliated. Disease incidence was between 40-50%.

The pathogen survive in the field in plant debris and the secondary infection take place by wind borne conidia. *Alternaria alternata* has a wide host of range including the other members of the family Solanaceae. Udit Narain *et al.*, (2000) reported an estimated losses of 75-85% has been observed at Kanpur, U.P. and upto 8.3-21.6% in M.P., the disease caused a loss of 30.76% of the produced.

Materials and Methods

Collection, isolation and identification of the pathogen

Isolation of pathogen : Infected leaves of Bell pepper with leaf spot were collected from experimental site and used for isolation of the pathogen. The leaves of bell pepper showing typical symptoms of disease leaf spot were collected and packed into clean polyethylene bags. The sample are then transferred to laboratory to isolate and identify the pathogen. The sample collected were washed with tap water and air dried and infected lesions with healthy part were cut into small pieces of about 2 cm each with the help of sterilized scissors and then surface sterilized by immersing in 0.1% sodium hypochloride solution for 30 seconds.

These pieces were thoroughly washed in at least three changes of sterilized distilled water to remove the residue of sodium hypochloride and then aseptically the leaf pieces are transferred to Petriplates containing sterile Potato dextrose agar medium. After that, incubation is done at 25±2° temperature and observed daily for mycelia growth of the fungus. After one week profuse growth of the fungus was observed. The fungus was purified through frequent sub-culturing and pure culture was maintained on slants and stored in refrigerator at 4° for further studies. Colonies which developed from the pieces were identified by microscopic observation by taking mycelial character as means for identifying the pathogen (John *et al.* 2018)

Identification of the pathogen : The morphological characters of the fungus were studied to confirm the identity of the isolated pathogen. The slides were made in water and cotton blue stain, after that fungal growth of the pathogen was examined through the compound microscope at 40X magnification. The morphological characters such as colony, color of the colony, mycelia growth, conidia, length and width of conidia were studied and compared with characters of *Alternaria alternata*.

Poisoned food technique : The poisoned food technique (Nene and Thapliyal., 1993) was adopted for in vitro evaluation of botanicals against the test fungus. For bioassay, concentrations of botanicals were prepared by dissolving 5, 10 and 15 ml of stock solution of plant extract in 95, 90, and 85 ml of sterilized PDA respectively to get the final concentration of 5, 10 and 15% each botanical separately. After that, the flasks were shaken gently to ensure proper mixing of botanicals in PDA. Then, 20 ml of molten PDA was poured in each Petri plate. After solidification of media, mycelial disc of 5 mm diameter were cut from three weeks old culture and inoculated with the help of sterilized cork borer. Incubation of Petriplates was done at 25±2°. Suitable control were kept in which the culture disc were grown under same condition on PDA without botanicals. The radial colony growth of the fungi was measured after 7 days of incubation. The

efficacy of botanicals was expressed as per cent inhibition of mycelial growth over control, calculated by using formula suggested by (Vincent 1947).

Field preparation and transplanting : Nursery preparation was done in the first week of March 2021. Field was prepared thoroughly by two ploughing with power tiller and mixing of FYM done followed by sowing of seeds. For transplanting, field preparation was done in the month of April.

Field was ploughed with power tiller and mixing of FYM was done followed by two cross tilling and it was leveled with the help of Pata then it was divided into plots having irrigation channels, path and distance to mark different replications as well as plots as shown in layout. Requisite numbers of plots of 1.2m × 1.2m sizes were prepared by mixing of well rotten FYM in the soil. 216 plants were transplanted at 40cm × 40cm apart per bed in the soil and there after watered with the help of roscan. Regular watering was done of the plots to maintain proper moisture for the growing seedlings. Plots were kept weed free by the way of hand weeding.

Per cent disease index : Disease index was calculated with the help of following formula and the scoring table given by (Wheeler, 1969).

$$\text{Disease index (\%)} = \frac{\text{Sum of all disease rating}}{\text{Total number of rating} \times \text{maximum disease grade}} \times 100$$

Per cent disease index : Calculating disease index, the diseased leaves will be categorized as per the scale.

Category	Grade/numeric value	Infected plant part
I	0	Disease free
II	1	1-10
III	3	11-25
IV	5	26-50
V	7	51-75
VI	9	>75

Results and Discussion

The fungus (*Alternaria alternata*) produced greenish-black dense growth on PDA. In initial stage fungal growth was light green which gradually turned to greyish black in colour with abundant sporulation.

In shape, the conidia were obclavate but few were oval or pyriform with a rather short, broadly rounded base with 3-8 transverse septa and several longitudinal septa with variable shape and size. The size of the conidia was 13.6 ÷ 46.30 ÷ 4.6 ÷ 14.12 ÷. Conidiophores were short straight erect or irregularly bent. The conidiophores of the fungus were brown to dark brown, simple, septate and sometimes difficult to distinguish from the mycelium.

Study on the growth of the pathogen (*In vitro*) : It is

Table-1 : Effects of different media on mycelial growth (mm) of the pathogen.

T. No.	Media	7 day ± SE.(m)
T ₁	Potato dextrose agar media	72.03 ± 0.633
T ₂	Oat meal agar media	70.12 ± 0.826
T ₃	Malt Extract Agar media	67.87 ± 0.625
T ₄	Corn meal Agar media	66.75 ± 0.595
T ₅	Richard's media	69.75 ± 0.777
SE(d) C.D.(0.05)		0.986 ± 2.122

evident from the results that among the five solid media tested, significantly highest mycelial growth of *A. alternata* was recorded on Potato dextrose agar (72.03 mm) which was followed by Oat meal agar media (70.12 mm). The next best treatment in order of merit was Richard's agar media (69.75mm), Malt extract agar media (67.87 mm) and significantly the lowest growth was recorded in Corn meal agar media (66.75mm). These results are in conformity with the finding of Kadam *et al.* (2018), Ginoya and Gohel (2015), Devappa and Thejakumar, (2016), Devi *et al.*, (2016).

***In vitro* evaluation of botanicals :** The data revealed that among the seven botanicals Garlic clove extract was found most effective inhibiting (34.66mm) of the pathogen *Alternaria alternata* followed by Ginger rhizome (43.83mm), Turmeric (43.66mm), Tulsi (49.33mm), Onion (49.50mm), Clove (51.16mm), Marigold (52.33mm). More or less similar results have been reported by Saloni *et al.* (2018) and noted that Garlic clove extract was effective in controlling *Alternaria alternata*.

***In vivo* evaluation of botanicals :** Different treatments viz., Onion, Garlic, Ginger, Clove, Turmeric, Tulsi, Marigold and a control was evaluated against *Alternaria alternata* on Leaf spot disease of Bell pepper and per cent disease index of the pathogen was recorded at 60,75 and 90 days after transplanting.

Per cent disease index (PDI) : In present investigation maximum disease index was recorded in Garlic, (40.11) followed by Ginger, (43.25%) Turmeric, (44.58%) Tulsi, (46.43%) Onion, (50.56%) Clove, (52.62%) and Marigold (55.39%) on 60,75 and 90 days, which was reported under *in vivo* condition. This information was confirmed by Mahapatra *et al.* (2013).

Yield (q/ha) : In plant extracts T3, Garlic extract @ 15% proved superior in increasing fruit yield (289.30 q/ha) followed by T4, Ginger (231.45q/ha) T6, Turmeric (194.44q/ha) T8, Tulsi (164.30q/ha) T2, Onion (134.23q/ha) T5, Clove (104.16q/ha) and T7, Marigold (74.00q/ha) over T1, Control (41.66q/ha). The results of this study indicate that foliar application garlic extract has great potential to be used to managed disease effectively and eco-friendly for the betterment of end users Sharma (2021).

Table-2 : Effects of botanicals on mycelial growth (mm) of pathogen at different concentrations (%).

T. No.	Treatments	5%±SE.(m)	10%±SE.(m)	15%±SE.(m)
T ₁	Control	72.83±2.33	72.83±2.33	72.83±2.33
T ₂	Onion	57.50*±3.60	51.16*±2.92	49.50*±3.50
T ₃	Garlic	45.00*±2.00	38.50*±3.68	34.66*±0.88
T ₄	Ginger	47.83*±1.20	45.83*±5.23	43.83*±0.44
T ₅	Clove	58.00*±0.57	55.83*±2.04	51.16*±1.42
T ₆	Turmeric	50.33*±1.92	49.50*±0.28	43.66*±0.92
T ₇	Marigold	60.16*±0.16	57.00*±3.12	52.33*±1.92
T ₈	Tulsi	53.50*±1.52	50.00*±0.28	49.33*±1.30
SE(d)		2.75	4.15	2.59
C.D.(0.05)		5.88	8.88	5.54

*Significant at 5% level of significance as compared with control.

Table-3 : Effects of botanicals on per cent mycelium (mm) inhibition of pathogen at different concentration.

T. No.	Treatments	5%±SE.(m)	10%±SE.(m)	15%±SE.(m)
T ₁	Control	0.00±0.00 (0.00)	0.00±0.00 (0.00)	0.00±0.00 (0.00)
T ₂	Onion	24.83*±4.71 (29.69)	33.11*±3.81 (35.04)	35.28*±4.57 (36.35)
T ₃	Garlic	50.54*±4.17 (45.29)	49.67*±4.81 (44.78)	54.68*±1.15 (47.66)
T ₄	Ginger	37.47*±1.57 (37.72)	40.08*±6.84 (39.17)	42.70*±0.57 (40.78)
T ₅	Clove	24.18*±0.75 (29.43)	27.01*±2.67 (31.25)	33.11*±1.86 (35.10)
T ₆	Turmeric	34.20*±2.51 (35.74)	35.29*±0.37 (36.43)	42.91*±1.21 (40.90)
T ₇	Marigold	21.34*±0.21 (27.50)	25.48*±4.08 (30.17)	31.58*±2.51 (34.15)
T ₈	Tulsi	30.06*±1.96 (33.21)	34.63*±0.37 (36.03)	35.50*±1.70 (36.54)
SE(d)		3.63(2.25)	5.21(3.13)	3.03(1.81)
C.D.(0.05)		7.78(4.81)	11.14(6.70)	6.48(3.87)

() Value in parenthesis are angular transformed

*Significant at 5% level of significance as compared with control

Table-4 : Effect of botanicals on per cent disease index (60, 75, 90 days after transplanting).

T. No.	Treatments	Dose(%)	60DAT±SE.(m)	75DAT±SE.(m)	90DAT±SE.(m)
T ₁	Control	15	42.65±0.58 (40.75)	49.54±0.69 (44.71)	59.64±0.60 (50.53)
T ₂	Onion	15	32.31*±0.57 (34.62)	40.25*±0.56 (39.36)	50.56*±0.76 (45.30)
T ₃	Garlic	15	22.52*±0.49 (28.31)	30.46*±0.52 (33.48)	40.11*±0.86 (39.28)
T ₄	Ginger	15	24.63*±0.47 (29.74)	32.69*±0.50 (34.85)	43.25*±0.64 (41.10)
T ₅	Clove	15	34.21*±0.90 (35.77)	42.46*±0.48 (40.65)	52.62*±0.55 (46.48)
T ₆	Turmeric	15	26.55*±0.75 (31.00)	34.51*±0.74 (35.96)	44.58*±0.47 (41.87)
T ₇	Marigold	15	36.57*±0.41 (37.19)	43.54*±0.74 (41.27)	55.39*±0.60 (48.07)
T ₈	Tulsi	15	29.69*±0.61 (33.00)	37.15*±0.47 (37.54)	46.43*±0.40 (42.93)
SE(d)			0.81(0.51)	0.87(0.51)	0.86(0.49)
C.D.(0.05)			1.77(1.11)	1.9(1.12)	1.86(1.07)

() Value in parenthesis are angular transformed

*Significant at 5% level of significance as compared with control

Table-5 : Effects of botanicals on Yield (q/ha).

T. No.	Treatments	Yield q/ha
T ₁	Control	41.66
T ₂	Onion	134.23*
T ₃	Garlic	289.30*
T ₄	Ginger	231.45*
T ₅	Clove	104.16*
T ₆	Turmeric	194.44*
T ₇	Marigold	74.00*
T ₈	Tulsi	164.30*

*Significant at 5% level of significance as compared with controls

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Growth, Acreage Response and Resource Use of Chickpea Production for Sustainable Development in Maharashtra

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Abstract

Pulses are the second most important food crops after cereals. Maharashtra is major producer of chickpea and in top five pulses producing states in India. This study covers the changes in area, production and productivity of chickpea during pre and post Technology Mission on Pulses (TMOP). Region wise as well as state level secondary data were used for growth and acreage response. The study period was divided into period-I (Pre TMOP) from 1969-70 to 1990-91, period-II (post TMOP) from 1991-92 to 2012-13 and period-III from 1969-70 to 2012-13 (entire period) and resource use structure in chickpea cultivation primary data were related to chickpea output and inputs collected from farmer by questionnaires during the year 2019-20 having sample size was 171. The acreage response of chickpea was analyzed by using linear multiple regression based on Nerlovian partial adjustment models. The production increase was brought about by both area expansion and productivity improvement. The significant increase in growth rate of the acreage, production and productivity of chickpea was noticed in all regions and at the state level during the period from 1969 to 2013. The factor such as lagged price and lagged acreage of chickpea, current acreage of competing crops play a major vital role in influencing chickpea acreage. In case resource use and yield gap was observed in study during the period. Hence need to train the farmer regarding use of different inputs in a manner to optimize yield and the positive appropriate long term price policy is necessary to maintain the increasing trends in area under chickpea in future to reduce gap between demand and supply of pulses for sustainable development in agriculture.

Key words : TMOP, ACGR, acreage response, resource use, chickpea.

Introduction

Maharashtra ranks second in area and third in production of chickpea in India with 22.82 per cent of area and 22.89 per cent production contribution. The area under chickpea in Maharashtra for the year 2019-20 was 2.32 million hectare and production was 2.60 million tonnes with average productivity 1119 kg ha⁻¹ (Agricultural Statistics at a Glance 2020). Keeping in view the implementation of Technology Mission on Pulses (TMOP) in the state, the present paper analyses the production performance of chickpea production in Maharashtra with the specific objectives to study the changes and growth in area, production and productivity, acreage response and resource use of chickpea in Maharashtra.

Objectives

To estimate the growth rates in area, production and productivity of chickpea.

To examine the acreage response of chickpea.

To study the region wise per hectare resource use structure and yield gap in chickpea.

Research Methodology

The present study is based on secondary and primary

data, the data in respect of area, production, productivity, rainfall, input-output and farm harvest prices of chickpea and its competing crops wheat and rabi jowar. To facilitate proper understanding entire period of 44 years from 1969-70 to 2012-13 will be divided as Period-I, 1969-70 to 1990-91 (Pre-TMOP period), Period-II, 1991-92 to 2012-13 (Post-TMOP period) and Overall 1969-70 to 2012-13 (Entire period). Wheat crop was first competing crop and *rabi* jowar are second competing crop according to region and state as whole. In case of resource use structure in chickpea cultivation primary data were related to chickpea output and inputs collected from farmer by questionnaires during the year 2019-20 having sample size was at state level 171 out of that 51 from Western Maharashtra, 39 in Marathwada and 81 from Vidarbha region.

Analytical tools

$$Y = ab^t$$

$$\log Y = \log a + \log b$$

$$\text{CGR (\%)} = (\text{Antilog } b-1) \times 100$$

Where,

$$Y = \text{Area (ha.)} / \text{Production (qt.)} / \text{Productivity (Kg.)}$$

a = Constant/Intercept

b = Trend value/Regression coefficient,

t = Time period in years

Estimation of Nerlovian Adjustment Model

$$At = a + b_1P_{t-1} + b_2A_{t-1} + b_3Y_{t-1} + b_4Rt + b_5Ac_{1t} + b_6Ac_{2t} + b_7Pc_{1t-1} + b_8Pc_{2t-1} + b_9Yc_{1t-1} + b_{10}Yc_{2t-1} + ut$$

Where,

- At : Acreage of Chickpea in '00' hectares during the current year
 P_{t-1} : Price (Rs/q) of Chickpea during the preceding year
 A_{t-1} : Acreage of Chickpea crop in '00' hectares during the preceding year
 Y_{t-1} : Productivity (kg ha⁻¹) of chickpea during the preceding year
Rt : Rainfall during pre-sowing period (mm)
 Ac_{1t} : Area under wheat in '00'hectares during the current year
 Ac_{2t} : Area under *Rabi* Jowar in '00'hectares during the current year
 Pc_{1t-1} : Price (Rs/q) of Wheat during the preceding year
 Pc_{2t-1} : Price (Rs /q) of *Rabi* Jowar crop during the preceding year
 Yc_{1t-1} : Productivity (kg ha⁻¹) of Wheat during the preceding year
 Yc_{2t-1} : Productivity (kg ha⁻¹) of *Rabi* Jowar crop during the preceding year
U : Error term
a : Intercept term
bi's : Regression co-efficient of respective variable

Results and Discussion

Growth rates in area, production and productivity of chickpea in Maharashtra : The region wise annual

compound growth rates in area, production and productivity of chickpea are indicated in Table-1. The production increase of chickpea has been contributed both by productivity improvement and area expansion as well. The similar observation was found by Gaikwad *et al.* (2017), Pichad *et al.* (2015), Gajbhiye *et al.* (2010) and Bhosale (1999).

During pre-TMOP period, the area, production and productivity of chickpea had highly significant and increased at the rate of 2.84, 5.62 and 2.71 per cent per annum, respectively in the state. The performance of chickpea was quite satisfactory during the period-II as compared to period-I in the state this may be perhaps due to the impact of Technology Mission on Pulses.

Acreage response of chickpea in Maharashtra : The results of acreage response functions for chickpea are presented in Table-2. In the period-I, the coefficient of lagged year's area and sowing time period rainfall have also significantly attributed itself in deciding the acreage of chickpea crop. The current area under *Rabi* Jowar was found to be negative and highly significant which indicated that current acreage of *Rabi* Jowar and chickpea have competitive relationship in this period. During Period-II, the coefficients of lagged price and lagged productivity of chickpea were positively significant, it revealed that chickpea grower do consider last year's price and productivity while acreage allocation decision during post TMOP in Maharashtra.

During the entire period the coefficients of lagged price and lagged productivity were positively significant, it shows that last year's price and productivity were important factors for deciding acreage allocation decision for chickpea. This result confirms the finding of Nethrayini *et.al.* (2013), Bhosale (1999), Kulkarni (1985).

Table-1 : Region wise annual compound growth rates in area, production and productivity of chickpea in Maharashtra.

Sr. No.	Region	Period		
		I (Pre TMOP)	II (Post TMOP)	Entire period
(A)	Area			
1.	Western Maharashtra	4.63***	1.59 ***	3.19 ***
2.	Marathwada	0.65	4.83 ***	2.16 ***
3.	Vidarbha	3.96***	6.26 ***	5.13 ***
	Maharashtra	2.84***	4.09 ***	3.32 ***
(B)	Production			
1.	Western Maharashtra	7.21***	3.28 ***	5.6 ***
2.	Marathwada	3.67**	7.68 ***	4.82 ***
3.	Vidarbha	6.00***	9.02 ***	7.97 ***
	Maharashtra	5.62***	6.44 ***	6.01 ***
(C)	Productivity			
1.	Western Maharashtra	2.47***	1.66 ***	2.33 ***
2.	Marathwada	2.99***	2.71 ***	2.61 ***
3.	Vidarbha	1.96***	2.6 ***	2.7 ***
	Maharashtra	2.71***	2.26 ***	2.61 ***

Table-2 : Results of estimated acreage response function for chickpea in Maharashtra.

Sr. No.	Factor	Periods		
		I (1969-70 to 1990-91)	II (1991-92 to 2012-13)	Entire period (1969-70 to 2012-13)
1.	Intercept	-9919.33	-1566.82	-6196.19
2.	P_{t-1}	-1.9183 (4.2952)	0.0332* (0.0154)	5.6567*** (1.2402)
3.	Y_{t-1}	0.7467 (2.7216)	4.3818** (1.5958)	5.2623 (3.8061)
4.	A_{t-1}	0.9078*** (0.2371)	-0.2526 (0.1489)	0.3264** (0.1386)
5.	R_t	1.5043** (0.6583)	0.6065 (1.3487)	0.4424 (1.1614)
6.	A_{c1t}	0.1213 (0.1547)	-1.1016*** (0.1707)	-0.2417*** (0.0783)
7.	A_{c2t}	-0.2720*** (0.0838)	-0.0642 (0.0845)	-0.2092*** (0.0590)
8.	P_{c1t-1}	13.5849 (12.4174)	4.7294 (3.3218)	-0.2937 (4.0622)
9.	P_{c2t-1}	-5.8611 (13.8757)	-1.6648 (2.1499)	-3.6973 (3.0443)
10.	Y_{c1t-1}	-2.3900 (1.6535)	4.9856 (3.4849)	-3.8392** (1.4569)
11.	Y_{c2t-1}	0.5828 (1.6236)	-2.0032 (1.6718)	0.6945 (1.4736)
	R^2	0.90	0.92	0.93
	F Value	10.22***	63.35***	73.47***

(Figures in parentheses are standard errors of respective regression coefficients)

*, ** and *** Significant at 10, 5 and 1 per cent level of significance, respectively.

Table-3 : Resource use for chickpea production in Maharashtra. (Per ha)

Sr. No.	Particular	Resource use	Region		
			Western Maharashtra	Marathwada	Vidarbha
1.	Seed	Recommended (kg)	100	75	85
		Actual (kg)	76.21	63.04	75.78
		Gap (kg)	23.79	11.96	9.22
		Gap (%)	23.79	15.94	10.85
2.	Manures	Recommended (q)	50	50	50
		Actual (q)	12.00	10.11	5.00
		Gap(q)	38.00	39.89	45.00
		Gap (%)	76.00	79.78	90.00
3.	Nitrogen	Recommended (kg)	25	25	25
		Actual (kg)	17.97	14.50	19.16
		Gap (kg)	7.03	10.50	5.84
		Gap (%)	28.11	41.98	23.35
4.	Phosphorus	Recommended (kg)	50	50	50
		Actual (kg)	26.81	31.82	30.25
		Gap (kg)	23.19	18.18	19.75
		Gap (%)	46.38	36.36	39.50
5.	Potash	Recommended (kg)	30	0	30
		Actual (kg)	6.56	3.68	0.80
		Gap (kg)	23.44	-3.68	29.20
		Gap (%)	78.13	0	97.34

Resource use of chickpea production Maharashtra :

For the chickpea, the recommended fertilizer dose of N:P:K is 25:50:30 kg ha⁻¹ for Western Maharashtra and Vidarbha regions while 25:50:00 kg ha⁻¹ for Marathwada region. In case of use of nitrogen gap was more in Marathwada (41.98 per cent) followed by Western Maharashtra (28.11 per cent) and Vidarbha (23.25 per cent), while in phosphorus use gap was more in Western Maharashtra (46.38 per cent) followed by Vidarbha (39.50 per cent) and Marathwada (36.36 per cent). In case of use of potash gap is more Vidarbha region (97.34 per cent) as compare to Western Maharashtra region (78.13) in Maharashtra state.

Conclusions

The Maharashtra state has experienced spectacular progress in respect of area under chickpea. The production increase was brought about by both area expansion and productivity improvement. During the entire period the coefficients of lagged price and lagged productivity were positively significant, it shows that last year's price and productivity were important factors for deciding acreage allocation decision for chickpea growers in Maharashtra.

Policy Implications

Need to train the farmer regarding use of different inputs in a manner to optimize yield and the positive appropriate long term price policy is necessary.

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Evaluation of Butachlor 50% EC in Transplanted Paddy and Residual Effect of Butachlor 50% EC on Succeeding Crop of Green Gram

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Abstract

Field investigations were executed at Agricultural Research Station, Nellore during *rabi*, 2014 to assess efficacy of Butachlor to control weeds in rice crop followed by its residual effect on succeeding greengram crop. The study was designed to select the appropriate dose of butachlor for weed control in rice. The treatments included Butachlor (2.5, 4.0, 1 ha-1 (Rainbow), Butachlor (2.5, 4.0 l. ha-1 (Market sample), Pretilachlor @ 1.5 lit/ha (Chemical check), weed free and weedy check (control). The data revealed that Butachlor 50% EC (Rainbow) was more effective at 4.0 lit/ha dose as compared to lower dose 2.5 lit/ha against all the weed species recorded. Butachlor 50% EC (Rainbow) @ 2.5 and 4.0 lit/ha was found more or less equally effective to other treatments Butachlor 50% EC (Machete) @ 2.5 and 4.0 lit/ha. Pretilachlor 50% EC @ 1.5 lit/ha was found relatively less effective but significantly superior to un weeded control. No weed population was recorded in weed free control. Succeeding greengram crop, sown immediately after the rice harvest was not affected by residues of herbicidal treatments of the preceding crop.

Introduction

Rice is the most important food grain crop grown in India next to wheat. Several biotic and abiotic factors hinder the rice productivity. Weeds are identified as a major biological constraint that hinders attainment of optimal rice productivity in major rice producing countries of South Asia like India (Rao and Nagamani, 2010). Yogita and Singh, (2018) reported that actual yield loss in transplanted rice ranged from 3 to 30% while the potential yield loss of 15-66% was observed and the actual economic losses of rice was as highest as 36% (28290.67 crore) of total loss (78591 crores) due to weeds in different crops and in different states in India. Among all the weed control methods, chemical weed control is commonly used to overcome weeds infestation which is easy, quick, time saving, cost effective and the most reliable method to control weeds in rice. Increasing labor crisis and high wage of labor encourages farmers to use herbicides for weed control in rice. Wide range of herbicides are available for the management of grassy weeds (pretilachlor, butachlor, anilofos and oxadiargyl) as well as broad-leaved weeds (metsulfuron, chlorimuron, ethoxysulfuron and 2, 4-D) (Sridevi *et al.*, 2013). For the past few years, a number of herbicides like butachlor, thiobencarb and anilofos are being applied as pre-emergence for effective control of weeds (Buddha, *et al.*, 1991). Considering these views the present investigation was undertaken to study the effectiveness of Butachlor on weed species in puddled rice.

Research Methodology

The experiment was laid out in randomized block design and replicated thrice during *rabi*, 2014. The effect of weedicides was studied on MTU 1010 variety under puddled conditions and size of the individual plot was 4 m X 5 m (20 m²) with a spacing of 15 cm x 15 cm. The treatments were applied at four days after crop transplantation, using knapsack sprayer fitted with flat fan nozzle with a spray volume of 500 lit/ha. The treatments included Butachlor (2.5, 4.0 l/ha (Rainbow), Butachlor (2.5, 4.0 l/ha (Market sample), Pretilachlor @ 1.5 l/ha (Chemical check), weed free crop and weedy check (control). To maintain the treatment free of weeds, manual weeding method was adopted twice at 15 and 45 days after crop transplantation. The recommended packages of practices were followed to raise the crop except for weed control.

The observations on species wise weed population were recorded using a quadrant (1 m x 1 m) per replication at 15, 30, 45 and 60 days after treatment application. Accordingly, dry weight of weed species wise was recorded simultaneously after drying in sun for 48 hrs and in oven at 70°C for 24 hrs. Weed control efficiency was calculated based on the dry weight of weed species. The data were analyzed statistically after transforming to square root wherever necessary.

Observations on plant height, number of tillers/hill and on other yield attributes were recorded at different stages of crop growth and at harvest, yield of paddy grain and straw in kg/ha was recorded.

Table-1 : Effect of pre emergence herbicides on weed population/m² in transplanted rice (15 and 30 days after application).

S. No.	Treatments	Dose (lit/ha)	Mean weed population/m ²									
			After 15 days of herbicide application					After 30 days of herbicide application				
			E. colona	L. chinensis	C. difformis	E. alba	A. baccifera	E. colona	L. chinensis	C. difformis	E. alba	A. baccifera
1.	Butachlor 50% EC (Rainbow)	2.5	2.67 (1.78)	0.00 (0.71)	0.00 (0.71)	0.67 (1.08)	0.00 (0.71)	3.33 (1.96)	0.00 (0.71)	0.00 (0.71)	1.33 (1.35)	0.00 (0.71)
2.	Butachlor 50% EC (Rainbow)	4.0	1.00 (1.22)	0.00 (0.71)	0.67 (1.08)	0.67 (1.08)	0.00 (0.71)	2.00 (1.58)	0.00 (0.71)	1.00 (1.22)	1.33 (1.35)	0.00 (0.71)
3.	Butachlor 50% EC (Market sample)	2.5	1.67 (1.47)	0.00 (0.71)	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	2.67 (1.78)	0.00 (0.71)	2.00 (1.58)	0.33 (0.91)	0.00 (0.71)
4.	Butachlor 50% EC (Market sample)	4.0	2.00 (1.58)	0.33 (0.91)	0.67 (1.08)	0.67 (1.08)	0.00 (0.71)	2.00 (1.58)	0.67 (1.08)	0.67 (1.08)	1.00 (1.22)	0.00 (0.71)
5.	Pretilachlor 50% EC	1.5	1.67 (1.47)	0.00 (0.71)	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	2.67 (1.78)	0.00 (0.71)	0.67 (1.08)	1.00 (1.22)	0.00 (0.71)
6.	Control (Weed free)	-	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
7.	Control (Unweeded)	-	4.33 (2.20)	0.67 (1.08)	1.67 (1.47)	2.00 (1.58)	0.67 (1.08)	7.00 (2.74)	1.33 (1.35)	3.33 (1.96)	4.00 (2.12)	0.67 (1.08)
S. Em +			0.13	0.09	0.11	0.14	0.07	0.21	0.08	0.09	0.19	0.07
CD (P=0.05)			0.38	0.27	0.34	0.41	0.21	0.63	0.26	0.27	0.58	0.21

Figures in parentheses are square root transformed values (x+0.5).

Table-2 : Effect of pre emergence herbicides on weed population/m² in transplanted rice (45 and 60 days after application).

S. No.	Treatments	Dose (lit/ha)	Mean weed population/m ²									
			After 45 days of herbicide application					After 60 days of herbicide application				
			E. colona	L. chinensis	C. difformis	E. alba	A. baccifera	E. colona	L. chinensis	C. difformis	E. alba	A. baccifera
1.	Butachlor 50% EC (Rainbow)	2.5	1.33 (1.35)	0.00 (0.71)	0.00 (0.71)	1.00 (1.22)	0.00 (0.71)	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	0.67 (1.08)	0.00 (0.71)
2.	Butachlor 50% EC (Rainbow)	4.0	1.67 (1.47)	0.00 (0.71)	0.33 (0.91)	1.00 (1.22)	0.00 (0.71)	2.00 (1.58)	0.33 (0.91)	0.33 (0.91)	1.33 (1.35)	0.00 (0.71)
3.	Butachlor 50% EC (Market sample)	2.5	1.67 (1.47)	0.00 (0.71)	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	1.33 (1.35)	0.00 (0.71)	0.67 (1.08)	0.67 (1.08)	0.00 (0.71)
4.	Butachlor 50% EC (Market sample)	4.0	2.00 (1.58)	0.33 (0.91)	2.33 (1.68)	0.67 (1.08)	0.00 (0.71)	2.00 (1.58)	0.67 (1.08)	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)
5.	Pretilachlor 50% EC	1.5	1.33 (1.35)	0.33 (0.91)	1.33 (1.35)	0.67 (1.08)	0.00 (0.71)	1.33 (1.35)	0.00 (0.71)	0.67 (1.08)	0.67 (1.08)	0.00 (0.71)
6.	Control (Weed free)	-	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
7.	Control (Unweeded)	-	5.00 (2.35)	1.33 (1.35)	3.67 (2.04)	2.00 (1.58)	0.33 (0.91)	7.00 (2.74)	1.33 (1.35)	4.33 (2.20)	3.00 (1.87)	0.33 (0.91)
S. Em +			0.15	0.10	0.09	0.08	0.07	0.27	0.08	0.32	0.14	0.07
CD (P=0.05)			0.45	0.31	0.26	0.25	NS	0.83	0.25	0.97	0.41	NS

Figures in parentheses are square root transformed values (x+0.5)

Table-3 : Effect of pre emergence herbicides on weed dry weight/m² in transplanted rice (15 and 30 days after application).

S. No.	Treatments	Dose (lit/ha)	Mean weed dry weight/m ²									
			After 15 days of herbicide application					After 30 days of herbicide application				
			E. colona	L. chinensis	C. difformis	E. alba	A. baccifera	E. colona	L. chinensis	C. difformis	E. alba	A. baccifera
1.	Butachlor 50% EC (Rainbow)	2.5	2.18 (1.64)	0.00 (0.71)	0.00 (0.71)	0.92 (1.19)	0.00 (0.71)	2.85 (1.83)	0.00 (0.71)	0.00 (0.71)	1.29 (1.34)	0.00 (0.71)
2.	Butachlor 50% EC (Rainbow)	4.0	1.87 (1.54)	0.00 (0.71)	0.81 (1.14)	0.43 (0.96)	0.00 (0.71)	2.41 (1.71)	0.00 (0.71)	0.37 (0.93)	0.71 (1.10)	0.00 (0.71)
3.	Butachlor 50% EC (Market sample)	2.5	1.76 (1.50)	0.00 (0.71)	0.32 (0.91)	0.14 (0.80)	0.00 (0.71)	2.02 (1.59)	0.00 (0.71)	0.51 (1.00)	0.30 (0.89)	0.00 (0.71)
4.	Butachlor 50% EC (Market sample)	4.0	1.97 (1.57)	0.28 (0.88)	0.78 (1.13)	0.39 (0.94)	0.00 (0.71)	2.64 (1.77)	0.49 (0.99)	0.54 (1.02)	0.93 (1.20)	0.00 (0.71)
5.	Pretilachlor 50% EC	1.5	1.11 (1.27)	0.00 (0.71)	0.39 (0.94)	0.31 (0.90)	0.00 (0.71)	2.71 (1.79)	0.00 (0.71)	0.59 (1.04)	0.80 (1.14)	0.00 (0.71)
6.	Control (Weed free)	-	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
7.	Control (Unweeded)	-	3.78 (2.07)	0.78 (1.13)	2.16 (1.63)	1.37 (1.37)	0.21 (0.84)	6.23 (2.59)	0.85 (1.16)	1.13 (1.28)	1.42 (1.39)	0.27 (0.88)
S. Em +			0.08	0.06	0.12	0.07	0.03	0.13	0.10	0.05	0.04	0.04
CD (P=0.05)			0.26	0.18	0.37	0.23	0.10	0.41	0.32	0.16	0.13	0.12

Figures in parentheses are square root transformed values (x +0.5)

Table-4: Effect of pre emergence herbicides on weed dry weight/m² in transplanted rice (45 and 60 days after application).

S. No.	Treatments	Dose (lit/ha)	Mean weed dry weight/m ²									
			After 45 days of herbicide application					After 60 days of herbicide application				
			E. colona	L. chinensis	C. difformis	E. alba	A. baccifera	E. colona	L. chinensis	C. difformis	E. alba	A. baccifera
1.	Butachlor 50% EC (Rainbow)	2.5	6.13 (2.57)	0.00 (0.71)	0.00 (0.71)	1.57 (1.44)	0.00 (0.71)	7.94 (2.91)	2.37 (1.69)	0.00 (0.71)	1.99 (1.58)	0.00 (0.71)
2.	Butachlor 50% EC (Rainbow)	4.0	5.76 (2.50)	0.00 (0.71)	0.38 (0.94)	1.16 (1.29)	0.00 (0.71)	6.13 (2.57)	0.41 (0.95)	0.55 (1.02)	0.91 (1.19)	0.00 (0.71)
3.	Butachlor 50% EC (Market sample)	2.5	5.83 (2.52)	0.00 (0.71)	0.47 (0.98)	1.40 (1.38)	0.00 (0.71)	7.50 (2.83)	0.00 (0.71)	1.73 (1.49)	2.47 (1.72)	0.00 (0.71)
4.	Butachlor 50% EC (Market sample)	4.0	5.80 (2.51)	0.27 (0.88)	0.75 (1.12)	0.88 (1.17)	0.00 (0.71)	5.93 (2.54)	1.84 (1.53)	0.97 (1.21)	1.26 (1.33)	0.00 (0.71)
5.	Pretilachlor 50% EC	1.5	6.81 (2.70)	0.53 (1.01)	1.23 (1.32)	2.13 (1.62)	0.00 (0.71)	9.79 (3.21)	0.00 (0.71)	2.36 (1.69)	2.55 (1.75)	0.00 (0.71)
6.	Control (Weed free)	-	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
7.	Control (Unweeded)	-	25.18 (5.07)	2.12 (1.62)	5.17 (2.38)	3.46 (1.99)	1.37 (1.37)	39.54 (6.33)	5.61 (2.47)	3.46 (1.99)	4.84 (2.31)	3.85 (2.09)
S. Em +			0.40	0.13	0.25	0.09	0.12	0.41	0.15	0.09	0.12	0.27
CD (P=0.05)			1.23	0.41	0.78	0.27	0.38	1.25	0.46	0.27	0.36	0.84

Figures in parentheses are square root transformed values (x +0.5)

Table-7 : Effect of different treatments on plant height, number of tillers per hill at different growth stages of crop and other yield attributes at harvest.

S. No.	Treatments	Dose (lit/ha)	Mean plant height (cm)			Mean No. of tillers/hill			Yield attributes at harvest				Grain yield (kg/ha)	Straw yield (kg/ha)
			30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	No. of panicles /hill	Panicle length (cm)	Filled grains/ panicle	Test weight (g)		
1.	Butachlor (Rainbow)	2.5	48.6	63.9	65.3	20.3	15.0	14.0	12.3	17.1	110.0	63.9	4790	5647
2.	Butachlor (Rainbow)	4.0	44.3	60.1	63.4	20.7	15.7	15.0	13.7	17.0	107.5	61.9	5170	5610
3.	Butachlor 50% EC (Market sample)	2.5	46.2	60.5	62.4	19.7	16.0	15.3	11.7	16.9	103.2	60.5	5020	5780
4.	Butachlor 50% EC (Market sample)	4.0	45.7	58.7	62.7	17.7	15.7	15.0	13.0	16.8	104.9	58.7	5103	5663
5.	Pretilachlor 50% EC	1.5	43.9	61.9	64.4	20.0	16.0	15.3	13.3	17.1	103.0	63.9	5153	5663
6.	Control (Weed free)	-	49.7	63.9	68.3	22.7	19.7	16.0	14.3	17.6	113.1	62.9	6080	6397
7.	Control (Unweeded)	-	41.9	58.1	61.0	16.0	15.0	13.3	11.0	16.9	91.8	58.1	4483	4937
8.	Butachlor (Rainbow)	8.0	43.2	59.1	62.3	21.0	17.3	14.7	12.7	17.1	105.4	59.1	4967	5430
	S. Em +	2.2	2.2	1.9	1.9	1.6	1.3	1.0	1.0	0.3	3.3	1.9	197	164
	CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	10.0	NS	599	497
	C.V %	8.4	5.2	5.0	5.0	13.8	14.7	12.0	12.0	3.4	5.4	5.2	6.7	5.0

DAT – Days after crop transplanting

Table-8 : Phytotoxicity evaluation of pre emergence herbicides on transplanted rice.

S. No.	Treatments	Dose (lit/ha)	Phytotoxicity parameters observed					
			(Mean observation recorded 5, 10, 15, 20, 30 and 45 days after treatment)					
			Leaf injury on tips/ surface*			Vein clearing		
			Wilting	Necrosis	Epinaasty	Hyponasty		
1.	Butachlor 50% EC (Rainbow)	2.5	1	Nil	Nil	Nil	Nil	Nil
2.	Butachlor 50% EC (Rainbow)	4.0	1	Nil	Nil	Nil	Nil	Nil
3.	Butachlor 50% EC (Market sample)	2.5	1	Nil	Nil	Nil	Nil	Nil
4.	Butachlor 50% EC (Market sample)	4.0	1	Nil	Nil	Nil	Nil	Nil
5.	Pretilachlor 50% EC	1.5	1	Nil	Nil	Nil	Nil	Nil
6.	Control (Weed free)	-	1	Nil	Nil	Nil	Nil	Nil
7.	Control (Unweeded)	-	1	Nil	Nil	Nil	Nil	Nil
8.	Butachlor 50% EC (Rainbow)	8.0	1	Nil	Nil	Nil	Nil	Nil

*Based on 1-10 scale: 1=0-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100%

Table-9 : Residual effect of pre emergence herbicides on succeeding crop of green gram.

S. No.	Treatments (applied in main transplanted paddy crop)	Dose (lit/ha)	Percent seed germination	Effect on yield attributes at crop harvest					Seed yield (kg/ha)
				Plant Population /m ²	Plant height (cm)	Branches /plant	No. of pods/plant	No. of seeds/pod	
1.	Butachlor 50% EC (Rainbow)	2.5	100.00	42.3	63.7	13.3	29.0	9.2	450
2.	Butachlor 50% EC (Rainbow)	4.0	100.00	41.7	63.3	14.3	29.7	9.6	406
3.	Butachlor 50% EC (Market sample)	2.5	100.00	41.0	63.2	15.0	27.3	8.9	378
4.	Butachlor 50% EC (Market sample)	4.0	100.00	46.0	69.3	13.3	26.7	9.5	382
5.	Pretilachlor 50% EC	1.5	100.00	41.3	65.5	16.7	32.0	9.2	450
6.	Control (Weed free)	-	100.00	46.3	57.8	14.7	28.7	8.8	466
7.	Control (Unweeded)	-	100.00	43.0	63.2	14.3	27.0	8.8	341
8.	Butachlor 50% EC (Rainbow)	8.0	100.00	41.3	61.5	14.3	30.3	8.1	369
	S. Em +			2.1	2.8	1.0	5.0	0.43	22.7
	CD (P=0.05)			NS	NS	NS	NS	NS	68.8
	C.V %			8.6	7.7	12.1	29	8.2	9.8

Table-10 : Phytotoxicity evaluation of pre emergence herbicides on succeeding green gram crop.

S. No.	Treatments (applied in main transplanted paddy crop)	Dose (l/ha)	Phytotoxicity parameters observed (Mean observations recorded 15, 20, 30 and 45 days after crop sowing)				
			Leaf injury on tips/ surface*	Wilting	Vein clearing	Necrosis	Epinasty
1.	Butachlor 50% EC (Rainbow)	2.5	1	Nil	Nil	Nil	Nil
2.	Butachlor 50% EC (Rainbow)	4.0	1	Nil	Nil	Nil	Nil
3.	Butachlor 50% EC (Market sample)	2.5	1	Nil	Nil	Nil	Nil
4.	Butachlor 50% EC (Market sample)	4.0	1	Nil	Nil	Nil	Nil
5.	Pretilachlor 50% EC	1.5	1	Nil	Nil	Nil	Nil
6.	Control (Weed free)	-	1	Nil	Nil	Nil	Nil
7.	Control (Unweeded)	-	1	Nil	Nil	Nil	Nil
8.	Butachlor 50% EC (Rainbow)	8.0	1	Nil	Nil	Nil	Nil

*Based on 1-10 scale: 1=0-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100%

Meteorological data for the experimental period.

Month	Week	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
		Maximum	Minimum	Maximum	Minimum	
Jan 2015	I	29.1	23.5	95	75	0
	II	27.9	19.2	86	77	0
	III	23.8	17.0	77	62	0
	IV	28.4	22.8	92	64	0
Feb 2015	I	28.2	20.1	91	61	0
	II	28.7	20.3	93	62	0
	III	30.9	19.7	91	64	0
	IV	30.3	19.5	91	54	0
Mar 2015	I	31.0	24.4	88	67	0
	II	31.4	23.3	88	64	0
	III	32.6	21.4	89	57	0
	IV	33.0	22.4	91	61	0
Apr 2015	I	35.8	25.3	90	59	0
	II	34.1	24.5	86	60	0
	III	33.4	24.3	85	59	0
	IV	36.6	26.1	78	55	0
May 2015	I	37.4	26.0	84	56	0
	II	36.9	27.0	86	56	0
	III	37.0	27.0	85	55	0
	IV	41.5	25.4	61	36	0

The observations on phytotoxicity parameters viz. leaf injury on tips/ surface, wilting, vein clearing, necrosis, epinasty and hyponasty were recorded at 5, 10, 15, 20, 30 and 45 days after the application of treatments. Leaf injury on tips/surface was recorded following 1-10 scale (1=0-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100%).

After harvesting paddy crop, green gram was sown as a succeeding crop during summer, 2015 in the undisturbed plots maintaining original lay out plan of the experiment. The recommended package of practices was followed for raising the greengram except for the plant protection measures. The per cent seed germination was recorded in greengram after 15 days of sowing. Plant population/m², plant height, branches/plant, number of pods/plant, number of seeds/pod, 100 seed weight and seed yield at harvest were also recorded to observe adverse effects of weedicide treatments applied in previous paddy crop on the succeeding greengram crop, if any. Observations on phytotoxicity parameters as described above were also recorded at 15, 20, 30 and 45 days of sowing in greengram.

Results and Discussion

Bioefficacy : The most common weed species observed in the experimental plots were grass species like *Echinochloa colona*, *Leptochloa chinensis*, *Cyperus difformis*, a sedge and broad leaved weeds like *Eclipta alba* and *Ammania baccifera*. *A. baccifera* was recorded only in unweeded (Control) plot and was not observed in

other treatments throughout the observation period followed by *L. chinensis* which was not recorded up to 30 days of treatment application. Significant differences were observed regarding the mean population of weed/m² with respect to *E. colona*, *C. difformis* and *E. alba*

The data revealed that Butachlor 50% EC (Rainbow) was more effective at 4.0 lit/ha as compared to lower dose 2.5 lit/ha against all the weed species recorded. Butachlor 50% EC (Rainbow) @ 2.5 and 4.0 lit/ha was found more or less equally effective to Butachlor 50% EC (Market sample) @ 2.5 and 4.0 lit/ha. Pretilachlor 50% EC @ 1.5 lit/ha was found relatively less effective but significantly superior to unweeded control. No weed population was recorded in weed free control. In wet-DSR, butachlor plus safener and pretilachlor plus safener were effective. Thiobencarb, pendimethalin, pretilachlor, azimsulfuron plus metsulfuron, bispyribac-sodium, butachlor, cinosulfuron, oxadiazon, and quinclorac were found promising for weed management in transplanted rice (Narayana Rao *et al.*, 2007).

The weed dry weight has been presented in Tables 3 and 4. The trend of weed control based on dry weight of weeds was similar to weed population. Based on weed dry weight weed control efficiency was calculated and presented in Tables 5 and 6. The results showed that all the treatments effectively controlled all the weed species. However weed free was most effective.

The effect of treatments on the yield attributes and yield has been presented in Table 7. The data on plant height, number of tillers/hill, number of panicles/hill,

panicle length and test weight (1000 grains) showed that there was no significant difference in various treatments. However difference in filled grains per panicle was significant which may be one of the reasons influencing grain yield. The grain yield was maximum in weed free control (6080 kg/ha) followed by Butachlor 50% EC (Rainbow) @ 4.0 lit/ha (5170 kg/ha) and other treatments. Chin *et al.* (2000) considered that hand weeding twice was the most effective treatment in terms of both controlling weeds in wet-seeded rice and crop safety and specified that the labour cost was high and often prohibitive. Minimum yield was in unweeded control (4483 kg/ha). The straw yield was also not affected by the application of various treatments as yield was significantly more than in weeded control. Mohan *et al.* (2010) reported that pre-emergent application of butachlor @ 1.0 kgha-1 + safener followed by pretilachlor @ 0.4 kgha-1 + safener have low toxicity on rice plant and plant stand was better compared to other treatments.

Phytotoxicity evaluation : The observations on phytotoxicity parameters viz. leaf injury on tips/ surface, wilting, vein clearing, necrosis, epinasty and hyponasty were recorded at 5, 10, 15, 20, 30 and 45 days after treatment application. No phytotoxicity due to application of treatments was observed on paddy crop even at higher dose of Butachlor 50% EC (Rainbow) @ 8.0 lit/ha (Table 8).

Effect of treatments on succeeding green gram crop : The study on the effect of herbicides on the succeeding greengram crop was conducted during summer, 2015. Cent per cent germination was recorded in all the treatments with regard to the effect of herbicides on germination of greengram, the plant stand ranged from 41 to 46/m² whereas the plant height ranged from 57.8 to 67.0, number of branches per plant was 13.3 to 16.7, number of pods per plant was 26.7 to 32, number of seeds/pod was 8.1 to 9.6, 100 seed weight was 3.9 to 4.1 gm. and highest yield of 466 kg/ha was observed in weed free plots followed by butachlor @ 2.5l/ha and pretilachlor @ 1.5 l/ha. There was no significant difference in plant population/m², plant height, branches/plant, number of pods/plant, number of seeds/pod, 100 seed weight and significant differences were observed with regard to the seed yield in various treatments. Also no phytotoxicity symptoms were observed in greengram crop in any of the treatments after 15, 20, 30 and 45 days of sowing. It shows that there was no adverse effect of Butachlor 50% EC (Rainbow) applied @ 2.5, 4.0 and 8.0 lit/ha on the succeeding green gram crop (Table 10). The herbicides (pendimethalin, pyrazosulfuron-ethyl, butachlor, pretilachlor, orthosulfamuron, acetochlor + bensulfuron methyl, butachlor + propanil and 2,4-D amine) used in

unpuddled transplanted aman rice had no residual effect on the germination and leaf chlorophyll content, seedling shoot length and dry matter of the succeeding wheat, lentil and sunflower crops (Taslina *et al.*, 2016).

Conclusion

The results revealed that Butachlor 50% EC applied @ 2.5 and 4.0 lit/ha was effective to control weeds in transplanted paddy. There was no phytotoxicity due to the application of Butachlor 50% EC applied @ 2.5, 4.0 lit/ha in transplanted paddy. There was no adverse effect of Butachlor 50% EC application on transplanted paddy @ 2.5, 4.0 and 8.0 lit/ha on succeeding green gram crop. Hence, the use of Butachlor 50% EC @ 2.5 and 4.0 lit/ha is suggested for the control of weeds on transplanted paddy.

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Effect of Integrated Phosphorus Management on Activity of Phosphatase Enzyme under Soybean-Wheat Cropping Sequence

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Abstract

A field experiment was conducted at PGI, farm of Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during *kharif* and *rabi* season of 2011-12 using randomized block design with three replication and nine treatments in *Vertic Haplustepts* Inceptisol soil to study the influence integrated phosphorus management on soil phosphatase enzyme activities under soybean-wheat cropping sequence. The study revealed that, application of manures and fertilizers as per STCRC equation with FYM to soybean and AST NK + residual P of preceding soybean to wheat resulted in the significantly increase in bacteria (31.03 and 24.88×10^6 cfu g⁻¹ soil), fungi (13.48 and 10.17×10^5 cfu g⁻¹ soil), actinomycetes (15.47 and 12.58×10^4 cfu g⁻¹ soil) and PSB population (22.55 and 17.64×10^4 cfu g⁻¹ soil), respectively at soybean and wheat harvest, respectively. The application of manures and fertilizers as per STCRC equation (yield target 25 q ha⁻¹) with FYM to soybean resulted significant increase acid and alkaline phosphatase in the treatment T₃ are 17.97 , 20.72 , 17.85 , 14.91 and 55.28 , 66.48 , 57.54 and 34.39 μ g PNP g⁻¹ hr⁻¹ under soybean growth stages viz., 3rd trifoliate, 50% flowering, pod filling and at harvest, respectively. However, application of manures and fertilizers as per STCRC equation with FYM to soybean and AST NK + residual P of preceding soybean to wheat had shown significantly increased acid and alkaline phosphatase 16.12 , 16.76 , 19.33 , 17.85 and 13.36 and 39.31 , 46.87 , 50.13 , 42.88 and 26.85 μ g PNP g⁻¹ hr⁻¹ under critical growth stages of wheat viz., CRI, tillering, flowering, grain filling/dough and at wheat harvest, respectively. The values of acid and alkaline phosphatase in integrated phosphorus management treatment were recorded the highest at flowering stage of both soybean and wheat crops under soybean wheat sequence.

Key words : Integrated phosphorus management, phosphorus, acid and alkaline, phosphatase, microbial population, soybean and wheat.

Phosphorus (P) is one of the major nutrients for plants and it plays an important role in plant metabolism by supplying energy required for metabolic processes (Lal, 2002). The availability of phosphate in soils is often limited by fixation reactions, which convert the monophosphate ion into various insoluble forms. The importance of organic manures in the soil has been recognized for centuries as the key to soil fertility and productivity. Organic manures, favourable by product of farming and allied industries contribute to plant growth through their favourable effect on physical, chemical and biological properties of soil.

The availability of soil phosphate is enhanced by addition of organic manures, due to chelation of polyvalent cations by organic acids and other decay products. Though, information is available on the conjunctive use of organic manures and inorganic fertilizers for improving soil fertility and crop yields, direct quantification of plant available phosphorus rendered available to the crops (main and residual benefits) from organic manures is scant. For increasing fresh and residual phosphorus use efficiency, integrated phosphorus management (IPM) for a cropping system is the only viable strategy. The balanced nutrition could be

achieved through application of multi-nutrients in balanced proportion through fertilizers, organic sources, biological sources and more accurately and precisely through integrated nutrient management on cropping system basis. Wang *et al.* (2011) reported that the soil microorganisms and plants root produce extracellular phosphatase which mineralises organically bound phosphorus.

However, plants cannot absorb insoluble forms of phosphorus and has to be converted into soluble forms by phosphatase enzyme such as acidic and alkaline phosphatase. To be available to plants, organic forms of soil phosphorus must be mineralized by those processes, which are mediated by phosphatase enzymes (Bielecki and Ferguson, 1983). Phosphate solubilising bacteria solubilise insoluble phosphate and make it available to the plants (Bhattacharyya and Jain, 2000).

Soil enzyme activities are 'sensors' of soil degradation since they integrate information about microbial status and physico-chemical conditions of soil in relation to nutrients availability (Baum *et al.* 2003). The microorganism and enzymes are interrelated with each other. The integration of organic manures with chemical

fertilizers significantly influenced phosphomonoesterase (acid and alkaline phosphatase) enzymes produced or present in soil and added organic manures helps to increase enzyme activity and the P availability in soil for crops as compared to application of chemical fertilizers alone.

Materials and Methods

A field experiment was conducted during *kharif* and *rabi* season of 2011-12 at the Post Graduate Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, in Inceptisols *Vertic Haplustepts*. The soil was medium in organic carbon (0.59%), low in available N ($166.20 \text{ kg ha}^{-1}$) and available P (13.78 kg ha^{-1}) and very high available K ($365.90 \text{ kg ha}^{-1}$) with alkaline pH 8.27 and EC 0.23 dS m^{-1} . Initial microbial population content were bacteria ($\times \text{cfu } 10^6 \text{ g}^{-1} \text{ soil}$) 8.20, Fungi ($\times \text{cfu } 10^5 \text{ g}^{-1} \text{ soil}$) 2.50, Actinomycetes ($\times \text{cfu } 10^5 \text{ g}^{-1} \text{ soil}$) 3.90, PSB ($\times \text{cfu } 10^4 \text{ g}^{-1} \text{ soil}$) 5.0 and enzyme activities viz., dehydrogenase ($\mu\text{g TPF g}^{-1} \text{ soil } 24 \text{ hr}^{-1}$) 6.18, acid and alkaline Phosphatase ($\mu\text{g PNP g}^{-1} \text{ soil hr}^{-1}$) 7.92 and 31.82, respectively. Experiment was laid out with nine treatment combinations in RBD with three replications to soybean (T_1 - Absolute control, T_2 - As per soil test crop response correlation (STCRC) equation without Farm Yard Manure (FYM), T_3 - As per STCRC equation with FYM, T_4 - As per soil test (AST) NK+P (SSP), T_5 - AST NK+P (25% P_2O_5 - FYM+75% P_2O_5 -SSP), T_6 - AST NK+P (25% P_2O_5 - Poultry manure (PM)+75% P_2O_5 -SSP), T_7 - AST NK+P (25% P_2O_5 - Vermicompost (VC)+75% P_2O_5 - SSP), T_8 - AST NK+P (25% P_2O_5 - Pressmud Compost (PMC) +75% P_2O_5 - SSP) and T_9 - AST NK+P (25% P_2O_5 - Neem cake (NC) +75% P_2O_5 - SSP). For wheat treatment combinations were T_1 - Absolute control, T_2 - As per STCRC equation without FYM and treatment T_3 - T_9 were AST NK+ residual effect of phosphorus. The PSB @ 5 kg ha^{-1} were applied in soil to all the treatments except absolute control (T_1) of soybean and wheat crops. Yield target 25 q ha^{-1} for treatment T_2 and T_3 and 45 q ha^{-1} for treatment T_2 was for soybean and wheat, respectively. While applying NPK through chemical fertilizer to soybean NPK content of inorganic manures were considered.

After harvest of *kharif* soybean the *rabi* wheat was sown at 22.5 cm row spacing in month of November and harvested in the month of March 2012 and one cycle of the crop sequence were completed without disturbing the plots. The different organic manures and fertilizers were applied as per soil test to supply required quantity of nutrients. Soil samples from $0\text{-}15 \text{ cm}$ depth were collected in triplicate, from individual plots as per critical growth stages of soybean and wheat crop. The soil was kept in the well labelled polythene bags, tagged and brought to

the laboratory. After processing, suitable amount (500 g) of soil was stored in incubator at 30°C for the bio-chemical analysis. The microbial population was determined by serial dilution plating method (Chhonkar *et al.* 2007). Phosphatase (alkaline and acid) were analysed following the method of Eivazi and Tabatabai (1977). The treatment wise soil samples were air-dried, processed to passed through 2 mm sieve and analysed for available P (0.5 M NaHCO_3 extractable) (Watanabe and Olsen (1965). Grain and straw yields were recorded at maturity of crop.

All the experimental data were statistically analyzed to draw conclusion of significance by using the methods prescribed by Panse and Sukhatme (1985).

Results and Discussion

Effect on microbial population : The data pertaining to influence of IPM treatments on microbial population at soybean and wheat harvest are presented in Table-1.

At soybean harvest : The data revealed that, the microbial population viz., bacteria, fungi, actinomycetes and PSB were found to be increase significantly due to IPM treatments to soybean. The application of manures and fertilizers as per STCRC equation (yield target 25 q ha^{-1}) of soybean with FYM (T_3) significantly recorded the highest bacterial ($31.03 \times 10^6 \text{ cfu g}^{-1} \text{ soil}$), fungi ($13.48 \times 10^5 \text{ cfu g}^{-1} \text{ soil}$), actinomycetes ($15.47 \times 10^4 \text{ cfu g}^{-1} \text{ soil}$) and PSB ($22.55 \times 10^4 \text{ cfu g}^{-1} \text{ soil}$) population, respectively at soybean harvest. Amongst IPM treatments (T_5 to T_9), the application of manures and fertilizers AST NK + P-25% P_2O_5 through PMC and 75% through SSP (T_8) treatment showed higher bacterial, actinomycetes, PSB and fungi population. This might be attributes to the increment in organic matter in soil which serves as a food and energy source for microbes. These results were supported by the similar findings of Breza-Boruta and Paluszak (2003) and Krishnakumar *et al.* (2005).

At wheat harvest : The residual P treatment application of fertilizers to wheat AST NK + residual effect of P (T_3) treatment significantly recorded highest bacterial ($24.88 \times 10^6 \text{ cfu g}^{-1} \text{ soil}$), actinomycetes ($12.58 \times 10^4 \text{ cfu g}^{-1} \text{ soil}$), PSB ($17.64 \times 10^4 \text{ cfu g}^{-1} \text{ soil}$) and fungi population ($10.17 \times 10^5 \text{ cfu g}^{-1} \text{ soil}$), respectively after harvest of wheat crop as compared with rest of treatments. Amongst residual P treatments T_5 to T_9 , the application of manures and fertilizers to wheat AST NK + residual P effect of PMC (T_8) treatment showed higher bacterial, PSB and fungi population as compared with AST NK + residual effect of P (SSP) (T_4) treatment. These findings are also in the line of the earlier observations made by Manna *et al.* (2007). The freshly application of inorganic fertilizer as per STCRC equation without FYM (T_2) to wheat showed

Table-1 : Effect of IPM on microbial population at soybean and wheat harvest.

Treatment	Soybean				Wheat			
	Bacteria ($\times 10^6$ cfu g ⁻¹ soil)	Fungi ($\times 10^5$ cfu g ⁻¹ soil)	Actinom- ycetes ($\times 10^4$ cfu g ⁻¹ soil)	PSB ($\times 10^4$ cfu g ⁻¹ soil)	Bacteria ($\times 10^6$ cfu g ⁻¹ soil)	Fungi ($\times 10^5$ cfu g ⁻¹ soil)	Actinom- ycetes ($\times 10^4$ cfu g ⁻¹ soil)	PSB ($\times 10^4$ cfu g ⁻¹ soil)
T ₁ - Absolute control	9.47	4.20	6.56	4.52	8.40	2.92	4.67	5.22
T ₂ - Soybean: As per STCRC equation without FYM Wheat : As per STCRC equation without FYM	15.26	6.58	8.64	13.52	13.00	5.75	9.83	10.09
T ₃ -Soybean: As per STCRC equation with FYM Wheat: AST RD NK + residual effect of P	31.03	13.48	15.47	22.55	24.88	10.17	12.58	17.64
T ₄ -Soybean: AST RD NK+ P (SSP) Wheat: AST RD NK + residual effect of P	13.20	6.00	7.56	9.90	9.50	4.50	7.67	8.90
T ₅ - Soybean: AST RD NK + P (25% P ₂ O ₅ - FYM+ 75% P ₂ O ₅ -SSP) Wheat: AST RD NK + residual effect of P	25.32	9.33	13.06	19.99	21.25	6.83	9.99	15.17
T ₆ - Soybean: AST RD NK + P (25% P ₂ O ₅ - PM+75% P ₂ O ₅ - SSP) Wheat: AST RD NK + residual effect of P	23.05	8.67	11.72	16.48	20.50	7.08	8.50	13.15
T ₇ - Soybean: AST RD NK + P (25% P ₂ O ₅ - VC +75% P ₂ O ₅ -SSP) Wheat: AST RD NK + residual effect of P	21.79	7.50	14.52	15.58	19.54	6.58	9.50	12.24
T ₈ - Soybean: AST RD NK + P (25% P ₂ O ₅ - PMC +75% P ₂ O ₅ -SSP) Wheat: AST RD NK + residual effect of P	27.14	12.81	10.89	19.55	22.42	8.55	10.15	16.70
T ₉ - Soybean: AST RD NK + P (25% P ₂ O ₅ - NC +75% P ₂ O ₅ -SSP) Wheat: AST RD NK + residual effect of P	18.24	7.00	12.97	14.86	13.91	5.00	8.01	11.86
S.E.(m)+	1.06	0.41	0.61	1.00	0.78	0.36	0.36	0.59
C.D. at 5(%)	3.17	1.22	1.83	3.00	2.33	1.07	1.08	1.76
Initial	8.20	2.50	3.90	5.00				

Table-2 : Effect of IPM on activity of acid and alkaline phosphatase enzyme at various growth stages of soybean.

Treatment	Acid phosphatase ($\mu\text{g PNP g}^{-1}$ soil hr ⁻¹)				Alkaline phosphatase ($\mu\text{g PNP g}^{-1}$ oil hr ⁻¹)			
	3 rd trifoliolate	50% Flowering	Pod filling	At harvest	3 rd trifoliolate	50% Flowering	Pod filling	At harvest
T ₁	9.65	10.47	8.84	7.89	36.88	42.84	34.15	19.17
T ₂	13.61	14.31	11.56	9.99	45.60	53.88	42.67	23.87
T ₃	17.97	20.72	17.85	14.91	55.28	66.48	57.54	34.39
T ₄	13.77	14.05	11.38	9.84	43.25	52.02	41.60	21.90
T ₅	15.90	19.86	15.96	12.94	53.14	63.59	53.49	32.91
T ₆	15.36	18.12	14.91	11.56	53.70	62.12	51.86	31.67
T ₇	14.61	15.67	13.69	11.29	50.72	60.01	48.65	29.02
T ₈	17.50	20.48	17.62	13.42	54.65	64.81	55.94	33.30
T ₉	14.10	15.04	12.88	11.05	50.17	56.97	45.58	28.36
S.E.(m)+	0.34	0.37	0.38	0.34	0.86	1.11	1.07	0.64
C.D. at 5 (%)	1.03	1.12	1.14	1.01	2.58	3.32	3.22	1.92
Initial		7.92				31.82		

relatively less population of bacteria, fungi and actinomycetes and PSB at wheat harvest.

Effect on enzyme activities : The data on activity of both the acid and alkaline phosphatase during various growth stages of soybean influenced by application of IPM

treatments to soybean and wheat are reported in Table 2 and 3.

At soybean harvest : Overall in all treatments, the activity of acid and alkaline phosphatase was found to be increased from 3rd trifoliolate stage to 50% flowering stage

Table-3 : Residual effect of IPM on activity of acid and alkaline phosphatase enzyme at various growth stages of wheat.

Treatment	Acid phosphatase ($\mu\text{g PNP g}^{-1} \text{ soil hr}^{-1}$)					Alkaline phosphatase ($\mu\text{g PNP g}^{-1} \text{ soil hr}^{-1}$)				
	CRI	Tillering	50% Flowering	Dough	At harvest	CRI	Tillering	50% Flowering	Dough	At harvest
T ₁	5.21	6.88	7.56	6.13	4.94	17.93	19.69	20.15	18.00	10.60
T ₂	6.56	6.13	8.34	7.90	5.98	21.63	24.51	29.67	25.65	14.11
T ₃	16.12	16.76	19.33	17.85	13.36	39.31	46.87	50.13	42.88	26.85
T ₄	8.18	10.35	11.24	8.76	7.86	27.07	35.60	37.38	32.43	18.42
T ₅	14.50	15.05	17.12	16.44	11.86	36.46	43.99	47.04	40.45	23.62
T ₆	13.49	14.99	16.19	14.37	8.67	34.12	42.36	43.28	37.53	22.59
T ₇	12.30	12.36	14.02	12.71	7.61	33.57	41.57	42.09	36.99	20.99
T ₈	14.90	15.77	18.37	16.97	12.27	37.39	45.04	49.14	41.19	25.18
T ₉	10.19	11.93	13.08	11.75	8.11	31.67	39.60	39.51	34.03	20.31
S.E.(m)+	0.51	0.46	0.35	0.37	0.46	1.15	1.25	1.31	1.10	0.76
C.D. at 5%	1.53	1.37	1.06	1.12	1.37	3.46	3.75	3.93	3.31	2.29

Table-4 : Correlation coefficient (r) between phosphatase enzymes and phosphorus availability at various growth stages of wheat.

Phosphatase enzymes	Phosphorus availability in wheat				
	CRI	Tillering	50% Flowering	Dough	At harvest
Acid phosphatase					
CRI	0.339	0.594	0.708*	0.669*	0.776
Tillering	0.304	0.561	0.685*	0.647	0.713
50% Flowering	0.145	0.419	0.560	0.514	0.659
40 Dough	0.260	0.523	0.647	0.607	0.681
At harvest	0.333	0.584	0.704*	0.673*	0.695
Alkaline phosphatase					
CRI	0.466	0.696*	0.800**	0.781*	0.745
Tillering	0.298	0.562	0.689*	0.666	0.782
50% Flowering	0.249	0.513	0.645	0.617	0.789
Dough	0.378	0.625	0.735*	0.697*	0.783
At harvest	0.369	0.616	0.729*	0.688*	0.796

*, ** : significant at 5 and 1% level of significance, respectively.

Table-4 : Correlation coefficient (r) between phosphatase enzymes and phosphorus availability at various growth stages of soybean.

Phosphatase enzymes	Phosphorus availability in soybean			
	At 3 rd trifoliate	50% Flowering	Pod filling	At harvest
Acid phosphatase				
At 3 rd trifoliate	0.725*	0.946**	0.982**	0.870**
50% Flowering	0.592	0.861**	0.942**	0.773*
Pod filling	0.550	0.848**	0.939**	0.815**
At harvest	0.570	0.866**	0.950**	0.854**
Alkaline phosphatase				
At 3 rd trifoliate	0.556	0.887**	0.949**	0.888**
50% Flowering	0.616	0.913**	0.973**	0.883**
Pod filling	0.577	0.877**	0.957**	0.848**
At harvest	0.448	0.817**	0.918**	0.838**

*, ** : significant at 5 and 1% level of significance, respectively.

of soybean and there after activity of phosphatases (acid and alkaline) were reduced with the advancement of growth stages of soybean. The data on both acid and alkaline phosphatase indicated the higher values by the alkaline phosphatase than acid phosphatase. This comparison of values of phosphatases indicates predominant role of alkaline phosphatase in enzymatic mineralization of organic P. However, at all stages of soybean, nutrients applied by using STCRC equation (yield target 25 q ha⁻¹) of soybean with FYM treatment (T₃) was significantly superior over all the treatments in respect of both acid and alkaline (Table 2) phosphatase activity. The value of acid and alkaline phosphatase in the treatment T₃ are 17.97, 20.72, 17.85, 14.91 and 55.28, 66.48, 57.54 and 34.39 $\mu\text{g PNP g}^{-1} \text{ hr}^{-1}$ under soybean growth stages viz., 3rd trifoliate, 50% flowering, pod filling and at harvest, respectively.

The treatment T₈ (25% P₂O₅ substituted through PMC) is at par with treatment T₃ in acid phosphatase at different growth stages of soybean. As regards alkaline phosphatase, the IPM treatments T₈ and T₅ are at par with T₃ treatment during different growth stages of soybean. The value of acid and alkaline phosphatase in the treatment T₈ are 17.50, 20.48, 17.62, 13.42 and 54.65, 64.81, 55.94 and 33.30 $\mu\text{g PNP g}^{-1} \text{ hr}^{-1}$ under soybean growth stages viz., 3rd trifoliate, 50% flowering, pod filling and at harvest, respectively.

The highest acid phosphatase activity under T₃ treatment might be probably due to increase in substrate like organic P in soil. These findings are in the line of the observations made by Ramesh *et al.* (2008) and Rai and Yadhav (2011).

At wheat harvest : The data on activity of acid and alkaline phosphatase during various growth stages of wheat due to treatments of residual effect of P reported in Table-3.

Acid and alkaline phosphatase : Predominance of alkaline phosphatase in all residual P treatments and their increasing trends in activity of both phosphatase up to flowering stage of wheat and there after decreasing trend were observed. However, treatment AST NK + residual effect of P (T₃) had shown statistically highest significant activity of acid phosphatase (16.12, 16.76, 19.33, 17.85 and 13.36 $\mu\text{g PNP g}^{-1} \text{ soil hr}^{-1}$) under critical growth stages of wheat viz., CRI, tillering, flowering, dough and at wheat harvest, respectively. In respect of alkaline phosphatase the same residual P treatment (T₃) recorded higher alkaline phosphatase (39.31, 46.87, 50.13, 42.88 and 26.85 $\mu\text{g PNP g}^{-1} \text{ soil hr}^{-1}$ under critical growth stages of wheat viz., CRI, tillering, flowering, grain filling/dough and at wheat harvest; respectively. However, it is on par with

the T₈ (AST NK + residual P of PMC to soybean) treatment.

As like trends of phosphatases activity during soybean growth stages between the residual P treatment T₅ to T₉, the T₈ wheat treatment (AST NK + residual P effect of PMC) had shown highest activity of phosphatase followed by FYM (T₅), PM (T₆), VC (T₇) and neem cake (T₉) P substituted sources for preceding soybean. However, in T₂ treatment the activity of alkaline phosphatase decreased in all growth stages of wheat as compared to other rest of treatments. These results are confirmatory with results of Cashi *et al.* (1989) and Balakrishnan *et al.* (2007).

Thus, results of present investigation indicate that the highest acid and alkaline phosphatase activity in soybean and residual P wheat were observed under T₃ treatment and occurred the peak rates during both crops of flowering stage.

Correlation coefficient(r) between phosphatase enzyme activities and available phosphorus : At wheat harvest, the significant positive correlation (Table 4) between phosphatase enzyme activities and available phosphorus were observed. The studies on correlation between residual available P at various growth stages and phosphatase enzyme activities of wheat indicated that available P correlated under influence of acid (r=0.708**) and alkaline (r=0.800**) enzyme activities at flowering stage in wheat.

Conclusions

On the basis of results, it was concluded that integrated phosphorus management through application of manures and fertilizers as per STCRC equation with FYM to soybean and as per soil test NK + residual P to wheat found highest microbial population, acid and alkaline phosphatase enzyme activities in soil under soybean wheat sequence.

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Influence of Nano Zinc Oxide on Yield, Nutrient Uptake and Economics of Maize (*Zea mays* L.)

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Abstract

A field study was conducted during *Kharif* 2018 at Zonal Agricultural Research Station, GKVK, UAS, Bengaluru to know the effect of nano zinc oxide particles on nutrient uptake of maize. Field experiment consist of eight treatments, which were laid out in a Randomized complete block design (RCBD) with three replications. The soils of the experimental site was red sandy loam having neutral pH, low electrical conductivity, and medium in available nitrogen, phosphorus, potassium and zinc content. The results revealed that seed priming with 800 ppm of nano zinc oxide for 30 minutes and foliar application of nano ZnO at 500 ppm along with RDF recorded higher kernel yield (8750 kg ha⁻¹) and stover yield (11136 kg ha⁻¹). Uptake of nitrogen, phosphorous, potassium and zinc was maximum in the same treatment. The available soil nutrients was higher in soil application of ZnSO₄@ 10 kg ha⁻¹.

Key words : Economics, nutrient uptake, nutrient status, nano ZnO, maize yield.

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice with an area of 185.9 m ha, production of 1075.5 mt and average productivity of 5790 kg ha⁻¹ (Anon., 2017). In India, it is cultivated on an area of 9.89 m ha with a production of 25.9 mt and the productivity of 2690 kg ha⁻¹ (Anon., 2017). In Karnataka, it is cultivated on an area of 1.3 million ha with a production of 4.4 million tonnes with an average productivity of 2970 kg ha⁻¹ (Anon., 2017). It comes up well under a wide range of soil and climatic conditions, there is a lot of scope to expand the present maize yields.

Indian soils are being exhausted heavily as 30 mt of nutrients removed, while 20 mt added by crops leaving a shortage of 10 mt consistently. Fertilizer response ratio of crops has declined radically. Socio and economic issues such as exodus of people from farming, inaccessibility of labourers and raising cost of cultivation add enormous pressure on agricultural scientists to evolve technologies that target multifaceted problems of Indian agriculture. Fertilizers play a pivotal role in agricultural production. Fertilizers contribute to the tune of 35-40% of the productivity of any crops. Zeolite based nano fertilizers are capable of releasing nutrients especially NO₃ – N for more than 50 days while nutrient release from conventional fertilizer (urea) ceases to exist beyond 10–12 days.

In India, Zn is now considered the fourth most important yield-limiting nutrient after nitrogen (N), phosphorus (P) and potassium (K). In India alone, 50 % of the soils that grow maize show Zn deficiency, leading to considerable yield loss (Singh, 2010). Zinc plays a major role in biomass production (Kaya and Higgs, 2002).

Among the micro nutrients, Zn and manganese (Mn) deficiency make plants susceptible to drought stress (Khan *et al.*, 2003). The present study was taken up to investigate the promotory or inhibitory effects of various concentrations of ZnO nanoparticles on growth and yield of maize (*Zea Mays* L.). Nanoparticles with small size and large surface area are expected to be the ideal forms for use as a Zn fertilizer in plants. Farmers are using both sulphates and chelated Zn (with ethylene di ammine tetra acetic acid, EDTA) for soil and foliar applications; however, the efficacy is low.

Materials and Methods

A field experiment was conducted during *kharif* 2018 at Zonal Agricultural Research Station, GKVK, UAS, Bengaluru to know the effect of nano zinc oxide particles on growth and yield of maize. The soil was red sandy loam having nearly neutral pH (6.56), low electrical conductivity (0.17) and medium in available nitrogen (445.69 kg ha⁻¹), phosphorous (46.36 kg ha⁻¹), potassium (243.9 kg ha⁻¹) and Zinc (0.45 ppm). The experiment was laid out in a RCBD having eight treatments with three replications. The treatment consists of five levels of nano zinc oxide as foliar application at 30 DAS and zinc sulphate (10 kg ha⁻¹ and 0.5 %) applied to soil and foliage as foliar application. The treatment details are *viz.*, T₁: Seed priming with Nano ZnO @ 800 ppm for 30 minutes, T₂: T₁+Foliar application of Nano ZnO@200 ppm, T₃: T₁+Foliar application of Nano ZnO@ 300 ppm, T₄: T₁+Foliar application of Nano ZnO@ 400 ppm, T₅: T₁+Foliar application of Nano ZnO@ 500 ppm, T₆: T₁+Foliar

application of Nano ZnO@ 600 ppm, T₇ : Foliar application of ZnSO₄ @ 0.5% and T₈: Soil application of ZnSO₄@ 10 kg ha⁻¹. The RDF: FYM @ 10 t + 150 kg N +75 kg P₂O₅ and 37.5 kg K₂O ha⁻¹ was applied for all the treatments.

Preparation of Particle Suspensions and Zinc Ion Solution : The nano particles were suspended directly in double distilled water (DDW) and dispersed by using magnetic stirrer for 30 min. Small magnetic beads were placed in the suspensions for stirring before use to avoid aggregation of the particles. Zinc ion (Zn²⁺) solution was prepared by dissolving zinc sulfate heptahydrate (ZnSO₄.7H₂O) in DDW.

The cultivar of maize BRMH-1 was sown at 60 cm × 30 cm spacing. All other agronomic practices were followed as per the UAS, Bengaluru recommended package of practices. Kernel and stover yield was recorded at harvest. Uptake of nitrogen, phosphorous, potassium and zinc was estimated by modified Micro-Kjeldhal's method, Vanadomolybdate phosphoric yellow colour method in nitric acid medium, flame photometer method and DTPA extraction method, respectively. The nutrient status of the soil after harvest the crop was estimated by Chromic acid titration method, Alkaline permanganate method, Olsen's method, Neutral normal ammonium acetate method and DTPA extraction method for Organic carbon, nitrogen, phosphorus, potassium and zinc, respectively. The experimental data was analyzed by using ANOVA technique. The significance of the treatment effect was judged with the help of "F" table and tested at 5% probability level.

Results and Discussion

Effect of nano Zinc oxide particles on yield of maize

: Significantly higher kernel yield (8750 kg ha⁻¹) and stover yield (11136 kg ha⁻¹) was observed in the seed treated with 800 ppm of nano ZnO for 30 minutes and foliar application of nano ZnO at 500 ppm and lower kernel yield (5441 kg ha⁻¹) and stover yield (8076 kg ha⁻¹) was recorded in the treatment soil application of ZnSO₄@ 10 kg ha⁻¹. This was mainly due to small size and large effective surface area of nanoparticles could easily penetrated into the plant lead to better uptake of zinc. Zinc plays as an activator of enzymes in plants and is directly involved in the biosynthesis of auxin, which produces more cells and dry matter that in turn will be stored in seeds as sink. Thus, increase in kernel yield is expected (Parmar snehalbhai, 2016). At higher concentration of ZnO nanoparticles, kernel yield decreased, these results were in accordance with

reports on radish, rapeseed, ryegrass, corn and lettuce (Lin and Xing, 2007). Increase in stover yield was attributed to significant increase in dry matter accumulation in leaves and stem at various growth stages. Progressive significant increase in dry matter accumulation was mainly attributed to increase in growth factors like plant height. Prasad *et al.* (2012) reported effect of ZnO nanoparticles on groundnut growth and suggested that higher concentrations of ZnO nanoparticles reduced the plant height. In present study also higher dose of ZnO nanoparticles, decreased the plant height which suggested the detrimental effect of ZnO nanoparticles at higher concentrations.

Effect of nano zinc oxide particles on nutrient uptake of maize

: The uptake of nitrogen (292.8 kg ha⁻¹), phosphorous (58.6 kg ha⁻¹), potassium (222.3 kg ha⁻¹) and zinc (37.2 mg kg⁻¹) by maize kernel was significantly highest in seed treated with 800 ppm of nano ZnO for 30 minutes and foliar application of nano ZnO at 500 ppm. Significantly higher nitrogen uptake by maize kernel, stover and total was recorded in seed treatment with 800 ppm of nano ZnO for 30 minutes and foliar application of nano ZnO at 500 ppm, Zn and Mn interfere with iron utilization in the leaves for chlorophyll synthesis. Further, zinc helps in activation of enzymes required for N assimilation. Higher dose of zinc has increased the potassium uptake by maize, it was mainly due to synergetic effect of Zn on K₂O and it helps the availability and uptake of potassium, similar research was reported by Adriano *et al.* (2001) and Biswas *et al.* (2007). The total Zn content of wheat tissues increased compared to control which suggested that ZnO nanoparticles were penetrated into plant cell and thereby enhancing uptake of Zn⁺² ions. It is, therefore, reported that the increased root Zn content was due to dissolved zinc ions (Zn⁺²) form ZnO nanoparticles. These findings are in line with report on groundnut by Prasad *et al.* (2012). Zinc plays as an activator of enzymes in plants and is directly involved in the biosynthesis of auxin, which produces more cells and dry matter that in turn will be stored in seeds as sink.

Effect of nano zinc oxide particles on nutrient availability at harvesting of maize

: Significantly higher available nitrogen (320.5 kg ha⁻¹), phosphorous (71.8 kg ha⁻¹), potassium (86.3 kg ha⁻¹) and zinc (0.62 mg kg⁻¹) was observed in soil application of ZnSO₄@ 10 kg ha⁻¹. The lower available nitrogen (252.5 kg ha⁻¹), phosphorous (35.5 kg ha⁻¹), potassium (53.8 kg ha⁻¹) and zinc (0.31 mg kg⁻¹) was recorded in seed treatment

Table-1 : Effect of nano zinc oxide particles on kernel yield and stover yield of maize.

Treatments	Kernel yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)
T ₁ : Seed priming with Nano ZnO @ 800 ppm for 30 minutes	6632	9520
T ₂ : T ₁ + Foliar application of Nano ZnO @ 200 ppm	6985	9592
T ₃ : T ₁ + Foliar application of Nano ZnO @ 300 ppm	7148	9739
T ₄ : T ₁ + Foliar application of Nano ZnO @ 400 ppm	7848	10254
T ₅ : T ₁ + Foliar application of Nano ZnO @ 500 ppm	8750	11136
T ₆ : T ₁ + Foliar application of Nano ZnO @ 600 ppm	7400	9742
T ₇ : Foliar application of ZnSO ₄ @ 0.5%	6161	8896
T ₈ : Soil application of ZnSO ₄ @ 10 kg ha ⁻¹	5441	8076
S.E(m) ±	266.21	313.60
C.D. at 5%	807.54	951.29

Table-2 : Effect of nano Zinc oxide particles on nutrient uptake by maize at harvest.

Treatments	N (kg ha ⁻¹)	P ₂ O ₅ (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)	Zn (mg kg ⁻¹)
T ₁ : Seed priming with Nano ZnO @ 800 ppm for 30 minutes	189.8	40.8	197.1	26.1
T ₂ : T ₁ + Foliar application of Nano ZnO @ 200 ppm	198.1	44.8	202.0	26.7
T ₃ : T ₁ + Foliar application of Nano ZnO @ 300 ppm	236.3	49.8	206.3	28.0
T ₄ : T ₁ + Foliar application of Nano ZnO @ 400 ppm	266.3	53.0	218.1	31.9
T ₅ : T ₁ + Foliar application of Nano ZnO @ 500 ppm	292.8	58.6	222.3	37.2
T ₆ : T ₁ + Foliar application of Nano ZnO @ 600 ppm	250.1	51.5	213.0	30.9
T ₇ : Foliar application of ZnSO ₄ @ 0.5%	179.0	39.5	195.1	25.2
T ₈ : Soil application of ZnSO ₄ @ 10 kg ha ⁻¹	149.8	36.3	192.5	24.5
S.E(m) ±	12.34	1.82	6.43	0.93
C.D. at 5%	37.41	5.53	19.53	2.82

Table-3 : Effect of nano Zinc oxide particles on available soil nutrients status at harvest.

Treatments	Available N (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)	Available Zn (mg kg ⁻¹)
T ₁ : Seed priming with Nano ZnO @ 800 ppm for 30 minutes	287.2	63.1	73.4	0.42
T ₂ : T ₁ + Foliar application of Nano ZnO @ 200 ppm	280.9	60.6	68.8	0.43
T ₃ : T ₁ + Foliar application of Nano ZnO @ 300 ppm	273.3	53.1	66.6	0.38
T ₄ : T ₁ + Foliar application of Nano ZnO @ 400 ppm	263.0	40.5	60.2	0.32
T ₅ : T ₁ + Foliar application of Nano ZnO @ 500 ppm	252.5	35.5	53.8	0.31
T ₆ : T ₁ + Foliar application of Nano ZnO @ 600 ppm	269.8	43.9	62.5	0.35
T ₇ : Foliar application of ZnSO ₄ @ 0.5%	288.9	67.2	75.2	0.43
T ₈ : Soil application of ZnSO ₄ @ 10 kg ha ⁻¹	320.5	71.8	86.3	0.62
S.E(m) ±	11.86	4.29	2.17	0.01
C.D. at 5%	35.99	13.00	6.59	NS

with 800 ppm of nano ZnO for 30 minutes and foliar application of nano ZnO at 500 ppm. Higher available soil nitrogen, phosphorous, potassium and zinc was noticed in soil application of ZnSO₄@10kg ha⁻¹ due to the fact that lower uptake of nitrogen, phosphorus, potassium and zinc. The results are in conformity with the findings of Babu and Reddy (2000), Wankeel *et al.* (2002), Govindan and Thirumuragan (2005), Adriano *et al.* (2001) and Biswas *et al.* (2007).

Effect of nano zinc oxide on economics of maize production : Seed priming with 800 ppm of nano ZnO for 30 minutes and foliar application of nano ZnO at 500 ppm recorded higher gross and net returns (133636

Rs. ha⁻¹ and 84777 Rs. ha⁻¹, respectively) and was followed by seed treatment with 800 ppm of nano ZnO for 30 minutes and foliar application of nano ZnO at 400 ppm (Table-4). The lower gross and net returns were recorded in soil application of ZnSO₄@ 10 kg ha⁻¹. The higher gross and net returns were observed in seed treatment with 800 ppm of nano ZnO for 30 minutes and foliar application of nano ZnO at 500 ppm due to higher kernel yield.

The benefit : cost ratio was based on the cost of cultivation and returns from the maize cultivation. The result showed that seed priming with 800 ppm of nano ZnO for 30 minutes recorded higher B:C ratio (3.45)

Table-4 : Influence of nano zinc oxide on economics of maize production.

Treatments	Cost of cultivation (Rs. ha ⁻¹)	Gross return (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	B:C ratio
T ₁ : Seed priming with Nano ZnO @ 800 ppm for 30 minutes	29656	102368	72712	3.45
T ₂ : T ₁ + Foliar application of Nano ZnO @ 200 ppm	37219	107382	70163	2.89
T ₃ : T ₁ + Foliar application of Nano ZnO @ 300 ppm	41000	109811	68811	2.68
T ₄ : T ₁ + Foliar application of Nano ZnO @ 400 ppm	44781	120126	75345	2.68
T ₅ : T ₁ + Foliar application of Nano ZnO @ 500 ppm	48859	133636	84777	2.74
T ₆ : T ₁ + Foliar application of Nano ZnO @ 600 ppm	52344	113342	60998	2.17
T ₇ : Foliar application of ZnSO ₄ @ 0.5%	29265	95150	65885	3.25
T ₈ : Soil application of ZnSO ₄ @ 10 kg ha ⁻¹	29795	84250	54455	2.83

and it was followed by foliar application of ZnSO₄ @ 0.5% (3.25). However lower B:C ratio was recorded in seed treatment with 800 ppm of nano ZnO for 30 minutes and foliar application of nano ZnO at 600 ppm (2.17). Higher profit per rupee invested was recorded in the results showed that seed treatment with 800 ppm of nano ZnO for 30 minutes (3.45), was due to adequate kernel yield. Lower B:C ratio was observed Seed treatment with 800 ppm of nano ZnO for 30 minutes followed by foliar application of nano ZnO @ 600 ppm (2.17), because of higher cost of nano ZnO leads to lower B:C ratio.

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Genetic Studies of Grain Iron and Zinc Content in Pearl Millet (*Pennisetum glaucum* (L.) R. Br)

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Abstract

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a major warm-season cereal, grown primarily for grain production in the arid and semi-arid tropical regions of Asia and Africa. Crop biofortification is a cost-effective and sustainable agricultural strategy to reduce micronutrient malnutrition arising from iron (Fe) and zinc (Zn) deficiencies. Improving Fe and Zn densities of staple crops by breeding offers a cost-effective and sustainable solution to reducing micronutrient malnutrition in resource poor communities. In the present study eleven inbred lines and their half diallel crosses were used to study the nature of gene action and heterosis for these micronutrients. The analysis of variance of diallel progenies exhibited significant genotypic differences. The general combining ability (GCA) effects of parents and specific combining ability (SCA) effects of hybrids showed significant differences for both of the micronutrients. However, the predictability ratio PR: $2\sigma^2_{gca}/(2\sigma^2_{gca} + \sigma^2_{sca})$ (PR for Fe=1.30, Zn=1.67) was around unity both for Fe and Zn densities, implying preponderance of additive gene action. Considering the performance *per se* and GCA effects together, the high Fe/Zn parents S-12/30060, S-12/30074 and S-12/30088 was identified as the best combiner for further breeding programs. Further, highly significant positive correlation between mid-parent values and hybrid *per se* performance (Fe: $r=0.84$, Zn: $r=0.92$, $P<0.01$), and no correlation between mid-parent values and mid-parent heterosis (Fe: $r=-0.14$, Zn: $r=0.12$, $P<0.01$) confirmed again the predominant role of additive gene action for these micronutrients. The level of heterosis varied widely among hybrids both for Fe (-31.55 to 34.15 %) and for Zn (-28.13 to 25.25 %). Highest positive significant mid-parent heterosis was observed in a cross 'RHRBI 138 x S-12/30088 (1 x 11)' for both Fe and Zn densities. High Fe and Zn levels in one of the parental lines would be required to increase the probability of breeding high Fe and Zn hybrids and there would be little opportunity, if any, to exploit heterosis for these mineral micronutrients in pearl millet.

Key words : Combining ability, grain iron and zinc density, gene action, heterosis, pearl millet, *Pennisetum glaucum*.

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is one of the most important staple food crops in Asia and Africa. It is a highly cross-pollinated crop with more than 85% out crossing (Burton, 1974). This floral system provides for open-pollinated varieties (OPVs) and hybrids as the two broad cultivar options. During 2019-20, pearl millet was grown in 7.41 million ha with average production of 10.3 million tones and 1391 kg/ha productivity (Anon. 2021). The major pearl millet growing states are Rajasthan, Maharashtra, Uttar Pradesh, Gujrat and Haryana contributing to 90 % of total production in the country, Rajasthan contribute nearly 4.283 million tones, followed by Uttar Pradesh (1.302), Haryana (1.079), Gujrat (0.961), Maharashtra (0.66) and Tamil Nadu (0.084). It owns a higher quantity of slowly digestible starch (SDS) and RS that account for lower glycemic index (GI) and is much preferred in recent times of transforming diets, food habits and the food industry (Satyavathi *et al.*, 2020). Pearl millet being a climate-resilient crop along with high nutritional value can be exploited for improving nutritional quality and

combating malnutrition (Satyavathi *et al.*, 2021). It is the cheapest source of Fe and Zn micronutrients as compared to other cereals and vegetables. Cultivated pearl millet has higher levels of both micronutrients, especially Fe content, than other major cereals such as rice, wheat, maize and sorghum (Dwivedi *et al.*, 2012). Micronutrient malnutrition resulting from the dietary deficiency of minerals such as iron (Fe) and zinc (Zn) has recently been recognized as a serious human health problem, especially in the developing countries (WHO 2002). A recent study has shown that pearl millet accounts for a major share of Fe and Zn intake in some of the region of pearl millet growing areas in India and it is the cheapest source of Fe and Zn as compared to other cereals (Parthasarathy Rao *et al.*, 2006). It is a major source of mineral micronutrients in several African countries as well. Results of a preliminary study have shown large variability for grain Fe and Zn among breeding lines and populations as well as within the populations (Velu *et al.*, 2007). An understanding of the nature of gene action and heterosis would be a significant input into designing effective breeding strategies for the development of OPVs and

hybrids. There is little information available on the nature of gene action and heterosis for grain Fe and Zn densities in pearl millet. The objective of the research reported in this paper was to fill this gap and examine its implications in breeding pearl millet cultivars with high levels of grain Fe and Zn densities.

Materials and Methods

The experimental material for the present study comprised of 11 inbred lines obtained from Bajra Research Scheme, College of Agriculture, Dhule and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Telangana. These inbreds were crossed in diallel fashion to obtain F_1 's excluding reciprocals during Summer 2013. Sufficient quantity of seed for 55 cross combinations was obtained. These 55 crosses along with eleven inbreds were used to study stability during Kharif-2013, at Post Graduate Institute Farm, Mahatma Phule Krushi Vidyapeeth, Rahuri. The 66 genotypes were raised in a randomized block design with three replications and two rows (of 3.0m length) plots per replication. Standard agronomic practices were followed for raising and maintenance of plants.

Representative soil samples were collected from each plot at 15 cm depth before sowing and at harvest of crop. The collected soil samples were air dried in shade on paper sheet, gently ground in wooden mortar and pestle, mixed and sieved through 2 mm plastic sieve. The processed soil samples were used for determination of Fe and Zn on Atomic Absorption Spectrophotometer at Micronutrient laboratory, MPKV, Rahuri by DTPA (Diethylene triamine penta acetic acid) extraction method (Lindsay and Norvell, 1978). The data on available soil Fe and Zn content (mg/ kg) diethylene triamine pentaacetic acid (DTPA) in the experimental fields were average 5.98 mg/kg for Fe and 0.73 mg/kg for Zn for the field used during the 2013-Kharif season. Representative grain samples from the middle of the ear head of the plants from net plot area were collected at harvest stage. The grains were manually cleaned and care was taken to avoid any contamination of the grains with dust particles and any other extraneous matter. The samples were dried in an oven at 70°C, ground to fine powder using sample mill consisting of hard plastic and used for micronutrient analysis. A known quantity (0.2 g) of grain samples powder were digested following wet digestion of the dried grain sample material with triacid mixture HNO_3 : HClO_4 : H_2SO_4 in the ratio of 9:3:1 and this acid extract was used for determination of Fe and Zn on Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978). The estimates of general combining ability (GCA), specific combining ability (SCA) and reciprocal effects

were obtained following Griffing's method 2 model 1 (fixed model) (Griffing 1956), which included one set of F_1 's excluding reciprocals, leading to $[p(p-1)/2]$ hybrids. Significance of GCA, SCA and reciprocal effects was determined by at test (Griffing 1956) Estimate of variances due to general combining ability (σ^2_{gca}) and specific combining ability (σ^2_{sca}) were derived to get estimates of predictability ratio (PR): $2 \sigma^2_{\text{gca}} / (2 \sigma^2_{\text{gca}} + \sigma^2_{\text{sca}})$ (Baker 1978). Estimation of relative heterosis as per Fonesca and Patterson (1968).

Results and Discussion

Analysis of variance of diallel set in Kharif-2013, Rahuri environment revealed significant mean sum of squares due to treatments and its sub division (parents, hybrids and parents vs. hybrids) for both micronutrients (Table-2). The analysis of variance further revealed that the parents vs. hybrids differed significantly for Fe and Zn indicating sufficient variability among parents and hybrids. The Fe density varied from 36.47 to 116.34 mg/kg and Zn density from 23.30 to 72.17 mg/kg (Tables 3, 4). The correlation of mid-parental values and hybrid *per se* performance for Fe ($r = 0.84$; $P \leq 0.01$) and Zn ($r = 0.92$; $P \leq 0.01$), indicating high levels of consistency of the rankings of parents for environment.

Combining ability analysis : Combining ability analysis indicated highly significant mean squares due to gca and sca for both micronutrients revealing importance of both additive and non additive gene effects controlling these two micronutrients. Significant mean sum of square due to gca and sca were also reported by Velu *et al.*, (2011) and Rai *et al.*, (2012) for Fe and Zn density.

However, the magnitude of GCA mean squares was much higher than SCA mean squares for both Fe and Zn densities, implying the predominance of additive gene action for these traits. Baker (1978) suggested that the ratio of combining ability variance components ($2\sigma^2_{\text{gca}} / (2\sigma^2_{\text{gca}} + \sigma^2_{\text{sca}})$) termed as predictability ratio provides a measure of the predictability of the performance of hybrids and its progenies. The closer this ratio to unity, the greater the predictability based on GCA alone. Based on combined analysis, predictability ratio was 1.30 for Fe and 1.67 for Zn, implying preponderance of additive gene action and indicating that hybrid performance can be predicted based on GCA alone. Assessing the contribution of individual lines to hybrid performance was accomplished by comparing the GCA effects among the parents (Tables 3, 4). GCA effects were highly significant ($P \leq 0.01$) for all the parents for both Fe and Zn densities. The high Fe and Zn parents were the best general combiners having positive significant GCA

Table-1 : The parents of diallel crosses in pearl millet.

Sr. No.	Code	Inbred/parent	Source/ Origin	Fe density (mg/kg)	Zn density (mg/kg)
1.	P1	RHRBI 138	MPKV	50.12	33.57
2.	P2	RHRBI 458	MPKV	77.37	53.28
3.	P3	DHLBI 967	MPKV	49.67	33.24
4.	P4	DHLBI 731	MPKV	38.24	26.34
5.	P5	ICMB 98222	ICRISAT	87.18	65.47
6.	P6	S-12/30069	ICRISAT	44.63	28.16
7.	P7	S-12/30109	ICRISAT	46.51	30.07
8.	P8	S-12/30071	ICRISAT	38.73	34.00
9.	P9	S-12/30060	ICRISAT	97.18	63.68
10.	P10	S-12/30074	ICRISAT	119.34	68.18
11.	P11	S-12/30088	ICRISAT	101.26	70.61

Table-2 : Analysis of variance of parents, hybrids and combining ability for grain Fe and Zn densities during season Kharif-2013 at Rahuri.

	df	Grain Fe (mg/kg)	Grain Zn (mg/kg)
Analysis of variance of parents and hybrids			
Treatments	65	1433.15**	576.29**
Parents	10	2536.43**	978.63**
Hybrids	54	1255.28**	512.44**
Parents Vs. Hybrids	1	15.66*	24.53*
Error	130	6.25	12.32
Analysis of variance for combining ability			
gca	10	2518.90**	1130.61**
sca	55	106.59**	21.46**
Error	130	2.08	4.11
² gca		193.60	86.65
² sca		104.51	17.35
² gca/ ² sca		1.85	4.99
² ² gca/(² gca + ² sca)		1.30	1.67

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

effects and the parents with medium and low grain Fe and Zn densities had significant negative GCA effects.

Out of eleven parents, five inbreds viz., RHRB 458, ICMB 98222, S-12/30060, S-12/30074 and S-12/30088 registered significant and positive estimates of gca effect for both micronutrients and grouped as good general combiners. While remaining inbreds viz., RHRB 138, DHLBI 967, DHLBI 731, S-12/30069, S-12/30109 and S-12/30071 depicted negative significant gca effect and identified as poor combiners for Fe and Zn density. Similar parallelism in pearl millet has been observed by Velu *et al.*, (2011), Rai *et al.*, (2012) and Pawar *et al.* (2019).

The correlation coefficient between mean performance *per se* of parents and GCA effects was highly significant and positive for both Fe ($r = 0.98$; $P \leq 0.01$) and Zn densities ($r = 0.99$; $P \leq 0.01$), indicating that selection of lines with high Fe and/or Zn levels would be highly effective in selecting for high GCA (Fig.-1).

Considering the performance *per se* and GCA effects together, the high Fe/Zn parent 'S-12/30088' was identified as the best combiner for further breeding programs. The SCA effects in each parental combination are shown in Tables 3 and 4 for Fe and Zn, respectively. Twenty eight hybrids for Fe and thirty hybrids for Zn had significant SCA effects, indicating presence of non-additive effects. Significant positive SCA effects were observed in 21 hybrids for Fe and 12 hybrids for Zn, of which four hybrids for Fe and two hybrid for Zn had 'S-12/30088' in their parentage.

Estimates of heterosis : Highly significant positive correlation between the mid-parental values and hybrid performance *per se* ($r = 0.84$; $P \leq 0.01$ for Fe and $r = 0.92$; $P \leq 0.01$ for Zn) (Fig. 2), and no correlation between mid-parent values and mid-parent heterosis ($r = -0.14$ for Fe and $r = 0.12$ for Zn) (Fig.-3), provided additional indications of the predominant role of additive gene action for these traits. Some of the earlier studies have also reported the greater importance of additive gene action

Table-3 : Average grain Fe density (mg/kg) of parents and hybrids, and general combining ability (GCA) and specific combining ability (SCA) of diallel during Kharif-2013 in pearl millet, Rahuri.

Parents /Hybrids	1	2	3	4	5	6	7	8	9	10	11
1.	50.12 (-3.72**)	76.24**	50.97	56.57	75.12**	47.21	47.24	43.61	81.60**	85.24**	75.59**
2.	9.07**	77.37 (3.06**)	75.59**	47.85	87.28**	45.49	61.34	52.94	52.94	69.3	94.84**
3.	-4.37**	13.47**	49.67 (-8.77**)	48.64	76.32**	50.71	39.62	50.81	65.61	77.35**	64.95
4.	6.48**	-9.02**	3.61**	38.24 (-14.02**)	77.00**	36.47	48.61	41.81	53.27	75.61**	69.3
5.	1.11	6.49**	7.37**	13.30**	87.18 (9.90**)	51.91	70.81	50.34	96.19**	79.10**	104.15**
6.	-0.46	-8.96**	8.09**	-0.89	2.58	44.63 (-16.44**)	41.24	43	76.37**	56.12	62.41
7.	-7.38**	-0.05	-9.94**	4.30**	2.58	-0.65	46.51 (-9.49**)	41.34	89.39**	98.61**	59.27
8.	1.11	-3.76**	5.95**	2.2	-13.19**	5.81**	-2.80*	38.73 (-14.19**)	84.67**	87.34**	56.09
9.	-0.48	0.84	-9.83**	-16.92**	2.08	8.60**	14.67**	14.65**	97.18 (16.39**)	111.19**	86.17**
10.	-0.48	-23.20**	-3.32*	0.19	-20.24**	-16.88**	18.66**	12.09**	5.36**	119.34 (21.61**)	116.34**
11.	13.47**	8.29**	-9.78**	-0.17	10.76**	-4.65**	-14.73**	-13.21**	-13.71**	11.23**	101.26 (15.67**)

Diagonal Fe density of parents, diagonal parentheses GCA effects of parents, above diagonal Fe densities of crosses, below diagonal SCA effects of crosses.

*, **Significant at 0. 05 and 0.01 probability levels, respectively.

Table-4 : Average grain Zn density (mg/kg) of parents and hybrids, and general combining ability (GCA) and specific combining ability (SCA) of diallel during Kharif-2013 in pearl millet, Rahuri.

Parents /Hybrids	1	2	3	4	5	6	7	8	9	10	11
1.	33.57 (-4.86**)	47.61	29.13	37.52	52.24*	29.37	27.22	24.28	54.39**	56.17**	47.37
2.	4.09*	53.28 (2.43**)	47.37	32.32	60.88**	33.64	43.26	38.5	38.5	52.35*	58.88**
3.	-5.02**	5.93**	33.24 (-6.94**)	30.28	47.11	29.04	28.44	36.31	45.07	53.19*	48.67
4.	4.81*	-7.67**	-0.34	26.34 (-8.38**)	54.75**	23.3	29.33	32.67	41	53.28*	55.22**
5.	1.65	3	-1.4	7.68**	65.47 (9.51**)	43.06	47.6	41.28	64.32**	61.27**	71.45**
6.	-1.1	-4.12*	0.65	-3.65	0.49	28.16 (-10.61**)	28.39	30.22	51	40.63	48.37
7.	-5.53**	3.22	-2.23	0.1	0.49	1.4	30.07 (-8.34**)	30.28	53.69**	51.05	43.51
8.	2.97	-2.63	4.55*	2.35	-6.93**	2.13	-0.08	34.0 (-7.24**)	53.18*	57.84**	44.55
9.	3.41	2.82	-4.27*	-6.90**	-1.47	5.33**	5.75**	4.15*	63.68 (10.34**)	68.72**	65.38**
10.	3.41	-7.70**	2.51	4.05*	-5.85**	-6.37**	1.77	7.47**	0.77	68.18 (11.67**)	72.17**
11.	5.93**	-1.9	-2.74	5.26**	3.6	0.64	-6.50**	-6.55**	-3.3	2.15	70.61 (12.40**)

Diagonal Fe density of parents, diagonal parentheses GCA effects of parents, above diagonal Fe densities of crosses, below diagonal SCA effects of crosses.

*, ** Significant at 0. 05 and 0.01 probability levels, respectively.

The correlation coefficient between mean performance per se of parents and GCA effects Zn densities, $r = 0.99$; $P < 0.01$.

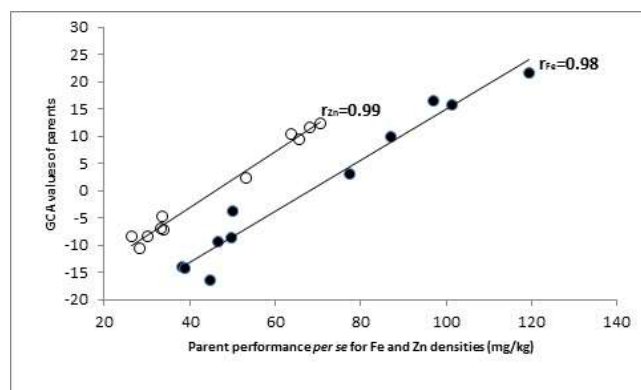


Fig-1 : Relationship between GCA values and parents performance per se for Fe (filled circles) Zn (open circles) densities (mg/kg) in pearl millet.

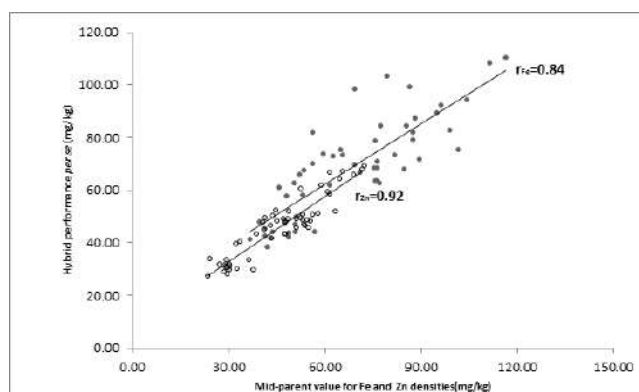


Fig-2 : Relationship between mid-parent values and hybrid performance per se for Fe (filled circles) Zn (open circles) densities (mg/kg) in pearl millet.

(GCA effects) for grain Fe and Zn densities in maize (Gorsline *et al.* 1964; Arnold and Bauman 1976; Long *et al.* 2004), rice (Gregorio 2002) and in pearl millet (Velu *et al.*, 2011; Rai *et al.*, 2012 and Pawar *et al.* (2019).

The level of heterosis varied widely among hybrids both for Fe (-31.55 to 34.15 %) (Fig.- 2a.) and for Zn (-28.13 to 25.25 %) (Fig.-2b.). Overall, average heterosis of the hybrids was negative for both Fe (-0.66%) and positive Zn (-0.30%). Among the hybrids, 42 hybrids showed significant mid-parent heterosis for Fe and 20 hybrids for Zn, of which 23 were in significant positive direction for Fe (4.35–34.15%) and 10 for Zn (10.41–25.25%). Highest positive significant mid-parent heterosis was observed in a cross 'RHRBI 138 x S-12/30088 (1 x 11)' for Fe, and 'RHRBI 138 x DHLBI 731 (1 x 4)' for Zn. Hybrids with significant mid-parent heterosis are shown in Figs. 3 a & b for Fe and Zn, respectively, and the significant heterotic hybrids were

clearly distinct from others as they were away from regression line, suggesting parents of the hybrids with significant positive mid-parent heterosis could be used as potential parents in breeding. Of the five hybrids having high grain Fe, three hybrids were derived from Low x high and one hybrid from a medium x low and one from medium x low cross combination (Table 3). Similarly for Zn, of the five hybrids having high Zn, four hybrids had one high parents and one hybrid from a medium x low parents cross (Table-4). None of the hybrids outperformed significantly the parents that had high levels of Fe and Zn, indicating that there would be little opportunity, if any, to exploit heterosis for these micronutrients. In general, higher micronutrient levels in one parental lines would be required to breed hybrids with elevated levels of grain Fe and Zn densities.

To conclude, high predictability ratios ($2^2 \text{gca} / (2^2 \text{gca} + 2^2 \text{sca})$) indicated that the expression of grain Fe and Zn densities in pearl millet is governed predominantly by additive gene effects, suggesting high effectiveness of progeny selection in pedigree selection or population breeding to develop lines and populations with increased levels of grain Fe and Zn densities. The higher additive genetic variance also prompts for recurrent selection method to improve the levels of grain Fe and Zn densities. The highly significant and positive correlation between GCA and performance per se of lines suggests that the performance per se of the genotypes could be a good indicator of its ability to transmit grain Fe and Zn densities to its hybrids and progenies; and genetically superior parents could be identified by evaluation of their Fe and Zn densities. Barring a few exceptions with one parent, none of the hybrids significantly outperformed the parents having high levels of Fe and Zn, indicating that there would be little opportunity, if any, to exploit heterosis for these micronutrients in pearl millet, and to breed high Fe and Zn hybrids would require incorporating these traits into both parental lines.

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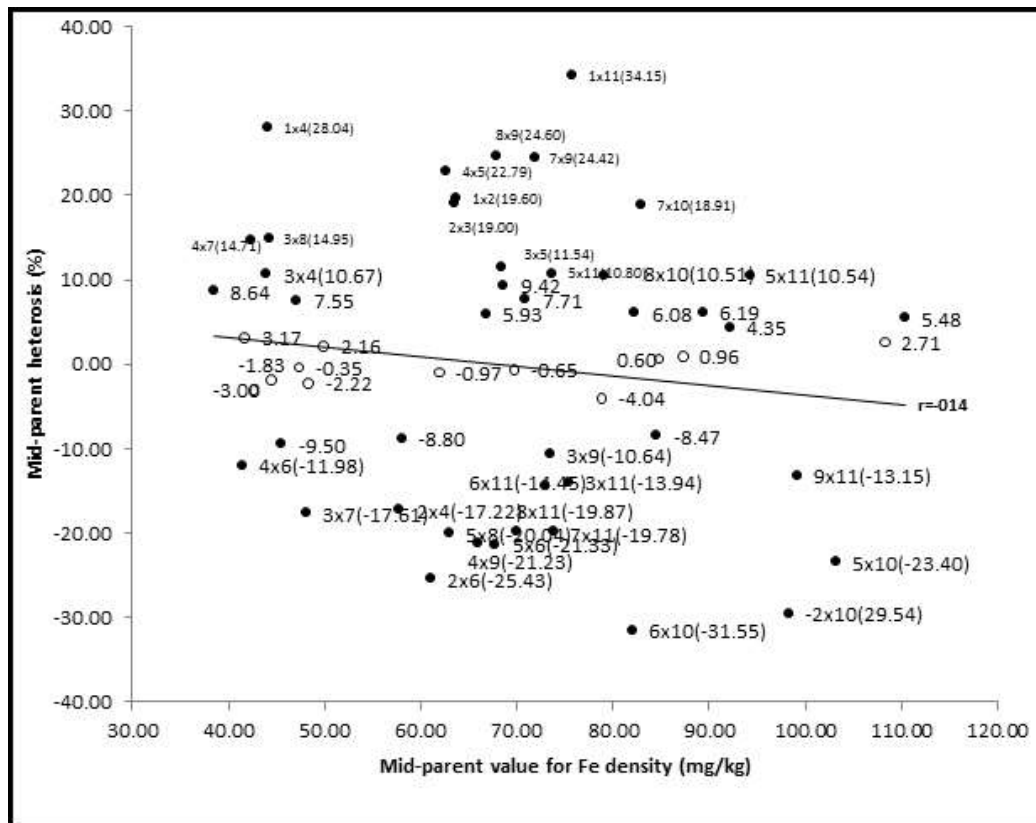


Fig-3 : (a) Relationship between mid-parent values and mid-parent heterosis for Fe density (filled circles hybrids with significant positive and negative midparent heterosis) in pearl millet.

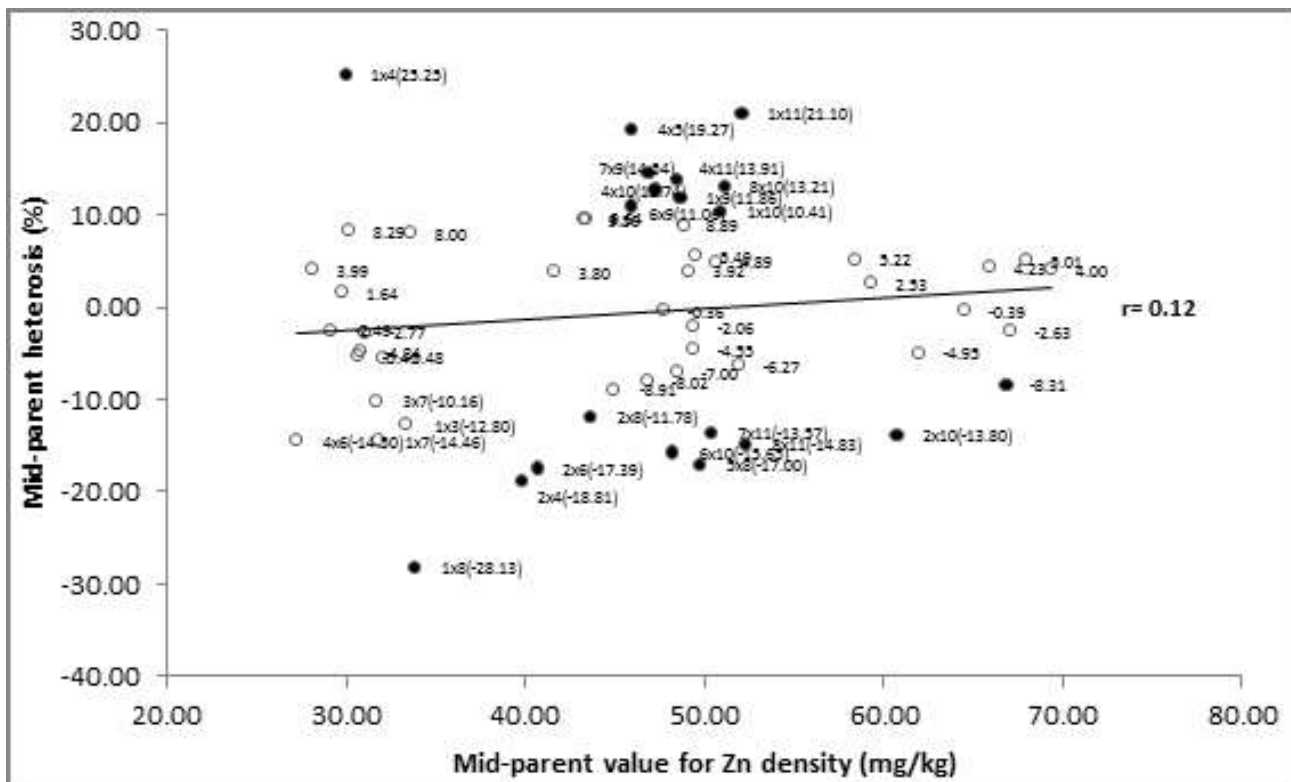


Fig-3 : (b) Relationship between mid-parent values and mid-parent heterosis for Zn density (filled circles hybrids with significant positive and negative midparent heterosis) in pearl millet.

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Effect of Gibberellic Acid on Oil Content of Safflower (*Carthamus tinctorius* L.)

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Abstract

A field experiment entitled "Effect of gibberellic acid on oil content of safflower (*Carthamus tinctorius* L.)" was undertaken during rabi season of 2020-21 at the experimental farm of All India Co-ordinated Research Project on Safflower, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.) and laboratory work for estimation of oil content was carried out at IIOR Hyderabad to evaluate Using varieties PBNS-12, PBNS-40, PBNS-86 and hybrid DSH-185. The experiment was laid out in factorial randomized block design with three treatment and two replications. The different treatments were foliar application of gibberellic acid of various concentrations viz., 100 ppm, 200 ppm, 300 ppm along with one control. Spraying was done at branching, flowering and seed filling stages of crop growth stages. Results revealed that, PBNS-86 was significantly superior for oil content and oil yield (kg/ha) than other varieties however, foliar application of 200 ppm gibberellic acid concentration showed significantly highest oil content with positive interaction. The variety PBNS-86 was significantly superior for oil yield but it was found at par with PBNS-12. GA₃ 200 ppm concentration was significantly superior for oil yield than all other concentrations.

Key words : Safflower, foliar application, gibberellic acid, oil content, oil yield.

Introduction

Safflower (*Carthamus tinctorius* L.) is a member of *asteraceae* family originated in the region spanning India, Afghanistan and Ethiopia. It is mentioned as kusumba in very old Indian scriptures but is known as kusumba in Kannada, kardai in Marathi and kusum in Hindi. The cultivated safflower is a diploid with 24 chromosomes. Subsequently, it is grown for edible oil, animal meal and bird feed, medicinal uses as a potential candidate crop for production of plant made pharmaceuticals, bio-fuel and oils (Sujatha 2007).

Safflower is one of the oldest multipurpose oil seed crops in the world traditionally. Safflower is grown for its seeds, flowers, fabric dyes, food colouring and for medicinal reasons. The natural dyes called carthamin is extracted from brilliantly coloured flowers. Safflower seeds are used for extraction of vegetable oil for consumption as well as industrial uses. The safflower oil is one of the best cooking oils due to its high level of unsaturated fatty acid content. Safflower oil crops in the world due to the favourable fatty acid composition of the oil with regard to human consumption. Rahamatalla *et al.*, (2001) found that, safflower seeds contain 35–50% oil, 15–20% protein and 35–45% hull fraction. Cosge *et al.*, (2007) reported that, safflower oil is high in linolenic acid and unsaturated fatty acid that aids the lowering of blood cholesterol levels. Besides that, the plant has gained significant interest amongst scientists as a drought-

tolerant crop which is able to obtaining moisture from levels not available to the majority of crops (Weiss 2000).

China, India, Mexico, USA, Ethiopia, Argentina and Australia are major growing safflower countries in the world. China mostly grows safflower for medicinal uses. Transgenic safflower has also been developed to produce human insulin from seeds which provides a cheaper option for meeting the global demand for human insulin (Boothe *et al.*, 2010). India contributes 0.45 lakh tones safflower production from 0.81 lakh ha area with productivity 557 kg/ha during 2017-2018. Whereas Maharashtra contributes 0.63 lakh tones safflower production from 0.18 lakh ha area with productivity 347 kg/ha. Also, Marathwada contribute 0.58 lakh tones safflower production from 0.16 lakh ha area with productivity 285 kg/ha during 2019 (Anonymous 2019).

The growth regulators are grouped under name growth promoters. They activate to root elongation, stem elongation, profused root initiation, flowering and branching (Bayder and Yuce 1996). The growth promoters also affect the quantity and quality (Raut *et al.*, 1995). Many endogenous growth hormones play active role in flowering in safflower (Ulger and Bayder 2000). While certain growth regulators grouped under growth retardant which decrease the plant height but increase yield of crop in safflower (Kene *et al.*, 1992).

The naturally occurring growth hormones like gibberellic acid is considered as growth promoting hormone in the plants. Exogenous application of

Table-1 : Mean oil content (%) as influenced by various treatments.

Treatment	Oil content (%)
Varieties	
V ₁ : PBNS-12	29.67
V ₂ : PBNS-40	30.85
V ₃ : PBNS-86	31.60
V ₄ : DSH-185	30.87
SE±	0.01
CD at 5%	0.05
Growth regulators	
T ₁ : GA ₃ 100 ppm	30.69
T ₂ : GA ₃ 200 ppm	31.79
T ₃ : GA ₃ 300 ppm	30.62
T ₄ : Control	29.88
SE±	0.01
CD at 5%	0.05
Interaction (V x T)	
SE±	0.03
CD at 5%	0.11

Table-1.1 : Mean oil content (%) as influenced by V x T interaction.

Variety/ Treatment	T ₁ (100 ppm)	T ₂ (200 ppm)	T ₃ (300 ppm)	T ₄ (control)
V ₁ : PBNS-12	29.66	30.74	29.78	28.50
V ₂ : PBNS-40	30.65	32.10	30.45	30.21
V ₃ : PBNS-86	31.65	32.42	31.79	30.55
V ₄ : DSH-185	30.80	31.92	30.47	30.29

gibberellic acid not only increases the vegetative growth but also increases the 1000 seed weight, crop yield and seed number/capitulum in sunflower (Shunkla *et al.*, 1987 and Madrap *et al.*, 1992). Gibberellic acid is a potent hormone and it has many effects regulating various physiological processes including seed germination, shoot growth, flowering, floral development and fruit set. Baydar (2002) cleared that, treating safflower plants by gibberellic acid had less oil content than the non-gibberellic acid treated plants. Khandagale *et al.*, (2009) found that foliar application of gibberellic acid at 200 ppm recorded 100-seed weight and higher number of capitula in safflower.

Gibberellic acid (GA₃) is an essential growth regulator that may have several uses to modify the growth, yield and yield contributing characters of plant (Rafeekher *et al.*, 2002). A field experiment was conducted by Baydar (2000) and reported that although fatty acid synthesis of safflower did not change with any application, oil synthesis increased significantly from 33.8% to 38.8 % with the application of 300 ppm GA₃ at the budding stage. Bibi *et al.*, (2003) reported that, increasing concentrations of GA₃ gradually improved oil content of sunflower.

Safflower oil contains the saturated fatty acids of palmitic, stearic and the unsaturated fatty acids of oleic, linoleic, linolenic. Conventional safflower seed oil has a fatty acid profile made up of 6–8% palmitic acid, 2–3% stearic acid, 16–20% oleic acid and 71–75% linoleic acid. Seed oil content and quality is influenced by various associated seed traits. For instance, hull content is an effective factor that influences the seed oil content in safflower. Safflower hull content and oil content in safflower are negatively correlated Rangarao *et al.*, (1977). Hu *et al.*, (2013) studied that oil content was negatively correlated with protein content but not correlated with fatty acid content in rapeseed.

Materials and Methods

The present experiment was undertaken during rabi season of 2020-21 at the experimental farm of All India Co-ordinated Research Project on Safflower, Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani. (M.S.) 431402 and laboratory work for estimation of oil content was carried out at IIOR Hyderabad to study effect of gibberellic acid on oil content of safflower. The soil of experiment site was medium black, clay loam, deep fertile with moderate moisture retention capacity and land having uniform topography. The experiment was laid out in factorial randomized block design with 2 replications and 12 treatment combinations. The certified seed of safflower varieties *viz.*, PBNS-12, PBNS-40, PBNS- 86 and hybrid DSH-185 was obtained from the Safflower Research Scheme, Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani. The safflower crop was sprayed with various concentrations of GA₃ 100, 200 and 300 ppm at Branching, flowering and seed filling stages of growth. Acetone and double distilled water were used to prepare the solutions of various concentrations and plot without treatment is control plot. The data were collected on various characters. About 25 gm clean seeds from each net plot were taken for calculating the oil content in per cent. The statistical analysis of safflower data was done by the method of Panse and Sukhatme (1961). Oil content in seed was estimated through NMR machine available at IIOR, Hyderabad. Oil yield was calculated by multiplying oil content and seed yield per hectare by following formula.

$$\text{Oil yield (kg/ha)} = \frac{(\text{Seed yield (kg / ha)} \times \text{Oil content (\%)})}{100}$$

Results and Discussion

Oil content (%) : The data obtained for mean oil content of seeds of the varieties is presented in the Table-1. The varieties PBNS-86 (V₃) was significantly superior for oil content (31.60 %) than the other varieties *viz.*; DSH-185 (V₄) (30.87 %) and PBNS-40 (V₂) (30.85 %). However, PBNS-12 (V₁) reported the lowest (29.67 %) oil content.

Table-2 : Mean oil yield (kg/ha) as influenced by various treatments.

Treatment	Oil yield (kg/ha)
Varieties	
V ₁ : PBNS-12	436
V ₂ : PBNS-40	366
V ₃ : PBNS-86	439
V ₄ : DSH-185	377
SE±	20.21
CD at 5%	60.81
Growth regulators	
T ₁ : GA ₃ 100 ppm	417
T ₂ : GA ₃ 200 ppm	493
T ₃ : GA ₃ 300 ppm	368
T ₄ : Control	341
SE±	20.21
CD at 5%	60.81
Interaction (V x T)	
SE±	40.42
CD at 5%	NS

All concentrations of growth regulators were found to be significant for oil content of seeds (%). GA₃ 200 ppm concentration (T₂) reported the highest oil content of seeds (31.79 %), followed by GA₃ 100 ppm concentration (T₁) (30.69 %) and GA₃ 300 ppm concentration (T₃) (30.62 %) as compared to the control which reported the lowest oil content of seeds (29.88 %). The differences amongst interaction effect were found significant for the oil content of seeds in Table-1. The interaction data of variety and treatments revealed that, variety PBNS-86 (V₃) was superior over remaining varieties to GA₃ 200 ppm concentration (T₂) (32.42%) and variety PBNS-12 (V₁) showed lowest seed oil content to control plot (28.50%).

Similar results were reported by Pramanik *et al.* (2004) taken research experiment on foliar application of gibberellic acid concentration at 50 ppm, 100 ppm, 200 ppm concentration were used at 25 days after sowing in safflower showed significantly positive results on oil content. Anton *et al.* (1995) revealed that, plants treated with gibberellic acid concentration showed increased oil content in sunflower than plants without treated with gibberellic acid concentration. Bibi *et al.* (2003) studied that, increasing concentration of gibberellic acid gradually improved oil content of sunflower.

Oil yield (Kg/ha) : The data obtained on mean oil yield (kg/ha) of the varieties is presented in the Table-2. The variety PBNS-86 (V₃) was significantly superior for oil yield (439 kg) and it was found at par with PBNS-12 (V₁) (436 kg). However, PBNS-40 (V₂) reported the lowest (366) oil yield. All concentrations of growth regulators were found to be significant for the oil yield (kg/ha). GA₃ 200 ppm

concentration (T₂) was significantly superior for oil yield (492 kg), followed by GA₃ 100 ppm concentration (T₁) (416 kg) and GA₃ 300 ppm concentration (T₃) (368.49 kg), as compared to the control (T₄) which reported the lowest (340 kg) oil yield. The differences amongst interaction effect were found non-significant for the oil yield (kg/ha). Similar results were reported by Hamza (2015) reported that, foliar application of 20 ppm, 40 ppm, 60 ppm gibberellic acid concentration showed increased oil yield in safflower. Baydar (2000) reported that, application of 300 ppm gibberellic acid concentration at the budding stage increased oil synthesis in safflower. Bibi *et al.* (2003) studied that, increasing concentration of gibberellic acid gradually improved oil content of sunflower.

Conclusions

On the basis of results, it is concluded that, PBNS-86 was significantly superior for oil content and oil yield. Foliar application of gibberellic acid concentration 200 ppm showed significantly highest oil content and oil yield.

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Effect of Gibberellic Acid on Seed Yield and Yield Contributing Characters of Safflower (*Carthamus tinctorius* L.)

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Abstract

A field experiment entitled "Effect of gibberellic acid on seed yield and yield contributing characters of safflower (*Carthamus tinctorius* L.)" was undertaken during rabi season of 2020-21 at the experimental farm of All India Co-ordinated Research Project on Safflower, Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.). Using varieties PBNS-12, PBNS-40, PBNS-86 and hybrid DSH-185. The experiment was laid out in factorial randomized block design with three treatment and two replications. The different treatments were foliar application of gibberellic acid of various concentrations viz., 100, 200, 300 ppm along with one control. Spraying was done at branching, flowering and seed filling stages of crop growth stages. Results revealed that, varieties PBNS-12 and PBNS-86 showed significant effect on yield and yield contributing characters i.e. days to 50% flowering, days to maturity, number of effective capitula per plant, number of seeds per primary capitula, capitula diameter, number of primary branches per plant, number of secondary branches per plant, test weight, volume weight, hull content, seed yield per plant, biological yield per plant, seed yield per plot, harvest index. Similarly, foliar spray of 200 ppm GA₃ significantly enhanced yield and yield contributing characters i.e. days to maturity, number of effective capitula per plant, number of seeds per primary capitula, capitula diameter, number of primary branches per plant, number of secondary branches per plant, test weight, volume weight, seed yield per plant, biological yield per plant, seed yield per plot, harvest index except days to 50% flowering and hull content showed non-significant effect. The differences amongst interaction effect were found significant for the test weight of seeds except other seed yield contributing characters.

Key words : Safflower, foliar application, gibberellic acid, seed yield, yield contributing characters.

Introduction

Safflower (*Carthamus tinctorius* L.) is a member of *asteraceae* family originated in the region spanning India, Afghanistan and Ethiopia. It is mentioned as kusumba in very old Indian scriptures but is known as kusumba in Kannada, kardai in Marathi and kusum in Hindi. The cultivated safflower is a diploid with 24 chromosomes. Subsequently, it is grown for edible oil, animal meal and bird feed, medicinal uses as a potential candidate crop for production of plant made pharmaceuticals, bio-fuel and oils (Sujatha 2007).

Gibberellic acid (GA₃) is an essential growth regulator that may have several uses to modify the growth, yield and yield contributing characters of plant (Rafeekher *et al.* 2002). Islam *et al.* (2007) studied that, gibberellic acids is one of those growth regulators that have positive effect on plant as enhancing vegetative growth, plant yield and increasing dry weight in onion. A field experiment was conducted by Baydar (2000) and reported that although fatty acid synthesis of safflower did not change with any application, oil synthesis increased significantly from 33.8 % to 38.8 % with the application of 300 ppm GA₃ at the budding stage. Potter *et al.* (1993) observed that, GA₃ increased total stem weight, but

decreased leaf weight, flower bud number and seed yield of safflower. In one more study, applying GA₃ doses increased capsule and seed yield and decreased pollen viability in poppy (Sarihan 2004; Khan *et al.* 2007). Bibi *et al.* (2003) reported that, increasing concentrations of GA₃ gradually improved oil content of sunflower.

The yield of safflower is depending on the number of capitula per plant and number of seeds per capitula, seed size (Dholekar *et al.* 2001). Different kind of growth regulators are presently used for this purpose. Generally foliar application of growth regulators is done in safflower field. This foliar application of growth regulators can be done at rosette stage, which gives beneficial results for the safflower.

Materials and Methods

The present experiment was undertaken during rabi season of 2020-21 at the experimental farm of All India Co-ordinated Research Project on Safflower, Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani. (M.S.) 431402 to study effect of gibberellic acid on seed yield and yield contributing characters of safflower. The soil of experiment site was medium black, clay loam, deep fertile with moderate moisture retention capacity and land

having uniform topography. The experiment was laid out in factorial randomized block design with 2 replications and 12 treatment combinations. The certified seed of safflower varieties viz., PBNS-12, PBNS-40, PBNS- 86 and hybrid DSH-185 was obtained from the Safflower Research Scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The safflower crop was sprayed with various concentrations of GA₃ 100, 200 and 300 ppm at branching, flowering and seed filling stages of growth. Acetone and double distilled water were used to prepare the solutions of various concentrations and plot without treatment is control plot. The data were collected on various characters. Number of days required for 50 % flowering were counted from date of sowing and average days recorded.

Number of days required from days of sowing to complete drying of plants in each entry were recorded. The number of effective capitula per plant was counted from five randomly selected plants from each row in each replication. Seeds from five capitulum were counted on each plant and number of seeds per capitulum were taken. Diameter of capitula was measured with the help of thread and measuring scale for five plants in each replication. The main effective branches on main shoot were counted as primary branches from each of the selected plants at maturity. Total number of effective branches developed from primary branches were recorded as secondary branches at maturity. The 100 seeds were collected at random from each treatment and replication separately. Weight of seeds were taken in gm using an electronic balance. Filled the seeds of safflower in a measuring cylinder or a beaker of 1 liter capacity. Recorded the weight of seeds and expressed the volume weight (gm/lit). Five gm of known seed quality was taken and seeds were soaked in water for 24 hours. Shells of the seed were separated from that wet seed and percent hull content was calculated by using following hull content formula.

$$\text{Hull content (\%)} = \frac{\text{Weight of oven dry weight}}{\text{Total weight of seeds}} \times 100$$

The capitulum of five plants of safflower were threshed separately and average weight was recorded as seed yield per plant in gm. Biological yield per plant was calculated by summation of straw yield and seed yield per plant expressed as gm/plant. All plants harvested from each plot were threshed, cleaned and seed weight per plot was counted separately in kg. The capitulum of five plants was threshed separately and average weight was recorded as seed yield per plant in gm. The statistical analysis of safflower data was done by the method of Panse and Sukhatme (1961).

Results and Discussion

Days to 50% flowering : The variety PBNS-12 (V₁) was significant for 50% flowering. PBNS -12 showed minimum (82.75) and PBNS-40 showed maximum (86.50) days to 50% flowering presented in Table.1. All concentrations of growth regulators were found to be non-significant for 50% flowering over control. All the treatment concentrations required minimum number of days for 50% flowering than control. It was observed that, GA₃ 200 ppm (T₂) was superior for minimum number of days required for 50% flowering, followed by GA₃ 100 ppm (T₁) and GA₃ 300 ppm (T₃), as compared to the control. The differences amongst interaction effect were found non-significant for 50% flowering.

Days to maturity : The variety PBNS-12 (V₁) significantly required the minimum days (129) for maturity, while PBNS- 40 (V₂) took the maximum days (135) for maturity presented in Table-1. All concentrations of growth regulators were found to be significant for days required for maturity. GA₃ 200 ppm concentration (T₂) required lowest number of days (131) for maturity, followed by GA₃ 100 ppm concentration (T₁) (132) and GA₃ 300 ppm concentrations (T₃) (133), as compared to the control which required the highest number of days for maturity (134). There was no interaction amongst the varieties and treatments.

Number of effective capitula per plant : The variety PBNS-86 (V₃) significantly reported the highest number of effective capitula per plant (31.12), followed by PBNS-12 (V₁) (30.75) and DSH-185 (V₄) (27.62) presented in Table.1. However, PBNS-40 (V₂) reported the lowest number of effective capitula per plant (24.87). All concentrations of growth regulators were found to be significant for the number of effective capitula per plant. It was observed that, GA₃ 200 ppm concentration (T₂) reported the highest number of effective capitula per plant (30.25), followed by GA₃ 100 ppm concentration (T₁) (29.62) and GA₃ 300 ppm concentration (T₃) (28.00), as compared to the control which reported the lowest number of effective capitula per plant (26.5). The differences amongst interaction effect were found non-significant for the number of effective capitula per plant. Dholekar *et al.* (2001) who found that, application of 50 ppm gibberellic acid at 30 days after sowing significantly increased number of effective capitula per plant in safflower.

Number of seeds per primary capitula : The variety PBNS-12 (V₁) had significantly the highest number of seeds per primary capitula (27.12), followed by PBNS-86(V₃) (26.50) and DSH-185 (V₄) (23.62) presented in Table-1. However, PBNS-40 (V₂) reported the lowest number of seeds per primary capitula (20.00).

Table-1 : Effect of gibberellic acid on yield and yield attributes of safflower as influenced by various treatments.

Treatment	Days to 50% flowering	Days to maturity	No. of effective Capitula /plant	Number of seeds/ Primary Capitula	Capitula diameter (mm)	Number of primary branches per plant
Varieties						
V ₁ : PBNS-12	82.75	129	30.75	27.12	7.90	9.00
V ₂ : PBNS-40	86.50	135	24.87	20.00	7.40	5.12
V ₃ : PBNS-86	83.75	131	31.12	26.50	7.61	7.00
V ₄ : DSH-185	85.37	133	27.62	23.62	7.47	5.75
SE±	0.70	0.68	1.18	0.32	0.11	0.28
CD at 5%	2.10	2.05	3.56	0.98	0.34	0.85
Growth regulators						
T ₁ : GA ₃ 100 ppm	84.12	132	29.62	25.12	7.75	7.12
T ₂ : GA ₃ 200 ppm	83.50	131	30.25	26.12	7.92	7.75
T ₃ : GA ₃ 300 ppm	85.00	133	28.00	23.62	7.43	6.12
T ₄ : Control	85.70	134	20.00	21.0	7.27	5.87
SE±	0.70	0.68	1.18	0.32	0.11	0.28
CD at 5%	(NS)	2.05	3.56	0.98	0.34	0.85
Interaction (V x T)						
SE±	1.40	1.36	2.37	0.65	0.23	0.56
CD at 5%	NS	NS	NS	NS	NS	NS

All concentrations of growth regulators were found to be significant for the number of seeds per primary capitula. It was observed that, GA₃ 200 ppm (T₂) reported the highest number of seeds per primary capitula (26.12), followed by GA₃ 100 ppm (T₁) (25.12) and GA₃ 300 ppm (T₃) (23.62), as compared to the control which reported the lowest number of seeds per primary capitula (21.00). The differences amongst interaction effect were found non-significant for the number of effective capitula per plant. Madrap *et al.* (1992) and Shunkala *et al.* (1987) reported that, application of GA₃ increases number of seeds per capitulum.

Capitula diameter (mm) : The variety PBNS-12 (V₁) significantly reported the maximum diameter (7.90 mm) while, PBNS-40 (V₄) reported the minimum diameter (7.40 mm) presented in Table.1. All concentrations of growth regulators were found to be significant for the capitula diameter. GA₃ 200 ppm concentration (T₂) reported the maximum capitula diameter (7.92 mm), followed by GA₃ 100 ppm concentration (T₁) (7.75 mm) and GA₃ 300 ppm concentration (T₃) (7.43 mm), as compared to the control which reported the minimum capitula diameter (7.27 mm). The differences amongst interaction effect were found non-significant for capitula diameter. Camas *et al.* (2005) who found that, application of gibberellic acid significantly increased capitula diameter in safflower and as capitula diameter increases seed yield also increases

Number of primary branches per plant : The variety PBNS-12 (V₁) (9.00) was found significantly superior over

all the other varieties and PBNS-40 (V₂) showed least number of primary branches (5.12) wherein, PBNS-12 showed profuse branching at all stages of crop growth. All the concentrations of growth regulators used were found superior over the control in the case of number of primary branches per plant. GA₃ 200 ppm concentration (7.75) was found to be significantly superior over all the remaining concentrations to increase the number of primary branches per plant presented in Table.1. The differences amongst interaction effect were found non-significant for number of primary branches per plant. Sarkar *et al.* (2002) reported that, application of 100 ppm and 200 ppm gibberellic acid at three different stages of crop growth showed increased number of primary branches in soybean.

Test weight (gm) : The varieties PBNS-12 (V₁) and PBNS-86 (V₃) significantly reported the similar and highest test weight of seeds (6.02 gm), among all varieties under study. However, PBNS-40 (V₄) reported the minimum test weight of seeds (5.61 gm). All concentrations of growth regulators were found to be significant for the test weight (gm). GA₃ 200 ppm concentration (T₂) reported the maximum test weight of seeds (6.23 gm), followed by GA₃ 100 ppm concentration (T₁) (6.0 gm) as compared to the control which reported the minimum test weight of seeds (5.36 gm) presented in Table.2. The differences amongst interaction effect were found significant for the test weight of seeds in Table.1. Khandagale *et al.* (2009) also reported that, application of 200 ppm gibberellic acid significantly increased 100 seed weight in safflower.

Table-2 : Effect of gibberellic acid on yield and yield attributes of safflower as influenced by various treatments.

Treatment	Test weight (gm)	Volume weight (gm/lit)	Hull content (%)	Seed yield / plant (gm)	Biological yield / plant (gm)	Seed yield (kg/plot)	Harvest index (%)
Varieties							
V ₁ : PBNS-12	6.02	573	53.25	14.65	55.70	0.912	26.17
V ₂ : PBNS-40	5.61	558	46.12	12.22	52.55	0.736	23.25
V ₃ : PBNS-86	6.02	565	50.81	14.20	54.91	0.861	25.55
V ₄ : DSH-185	5.73	565	48.31	12.61	52.65	0.757	23.85
SE±	0.03	1.49	0.92	0.43	0.90	0.04	0.71
CD at 5%	0.09	4.50	2.78	1.30	2.73	0.12	2.14
Growth regulators							
T ₁ : GA ₃ 100 ppm	6.00	568	50.68	13.82	54.91	0.845	25.10
T ₂ : GA ₃ 200 ppm	6.23	574	51.25	15.17	56.05	0.965	26.67
T ₃ : GA ₃ 300 ppm	5.80	562	48.43	12.60	52.69	0.748	23.88
T ₄ : Control	5.36	557	48.12	12.08	52.16	0.708	23.17
SE±	0.03	1.49	0.92	0.43	0.90	0.04	0.71
CD at 5%	0.09	4.50	NS	1.30	2.73	0.12	2.14
Interaction (V x T)							
SE±	0.06	2.99	1.84	0.87	1.81	0.08	1.42
CD at 5%	0.19	NS	NS	NS	NS	NS	NS

Volume weight (gm/lit) : The variety, PBNS-12 (V₁) significantly reported the highest volume weight of seeds (573 gm/lit), followed by PBNS-86 (V₃) (565 gm/lit) and DSH-185 (V₄) (565 gm/lit). However, PBNS-40 (V₂) reported the lowest volume weight of seeds (558 gm/lit) presented in Table-2. All concentrations of growth regulators were found to be significant for the volume weight of seeds (gm/lit). GA₃ 200 ppm concentration (T₂) reported the maximum volume weight of seeds (574 gm/lit), followed by GA₃ 100 ppm concentration (T₁) (568 gm/lit) and GA₃ 300 ppm concentration (T₃) (562 gm/lit), as compared to the control which reported the minimum volume weight of seeds (557 gm/lit). The differences amongst interaction effect were found non-significant for the volume weight of seeds.

Hull content (%) : The variety PBNS-12 (V₁) was significantly superior for hull content of seeds (53.25%) than the other varieties viz; PBNS-86 (V₃) (50.81%) and DSH-185 (V₄) (48.31%). However, PBNS-40 (V₂) reported the lowest hull content of seeds (46.12%) presented in Table-2. All concentrations of growth regulators were found to be significant for the hull content of seeds (%). GA₃ 200 ppm concentration (T₂) was significantly superior for hull content of seeds (51.25%), followed by GA₃ 100 ppm concentration (T₁) (50.68%) as compared to the control which reported the minimum hull content of seeds (48.12%). Baydar, H. (2000) who found that, the seeds from GA₃ treated plants have more hull content than seeds from non-GA₃ treated plants in safflower.

Seed yield per plant (gm) : The variety PBNS-12 (V₁) was significantly superior for seed yield per plant (14.65

gm) followed by PBNS-86 (V₃) (14.20 gm). However, DSH-185 (V₄) (12.61gm) and PBNS-40 (V₂) reported the at par seed yield per plant presented in Table-2. All concentrations of growth regulators were found to be significant for the seed yield per plant. GA₃ 200 ppm concentration (T₂) was significantly superior for seed yield per plant (15.17 gm), followed by GA₃ 100 ppm concentration (T₁) (13.82 gm) and GA₃ 300 ppm concentration (T₃) (12.60 gm), as compared to the control (T₄) which reported the lowest seed yield per plant (12.08 gm). The differences amongst interaction effect were found non-significant for the seed yield per plant.

Mishra *et al.* (1985) reported that, groundnut plants treated with 50 ppm gibberellic acid concentration at flowering and pegging stage significantly increased number of seeds per plant.

Biological yield per plant (gm) : All varieties were found to be non-significant for the biological yield per plant. The variety PBNS-12 (V₁) reported the highest biological yield per plant (55.70 gm), followed by PBNS-86 (54.91 gm) and DSH-185 (52.65 gm) presented in Table-2. However, PBNS-40 (V₄) reported the lowest biological yield per plant (52.55 gm). The differences amongst interaction effect were found non-significant for the biological yield per plant. Jafri *et al.*, (2015) found that, significantly enhanced the biological yield of sunflower by the application of GA seed priming with maximum stimulation followed by 8 hr soaking treatment with 10-5 MGA.

Seed yield per plot (kg/plot) : Variety PBNS-12 (V₁) was significantly superior for seed yield per plot (0.912 kg) than the other varieties viz; PBNS-86 (0.861 kg) and DSH-185

(0.757 kg). However, PBNS-40 (V_2) reported the lowest seed yield per plot (0.736 kg) presented in Table-2. All concentrations of growth regulators were found to be significant for the seed yield per plant (kg). GA_3 200 ppm concentration (T_2) was significantly superior for seed yield per plot (0.965 kg), followed by GA_3 100 ppm concentration (T_1) (0.845 kg) and GA_3 300 ppm concentration (T_3) (0.748 kg), as compared to the control which reported the lowest seed yield per plot (0.708 kg). The differences amongst interaction effect were found non-significant for the seed yield per plot (kg). Tobakh (1982) showed that, foliar application of gibberellic acid with 125 ppm concentration increased seed yield in sunflower.

Harvest index (%) : The variety PBNS-12 (V_1) was significantly superior for harvest index (26.17%) than the other varieties viz; PBNS-86 (V_3) (25.55%) and DSH-185 (V_4) (23.85%) presented in Table.2. However, PBNS-40 (V_2) reported the lowest harvest index (23.25%). All concentrations of growth regulators were found to be significant for the harvest index. GA_3 200 ppm (T_2) was significantly superior for harvest index (26.67%), followed by GA_3 100 ppm (T_1) (25.10%) and GA_3 300 ppm (T_3) (23.88%), as compared to the control which reported the lowest harvest index (23.17%). The differences amongst interaction effect were found non-significant for the harvest index. Emongor and Ndambole (2011) studied that, application of GA_3 at 7 days after emergence at 0, 100, 200 or 300 mg /L significantly increased harvest index in cow pea.

Conclusions

On the basis of results, it is concluded that, foliar application of gibberellic acid concentration 200 ppm influenced seed yield and yield contributing characters of safflower. Foliar application of gibberellic acid concentration 200 ppm showed significantly positive yield and yield contributing characters i.e. number of effective capitula/plant, number of seeds/primary capitula, capitula diameter, number of primary branches/plant, test weight, volume weight, seed yield/ plant, biological yield/plant, seed yield/plot, harvest index with PBNS-12 variety when compared to rest of treatments and control.

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Economics of Processing of Starch in North Karnataka

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Abstract

Maize belongs to family Poaceae or Gramineae. Maize is one of the most important cereal crop in the world and it provides stable food to many populations in the world. Maize is consumed directly by humans and it is also used as animal feed. Other maize products like corn syrup, corn starch, glucose and corn oil are also produced and consumed in large quantities. Based on the highest production of maize in the state, two districts namely Haveri and Belagavi were selected for the study. Proportionate sampling procedure was followed to select the processing units. Both primary and secondary data were collected from processing units. Analytical tools employed for the study were tabular analysis and rank based quotient. Around 188 persons were required to run the starch processing units with payment of salary and wages of 42,23,933 per month. Annual installed capacity in starch processing units was 1,33,2,000 quintals and total quantity processed per day was found to be 3,500 quintals. Starch processing unit had processed 10,50,000 quintals annually. Total capacity utilization was 78.82 per cent. The total cost of processing incurred to produce one quintal starch was 2,768 out of which the variable cost 2,664 (96.24%) followed by the total fixed cost with the share of 104 (3.75%) of the total processing cost. The main product obtained was 76.5 per cent and byproducts obtained were 23.50 per cent. The gross and net returns realized from processing of one quintal of maize accounted for 3,730 and 846 per quintal. High price of raw materials, lack of availability of sufficient raw materials, high moisture content of the raw material and improper quality of raw materials were the severe problems faced by processors in production of starch.

Key words : Starch, procurement, capacity utilization, cost of processing, returns and constraints

Introduction

Maize (*Zea mays*) is commonly known as corn. It is originated in Mexico region. Maize belongs to family Poaceae or Gramineae. Maize is one of the most important cereal crop in the world and it provides stable food to many populations in the world. Maize is enriched with macronutrients like fiber, starch, protein and fat along with micronutrients like Vitamin B complex, beta carotene and essential minerals like magnesium, zinc, phosphorus, copper, etc. Maize is consumed directly by humans and it is also used as animal feed. The starch is the main product of a maize processing unit, which is consumed in various other industries like food, pharmaceuticals, textiles, paper, hotels and restaurants, etc. The other products include Gluten, Germ, Fibre (husk) and Corn Steep Liquor. Gluten has great demand in animal feed industry because of its high protein content (70%). Germ is expressed to extract germ oil which is a low cholesterol containing edible oil. Fibre, mainly the husk, is used by animal feed manufacturers. It has demand in wet form itself for animal feed. Corn Steep Liquor is one of the substrates for culture media for manufacturing of antibiotics and other microbial production systems. In India, Mumbai, Delhi, Ahmedabad and Kolkata are the major markets for processed maize products. Other

important markets include Bhopal, Hyderabad, Chandigarh, Lucknow, Bangalore etc. Most of the starch manufacturers of Gujarat, Maharashtra, Punjab, etc., have their marketing offices in Mumbai. Hence, Ahmedabad and Mumbai are the major trading centres for corn starch in India. Maize occupies the fourth position among all food grains area in the country accounting for 7.23 per cent of total food grains area and 3rd position in total food grain production accounting for 9.72 per cent. (2019-20). Karnataka and Madhya Pradesh states stand first and second position in India respectively with respect to area of maize. The total area and production of maize in Karnataka state was 13.39 lakh hectares and 37.57 lakh tons respectively, which accounted for nearly 14.84 and 13.56 per cent and in Madhya Pradesh state was 12.67 lakh hectares and 41.31 lakh tons in that order, which accounted for nearly 14.04 and 14.91 per cent of area and production of maize in India, during 2019-20.

Maize processors directly market their products to the consumers like pharmaceutical industries, hotels, textiles, paper industries, etc. and through traders as well. Most of them have their marketing offices in metros and big cities for direct sale. They also sell through trading agencies as well. These traders restrict marketing of the products of one or a few companies and prefer to procure different maize products from a single supplier. Therefore,

it is advisable for a maize processor to have processing facilities for starch and its derivatives like liquid glucose, dextrose monohydrate, etc. Also, different industries require different types of starch and the processor should be able to meet their demand to compete in the market. Starch and Gluten have good export potential as well. India exports these products to Sri Lanka, South East Asian countries, Bangladesh and South Africa.

The wet milling industry in India is limited to certain pockets of Gujarat, Maharashtra, Madhya Pradesh, Punjab, Karnataka and Chattisgarh. There are about 17 wet milling units with a crushing capacity of about 3400 metric tonne of maize per day. The starch is the main product of a maize processing unit, which is consumed in various other industries like food, pharmaceuticals, textiles, paper, hotels and restaurants, etc. The other products include Gluten, Germ, Fibre (husk) and Corn Steep Liquor. Gluten has great demand in animal feed industry because of its high protein content (70%). Germ is expressed to extract germ oil which is a low cholesterol containing edible oil. Fibre, mainly the husk, is used by animal feed manufacturers. It has demand in wet form itself for animal feed. Corn Steep Liquor is one of the substrates for culture media for manufacturing of antibiotics and other microbial production systems.

Bellary and Haveri are the leading districts in North Karnataka with respect area of maize. The total area of maize in Bellary and Haveri districts was 2,03,914 and 1,91,315 hectares which accounted for nearly 23.75 and 22.28 per cent, respectively. The total production of maize in Belagavi and Haveri districts was 6,16,404 and 5,55,187 tons which accounted for nearly 24.67 and 22.22 per cent of maize production in North Karnataka, respectively during 2019-20.

Research Methodology

Based on the highest production of maize in the state, two districts namely Haveri and Belagavi were selected for the study. Based on the number of processing units involved in production of starch, proportionate sampling procedure was followed to select the production units in the study area. From both the districts two processing units were selected for the study. For evaluating the objective of the study, the required data were collected through personal interview method using well-structured and pre-tested schedule. The secondary data relating to costs and returns involved in production of value added products were obtained from processing units. These data were collected from the respective processing units situated in the study area from the books of accounts of those processing units.

Analytical Techniques Employed

Tabular analysis : Tabular analysis was followed to analyze the capacity utilization, raw materials procurement management, inventory management, human resource management, processing management, storage costs, and economics of processing of starch in the study area. The data collected were presented in tabular form to facilitate easy comparisons with the help of averages and percentages.

Rank Based Quotient : RBQ technique was adopted for studying the severity of problems faced by the respondents in production of starch. The respondents were asked to give ranks for the problems, based on severity. The data thus collected were tabulated and statistically analysed to interpret the results. The processors were asked to list the constraints faced by them in production of starch. Later on respondents were asked to rank the constraints individually. These were compiled together and Rank Based Quotient (RBQ) technique was used to quantify the data collected by Preferential Ranking Technique. For calculating the Rank Based Quotient (RBQ), the following formula was used :

$$RBQ = \frac{\sum f_i (n - 1 + i)}{N * n}$$

Wherein, f_i = number of processors and market intermediaries reporting a particular constraint under i^{th} rank

N = number of processors

n = number of constraints identified

Results and Discussion

It could be observed from the Table-1 that, the total quantity of raw materials procured by starch processing units was found to be around 10,50,000 quintals, with a each time procurement of 17,500 quintals with the periodicity of 60 times per year. As, depicted in Table-2, the quantity of raw materials stored was around 12,500 quintals per year, a decision with regard to replenishment of raw materials, forecasting and planning decision was followed in purchase of raw materials and first come first serve inventory method was followed in starch processing units. The results pertaining to the staffing pattern in the case of starch processing units is depicted in Table 3. It is evident from the table that every day 188 persons were required to run the starch processing units with payment of salary and wages of ₹ 42,23,933 per month. The labour requirement was directly proportional to the size of the unit. Similar pattern of labour usage was noticed in red gram processing units indicating higher employment generation in the study conducted by Avinash (2014) in red gram processing units in Gulberga district of

Table-1 : Pattern of procurement of raw materials in starch processing units.

Sl. No.	Particulars	Starch unit	
		Particulars	Rate of procurement (/q)
1.	Total quantity of raw materials procured in value addition and quantity procured per time (q)	Maize (10,50,000) [17,500]	2,214
2.	Source of procurement	Framers and Traders	
3.	Periodicity of procurement (per year)	60 times	
4.	Lead time (days)	3	
5.	Period of maximum procurement	Dec – Jan	
6.	Method for procurement	Open market	
7.	Mode of transportation	Lorry	

Note : 1. Figures in '()' indicate the total quantity procured in a year.

2. Figures in '[]' indicate the quantity procured per time.

Table-2 : Inventory management in starch processing units. (per year)

Sl. No.	Particulars	Starch processing units
1.	Quantity of raw material stored (q)	12,500
2.	Method of inventory management (%)	
	a. First come first serve	100
	b. First come last serve	-
	c. Demand based	-
3.	Decision with regard to replenishment of raw material (%)	
	a. As and when exhausted	-
	b. Period Replenishment	-
	c. Forecasting and planning the purchases	100

Table-3 : Human resource management in starch processing units. (per month)

Sl. No.	Staff Particulars	Starch unit		
		No.	Salaries/Wages per employee (₹)	Total
1.	Manager	07	52,857	3,69,999
2.	Technician	33	36,666	12,09,978
3.	Supervision	12	28,333	3,39,996
4.	Accountant	05	24,000	1,20,000
5.	Purchase	02	20,000	40,000
6.	Security guard	17	33,470	5,68,990
7.	Skilled labours (Men)	80	14,937	11,94,960
8.	Skilled labours (Women)	02	15,000	30,000
9.	Unskilled labours (Men)	30	11,667	3,50,010
10.	Unskilled labours (Women)	-	-	-
	Total	188		42,23,933

Table-4 : Capacity utilization in value addition process of starch processing units.

Sl. No.	Particulars	Starch unit
1.	Installed capacity per hour (q)	185
2.	Number of working days/annum	300
3.	Number of shifts/day	3
4.	Duration of each shift (hours)	8
5.	Annual installed capacity (q)	1,33,2,000
6.	Quantity processed/day (q)	3,500
7.	Annual quantity processed (q)	10,50,000
8.	Capacity utilization (%)	78.82

Table-5 : Cost of processing of maize into starch. (₹/q)

Sl. No.	Particulars	Unit	Starch		
			Price (₹/unit)	Quantity	Total (₹)
A	Variable Cost				
1.	Cost of raw material	quintal	2,214.29	1	2,214.29 (79.99)
2.	Cost of gunny bags	Rupees	12.50	2	25.00 (0.90)
3.	Electricity and water charges	Rupees	-	-	51.43 (1.85)
4.	Loading and unloading	Rupees	2.45	2	4.90 (0.17)
5.	Transportation charges	Rupees	41.90	2	83.81 (3.02)
6.	Wages for labours	Rupees	3.33	1	3.33 (0.12)
7.	Telephone charges	Rupees	-	-	0.02 (0.14)
8.	Market fee and commission	Rupees	-	-	34.76 (1.25)
9.	Repair and maintenance	Rupees	-	-	4.00 (0.14)
10.	Miscellaneous	Rupees	-	-	0.23 (0.008)
11.	Interest on working capital@10%	Rupees	-	-	242.18 (8.74)
	Total Variable Cost		-	-	2,663.95 (96.24)
B.	Fixed Cost				
1.	Depreciation on building	Rupees	-	-	0.31 (0.01)
2.	Depreciation on machinery	Rupees	-	-	1.08 (0.03)
3.	Insurance and license fee	Rupees	-	-	0.50 (0.01)
4.	Salary to permanent employees	Rupees	-	-	43.57 (1.57)
5.	Taxes	Rupees	-	-	45.71 (1.65)
6.	Interest on fixed capital@14%	Rupees	-	-	12.76 (0.46)
	Total fixed cost				103.93 (3.75)
	Total processing cost (A+B)				2,767.88 (100.00)

Note : Figures in parentheses indicate percentage to total.

Table-6 : Returns from value addition process of maize processing units.

Sl. No.	Particulars	Starch		
1.	Total quantity of raw material processed (q/annum)		10,50,000.00	
2.	Total quantity of main product obtained (q/annum)		8,16,000.00	
3.	Total quantity of by product obtained (q/annum)		2,34,000.00	
	a. Germ		52,500.00	
	b. Gluten		42,000.00	
	c. Bran		1,39,500.00	
4.	Total value of main product (lakh/annum)		32,640.00	
5.	Total value of by products (lakh/annum)		6,811.00	
6.	Total returns (4+5)		39,451.00	
A.	Total processing cost (₹/q)		2,884.35	
	Particulars	Quantity (kgs)*	Price (₹/kg)	Value (₹)
B.	Returns from main product			
	a. Starch	76.50	40.00	3,060.00
	b. Poultry feed	-	-	-
	Sub total	76.50		3,060.00
C.	Returns from by product			
	a. Germ	5.00	45.90	229.50
	b. Gluten	4.00	45.00	180.00
	c. Bran	14.50	18.00	261.00
	Sub total	23.50		670.50
	Total (B + C)	100.00		3,730.50
D.	Gross returns (₹/q)		3,730.50	
E.	Net returns (₹/q)		846	

Note : *Quantity obtained by processing one quintal of maize

Total processing cost includes processing cost, storage cost and marketing cost of processor.

Table-7 : Storage cost of value added product of maize.

Sl. No.	Particulars	Starch
1.	Quantity of value added product stored (q)	8,300
2.	Period of storage (days)	13
3.	Storage cost (Rent /q)	10.8
4.	Cost of stock maintenance (/q)	3.62
	Total storage cost (3+4)	14.47

Table-8 : Constraints faced by processors in production of starch.

Sl. No.	Constraints	Starch	
		RBQ score	Rank
1.	High price of raw material	100.00	I
2.	Lack of availability of sufficient raw material	83.33	II
3.	High moisture content of the raw material	66.67	III
4.	Improper quality of raw material	50.00	IV
5.	High market competition	33.33	V
6.	High transportation cost	16.67	VI

Karnataka, since it was handling larger quantity of raw material.

It can be observed from the Table-4 that, the installed capacity per hour in the case of starch processing units was 185 quintals, with the working of 300 days in a year. The average working hours per day was found to be 8 hours per day. Annual installed capacity in starch processing units was 1,33,2,000 quintals and total quantity processed per day was found to be 3,500 quintals. Starch processing unit had processed 10,50,000 quintals annually. Total capacity utilization was 78.82 per cent.

The details of cost of processing of maize into starch are presented in the Table-5. It could be observed from the table that the total cost of processing incurred to produce one quintal starch was ₹ 2,768 out of which the variable cost ₹ 2,664 (96.24%) followed by the total fixed cost with the share of 104 (3.75%) of the total processing cost. Among the variable cost, the raw materials cost was accounted for highest share ₹ 2,214 (79.99%) followed by interest on working capital (8.74%), transportation charges (3.02%), electricity and water charges (1.85%). The remaining items altogether accounted for only ₹ 2.64 per cent. These findings were in line with findings of Vijaylaxmi (2015) in her study on processing and marketing of maize products in Karnataka. The purchases of raw materials from far places have resulted in higher transportation costs. The researcher found that variable cost accounts more than ₹ 80.00 per cent in the cost of processing of maize products. In the total fixed cost ₹ 104 per quintal accounted for ₹ 3.75 per cent followed by taxes (1.65%), salaries to permanent employees (1.57%),

interest on fixed capital (0.46%), depreciation on machinery (0.03%), insurance and license fee (0.01%) and depreciation on building (0.01%) of the total processing cost.

The details of returns obtained from processing of maize into starch are depicted in Table-6. The total quantity of main product obtained was found to be 8,16,000 quintals out of 10,50,000 quintals of total maize processed. The total processing cost was observed to be ₹ 2,884 per quintal. The gross returns realized from processing of one quintal of maize accounted for 3,730 per quintal i.e., ₹ 3,060 per quintal were from main product (starch) indicating ₹ 76.50 per cent of recovery and ₹ 670 per quintal from byproduct of maize indicating ₹ 23.50 per cent of recovery and net returns were ₹ 846 per quintal. The byproducts obtained were germ (5%), gluten (4%) and bran (14.5%).

Annual quantity of starch stored was 8,300 quintals for period of 13 days with a storage cost of ₹ 14.47 per quintal (Table-7). The constraints faced by processor in production of starch are presented in Table 8. High price of raw materials, lack of availability of sufficient raw materials, high moisture content of the raw material and improper quality of raw materials were the severe problems faced by processors in production of starch. The availability of raw materials was less because the production of raw material in the study period was low. In order to earn more money by showing higher weight, the farmers did not maintain the required moisture content in the raw materials which they sold to the processors. To overcome this problem, the processors have to advice the farmers to maintain the minimum required moisture content and assure them that they would get better price. Improper quality of raw materials was because of adulteration in the raw material. The similar results were witnessed by Lal (2008), Naik (2009), Xess (2010), Amitkumar (2013) and Renuka (2019) in their respective study regarding the problems faced by processing units.

Conclusions

The starch processing industries are working with huge equipments and modern technologies. Human labour are required compulsorily to carry out different manual activities in the units and also the skilled employees are needed to manage the processing activities and supervise the working of labour. High price of raw materials, lack of availability of sufficient raw materials, high moisture content and improper quality of raw materials were the major problems faced by the processors in production of starch. The availability of raw materials was less because the production of raw materials in the study area was low. In order to earn more money by showing higher weight the farmers did not maintain the required moisture content in

the raw materials which they sold to the processors. To overcome this problem, the processors have to advice the farmers to maintain the minimum required moisture content and assure them that they would get better price.

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Collection, Characterization and Evaluation of Periwinkle (*Catharanthus roseus* L.) Genotypes

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Abstract

The present investigation was performed at Horticultural Research cum Instructional Farm, Department of Floriculture and Landscape Architecture and laboratory of Department of Plant Physiology, Agricultural Biochemistry and MAP's, College of Agriculture, IGKV, Raipur (Chhattisgarh), during *Rabi* season of 2020-21. Twenty one genotypes including three checks were evaluated to study their mean performance for flower yield and other yield components. The analyses of variance revealed that mean sum of squares due to genotypes were highly significant for all the traits under study. Among all the other genotypes, Nirmal recorded highest flower weight. IGPW-20-KNR-1 recorded highest flower yield per pot and flower yield. Nirmal recorded highest alkaloid content in leaves and genotype IGPW-20-JDP-4 recorded highest alkaloid content in roots. While, genotype Dhawal recorded highest primary branches, leaf blade width, dry weight of leaves, length of main root, dry weight of roots and length of corolla tube.

Key words : Periwinkle, genotypes, mean performance, flower yield, morphological characterization.

Introduction

"Periwinkle" or *Catharanthus roseus* (Family Apocynaceae), commonly known as "Nayantara" or "Sadabahar", the word *Catharanthus* derived from the Greek language meaning "pure flower". While, *roseus* means red, rose or rosy (Aruna *et al.*, 2015).

Periwinkle is one of the most important loose flower and mostly available in gardens of the every home in India. Flowers of periwinkle used for preparation of mixed flower garlands and loose flower also used for daily worship. Periwinkle mostly planted in the pots and some time on the flower beds.

Neoplasma was treated by using Vinblastine sulphate commercially and also recommended for generalized Hodgkin's disease and resistant choiocarcinoma, diabetes, hypertension, tuberculosis, laryngitis, sore throat, dyspepsia, malaria was early treated and also to regulate menstruation by using the plant (Moreno *et al.*, 1993; Soo-Young Lee *et al.*, 2003).

Materials and Methods

The present investigation was performed at Horticultural Research cum Instructional Farm, Department of Floriculture and Landscape Architecture and laboratory of Department of Plant Physiology, Agricultural Biochemistry and MAP's, College of Agriculture, IGKV, Raipur (Chhattisgarh), during *Rabi* season of 2020-21.

The investigation consists of total twenty one periwinkle genotypes. The experiment was laid out in completely randomized design (CRD) having two replications. Cement pots with drainage holes at the bottom were used for each plant. Following which all the cultural practices were carried out as recommended. Observations were recorded on each plant for various characters viz. plant height (cm), plant spread (E-W) (cm), plant spread (N-S) (cm), primary branches, secondary branches, internodal length (cm), leaf blade length (cm), leaf blade width (cm), dry weight of leaves (g), flower diameter (cm), length of corolla tube (cm), number of siliqua per plant, length of siliqua (cm), number of roots per plant, length of main root (cm), dry weight of roots (g), alkaloid content in leaves (%), alkaloid content in roots (%), biomass yield (g), flower weight (g) and flower yield Kg ha⁻¹. The data recorded were statistically analyzed as per the model by Gomez and Gomez (1984).

Results and Discussion

The analysis of variance of the observations indicated that the mean sum of squares due to genotypes were highly significant for most of the studied characters except number of seeds per siliqua and are presented in table-1 and table-2.

The genotypes recorded significant variation for all the characters under observations. The highest mean of plant height was recorded in genotype Prabhal and least

Table-1 : Analysis of quantitative data.

Characters	Min	Max	Range	Sum	Mean	S.E. (m)	C.D.	C.V%
Plant height (cm)	20.75	70.22	49.47	1597.88	33.30	2.52	7.36	14.25
Plant spread (E-W) (cm)	18.43	32.15	13.72	1178.37	24.55	2.33	6.81	13.53
Plant spread (N-S) (cm)	19.55	34.58	15.03	1204.13	25.09	1.92	5.60	11.61
Primary branches	5.00	22.00	17.00	406.40	8.47	0.70	2.03	13.57
Secondary branches	4.00	41.00	37.00	409.50	8.53	0.67	1.96	23.73
Internodal length (cm)	1.25	2.88	1.63	94.25	1.96	0.20	0.59	17.78
Leaf blade length (cm)	4.13	7.65	3.52	250.44	5.22	0.60	1.74	19.90
Leaf blade width (cm)	1.90	3.66	1.76	116.98	2.44	0.18	0.54	9.32
Dry weight of leaves (g)	1.20	7.67	6.47	140.27	2.92	0.30	0.88	14.50
Flower diameter (cm)	2.35	5.54	3.19	171.87	3.58	0.27	0.80	12.05
Length of corolla tube (cm)	2.03	3.40	1.37	114.85	2.39	0.19	0.55	11.23
Number of siliquae per plant	19	63.54	44.54	2166.93	45.14	4.84	14.12	12.38
Length of silique (cm)	1.60	3.32	1.72	108.03	2.25	0.19	0.54	13.37
Number of seeds per silique	17.75	22.10	4.35	923.80	19.25	1.05	3.08	8.06
Number of roots per plant	7.00	28.00	21.00	631.00	13.15	1.05	3.05	12.33
Length of main root (cm)	7.00	70.00	63.00	764.50	15.93	0.73	2.12	9.47
Dry weight of roots (g)	0.28	2.95	2.7	41.67	0.87	0.06	0.18	17.81
Alkaloid content in leaves (%)	2.35	6.78	4.43	187.68	3.91	0.08	0.23	3.91
Alkaloid content in roots (%)	2.41	7.70	5.29	227.52	4.74	0.05	0.14	0.80
Biomass yield (g)	2.50	18.85	16.35	320.06	6.67	0.49	1.42	13.17
Flower weight (g)	1.42	1.89	0.47	81.97	1.71	0.08	0.23	6.29
Flower yield Kg ha ⁻¹	151.00	639.50	488.50	14854.00	309.46	15.64	45.64	8.46

Table-2 : Mean performance of quantitative characters.

Characters	Mean sum of square	
	Treatments	Error
d.f.	23	46
Plant height (cm)	285.52*	12.72
Plant spread (E-W) (cm)	25.61*	10.88
Plant spread (N-S) (cm)	27.05*	7.36
Primary branches	30.70*	0.97
Secondary branches	240.92*	0.90
Internodal length (cm)	0.38*	0.08
Leaf blade length (cm)	2.33*	0.71
Leaf blade width (cm)	0.28*	0.07
Dry weight of leaves (g)	4.76*	0.18
Flower diameter (cm)	0.99*	0.15
Length of corolla tube (cm)	0.21*	0.07
Number of siliquae per plant	205.60*	46.80
Length of silique (cm)	0.42*	0.07
Number of seeds per silique	3.63	2.22
Number of roots per plant	62.06*	2.19
Length of main root (cm)	313.21*	1.06
Dry weight of roots (g)	1.04*	0.007
Alkaloid content in leaves (%)	0.015*	0.00
Alkaloid content in roots (%)	0.031*	0.00
Biomass yield (g)	125.53*	0.48
Flower weight (g)	0.05*	0.01
Flower yield Kg ha ⁻¹	29846.82*	488.96

Note : *Significant at 5% and **Significant at 1%.

was recorded in genotype IGPW-20-RGH-3. Superior plant spread (E-W) noted in genotype IGPW-20-MSD-1 and least mean noted in genotype IGPW-20-RP-4 and IGPW-20-RJN-3. Superior plant spread (N-S) noted in genotype IGPW-20-BLD-1 and least mean noted in genotype IGPW-20-RP-4. The greatest primary branches noted in Dhawal and least in IGPW-20-RP-5 and IGPW-20-JDP-1. The greatest secondary branches noted in Prabal and least in IGPW-20-RP-4, IGPW-20-RGH-1, IGPW-20-RGH-2, IGPW-20-RGH-3, IGPW-20-RGH-5 and IGPW-20-JDP-1. The highest plant internodal length noted in genotype IGPW-20-RP-4 and least in genotype Dhawal. Superior leaf blade length noted in genotype IGPW-20-MSD-1 and least mean noted in genotype IGPW-20-RGH-3. Superior leaf blade width noted in genotype Dhawal and least mean noted in genotype IGPW-20-JDP-4. The greatest dry weight of leaves noted in Dhawal and least in IGPW-20-RGH-1. The greatest number of siliquae per plant noted in IGPW-20-MSD-1 and least in Nirmal. The highest length of silique noted in genotype Prabal and least in genotype IGPW-20-JDP-2. Superior number of seeds per silique noted in genotype IGPW-20-RJN-1 and least mean noted in genotype IGPW-20-RP-2 and IGPW-20-BLD-1. The greatest number of roots per plant noted in Prabal and least in IGPW-20-RP-5. The greatest length of main root noted in Dhawal and least in IGPW-20-JDP-3. The highest dry weight of roots noted in genotype Dhawal and least in genotype IGPW-20-AMBK-1. Superior alkaloid content in leaves noted in genotype Nirmal and least mean noted in

Table-3 : Morphological description of qualitative characteristics.

S. No.	Genotypes	Plant growth habit	Anthocyanin pigmentation	Leaf shape	Leaf lamina margin
1.	IGPW-20-RP-1	Semi-erect	Present	Linear	Entire
2.	IGPW-20-RP-2	Semi-erect	Present	Elliptic	Wavy
3.	IGPW-20-RP-3	Semi-erect	Absent	Elliptic	Entire
4.	IGPW-20-RP-4	Spreading	Present	Elliptic	Entire
5.	IGPW-20-RP-5	Erect	Present	Linear	Wavy
6.	IGPW-20-RGH-1	Semi-erect	Absent	Elliptic	Entire
7.	IGPW-20-RGH-2	Semi-erect	Absent	Linear	Entire
8.	IGPW-20-RGH-3	Semi-erect	Present	Oblong	Wavy
9.	IGPW-20-RGH-4	Semi-erect	Present	Linear	Wavy
10.	IGPW-20-RGH-5	Semi-erect	Present	Oblong	Wavy
11.	IGPW-20-JDP-1	Semi-erect	Present	Linear	Entire
12.	IGPW-20-JDP-2	Spreading	Present	Elliptic	Entire
13.	IGPW-20-JDP-3	Spreading	Present	Linear	Wavy
14.	IGPW-20-JDP-4	Semi-erect	Present	Linear	Entire
15.	IGPW-20-RJN-1	Spreading	Present	Linear	Entire
16.	IGPW-20-RJN-2	Semi-erect	Present	Linear	Wavy
17.	IGPW-20-RJN-3	Spreading	Present	Elliptic	Entire
18.	IGPW-20-AMBK-1	Semi-erect	Present	Oblong	Entire
19.	IGPW-20-BLD-1	Semi-erect	Absent	Linear	Wavy
20.	IGPW-20-KNR-1	Semi-erect	Absent	Linear	Wavy
21.	IGPW-20-MSD-1	Semi-erect	Absent	Elliptic	Wavy
22.	Nirmal	Erect	Absent	Oblong	Entire
23.	Dhawal	Semi-erect	Absent	Oblong	Entire
24.	Prabal	Erect	Present	Oblong	Entire

genotype IGPW-20-MSD-1. The greatest alkaloid content in roots noted in IGPW-20-JDP-4 and least in IGPW-20-MSD-1. The highest biomass yield noted in genotype Dhawal and least in genotype IGPW-20-AMBK-1. The flower diameter of periwinkle noted highest mean in genotype Nirmal and least in genotype IGPW-20-RP-2. The utmost length of corolla tube noted in genotype Dhawal and least in genotype IGPW-20-RGH-2 and IGPW-20-RGH-4. The flower weight of periwinkle noted highest mean in genotype Nirmal and least in genotype IGPW-20-RP-5. The utmost flower yield per ha noted in genotype IGPW-20-KNR-1 and least in genotype Prabal.

The results of morphological characterization and grouping of periwinkle genotypes on the basis of qualitative and quantitative characteristics which were carried out as per DUS guidelines of periwinkle by PPV & FRA (2011) discussed in Table-3 and Table-4.

Conclusions

As per the results obtained through present investigation, it can be concluded that estimates of mean sum of

squares were significant for all the characters under study. The analysis of mean performances of genotypes for various characters revealed that genotype Nirmal recorded highest flower weight (1.89 g). IGPW-20-KNR-1 recorded highest flower yield per pot (13.75 g) and flower yield (639.50 kg/ha). Nirmal recorded highest alkaloid yield in leaves (6.78 %) and genotype IGPW-20-JDP-4 recorded highest alkaloid yield in roots (7.70 %). While, genotype Dhawal recorded highest primary branches (22), leaf blade width (3.66 cm), dry weight of leaves (7.67 g), length of main root (70 cm), dry weight of roots (2.95 g) and length of corolla tube (3.40 cm).

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Table-4 : Morphological description of quantitative growth characteristics.

S. No.	Genotypes	Plant height	Plant spread	Primary branches	Secondary branches	Internodal length	Leaf blade length	Leaf blade width	Length of siliqua	Number of seeds per siliqua	Length of main root	Dry weight of roots	Alkaloid content in leaves	Alkaloid content in roots
1.	IGPW-20-RP-1	Short	Medium	Low	Low	Medium	Medium	Medium	Long	Low	High	Low	High	High
2.	IGPW-20-RP-2	Short	Medium	Low	Low	Medium	Short	Medium	Short	Low	High	Low	High	High
3.	IGPW-20-RP-3	Short	Narrow	Low	Low	Medium	Short	Medium	Long	Low	High	Low	High	High
4.	IGPW-20-RP-4	Short	Narrow	Medium	Low	Long	Long	Medium	Long	High	High	Low	High	High
5.	IGPW-20-RP-5	Short	Medium	Low	Low	Medium	Short	Medium	Short	Low	High	Low	High	High
6.	IGPW-20-RGH-1	Short	Medium	Low	Low	Medium	Short	Medium	Short	Low	High	Low	High	High
7.	IGPW-20-RGH-2	Short	Medium	Low	Low	Medium	Short	Medium	Short	Low	High	Low	High	High
8.	IGPW-20-RGH-3	Short	Medium	Low	Low	Medium	Short	Medium	Long	Low	High	Low	High	High
9.	IGPW-20-RGH-4	Short	Medium	Low	Low	Medium	Short	Medium	Long	Low	High	Low	High	High
10.	IGPW-20-RGH-5	Short	Medium	Low	Low	Medium	Short	Medium	Short	Low	High	Low	High	High
11.	IGPW-20-JDP-1	Short	Medium	Low	Low	Medium	Short	Medium	Short	Low	High	Low	High	High
12.	IGPW-20-JDP-2	Short	Medium	Low	Low	Medium	Short	Medium	Short	Low	High	Low	High	High
13.	IGPW-20-JDP-3	Short	Medium	Low	Low	Medium	Short	Medium	Long	Low	Low	Low	High	High
14.	IGPW-20-JDP-4	Short	Medium	Low	Low	Medium	Short	Narrow	Short	Low	High	Low	High	High
15.	IGPW-20-RJN-1	Short	Medium	Medium	Low	Long	Medium	Medium	Long	High	High	Low	High	High
16.	IGPW-20-RJN-2	Short	Medium	Low	Low	Medium	Long	Medium	Long	High	High	Low	High	High
17.	IGPW-20-RJN-3	Short	Medium	Low	Low	Long	Long	Medium	Long	High	High	Low	High	High
18.	IGPW-20-AMBK-1	Short	Medium	Low	Low	Long	Short	Medium	Long	Low	High	Low	High	High
19.	IGPW-20-BLD-1	Short	Medium	Low	Low	Medium	Long	Medium	Long	Low	High	Low	High	High
20.	IGPW-20-KNR-1	Short	Medium	Low	Low	Long	Short	Medium	Long	Low	High	Low	High	High
21.	IGPW-20-MSD-1	Short	Medium	Low	Low	Long	Long	Broad	Long	Low	High	Low	High	High
22.	Nirmal	Medium	Medium	Medium	Medium	Long	Medium	Medium	Long	High	High	Low	High	High
23.	Dhawal	Medium	Medium	Medium	Medium	Medium	Long	Broad	Long	High	High	Low	High	High
24.	Prabal	Medium	Medium	Medium	High	Long	Medium	Medium	Long	High	High	Low	High	High

Plate-1 : Description of flower colour by means of RHS colour chart [DUS guideline Periwinkle (PPV&FRA in 2011)].

Genotypes	Colour of petal	Colour of base of petal	Colour of eye zone	Genotypes	Colour of petal	Colour of base of petal	Colour of eye zone
IGPW-20-RP-1	 N57B	 White D	 Brilliant yellow A	IGPW-20-JDP-3	 NN74 B	 NN74 A	 N57 B
IGPW-20-RP-2	 White C	 N66 A	 N66 A	IGPW-20-JDP-4	 White C	 N66 A	 N66 A
IGPW-20-RP-3	 NN155D	 NN155D	 6 C	IGPW-20-RJN-1	 NN74 C	 N57 B	 50 A
IGPW-20-RP-4	 NN74 C	 N57 B	 50 A	IGPW-20-RJN-2	 45 C	 NN155 B	 8A
IGPW-20-RP-5	 NN74 B	 NN155 C	 1 C	IGPW-20-RJN-3	 NN74 C	 N57 B	 60 A
IGPW-20-RGH-1	 NN155 D	 NN155 D	 6 C	s	 45 C	 NN155 B	 8 A
IGPW-20-RGH-2	 62 C	 62 C	 4 C	IGPW-20-BLD-1	 59 A	 59 A	 4 B

Plate-1 : Contd.....

Genotypes	Colour of petal	Colour of base of petal	Colour of eye zone	Genotypes	Colour of petal	Colour of base of petal	Colour of eye zone
IGPW-20-RGH-3	 White C	 N66 A	 N66 A	IGPW-20-KNR-1	 59 A	 59 A	 4 B
IGPW-20-RGH-4	 N57 B	 White D	 4 A	IGPW-20-MSD-1	 59 A	 59 A	 59 A
IGPW-20-RGH-5	 62 B	 67 A	 67 A	Nirmal	 NN155 D	 NN155 D	 6 C
IGPW-20-JDP-1	 59A	 59 A	 8 B	Dhawal	 NN155 D	 NN155 D	 6 C
IGPW-20-JDP-2	 NN74 A	 NN74 A	 N57 B	Prabal	 White C	 White C	 N66A

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A Study on Knowledge Level of Maize Growers About Recommended Maize Production Technologies in Koppal District of Karnataka

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Abstract

The present investigation was conducted in Koppal district of Karnataka state with an objective to analyse knowledge level of the maize growers regarding recommended maize production technologies. Ex-post facto research design was followed for the study and the data were collected by personally interviewing the selected 120 respondents with the help of structured interview schedule. Results of the study revealed that 41.67 per cent small farm maize growers had medium knowledge followed by low (30.00 %) and high (28.33 %) knowledge level with respect to maize production, respectively. Whereas exactly half (50.00 %) of the big farm maize growers had high knowledge level. While 33.33 per cent and 16.67 per cent of the growers had medium and low knowledge level. With reference to the pooled data large number of maize growers had high (39.17 %) knowledge level with respect to maize production followed by medium (37.50 %) and low (23.33 %) respectively. Better knowledge of respondents could be attributed by their social participation and their willingness to gather more information regarding improved agricultural practices.

Introduction

Maize is one of the most important cereal crops in India. It has very high yield potential and it is called as “Queen of the cereals”. Maize is versatile crop grown over a range of agro-climatic zones. Maize is principally a rainy season crop but grown in all three seasons: Kharif, Rabi and Summer. In a country like India, where majority of the population depends on vegetarian diet, maize offers a good source of energy. Maize has a great importance as a food and fodder crop for human as well as animal and it is also useful for industrial purposes. Maize crop furnishes huge quantities of green fodder, grown throughout the year and can be fed to cattle at any stage of growth. Sweet corn as fodder for milch animal increases fat percentage in the milk. In industrial production or manufacture of starch, syrup, alcohol, acetic acid, glucose, sugar, milk, paper, rayon, plastic, textile, adhesive, dyes, synthetic rubber, raisins, artificial leather and shoe polish etc.. The acreage under maize crop increased, but as compared to acreage, the yield has not been increased. The average yield after following all the recommended practices is expected to be 45 to 50 q/ha, (Annual report 2019, AICRP on Maize) but average productivity of maize crop in Karnataka in general and Koppal district in particular is low mainly because of non-adoption or low adoption and low knowledge about recommended cultivation practices of maize by the farmers. There is a need to increase maize yield, it is therefore, necessary to create awareness among farmers about improved cultivation practices and motivate them for adoption of recommended improved cultivation practices. The present research paper focuses on the

knowledge level of maize growers regarding recommended production technologies. Which was actually studied in the main research study. The main study is on the knowledge level, yield gap and extent of adoption of recommended production technologies by maize growers would provide better insight into constraints faced and suggestions made by them which would help in improvement of extent of adoption of new production technologies for increasing production and productivity of maize.

Research Methodology

Koppal district was selected purposively, because of its highest area under maize cultivation. It is one of the major producers of maize in Karnataka and also maize cultivation is being taken up in almost all the taluks of the district. Koppal district has seven taluks, out of which Koppal and Yalburga taluks were selected purposively considering the highest area and production. “Ex-post facto” research design was used in the present investigation. The data collection was done by personal interview method with the help of the structured interview schedule. The data collected from all the respondents were coded, scored and tabulated. Keeping in view of the objectives of the study, the data were subjected to different statistical measures and software was used for analysis.

Results and Discussion

Knowledge level of small and big farm maize growers about recommended maize production technologies : The data in Table-1 shows that, cent per cent of both small and

Table-1 : Knowledge level of small and big farm maize growers about recommended maize production technologies. (n=120)

Sl. No.	Recommended technologies	Small farm maize growers (n ₁ =60)				Big farm maize growers (n ₂ =60)			
		Correct Knowledge		Incorrect Knowledge		Correct Knowledge		Incorrect Knowledge	
		f	%	f	%	f	%	f	%
1.	Land preparation	60	100.00	00	00.00	60	100.00	00	00.00
2.	Time of sowing	60	100.00	00	00.00	60	100.00	00	00.00
3.	Recommended maize hybrids/varieties	05	08.33	55	91.67	17	28.33	43	71.67
4.	Recommended Seed rate	56	93.33	04	06.67	60	100.00	00	00.00
5.	Seed treatment with insecticide/fungicide	07	11.67	53	88.33	07	11.67	53	88.33
6.	Seed treatment with biofertilizer	01	01.67	59	98.33	03	05.00	57	95.00
7.	Spacing	53	88.33	07	11.67	56	93.33	04	06.67
8.	Intercultivation	60	100.00	00	00.00	60	100.00	00	00.00
9.	Nutrient management								
	a. FYM	47	78.33	13	21.67	53	88.33	07	11.67
	b. Basal dose application	07	11.67	53	88.33	11	18.33	49	81.67
	c. Top dressing	05	08.33	55	91.67	08	13.33	52	86.67
10.	Application of Micronutrient	20	33.33	40	66.67	26	43.33	34	56.67
11.	Thinning	58	96.67	02	03.33	60	100.00	00	00.00
12.	Inter cropping	60	100.00	00	00.00	60	100.00	00	00.00
13.	Crop rotation	60	100.00	00	00.00	58	96.67	02	03.33
14.	Chemical weed management	11	18.33	49	81.67	16	26.67	44	73.33
15.	Army worm management	36	60.00	24	40.00	47	78.33	13	21.67
16.	Turcicum leaf blight management	27	45.00	33	55.00	39	65.00	21	35.00
17.	Mechanization for harvesting and threshing	49	81.67	11	18.33	57	95.00	03	05.00
18.	Timely harvesting and threshing	60	100.00	00	00.00	60	100.00	00	00.00

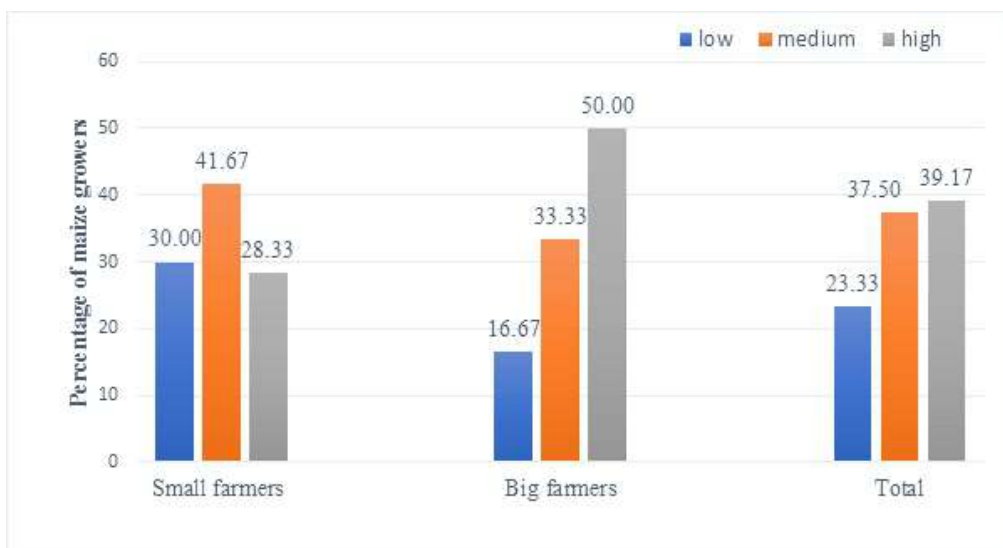
Table-2 : Knowledge level of maize growers about recommended maize production technologies. (n=120)

Sl. No.	Recommended technologies	Maize growers (n=120)			
		Correct Knowledge		Incorrect Knowledge	
		f	%	f	%
1.	Land preparation	120	100.00	00	00.00
2.	Time of sowing	120	100.00	00	00.00
3.	Recommended maize hybrids/varieties	22	18.33	98	81.67
4.	Recommended Seed rate	116	96.67	04	03.33
5.	Seed treatment with insecticide/fungicide	14	11.67	106	88.33
6.	Seed treatment with biofertilizer	04	03.33	116	96.67
7.	Spacing	109	90.83	11	09.17
8.	Intercultivation	120	100.00	00	00.00
9.	Nutrient management				
	a. FYM	100	83.33	20	16.67
	b. Basal dose application	18	15.00	102	85.00
	c. Top dressing	13	10.83	107	89.17
10.	Application of Micronutrient	46	38.33	74	61.67
11.	Thinning	118	98.33	02	01.67
12.	Inter cropping	120	100.00	00	00.00
13.	Crop rotation	118	98.33	02	01.67
14.	Chemical weed management	27	22.50	93	77.50
15.	Army worm management	83	69.17	37	30.83
16.	Turcicum leaf blight management	66	55.00	54	45.00
17.	Mechanization for harvesting and threshing	106	88.33	14	11.67
18.	Timely harvesting and threshing	120	100.00	00	00.00

Table-3 : Overall Knowledge level of small and big farm maize growers about recommended maize production technologies. (n=120)

Knowledge level	Small farm maize growers (n ₁ = 60)		Big farm maize growers (n ₂ = 60)		Total (n = 120)	
	f	%	f	%	f	%
Low (<10.27)	18	30.00	10	16.67	28	23.33
Medium (10.27-12.71)	25	41.67	20	33.33	45	37.50
High (> 12.71)	17	28.33	30	50.00	47	39.17

Mean = 11.49 SD = 2.44

**Fig-1. : Overall Knowledge level of small and big farm maize growers about recommended maize production technologies.**

big farm maize growers had correct Knowledge about the practices like land preparation, time of sowing, intercultivation, intercropping, timely harvesting and threshing. Majority of both small and big farm maize growers had correct knowledge about practices like thinning (96.67 % and 100.00 %) followed by crop rotation (100.00 % and 100.00 %), recommended seed rate (93.33 % and 100.00%), spacing (88.33 % and 93.33 %), mechanization for harvesting and threshing (81.67 % and 96.00 %), application of FYM (78.33 % and 88.33), Army worm management (78.33 % and 60.00%) and Turicum leaf blight management (65.00% and 45.00%) respectively.

Whereas significant percentage of small and big farm maize growers possess incorrect knowledge about the following practices like seed treatment with biofertilizer (98.33 % and 95.00 %) followed by seed treatment with fungicide (88.33 % and 88.33 %), topdressing (91.67 % and 86.67 %), basal dose application (88.33 % and 81.67 %), chemical weed management (81.67% and 73.33%) and application of micronutrients (66.67 % and 56.67 %). However big farm maize growers had better knowledge about recommended production technologies compared to small farm maize growers.

Knowledge level of maize growers about recommended maize production technologies : The data in Table-2 indicates that with reference to the pooled data of total maize growers, cent per cent of maize growers had correct Knowledge about the practices like land preparation, time of sowing, intercultivation, intercropping and timely harvesting and threshing. Whereas majority of maize growers had correct knowledge about practices like thinning and crop rotation (98.33%) followed by recommended seed rate (96.67%), spacing (90.83%), mechanization for harvesting and threshing (88.33%), application of recommended quantity of FYM (83.33%), army worm management (69.17%) and turicum leaf blight management (55.00%).

Majority of the maize growers had incorrect knowledge about the practices like seed treatment with biofertilizer (96.67%) followed by topdressing (89.17%), basal dose application (85.00 %), seed treatment with fungicide (83.33%), chemical weed management (77.50 %), application on micronutrients (61.67%) and turicum leaf blight management (45.00%). The possible reason for incorrect knowledge may be due to lack of awareness about importance of seed treatment, basal dose application of nutrients and topdressing, micronutrients application. Other possible reasons may be lack of

conviction and motivation to learn about improved production technologies by maize growers.

Overall Knowledge level of small and big farm maize growers about recommended maize production technologies : A close look at Table-3 reveals that, more than two-fifth of small farm maize growers had medium (41.67 %) knowledge level with respect to maize production followed by low (30.00 %) and high (28.33 %) knowledge level with respect to maize production, respectively. The above trend is due to medium extension contact, extension participation, and scientific orientation of Small farm maize growers with agricultural officers. The findings are in accordance with the studies of Kothari *et al.* (2010) and Raut (2014).

Exactly half (50.00%) of the big farm maize growers had high knowledge level. While 33.33 per cent and 16.67 per cent of the growers had medium and low knowledge level respectively. Better knowledge of big farm maize growers could be attributed to their respective educational level, annual income, mass media exposure, extension participation and social participation of the big farm maize growers and their willingness to gather more information regarding improved agricultural practices than the small farm maize growers. The findings are in accordance with the studies of Chouhan (1994) and Biradar (2012).

With reference to the pooled data large number of maize growers had high (39.17%) knowledge level with respect to maize production followed by medium (37.50%) and low (23.33%) respectively (fig1). Better knowledge of respondents could be attributed by their social participation and their willingness to gather more information regarding improved agricultural practices. The findings are in accordance with the studies of Thiagarajan (2011) and Biradar (2012).

Conclusions

In order to harvest better yield of the crop, adoption of recommended production technologies by the maize growers is essential. Even with the advancement of improved technology in maize cultivation, it has been observed that either the same has not reached to the field or farmers are reluctant to use this technology. The

recommended maize production technologies are being communicated to the maize growers through various extension programmes and activities. However, a wide gap still exists between available technologies and their adoption by the maize growers. Thus, technological gap seems to be a major problem in the way of increasing maize production in India in general and Koppal District of Karnataka in particular. The results revealed that a majority of big farm maize growers had high knowledge regarding recommended cultivation practices of maize compared to small farmers. Hence, the extension functionaries need to intensify their efforts in increasing the knowledge level of small farm maize growers particularly through adopting suitable extension strategies and providing critical inputs in time at subsidized rate.

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Employment Generation thorough Sericulture in Rajouri District of Jammu and Kashmir

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Abstract

Sericulture is an eco-friendly agro-based labor intensive and commercially attractive economic activity, falling under cottage and small-scale sector. Sericulture enterprise in its totality is a long chain industry from mulberry cultivation to fabric making. India stands second in silk production; next to China. Sericulture Industry in India has classified the employment generation pattern of the industry into two major types: Direct Employment – (a) Mulberry Cultivation; (b) Leaf Harvesting; (c) Silk Worm Rearing; Indirect Employment – (a) Reeling; (b) Twisting; (c) Weaving; (d) Printing & Dyeing; (e) Finishing; (f) Silk Waste Processing. The production of raw silk and silk fabrics are limited to only a few countries in the World of which China (53,359 MT; 58.03 %) occupies the first place and India (33,770 MT; 36.72 %), the second in the year of 2020. India is the second largest producer of silk in the world next only to China. Karnataka is the leading sericulture state which contributes more than 50 per cent of the total silk production in India. It is estimated that the indirect effect of sericulture to the farm income is about 25 per cent. Sericulture is practiced in about 52360 villages all over the country and employment to about 7.56 million people, most of them being small and marginal farmers in rural areas, creating employment to at least for 10.21 people per hectare of mulberry. Rajouri is leading sericulture district in Jammu and Kashmir. In view of the importance of sericulture enterprise, the paper will explain the significance of sericulture for employment generation in Indian sericulture industry. Present paper explores the possible employment opportunities in the study area.

Key words : Sericulture, Employment generation, Silkworm rearing, Small and Marginal farmers.

Introduction

Sericulture is rearing of silkworm for production of cocoons which is the raw material for the production of silk. It is the only cash crop that gives returns within 30 days (Kamili and Masoodi, 2000). Sericulture is the only cash crop, which provides frequent and attractive returns in the tropical states of the country through year. The average annual income per hectare was around Rs. 40,000 (Jagannath, N. 1995). India is the second largest producer of silk in the world next only to China. Karnataka is the leading sericulture state which contributes around 50 per cent of the total silk production in India. It is estimated that the indirect effect of sericulture to the farm income is about 25 per cent (Mattigatti and Iyengar, 1995). Sericulture is practiced in about 52,360 villages all over the country and employment to about 7.56 million people, most of them being small and marginal farmers in rural areas, creating employment to at least for 12-13 people per hectare of mulberry; hence migration of people from rural to urban areas in search of jobs can be minimized (Planning Commission Report). India exported silk goods to the value of 364.40 and 1745.65 crores during 1978-79, and 2019-20, respectively and the value of import of silk goods from other countries was 80.11, and 3315.00 crores during 1978-79 and 2019-20, respectively. Usha Rani (2007) has shown that 96.36 man days of employment are generated from the establishment of one acre of mulberry garden for rearing 300 dfls (disease free

layings) of silkworms in two months Gangopadhyay (2008), in his review of Sericulture Industry in India has classified the employment generation pattern of the industry into two major types: Direct Employment – (a) Mulberry Cultivation; (b) Leaf Harvesting; (c) Silk Worm Rearing; Indirect Employment – (a) Reeling; (b) Twisting; (c) Weaving; (d) Printing & Dyeing; (e) Finishing; (f) Silk Waste Processing. Manjunath et al., (2015) employed exponential growth model to know the scenario of mulberry and cocoon production in major silk producing States of India. Keeping the importance of sericulture this paper is proposed to study the employment days (man days) from sericulture and also income from sericulture in Lamberi cluster, District-Rajouri, Jammu and Kashmir.

Balakrishnanappa and Rajan (2010) have observed that sericulture is one of the prominent enterprises, which provided full time employment to the entire family, offering high income and better standard of living. Ali (2010) revealed that 26.66 per cent respondents had annual income between 50,000/- to 1, 00,000/- followed by 1, 00,000/- to 1, 50,000/- of 20 per cent respondents, respectively. While, there is similar type of annual income from other group. (Brahmachari, B.N.; et.al. 2006). In Surguja, the tribal women engaged in this activity were living below the poverty line (BPL), having an annual family income of Rs. 11,850.00 or less (Bhatia, N.K., et.al. 2009). Sericulture is an eco-friendly agro-based labor intensive and commercially attractive economic activity, falling under cottage and small-scale sector. Sericulture

enterprise in its totality is a long chain industry from mulberry cultivation to fabric making. India stands second in silk production; next to China. Total raw silk production in India was 35.82 MT, out of which mulberry raw silk production was 25.23 MT (70.46%) during 2019-2020 (Annual report, CSB, 2019-2020). India is the only Country in the world to produce all the four known varieties of silk including Mulberry, Eri, Tasar and Muga. Sericulture in India is a fairly organized activity that is in the cottage industry segment and is largely rural based and labor intensive. Cultivation is spread Over 22 states, Covering 172000 hectares across 54000 villages operating 258000 handlooms and 29340 power looms. (Dewangan, S.K. *et al.*, 2011). Thangamuthu and Venkataravi (1989) made an analysis of trends in mulberry cultivation, cocoon production and the reeling of raw silk for the period of 1979-80 to 1986-87 found that there was a substantial increase in the area under mulberry cultivation resulting in an increase of about 40 per cent per annum in cocoon production. They also estimated that the development of the weaving sector could result in the generation of direct employment for more than 8000 persons. Dewangan *et al.* (2012) revealed that the total monthly income obtained from all sources to the families involved in sericulture occupation is average 3840/-. The total monthly expenditure is about 2380/-. The respondent tribe of study area collects forest minor products and thus they earn income about 5950/- 29 once in year which is a satisfactory amount for poor families. Socio-economic condition of the tasar rearers / reelers/weavers in Korba district (Chhattisgarh), Were majority of the rearers (44%) fall in the income group of Rs. 5000-10000 from tasar silkworm rearing, which formed about 19% of the total income Rs. 47631.58. Dewagan (2017) in his study on employment generation and income through sericulture in kharasia block Chhattisgarh found that out of 100 respondents 37% respondents received employment for 100-150 days and 42% respondents received 151-200 days, 16% respondents received 201-300 days employment and 301-365 days employment receiver's respondents are 5%.

Materials and Methods

The present investigation was carried out in Lamberi cluster of Rajouri district, jammu and kashmir state, was purposely selected for the study, and based on potentiality and production of cocoons. For the study in area four Sericultural villages (Lamberi-A, Dharat, Bagnoti and Dandani) was selected purposively because of good cocoon production as compared to other villages of Lamberi cluster and the names of respondents were selected with 25 beneficiaries in each village at random for collection of data. Thus total 100 beneficiaries were selected from cluster. The primary data was collected

from the respondents following the personal interview method. The information sought from the respondents/ beneficiaries consisted of three types. The first type pertained to general information. The second type sought was related to Occupational Status, Employment days in a year, income from sericulture, Crops taken in a year, Cocoon produced in each crop. The third type of information pertained to the Losses in Sericulture, Change in economic status, Change in Annual Income through Sericulture, Impact of Sericulture in Life Style and economics of silk production. All the data for this study is the average of year 2018, 2019 and 2020.

Results and Discussion

A. Age : It is clear from below Table that majority of the respondents (55.00%) were old aged (58-75 years) followed by 27.00 percent belonged to middle age group and rest 18.00 percent were from young age group.

S. No.	Age group	Frequency	Percentage
1.	Young (24-40)	18	18.00
2.	Middle (41-57)	27	27.00
3.	Old (58-75)	55	55.00
	Total	100	100.00

B. Education : Data regarding education of respondents has been presented in below table. It shows that 31.00 percent of the respondents were educated upto high school followed by 18.00 percent respondents who were educated upto higher secondary level and 17.00 percent were educated upto middle level. It was found that 13.00 percent respondents were educated upto primary level and 11.00 percent respondents were illiterate and only 10.00 percent respondents were educated upto graduate level.

S. No.	Category	Frequency (n=100)	Percentage
1.	Illiterate	11	11.00
2.	Primary Level	13	13.00
3.	Middle Level	17	17.00
4.	High School	31	31.00
5.	Higher Secondary	18	18.00
6.	Graduate Level	10	10.00
	Total	100	100

C. Family size : Below table indicates that more than half of the respondents (67.00 %) were living in joint family and 22.00 percent respondents were from nuclear family. Only 11.00 percent respondents belonged to extended family. This shows that joint family system is still common in sericulture dominated rural areas.

S. No.	Category	Frequency (n=100)	Percentage
1.	Nuclear	22	22.00
2.	Joint	67	67.00
3.	Extended	11	11.00
	Total	100	100

D. Status of working member in the family : It was found that in Lamberi block the number of working members in 43 families 2, in 22 families 3, in 19 families 4 and in 9 families 5 members were working. It is clear through the analysis that 3 members were involved in the occupation from the average families.

S. No.	Number of working members in the family	Number of respondents	Percentage
1.	1	Nil	0.00
2.	2	29	29.00
3.	3	43	43.00
4.	4	19	19.00
5.	5	9	9.00

E. Number of crops per year : From the below table it was found that 67% respondents were taking one crop per year and 33% respondents were taking 2 crops in a year.

S. No.	Number of crops	Frequency	Percentage
1.	1	67	67.00
2.	2	33	33.00

F. Employment days (Man Days) from sericulture : It was found that in Lamberi block 67% respondents received employment for 30-45 days and 23% respondents received 46-90 days. 6% respondents received employment for 90-135 days and only 4% respondents received employment for 135-189 days.

S. No.	Employment days from sericulture	Frequency	Percentage
1.	30-45	67	67.00
2.	46-90	23	23.00
3.	90-135	6	6.00
4.	135-180	4	4.00

G. Income from sericulture : It was found that in Lamberi cluster majority of the farmers (67%) earning less than or equal to 20000 in a year and 29 % farmers were earning 20000 to 40000 in a year and only 4 % farmers earning more than 40000 in a year. The average family income from sericulture was 25667 Rs.

S. No.	Income category (Rs.)	Frequency	Percentage
1.	20000	67	67.00
2.	20000 – 40000	29	23.00
3.	40000	4	4.00

H. Sericulture and risk factor : In that three year duration out of 100 farmers 45 farmers bore a loss from sericulture at least once. It indicates the hardship and risk involved in it. The loss to atmospheric and adverse weather conditions viz unseasonal rains (42), high temperature (20) and disease (37) which lead to almost complete failure of their crops.

I. Sericulture and social impact : It was also found that out of 100 respondents' majority of respondents (65 %) feel that their social participation is increased at high level and now he is easily recognisable person in their village. 23% respondents feel that because of sericulture their social participation is middle level in their society and only 12% respondents feel that because of continuous loss in sericulture they feel low in their society.

J. Suggestions for further development :

(a) The government should give them compensation for the losses incurred during rearing due to disease and unsuitable weather.

(b) Need of proper training specially for new silkworm rearers.

(c) Good price for their cocoon.

(d) Proper and on time marketing facilities.

(e) Rearing house assistance should be provided to each and every farmer.

(f) During rearing government staff should be present for on time problem solving.

(g) Good quality mulberry plant should be provided to all farmers specially for the farmers which do not have enough mulberry plant.

Conclusions

From the above study it can be concluded that sericulture provide very good employment opportunities in village in which women can also participate very actively because sericulture is women friendly occupation. It is short duration and highly profitable crop and there is no high technical knowledge is needed. It can be adopted by any type of farmers. It is very good for small and marginal farmers because they do not have much options for earning.

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Effect of GA₃ and Bio-Fertilizers on Seed Yield of Fenugreek (*Trigonella foenum-graecum* L.) Cv. RMT-1

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Abstract

Fenugreek (*Trigonella foenum-graecum* L.) is an important seed spice. It belongs to sub family papilionaceae of the family fabaceae. Fenugreek is considered to be a native of Eastern Europe and Ethiopia. Present experiment on fenugreek cv. RMT-1 was carried out with RBD during the year 2018-19 under the agro-climatic conditions of Gwalior, Madhya Pradesh. On the basis of one year research trial it could be concluded that the treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃, was found best in seed yield from all the treatments.

Introduction

Fenugreek (*Trigonella foenum-graecum* L.) is an important seed spice. It belongs to sub family papilionaceae of the family fabaceae. Fenugreek is considered to be a native of Eastern Europe and Ethiopia. The leaves are rich in minerals (1.5 g), vitamin A (6450 I.U), vitamin C (54 mg) and protein (4.4 g) per 100 g of edible portion. Seeds are rich in protein (6.3%), fat (9.5%), carbohydrates (42.30%), vitamin A (1040 IU), calories (370/100g), gums (22.06%), mucilage (28%), trigonelline (0.13-0.35 %), diosgenin (1g), gitogenin (0.1g) and traces of trigonelline per kg of dried seeds (Aykroyd, 1963). Fenugreek is being extensively cultivated in most regions of the world for its medicinal value. Plants are used medicinally in different countries and are a source of many potential and powerful drugs for diabetes, Blood sugar, cholesterol etc. Both leaves and seeds are extensively used for medicinal purpose and prescribed in treatment of chronic dysentery, diarrhoea, chronic cough. Dropsy, dyspepsia enlargement of liver and spleen, appetizing, diuretic, Anti arthritic, Anti diabetic, and prevents abscesses, ulcers and rickets. In India Fenugreek occupies an area of 220('000 Ha.) with a production of 311('000 MT) and productivity of 1413 kg/ha (NHB, 2017-18,). However, In Madhya Pradesh fenugreek covers an area of 34.29 ('000ha) with 25('000 MT) production and 729kg / ha productivity. Microbial fertilizer application including Rhizobium as well as phosphate solubilizing bacteria (PSB) has been found promising to improve soil health and crop production. Gibberellic acid (GA₃) is a plant growth hormone that regulates seed germination, stem elongation, leaf expansion, fruit development, flowering, and stimulation of secondary metabolite production in plants.

Materials and Methods

The present investigation titled "Response of GA₃ and

Bio-fertilizers on Growth and Seed Yield of Fenugreek (*Trigonella foenum-graecum* L.) cv.- RMT-1" was carried out during the year 2018-19 under the agro-climatic conditions of Gwalior, Madhya Pradesh. In the present investigation fenugreek cv. RMT-1 was selected and different levels of PGR and bio-fertilizers are used in different levels in each treatment and replicated three times and to form the Asymmetrical Factorial Randomized Block Design. Treatment details T₁ : Control (water spray), T₂ : Seed Inoculation with Rhizobium, T₃ : Seed Inoculation with Rhizobium + 25 ppm GA₃ (Foliar spray), T₄ : Seed Inoculation with Rhizobium + 50 ppm GA₃ (Foliar spray), T₅ : Seed Inoculation with Rhizobium + 100 ppm GA₃ (Foliar spray), T₆ : Seed Inoculation with PSB, T₇ : Seed Inoculation with PSB + 25 ppm GA₃ (Foliar spray), T₈ : Seed Inoculation with PSB + 50 ppm GA₃ (Foliar spray), T₉ : Seed Inoculation with PSB + 100 ppm GA₃ (Foliar spray), T₁₀ : Seed Inoculation with Rhizobium + PSB, T₁₁ : Seed Inoculation with Rhizobium + PSB + 25 ppm GA₃ (Foliar spray), T₁₂ : Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (Foliar spray), T₁₃ : Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (Foliar spray).

Results and Discussion

Response of GA₃ and Bio-fertilizers on yield attributing parameters of fenugreek

No. of pods/plant : The results on no. of pods/plant were presented in table-1 the data significantly influenced by treatments. The maximum no. of pods/plant was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (69.54), which were at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (67.18), (T₉) Seed Inoculation with PSB + 100 ppm GA₃ (66.69) and (T₈) Seed Inoculation with PSB + 50 ppm GA₃ (63.56). The minimum no. of pods/plant was recorded in (T₁) Control (37.26).

Table-1 : Response of GA₃ and Bio-fertilizers on no. of pods/plant, pod length (cm) and no. of seeds/pod of fenugreek.

Treatments	No. of pods/plant	Pod length (cm)	No. of seeds/pod
T ₁	37.26	12.73	12.16
T ₂	44.90	14.23	15.09
T ₃	45.57	14.45	15.99
T ₄	53.57	14.86	17.26
T ₅	57.57	14.91	17.59
T ₆	45.24	14.40	15.93
T ₇	45.57	14.50	16.53
T ₈	63.56	15.21	17.93
T ₉	66.69	15.40	17.99
T ₁₀	46.24	14.70	16.89
T ₁₁	46.90	14.72	17.06
T ₁₂	67.18	15.47	18.13
T ₁₃	69.54	15.73	18.33
S.Em. ±	2.052	0.176	0.631
CD at 5% level	5.989	0.514	1.842

Table-2 : Response of GA₃ and Bio-fertilizers on test weight of seed (1000 Seeds in g), seed weight/pod (g) and seed weight/plant (g) of fenugreek.

Treatments	Test weight of seed (1000 Seeds in g)	Seed weight/pod (g)	Seed weight/plant (g)
T ₁	13.92	0.08	2.85
T ₂	17.04	0.08	3.64
T ₃	17.31	0.09	4.26
T ₄	17.91	0.11	5.69
T ₅	17.94	0.11	6.11
T ₆	17.31	0.09	4.22
T ₇	17.34	0.10	4.42
T ₈	18.01	0.09	5.50
T ₉	18.14	0.10	6.73
T ₁₀	17.61	0.10	4.60
T ₁₁	17.71	0.10	4.81
T ₁₂	18.44	0.11	7.18
T ₁₃	18.54	0.12	8.09
S.Em. ±	0.398	0.006	0.411
CD at 5% level	1.161	0.019	1.199

Pod length (cm) : The results on pod length (cm) were presented in table 1 the data significantly influenced by treatments. The maximum pod length (cm) was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (15.73 cm), which were at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (15.47 cm) and (T₉) Seed Inoculation with PSB + 100 ppm GA₃ (15.40 cm). The minimum pod length (12.73 cm) was recorded in (T₁) Control.

No. of seeds/pod : The results on no. of seeds/pod were presented in table 1 the data significantly influenced by treatments. The maximum no. of seeds/pod was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium +

PSB + 100 ppm GA₃ (18.33), which were at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (18.13), (T₁₁) Seed Inoculation with Rhizobium + PSB + 25 ppm GA₃ (17.06), (T₁₀) Seed Inoculation with Rhizobium + PSB (16.89), (T₉) Seed Inoculation with PSB + 100 ppm GA₃ (17.99), (T₈) Seed Inoculation with PSB + 50 ppm GA₃ (17.93), (T₇) Seed Inoculation with PSB + 25 ppm GA₃ (16.53), (T₅) Seed Inoculation with Rhizobium + 100 ppm GA₃ (17.59) and (T₄) Seed Inoculation with Rhizobium + 50 ppm GA₃ (17.26). The minimum no. of seeds/pod (12.16) was recorded in (T₁) Control.

Response of GA₃ and Bio-fertilizers on yield parameters of fenugreek

Weight of seed (1000 Seeds in g) : The results on test weight of seed were presented in table-2 the data significantly influenced by treatments. The maximum test weight of seed was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (18.54 g), which were at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (18.44 g), (T₁₁) Seed Inoculation with Rhizobium + PSB + 25 ppm GA₃ (17.71 g), (T₁₀) Seed Inoculation with Rhizobium + PSB (17.61 g), (T₉) Seed Inoculation with PSB + 100 ppm GA₃ (18.14 g), (T₈) Seed Inoculation with PSB + 50 ppm GA₃ (18.01 g), (T₅) Seed Inoculation with Rhizobium + 100 ppm GA₃ (17.94 g) and (T₄) Seed Inoculation with Rhizobium + 50 ppm GA₃ (17.91 g). The minimum test weight of seed (13.92) was recorded in (T₁) Control.

Seed weight /pod (g) : The results on seed weight /pod (g) were presented in table 2 the data significantly influenced by treatments. The maximum seed weight /pod (g) was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (0.12 g), which were at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (0.11 g), (T₁₁) Seed Inoculation with Rhizobium + PSB + 25 ppm GA₃ (0.10 g), (T₁₀) Seed Inoculation with Rhizobium + PSB (0.10 g), (T₉) Seed Inoculation with PSB + 100 ppm GA₃ (0.10 g), (T₇) Seed Inoculation with PSB + 25 ppm GA₃ (0.10), (T₅) Seed Inoculation with Rhizobium + 100 ppm GA₃ (0.11 g) and (T₄) Seed Inoculation with Rhizobium + 50 ppm GA₃ (0.11 g). The minimum seed weight /pod (g) (0.08) was recorded in (T₁) Control and (T₂).

Seed weight/plant (g) : The results on seed weight/plant (g) were presented in table 2 the data significantly influenced by treatments. The maximum seed weight/plant (g) was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (8.09 g), which were at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (7.18 g). The minimum seed weight/plant (2.85 g) was recorded in (T₁) Control and (T₂).

Table-3 : Response of GA₃ and Bio-fertilizers on seed yield/plot (kg), seed yield/plant (g), seed yield/ha (kg) and seed yield/ha (q) of fenugreek.

Treatments	Seed yield/plot (kg)	Seed yield/plant (g)	Seed yield/ha (kg)	Seed yield/ha (q)
T ₁	0.49	2.85	950.26	9.50
T ₂	0.62	3.64	1213.76	12.14
T ₃	0.73	4.26	1420.18	14.20
T ₄	0.97	5.69	1895.86	18.96
T ₅	1.04	6.11	2036.23	20.36
T ₆	0.72	4.22	1405.27	14.05
T ₇	0.76	4.42	1474.04	14.74
T ₈	0.94	5.50	1831.84	18.32
T ₉	1.15	6.73	2241.78	22.42
T ₁₀	0.79	4.60	1532.44	15.32
T ₁₁	0.82	4.81	1604.78	16.05
T ₁₂	1.23	7.18	2393.90	23.94
T ₁₃	1.38	8.09	2697.24	26.97
S.Em.±	0.070	0.411	136.89	1.369
CD at 5 % level	0.205	1.199	399.55	3.996

Seed yield/plot (kg) : The results on seed yield/plot (kg) were presented in table 3 the data significantly influenced by treatments. The maximum seed yield/plot was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (1.38 kg), which was at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (1.23 kg). The minimum seed yield/plot (0.49 kg) was recorded in (T₁) Control.

Seed yield/plant(g) : The results on seed yield/plant (g) were presented in table 3 the data significantly influenced by treatments. The maximum seed yield/plant was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (8.09 g), which was at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (7.18 g). The minimum seed yield/plant (2.85 g) was recorded in (T₁) Control.

Seed yield/ha (kg) : The results on seed yield/ha (kg) were presented in table 3 the data significantly influenced by treatments. The maximum seed yield/ha was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (2697.24 kg), which was at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (2393.90 kg). The minimum seed yield/ha (950.26 kg) was recorded in (T₁) Control.

Seed yield/ha (q) : The results on seed yield/ha (q) were presented in table 3 the data significantly influenced by treatments. The maximum seed yield/ha was recorded under treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃ (26.97 q/ha), which was at par with (T₁₂) Seed Inoculation with Rhizobium + PSB + 50 ppm GA₃ (23.94 q/ha). The minimum seed yield/ha (9.50 q/ha) was recorded in (T₁) Control.

The maximum test weight of seed, seed weight /pod (g), seed weight/plant (g), seed yield/plant and seed yield/ha was recorded under treatment (T₁₃) seed Inoculation with Rhizobium + PSB + 100 ppm GA₃, while the minimum, test weight of seed, seed weight /pod (g), seed weight/plant (g), seed yield/plant and seed yield/ha was recorded in (T₁). The higher number of pods per plant in the nutrient combination might be due to optimum dosage of organic and inorganic combinations could be attributed to increase the available nitrogen in the soil throughout the life cycle of crop. The increased and balanced supply of nitrogen to plant promotes synthesis of more carbohydrates resulted in more flowering, fruiting and partitioning of food material and subsequent distribution from source to sink. The organic manures and bio-fertilizers increase the soil microbial activity, improve the availability of phosphorous and in turn plays unique role in energy conversion and transfer, helpful in flowering and increased the number of pods plant⁻¹ as reported by Khiriya *et al.* (2003) and Choudhary *et al.* (2011) in fenugreek. Higher photosynthetic rate and better source-sink relationship through *Rhizobium* and PSB inoculation resulted in higher productivity of fenugreek (Purbey and Sen, 2005).

The increase in yield components resulted from inoculation treatment with rhizobium is due to the stimulatory effects of bio-fertilizer secretion of growth regulators *i.e.*, IAA and GA, Rabie (1996). The increase in dry matter production of inoculated plants may be attributed to enhancement of nodulation, higher rate of nitrogen fixation and general improvement of root development Erum and Bano (2008). Inoculation with *Rhizobium* spp. caused a greater increase in growth and

this in turn increase yield. Akhtar and Siddiqui (2009) came to similar results.

Conclusions

On the basis of one year research trial it could be concluded that the treatment (T₁₃) Seed Inoculation with Rhizobium + PSB + 100 ppm GA₃, was found best in all the stages of growth parameter like plant height 30, 60 and 90 DAS, number of primary branches per plant at 30, 60 and 90 DAS, number of secondary branches per plant at 60 and 90 DAS, length of internode, days to 50% flowering, fresh weight of the plant, dry weight of the plant and yield parameters like days to first pod formation, days to 50 % pod formation, number of pods per plant, weight of pod, pod length, number of seeds per pod, weight of seeds per pod, seed yield per plant, seed yield/ha, harvest index and days taken to maturity showed better performance from other treatments of organic, bio-fertilizers and plant growth regulators applications.

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Response of Different Plant Growth Regulators on Growth and Flower Yield of *Calendula officinalis* L.) Cv. Bon Bon Yellow under Raipur condition

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Abstract

The present study was carried out to find out the response of different plant growth regulators on vegetative, flowering and yield parameters of *Calendula officinalis* cv. Bon Bon Yellow during *rabi* 2020-21 at Horticulture Farm in Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was performed in "Randomized Block Design" with 13 treatments. The treatments consists of different combinations of plant growth regulators GA₃ (200, 300, 400 ppm) NAA (200, 300, 400 ppm), MH (250, 500, 750, ppm), Cycocel (250, 500, 750, ppm) and a control (water spray). The result revealed that GA₃ at 300 ppm significantly increased number of branches plant⁻¹, plant spread, number of leaves plant⁻¹, early flowering, number of flower plant⁻¹, seed yield. The application of NAA @ 200 ppm significantly affects the individual flower weight. Similarly CCC @ 750 ppm gave the maximum reduction in plant height, number of branches, flower weight, seed yield, flower number and also delayed the flowering as compared to other growth regulators. Further CCC @ 750 ppm also resulted in increased diameter of stem and caused late flowering as compare to control. Hence among all the treatments GA₃ @ 300 ppm was found to be optimum dose for commercial farming of calendula under open condition at Raipur areas of Chhattisgarh

Key words : *Calendula*, plant growth regulators, GA₃, NAA, MH, CCC.

Introduction

Calendula (*Calendula officinalis* L.) is one of the most popular seasonal flowers. It belongs to the Asteraceae family and is also known as "English Marigold" "Pot Marigold" or orange pot marigold, Ox-eye it's widely planted across the country. *Calendula officinalis* is a common garden plant associated with Virgin Mary and Queen Mary in old English, hence the name marigold (Grieve 1931; Kemper 1999; Mills 1991). It's also been utilized for therapeutic purposes. Its cultivation is aided not just by the pharmaceutical industry, but also by the rapidly expanding cosmetics industry. The pharmaceutical industry either employs ligulate florets (Flores Calendulae) or entire composite calendula flowers (Flores Calandulae con Calycibus), which are rich orange in colour and have a distinct aroma and bitter in taste. In floriculture, the plant growth regulators play very important role in flower crop production and they significantly influenced the plant growth characters, flowering attributes, flowering regulation, yield and quality attributes of flower crops. In calendula, naphthalene acetic acid (NAA) was used to induce more concentrated flowering, which allowed for a greater number of harvests. This success was formerly attributed to the involvement of natural auxins in flowering. Cycocel (CCC), on the other hand, is a large series of chemicals that slow stem elongation by stopping cell division in the sub-apical meristem, usually without affecting the apical meristem. In many herbaceous flower crops, gibberellic acid (GA₃) is a well-known plant growth regulator for bloom induction.

Maleic hydrazide (MH) is a plant growth retardant which retards plant height by reducing internodal length and it also reduces the formation of lateral shoots there by plant produces more number of flower bearing shoots. (Kalaimani *et al.* 2017). Keeping the above facts in mind, the present investigation entitled "Response of different Plant Growth Regulators on growth and flower yield of *Calendula* (*Calendula officinalis* L.) Cv. Bon Bon Yellow under Raipur condition" was performed under Raipur (C.G.) climatic conditions to optimize the appropriate concentration of plant growth regulators for growth, flowering and yield parameters of calendula.

Materials and Methods

An experiment was under taken at research field of Horticulture Farm, Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishwavidyalaya, Raipur. during *rabi* 2020-21. The 15 days old established plants of calendula, grown in polythene bags were planted at a spacing of 30 cm × 30 cm for the present investigation. The experimental site is fairly level land with sandy loam soil of uniform fertility status with low clay and high sand percentage. The experiment was layout in Randomized Block Design (RBD) with 13 treatments and each treatment replicated thrice. The treatments consists of different combinations of plant growth regulators GA₃ (200, 300, 400 ppm) NAA (200, 300, 400 ppm), MH (250, 500, 750, ppm), Cycocel (250, 500, 750, ppm) and control (water spray). Gap filling, irrigation, mulching, weeding and plant protection measures were carried out as per the requirement of the

Table-1 : Effect of plant growth regulators on vegetative parameters of Calendula (*Calendula officinalis* L.) cv. Bon Bon Yellow.

Treatment	Plant height (cm)	Number of branches	Number of leaves	Plant spread		Stem diameter (mm)
				(N-S)	(E-W)	
T ₀ Control	27.7	9.0	200.0	38.6	39.0	7.9
T ₁ GA ₃ @ 200 ppm	44.9	11.4	223.0	45.6	45.5	10.3
T ₂ GA ₃ @ 300 ppm	48.7	12.0	225.7	46.34	45.9	10.4
T ₃ GA ₃ @ 400 ppm	50.6	9.6	221.0	42.9	43.1	10.2
T ₄ NAA @ 200 ppm	30.5	9.2	218.3	44.3	45.1	8.9
T ₅ NAA @ 300 ppm	25.6	9.7	217.1	43.7	40.7	8.7
T ₆ NAA @ 400 ppm	27.0	10.3	216.7	42.5	40.9	8.5
T ₇ MH @ 250 ppm	28.3	11.0	218.1	40.8	42.8	10.8
T ₈ MH @ 500 ppm	27.5	9.5	215.2	39.8	40.6	10.3
T ₉ MH @ 750 ppm	25.2	9.8	215.7	34.2	39.9	9.8
T ₁₀ CCC @ 250 ppm	29.2	11.0	216.8	38.0	37.6	11.5
T ₁₁ CCC @ 500 ppm	28.2	9.6	217.1	33.9	34.6	11.3
T ₁₂ CCC @ 750 ppm	25.0	9.4	214.9	30.1	30.9	10.6
SEm±	0.95	0.43	3.42	0.82	0.66	0.92
C.D.	2.80	1.28	10.11	2.42	1.96	2.70

Table-2 : Effect of plant growth regulators on flowering and yield of Calendula (*Calendula officinalis* L.) cv. Bon Bon.

Treatment	Days to 50% flowering days	Flower diameter (cm)	Flower weight (g)	Number of flowers plant ⁻¹	Yield of flower plant ⁻¹ (g)	Flower yield hectare ⁻¹ (qha ⁻¹)	Seed yield plot ⁻¹ (g)	Seed yield hectare ⁻¹ (qha ⁻¹)
T ₀ Control	69.0	4.8	13.1	78.7	197.0	143.37	9.6	2.66
T ₁ GA ₃ @ 200 ppm	64.0	6.3	13.9	97.1	216.8	192.88	11.1	3.08
T ₂ GA ₃ @ 300 ppm	63.0	6.5	16.4	99.4	217.9	198.53	12.1	3.36
T ₃ GA ₃ @ 400 ppm	67.0	6.2	17.8	95.8	211.7	167.41	10.1	2.8
T ₄ NAA @ 200 ppm	68.0	5.7	20.5	91.3	174.5	172.36	9.9	2.75
T ₅ NAA @ 300 ppm	68.0	5.3	18.9	95.0	175.6	188.60	9.9	2.75
T ₆ NAA @ 400 ppm	76.0	5.9	18.6	87.7	174.2	180.39	10.0	2.77
T ₇ MH @ 250 ppm	74.0	5.4	18.8	79.2	176.4	171.94	11.0	3.05
T ₈ MH @ 500 ppm	72.0	5.3	15.5	84.0	210.3	181.09	10.0	2.76
T ₉ MH @ 750 ppm	74.0	5.4	15.46	85.3	208.4	178.87	10.0	2.71
T ₁₀ CCC @ 250 ppm	78.7	4.9	13.23	87.0	193.4	148.07	9.4	2.61
T ₁₁ CCC @ 500 ppm	75.0	4.7	14.4	78.0	175.8	141.82	9.0	2.50
T ₁₂ CCC @ 750 ppm	79.0	4.2	15.3	77.3	171.8	140.64	8.6	2.38
SEm±	1.80	0.13	1.13	1.75	2.61	4.89	0.54	0.36
C.D.	5.20	0.41	3.6	5.17	7.73	14.22	1.64	1.04

crop. The experimental data were subjected to statistical analysis in order to find out which of the treatments showed significant variation in different parameters studied under investigation. The technique of analysis of variance (ANOVA) for randomized block design (RBD) was adopted.

Results and Discussion

Growth parameters : The data indicates that vegetative parameters were significantly influenced by different plant growth regulators treatments (Table-1). The maximum plant height 50.6 cm was recorded under the treatment GA₃ @ 400 ppm (T₃) which was *at par* with GA₃ @ 300 ppm (T₂), while the minimum plant height of 25.0 cm was observed under treatment CCC @ 750 ppm (T₁₂). The result also revealed that GA₃ at 300 ppm resulted

significantly increased number of branches plant⁻¹ (12), maximum plant spread (46.34 cm in north-south direction and 45.9 cm in east-west direction), number of leaves plant⁻¹ (225.7) while the minimum values of these parameters were recorded under control treatment. The thickest stem (11.5 cm) was observed under the treatment CCC @ 250 ppm (T₁₀) and minimum 7.9 cm was recorded under the treatment Control (T₀).

The increased plant height, number of branches and plant spread in GA₃ treated plants might be due to increased cell division of inter calary meri-stemic region and cell elongation which ultimately helpful in increasing the length of internodes, number of leaves and plant spread. The beneficial effect of GA₃ on increased growth parameters might be due to increasing auxin level of tissues which probably enhanced the conversion of

tryptophan. The similar trend of growth parameters was confirmed and reported by Khudus *et al.* (2017), Malik *et al.* (2017), Tamrakar *et al.* (2018). Murugan *et al.* (2020).

The thickest stem (11.5 mm) was recorded under the treatment CCC @ 250 ppm (T_{10}) followed by CCC @ 500 ppm (T_{11}) and minimum stem diameter (7.9 mm) was observed in control.

The significant increased stem diameter might be result of increased stem girth by enhancement of cell division, cell enlargement and suppression of vertical growth by growth retardants. Similar results were also reported by Choudhary *et al.* (2017).

Floral and Yield parameter : The data pertaining to yield parameters under different treatments are presented in Table-2. It is obvious from data that GA_3 application drastically improved all the flowering parameters and its 300 ppm had been proved most suitable concentration and resulted

The number of days taken by plants for 50 % flowering ranged between 63.00 and 78.7 days. The minimum number of days (63.00 days) for 50 % flowering was taken by plants sprayed with 300 ppm GA_3 followed by 200 ppm GA_3 (64.0 days). These findings further revealed that the maximum days taken to 50% flowering or late flowering (79 days) was noticed under the treatment CCC @ 750 ppm (T_{12}) which was *at par* with CCC @ 250 ppm (T_{10}) 78.7 days. In general, it is concluded that GA_3 @ 300 ppm promoted early flowering.

On the basis of above data, it was observed that 50 % flowering was gradually delayed with increase in cycocel concentration. Delay flowering because of CCC application owing to checking of biosynthesis of gibberellins like substances action of gibberellins is promotion of flowering in the plant metabolism.

Gibberellin promotes blooming in short-day plants grown in an inductive environment. The development of flowers in long-day and long-short-day plants may be regulated by lowering the endogenous level of gibberellin-like compounds. Similar effect was also recorded by Kumar and Saravana (2018).

GA_3 gave significant more diameter of flowers. Significantly maximum flower diameter (6.5 cm) was recorded under the treatment GA_3 @ 300 ppm (T_2) followed by GA_3 @ 200 ppm (T_1) 6.3 cm while the minimum 4.2 cm was noticed under the treatment CCC @ 750 ppm (T_{12}).

There was a slight decrease in floral diameter with increase in cycocel concentration which might be due to its properties of reducing cell elongation and lowering the rate of cell division. Gibberellic acid (GA_3) is a

well-recognized plant growth regulator for flower induction and enhancement flower diameter in many herbaceous flower crops. The beneficial effect of GA_3 and NAA on growth and flowering was also reported by Bhat *et al.* (2011) and Khudus *et al.* (2017) in *Calendula*.

It was revealed from data that significantly maximum flower weight (20.5 g) was noticed under the treatment NAA @ 200 ppm (T_4) which was statistically similar with NAA @ 300 ppm (T_5) 18.9 g. However, minimum weight of flower (13.1 g) was noticed under the control (T_0) which was statistically similar with CCC @ 500 ppm (T_{10}) 13.23 g.

The favorable effect of NAA might be attributed due to greater amount of carbohydrate accumulation and increased metabolic activities which leads to initiation of cell division and cell enlargement by promotion of protein synthesis coupled with higher dry matter of apical dominance. Similar results were also reported in chrysanthemum, marigold, gladiolus, spider lily and rose by Khudus *et al.* (2017).

The significantly maximum flower yield per plant (217.9 g), per ha. () and seed yield per plant (12.1 g) and per ha. (3.6 q) was recorded in plants treated with 300 ppm GA_3 followed by its lower concentration i.e. 200 ppm. On the other hand CCC significantly reduced the yield of flower plant⁻¹. The minimum flower yield plant⁻¹ (171.8 g), per ha. (140.64 q) and seed yield (8.6 g) and per ha. (2.38 q) was recorded under the treatment CCC @ 750 ppm (T_{12})

On the basis of above data GA_3 significantly influenced the yield of flower plant⁻¹. It might be due to the gibberellins act as floral hormone which stimulate the action of agamous gene which ultimately induces the action of floral homeotic gene which responsible for early flowering. Gibberellin usually enhances flowering in short day plant growing under inductive condition. Similar effect was also reported by Kumar and Saravana (2018).

Similarly above data revealed that, CCC gradually decreased the yield of flower and seed with the increase in concentration, it might be due to cycocel (CCC) is very diverse group of compound that generally retarded stem elongation by preventing cell division in the sub apical meristem usually without similarly affecting the apical meristem. These substances modify plant character viz, height, number and size of leaves and flowers, branching habits, internodes length, root growth, fresh and dry weight etc. Plant growth retardants in ornamental plants are applied for limiting stem elongation and produce a more appressed, sturdy potted and bedding plants with minimum changes in developmental patterns or exerting phytotoxic effects, similar finding was reported by Khudus *et al.* (2017).

The favorable effect of GA₃ might be attributed due to greater amount of carbohydrate accumulation and increased metabolic activities which leads to initiation of cell division and cell enlargement by promotion of protein synthesis coupled with higher dry matter. Similar results were also reported in chrysanthemum, marigold, gladiolus, spider lily and rose. Similar result was also reported by Khudus *et al.* (2017) in calendula.

Conclusions

It is concluded from the study that application of GA₃ @ 300 ppm was found to be the most suitable for increasing number of branches, number of leaves, earliness in flowering, number of flower plant⁻¹ and number of seed plant⁻¹. In case of NAA treatment its concentration @ 200 ppm was most effective for higher in flower weight (g). Application of CCC @ 750 ppm gave maximum reduction in plant height, number of branches, delayed flowering and number of flower plant⁻¹.

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Efficacy of Fungicides and Phytoextractsa Against *Didymella bryoniae* Causing Blight of Ridge Gourd [(*Luffa acutangulla* L. (Roxb.)]

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Abstract

Didymella blight is a newly emerged disease of ridge gourd under Kashmir conditions. Ten fungitoxicants, including both systemic and non systemic and five locally available botanicals were evaluated under *in vitro* conditions at different concentrations by poisoned food technique against *Didymella bryoniae* causal organism of blight of ridge gourd. The studies revealed that among systemic fungitoxicants, carbendazim exhibited maximum inhibition of mycelial growth (87.5%) and spore germination (74.6%), followed by thiophanate methyl (76.1% and 69.5%) and myclobutanil (63.0 and 59.9%). Amongst non-systemic fungitoxicants chlorothalonil proved most effective which exhibited 67.4 and 74.3 per cent inhibition of mycelial growth and spore germination, respectively, which was followed by mancozeb with inhibition of 63.0 and 65.1 per cent, respectively. Of the botanicals, *Allium sativum* was found superior with 53.5 and 47.6 per cent inhibition of mycelial growth and spore germination, respectively.

Key words : Blight, botanicals, fungitoxicants, *Didymella bryoniae*, management, ridge gourd.

Introduction

Didymella blight of cucurbitaceous crops incited by *Didymella bryoniae* (anamorph: *Phoma cucurbitacearum* (Foutry) Saccardo), is widely distributed in tropical and sub-tropical countries and also reported frequently in areas having temperate climate (Sitterly, 1969). The disease is highly destructive of all the cucurbitaceous crops worldwide, reducing their yield as a result of defoliation of vines, fruit infection and subsequent decay (Schenck, 1968). The disease was first reported from France in 1891 on a Chinese variety of cucumber (Roumeguere, 1891) and since then it has been reported from many countries namely, USA, Britain, Germany, Japan, New Zealand, Brunei, Mexico, Netherlands, Republic of Ireland, Salvador (Punithalingam and Holliday, 1972). In India, the disease was first reported from Mysore on leaves of *Scheum edule* (Sohi and Prakash, 1972) and then subsequently on *Cucumis sativus* (Kumar and Khan, 1984), *Mamordicha charanta* (Kulwant and Shetty, 1996), *Benincasa hispida* (Pandey and Pandey, 2003) and *Cucumis melo* (Sudisha *et al.*, 2004). Yield losses due to this disease on watermelon have been estimated up to 100 per cent in Trinidad (Bala and Hosein, 1986), 43 per cent in USA (Kienath and Duthie, 1998), 30 per cent on muskmelon in Australia (Mc Grath *et al.*, 1993) and 35 per cent on cucumber in Poland (Leski, 1984). The disease has been noticed on ridge gourd in Kashmir regularly for the last few years inflicting heavy

economic losses thereby warrants immediate action of plant pathologists (Bhat *et al.*, 2010). The practice of monoculture and prevailing disease favourable environmental conditions seems to have given fillip to the spread and development of this disease in the valley. Management of this disease of ridge gourd through fungicide application is feasible, however, long term usage of fungicides has led to the resistance development in pathogens besides, environmental consequences associated with their use. The most efficient and economical method to mitigate the menace of this disease is therefore, integrated disease management (IDM) approach where other non chemical and eco-friendly management strategies are integrated with chemical methods in order to manage the diseases more efficiently with reduced use of chemicals. Use of botanical extracts is gaining interest as an alternative or complement to chemical treatment in integrated disease management strategies. The effective use of botanical extracts against many diseases has been demonstrated in several instances. Therefore, the present investigation was undertaken to devise IDM module by way of reduced use of fungicides after incorporating other non chemical management options.

Materials and Methods

Ten fungitoxicants including both systemic and non systemic and five botanicals were evaluated for their efficacy against *Didymella bryoniae* by poisoned food

Table-1 : *In vitro* efficacy of various systemic fungitoxicants in inhibiting the mycelial growth and spore germination of *Didymella bryoniae*.

Fungitoxicant	Per cent radial growth inhibition at concentration (*µg/ml)					Percent spore germination inhibition at Concentration (*µg/ml)				
	10	50	100	200	Mean	10	50	100	200	Mean
Carbendazim 50 WP	55.9 (48.3)	94.4 (81.9)	100.0 (89.9)	100.0 (89.9)	87.5 (77.5)	49.2 (44.5)	63.8 (53.0)	85.4 (67.7)	100.0 (89.9)	74.6 (63.8)
Thiophanate Methyl 70 WP	34.8 (36.1)	69.6 (56.5)	100.0 (89.9)	100.0 (89.9)	76.1 (68.1)	38.6 (38.3)	55.8 (48.3)	83.6 (66.2)	100.0 (89.9)	69.5 (60.7)
Myclobutanil 10 WP	22.5 (28.3)	52.5 (46.4)	77.0 (61.3)	100.0 (89.9)	63.0 (56.5)	31.7 (34.2)	43.8 (41.4)	66.8 (54.9)	97.4 (82.4)	59.9 (53.2)
Diniconazole 25 WP	17.4 (24.6)	31.4 (34.1)	64.8 (53.6)	100.0 (89.9)	48.7 (44.2)	16.4 (23.7)	28.1 (31.9)	52.6 (46.5)	85.4 (67.6)	45.6 (42.4)
Bitertanol 25 WP	11.1 (19.3)	33.3 (35.2)	51.1 (45.6)	81.4 (64.5)	41.6 (39.4)	22.3 (28.0)	38.0 (38.0)	66.1 (54.5)	93.0 (74.7)	54.8 (48.8)
Mean	28.3 (31.3)	56.2 (50.8)	78.5 (68.1)	90.5 (78.3)		31.6 (33.7)	45.9 (42.5)	70.9 (58.0)	95.1 (80.9)	
CD (P=0.05) Fungitoxicant (2.83)								(3.27)		
Concentration (2.53)								(2.92)		
Fungitoxicant x Concentration (5.66)								(6.55)		

Table-2 : *In vitro* efficacy of various non-systemic fungitoxicants in inhibiting the mycelial growth and spore germination of *Didymella bryoniae*.

Fungitoxicant	Per cent radial growth inhibition at concentration (*µg ml ⁻¹)					Percent spore germination inhibition at concentration (*µg ml ⁻¹)				
	100	250	500	1000	Mean	100	250	500	1000	Mean
Chlorothalonil 75 WP	22.9 (28.6)	46.6 (43.0)	100.0 (89.9)	100.0 (89.9)	67.4 (62.9)	42.8 (40.7)	66.3 (54.5)	88.4 (70.2)	100.0 (89.9)	74.3 (63.8)
Zineb 75 WP	15.1 (22.8)	31.4 (34.1)	55.5 (48.1)	100.0 (89.9)	50.5 (48.7)	22.6 (28.2)	47.7 (43.6)	65.2 (53.8)	100.0 (89.9)	58.9 (53.9)
Captan 50 WP	6.6 (14.5)	27.0 (31.2)	58.8 (50.1)	96.3 (83.4)	47.2 (44.8)	11.1 (19.2)	40.2 (39.3)	61.4 (51.7)	100.0 (89.9)	53.2 (50.0)
Copper oxychloride 50 WP	5.1 (12.8)	20.0 (26.2)	48.1 (43.9)	74.4 (59.6)	36.9 (35.6)	5.7 (13.3)	30.1 (33.2)	52.3 (46.3)	93.5 (75.2)	45.4 (42.0)
Mancozeb 75 WP	19.6 (26.2)	45.1 (42.2)	87.4 (69.2)	100.0 (89.9)	63.0 (56.9)	30.8 (33.6)	51.4 (45.7)	78.3 (62.2)	100.0 (89.9)	65.1 (57.9)
Mean	13.9 (21.0)	34.0 (35.3)	69.9 (60.2)	94.1 (82.5)		22.62 (27.06)	47.1 (43.3)	69.1 (56.8)	98.7 (87.0)	
CD (P=0.05) Fungitoxicant (2.94)								(3.13)		
Concentration (2.62)								(2.79)		
Fungitoxicant x Concentration (5.88)								(6.26)		

(Grower and Moore, 1962) and spore germination (Montgomery and Moore, 1938) techniques.

Poisoned food technique : Appropriate quantity of each fungicide was separately dispensed in molten sterilized PDA medium, contained in 100 ml Erlenmeyer flasks, under aseptic conditions to make a desired concentration viz., 10, 50, 100 and 200 µg/ml. The plant leaf extracts were prepared following the method given by (Jadeja, 2003). One hundred g of each plant material was crushed in 100 ml of sterilized distilled water for crude extract preparation. The extract was homogenized, filtered and centrifuged at 5000 rpm for 15 minutes. The supernatant was filtered through Whatman No. 1 filter paper. The clear extract so obtained, referred to as 100 per cent stock solution, was used for experiment. Desired concentrations viz., 1, 5, 10 and 15 per cent were prepared by adding appropriate amount of standard solution of plant extracts

to PDA medium. After thorough mixing, 20 ml of poisoned food, thus prepared, was poured in 90 mm diameter Petri plates. The mycelial discs of 5 mm dia, taken from 10 days old monospore culture of the test fungus with the help of sterilized cork borer, were aseptically placed at the centre of solidified poisoned PDA. Three replications were maintained for each concentration. The Petri plates were incubated at 24±1°C and observation on mycelial growth of test fungus recorded after seven days of incubation. The growth of the test fungus on non-poisoned PDA served as check. The per cent inhibition in growth due to various fungitoxicant treatments at different concentrations was computed by the following formula of Vincent (1947).

Percent inhibition

$$= \frac{\text{Growth in check} - \text{Growth in treatment}}{\text{Germination in check}} \times 100$$

Table-3 : *In vitro* efficacy of various botanicals in inhibiting the mycelial growth and spore germination of *Didymella bryoniae*.

Botanical	Percent radial growth inhibition at concentration (%)					Percent spore germination inhibition at concentration (%)				
	1	5	10	15	Mean	1	5	10	15	Mean
<i>Urtica dioica</i>	1.4 (6.8)	7.7 (16.0)	22.2 (28.0)	36.6 (37.2)	17.0 (22.0)	3.5 (10.8)	17.5 (24.6)	27.3 (31.4)	41.3 (40.0)	22.4 (26.7)
<i>Artemisia annua</i>	5.1 (12.9)	19.2 (25.9)	34.4 (35.9)	51.8 (46.0)	27.6 (30.2)	10.8 (18.9)	27.7 (31.7)	39.6 (38.9)	57.9 (49.5)	34.0 (34.8)
<i>Datura stramonium</i>	2.5 (9.2)	8.5 (16.9)	21.8 (27.8)	40.7 (39.6)	18.4 (23.4)	3.1 (9.5)	14.3 (22.1)	36.1 (36.9)	47.7 (43.6)	25.3 (28.0)
<i>Allium cepa</i>	6.3 (14.3)	24.0 (29.3)	53.3 (46.8)	75.1 (60.1)	39.7 (37.6)	10.1 (18.4)	30.8 (33.7)	50.8 (45.4)	73.7 (59.2)	41.4 (39.2)
<i>Allium sativum</i>	9.6 (18.0)	41.1 (39.8)	63.3 (52.7)	100.0 (89.9)	53.5 (50.1)	14.7 (22.5)	35.0 (36.2)	61.7 (51.7)	78.9 (62.7)	47.6 (43.3)
Mean	5.0 (12.2)	20.1 (25.6)	39.0 (38.2)	60.8 (54.6)		8.4 (16.0)	25.1 (29.7)	43.1 (40.9)	59.9 (51.0)	
CD (P=0.05) Botanical			(1.27)					(2.18)		
Concentration			(1.42)					(1.94)		
Botanical x Concentration			(2.85)					(4.36)		

Spore germination technique : One drop of the fungitoxicant/botanical extract solution with double the required concentration was placed in a cavity slide to which one drop of spore suspension was added. After 24 hour of incubation at $24\pm 1^\circ\text{C}$ in a moist chamber of Petri plates, observations on spore germination were taken and percent germination inhibition was calculated. In case of control a drop of sterilized distilled water was put in a cavity slide instead of fungicidal solution.

Results and Discussion

The results on *in vitro* evaluation of five systemic and five non-systemic fungitoxicants as well as five botanical extracts at different concentrations against the mycelial growth and spore germination of *D. bryoniae* revealed that among systemic fungitoxicants carbendazim exhibited maximum inhibition of 87.5 and 74.6 per cent of the mycelial growth and spore germination, respectively, followed by thiophanate methyl (76.1 and 69.5%) and myclobutanil (63.0 and 59.9%), while as among non-systemic fungitoxicants chlorothalonil proved most effective exhibiting 67.4 and 74.3 per cent inhibition of mycelial growth and spore germination, respectively, which was followed by mancozeb causing an inhibition of 63.0 and 65.1 per cent, respectively. The present findings on effectiveness of chlorothalonil are in agreement with the results reported by Van Steekelenburg (1978), who found satisfactory inhibition of mycelial growth of *Didymella bryoniae* by chlorothalonil. The efficacy of carbendazim against blight of field peas caused by complex of *Ascochyta pinodes*, *A. pinodella*, *A. pisi* and *Phoma koolunga* has been reported by Liu *et al.*, (2016). The effectiveness of carbendazim has been attributed to its ability to inhibit mitosis in sensitive fungi (Davidse, 1973), suppression of DNA production in fungal

cells (Hammerschlag and Sisler, 1973) and binding of tubulin which is required for spindle formation (Davidse, 1975; Davidse and Flach, 1977). *A. sativum* among botanicals tested against *D. bryoniae* was found superior in the present study with 53.5 and 47.6 per cent inhibition of mycelial growth and spore germination, respectively. The effectiveness of various botanical against *D. bryoniae* has previously been reported by Flori *et al.* (2000) who reported the 100 per cent inhibition of mycelial growth and spore germination of *D. bryoniae* by essential oils of *Cymbopogon citrates*, *Ageratum conyzoides* and *Eucalyptus citriodora*. Similarly, Favaron *et al.* (1993) reported inhibitory effect of onion and garlic extracts against the polygalacturonases produced *in vitro* by *D. bryoniae*. The antifungal activities of plant extracts has been earlier reported by many workers (Dubey and Dwivedi, 1991; Biswas *et al.*, 1995). The antifungal properties of garlic extract has been attributed to Allicin (diallyl-dithiosulfinate), which is produced by the garlic enzyme alliinase from the alliin (Ankri and Mirelman, 1999).

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Efficacy of Botanical Insecticides Against Major Sucking Insect-Pests of Brinjal (*Solanum melongena* L.) under Eastern Uttar Pradesh Condition

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Abstract

The present investigation was carried out at the Agricultural Research farm of BRD (PG) College Deoria, (U.P.) during *Rabi*, 2020-21. A total of eight treatments including untreated check were evaluated against major sucking insect-pests in randomized block design with three replications. Among the treatments six were botanical, while one was organic synthetic insecticide. Brinjal variety purple round was grown with all recommended packages of practices. Insecticides were applied when the pest population reached ETL. Subsequent four sprays were applied at 15 days interval. Observations were observed before spray and 3,7,10 and 15 days after spray. Results revealed that insecticides significantly reduced sucking pests population over untreated check. Although four sprays of Imidacloprid 6% + Lambda cyhalothrin 4% at 15 days interval were found to be most effective against sucking Insect-pests. Among the botanicals, Neem oil 5%, NSKE 5% and Nimbecicine was most effective against sucking Insect-pests.

Introduction

Brinjal or eggplant (*Solanum melongena*) belong to the family Solanaceae is an important vegetable crop of subtropics and tropics. In Uttar Pradesh the brinjal crop grown over of 8.01 ha. with an annual production of 275.40 MT (National Horticulture Statistics at a Glance 2018-19). Brinjal fruit contains moisture (91.5%), protein (1.3%), minerals (6.5%), calcium (0.02%), iron (1.3%) and phosphorus (0.06%). It also contains vitamin A, vitamin B, (nicotinic acid, riboflavin) and vitamin C (Wankhede, 2009). whitefly (*Bemisia tabaci* Genn.), Jassid (*Amrasca biguttula biguttula* Ishida) and Aphid (*Aphis gossypii* Glover) are the major sucking pests observed in brinjal. Several species of whiteflies may infest eggplants, but silverleaf whitefly is the primary one. Whiteflies are found mostly on the underside of leaves. They transmit plant viruses besides sucking the sap from the plant infested plants severely lose their productivity.

Jassid, is becoming another major pest of brinjal considering its infestation severity and damage to the plant (Mahmood *et al.*, 2002) and (Kalawate and Dethé, 2012). In severe conditions, leaves become cup-shaped and dried later on and plants get stunted. Finally productivity is worst affected.

Another sucking pest, *Aphis gossypii* also adversely affects the productivity of plants by sucking and devitalizing the brinjal plants.

Generally, the chemical insecticides are used to control insect-pest in brinjal, but their residual activity remains a cause of concern as the brinjal fruit are

harvested several times during the season. It is therefore become essential to evolve safer means of insect-pests management in brinjal. Botanical products have been claimed to be effective in managing insect-pests in several crops. Botanicals are effective in controlling insect-pests because they possess repellent, knock down and antifeedant properties that are less hazardous, biodegradable and promote biodiversity of insect-pests. The plant derived bioactive compounds are thought to be an important factor in recent plant protection efforts.

Eco-friendly and cost effective measures like use of botanicals in IPM are more advantageous over insecticides and fit well in IPM (Prakash *et al.*, 2008). Neem (*Azadirachta indica*) and some other plants have been used as a source of botanical pesticide (Sharma *et al.*, 1992; Efil *et al.*, 2005; Lloba and Ekrakene, 2006). However, deriving pure new biopesticide substance from plants remains a complex task because it needs chemical screening complemented with biological effect. Plant products are mostly target specific and exhibit their anti-insect property in many ways. They act as repellents, attractant, oviposition-deterrent, anti-feedant and anti-growth regulators. This multifaceted action of botanicals is advantageous for control of pest population.

Materials and Methods

The present investigation was carried out at the Agricultural Research farm of Baba Raghav Das Post Graduate College Deoria, (Uttar Pradesh) during *Rabi*, 2020-21. The experiment was laid out in Randomized Block Design with eight treatments including control viz. Neem oil 3%, Neem oil 5%, NSKE 5%, Aak based extract,

Table-1 : Effectiveness of different plant extracts against Whitefly, Jassid and Aphid during Rabi, 2020-21.

Treatment	Dose (ml)	Population of whitefly/leaf (Days after spray)					Population of jassid/leaf (Days after spray)					Population of aphid/leaf (Days after spray)				
		Before spray	3DAS	7DAS	10DAS	15DAS	Before spray	3DAS	7DAS	10DAS	15DAS	Before spray	3DAS	7DAS	10DAS	15DAS
Neem oil 3%	3ml	2.20 (1.64)*	0.44 (0.96)	0.61 (1.04)	0.57 (1.02)	1.57 (1.43)	1.60 (1.45)*	0.30 (0.89)	0.28 (0.88)	0.48 (0.98)	0.50 (0.98)	16.26 (4.08)*	6.37 (2.50)	5.66 (3.92)	16.84 (3.92)	5.68 (2.42)
Neem oil 5%	5ml	2.20 (1.60)	0.39 (0.94)	0.57 (1.03)	0.55 (1.00)	1.24 (1.31)	1.46 (1.39)	0.26 (0.87)	0.28 (0.87)	0.30 (0.89)	0.46 (0.98)	17.93 (4.25)	4.20 (2.11)	4.17 (2.49)	5.84 (2.49)	2.67 (1.73)
NSKE 5%	5ml	1.70 (0.47)	0.44 (0.95)	0.53 (1.01)	0.55 (1.00)	1.38 (1.39)	1.36 (1.36)	0.35 (0.87)	0.20 (0.84)	0.37 (0.93)	0.53 (0.99)	17.80 (4.27)	5.05 (2.29)	10.97 (2.99)	9.55 (2.91)	4.57 (2.20)
Aak based extract	As such	1.83 (1.53)	0.51 (1.00)	0.44 (0.96)	0.86 (1.17)	1.17 (1.29)	1.66 (1.47)	0.28 (0.87)	0.26 (0.87)	0.37 (0.92)	0.46 (0.98)	16.86 (4.16)	8.44 (2.80)	8.48 (2.91)	9.77 (3.46)	4.53 (2.20)
Neem based extract	As such	1.76 (1.49)	0.51 (1.00)	0.68 (1.08)	0.75 (1.11)	0.84 (1.14)	1.70 (1.48)	0.28 (0.87)	0.24 (0.86)	0.37 (0.93)	0.57 (1.03)	16.90 (4.15)	6.12 (2.56)	8.13 (3.46)	12.02 (2.84)	7.09 (2.73)
Nimbecidine 0.03%	5ml	1.90 (1.53)	0.53 (1.01)	0.37 (0.93)	0.72 (1.10)	1.15 (1.27)	1.73 (1.49)	0.26 (0.87)	0.24 (0.86)	0.41 (0.92)	0.39 (0.94)	15.66 (4.02)	3.79 (2.05)	7.89 (2.84)	8.50 (2.84)	4.06 (1.92)
Imidacloprid 6%+Lambda cyhalothrin 4%	2ml	1.80 (1.50)	0.33 (0.91)	0.28 (0.88)	0.50 (0.99)	0.67 (1.06)	1.66 (1.46)	0.17 (0.81)	0.15 (0.90)	0.26 (0.87)	0.11 (0.77)	17.53 (4.14)	1.35 (1.30)	0.72 (1.12)	1.06 (1.12)	1.19 (1.23)
Untreated check		2.13 (1.62)	0.57 (1.03)	0.85 (1.15)	1.22 (1.30)	1.90 (1.54)	1.66 (1.46)	0.39 (0.94)	0.42 (0.95)	0.57 (1.03)	0.66 (1.07)	18.26 (4.19)	9.95 (3.10)	12.19 (4.13)	20.46 (4.13)	7.28 (2.66)
SE.(m)		0.14	0.07	0.07	0.09	0.06	0.06	0.03	0.06	0.04	0.05	0.41	0.27	0.34	0.28	0.27
C.D.		NS	NS	NS	NS	0.20	NS	NS	NS	0.15	0.84	NS	0.87	1.05	0.87	0.82

*Figures in parenthesis are square root transformed values.

Neem based extract, Nimbecidine 0.03%, Imidacloprid 6% + Lambda cyhalothrin 4% and untreated check replicated three times in 2m×2m plot size. The spacing between row to row and plant to plant was maintained at 60×50 cm, respectively. The brinjal variety Purple round was selected for the experiment. The observations on insect-pests were recorded before spray and 3, 7, 10 and 15 days after spray. The observations of Whitefly, Jassid and Aphid were recorded on fifteen randomly selected leaves in each plot (top, middle and lower leaves). The values of insect population were transferred using $\ln+0.5$ transformation to make the data satisfy the normality assumption involved in statistical analysis.

Method of preparation of various plant extracts:

NSKE 5% : Materials required: Well dried neem seed kernel-5kg, Water-100 litres, Detergent-200g and Muslin cloth for filtering.

Methodology : Take required quantity of Neem seed kernel 5kg. Grind the kernel gently to powder it. Soak it overnight in 10 litres of water. Stir with wooden planks in the morning till the solution becomes milky white. Filter through a double layer of muslin cloth and make the volume to 100 litres. Add 1% detergent (make a paste of detergent and then mix it in the spray solution). Mix the spray solution well and use. Always use freshly prepared neem seed kernel extract (NSKE). Spray the extract after 4:00 PM to get effective results.

Aak leaf extract : Materials used : Aak leaf-1kg, Citronella-500gm, Tobacco 500gm, Water-10 lit., Detergent-20g and Muslin cloth for filtering.

Methodology : Took Aak leaf, Citronella and Tobacco, 1kg, 500gm and 500gm, respectively. Chop the materials in smaller bits. Soak it for 24 hours in 10 litres of water. Stir with wooden planks in the morning till the solution completely changes its colour. filter through double layered muslin cloth and make the volume 10 litres. Add 1% detergent (make a paste of detergent then mix it in the spray solution). Mixed the spray solution well and used. Always use freshly prepared extract. Spray the extract after 4:00PM to get desired results.

Neem leaf extract : Materials used : Neem leaf-2kg, Datura leaf & fruits-0.5kg, Behaya leaf-0.5kg, Congress grass-0.5kg, Garlic-250g, Green chilli-100g, Water-10 litres, Detergent 20g and Muslin cloth for filtering.

Methodology : Took all the ingredients in the amount specified. Chop neem leaves, Datura leaf and fruits, behaya leaf and Congress grass into smaller bits and make paste of garlic and chilli. Soak all the chopped and paste ingredients in 10 litres of water for 24 hours. Stir with wooden plank after 24 hour for 10 minutes. Filter through double layered muslin cloth and make the volume 10 litres. Add 1% detergent (Make a paste of detergent then mix it in the spray solution). Mix the spray solution thoroughly and use. Always use freshly prepared extract. Spray the extract after 4:00 PM to get the desired result.

Results and Discussion

Whitefly : The Efficacy of seven botanical insecticides were evaluated under field condition with untreated check against whitefly in brinjal. All the treatments were superior over untreated check but the variation was statistically non-significant in reducing whitefly population. Imidacoprid 6% + Lambda cyhalothrin 4% was found most effective treatment in controlling whitefly population throughout the crop period. Mhaske and Mote (2005) reported the effectiveness of Imidacloprid against whitefly in brinjal. Gopal Das *et al.* (2014) found that Imidacloprid was significantly effective against whitefly. Among the botanical plant extracts Neem oil 5% was most effective against whitefly, followed by NSKE @ 5% and Neem oil @ 3%. Although, Neem based extract and Aak based extract were also effective in reducing whitefly population. These findings are in accordance with that of Karkar *et al.* (2014) who reported that the spray of NSKE @ 5% and Neem oil @ 0.3% were effective against sucking pests including whitefly. Kumar *et al.* (2017) also reported that the plot treated with Azadirachtin and NSKE @ 5% reduced whitefly population minimum in comparison to Imidacloprid conforms the present findings.

Jassid : It is obvious from data presented in Table-1 that the jassid population under different treatments showed non-significant variation up to 7 days after spray, followed by a significant variation 10 days and 15 days after spray. Among various treatments Imidacloprid 6% + Lambda cyhalothrin 4% was most promising up to 15 days after spray, recorded minimum population of jassid. Botanical extracts did not followed a definite trend in reduction of the jassid population. However, Neem oil 5% was best in controlling jassid, followed by NSKE 5% and Aak based extracts. Other botanical extracts were also found effective and registered lower population of jassid over untreated check. Effectiveness of botanical pesticides against jassid in brinjal has already been studied by Deharia *et al.* (2018) and reported better efficacy against jassid in brinjal. Among the botanicals Neem oil was found superior over all the botanicals, followed by NSKE 5%

conform to the present finding. Imidacloprid was significantly effective against jassid Kandil *et al.* (2014) conform the present finding. Our findings are in close conformity with the findings of Sarangdevot *et al.* (2006) who reported Neem oil @ 10 ml and 2.5 ml per liter of water, respectively, provided good control of leafhopper population.

Aphid : Data presented in Table-1 revealed that all the treatments were significantly superior over untreated check at all the intervals of observations. There was a significant difference among the treatments as well. Among the treatments evaluated Imidacloprid 6% + Lambda cyhalothrin 4% proved most effective against aphid up to 15 DAS. It was followed by Neem oil 5%, Nimbecidene and NSKE 5%. The efficacy of Aak based extract and Neem based extract was comparatively lower but superior to untreated check. Neem oil 3% was least effective among the treatments against aphids. Imidacloprid as a very effective insecticides against aphid has also been reported by Ameta and sharma (2005), Dhanalakshmi and Mallapur (2008), Corroborate the present finding. The joint action of which was more toxic to aphids. Patil *et al.* (2009) also found fipronil 40% + Imidacloprid 40% were better than Imidacloprid 200 SL alone against sucking pests of cotton. Our findings are in accordance with that of Boopathi *et al.* (2010) who reported Neem oil significantly reduced the population of aphids.

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Efficacy of Various Novel Insecticides Against Mustard Aphid (*Lipaphis erysimi*) on Indian Mustard

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Abstract

Field experiment was conducted at Agricultural research farm, Baba Raghav Das Post Graduate College Deoria, Uttar Pradesh during Rabi session of the 2020-21. Seven treatments including untreated check was evaluated against mustard aphid in randomised block design. The results revealed that all the insecticidal treatments were significantly superior in reducing mustard aphid population over untreated check. Overall performance of insecticides in current investigation revealed that Beta-cyfluthrin 8.49% + Imidacloprid 19.8% was recorded as best control in terms of highest aphid population reduction amongst all the insecticidal treatments. It was recorded at par with Imidacloprid 4% + Lambda cyhalothrin 6% and Imidacloprid 70% WG recorded 9.46 and 4.33 aphid/10cm apical twig, respectively. All the insecticides evaluated against per cent plant infestation due to aphid in mustard proved significantly superior over untreated check. Beta-cyfluthrin 8.49% + Imidacloprid 17.8%, Imidacloprid 4% + Lambda cyhalothrin 6% and Thiamethoxam 18.7% SG found to be most effective insecticides as minimum aphid infestation was observed on plant. Where as Imidacloprid 70% WG, Dimethoate 30 EC and NSKE 5% found more or less equally effective as these treatments were statistically at par with each other. All the treatments significantly increased the seed yield of mustard in comparison to untreated check in present investigation. The highest seed yield was recorded in plot treated with Thiamethoxam 18.7% SG followed by Imidacloprid 4% + Lambda cyhalothrin 6%, Beta-cyfluthrin 8.49% + Imidacloprid 19.8% and Imidacloprid 70% WG. These treatments were statistically comparable to each other in enhancing the seed yield of mustard. As the cost benefit ratio is concerned the application of Thiamethoxam 18.7% SG was found most beneficial as it returned Rs. 3.51 per rupee invested, followed by Imidacloprid 4% + Lambda cyhalothrin 6% (1:3.06) and Imidacloprid 70% WG (1:2.46).

Introduction

Oil seed crop play a vital role in Indian agricultural economy. Indian vegetable oil economy is the fourth largest in the world. Mustard is second most important oil crop of India after groundnut. Mustard (*Brassica campestris*) commonly known as rai or sorson belong to family Brassicaceae or cruciferae. Mustard is grown mainly for its seed which yield good quality of edible oil to the extent of 30 to 33 percent. Mustard is the main cooking medium in northern India. The seed oil are used as condiments in the preparation of pickles, flavouring the curries and vegetable and the cake as cattle feed. The estimated area production and yield of mustard in the world is 72.37 million hectares and 1980 kg/ha respectively, (Anonymous 2020). In India total mustard production is 86-93 lakh MT while in Uttar Pradesh 8.46 million MT (www.nbh.kisanindia.com). Insect pests are important biotic constraints that posed severe threat to mustard from germination to harvest. About 50 insect species have been found infesting the rapeseed mustard in India Sharma and Singh 2010, out of which about a dozen of species are considered as major pest Singh 2009. Among these, *L. erysimi* referred as the major factors causing up to 96 percent yield losses Sharma and Kashyap 1998, Singh and Sharma 2002 and Shylesha *et al.*, 2006. Verma

and Singh, 1987 recorded 15% reduction in oil content due to mustard aphid infestation. Aphid sucks the cell sap from the stems, twigs buds, flowers and developing pods causing a significant loss in yield. Kular and Kumar 2011 reported that the losses in seed yield ranged from 6.5 to 26.4 per cent of different Brassica species (*B. juncea*, *B. napus*, *B. carinata*, *B. rapa* and *E. sativa*) by the infestation of mustard aphid. Control of aphids is a difficult task because of their rapid growth, mode of reproduction, polymorphic nature and ability to adopt different kinds of environment. A number of chemical insecticides have been found effective against this pest in different parts of the country (Singh and Verma, 2008; Singh and Singh, 2009). But the indiscriminate use of the insecticides has resulted into several problems like environmental pollution, health hazards to human beings, toxicity to pollinators & natural enemies etc. (Singh, 2001). So it is necessary to find alternate economical and environmentally safe methods for pest control. A number of novel insecticides are now available to manage noxious insect pest, need to be evaluated against mustard aphid for sound management. Therefore the investigation was planned for effective management of aphid in mustard under agro climatic conditions of tarai region of eastern Uttar Pradesh.

Table-1 : Insecticides treatment used in experiment.

Name of Insecticides	Trade Name	Concentration/Amount used	Cost of Insecticides (Rs/ liter or kg)	Source of Availability
Imidacloprid 4% + Lambda cyhalothrin 6%	+Inovexia	2ml/liter	2400	Willowood Crop Science Pvt. Ltd.
Beta-cyfluthrin 8.49% + Imidacloprid 19.8%	Solomon	1ml/liter	3300	Bayer Crop Science Ltd.
Thiamethoxam 18.7% SG	Actara	0.5gram/liter	2290	Syngenta India Ltd.
Imidacloprid 70% WG	Admire	0.5gram/liter	2200	Bayer India Ltd.
Dimethoate 30% Ec	Tafgor	1.5ml/liter	1640	FMC India Pvt. Ltd.
NSKE 5%	Selfmade		500	Locally Available

Table-2 : Efficacy of different insecticides against mustard aphid population.

Treatment	Mean Aphid Population (Per 10 cm Apical Twig)				
	Before spray	3 Days	7 Days	10 Days	15 Days
Imidacloprid 4% + Lambda cyhalothrin 6%	142.33 (11.95)	9.46 (3.16)	4.95 (2.33)	12.40 (3.59)	20.36 (4.57)
Beta-cyfluthrin 8.49% + Imidacloprid 19.8%	100.53 (10.05)	1.80 (1.52)	10.56 (3.33)	12.45 (3.60)	16.96 (4.18)
Thiamethoxam 18.7% SG	110.46 (10.53)	17.51 (4.24)	9.26 (3.12)	11.23 (3.42)	17.36 (4.23)
Imidacloprid 70% WG	125.06 (11.21)	4.33 (2.20)	9.92 (3.23)	10.00 (3.24)	19.33 (4.45)
Dimethoate 30 EC	86.80 (9.21)	13.53 (3.75)	25.63 (5.11)	26.59 (5.20)	27.73 (5.31)
NSKE 5%	106.60 (10.35)	20.60 (4.59)	23.30 (4.88)	28.13 (5.35)	47.43 (6.25)
Untreated check	120.86 (11.02)	47.13 (6.90)	138.46 (11.79)	73.00 (8.57)	78.30 (8.88)
SE(+/-)	0.707	0.654	0.750	0.779	0.774
CD	NS	2.01	2.31	2.40	2.38

Materials and Methods

In order to study the effect of different insecticides the experiment was laid out in a randomised block design with replication having plot size of 2.00 in to 1.5 m during *Rabi 2020-21* at Agricultural research farm B.R.D.P.G. college Deoria (U.P.) Mustard variety "Urja" was sown at spacing of row to row 30 cm and plant to plant 15 cm with recommend agronomical practice. A total of seven treatments including untreated check was evaluated is RBD with three replication. The details of the treatments in table-1. Two sprays were given first spray application of respective insecticides was given on ETL level and subsequent spray was given at 15 days after first spray by manually operated knapsack sprayer having duromist nozzle. Aphids population was recorded in terms of aphid on five randomly selected and tagged plants from each plots on 10cm terminal shoot, one day before and 3, 7, 10 and 15 days after spray of insecticides in both spray. The data on aphid population was used for statistical analysis after transferring in

Besides total number of aphid infested for were counted from each replication for purposes total number of branches in each plant of the plots were counted before and after application of Insecticides. Total number of

aphid infested branches and aphid free branches were counted separately to get per cent infestation in plant by using formula:-

Per cent Plant infestation

$$= \frac{\text{No. of infested branch}}{\text{Total no. of branches in each treatment}} \times 100$$

Results and Discussion

Efficacy of different insecticides against mustard aphid population : Overall performance of insecticides in current investigation revealed that Beta-cyfluthrin 8.49% + Imidacloprid 19.8% was recorded as best control in terms of highest aphid population reduction amongst all the insecticidal treatments. It was recorded at par with Imidacloprid 4%+Lambda cyhalothrin 6% and Imidacloprid 70% WG recorded 9.46 and 4.33 aphid/10cm apical twig, respectively. Other treatments Imidacloprid 70% WG Dimethoate 30EC and NSKE 5% found more or less equally effective as mustard Viz. These treatments were statistically at par with each other. These finding are in closed proximity with the finding with Yadav and Singh 2016 who reported all the insecticidal treatments significantly reduced the population of aphid at all the intervals of observation. Among insecticides Imidacloprid

Table-3 : Per cent plant infestation due to aphid under different insecticides treatments.

Treatment	Per cent plant infestation				
	Before spray	3 DAS	7 DAS	10 DAS	15 DAS
Imidacloprid 4% + Lambda cyhalothrin 6%	76.79 (51.19)	6.93 (15.26)	7.95 (16.37)	9.99 (18.42)	14.86 (22.67)
Beta-cyfluthrin 8.49% + Imidacloprid 19.8%	62.35 (52.14)	4.60 (12.38)	10.92 (19.29)	11.50 (19.82)	13.54 (21.59)
Thiamethoxam 18.7% SG	68.14 (55.63)	6.54 (14.81)	17.60 (24.80)	13.80 (21.80)	14.46 (22.34)
Imidacloprid 70% WG	49.63 (44.78)	10.14 (18.56)	11.88 (20.16)	14.39 (22.29)	18.23 (25.27)
Dimethoate 30 EC	85.51 (67.62)	14.74 (22.57)	23.30 (28.86)	20.80 (27.13)	18.59 (25.54)
NSKE 5%	75.04 (60.02)	43.00 (40.97)	21.58 (27.68)	34.06 (35.70)	34.87 (36.19)
Untreated check	65.74 (54.17)	65.19 (53.84)	58.33 (49.79)	63.10 (52.59)	46.84 (43.18)
SE(+/-)	0.0819	2.393	2.027	4.364	3.273
CD	NS	7.37	6.24	13.44	10.08

Table-4 : Economics of various insecticidal application during Rabi session 2020-21.

Treatment	Number of spray	Price of insecticides (Rs/Lit.)	Total cost of application (Rs/ha.)	Yield (q/ha)	Increase in yield over control (q/ha.)	Value of yield saved by insecticides	Gross income (Rs/ha.)	Additional income (Rs/ha.)	C:B ratio Rupees/ rupees invested
Imidacloprid 6% + Lambda-cyhalothrin 4%	2	2400	6100	7.19	4.23	18717.5	31815.75	12617.75	1:3.06
Beta-cyfluthrin 8.49% + Imidacloprid 17.8%	2	3300	7900	6.70	3.74	16549.5	29647.50	8649.50	1:2.09
Thiamethoxam 18.7% SG	2	2290	5880	7.63	4.67	20664.75	33762.75	14784.75	1:3.51
Imidacloprid 70% WG	2	2200	5700	6.14	3.18	14071.5	27169.50	8371.50	1:2.46
Dimethoate 30EC	2	1640	3580	4.50	1.54	6814.5	19912.50	3234.50	1:1.90
NSKE 5%	2	500	2300	3.00	0.04	177	13275	2123	1:0.07
Water spray	2	-	-	2.96	-	-	13098	-	-

Amount of water used = 500 lit./ha/spray, Labour cost = Rs.300/day, Sprayer rent = Rs. 50/day

Sale price of produce = 4425 Rs/Q

17.8 SL and Thiamethoxam 25 WG was most effective against mustard aphid. Imidacloprid and Thiamethoxam were found most effective against mustard in field was also reported by Rohilla *et al.* 2004, Mandal and Mandal 2010 and Kantipudy, 2013 conformed the present finding. The treatments of combined insecticides in present studies may also enhance the toxicity of both the insecticides so that they were most effective at all the days of observation.

Per cent plant infestation due to aphid under different insecticides treatments : All the insecticides evaluated against per cent plant infestation due to aphid in mustard proved significantly superior over untreated check. Beta-cyfluthrin 8.49% + Imidacloprid 17.8%, Imidacloprid 4% + Lambda cyhalothrin 6% and Thiamethoxam 18.7% SG found to be most effective insecticides as minimum aphid infestation was observed on plant. Where as Imidacloprid 70% WG, Dimethoate 30 EC and NSKE 5% found more or less equally effective as these treatments were statistically at par with each other. The finding are in

closed proximity with the finding of Khedekar *et al.* 2012 who reported Imidacloprid, acetomiprid and Thiamethoxam proved to be more effective followed by Acephate, Dimethoate and thiodiazinon against mustard aphid. Gour and Pareek 2003 also found Imidacloprid as the most effective insecticides against aphid followed by Dimethoate and Acephate.

Similarly Rohilla *et al.* (2004) observed that Imidacloprid and Thiamethoxam were highly effective against mustard aphid. According to Bapari *et al.* (2008), Imidacloprid showed the best knock-down effect on aphid with longest persistency.

Effect of different insecticidal application on seed yield of mustard : All the treatments significantly increased the seed yield of mustard in comparison to untreated check in present investigation. The highest seed yield was recorded in plot treated with Thiamethoxam 18.7% SG followed by Imidacloprid 4% + Lambda cyhalothrin 6%, Beta-cyfluthrin 8.49% +

Imidacloprid 19.8% and Imidacloprid 70% WG. These treatments were statistically comparable to each other in enhancing the seed yield of mustard. The treatment viz Dimethoate 30EC and NSKE 5% proved moderately effective in enhancing the yield of mustard. These findings are in close proximity with the finding Patel *et al.* 2020 who reported that the maximum seed yield of 21.69q/ha was recorded in Thiamethoxam which remain at par with Imidacloprid 21.43q/ha and Dimethoate 20.69q/ha. The lowest seed yield was obtained from untreated plot 10.44q/ha. Bhattacharya and Dhar 2008 and Bana et al. 2011 also reported that insecticides like Imidacloprid and Thiamethoxam were increased the seed yield of mustard corroborated the present finding.

Economics of various insecticidal application : The economics of different insecticidal treatments were calculated to know the feasibility of their acceptability by farmers going to control major insects pest of mustard. In present study application of two spray of all the insecticidal were found economical in comparison to untreated check except NSKE 5%. However, maximum additional income Rs 14784.75/ha was recorded with Thiamethoxam 18.7% SG followed by Imidacloprid 6% + Lambda cyhalothrin 4% Rs 12617.75/ha Imidacloprid 70% WG Rs 8371.50/ha and Beta-cyfluthrin 8.49% + Imidacloprid 19.8% Rs 8649.50/ha. As the C:B ratio is concerned, the application of Thiamethoxam 18.7% SG was found most economical as it gave maximum return of Rs 1:3.51 per rupee invested followed by Imidacloprid 4% + Lambda cyhalothrin 6% 1:3.06, Imidacloprid 70% WG 1:2.46 and Beta-cyfluthrin 8.49% + Imidacloprid 19.8% (1:2.09). These findings are in partial agreement with that of Singh et al. 2014 and Bhattacharya and Dhar 2008 who got better return rupees per rupee invested with application of Imidacloprid and Thiamethoxam. The benefit or loss of particular treatment depends on their cost and corresponding yield.

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Differential Responses of Yield, Economics and Post Harvest Soil Status to Integrated Nutrient Management Practices in Sweet Corn (*Zea mays* L. *Saccharata*)

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Abstract

A field experiment was conducted on sandy loam soil of research farm, Ambikapur during *kharif* 2019-20. The experiment was laid out in a randomized block design with seven treatments, each replicated three times viz., 50% RDF (T₁), 75% RDF (T₂), 100% RDF (T₃), 50% RDF + vermicompost @ 3 t ha⁻¹ (T₄), 75% RDF + vermicompost @ 3 t ha⁻¹ (T₅), 50% RDF + FYM @ 5 t ha⁻¹ (T₆) and 75% RDF + FYM @ 5 t ha⁻¹ (T₇) where, RDF was 120:60:40 kg N, P₂O₅, K₂O ha⁻¹. Among the fertility levels trialed, application of 100% RDF through inorganic fertilizers resulted significantly higher green cob yield (17228.45 kg ha⁻¹), green fodder yield (2104045 kg ha⁻¹) and net profit (128233.05 ₹ ha⁻¹) which was however, found parity with the application of 75% RDF along with vermicompost @ 3 t ha⁻¹ and 75% RDF along with FYM @ 5 t ha⁻¹ but significantly superior over other treatments. Post harvest availability of N, P₂O₅, K₂O and organic carbon were enhanced significantly by the application of organic manures viz., vermicompost followed by FYM.

Key words : Sweet corn, vermicompost, farm yard manure, organic carbon.

Introduction

Maize (*Zea mays* L.) is one of the important cereal crops occupying a prominent position in global agriculture and one of the most important staple food crops of the world and ranks next to wheat and rice. Maize has been an important cereal because of its great production potential and adaptability to wide range of environmental conditions. Maize occupies an important place in

Indian economy also known as the “Queen of Cereals”. Recently specialty corns such as sweet corn, baby corn and popcorn have emerged as alternative food sources, especially for affluent society. Maize growers are shifting towards specialty corn production due to higher returns and also opening opportunities for employment generation in peri-urban areas. Sweet corn (*Zea mays* L. *saccharata*) used as a human food in soft dough stage with succulent grain. The sugar (20% on dry basis at green ear stage) and starch make the major component of the endosperm, which results in sweetish taste of the kernel before they attain the maturity. The cobs are picked up at green stage (with 70% moisture) for canning and table purpose. The higher content of water soluble polysaccharide in the kernel adds texture and quality in addition to sweetness (Venkatesh *et al.*, 2003).

In India, maize is grown over an area of 9.28 million ha with an average productivity of 2.82 t ha⁻¹ (Department of Agriculture, Cooperation and Farmers Welfare Ministry of Agriculture and Farmers Welfare Government of India, 2018). In Chhattisgarh maize covers 226.79 thousand

hectare land having productivity of 2458 kg ha⁻¹ in *Kharif* 2017-18 (Directorate of Agriculture, Government of Chhattisgarh 2018).

It is an exhaustive crop and it is harvested at milky stage and requires fertile soil along with good organic matter for sustaining productivity of sweet corn. Results from the study showed that integrated nutrient management over the years resulted better soil properties as well as status of available nutrients in the soil. Continuous application of urea as a source of N has resulted in acidification of soils (pH 4.3) while lime application increased the pH to 6.2 in the surface soil and 6.0 in subsurface soil. 100 % NPK + FYM resulted 66 per cent increase in soil organic carbon content over initial value. Similar effects were recorded on cation exchange capacity and available nutrients (Bharti and Sharma, 2017). Application of 180-75-60 kg N P K ha⁻¹ + vermiwash at 20, 35 and 50 DAS found parity with 180-75-60 kg N P K ha⁻¹ + vermi compost but exhibited their superiority at the highest levels of fertilization over the same levels under chemical sources in enhancing green cob yield (Keerthi *et al.*, 2013).

Materials and Methods

The field experiment was carried out during *Kharif* season of 2019-20 at the Research farm, RMD College of Agriculture & Research Station, Ambikapur situated at 23°18' N latitude and 83°15' E longitude and at altitude of 611 meter above mean sea level which represents the northern hills agro-climatic zone of Chhattisgarh. The soil

Table-1 : Properties of soil of experimental site.

S. No.	Soil properties	Value	Method of analysis
A. Physical-Mechanical analysis			
a.	Sand (%)	60.3	International pipette method (Black, 1965)
b.	Silt (%)	14.9	
c.	Clay (%)	23.4	
	Texture	Sandy loam	
B. Chemical analysis			
a.	Soil reaction (pH)	5.7	Glass electrode pH meter (Piper, 1967)
b.	Electrical conductivity (dS/m)	0.27	Solubridge method (Black, 1965)
c.	Organic carbon (%)	0.56	Rapid titration (Walkley and Black, 1934)
d.	Available N (kg ha ⁻¹)	234	Alkaline permanganate (Subbiah and Asija, 1956)
e.	Available P ₂ O ₅ (kg ha ⁻¹)	8.4	Olsen's extractant (Olsen et al., 1954)
f.	Available K ₂ O (kg ha ⁻¹)	268	Flame photometer (Muhr et al., 1965)

Treatment :

T₁ - 50% RDF

T₃ - 100% RDF

T₅ - 75% RDF + vermicompost @ 3 t ha⁻¹

T₇ - 75% RDF + FYM @ 5 t ha⁻¹

T₂ - 75% RDF

T₄ - 50% RDF + vermicompost @ 3 t ha⁻¹

T₆ - 50% RDF + FYM @ 5 t ha⁻¹

of the experimental site was sandy loam in texture, acidic in reaction (pH 5.7), medium in organic carbon (0.56), available nitrogen (234 kg ha⁻¹), available phosphorus (8.4 kg ha⁻¹) and available potassium (268 kg ha⁻¹) (Table 1). The experiment was carried out in randomized block design (RBD) with 3 replications. The treatments contained of seven nutrient management practices.

Where, RDF was 120:60:40 kg N, P₂O₅, K₂O ha⁻¹. Sowing was done manually in 1st week of July 'Sugar 10' sweet corn variety was used. Manure and fertilizers were used as per the treatments. RDF was applied through ifco (12:32:16), urea and MOP. One third nitrogen, full dose of P₂O₅ and K₂O were applied as basal at the time of sowing. Remaining nitrogen was top dressed in two equal splits at knee high stage (30 DAS) and tasseling stage (45 DAS) equally in all treatments. Crop was sown at spacing of 60 cm with plant to plant spacing 15 cm to maintain the plant population of 111,111 plants ha⁻¹ using 5 kg seeds ha⁻¹. Weeds were removed as and when they appeared and also other inter culture operations were taken up as per package of practices. Cobs from the net plot area were harvested at milky stage and weighed for cob yield. After peaking the cobs green fodder was bundled and weighed for fodder yield. Economics of different treatments were worked out taking into consideration of input costs and returns from the produce of experimental crop. Soil samples from each treatment were taken independently of required quantity using core sampler just after harvesting of crop, and analyzed for available macronutrients and organic carbon content by using the methods as mentioned in Table 1. All data obtained from the experiment was statistically analyzed using *F*-test, the procedure given by Gomez & Gomez (1984), critical difference (CD) values at *P*= 0.05 were used to determine the significance of differences between means.

Results and Discussion

Green cob yield was significantly influenced by integration of different organic and inorganic sources. (Table-2 and depicted in fig.-1). The maximum cob yield (17228.45 kg ha⁻¹) was obtained with the application of 100% RDF through inorganic fertilizers (T₃) followed by 75% RDF + vermicompost @ 3 t ha⁻¹ (T₅) and 75% RDF + FYM @ 5 t ha⁻¹ (T₇). There was an increase of 46.57%, 40% and 34.18% more yield in T₃, T₅ and T₇ respectively when compared to 50% RDF (T₁), which recorded the lowest green cob yield (11754.44 kg ha⁻¹).

Similar to green cob yield, green fodder yield was also significantly influenced by different organic and inorganic sources. (Table-2 and fig-1). Similar green fodder yield was recorded highest (21040 kg ha⁻¹) with the application of 100% RDF through inorganic fertilizers (T₃) followed by 75% RDF along with vermicompost @ 3 t ha⁻¹ (T₅) and 75% RDF along with FYM @ 5 t ha⁻¹ (T₇) but found significantly higher over other treatments. This might be due to application of recommended dose of nitrogen in three splits to a short duration crop resulted in higher vegetative growth of sweet corn whereas increase in cob yield under treatments T₅ and T₇ might be due to the fact that organic manures which improved physical conditions of soil and aid better uptake of nutrients that leads to better growth of plant. The results are in close accordance with those reported by Grazia *et al.*(2003), Keerthi *et al.*(2013) and Rasool *et al.* (2015).

Net returns and B:C ratio (Table 2) were worked out for sweet corn by taking into consideration of the cost of inputs used and market price of the crop produce. The maximum net returns (128233.05 ₹ ha⁻¹) and B:C ratio (2.35) were obtained with the application of entire dose of recommended NPK through inorganic fertilizers (T₃)

Table-2 : Effect of different nutrient management practices on yield and economics of sweet corn.

Treatments	Treatment details	Yield		Economics	
		Green cob yield (kg ha ⁻¹)	Green fodder yield (kg ha ⁻¹)	Net return (ha ⁻¹)	B:C ratio
T ₁	50% RDF	11754.44	15180	73611.05	1.43
T ₂	75% RDF	14263.11	18068.89	98601.07	1.86
T ₃	100% RDF	17228.45	21040	128233.05	2.35
T ₄	50% RDF + vermicompost @ 3 t ha ⁻¹	13682.22	17617.33	79107.49	1.19
T ₅	75% RDF + vermicompost @ 3 t ha ⁻¹	16460	20064.45	106567.7	1.57
T ₆	50% RDF + FYM @ 5 t ha ⁻¹	13442.22	17000	88398.85	1.62
T ₇	75% RDF + FYM @ 5 t ha ⁻¹	15772.44	19782.22	111551.07	1.99
Sem±		532.49	529.76	5465.12	0.10
CD (P=0.05)		1640.76	1632.35	16839.92	0.31

Table-3 : Effect of different nutrient management practices on post harvest soil status in sweet corn.

Treatments	Treatment details	Available N (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)	Organic Carbon (%)
T ₁	50% RDF	175.55	10.37	116.65	0.167
T ₂	75% RDF	175.95	10.8	117.13	0.17
T ₃	100% RDF	176.19	11.80	117.67	0.18
T ₄	50% RDF + vermicompost @ 3 t ha ⁻¹	179.49	14.67	120.27	0.277
T ₅	75% RDF + vermicompost @ 3 t ha ⁻¹	182.28	16.94	123.83	0.297
T ₆	50% RDF + FYM @ 5 t ha ⁻¹	178.48	9.87	119.89	0.267
T ₇	75% RDF + FYM @ 5 t ha ⁻¹	181.89	16.37	122.97	0.28
Sem±		0.40	1.79	0.41	0.005
CD (P=0.05)		1.23	5.52	1.26	0.015

which was followed by 75% of the recommended dose through fertilizers along with FYM @ 5 t ha⁻¹ (T₇) and 75% of the recommended dose through fertilizers along with vermicompost @ 5 t ha⁻¹ (T₅). This might be due to higher green cob yield and fodder yields obtained in these treatments. However, the lowest net returns (73611.05 ? ha⁻¹) with 1.43 B:C ratio was obtained with the application of 50% of the recommended dose through fertilizers. Lower net return and B:C ratio of vermicompost treated plots is due to higher cost of vermicompost. These results are in agreement with the findings of Mathukia *et al.*, (2014), Nath *et al.*, (2009) and Patra and Biswas (2009).

The results of the investigation showed that application of integration of organic and inorganic sources significantly influenced the available nitrogen, phosphorus and potassium status after harvest of crop and the results are furnished in Table-3 and Fig.-3. The maximum available nitrogen at harvest (182.28 kg ha⁻¹) was recorded with T₅ (75% of RDF along with vermicompost @ 3 t ha⁻¹) followed by T₇ (75% RDF along with FYM @ 3 t ha⁻¹) whereas the lowest (175.55 kg ha⁻¹) was recorded with T₁ (50% RDF). A considerable quantities of nutrients were left over in soil which might have remained after meeting the maximum requirement of sweet corn (Singh *et al.*, 2012). The low available

nitrogen status in sole inorganic nitrogen treated plots might be ascribed to higher leaching loss of nitrogen compared to integrated treatments. Similar increase in availability of nitrogen was reported by Ponmurugan and Gopi (2006). The highest available phosphorus at harvest stages (16.94 kg ha⁻¹) was observed with application of 75% RDF along with vermicompost @ 3 t ha⁻¹ (T₅) followed by 75% RDF along with FYM @ 5 t ha⁻¹ (T₇). Phosphorus is relatively immobile nutrient which moves in soil by diffusion and is regulated by soil moisture (Marschner, 1995). Addition of organic manure increases soil moisture content (Boateng *et al.*, 2006) thereby improving the P availability in soil. Available phosphorus content of the soil was higher in treatments receiving vermicompost or FYM might be due to more effectiveness of solubilizing the insoluble phosphorus in the presence of these manures, which acts as an immediate nutrient source for microbes (Keerthi *et al.*, 2013). Maximum available K contents at harvest (123.83 kg ha⁻¹) was observed in T₅ (application of 75% RDF + vermicompost @ 3 t ha⁻¹) followed by T₇ (application of 75% RDF + FYM @ 5 t ha⁻¹). The lowest was observed in (116.65 kg ha⁻¹) T₁ (50% RDF) at harvest. The higher build-up of available potassium in the soil treated with FYM/vermicompost compared to sole inorganic treated soil might be due to addition of potassium to available pool of the soil. In

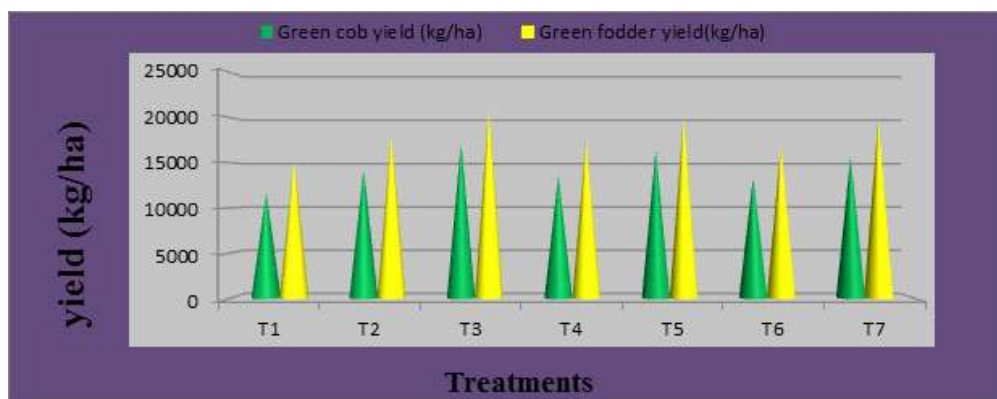


Fig.-1 : Effect of different nutrient management practices on yield of sweet corn.

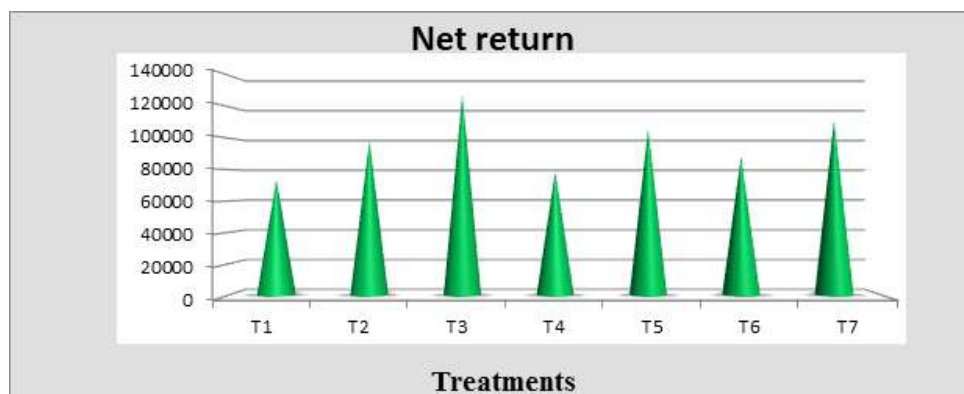


Fig.-2 : Effect of different nutrient management practices on economics of sweet corn.

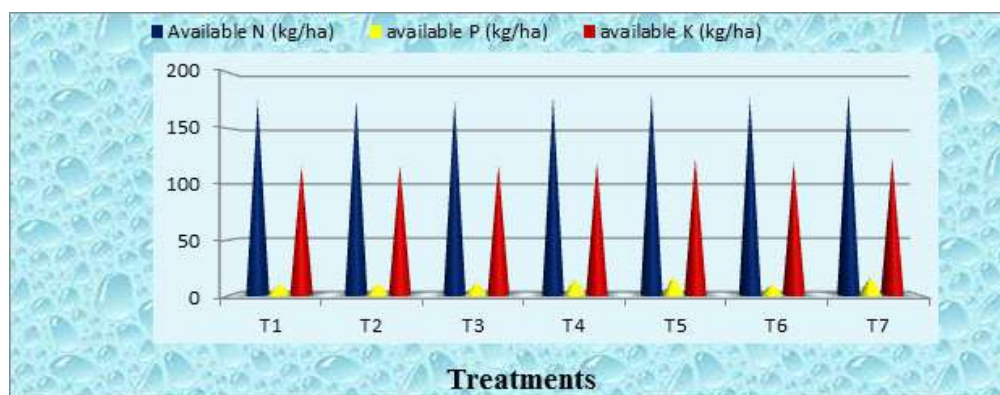


Fig.-3 : Effect of different nutrient management practices on post harvest soil status in sweet corn.

addition, the organic acids released during decomposition of manures mobilize the native or non exchangeable forms of potassium and charge the soil solution with potassium ions, so that it will be readily available. The results were in close conformity with Thakur *et al.* (2010), Pande *et al.* (2013). Organic matter content of the soil was found significantly affected by the imposed treatments based on statistical analysis. Highest organic matter content was observed in plots applied with 75% RDF + vermicompost @ 3 t ha⁻¹ (T₅) followed by T₇ (application of 75% RDF + FYM @ 5 t ha⁻¹). These were significantly higher with other treatments. Application of organic manure like vermicompost and FYM can readily

increase and improve the amount of organic matter in the soil as reported by Canatoy, 2018.

Conclusions

Green cob yield and green fodder yield of sweet corn were high with the application of recommended dose of chemical fertilizers alone followed by 75% RDF along with vermicompost @ 3 t ha⁻¹ and 75% RDF along with FYM @ 5 t ha⁻¹.

Net returns and B: C ratio realized due to the treatments supplied with 100 per cent RDF and 75 per cent RDF + FYM @ 5 t ha⁻¹ were higher compared to rest of the treatments.

The findings of the investigation have clearly showed that in sweet corn, organic manures like vermicompost and FYM could be effectively used in combination with chemical fertilizers to benefit the crop and improve soil health.

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Comparative Efficacy of Different Novel Insecticides Against Major Insect-Pests of Mungbean (*Vigna radiata* L)

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Abstract

The present investigation was carried out at the Agricultural Research farm of B.R.D.P.G. College Deoria (U.P.), during *Zaid* 2021. Seven insecticides including untreated check were evaluated against major insect-pests of mungbean in randomized block design with three replication. Results revealed that all the insecticides evaluated significantly reduced the population of insect-pest. Among the insecticides Profenofos 40% + Cypermethrin 4% EC proved most effective in controlling Aphids, Jassids and Pod borers. Most effective insecticidal treatment against Whitefly and MYMV was Imidacloprid 70 WG followed by Profenofos 40% + Cypermethrin 4% EC. Other treatments viz., Thiamethoxam 25% WG, Emamectin benzoate 5% SG and Fipronil 5% SC were next in order of effectiveness against insect-pests. The efficacy of Nimbecidine was moderate against insect-pest. A significantly higher grain yield was observed in the treated plot. However the plot treated plot treated with Profenofos 40% + Cypermethrin 4% EC @ 2ml/l recorded maximum yield (9.47 q/ha) followed by Imidacloprid 70WG @ 0.5g/l (8.35q/ha), Emamectin benzoate 5% SG @ 2ml/l (5.62q/ha), Fipronil 5% SC @ 2ml/l (4.81q/ha) and Thiamethoxam 25% WG @ 0.3g/l (4.51q/ha). The least effective treatment was Nimbecidine @ 5ml/l which produced 4.40q/ha but was superior to untreated check recorded 4.38 q/ha.

Introduction

Green gram commonly known as Mungbean or Mung (*Vigna radiata* L.) belong to the family Fabaceae and are the third most important pulses crop of India after chickpea and pigeon pea. Mungbean is a warm season crop. Mungbean contains nutritive value, Carbohydrates (56%), Protein (24-25%), Fiber (4.1%), Mineral (3.5%), Iron (7.3mg/100g), Calcium (124/100g), Phosphorus (326 mg/100g), Moisture (10%) (Tiwari and Shivhare, 2016). In India total Mungbean production is 1.60 million tons under the area of 3.83 million hectares and productivity 418kg/ha. In Uttar Pradesh area under mungbean cultivation is 51000ha with production of 33000 tonnes and average productivity of 666 kg per ha (Project Co-ordinator's Report. AICRP on MULLARP crops, IIPR, Kanpur, 2017). About 60 species of insect-pest have been recorded on mungbean in India only some cause economic damage and can be classified as storage pests, foliage feeders, pod feeders and stem feeders. The major insect-pest reported on green gram includes Jassid (*Empoasca motti*), Thrips (*Caliothrips indicus*), Whitefly (*Bemisia tabaci*), Semilooper (*Plusia orichalcea*), Cut worm (*Agrotis ipsilon*), Gelerucid beetle (*Inadurasia obscurella*), Tortricid moth (*Cydia ptychora*), Pod borer (*Maruca testulalis*), Pod borer (*Helicoverpa armigera*), Stem fly (*Ophiomyia phaseoli*), Green bug (*Nezara viridula*) (Kumar *et al.* 2004). Whitefly, Jassid, Thrips are the major sucking insect-pest of eastern Uttar Pradesh (Bairwa and Singh, 2016). The avoidable losses due to

pest complexes on different varieties of green gram ranged from 27.03 to 38.06% with an average of 32.97% (Duraimuruganand Tyagi, 2014). Pod borer is the most formidable and potential pest that causes extensive damage to green gram under field conditions. To keep the population of insects below economic injury level (EIL), foliar application of insecticides seems to be only remedy at later stages of crop growth. At present, several new molecules which are safer and more selective with narrow spectrum of activity with new chemistries are also available for the control of insect-pests. Therefore the studies on efficacy of some traditional as well as newer insecticide molecules along with botanicals are of vital importance in the effective management of Insect-pests in mungbean.

Materials and Methods

The present investigation was carried out at the Agricultural Research farm of Baba Raghav Das Post Graduate College, Deoria (Uttar Pradesh) during *Zaid* (Summer season crop) 2021. The details regarding insecticides and their concentration or dosage have been presented in table-1. The experiment was carried out in Randomized Block Design (RBD) consisting of 7 treatments including untreated check and these treatments were replicated thrice. Mungbean variety Dinkar-Sharif 6 which is commonly cultivated in this area was grown in plots having 7 rows, plot size 2x1.5m² in each plot. The plant spacing between rows and plants were 30x10cm respectively. For recording the observation of Aphids, Whiteflies and Jassids population

was counted from three leaves representing upper, middle and bottom leaves and pod borers population was observing the entire plant from randomly taken on five plants from each treatment. The observation on insect pests population count were recorded before spraying the insecticides and after 3, 7 and 10 days after each spray. For recording MYMV incidence observation were recorded at the end of spray and percent disease incidence was calculated by using the formula :

$$\text{MYMV disease incidence \%} = \frac{\text{Number of diseases plants}}{\text{Total number of plants}} \times 100$$

Results and Discussion

Aphid : The data on aphid population recorded periodically was pooled and presented in table-2. In the present investigation, all the treatments were effective in reducing the population of aphid as compared to untreated check. Profenofos 40% + Cypermethrin 4% EC @ 2ml/l proved most effective in controlling the incidence of aphid followed by Imidacloprid 70 WG @ 0.5g/l, Thiamethoxam 25% WG @ 0.3g/l, Fipronil 5% SC @ 2ml/l and Eamectin benzoate 5% SG @ 2ml/l. Botanical insecticide Nimbecidine was comparatively least effective among the treatments evaluated. These finding are very close to that of Sujatha and Bharpoda (2017) and Khutwad *et al.* (2002) also reported Thiamethoxam 25 WG and Imidacloprid 70 WG as the best treatment among the treatments evaluated against aphid. Imidacloprid as a most effective insecticide has been reported by Khade *et al.* (2014) and Reddy *et al.* (2014) against aphids in green gram. Similar to present study Yadava *et al.* (2011) also found Neem product (NSKE 5%) as a least effective insecticide against aphids in comparison to other treatments corroborate the present finding.

Whitefly : The data on whitefly population recorded at 3, 7 and 10 DAS was also pooled and summarized in table-2. In the present investigation, all the insecticidal treatments were significantly effective in reducing the population of whitefly as compared to untreated check. Imidacloprid 70 WG @ 0.5 g/l proved the most effective recorded minimum population of whitefly. Profenofos 40% + Cypermethrin 4% EC @ 2 ml/l, Thiamethoxam 25% WG @ 0.3 g/l, Fipronil 5% SC @ 2 ml/l and Eamectin benzoate 5% SG @ 2 ml/l proved next in order of effectiveness against whitefly. Nimbecidine @ 5 ml/l was the least effective treatment with a recorded maximum population of whitefly but was superior to untreated check. These finding are a accordance with the findings of Shah *et al.*, (2007),Khattak *et al.*, (2004) and Sreekanth *et al.* (2004) reported Imidacloprid was the most effective treatment in reducing the whitefly population. Thiamethoxam 25 WG had also been reported as the

Table-1 : Efficacy of insecticides against Aphid, Whitefly & Jassid population in mungbean during Summer, 2021.

Treatment	Dose (ml or g/l)	Population of Aphid/trifoliolate (Days after spray)				Population of Whitefly/trifoliolate (Days after spray)				Population of Jassid/trifoliolate (Days after spray)			
		Before spray	3 DAS	7 DAS	10 DAS	Before spray	3 DAS	7 DAS	10 DAS	Before spray	3 DAS	7 DAS	10 DAS
Thiamethoxam 25% WG	0.3g	1.66 (1.47)	0.43 (0.96)	0.36 (0.93)	0.43 (0.96)	1.53 (1.42)	0.66 (1.08)	0.68 (1.09)	1.28 (1.33)	0.53 (1.01)	0.30 (0.89)	0.21 (0.84)	0.44 (0.97)
Fipronil 5% SC	2ml	1.86 (1.54)	0.43 (0.96)	0.33 (0.91)	0.63 (1.06)	1.66 (1.47)	1.06 (1.25)	0.84 (1.16)	1.44 (1.39)	0.51 (1.03)	0.37 (0.93)	0.28 (0.88)	0.46 (0.98)
Emamectin benzoate 5% SG	2ml	1.60 (1.45)	0.63 (1.06)	0.43 (0.96)	0.70 (1.09)	1.60 (1.45)	1.31 (1.35)	1.06 (1.25)	1.59 (1.45)	0.73 (1.11)	0.30 (0.89)	0.24 (0.86)	0.48 (0.99)
Imidacloprid 70 WG	0.5g	1.73 (1.49)	0.33 (0.91)	0.33 (0.91)	0.56 (1.03)	1.66 (1.47)	0.53 (1.01)	0.50 (1.00)	1.04 (1.24)	0.66 (1.08)	0.18 (0.82)	0.13 (0.79)	0.33 (0.91)
Profenofos 40% + Cypermethrin 4% EC	2ml	1.66 (1.47)	0.30 (0.89)	0.23 (0.85)	0.43 (0.99)	1.73 (1.49)	0.53 (1.01)	0.64 (1.07)	1.21 (1.31)	0.93 (1.20)	0.13 (0.79)	0.10 (0.77)	0.22 (0.85)
Nimbecidine	5ml	1.93 (1.56)	1.20 (1.30)	0.90 (1.18)	1.13 (1.28)	1.80 (1.52)	1.37 (1.37)	1.97 (1.57)	2.48 (1.73)	1.00 (1.22)	0.35 (0.92)	0.39 (0.94)	0.68 (1.09)
Untreated check		1.73 (1.49)	1.31 (1.35)	1.06 (1.24)	1.23 (1.32)	1.53 (1.42)	1.95 (1.57)	2.22 (1.65)	3.08 (1.89)	0.73 (1.11)	0.44 (0.97)	0.53 (1.01)	0.73 (1.11)
SE (m)		0.12	0.07	0.06	0.03	0.12	0.08	0.08	0.07	0.10	0.02	0.04	0.03
C.D.		NS	0.23	0.18	0.09	N.S	0.25	0.26	0.22	N.S	0.06	0.05	0.10

Figures in parenthesis are $\sqrt{x}$ 05.

Table-2 : Efficacy of insecticides against Pod borer population, MYMV & Yield in mungbean during Summer, 2021.

Treatment	Doses (ml or g/l)	Population of Pod borer/Plant (Days after spray)				MYMV	Yield (q/ha)
		Before spray	3DAS	7DAS	10DAS		
Thiamethoxam 25% WG	0.3g	0.73 (1.11)	0.15 (0.81)	0.19 (0.83)	0.46 (0.98)	10.00 (18.57)	4.51 (4.51)
Fipronil 5% SC	2ml	0.93 (1.19)	0.24 (0.86)	0.24 (0.86)	0.55 (1.02)	12.76 (20.92)	4.81 (4.81)
Emamectin benzoate 5% SG	2ml	0.80 (1.14)	0.17 (0.82)	0.13 (0.79)	0.24 (0.86)	11.84 (20.12)	5.62 (5.62)
Imidacloprid 70 WG	0.5g	0.66 (1.08)	0.15 (0.81)	0.15 (0.81)	0.39 (0.94)	5.66 (13.76)	8.35 (8.35)
Profenofos 40% + Cypermethrin 4% EC	2ml	0.76 (1.12)	0.15 (0.81)	0.08 (0.76)	0.22 (0.85)	7.55 (15.94)	9.47 (9.47)
Nimbecidine	5ml	0.66 (1.08)	0.28 (0.88)	0.31 (0.90)	0.62 (1.06)	12.77 (20.93)	4.40 (4.40)
Untreated check		0.73 (1.11)	0.44 (0.97)	0.57 (1.03)	0.68 (1.09)	13.70 (21.72)	4.38 (4.38)
SE (m)		0.03	0.01	0.04	0.03	0.87	0.29
C.D.		N.S	0.05	0.13	0.10	2.68	0.91

most effective insecticide against whitefly in green gram Ganapathy and Karuppiyah, (2005). Similar to the present result the efficacy of Fipronil was also reported by Sathyan *et al.*, (2016).

Jassid : The data on jassid population recorded periodically was pooled and presented in table-2. Present investigation revealed that all the insecticidal treatments were significantly effective in reducing the population of jassids as compared to untreated check. Profenofos 40%+Cypermethrin 4% EC @ 2ml/l proved most effective recorded minimum population of jassids followed by Imidacloprid 70 WG @ 0.5g/l. Thiamethoxam 25% WG @ 0.3g/l, Emamectin benzoate 5% SG @ 2ml/l and Fipronil 5% SC @ 2ml/l proved next in order of effectiveness against jassids. Nimbecidine @ 5ml/l was least effective treatments recorded maximum population of jassids but was superior to untreated check. Iqbal *et al.*, (2013) and Ahirwar *et al.* (2016) also reported Thiamethoxam and Imidacloprid as a higher efficacy in green gram against jassids, confirm the present findings. Khattak *et al.*, (2004) reported the highest reduction of jassids in the green gram plots treated with Thiamethoxam followed by Imidacloprid. In present study Profenofos in combination of Cypermethrin proved most effective against jassid. Fipronil as an effective insecticide against jassid has also been reported by Sathyan *et al.* (2016). Asawalam and Constance (2018) evaluated several plant extracts against insect-pests of mungbean and reported significantly effective is population reduction of sucking insect-pests. These finding did not support the present result in which Neem insecticide was found moderately effective against sucking insect-pests.

Pod borer : The data on pod borer population recorded

periodically was pooled and presented in table-3. All the insecticidal treatments were significantly effective in reducing the population of pod borer as compared to untreated check. Profenofos 40%+Cypermethrin 4% EC @ 2ml/l proved most effective recorded minimum population of pod borer. Emamectin benzoate 5% SG @ 2ml/l, Imidacloprid 70 WG @ 0.5g/l, Thiamethoxam 25% WG @ 0.3g/l and Fipronil 5% SC @ 2ml/l proved next in order of effectiveness against pod borer. Nimbecidine @ 5ml/l was least effective treatment recorded maximum population of pod borer among the treatments, but was superior to untreated check. These findings are very close to that of Kambrekar *et al.* (2012) who reported Emamectin benzoate 5% SG resulted in maximum larval reduction, lesser pod damage and higher grain yield in chickpea. Hossain (2015) also reported Imidacloprid @ 5ml/l gave the best results against pod borer in green gram corroborate present findings. Similar to present finding Neem based insecticide (Azadirachtin) was also reported as least effective against pod borer in mungbean by Yadav and Singh (2014), confirm the present result. The efficacy of Cypermethrin and Profenofos had also been studied by Randhawa and Saini (2015) against pigeonpea pod borer. They were found most effective in reducing the larval population of pod borers and decrease pod damage. Similar findings were observed in present study but these two insecticides were in a single formulation.

Mungbean Yellow Mosaic Virus : The data presented in table-3 on incidence of MYMV under different insecticidal treatments revealed that the disease incidence was minimum in plot treated with Imidacloprid 70 WG @ 0.5g/l followed by Profenofos 40%+Cypermethrin 4% EC @ 2ml/l, Thiamethoxam 25% WG @ 0.3g/l, Emamectin

benzoate 5% SG @ 2ml/l and Fipronil 5% SC @ 2ml/l . Nimbecidine @ 5ml/l treated plots recorded maximum MYMV incidence. These findings are in accordance with the findings of Khan *et al.* (2012) who reported that Imidacloprid was most effective to control mungbean yellow mosaic virus. Panduranga *et al.* (2011) also reported that foliar spray of Thiamethoxam 25 WG @ 0.005% recorded low mungbean yellow mosaic virus incidence confirm present study. Reduction in the infection of yellow mosaic virus by spraying NSKE has been recorded by Sethuraman *et al.* (2001). In present investigation NSKE recorded maximum MYMV incidence among the treatments were statistically at par to untreated check. So, these findings can not be compared. The difference may be due to the amount and frequency of insecticide used. It is obvious that the treatment which reduced the maximum population of whiteflies was proportionally effective against MYMV.

Yield : The data presented in table-3. In the present investigation all the insecticidal treatments recorded significantly higher grain yield. The plot treated with Profenofos 40%+Cypermethrin 4% EC @ 2ml/l recorded maximum yield (9.47 q/ha) followed by Imidacloprid 70WG @ 0.5g/l (8.35q/ha), Emamectin benzoate 5% SG @ 2ml/l (5.62q/ha), Fipronil 5% SC @ 2ml/l (4.81q/ha) and Thiamethoxam 25% WG @ 0.3g/l (4.51q/ha). The least effective treatment was Nimbecidine @ 5ml/l which produced 4.40q/ha but was superior to untreated check recorded 4.38 q/ha. Our findings are in close conformity with that of Shah *et al.* (2007), Gopalaswamy *et al.* (2012), Hossain. (2013) who reported higher yield in the plots treated with Imidacloprid in mungbean and urdbean. Mandal *et al.* (2015) reported higher yield and net return of green gram in Thiamethoxam treated plot confirm the present finding. Ahirwar *et al.* (2016) reported higher yield of green gram in Thiamethoxam followed by Imidacloprid, Dimethoate and Acephate are more or less in agreement of present study. Our finding did not support the findings of Sethuraman *et al.* (2001) who reported higher seed yield of green gram with the application of NSKE spray.

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Efficacy of Newer Insecticides and Biopesticides Against Major Insect Pests Infesting Vegetable Pea (*Pisum sativum*)

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Abstract

The experiment was conducted at agriculture research farm of Baba Raghav Das Post Graduate College Deoria, Uttar Pradesh in randomised block design with 7 treatments and 3 replications to evaluate the performance of newer insecticides and botanicals against major insect-pests of vegetable pea. The insect-pests population was recorded one day before spraying and 3, 7 and 10 days after spraying. The result revealed that Chlorantraniliprole 18.5% SC was most effective in reducing aphid population followed by Profenphos + Cypermethrin 44% EC, Lambda Cyhalothrin 5% EC, Thiamethoxam 25% WG and Nimbecidine. While Profenphos + Cypermethrin 44% EC recorded significantly least percent pod damage, followed by Chlorantraniliprole and Lambda Cyhalothrin were most considered more effective against pea pod borer. The higher yield was recorded in treatment of Profenphos + Cypermethrin 44% EC treated plots (45q/ha). It was followed by Chlorantraniliprole 18.5 SC (41.00q/ha), Lambda Cyhalothrin 5% EC (40.00q/ha), NSKE (37.50q/ha) and Nimbecidine (36.00q/ha). Lowest yield (15.00q/ha) was registered in untreated control. The application of two spray of NSKE 5% followed by Profenphos + cypermethrin 44% EC was found most economical as Rs. 52.94 and Rs. 52.17 obtained per rupee invested respectively.

Introduction

Pea is an important grain legume vegetable crop in India. Pea is commonly known as 'Matar' (*Pisum sativum* L.) belonging to the family Leguminosae (sub family Papilionaceae). India is the second largest producer of vegetables in the world. Pea pods have high nutritive value for human consumption and contain 7.2 % protein, 9.2 % carbohydrates, 0.8 % mineral matter, 8.0% phosphorus and 1.8% iron in fresh pea. While in dried peas it contains 9.7 % protein, 56.6% carbohydrate, 2.1% mineral matter and 4.4% iron. Many insect-pests damage and affect the yield of pea crop to a great extent. (Mittal and Ujaga 2007) have listed about 32 insect species aborering different stages of growth of the pea crop, among these pea aphids (*Acyrtosiphon pisum*), pea stem fly (*Melanagromyza phaseoli* Tryon), pea leaf miner (*Chromatomyia horticola* Goureau), pod borer complex (*Helicoverpa armigera*, *Lampides boeticus* and *Etiella zinckenella* Tr.), and thrips (*Caliothrips indicus*) are serious insect pests and offense causes substantial loss to the crop. Insect - pests damage to this crop imposes severe limits in its production. In insect pest of pea, pea aphid *Acyrtosiphon pisum* is considered to be a serious pest because reduce both weight and caloric content of young pea plant by as much as 64 and 113% respectively depending on the number of feeding aphids (Bar low *et al.*, 1977). *E. zinckenella* may cause 50.9 % pod infestation with 77.64 % seeds damage resulting in a 23.9 % loss in the grain yield of pea (Singh and Dhooria 1971). In view of the limitations in the use of older insecticides, there is a need to find out the efficacy and

effectiveness of novel chemicals against insect-pests. A number of insecticides have been reported to be effective against insect pests of pea crop. However, the excessive use of the chemical Insecticides is not desirable because of its residual effects on the food chains. Hence, there is a need for continuous evaluation of chemicals against pest and safety to the non-target species. Now a days many new emerging chemients are available in the market with good efficacy for pest control and safety to non-target organisms.

Materials and Methods

The experiment was conducted to evaluate the efficacy of newer insecticides and botanical products against the major insect-pests of infesting vegetable peas at Agricultural Research Farm of Baba Raghav Das Post Graduate Deoria Uttar Pradesh during *rabi* 2020-21. Experiment was planned in Randomized Block Design with 7 treatments replicated thrice in 2x1m plot size. The spacing between row to row and plant to plant was maintained at 30x15 cm, respectively. The pea variety GS-10 was selected for the experiment. The insect pests population was recorded one day before spraying and 3, 7 and 10 days after spraying. The observations of pea aphid were taken on five plants from each treatment were selected and the population counted the entire plant and pod borer population was observed at each picking number of damaged as well as healthy pods were separated and counted. All the subsequent pickings were pooled in the form of healthy and damaged pod after last picking and percent pod damage was calculated by using following formula :

Table-2 : Efficacy of insecticides against Pooled Aphid population in pea during winter (Rabi) 2020-21.

Treatment	Dose (ml or g/l)	Population of Aphid/Plant (Days after spray)		
		3 DAS	7 DAS	10 DAS
Lambda Cyhalothrin 5% EC	2 ml	4.91 (2.33)	7.63 (2.85)	1.48 (1.41)
Profenofos + Cypermethrin 44% EC	2 ml	4.86 (2.32)	3.98 (2.12)	1.40 (1.38)
Chlorantraniliprole 18.5 SC	0.5 ml	4.53 (2.24)	3.63 (2.03)	1.33 (1.35)
Thiamethoxam 25% WW	0.3 gm	5.88 (2.53)	11.20 (3.42)	1.88 (1.54)
Nimbecidine	5 ml	9.00 (3.08)	12.80 (3.65)	3.18 (1.92)
N. S. K. E	50 ml	13.75 (3.77)	16.05 (4.07)	3.48 (1.99)
Water spray		24.20 (4.97)	18.41 (4.35)	3.53 (2.01)
SE (m)		0.29	0.30	0.15
C.D.		0.89	0.95	0.47

Table-3 : Pod damage (%) under different insecticidal treatment during winter (Rabi)-2020-21.

Treatment	Dose (ml or gm/l)	Pod damage (%)	Pod Yield (q/ha)
Lambda Cyhalothrin 5% EC	2 ml	39.42 (38.85)	40.00
Profenofos + Cypermethrin (44%) EC	2 ml	33.84 (35.53)	45.00
Chlorantraniliprole 18.5% SC	0.5 ml	38.98 (38.58)	41.00
Thiamethoxam ai. 25%w/w	0.3 gm	42.15 (40.38)	25.00
Nimbecidine	5 ml	41.27 (40.97)	36.00
NSKE	50 ml	40.51 (39.53)	37.50
Water Spray	—	45.68 (42.68)	15.00
SE (m)	—	0.98	0.117
C.D.	—	3.03	

$$\text{Percentage of Pod infestation} = \frac{\text{Damaged pod}}{\text{Total Number of pod}} \times 100$$

Results and Discussion

Pea aphid : The results are depicted in table-2. The efficacy of six insecticides were evaluated under field conditions with untreated check against aphid in pea. All the insecticides proved significantly superior over untreated check at all the intervals of observation. Most of the insecticides showed non significant variation to each other in their effectiveness at all the intervals of observation after spray. Over all performance of insecticides in current investigation revealed that Chlorantraniliprole 18.5% SC was most effective in reducing aphid population, followed by profenofos + cypermethrin 44 % EC, Lambda cyhalothrin 5% EC, thiamethoxam 25% WG and Nimbecidine respectively. Application of NSKE 5 percent considered less effective but was superior to untreated check. The efficacy of insecticides at all the intervals of observation, it is seen that a remarkable reduction in aphid population was noticed five days after spray, although the effectiveness was maintained upto 10 days after spray. Our finding is also in agreement with Vishwanath and Singh (2002) who reported that mix formulation of profenofos + cypermethrin provides better control of aphids. Present finding inclosed conformity with that of Deharya *et al.* (2018) who revealed synthetic insecticides treated plots were most effective in comparison to botanicals. In

botanical NSKE 5% proved superior over untreated check.

Pod borer : The data on pod borer population recorded periodically was pooled and presented in table-3. All the insecticidal treatments were found significantly effective in reducing the percent pod damage as compared to untreated plots. The combine analysis of the data obtained after two spray indicate that Profenofos + Cypermethrin 44% EC record significantly least percent pod damage followed by Chlorantraniliprole and Lambda cyhalothrin were most effective against pod borer in pea, NSKE, Nimbecidine and Thiamethoxam showed moderate effect in reducing percent pod damage. The findings are also enclosed agreement with that of Barbar *et al.* (2012) who also revealed Chlorantraniliprole (Rynaxypyr) was most effective against chickpea pod borer after Flubendiamide. Our results are also in accordance with Shah *et al.* (2003) who reported lambda cyhalothrin and cypermethrin as effective against chickpea pod borer. Similar to present finding yadav (2009) also found lambda cyhalothrin was used for controlling the gram pod borer in chickpea. The present results are in conformity with that of Adure and Mohite (2013) who reported Chlorantraniliprole (Rynaxypyr) as the most effective treatment against gram pod borer among the treatments evaluated.

Economics of various insecticidal application : The data presented in table-4. The economics of different insecticidal treatments were calculated to know the feasibility of their acceptability by farmers going to control

Table-4 : Economics of insecticidal for the control major insect of Vegetable pea during winter (Rabi) 2020-21.

Treatment	No. of Spray	Cost of insecticide (Rs./l)	Total cost of treated application (Rs./l)	Yield (Q/ha)	Increase yield over control (Q/ha)	Gross income (Rs./ha)	Additional income (Rs./ha)	C. B. Ratio
Lambda Cyhalothrin 5% EC	2	1240	1940	40.00	25.00	160,000.00	98,060.00	50.54
Profenofos 40%+Cypermethrin% 4% EC	2	1600	2300	45.00	30.00	180,000.00	117,700.00	51.17
Chlorantraniliprole 18.5 % SC	2	14400	15100	41.00	26.00	164,000.00	88,900.00	5.88
Thiamethoxam 25% w/w	2	4580	5280	25.00	10.00	100,000.00	34,720.00	6.57
Nimbecidine (0.03)	2	1200	1900	36.00	21.00	144,000.00	82,100.00	43.21
NSKE	2	1000	1700	37.00	22.50	150,000.00	88,300.00	51.94
Water	2			15.00	0.00	60,000	0.00	0.0

Note : 1. Labour charge @ of Rs. 300/day.

2. Sprayer rent @ of Rs. 50/day.

3. Sale price of produce @ of Rs. 4000/Q.

4. Amount of water used @ of 400 liter

major insect- pests of pea. In the present study application of two sprays of all the insecticidal treatments were found economical in comparison to untreated check. However, maximum additional income (Rs./ha) was recorded with profenofos + cypermethrin (Rs. 117,700.00), followed by Lambda Cyhalothrin (Rs. 98,060.00) and chlorantraniliprole (Rs. 88,900.00). As the C:B ratio in concerned the application NSKE was found most economical as it gave maximum return of Rs. 52.94 per rupee invested followed by profenofos + cypermethrin (Rs. 52.17). Next economical treatment in order were Lambda cyhalothrin, Nimbecidine, Thiamethoxam and chlorantraniliprole. Then finding are in accordance with the finding of Hossain et al (2010) who found neem seed extract showed a marginal performance to control chickpea pod borer and highest marginal cost benefit ratio (3.19) was recorded from Lambda Cyhalothrin similar result are also found Kumar *et al* (2019), the higher grain yield of 24.07 q/ha and 22.65 q/ha was recorded with application of NSKE @ 5 percent during both year.

Conclusions

All the insecticides were significantly superior over untreated check up to 10 days after spray. Two sprays of chlorantraniliprole 18.5% SC or profenofos + cypermethrin 44% EC emerged as most effective treatment against insect-pests of pea. Application of NSKE 5% and profenofos + cypermethrin was found most economical treatment recorded respectively Rs. 52.94 and Rs. 52.17 per rupee invested.

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Host Range Studies on *Erysiphe cichoracearum* DC. Causing Okra Powdery Mildew in Northern Karnataka

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Abstract

Okra (*Abelmoschus esculentus* (L.) Moench) is a globally important annual vegetable belongs to family malvaceae. Many factors are responsible for yield loss of the crop, one of them is the diseases which are the major constraints for low yield of okra. Among the fungal diseases affecting okra crop, powdery mildew caused by *Erysiphe cichoracearum* DC. is the most important disease causing considerable yield losses. An experiment was conducted under glasshouse conditions to find out alternate hosts for okra powdery mildew (*E. cichoracearum*) in which it survives during off season. Results revealed that, among seventeen different crop plants consisting of cultivated field crops and weed plants examined for their reaction to *E. cichoracearum* under artificial conditions *E. cichoracearum* was found to infect and produce powdery mildew symptoms on cucumber, ridge gourd, black gram, green gram, cowpea and weed plants viz., *Parthenium hysterophorus* and *Euphorbia geniculata*. Hence, these crop plants and weed plants served as collateral hosts for the pathogen survival during off season which helped to start fresh infection on newly sown crop in the next season.

Key words : Okra, powdery mildew, *Erysiphe cichoracearum*, host range.

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is a globally important annual vegetable belongs to family malvaceae, it is most broadly distributed vegetable all over the world. In the world it is cultivated in tropical, sub-tropical and warm temperate regions. The crop is usually grown both under irrigated and rainfed conditions. It is grown over an area of 534 thousand hectares with a production of 6,371 thousand metric tonnes in India (Anon., 2020). In Karnataka it is cultivated over an area of 10.91 thousand hectares with a production of 98.91 thousand metric tonnes. West Bengal, Gujarat, Chattisgarh, Haryana, Madhya Pradesh, Odisha, Bihar are the major okra growing states of India. West Bengal has the largest area of 77.55 thousand ha followed by Gujarat (75.27 thousand ha). Gujarat ranks first in production (921.72 thousand metric tonnes) followed by West Bengal (914.86 thousand metric tonnes) (Anon., 2019).

Many factors are responsible for yield loss of the crop, one of them is the diseases which are the major constraints for low yield of okra (Sastry and Singh, 1974). A number of fungal, bacterial and viral diseases have been reported in India. Among the fungal diseases affecting okra crop, powdery mildew caused by *Erysiphe cichoracearum* DC. is the most important disease causing considerable yield losses. The disease initiates as white minute powdery patches first on the upper surface of leaf and lower older leaves and then spreads to younger ones. Grayish white powdery coating is visible on severely

affected leaves. Leaves finally show necrosis resulting in withering, drying and defoliation. Powdery mildew affects plants at all the growth stages and may result in yield losses up to 17 to 86.6 per cent (Sridhar and Sinha, 1989).

In and around the field, many crop plants as well as weeds are found infected with powdery mildew disease. There is possibility of some of the crop plants and weeds acting as collateral hosts for the pathogen survival during off season. This helps to start fresh infection on newly sown crop in the next season. Thus, host range studies would help to know the ability of the test pathogen to interact with the other crop plants and weeds.

Materials and Methods

Finding of alternate hosts for okra powdery mildew (*E. cichoracearum*) in which it survives during off season is very important in the epidemiological perspective, therefore, the following crops and weeds were raised in a separate polythene bags in glass house. The healthy seeds of these crops and weeds were sown in Sand: Soil: FYM (3:1:1) mixed polythene bags. Fresh okra leaves infected with powdery mildew were collected from the field and conidial suspension of the pathogen was prepared in 1.5 per cent sugar solution then inoculated on to 30 days old seedlings by spraying conidial suspension. Duration taken for the appearance of symptoms and type of conidia produced were recorded.

List of crop plants and weeds used for host range study

Common name	Scientific name
Cotton	<i>Gossypium hirsutum</i> L.
Fenugreek	<i>Trigonella foenumgraecum</i> L.
Cucumber	<i>Cucumis sativus</i> L.
Ridge gourd	<i>Luffa acutangula</i> (L.) Roxb.
Black gram	<i>Vigna mungo</i> (L.) Hepper
Green gram	<i>Vigna radiate</i> (L.) R. Wilczek
Pigeon pea	<i>Cajanus cajan</i> (L.) Millsp.
Chickpea	<i>Cicer arietinum</i> L.
Cowpea	<i>Vigna unguiculata</i> (L.) Walp.
Chilli	<i>Capsicum annum</i> L.
Cluster bean	<i>Cyamopsis tetragonoloba</i> (L.) Taub.
Coriander	<i>Coriandrum sativum</i> L.
Carrot grass	<i>Parthenium hysterophorus</i> L.
Milk weed	<i>Euphorbia geniculata</i> L.
Dwarf copper weed	<i>Alternanthera sessalis</i> (L.) DC.
Garden spurge	<i>Euphorbia hirta</i> L.
Nela nalli	<i>Phyllanthus niruri</i> L.

Results and Discussion

An attempt was made to know the host range of *E. cichoracearum* under glasshouse conditions. Seventeen different crop plants consisting of cultivated field crops and weed plants were examined for their reaction to *E. cichoracearum* under artificial conditions and results obtained are presented in Table-1.

It was noticed that, among the different crop plants tested, *E. cichoracearum* was found to infect and produce powdery mildew symptoms on cucumber, ridge gourd, black gram, green gram, cowpea and weed plants viz., *Parthenium hysterophorus* and *Euphorbia geniculata*

(Plate-1). Initially, white powdery specks were observed on the infected leaves of these host plants later on as the disease progressed specks enlarged and the leaves were covered with white powdery mass of the fungus. The period between inoculation and appearance of symptoms on cucumber, ridge gourd, black gram, green gram, cowpea *Parthenium hysterophorus* and *Euphorbia geniculata* was seven, seven, ten, ten, ten, eight and nine days respectively. The crop plants which were inoculated and did not show the powdery mildew symptoms included cotton, fenugreek, pigeon pea, chickpea, chilli, cluster bean, coriander, *Alternanthera sessalis*, *Euphorbia hirta* and *Phyllanthus niruri*.

The host range study was conducted to know the survival ability of *E. cichoracearum* on different hosts in the absence of main host. This would help to locate the source of initial inoculum of the pathogen in the disease cycle and to develop suitable management strategies. The frequency of occurrence of powdery mildew is largely dependent on the number of available hosts based on the geophytopathological model (James and Ellis, 1978).

The present investigations are in accordance with the findings of earlier workers viz., Biju (2000) who observed that, the six plants viz., bean, cowpea, green gram, black gram, *Euphorbia hirta* L. and *Leymus mollis* (Trin.) Pilg. developed symptoms at fifteen days after inoculation with the conidia of *E. polygoni*. Thus these plants played an important role for the perpetuation of the pathogen. Praveenkumar (2013) observed that, green gram, black gram, cowpea and *Euphorbia geniculata* were infected by *E. polygoni* at ten days after inoculation, and thus proved to be collateral hosts of *E. polygoni*.

Table-1 : Host range of *Erysiphe cichoracearum* causing okra powdery mildew.

Sl. No.	Name of the host	Common name	Reaction	Incubation period
1.	<i>Gossypium hirsutum</i> L.	Cotton	-	
2.	<i>Trigonella foenumgraecum</i> L.	Fenugreek	-	
3.	<i>Cucumis sativus</i> L.	Cucumber	+	7
4.	<i>Luffa acutangula</i> (L.) Roxb.	Ridge gourd	+	7
5.	<i>Vigna mungo</i> (L.) Hepper	Black gram	+	10
6.	<i>Vigna radiate</i> (L.) R. Wilczek	Green gram	+	10
7.	<i>Cajanus cajan</i> (L.) Millsp.	Pigeon pea	-	
8.	<i>Cicer arietinum</i> L.	Chickpea	-	
9.	<i>Vigna unguiculata</i> (L.) Walp.	Cowpea	+	10
10.	<i>Capsicum annum</i> L.	Chilli	-	
11.	<i>Cyamopsis tetragonoloba</i> (L.) Taub.	Cluster bean	-	
12.	<i>Coriandrum sativum</i> L.	Coriander	-	
13.	<i>Parthenium hysterophorus</i> L.	Carrot grass	+	8
14.	<i>Euphorbia geniculata</i> L.	Milk weed	+	9
15.	<i>Alternanthera sessalis</i> (L.) DC.	Dwarf copper weed	-	
16.	<i>Euphorbia hirta</i> L.	Garden spurge	-	
17.	<i>Phyllanthus niruri</i> L.	Nela nalli	-	

+ Indicates development of powdery mildew symptoms

- Indicates no development of powdery mildew symptoms



Kumawat *et al.* (2017) conducted the host range study of *E. polygoni* under greenhouse conditions on fifteen different plants species. They found that the crop plants inoculated and showed the symptoms included *Pisum sativum* L., *Cuminum cyminum* L., *Foeniculum vulgare* Mill., *Calendula officinalis* L. and *Lathyrus odoratus* L.

Conclusions

Out of seventeen crop plants tested for host range studies, powdery mildew symptoms were developed on five cultivated crops viz., cucumber, ridge gourd, black gram, green gram, cowpea and two weed plants viz., *Parthenium hysterophorus* and *Euphorbia geniculata*, respectively. Hence, these crop plants and weed plants served as collateral hosts for the pathogen survival during off season which helped to start fresh infection on newly sown crop in the next season.

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Studies on Insect-Pests Complex of Mustard (*Brassica campestris*) and Estimation of Avoidable Yield Loss Caused by them under Agro-Climatic Condition of Tarai Region in Eastern U.P.

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Abstract

Present investigation was carried out during *Rabi* season, 2021 at research farm of B.R.D.P.G. College, Deoria, Uttar Pradesh. The experiment was performed in large plot techniques as well as in Randomized Block Design. The results revealed a total of seven insect-pests were associated with mustard crop. Among the insect-pests four were crop pests while three insects were predators. Among the insect-pests mustard aphid was considered major insect-pests while flea beetle, mustard sawfly and cabbage butterfly were minor insect-pests on the basis of their relative abundance and extent of crop damage. Among the predators coccinellid beetles were more prevalent and recorded as major natural enemies. A significant reduction in yield was observed in untreated check over treated one. The yield increased in plot protected by Lambda cyhalothrin 4% + Imidacloprid 6% was 139.66% higher over untreated check while Beta-cyfluthrin 8.48% + Imidacloprid 19.81% treated plots registered 123.33% increased yield over untreated check. The result clearly indicated that by providing protections with effective insecticides against insect-pests 3.70 to 4.19 q/ha yield loss can be saved. Total avoidable yield loss could be worked out as 55.22 to 58.27%.

Introduction

Mustard crop is an annual herb having dicotyledonous seed. Their seed is very tiny refer to as “eye of newt”. Mustard is grown mainly for its seed which contain oil varies from 35 to 46%. It plays vital role in Indian agriculture economy as edible oil. Mustard crop is of multifarious use providing oil, green leafy vegetables, oil cakes and used for various purpose as medicinal purpose, and for agro based industries engaged in manufacturing of soap, varnishes, paints, hair oil lubricants etc. (Patel, 2005). Mustard oil is one of the healthiest edible oils as it has no trans-fat has low saturated fat, high mono unsaturated and poly unsaturated fat like omega 3 (Das *et al.*, 2009). Oil cake widely used in cattle feed and as organic manure and as nematicide containing 5.2% N₂ 1.8% P₂O₅, 1.2% K₂O 37-44% Protein, 5-9% ash in cake, iodine value is 74-98. India ranked 3rd in area while 4th in production of rapeseed-mustard. In India the major rapeseed-mustard growing states are Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, West Bengal, Assam, and Gujrat. The major constraints affecting or reducing the yield of mustard crop are insect-pests, causing injury to different stage right from seedling to maturity stage of the crop. In India Keot *et al.*, (2002) recorded ten insect-pests infesting the *Brassica* vegetables. Whereas, 36 insect-pests are found associated with rapeseed mustard crop (Singh, 1882 and Bakhettia and Sekhon, 1989). Purwar *et al.*, (2004) recorded 43 insect-pests of mustard in India.

Out of several reported insect-pests some have major importance to mustard crop viz., sawfly (*Athalia lugens proxima*), leaf miner (*Chromatomyia horticola*), painted bug (*Bagrada cruciferarum*), flea beetle (*Phyllotreta cruciferae*), diamondback moth (*Plutella xylostella*), cabbage head borer (*Hellula undalis*), cabbage butterfly (*Pieris brassicae*) mustard aphid (*Lipaphis erysimi*), green peach aphid (*Myzus persicae*) are considered important which cause considerable yield losses. Yield loss due to these pests ranged from 20-70% (Reddy, 2009). In general insect-pests complex of particular crop vary area to area depends on agro-climatic condition of that particular region. This eastern part of Uttar Pradesh is very rich in biodiversity because of specific topography soil and climatic condition favors high species richness. The region is highly dynamic in case of weather, thus very suitable for multiplication of insect-pests and their natural enemies. Furthermore, status of insect-pests of a particular crop shifting under changing climate scenario. Therefore, periodical assessment of pest complex may help to know the relative economic importance of different insect-pests on that crop. The main weapon of mustard pests control so far been is application of insecticides. Whenever there is infestation of insect-pests, farmers frequently used insecticides. The insecticide usage pattern in the state varies greatly from one situation to the other. Often, excessive use of pesticide intensifies pest problems and complicated pest control strategies causing ecological disruption and endangerment of human health. overall,

the aim is to select right safer newer molecule and apply at appropriate dose and time so that maximum yield can be saved without impairing human and environmental health. These practices show a new direction to mustard growers going to manage pest problems through insecticides. Therefore, keeping in view, the economic importance of the crop and the magnitude of damage caused by various insect-pests the present study was carried out.

Materials and Methods

In order to study the insect-pests complex of mustard, the field trial was conducted during *Rabi* season, 2020-21 at Research Farm of B.R.D.P.G College, Deoria, Uttar Pradesh. The investigation was conducted on 180.00 m² total plot area, which was divided into 15 equal quadrates measured 6x2m² each plot, surrounding each block 0.30m bunds were left. In each block mustard seeds were sown in the line and maintained 30x15 cm R x P distance at 1.5-2.5cm depth. Randomly ten plants from each quadrate were selected to record the insect-pests population. The infestation of insect-pests complex associated with mustard crop were observed visually at different stages of crop growth by randomly selected ten plants from each quadrate. The observations were made at weekly intervals in morning hours before 8:00 am. The observations were made just after appearance of the insect-pests till the harvesting of crop.

To study avoidable yield loss in mustard due to insect-pests at research farm of B.R.D.P.G. College, Deoria. The experiment was performed in large plot technique as well as in Randomized Block Design with five replications. Each replication occupied three treatments including untreated check as :

1. Unprotected (plot-1) : The crop was kept free from insecticides and subjected to the natural infestation of insect-pests of mustard.

2. Protected (plot-2) : Under this treatment the crop was protected against the insect-pests through application of a newer molecules of insecticide i.e. Lambda cyhalothrin 4% + Imidacloprid 6% @ 1ml /litter of water applied at 15 days intervals.

3. Protected (plot-3) : Under this treatment the crop was protected against the insect-pests through application of another newer molecule of insecticides i.e. Beta-cyhalothrin 8.49% + Imidacloprid 19.81% @ 0.5 ml/ litter of water applied at 15 days intervals.

Observations were recorded on :

1. Yield of treated plots (plot-1 & 2) kg/quadrat (6.00x2.00).
2. Yield of untreated (control) plot kg/quadrat (6.00m x 2.00m).

Yield of mustard from protected and unprotected plots were recorded from each quadrate at harvest and then analysed statistically. Before analysis the yield of protected and unprotected plots was finally converted into per hectare. The yield increased in protected plots over the unprotected (control) and avoidable loss was worked out from final yield of mustard using the formula mentioned below given by Pradhan (1964).

$$\text{Increased yield (\%)} = 100 \times \frac{T - C}{T}$$

$$\text{Avoidable yield loss (\%)} = 100 \times \frac{T - C}{T}$$

Whereas,

T = yield from treated / protected plot (q/ha).

C = yield from control / unprotected plots (q/ha).

Results and Discussion

Insect-pests complex of mustard crop : During the present investigation, a total number of seven insect-pests (Table 1&2) were recorded at different stages of mustard crop. Among the insect-pests recorded four were of insect-pests of crop, while three insects were predators. Among the insect-pests, mustard aphid was more abundant and persisted for a longer period was considered as major insect-pests of mustard. Another, insect-pests viz., flea beetle, mustard sawfly and cabbage butterfly observed in scattered as well as negligible manner hence considered as the minor pest of mustard. During present investigation, total three predators viz., coccinellid beetle, syrphid fly and spider were recorded. Among these, coccinellid beetles were recorded as major natural enemy on insect pests of mustard. Several studies have shown that different insect-pests infest rapeseed-mustard at different locations in India. Rai, (1976) enlisted a total of 24 species of key insect-pests of mustard crop in India which responsible for severe infestation in different stages of crop. Bakhietia and Sekhon, (1989) recorded 38 number of insect-pests. Purwar *et al.* (2004) recorded more than 43 species of insect-pests of mustard crop in India. Chaudhury and Pal (2006) reported 14 insects including natural enemies on rapeseed-mustard out of which *L. erysimi* was categorized as major insect-pests corroborate present findings. Singh *et al.* (2007) reported 21 insect species during the various crop stages. Our findings are in close conformity with the findings of Patel *et al.* (2019) who reported eight insect-pests associated with mustard crop at Pantnagar. Similar to present findings they reported mustard aphid as major insect-pests, while *Athalia lugens proxima*, *Phyllotreta cruciferae* and *Pieris brassicae* as a minor insect-pests of mustard on the basis of their relative abundance and extent of crop damage.

Table-1 : Insect-pests complex associated with mustard during Rabi, 2020-21.

S. No.	Name of the insect	Scientific name	Order & Family	Damaging stage	Crop stage	Period of infestation	Status of the pest
1.	Flea beetle	<i>Phyllotreta cruciferae</i>	Coleoptera, Chrysomelidae	Adult	Early seedling	3 rd week of December to January	Minor
2.	Mustard sawfly	<i>Athalia lugens proxima</i>	Diptera, Tenthredinidae	Larvae	Seedling	1 st week of January to 4 th of January	Minor
3.	Mustard aphid	<i>Lipaphis erysimi</i>	Hemiptera, Aphididae	Nymph and adult	Pre-flowering	2 nd week of March to till the harvest	Major
4.	Cabbage butterfly	<i>Pieris brassicae</i>	Lepidoptera, Pieridae	Caterpillar	Pod maturity stage	4 th week of February to 2 nd week of March	Minor

Table-2 : Natural enemies of insect-pests of mustard observed during Rabi, 2020-21.

S. N.	Common name	Scientific name	Order family	Host	Period of occurrence	Crop stage	Economic status
1.	Coccinellid beetle	<i>Coccinella species</i>	Coleoptera, Coccinellidae	Aphid	2 nd week on January to 2 nd week of march	Pre-flowering	Predator
2.	Syrphid fly	<i>Sphaerophoria philanthus</i>	Diptera, Syrphidae	Aphid	1 st week of February to 4 th week of February	Flowering	Predator

Table-3 : Assessment of yield loss due to insect-pests of mustard during Rabi, 2020-21.

Treatment	Yield (q/ha)	Increase in yield over control (%)	Avoidable loss (%)	Yield loss Over T ₁ (q/ha)	Yield loss Over T ₂ (q/ha)
T ₁ (Lambda cyhalothrin 4% + Imidacloprid 6%)	7.19	139.66	58.27	4.19	3.70
T ₂ (Beta-cyhalothrin 8.49% + Imidacloprid 19.81%)	6.70	123.33	55.22	-	-
T ₃	3.00				
SEM. ±	0.73				
CD at 5%	2.85				

Estimation of yield loss in mustard due to insect-pests complex : In present investigation the mean yield of 7.10q and 6.70q/ha recorded from treated plots which was significantly higher than the yield obtained in untreated check (3.00q/ha). Among both of the insecticide treatment, Lambda cyhalothrin 4% + Imidacloprid 6% treated plot was better than the plot treated with Beta-cyfluthrin 8.49% + Imidacloprid 19.81%, but the difference was non-significant. The efficacy of imidacloprid against mustard aphid was earlier studied by Bana *et al.* (2011) Khedkar *et al.* (2012) who found most effective and economical insecticide than rest of the insecticides evaluated against mustard aphid. Cyhalothrin is a synthetic pyrethroid group of insecticide is more toxic to insect-pests including aphid but less toxic to natural enemies. The joint formulation of Imidacloprid with Cyhalothrin increased the efficacy of insecticides against most of the harmful pests and had no adverse effects on biocontrol agents so that much increased yield was obtained. The yield increased in protected plots viz., Lambda cyhalothrin 4% + Imidacloprid 6% and Beta-cyfluthrin 8.48% + Imidacloprid 19.81% treated plots

were 4.19q/ha and 3.70q/ha, respectively over untreated plot, it showed 139.66% and 123.33% yield increased over control. Total avoidable loss in yield was calculated as 58.27% in case of Lambda cyhalothrin 4% + Imidacloprid 6%, while 55.22% loss in case of Beta-cyfluthrin 8.49% + Imidacloprid 19.81%. The result clearly indicated that by providing protection with effective pesticide against insect-pests 3.70-4.19 q/ha yield loss can be saved. Total avoidable yield loss could be worked out as 55.22 to 58.27%. In past several researchers worked on same aspect and reported their own findings. Present findings are being cited in light of previous researchers. It was Dotasara *et al.*, (2018) estimated an avoidable loss of 41.14% due to insect-pests of Indian mustard in two consecutive years of study. Singh *et al.* (2010) reported the avoidable yield loss due to mustard aphid as 88.72 and 90.52% during two consecutive years of study. Tomer *et al.* (2017) reported yield loss was 84.96%, 89.53% and 74.57%, respectively in 2002-03, 2003-04 and 2004-05. Arora (1999) reported yield losses in mustard in India were estimation to be 35-73% corroborate the present study.

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Synchrony of Phenophase and Seasonal Variations in Wild Species from Anacardiaceae Family in Garhwal Himalaya

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Abstract

Local environmental factors and changing climatic conditions have been known to induce shift in phenological trends. The present study provides an explanation of environmental impact on phenophase development and seasonal variations of existing plant communities. We examined 24-month data on vegetative, reproductive and fruiting phenophase of Ten individuals each from seven wild species of Anacardiaceae family. 10 quadrates were randomly laid down in five sites at western Himalaya. The selected individuals of targeted species were marked for documentation of phenophase. Synchrony Index and Circular statistics applied to determine phenophase development and seasonal variations while Mean vector and Rayleigh's Z values estimated seasonal variations in vegetative, reproductive and fruit/seed phenophase. In the findings, synchrony (0.65-0.71) was more pronounced in the second year as compared to the previous. The young leaf stage was found more asynchronous whereas, many of the phenophase stages were overlapped with each other in the individuals. Leaf bud initiation, colored leaves/leaf senescence and falling leaves/leaf abscission were strongly prominent with highly significant Rayleigh's Z values for all the species. It indicated the dates are not distribute randomly or uniformly for phenophase throughout the with significant mean angle or mean direction.

Key words : Anacardiaceae, phenophase, species, seasonality, synchrony, variations.

Introduction

Rapid climate change is altering biological systems across the globe (IPCC, 2007) with changes in phenology being the most frequently documented response (Simonds *et al.*, 2020). In plant communities, the phenological behavior and its pattern is a result of variation in trends of different population and to individual's response within that one population (Devineau, 1999). Phenological variation has led on one hand to an expectation that phenological patterns are adaptive, leading to the synchronization of reproductive activity with available biotic resources (Nanda *et al.*, 2009). The variation in individual of the same population can be regarded as a major component of the adaptive character which is directly related to the species habitat and ecology (Grime *et al.*, 1986). In tropical forests, the precipitation is expected to decrease 10-20% and temperature to increase about 1-3°C (IPCC, 2007), therefore, synchronization of phenophase among individuals and between population is expected due to changes in regional weather pattern (Valdez-Hernandez *et al.*, 2010).

The phenology of the wild plant species of Anacardiaceae family is not well known in montane and sub-montane zone of the Garhwal Himalaya. The species are well distributed with Sal (*Shorea robusta*) mixed forest in the region, and exhibits a large difference in phenophase stages. The seasonal changes in the

phenophase stages are indicators of the climate change which affects the consecutive phenology of the species. Temperature, rainfall and photoperiod play major role in seasonal changes in particular phase among the individuals of a population. The reproductive phase mainly flowering cue determine the variability in flowering phase among the individuals' response to synchrony, and consequently affect the synchrony and flowering abundance of the population. In addition, the level of asynchrony in phenophase will help to understand the impact of climate change and its consequences on ecological communities (Singh and Khuswaha, 2005). Still, the phenological studies provide the facts about the pattern of growth and development of plants in relation to environmental factors and selective pressure on reproductive and fruit phase (Omondi *et al.*, 2016).

Seasonality study helps in the assessment of environment factors and their shift in mean angle of different phenophase (Nanda *et al.*, 2009). The tree and shrubs species of Anacardiaceae are deciduous to semi-deciduous in nature, associated with *Shorea robusta* and *Pinus roxburghii* distributed in Shivalik range of Garhwal Himalaya in Uttarakhand. Studies that investigate people's perception of the phenological behaviour of certain species from Anacardiaceae in the Western Himalayan region is still few. Yet this approach is important for effective decision making for conservation, keeping climate change and local environmental condition in concerns. Secondary literature and published

articles did not give sufficient information about phenology of these species. Therefore, a comprehensive study is needed to analyze the effects of temperature and precipitation on phenophase event of selected species in Garhwal Himalaya.

Research Methodology

The present study was conducted in submontane and montane zone of the Pauri district of Garhwal Himalaya. In Sub-montane zone the sites were located in Lansdowne Forest Division i.e. Bhasora, Dugadda, Hanumanthi, and Sindhikhal; whereas only one site was selected as of Garhwal Forest Division (Figure 1). The highest rainfall was recorded in month of August (116.33 mm) and the lowest in December (0.60 mm) and January (6.11 mm) for both the years. The maximum temperature was recorded during June (34.00 °C) and minimum in January (13.00 °C). The sites were selected on the basis of vegetation type because most of the wild species belonging to anacardiaceae family are found in the region. In all the study sites, the vegetations are dominated by trees (*Shorea robusta*, *Buchanania lanzan*, *Pinus roxburghii*, *Acacia catechu*, *Myrica esculenta*, *Quercus leucotrichophora*, *Lyonia ovalifolia* etc.) and shrub (*Rhus parviflora*, *Cotinus coggygia*, *Lantana camara*, *Murraya koengii* etc.). The tropical to sub-tropical zone is dominated by both deciduous and semi-deciduous type of vegetation of which the *Shorea robusta* is the most important species and found up to an altitude of 1400 meter, associated with *Acacia catechu*, *Bombax ceiba* and *Adina cordifolia*. The sub-tropical to temperate zone consists of species *Pinus roxburghii* with *Myrica esculenta* and *Quercus leucotrichophora* up to an altitude of 900 to 2100 meter.

Data collection : To document the phenological events of seven selected species of anacardiaceae, 10 quadrates of 10 x 10 m² were established in each five sites (Valdez-Hernández et al., 2010). The phenological pattern of ten individuals of each species were observed at monthly interval from January, 2017 to December, 2018 in their natural conditions where they were distributed abundantly in relation to environmental factor. The starting date of the particular phenophase was considered as monitoring date within that month in which more branches were observed to have entered in that phase, whereas the completion of the phenophase in next or within the month was considered as ending of that phase when no branch was observed in the phase. At population level, peak phenophase was only used to refer to month in which most of the individual of a population reached a maximum in that phase. The phenological observation were categorized into three phenophase i.e. vegetative phase (i. leaf bud initiation, ii. young leaves, iii. coloured

leaves/leaf senescence, and iv. falling leaves/leaf abscission), reproductive phase (v. flower/flowering bud, and vi. open flower), and fruit/seed phase (vii. ripen fruit/seed, viii. unripe fruit/seed, and ix. recent fruit/seed drop) (Denny et al., 2014). Synchrony indices for different phenophase such as leaf bud initiation, young leaves, coloured leaves, falling leaves, flower or flowering bud, open flower, ripen fruit or seed, unripe fruit or seed and recent fruit or seed drop for *B. lanzan*, *P. khnjuk*, *S. anacardium*, *L. coromandelica*, *S. pinnata*, *R. parviflora* and *C. coggygia* were calculated as the ratio between marked individual's mean duration of a particular phenophase and the overall duration of the phase (Singh and Kushwaha, 2005). The higher ratio indicates the maximum chances of a particular phenophase between the individuals of a species (1.00 indicates the perfect synchrony while the ratio decreases from 1.00 indicate increase in asynchrony). The percentage scale of each phenophase can be calculated by the ratio of the number of phenological observation to the total number of observed trees (Omondi et al., 2016).

Data analysis : To test the seasonality of phenophase for each species, the circular statistics was used by using Oriana 4.02. Phenophase events of each species were scored according to the intensity on 0 to 100% scale to estimate the activity at different stages within each phenophase. For seasonality analysis, circular plots were constructed with frequency distribution of each phenophase for all species at monthly interval, when January was supposed to be 0° and December as 330° at interval of 30. Synchrony index was evaluated to determine the variations in phenotypic events. The data of each phenophase exhibited unimodal distribution except *Semecarpus anacardium* i.e. two peak period for reproductive and fruit/seed phase within a year due to its polygamous nature of flowering. The mean vector 'r' measures the length of mean date or month or year for phenophase. The 'r' has no units and varies from 0 (when H₀ is accepted) to 1 (H_A is accepted i.e. phenophase event occurs around one single date or time throughout the year). Rayleigh's Z test was used to determine the level of significance at different phenophase categories.

Results and Discussion

(i) Synchrony of phenophase : Maximum synchrony ratio indicated higher coincidence of the phase within and between the populations while it was negligent in *Cotinus coggygia*. For falling leaves/leaf abscission, it was recorded as 0.65 and 0.61 respectively. Synchrony ratio valued as 0.50 for flowering/flower bud, coloured leaves, open flower, ripen and unripen fruit or seed phase (Table-1).

Table-1 : Synchrony Index for phenophase development of selected species.

Phenophase	Species													
	<i>Buchanania lanzan</i>		<i>Pistacia khinjuk</i>		<i>Semecarpus anacardium</i>		<i>Lannea coromandelica</i>		<i>Spondias pinnata</i>		<i>Rhus parviflora</i>		<i>Cotinus cogglygia</i>	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Leaf budinitiation	0.29	0.33	0.29	0.33	0.41	0.39	0.40	0.45	0.37	0.46	0.21	0.24	0.33	0.50
Young leaves	0.13	0.12	0.16	0.14	0.14	0.14	0.14	0.15	0.14	0.16	0.08	0.08	0.12	0.13
Colored leaves	0.21	0.44	0.21	0.42	0.31	0.39	0.28	0.46	0.50	0.50	0.28	0.26	0.48	0.50
Falling leaves	0.22	0.35	0.46	0.40	0.29	0.48	0.34	0.33	0.35	0.36	0.23	0.25	0.65	0.61
Flowering or flower bud	0.40	0.50	0.45	0.45	0.50	0.50	0.46	0.50	0.35	0.50	0.36	0.50	0.50	0.48
Open flower	0.50	0.48	0.50	0.50	0.59	0.49	0.50	0.50	0.44	0.50	0.50	0.50	0.50	0.50
Ripen fruit/seed	0.48	0.50	0.50	0.50	0.50	0.50	0.50	0.33	0.50	0.50	0.42	0.33	0.50	0.50
Unripe fruit/seed	0.54	0.50	0.50	0.50	0.49	0.46	0.43	0.50	0.50	0.50	0.41	0.50	0.50	0.50
Recent fruit or seed fall	0.78	0.62	0.50	0.50	0.67	0.92	0.68	0.71	0.50	0.50	0.50	0.66	0.50	0.50

Table-2 : Seasonality in vegetative phases of the selected wild species of Anacardiaceae.

Vegetative Phases	Mean vector (month)		Length of mean vector (r)		Circular SD1		Rayleigh' Z	
	2017	2018	2017	2018	2017	2018	2017	2018
(a) Leaf bud initiation	101.103° (April)	96.22° (April)	0.78	0.81	39.44°	36.46°	147.53** (0.002)	139.40** (0.005)
(b) Young leaves	177.13° (June)	190.72° (July)	0.44	0.44	73.41°	72.57°	145.62NS (0.113)	150.92NS (0.125)
(c) Coloured leaves/leaf senescence	1.66° (January)	308.03° (November)	0.31	0.83	86.96°	34.58°	22.76NS (0.142)	108.36** (0.001)
(d) Falling leaves/leaf abscission	340.39° (December)	327.99° (November)	0.65	0.80	52.69°	37.99°	90.56* (0.024)	105.00** (0.001)

Table-3 : Seasonality in flowering/flower bud and open flower phases.

Reproductive phase	Mean vector (month)		Length of mean vector (r)		Circular SD1		Rayleigh' Z	
	2017	2018	2017	2018	2017	2018	2017	2018
(a) Flowering/flower bud	79.48° (March)	76.70° (March)	0.51	0.53	65.99°	63.68°	50.42* (0.047)	50.00* (0.033)
(b) Open flower	98.57° (April)	97.95° (April)	0.50	0.52	66.88°	64.72°	42.23* (0.036)	42.69* (0.043)

** p-value<0.01, * p-value<0.05, 1 Standard Deviation.

Table-4 : Seasonality in fruit/seed phases of the selected wild species of Anacardiaceae.

Fruit/seed Phase	Mean vector (month)		Length of mean vector (r)		Circular SD1		Rayleigh' Z	
	2017	2018	2017	2018	2017	2018	2017	2018
(a) Unripen fruit/seed	136.38° (May)	146.38° (May)	0.50	0.48	66.97°	68.60°	46.41* (0.032)	40.52NS (0.053)
(b) Ripen fruit/seed	164.65° (June)	184.20° (July)	0.52	0.48	65.56°	69.00°	46.16* (0.038)	41.73NS (0.059)
(c) Recent fruit/seed drop	162.30° (June)	190.21° (July)	0.46	0.55	71.33°	62.69°	24.40NS (0.158)	33.21* (0.025)

** p-value<0.01, * p-value<0.05, 1 Standard Deviation.

(ii) Variation in seasonality among various phenophases

Vegetative phase : The leaf bud initiation, coloured leaves/leaf senescence and falling leaves/leaf abscission was found strongly prominent showing highly significant Rayleigh's Z values for all the species. The mean vector month for leaf initiation was April for both the year and had a difference of 4.88°, June for young leaves with a difference of 177.13° for year 2017 and July (190.72°) for

year 2018. In coloured leaves/leaf senescence, the mean vector month was January (1.66°) for year, 2017 and November (308°) for year 2018, with a difference of 50.37°. The mean vector month for falling leaves/leaf abscission was December (340.39°) for year 2017 and November (327.99°) for year, 2018 and had a significant difference of 12.40°. The observations indicated that the length of mean vector 'r' had strong influence on seasonality of leaf bud initiation ($r = 0.78$) and falling leaves/leaf abscission ($r = 0.65$) for year 2017 as

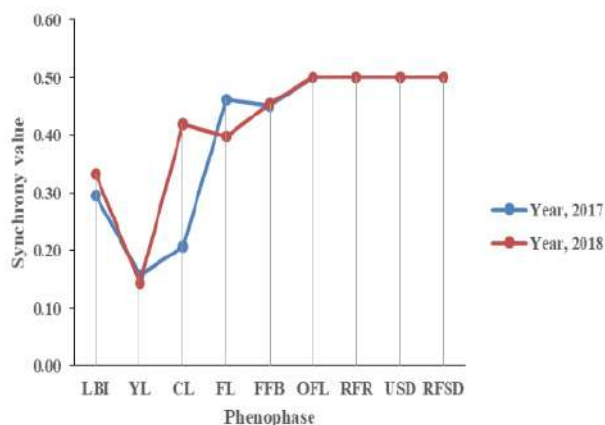


Figure-1 : Synchrony values and phenophase variation in *Buchanania lanzan*.

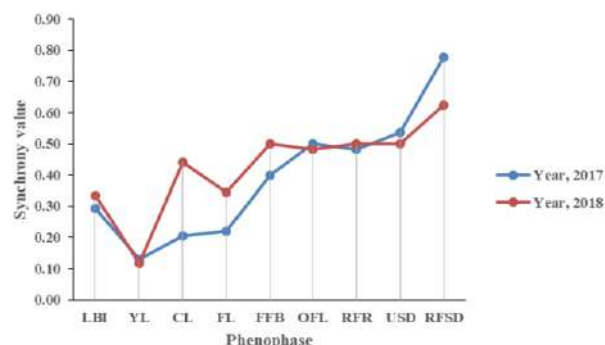


Figure-2 : Synchrony values and phenophase variation in *Pistacia khinjuk*.

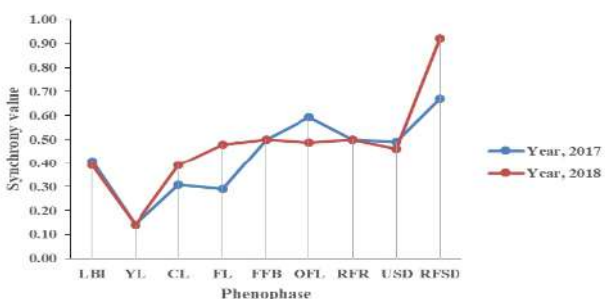


Figure-3 : Synchrony values and phenophase variation in *Semecarpus anacardium*.

compared to young leaves and coloured leaves/leaf senescence (Table 2).

Reproductive phase : In reproductive phase, the flowering/flower bud starts *Semecarpus anacardium* and *Spondias pinnata* from December and peaks in March for the rest of species. The flower bud initiate from February

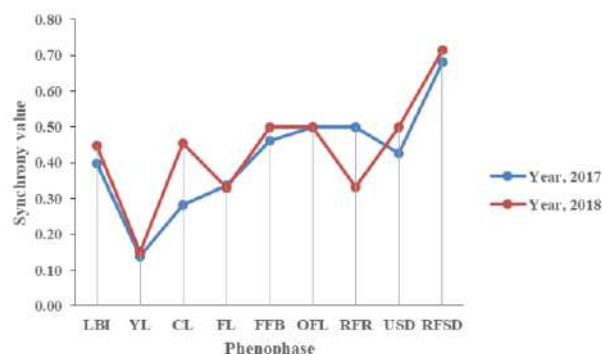


Figure-4 : Synchrony values and phenophase variation in *Lannea coromandelica*.

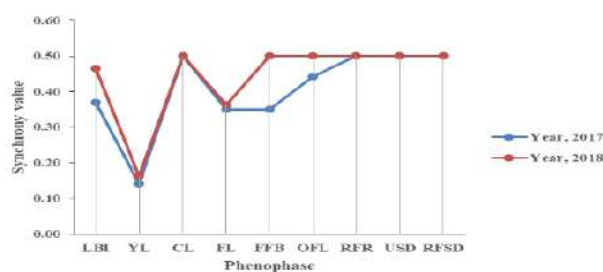


Figure-5 : Synchrony values and phenophase variation in *Spondias pinnata*.

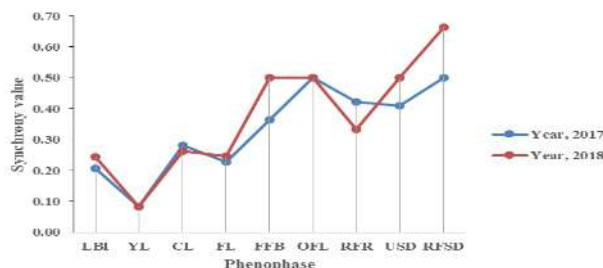


Figure-6 : Synchrony values and phenophase variation in *Rhus parviflora*.

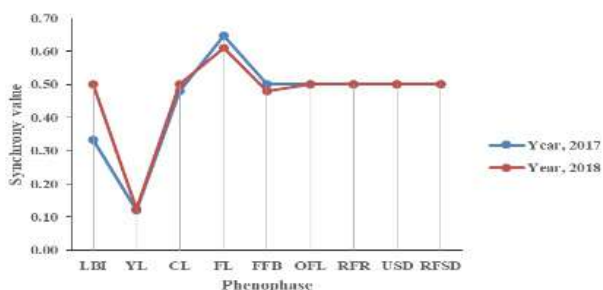


Figure-7 : Synchrony values and phenophase variation in *Cotinus coggia*.

and peaks in June. For flowering/flower bud, the mean vector month was March for both years and had a significant difference of 2.78° . Open flower starts from January for *Semecarpus anacardium* and *Spondias pinnata*, and peaks in April for *Buchanania lanzan*, *Pistacia khinjuk*, *Lannea coromandelica* and *Cotinus coggia*. In open flower, the mean vector month was April for both the year and had a significant difference of 0.62° .

Fruit/seed phase : During the investigation, the fruit season began from March for *Semecarpus anacardium* and *Spondias pinnata*, and peaks in May for *Buchanania lanzan*, *Pistacia khinjuk*, *Lannea coromandelica* and *Cotinus coggia*. In unripen fruit/seed, the mean vector month was May for both the years and had a difference of 10° . For ripen fruit/seed, the mean vector month was June (164.65°) for year, 2017 and July (184.20°) for year, 2018, whereas the differences was about 19.55° . For recent fruit/seed fall, the mean vector month was June (162.30°) for year, 2017 and July (190.21°) for year, 2018, while the differences was about 27.91° prior to onset of monsoon. (Table-4).

Synchrony of phenophase : The results have shown the key patterns of synchrony among the species. The first one is occurrence of asynchrony in phenophase stages of young leaves. The young leaves were found more asynchronous in both the years for all species as compared to all other phases. Least asynchrony was found during the young leaves phase in individuals of all species for both the years. It is because of the variation in timing of young leaves of some species like *Buchanania lanzan* and *Rhus parviflora* starts from the February, and ends up to July in rest of the species. The synchrony was found more pronounced in year 2018 as compare to the year 2017 for all species. Hence, many of the phenophase stages were overlapped with each other in the individuals of the studied species. While some loss of synchrony occurs, this is not sufficient to create a negative impact on population dynamics (Simmonds *et al.*, 2020).

The second pattern is a more pronounced synchrony ratio among the individuals of the 6 species except *Cotinus coggia* with falling leaves in recent fruit or seed drop phase for both years. The seasonality in different phenophase for all species revealed that dates are not distributed uniformly or randomly throughout the years and exhibited the significant mean angle or mean direction for a particular stage. However, the findings contradict to Singh and Kushwaha (2005) who reported that the fruit fall phase was found least synchronous in conspecific trees, which is in contrast to the synchrony found for the same phase in present study. Similarly, Atluri *et al.* (2004) reported that flowering phase in *Shorea*

commences during late February, while leafless phase is little asynchrony among the individuals—The synchronization of flowering and leaf flushing in *Schleichera oleosa* and *Lagerstroemia lanceolata* seems to be related to moisture, temperature and day length were stated by Nanda *et al.* (2014) and confirmed his statement with those of Murali and Sukumar (1994).

Variation in seasonality among various phenophases

: Seasonality of various phenophase was studied to understand variations in their cyclicity. It was observed that different phenophase had shown characteristic variations during 24 month. The seasonality in vegetative phase *i.e.* leaf bud initiation, coloured leaves/leaf senescence and falling leaves/leaf abscission was found significantly for the previous year whereas the young leaves was non-significant for both the years. Similarly, the occurrence of mean data around the years for leaf flush was not found statistically significant. Further in year 2018, the length of mean vector 'r' had strong influence on seasonality of leaf bud initiation ($r = 0.81$), coloured leaves/leaf senescence ($r = 83$) and falling leaves/leaf abscission ($r = 80$) as compared to young leaves. Here, the length of seasonality measured by mean vector 'r' shows that flowering/flower bud and open flower had significantly strong influence on seasonality for both the years. The seasonality in reproductive phase *i.e.* flowering/flower bud and open flower was found significant for both the years. Flowering phenophase were seasonal and most of species-initiated flowering during March. It is due to the length of mean vector for these phase ranges from 0.50 to 0.53 which shows some seasonality. The findings are supported by Nanda *et al.* (2009) who remarked similar pattern of flowering phenophase. In addition, the dates for reproductive phase for all species were not distributed uniformly or randomly throughout the year.

The length of mean vector 'r' showed strong influence on seasonality for unripen fruit/seed ($r = 50$) and ripen fruit/seed ($r = 52$) for year 2017 as compared to the recent fruit/seed fall. Whereas, in year 2018, the length of mean vector 'r' showed strong effect on seasonality for recent fruit/seed drop ($r = 0.55$) as compared to the other phases. The seasonality for unripen and ripen fruit/seed were found different in inter annual period. In fruit or seed phase, significant during the year 2017 while in recent fruit/seed drop was found significant for the year 2018. Hence, in this phase, the finding supports the fact that phenophase is adapted to dry season prior to onset of monsoon which indicates adaptations of reproductive phenology of studied species to their local climatic conditions. Ripen fruit /seed drop (peak month June-July) was found significant during 2018 as explosive dispersed fruits dehiscence during dry months when relative humidity is

low as mentioned by Murali and Sukumar (1994). Similar inter annual differences were reported on fruiting ecology of *Osyris quadripartita* were done by Herrera (1998).

Conclusions

The key points indicate that the effect of environmental factors on different events under vegetative phases are based on real time. The main conclusion is that the studied species are adapted to local environmental conditions with varied seasonality during interannual period. Changing local environmental conditions pose a profound effect on the phenological behavior of the species belonging to the same family. Also use of traditional knowledge can be utilized as interesting tool for rapid phenological diagnosis. However, the long-term studies are need to understand the environmental impact on the growth and development of the species in the region.

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Field Screening of Pea (*Pisum sativum* L.) Genotypes Against Pod Borer Complex

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Abstract

Field screening of seven pea (*Pisum sativum* L.) genotypes against pod borer complex like (*Helicoverpa armigera*, *Etiella zinckenella* and *Polymommatus boeticus*) was carried out at Agriculture research farm of Baba Raghav Das Post Graduate College, Deoria (Uttar Pradesh) during Rabi, 2019-20. Among the seven genotypes of pea like (NYX-1010, UCS-10, Arkel, PS-10, Amulya-10, Deshi and GS-10) none was found free from infestation of borer complex. A significant variation in pod damage per cent was record in different genotypes of pea under investigation. Per cent pod damage due to pod borers varied between 18.84 to 28.16 per cent in different genotypes of pea. On the basis of pest susceptibility rating three genotypes of pea (Deshi, Arkel and NYX-1010) emerged as most promising showed resistant against borer complex, whereas UCS-10, PS-10 and Amulya-10 were found moderately resistant to pod borers. Per cent weight loss of seed in different genotypes of pea showed non-significant variation. However, weight loss in different genotypes was proportional to the degree of pod damage per cent.

Introduction

Pea (*Pisum sativum* L.) $2n = 2x = 14$, is one of the most important pulse crop grown in India for vegetable as well as a pulse crop. Pea also called as mater in Hindi belongs to the family – Leguminasae. Pea is highly nutritious vegetable. Pea is very palatable and nutritious for human consumption and contains higher proportion of digestible proteins, carbohydrates, vitamins (A, B, and C) and minerals like phosphorous, iron etc. (Cherian *et al.*, 1995). In India the total area under field pea is 11.0 lakh ha, production 11.20 lakh tonnes and productivity 927.2 kg/ha. Uttar Pradesh is largest producer of pea, occupying 355.89 thousand ha area with annual production of 236.21 thousand tonnes with average productivity of 740 kg/ha (Anonymous, 2016). Pea crop subjected to attack by large number of insect-pests in field like - pea pod borer (*Etiella zinckenella*), pod borer (*Helicoverpa armigera*), pea blue butterfly (*Lampedes boeticus*), pea stem fly (*Ophiomyia phaseoli*), pea leaf miner (*Chromatomyia horticola*), pea aphid (*Acyrtosiphon pisum*), thrips (*Caliothrips indicus*) and mite (*Tetranychus telarius*) are serious insect-pests and often cause substantial loss to the crop.

Pea pod borer (*Etiella zinckenella*) and gram pod borer (*Helicoverpa armigera*) are the major pests of field pea causing as high as 50.9 % pod infestation with 77.64 %, seed damage resulting in 23.9 % loss in seed yield (Yadav and Patel, 2015). Yadav and Chauhan (2000) observed that *Etiella zinckenella* caused 3.5 to 30.8 % pod damage in pea crop in Uttar Pradesh alone. The

newly emerged larvae of *Etiella zinckenella* (Treitschke) feed on the floral part and subsequently bore into the pods. The tiny greenish caterpillars enter the pod and eat away the young grains. The young larvae of *Helicoverpa armigera* (Hubner) feed on the foliage and flowers for some time and later bore into the pods and feed on the developing seeds with their bodies hanging out side. A single larva may destroy several pods before reaching to maturity.

Host plant resistance is an important component of IPM (Kogan, 1988). Moderate level of resistance has many advantages in relation to IPM. Among the most desirable features of plant resistance from an ecological point of view are its specificant to a pest complex of pest organism, cumulative effect, persistence, harmony with environment, ease of adaptation and compatibility with other components in pests management. A partially resistant variety could provide the foundation open, with which other management measures could be built (Adkinson and Dyck, 1980).

Materials and Methods

The present investigation was carried out at the Agriculture research farm of Baba Raghav Das Post Graduate College Deoria (Uttar Pradesh) during Rabi, 2019-20. The experiment was conducted in Randomized Block Design (RBD) consisting of seven genotypes [*i.e.* NYX-1010, UCS-10, Arkel, PS-10, Amulya-10, Deshi and GS-10 (check)] and these treatments replicated thrice. Field pea genotypes were grown in plots having 7 rows, each plot size was 2x1 square meter. The spacing of row

to row and plants to plants were 30x10 cm. respectively. The borers attack was compared on the basis of infestation of pods. The pod damage was recorded at the time of harvesting stage for which randomly selected pods from 10 plants of each variety were collected separately. Total number of pods and damage pods were counted to calculate the per cent pod damage of each varieties using formula as :

$$\text{Pod damage \%} = \frac{\text{Number of damage pods}}{\text{Total number of pods}} \times 100$$

Data on per cent pod damage was transformed in angular transformation before statistical analysis.

Table-1 : Range of infestation index.

Characteristics	Range of infestation index
Resistant	0-20 per cent pods bored
Moderately resistant	21-40 per cent pods bored
Intermediate	41-60 per cent pods bored
Susceptible	61-80 per cent pods bored
Highly susceptible	81-100 per cent pods bored

The damage of pod borer complex was identify as round holes for *Helicoverpa armigera*, older pods worked with brown spot at larvae entry point for *Etiella zinckenella* and young pods with bore holes and presence of slug like caterpillar for *Polyommatus boeticus* whatever, damaging sign obtain on pods collectively consider pod damage due to pod borer complex.

Pest susceptibility ratings (PSR) were calculated on basis of total pod damage by pod borer complex, by taking GS-10 as check. Based on pod damage the pest susceptibility rating (PSR) was counted as suggested by using a formula derived from Abbott (1925) as given below:

$$\text{Pest resistance (\%)} = \frac{(\% \text{ pod damage in check} - \% \text{ pod damage in test entry})}{\% \text{ pods damage in check}} \times 100$$

Table-2 : Pest resistance and relative resistance / susceptibility rating.:

Pest resistance (%)	Relative resistance/susceptibility Rating
100	1 Increasing resistance
75 to 99	2
50 to 75	3
25 to 50	4 Moderately resistance
10 to 25	5
-10 to 10	6 Equal to check
-25 to -10	7
-50 to -25	8 Highly susceptible
-50 to less	9

Weight loss per cent was determined by number of seeds in healthy and infested pod from randomly selected

10 plants from each variety. Seeds obtained from healthy and damage pods their weight and per cent weight loss was calculated by using formula for each varieties as :

Results and Discussion

1. Pod damage per cent by the pod borer complex :

The data presented in table-3 indicated that pod damage varied from 18.84 to 28.16 per cent in different genotypes under study. No any genotype of pea was found free from infestation of pod damage. Among the genotypes evaluated Deshi variety of pea recorded least damage (18.84 %) followed by Arkel (19.57 %) and NYX-1010 (19.85 %), were considered superior over check variety GS-10 (28.16 %). These superior genotypes were categorized as resistant. Remaining genotypes in which pod damage per cent was between 21.35 to 28.16 per cent were categorized as moderately resistant against pod borers.

Pest Susceptibility Rating (PSR) was ranged from 4 to 6 for borer complex in different genotypes (Table-3). It revealed a slight narrow categories and characteristics in genotype understudy were grouped into 2 groups on the basis of pod damage susceptibility rating that is resistant and moderately resistant over pod damage in check cultivar GS-10. The genotype NYX-1010, Arkel and Deshi had pest susceptibility rating of 4, indicated resistant to pod borers. The pest susceptibility rating (PSR) of 5 was observed in pea variety UCS-10 and PS-10 while in variety Amuly-10 the pest susceptibility rating was 6 indicated moderately resistant to pod borers showed superiorly over check genotype GS-10. Some of the genotypes under present study viz. GS-10 and Arkel had also been studied by Abhilasha and Sekharappa (2017, b) who also reported GS-10 as moderately resistant to pod borers but Arkel as intermediate (between moderately resistant and susceptible), did not corroborate the present findings as Arkel was categorized as resistant to pod borer in present study.

2. Weight loss per cent by pod borer complex :

The data presented in table-4 indicated that weight loss per cent varied from 14.89 to 19.90 per cent in different genotypes under study. Among the genotypes evaluated Arkel variety of pea recorded least weight loss (14.89 %) followed by Deshi (15.66 %) and UCS-10 (15.86 %), were considered superior over check variety GS-10 (19.90 %). Weight loss in different genotypes of pea is proportional to the pod damage per cent as the genotypes recorded maximum pod damage, the maximum weight loss per cent was observed and vice-versa. It has been agreed upon that the resistance to particular insect-pests is governed by the morphological and physiological factors of genotypes or cultivar.

Table-3 : Per cent pod infestation in different genotypes of pea due to borer complex.

S. No.	Genotype	% Pod number	S.E.	PSR rating	Categories
1.	NYX-1010	19.85 (26.39)	1.42	4	Resistant
2.	UCS-10	21.35 (27.50)	0.08	5	Moderately resistant
3.	Arkel	19.57 (26.23)	0.58	4	Resistant
4.	PS-10	22.18 (28.08)	0.24	5	Moderately resistant
5.	Amulya-10	25.42 (30.19)	1.93	6	Moderately resistant
6.	Deshi	18.84 (25.71)	0.28	4	Resistant
7.	GS-10	28.16 (32.00)	1.44	—	—
C.D. at 0.05%		3.51	—	—	—
C.V.		6.97	—	—	—

Table-4 : Per cent weight loss in different genotypes of pea due to borer infestation.

S. No.	Genotype	% Weight loss	S.E.
1.	NYX-1010	17.77 (24.91)	0.48
2.	UCS-10	15.86 (23.45)	0.48
3.	Arkel	14.89 (22.63)	1.22
4.	PS-10	16.62 (23.98)	1.43
5.	Amulya-10	18.45 (25.39)	1.18
6.	Deshi	15.66 (23.30)	0.34
7.	GS-10	19.90 (26.37)	2.05
C.D. at 0.05%		N.S.	—
C.V.		8.30	—

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Correlation and Path Analysis of Quantitative Traits in Different Wheat (*Triticum aestivum* L. em. Thell) Genotypes under Alluvial Soil Condition

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Abstract

The experiment was conducted to evaluate 72 wheat germplasm lines in normal soil under timely soon and irrigated conditions following augmented block design the entire experiment field was divided in 8 blocks of equal size and each the 3 checks, namely, PBW-343, PBW-502 and PBW-154 were randomly allocated each block. The present investigation was conducted during Rabi 2016-17 at Agriculture Research form of B.R.D.P.G College (Campus), Deoria UP) in the east part of up india. The data were recorded from five randomly selected plants for 14 quantitative traits viz., Day to 50% flowering, Days to maturity, Plant height (cm), Number of effective tillers per plant, Length of spike (cm), Number of spikelet's per spike, Number of grain per spike, 1000-grain weight (g), Grain yield per Plant (g), Flag leaf area per plant (cm²), Peduncle length per plant (cm), Grain yield per spike (g), Biological yield per plant (g), Harvest index (%) The data on 14 quantitative traits was utilized for estimation of correlation and path coefficients among traits. Existence of highly significant positive correlation amongst yield and important yield components suggested that selection would be high effective and efficient in improving these traits due to possibility of correlated response. The path-coefficient analysis, carried out at genotypic as well as phenotypic level, identified harvest index yield per plant as the major direct positive contributors towards expression of grain yield per plant, while biological yield per plant, effective tillers per plant, plant height, 1000 grains weight, grain yield per spike, days to 50% flowering, peduncle length, days to maturity and grains per spike as most important indirect yield component.

Key words : Wheat cultivars, quantitative characters, correlation coefficient, path coefficient, genotypes

Introduction

India the Second largest producer of wheat in the world. The area under wheat in India is 311.88 lakh ha with a production of 95.91 million tones and productivity of 3075 kg/ha (Annual Report 2015-16, Department of Agriculture & Co-operation Ministry of Agriculture Govt. of india). Wheat (*Triticum aestivum* L. 2n=42), a self pollinated crop of the Gramineae family (Sub-family poaceae) and genus *Triticum*, is the world's largest famous energy rich cereal crop. The first dwarf and Sami dwarf wheat variety having short plant stature, fertilizer responsive, lodging resistance, diseases resistance, photo- insensitive, wide adaptableness and higher grain yield was Norin 10 that was brought to USA by S.O. Salamon in the year 1948 from Japan. after knowing prospect of ever-increasing wheat production in India, five dwarf varieties viz. Lerma Rajo 64A, Sonara-63, Sonara-64, Nayo-64 and S-227 were introduced. Ultimately in 1969 central variety release committee of India released several dwarf varieties like Kalyan sona, Sonalika, safed Irma, choti Irma, Sharbati Sonara, Arjun, Patap, Janak, having Mexican wheat as base breeding material. The central Asia near East Mediterranean and Ethiopian are the world's most important centers of diversity of wheat and its related species (Kundu and Nagarajan, 1996; Perrino and

porcedu, 1990). Hindukush region is the center of diversity of hexaploid wheat (Kundu and nararajan, 1996). The majority of the cultivated wheat varieties belong to three major species of the These genus *Triticum*. are the hexaploid (2n=28), *T.aestivum* L. (Bread wheat), the tetraploid (2n=28) *T.durum* and the diploid (2n=14), *T. dicoccum* and *T.monococcum*. Globally, aestivum wheat is most important species which covers 90 per cent of the area. Second popular wheat being durum wheat which covers about 9 percent of the total area while *T.diccoum* wheat and *T.monococcum* wheat cover up less than the 1 per cent of the total area. The Bread wheat belong to family of Gramineae and it is a hexaploid species with (2n = 42) having AABBDD with A, B and D genome). The species of bread wheat may be divided into diploid, tetraploid and hexaploid species with chromosome number 2n = 14 = AA, 2n = 14 = BB, 2n = 28 = AABB and 2n = 42 = AABBDD respectively with basic of chromosome number (x) = 7 (Sleper and Poehlman, 2006). However, DNA studies revealed *Triticum urartu*, which is diploid as a donor of A genome instead of *Triticum monococcum* (Dvorak et al., 1993) and *Aegilops speltoides* which is a wild diploid as possible donor of B genome. Yield being a complex character is a function of several component characters and their interaction with

Table-1 : Estimates of correlation coefficients computed between 4 character indigenous and exotic lines of wheat Genotypical Correlation Matrix.

Character	Days to 50% Flowering	Plant Height cm	Peduncle Length cm	Flag's Leaf Area cm ²	Ear Length cm	Productive Tillers/Plant	Spikelet's /Spike	Day to Maturity	Biological Yield/Plant (g)	Yield / Spike (g)	Grains/ Spike	1000 Grain's Weight (g)	harvest Index %
Days to 50% Flowering	1.0000	0.1046	-0.0896	-0.0018	-0.1059	0.0005	0.1528	0.1900	-0.0385	0.1419	0.0962	0.1597	-0.0300
Plant Height cm	0.1046	1.0000	0.4507	-0.1106	0.3912	0.3535	0.3874	0.1282	0.2456	0.1946	0.2439	0.3729	0.5265
Peduncle Length cm	-0.0890	0.4500	1.0000	0.0166	0.4152	0.4918	0.2373	-0.0502	0.3254	0.2588	0.1786	0.3331	0.5112
Flag's Leaf Area cm ²	-0.0017	-0.1107	0.0166	1.0000	-0.2154	-0.3132	-0.3134	0.0597	-0.1467	0.05196	-0.1087	-0.0505	-0.2951
Ear Length cm	-0.1058	0.3913	0.4154	-0.2153	1.0000	0.5035	0.5531	0.0692	0.4198	0.2936	0.3493	0.4345	0.5307
Productive Tillers/Plant	0.0005	0.3535	0.4918	-0.3132	0.5036	1.0000	0.2945	-0.0449	0.8922	0.3219	0.0627	0.2902	0.4045
Spikelet's/Spike	0.1528	0.3874	0.2373	-0.3135	0.5530	0.2945	1.0000	-0.1187	0.4427	0.3966	0.4877	0.2761	0.1444
Day to Maturity	0.1900	0.1282	-0.0502	0.0597	0.0692	-0.0449	-0.1187	1.0000	-0.0653	0.1223	-0.0087	0.1472	0.2078
Biological Yield/Plant (g)	-0.0385	0.2456	0.3254	-0.1469	0.4199	0.8922	0.4427	-0.0653	1.0000	0.4824	0.1386	0.3805	0.3448
Yield / Spike (g)	0.1419	0.1946	0.2588	0.0519	0.2935	0.3219	0.3966	0.1223	0.4824	1.0000	0.4510	0.5520	0.2047
Grains / Spike	0.0962	0.2439	0.1786	-0.1088	0.3492	0.0627	0.4877	-0.0087	0.1386	0.4510	1.0000	0.1386	0.1590
1000 Grain's Weight (g)	0.1597	0.3729	0.3331	-0.0505	0.4346	0.2902	0.2761	0.1472	0.3805	0.5520	0.1386	1.0000	0.2579
harvest Index %	-0.0300	0.5265	0.5112	-0.2951	0.5307	0.4045	0.1444	0.2078	0.3448	0.2047	0.1590	0.2579	1.0000
Grain Yield / Plant (g)	-0.0175	0.3249	0.4232	-0.1869	0.4731	0.7779	0.3300	0.0137	0.7215	0.3772	0.1346	0.4096	0.9312

Table-2 : Direct and indirect effects of different characters on grain yield per plant in wheat germplasm Genotypical Correlation Matrix.

Character	Days to 50% Flowering	Plant Height cm	Peduncle Length cm	Flag's Leaf Area cm ²	Ear Length cm	Productive Tillers/Plant	Spikelet's /Spike	Day to Maturity	Biological Yield/Plant (g)	Yield / Spike (g)	Grains/ Spike	1000 Grain's Weight (g)	harvest Index %
Days to 50% Flowering	1.0000	0.1046	-0.0896	-0.0018	-0.1059	0.0005	0.1528	0.1900	-0.0385	0.1419	0.0962	0.1597	-0.0300
Plant Height cm	0.1046	1.0000	0.4507	-0.1106	0.3912	0.3535	0.3874	0.1282	0.2456	0.1946	0.2439	0.3729	0.5265
Peduncle Length cm	-0.0892	0.4503	1.0000	0.0164	0.41522	0.4916	0.2371	-0.0503	0.3252	0.2587	0.1786	0.3331	0.5112
Flag's Leaf Area cm ²	-0.0017	-0.1105	0.0168	1.0000	-0.2153	-0.3132	-0.3135	0.0597	-0.1469	0.0519	-0.1088	-0.0505	-0.2951
Ear Length cm	-0.1058	0.3913	0.4154	-0.2153	1.0000	0.5035	0.5532	0.0693	0.4198	0.2936	0.3492	0.4346	0.5307
Productive Tillers/ Plant	0.0005	0.3535	0.4918	-0.3132	0.5036	1.0000	0.2945	-0.0449	0.8922	0.3219	0.0627	0.2902	0.4045
Spikelet's /Spike	0.1528	0.3874	0.2373	-0.3135	0.5530	0.2945	1.0000	-0.1187	0.4427	0.3966	0.4877	0.2761	0.1444
Day to Maturity	0.1900	0.1282	-0.0502	0.0597	0.0692	-0.0449	-0.1187	1.0000	-0.0653	0.1223	-0.0087	0.1472	0.2078
Biological Yield/ Plant (g)	-0.0385	0.2456	0.3254	-0.1469	0.4199	0.8922	0.4427	-0.0653	1.0000	0.4824	0.1386	0.3805	0.3448
Yield / Spike (g)	0.1419	0.1946	0.2588	0.0519	0.2935	0.3219	0.3966	0.1223	0.4824	1.0000	0.4510	0.5520	0.2047
Grains/ Spike	0.0962	0.2439	0.1786	-0.1088	0.3492	0.0627	0.4877	-0.0087	0.1386	0.4510	1.0000	0.1386	0.1590
1000 Grain's Weight (g)	0.1597	0.3729	0.3331	-0.0505	0.4346	0.2902	0.2761	0.1472	0.3805	0.5520	0.1386	1.0000	0.2579
harvest Index %	-0.0300	0.5265	0.5112	-0.2951	0.5307	0.4045	0.1444	0.2078	0.3448	0.2047	0.1590	0.2579	1.0000
Grain Yield /Plant (g)	-0.0175	0.3249	0.4232	-0.1869	0.4731	0.7779	0.3300	0.0137	0.7215	0.3772	0.1346	0.4096	0.9312

environment (Khan and Naqvi, 2012). Probing of structure of yield involves assessment of mutual relationship among various characters contributing to the yield (Desheva, 2016). In this regard, genotypic and phenotypic correlation reveals the degree of association between different characters and thus aid in selection to improve the yield and its attributing traits simultaneously. Further, path coefficient analysis helps in partition of correlation-coefficients into direct and indirect effects and in the assessment of relative contribution of each component character to the yield. Singh, B.N., Vishwakarma, S.R. and Singh, V.K. (2010).

Materials and Methods

The present investigation was conducted during Rabi 2016-17 at Agriculture Research farm of B.R.D.P.G College (Campus), Deoria UP) in the east part of up india. the site of experiment is located at 26.5°N latitude, 83. 79°E longitude and 68 meter (223feet) higher than the sea level. The climate of district Deoria is semi arid with hot summer and cold winter nearly 80% of total rain fall is received during the monsoon (only up to September) with a few shower in the winter. The experimental material was consisted 72 wheat genotypes form exotic and indigenous excluding 3 check varieties these genotypes were procure from Genetic stock obtainable in wheat section, Department of Genetics and Plant Breeding, I.A.Sc. B.H.U. Varanasi" UP India The check used in experiment are well adopted varieties of the region. The experiment was conducted to evaluate 72 wheat germplasm lines in normal soil under timely soon and irrigated conditions following augmented block design the entire experiment field was divided in 8 blocks of equal size and each the 3 checks, namely, PBW-343, PBW-502 and PBW-154 were randomly allocated each block .the remaining a plots of a block were used for accommodating the test genotypes which were not replicated . A test genotype was present only one block while the three checks were replicated in all the 8 blocks. Each plot consisted of two rows 2.5 meters length with spacing of five cm in the row and 23 cm .between the rows. The data were recorded from five randomly selected plants for 14 quantitative traits viz., Day to 50% flowering , Days to maturity , Plant height (cm), Number of effective tillers per plant, Length of spike (cm), Number of spikelet's per spike , Number of grain per spike, 1000-grain weight (g), Grain yield per Plant (g), Flag leaf area per plant (cm²), Peduncle length per plant (cm), Grain yield per spike (g), Biological yield per plant (g), Harvest index (%) the genotype collection was done computing coefficient of variance genotype-phenotype and environmental level .the nature of Association among different character Anwar, J., Ali, M.A., Hussain, M., Sabir, W., Khan, M.A., Zulkiffal, M.

and Abdullah, M. (2009).was studies by using simple correlation and path-coefficient analysis (Wright, 1921; Dewey and LU, 1959).

Results and Discussion

The estimates of genotypic correlation coefficients between different characters, showed close parallelism in direction with their corresponding phenotypic correlation coefficient. .The genotype correlations were higher in magnitude then corresponding correlation at phenotypic level. The estimates of phenotypic, genotypic and environmental correlation coefficients computed between the 14 characters of indigenous and exotic lines of wheat. The results of correlation coefficient analysis are presented in Table 1.1. At phonotypic Level grain yield per plant (g) (0.730) exhibited highly significant and positive correlation productive tillers par plant. The grain yield per plant (0.6668) exhibited positive highly significant and positive correlation with biological yield/plant (g).The grain yield per plant (0.6653) exhibited highly significant and positive with correlation 1000 grains weight .The grain yield per plant (0.3473) exhibited highly significant and positive correlation with yield per spike. The biological yield/plant (g) (0.7510) exhibited highly significant and positive correlation with Productive tiller's per plant (g).The Productive tilleres per plant (0.3475) exhibited highly significant and positive correlation with Harvest index. The day of maturity (0.2453) exhibited highly significant and positive correlation with days to 50% flowering. The grain per spike (0.4371) exhibited highly significant and positive correlation with spikelets per spike. Path coefficient analysis was worked out from phenotypic as well as genotypic correlations coefficients to resolve the direct and indirect effect of different characters on grain yield per plant. The results of path coefficient analysis are presented in Table 1.2. The biological yield (0.686) followed by harvest index (0.684) exhibited high order positive direct effects on grain yield .However were to low to be considered of any consequence peduncle length (0.0853),1000 grain's weight (0.0709), Day's to 50% flowering (0.0034)made substation indirect positive contribution on grain yield. The plant height cm (-0.0584) days' to maturity (-0.0527) ,spikelet's per spike (-0.047) ,Productive tillers per plant (-0.470) ,yield per spike (g) (-0.0296) grains per spike (0.0162) ,Flag's leaf area (0.0058), Ear length cm (0.0032) showed considerable negative indirect effect on economic yield per plant .via harvest index.

Conclusions

The genotypic correlations were generally similar in nature and higher in magnitude then the corresponding phenotypic correlations. Grain yield per plant showed

highly significant and positive association with harvest index. The genotypic correlations were generally similar in nature and higher in magnitude than the corresponding phenotypic correlations. spikelet's per spike and ear length exhibited significant and positive correlation with grain per spike. Existence of highly significant positive correlation amongst yield and important yield components suggested that selection would be high effective and efficient in improving these traits due to possibility of correlated response. The path-coefficient analysis, carried out at genotypic as well as phenotypic level, identified harvest index yield per plant as the major direct positive contributors towards expression of grain yield per plant, while biological yield per plant, effective tillers per plant, plant height, 1000 grains weight, grain yield per spike, days to 50% flowering, peduncle length, days to maturity and grains per spike as most important indirect yield component. The characters identified above as important direct and indirect component. The characters identified above as important direct and indirect yield components merit due to consideration in formulating effective selection strategy for developing high yielding varieties in wheat.

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Economic Impact of Agromet Advisories Services by DAMU of KVK in Baramulla District of Jammu & Kashmir

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Abstract

A study was conducted during Summer and *Kharif* 2020 across Tangmarag, Kunzer and Malpora blocks of Baramulla district under the temperate zone of J&K to evaluate the adoption of Agromet Advisory Services (AAS) and to quantify the economic returns of farmers through advisory adoption in their regular farming practices. To achieve this, the groups of farmers were formed namely, a group adopting the agro-met advisories (AAS farmers) and other group not aware of agro-met advisories (non-AAS farmers). A total of 75 farmers (including AAS and Non AAS) were identified. The agro-met advisory were circulated among AAS farmers and care was taken for proper implementation of advisories by this group. The assessment of farmers in relation with advisories adoption and net economic gain was analysed for Rice, Maize and Apple crop usually grown in Kashmir Valley. Expenditure incurred & crop situation of both the group of farmers were compared at every stage from land preparation to harvest and crop growth and yields were monitored regularly among them. Significant results were reported for crop growth and yield among the AAS farmers compared to non-AAS. AAS farmers have obtained a net income of Rs. 56900, Rs. 29500 and Rs. 986200 while, non AAS farmers obtained a net income of Rs. 45200, Rs. 12000 and Rs. 682200 for rice, maize and apple crops respectively. The AAS farmers reported 20.5, 59.3 and 30.8 per cent of additional benefit in rice, maize and apple respectively. These additional benefit retention was attained due; practicing and following the shared weather based agro advisory bulletins by farmers for the effective management of crops as accordingly. Therefore, adoption of weather based agro advisory bulletin based on past, current and future weather forecast is an effective tool for enhancing the net productivity and income.

Key words : *Weather forecasting; AAS bulletin; rice; maize; apple and economics.*

Introduction

In India the Monsoon characteristic behaviour is changing regularly and confines a major impact on Agricultural sector. The weather behavioural changes under changing climatic patterns ascertained the urgent demand of weather predictable information for future upcoming days/weeks/months/seasons so that, with an exploration of the seeking necessities the awareness on future monsoon behaviours may supports the local farmers or stakeholders in effective ways for making better decisions on day to day farming operations. For this, the future weather information for a given locality plays a major role before and during the cropping season and if information on weather is provided in advance that confines being very helpful in inspiring the farmer to plan their own resources in order to gain the maximum economic benefits.

Hence, improved Agromet Advisory Services (AAS) greatly help the farmers to take benefit of congenial weather information his/her respective areas so that, may be able to regulate the impacts of bad weather situations. The AAS provide a very special kind of inputs to farmers as advisories are prepared for major field and horticultural crops grown in the respective area with this other

information on such agri-enterprises like Apiculture, Fisheries, Livestock, Mushroom, Agroforestry, Sericulture etc., were incorporated as per according with future weather situations and convincing with particular phenophase/stage of the crop or any other agri-enterprise. Further, weather forecast and weather based agro advisories are also help in increasing the economic benefit to the farmers with appropriate crop management practices (Ramachandrapa, 2018).

Under the Atmosphere & Climate Research-Modelling Observing Systems & Services (ACROSS) scheme of Government of India, The National Centre for Medium Range Weather Forecasting (NCMRWF) under the Ministry of Earth Sciences (MoES) in collaboration with India Meteorological Department (IMD) and Indian Council of Agricultural Research the State Agricultural Universities and ICAR-Central Institutes are being providing Agrometeorological Advisory Services (AAS) with extending the service (in operational mode) at the block level to the farming community based on location-specific medium-range weather forecast (MRWF). In currently in name of Gramin Krishi Mausam Sewa scheme these services are rendering in selected Krishi Vigyan Kendra's (KVKs) of India including KVK, Baramulla as District Agro-met Unit (DAMU). Thus, the

Table-1 : Economic impact analysis in Rice (Rs. /acre) in KVK Baramulla during 2020.

S. No.	Type	Rice			
		AAS	Non AAS	Benefits	B:C Ratio
1.	Land Preparation/ Sowing	10000	12000	2000	0.16
2.	Seed Fertilizers & Manure	1200	1600	400	0.25
3.	Pesticides/Insecticide/Herbicide	7500	9200	1700	0.18
4.	Irrigation	-	-	-	-
5.	Harvesting / Threshing	10000	12000	2000	0.16
6.	Input Benefit	85600	80000	5600	0.07
7.	Yield (q/acre)	30	24	6	0.25
8.	Rs. Net Benefit	56900	45200	11700	

Table-2 : Economic impact analysis in Maize (Rs./acre) in KVK Baramulla during 2020.

S. No.	Type	Maize			
		AAS	Non AAS	Benefits	B:C Ratio
1.	Land Preparation / Sowing	7200	8000	800	0.10
2.	Seed Fertilizers & Manure	1600	2400	800	0.33
3.	Pesticides / Insecticide / Herbicide	1200	1600	400	0.25
4.	Irrigation	6500	8000	1500	0.18
5.	Harvesting / Threshing	6000	8000	2000	0.25
6.	Input Benefit	52000	40000	12000	0.30
7.	Yield (q / acre)	24	16	8	0.50
8.	Rs. Net Benefit	29500	12000	17500	

AAS set up exhibits a multi-institutional, multidisciplinary synergy to render an operational service for the farming community. The AAS service rendered by IMD, MoES is a mechanism to implement relevant meteorological information by helping the farmers for efficient management of natural resources, with the aim of qualitative & quantitative improvement of agriculture production (Hussain *et al.*, 2021).

Materials and Methods

The Integrated Agromet Advisory Services located in the ICAR-CITH, Krishi Vigyan Kendra, Baramulla as District Agromet Unit (DAMU) centre, Kunzer, Baramulla has been serving the farming community in and around of the district at block and village levels. Progressive farmers have been taking keen interest in the agro-advisories and are the foremost beneficiaries. The major objective of this programme is to advise timely and need-based crop management practices. Weather forecast on rainfall, maximum and minimum temperature, wind speed, wind direction, cloud cover, maximum and minimum humidity are being received on every Tuesday and Friday from IMD, New Delhi and after its value addition by Meteorological Centre, Srinagar the forecast is received regularly, by the experts' and based on such forecast the opinions on agricultural based information were discussed from different disciplined scientists of KVK and with a collaborative scientific approach the advisories are obtained. Based on the suggestions from experts, the

agro advisories are being prepared for every Tuesday and Friday in Regional (Kashmiri) as well as in English languages. These advisories are sent to IMD for preparation of national bulletins and are uploaded on the IMD website (www.imdagrimet.gov.in) in both Regional and English language. Bulletins are regularly communicated to the farmers on real time basis through telephone (Whatsapp/ Facebook/ Instagram/ Twitter), E-mail and text SMS (M-Kissan). Agro-met advisory bulletins are also sent by E-mail to local regional newspapers and disaster management agencies. The weather forecast based agro-advisory bulletin contains a general summary of previous weeks' weather, deviation of weather from the normal value, weather forecast information for the next five days, crop management, which is based on weather forecast and giving warning to the farmers well in advance, regarding rainfall variation, its amount and other weather variables including pest/disease problems. Thus, farmers can decide on crop management options, application of nutrients and strategies to overcome other problems.

To evaluate the impact of services, this study was, therefore, undertaken on adaptation of agromet advisory bulletin and economic impact of agromet advisory services for rice, maize and apple during Summer and Kharif 2020. For assessing the impacts of agromet advisory services, users of agromet advisory services (AAS) and non-users of agromet advisory services (non AAS) were selected for rice, maize and apple crop. The

Table-3 : Economic impact analysis in Apple (Rs./acre) in KVK Baramulla during 2020.

S. No.	Type	Apple			
		AAS	Non AAS	Benefits	B:C Ratio
1.	Land Preparation / Sowing	2000	2000	0	0
2.	Seed Fertilizers & Manure	8000	10500	2500	0.23
3.	Pesticides / Insecticide / Herbicide	3300	4300	1000	0.23
4.	Irrigation	500	1000	500	0.50
5.	Harvesting / Threshing	20000	20000	0	0
6.	Input Benefit	1020000	720000	300000	0.41
7.	Yield (q / acre)	180	135	45	0.33
8.	Rs. Net Benefit	986200	682200	304000	0.44

study area lays around 20 km range from DAMU, KVK Baramulla.

Results and Discussion

Results showed that the farmers who followed the agromet advisories are able to reduce the input cost upto 17.5% in rice, 19.6% in maize and 10.5% in apple crop and increases the net profit by 20.5, 59.3 and 30.8% in rice (Table 1), maize (Table 2) and apple (Table 3) respectively as compared to the non AAS farmers, who did not follow the weather based agri -information. AAS farmers were able to reduce the input cost up to Rs. 6100/acre in rice, Rs. 5500/acre in maize, and 4000/acre in apple. Increases in the net profit were Rs. 11700/acre in rice, Rs. 17500/acre in maize and Rs 304000/ acre in apple compared to the non AAS farmers. More net returns of AAS farmers over non-AAS farmers can be due to low input cost, following weather based management practices and timely management of pests and diseases. This profit was due to the crop management done by the farmers such as timely land preparation and sowing, adoption of recommended seed rate and suitable varieties, timely weeding, harvesting and irrigation and pesticide applications, according to agromet advisory bulletins.

Rice crop (SR 4) grown in **Tangmarag** block of Baramulla, and the feedbacks regarding costs and benefits were collected from 25 farmers of the block. The crop is grown at an altitude of 1577 m above msl. The crop experienced optimum temperature of 24-30 degree C with very light to light rainfall throughout crop growing season.

Maize crop (C4) grown in **Malpora** block of Baramulla, and the feedbacks regarding costs and benefits were collected from 18 farmers of the block. The crop is grown at an altitude of 1717 m above msl. The crop experienced optimum temperature of 24-30 degree C with very light to light rainfall throughout crop growing season.

Apple, horticulture crop (Bulgarian variety) grown in **Kunzer** block of Baramulla, and the feedbacks regarding costs and benefits were collected from 32 farmers of the block. The crop

is grown at an altitude of 1761 m above msl with 1000-1500 hours of chilling (the no. of hours during which temperature remains at or below 7⁰C during the winter season). The temperature during the growing season (April to October) is around 21-24⁰C. For optimum growth and fruiting, apple trees generally needs 100-125 cm of annual rainfall., but this area received less rainfall than normal during the growing season.

Conclusions

Through feedback analysis and assessment from 75 farmers (including AAS and Non AAS) on economic gains; it was resulted that, with an awareness on weather based agriculture rendering services to farmers of the concerned blocks the adopted farmers were able to cut down their input costs than before and able to manage their crops much effectively than as before from harnessing poor weather conditions from which they were not aware off. They replied for the regularisation of advisories and mentioned some suggestions for the improvements in advisories, for more easable in use as understandable and with prescriptions on new high yielding seeds/varieties for his/her own area as applicable, monitoring timely pesticides/herbicide schedule for effective use with relevant doses to avoid pollution and soil health degradation, modern technical innovative farming practice to lower input cost and efficient harvesting machineries; may help in minimizing the working time hours and efficiency during intercultural operations at field and during harvesting period.

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Population Dynamics of Black Aphid in Relation to Climatic Factors and Estimation of Avoidable Yield Loss due to Insect-Pests in Lentil

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Abstract

An investigation was conducted on "Population dynamics of black aphid in relation to climatic factors and estimation of avoidable yield loss due to insect-pests in lentil" during *Rabi*, 2020-21 at Agricultural Research Farm of B.R.D.P.G. College, Deoria (U.P.), India. Present investigations revealed that the incidence of black aphid commenced on the lentil from 2nd to 10th standard week. The population gradually increased and reached maximum (19.50 aphid /10 cm apical twigs) on the 4th standard week when the maximum, minimum temperature, relative humidity, sunshine hours and wind velocity 19.70 °C, 7.62 °C, 80.80%, 11.08hr and 7.66km/hr, respectively, were recorded. The black aphid population had negative correlation with minimum ($r = -0.897$) and maximum temperature ($r = -0.906$), sun-shine hours ($r = -0.529$) and wind velocity ($r = -0.689$). While relative humidity ($r = 0.267$) correlated positively. Among the weather factors coefficient of determination (r^2) was maximum with minimum (0.805) and maximum (0.821) temperature as influenced at 80.5% and 82.2% population of black aphid, respectively. Protected crop recorded more yield than unprotected on maximum yield (12.54q/ha) registered in crop protected with 3 spray of Fipronil 5 SC 5% followed by 11.6q/ha with Beta-cyfluthrin 8.49% + imidacloprid 17.8%. Although unprotected crop recorded only 8.6q/ha, Proportional increase in yield i.e. 45.81% and 35.58% was obtained against unprotected. The avoidable yield loss was between 26.24% to 31.41% in lentil caused by various insect-pests.

Introduction

Lentil (*Lens culinaris* L. Medikus) is the fourth most important cool season, bushy annual pulse crop. Locally it is known as "masoor" and also known by many regional names viz. adas (Arabic), masur (Hindi). It is mainly cultivated in Uttar Pradesh, Chhattisgarh, Jharkhand, Bihar and West Bengal. The crop is generally grown on less fertile soils with low inputs. Lentil is called as poor man meat because of its rich protein 28%, carbohydrates 59%, nitrogen and fiber contents, high proportion of vitamin-A, vitamin-B, potassium and iron and low sodium and fat that regulates growth and development, low level of anti nutrients and ability to grow in water stress conditions which are main attributes that make lentil an important crop (Anonymous, 2003). The productivity of lentil has steeply come down in changing climatic scenario due to effect of wide range of biotic and abiotic constraints. Out of these, are attacks insect pests from seedling to podding stage cause a considerable loss in yield. About three dozen insect pests have been reported to infest lentil under field and storage conditions (Hariri, 1981). Among different insect pests of lentil, aphid (*Aphis craccivora* Koch.) infestation is one of the major problems in this region and widely distributed throughout the world. Aphid causes damage directly by sucking the phloem for the different parts of the plants (Ali and Rizvi, 2007). Aphids feed on plant sap, disrupting the normal plant growth pattern including reduction in root and nodulation growth. At high aphid densities, plants are deformed,

stunted and seed set is reduced (Sharma *et al.*, 2014). The population dynamics of this pest considered to be highly influenced by prevailing weather condition particularly temperature and relative humidity. Several studies have been indicated that weather plays an important role on the aphid appearance, multiplication and disappearance (Srivastava and Srivastava, 1972; Roy, 1975; Kumar *et al.*, 1999; Srivastava, 1999; Vekaria and Patel, 2000). The changes in aphid population with change in weather parameters enable to forecast the population of lentil aphid under changing scenarios of climate using statistical approaches. Statistical forecasting model is the best approach that would be helpful to provide the information regarding incidence of pest in advance based on medium range weather forecast.

Estimation of avoidable yield losses makes one to understand the damage levels caused by the insect pests and allows one to take preventive measures without causing economic damage. The main weapon of lentil pest control so far been is application of insecticides. Whenever there is infestation of insect-pests, farmers frequently used insecticides. The insecticide usage pattern in the state varies greatly from one situation to the other. Often, excessive use of pesticides intensifies pest problems and complicate pest control strategies causing ecological disruption and endangerment of human health. Pest resistant, resurgence and pesticide residue are the most potential problems associated with the

Table-1 : Weekly population of black aphid on lentil during Rabi season 2020-21 in relation to weather parameters.

Month/ Standard week	Black aphid Population/ Plant (10 cm apical twigs)	Meteorological variables				
		Temperature (°C)		Relative humidity (%)	Sunshine Hours (hr)	Wind Velocity (Km/hr)
		Minimum	Maximum			
2	6.40	9.71	23.60	66.66	10:59	15.31
3	11.21	8.33	20.81	71.08	11:08	9.70
4	19.50	7.62	19.70	80.80	11:20	7.66
5	18.12	6.66	19.66	74.72	11:33	9.80
6	11.30	9.40	23.10	66.00	11:26	10.30
7	5.21	12.00	26.40	59.10	11:43	10.90
8	1.80	13.00	28.10	51.20	12:01	10.51
9	1.90	15.30	31.80	35.50	12:19	17.30
10	1.50	16.10	32.40	31.10	12:26	15.30

Table-2 : Correlation coefficient and regression equation between meteorological variable and black aphid population (*Aphis craccivora*).

Meteorological variables		Correlation coefficient	Regression equation	R ²
Temperature (°C)	Minimum	-0.897	Y=28.061-1.789x	0.805
	Maximum	-0.906	Y=40.550-1.276x	0.821
Relative humidity (%)	0.267		Y=4.210+0.760x	0.071
Sunshine hours (hr)	-0.529		Y=56.425-4.224x	0.280
Wind velocity (Km/hr)	-0.689		Y=29.518-1.853x	0.475
Multiple	0.968		Y=-25.99-5.02x ₁ +1.92x ₂ +0.0 1x ₃ +4.28x ₄ -0.73x ₅	0.938

indiscriminate use of pesticides made cultivation of such pulses non-profitable. At the same time looking to pest complexities it is difficult to totally eliminate the chemical component from the pest management strategies. One has to have a chemical option under high pest pressure situation. This could be accomplished either by incorporating a safer molecule of chemical or an eco and environment friendly pesticide delivery technique so that the pest could be managed with least problem to its natural enemies fauna and environment. Overall, the aim is to select, right safer newer molecule and apply at appropriate dose and time so that maximum yield can be save without impairing human and environmental health.

Materials and Methods

A field experiment was conducted at agriculture research farm of B.R.D.P.G. College, Deoria during *Rabi* season 2020-21. ALKA was grown as test variety which was sown in a plot size 18 x 10 m² area by adopting all the recommended agronomic practices. Both treated and untreated plots were divided into 15 quadrates three strip each of 6.0m x 10.0m were prepared and divided into 15 quadrates of size 6.0m x 2.0m. The number of black aphids per 10cm of the main shoot on the 10 randomly selected plants was counted at weekly interval from the day of aphid appearance in the field and then was averaged. The population of aphid was counted during morning hours before 7:00hrs. The daily meteorological parameters like maximum temperature, minimum temperature, relative humidity, sun-shine-hours and wind

velocity were recorded and then converted into weekly basis against standard meteorological week (SMW) with correspondence to weekly population of aphid. The weekly mean data of both the insect-pests was taken for correlation and regression analysis.

To study avoidable yield loss in lentil due to insect-pests at research farm of B. R. D. P. G. College, Deoria, the experiment was performed in large plot technique as well as in Randomized Block Design with five replications. Each replication occupied three treatments including untreated check as :

Unprotected plot the crop was kept free from insecticides and subjected to the natural infestation of insect-pests of lentil.

Protected plot-1 the crop was protected against the insect-pest through application of newer molecules of insecticide viz. Beta-cyfluthrin 8.49% + imidacloprid 17.8% @ 1ml/lit of water applied at 10 days interval.

Protected plot-2 under this treatment the crop was protected against the insect-pests through application of another newer molecule of insecticide i.e Fipronil 5SC @ 2 ml /lit of water applied at 10 days interval.

Randomly ten plants from each quadra were randomly selected to record the population of black aphid. The whole plot was kept free from any insecticidal spray throughout the crop period.

Table-3 : Assessment of yield loss due to insect-pests of lentil during Rabi season 2020-21.

Treatment	Yield (q/ha)	Increase in yield over control (%)	Avoidable loss (%)	Yield loss over T ₁ (q/ha)	Yield loss over T ₂ (q/ha)
Fipronil 5SC	12.54	45.81	31.41	3.94	3.06
Beta-cyfluthrin 8.49% + imidacloprid 17.8%	11.66	35.58	26.24	-	-
Unprotected	8.60	-	-	-	-
SEM.	0.381	-	-	-	-
C D at 5%	1.48	-	-	-	-

Observation were recorded :

1. Yield of treated plots (plots-1&2) kg/quadrat (6.0 m x 2.0 m)

2. Yield of untreated (control plot) kg/quadrat (6.0 m x 2.0 m)

Yield of lentil from protected and unprotected plots was recorded from each quadrat at harvest and then analysed statistically. Before analysis the yield of protected and unprotected plots were finally converted into per hectare. The yield increased in protected plots over the unprotected (control) and avoidable loss was worked out from final yield of lentil using formula mentioned below given by Pradhan (1964).

$$\text{Increased yield (\%)} = 100 \times \frac{T - C}{C}$$

$$\text{Avoidable yield loss (\%)} = 100 \times \frac{T - C}{C}$$

Whereas,

T = yield from treated / protected plot (q/ha).

C = yield from control / unprotected plots (q/ha).

Results and Discussion

Black Aphid (*Aphis craccivora*) : Data presented in table-1 revealed that the incidence of black aphid was started from 2nd standard week (SW) and continued up to 10th S.W. At the time of incidence, the population of black aphid was 6.40 per 10 cm apical twig which gradually increased in subsequent weeks and reached its peak (19.50 Aphid per 10 cm apical twig) in the 4th S.W. Thereafter, population of black aphid declined gradually. Peak population of black aphid was coincided with vegetative stage of the crop (4th SW) when weekly mean minimum temperature, maximum temperature, relative humidity, sun shine hours and wind velocity was 7.62°C, 19.70°C, 80.80 %, 11:20 hours, and 7.66 km per hour, respectively. Lowest population of black aphid (1.50/10 cm apical twig) was recorded a week prior to harvest the crop (10th SW). The incidence of black aphid was maximum during first half growth period of the crop (3rd to 6th SW). As maximum population 11.21 to 19.50 aphid /10

cm apical twig was recorded the corresponding weather parameters viz. temperature ranged between 6.66°C to 23.10°C, relative humidity 66.00% to 80.80% and sunshine between 11.08 to 11.26 hours coincided with the incidence of maximum population of black aphid. The population of black aphid in the second half of the crop growth was comparatively lower as only 1.50 to 5.21 aphid/10 cm apical twig was observed. The corresponding weather parameters were viz. temperature fluctuated between 12.00°C to 32.40°C, relative humidity between 31.10% to 59.10% and sunshine hour occurrence of black aphid (7th S.W to 10th SW). These findings are supported by (Hossian *et al.*, 2006, Nevpare and Subedi and 2019 and Kishor *et al.*, 2019).

Correlation and regression studies : Data presented in table-2 revealed that population of black aphid (*Aphis craccivora*) were highly negative with minimum temperature (°C), as well as with maximum temperature (°C), showing correlation value of -0.897 and -0.906 respectively. A mild positive correlation was recorded between relative humidity (%) and black aphid population showing correlation value of 0.267. A moderately negative correlation with sunshine hours was obtained showing r-value of -0.529. However, wind velocity (km/hr) showed moderate negative correlation with r-value of -0.689. Overall, relative humidity (%) favoured the incidence of *Aphis craccivora*, while minimum and maximum temperature (°C), sunshine hours (hr) and wind velocity (km/hr) had adverse effect. The minimum temperature varied from 6.66°C to 16.10°C during experimental period and was responsible for the maximum 80.5 per cent variation in population of black aphid data as evident from the coefficient of determination value ($r^2 = 0.805$). When the other environmental factors were constant, for every 1°C increase in minimum temperature there was decrease of 1.789 number of black aphid. On the other hand maximum temperature varied from 19.66 to 32.40 °C during conducting experiment and responsible to influenced 82.1 per cent variation in population of black aphid ($r^2 = 0.821$). According to the regression equation the relationship was highly negative, where 1°C increase in maximum temperature there would be decrease in 1.276 number of black aphid (*Aphis craccivora*). Data on

population of black aphid and per cent relative humidity were analysed statistically to find out the relationship between them. The relative humidity varied from 31.10 to 80.80 per cent, during the period of experimentation (Table-1). The regression coefficient revealed that relative humidity contributed 7.1 per cent variation in *Aphis craccivora* population ($r^2 = 0.071$). The regression equation indicated positive relationship as 1 unit increase of relative humidity there would be increase of 0.760 number of black aphid. When the black aphid and sunshine hours were analysed statistically to find out the relationship between them and indicated that the Sun-shine hours varied from 10:59 to 12:26 hours, during the period of experimentation. The regression coefficient revealed that sun-shine contributed 28 per cent variation in *Aphis craccivora* population ($r^2 = 0.280$). The regression equation indicated negative relationship as 1 unit increase of sun-shine hour there would be decrease of 4.224 number of *Aphis craccivora*. It is evident from Table wind velocity varied from 7.66 to 17.30 km/hr during conducting experiment and was responsible to influenced 47.5 per cent variation in black aphid population ($r^2 = 0.475$). According to the data the relationship was moderately negative, where 1 unit increase of wind velocity there would be decrease 1.853 number of black aphid. The multiple linear regression analysis established between black aphid population on lentil and the weather parameters (Table-2) during *Rabi* season 2020-21. All the weather factors together influenced aphid population to an extent of 93.80 per cent. The multiple linear regression model fitted was $Y = -25.99 - 5.02 x_1 + 1.92x_2 + 0.01x_3 + 4.28x_4 - 0.73x_5$. Where x_1 = minimum temperature, x_2 = maximum temperature, x_3 = relative humidity, x_4 = sun-shine hours and x_5 = wind velocity. Our finding are in accordance with the findings of Kumar and Kumar (2018) who found significant negative correlation of with minimum and maximum temperature, rainfall and sun shine hours while positive with relative humidity. Kumar and Kumar (2015) also reported the population of aphid influenced positively by relative humidity. Our results are in close conformity with the results of Kishor *et al.*, (2019) who suggested that the maximum and minimum temperature had negative but significant correlation with aphid population while, relative humidity have positive but no significant correlation. A lot of work had been done in post by several workers viz. Dalwadi *et al.*, (2007), Parsad *et al.*, (2008), Hasan *et al.*, (2009), Rakhshan and Ahmad (2017) and Neupane and Subedi (2019) who worked on same aspect with more or less similar results like present study.

Estimation of yield loss in lentil due to insect-pests complex : The data on yield loss in lentil due to pest complex are presented in Table -3 revealed significantly

higher lentil yield 12.54q/h and 11.66q/h were recorded from protected plots due to three spray of fipronil 5SC 5% and Beta-cyfluthrin 8.49% + imidacloprid 17.8% respectively. While the yield of 8.60q/h was recorded from unprotected plots, the yield increased in protected plots viz. fipronil 5SC 5% treated and Beta-cyfluthrin 8.49% + imidacloprid 17.8% treated plots were 3.94q/h and 3.06q/h, respectively over unprotected plot. It showed 45.81 per cent and 35.58 per cent. Yield increased over control total avoidable loss in yield was calculated as 31.41% in case of fipronil treatment, while 26.24% in case of Beta-cyfluthrin + imidacloprid treatment. The result clearly indicated that by providing protection with effective pesticides against pests 3.06 - 3.94q/h yield loss can be saved. Total avoidable yield loss could be worked out as 26.24 to 31.41 per cent. Among both the insecticide treatment, Fipronil 5SC treated plot produced better yield than the plot treated with Beta-cyfluthrin 8.49% + imidacloprid 17.8% but the difference was statistically non significant. These findings are very close to that of Hossain (2015) who found spraying of fipronil @ 0.5m/la was the most effective and profitable against insect pests of mungbean, followed by imidacloprid at the same dose.

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Field Screening of Wheat Genotypes Against Wheat Aphids

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Abstract

Present study was carried out in the research farm of B.R.D.P.G. College Deoria (U.P.) during *Rabi*, 2020-21. A total number of sixteen genotypes of wheat were screened against wheat aphids in Randomised Block Design with 3 replications. The overall results regarding mean population of aphids/shoot/plant on various genotypes of wheat at different dates of observation revealed highly significant difference among the genotypes. Significantly lower aphid load per shoot per plant was recorded in genotype PBW-154 (14.77) followed by PBW-343 (15.20), WB-02 (16.20), PBW-373 (16.34), AKASH-3003 (16.48), HD-2967 (18.38), PBW-502 (18.65) and WHEAT-303 (19.77) had non-significant variation were categorized as susceptible genotypes on the basis of resistant rating. Rest of the genotypes in present study harboured significantly maximum aphid population per shoot per plant categorized as highly susceptible genotypes on which 25.80 to 32.80 aphid per shoot per plant recorded. A significant variation in yield (kg/plot) was observed among the genotypes under study. Maximum yield i.e. 0.238 kg/plot (39.66 q./ha) which was significantly higher followed by HD-3086, AAIDU WL-1, AAIDU WL-10, AAIDU WL-12 and AAIDU WL-6 recorded 0.230, 0.212, 0.201, 0.197 and 0.184 kg/plot, respectively showed non significant variation to each other. Remaining genotypes in which grain yield recorded were comparatively lower, ranged between 0.177-0.065 kg/plot.

Introduction

Wheat (*Triticum aestivum* L.) is a major cereal crop occupies an important place in the economy of India. It is a major cereal crop in most of the areas of the world. Wheat is the second most produced food among the cereal crops (Gilles *et al.*, 2001). Its contribution towards the value added in agriculture is 12.5 % and in GDP is 2.6%. The total area under the crop is about 29.8 million hectares in the country. India stands at 2nd position in wheat production after China in the world and in the year 2016-17, wheat production was 97.44 Million metric tons after China which has production of 126 million metric tons (USDA., 2016). The highest wheat producing states in India are U.P., Punjab and Haryana with 30.01, 16.47 and 11.63 MT production respectively (FAOSTAT, 2015). Numerous factors are responsible for the low production yield of wheat. Insect-pests are one of these biotic factors and are known to attack wheat worldwide (Hatchett *et al.*, 1987). Insect-pests can cause enormous damage in two important growth stages (Heading of growth and Flowering phases) (Freier *et al.*, 2007). The major insect-pests attacking wheat crop reported in various parts of India are Termites, Cutworm and Armyworm, Wheat beetles and weevils, Aphids, Thrips, and Leafhopper (Miller and Pike, 2002). Of these, wheat aphids have been considered as the most prevalent pest distributed worldwide (Carter *et al.*, 1980; Steffey and Gray, 2009). Several aphids species have been reported on cereal crops including, Bird cherry-oat aphid, Wheat grain aphid, Grain aphid, Corn leaf aphid and Russian

wheat aphid (Buriro *et al.*, 1996; Blackman and Eastop, 2000).

The damage caused by aphids is severe in cold and cloudy weather during winter. Both the stages, nymphs and adults reduce the yield (Sekhar *et al.*, 2001). They appear mostly from December to January and cause direct damage by sucking cell sap of leaves, young shoots, causing distortion, stunting, leaf curling, wilting and twisting. They also cause indirect damage by depositing honey dew that reduce photosynthesis activity and induce sooty mould production and premature leaf senescence (Ozder, 2002). Aphids may reduce wheat production by causing 35-40% yield losses directly through sucking injury and 20-80% yield losses indirectly by transmitting viral and fungal diseases (Trdan and Milevoj, 1999). At the population of 15 aphids per plant 30 to 40 per cent grain yield losses have been reported by Kieckhefer and Gellner (1992). Among various control strategies; host plant resistance is of eminent importance with the help of which aphid infestation could be kept below threshold level. This could also be helpful to minimize the chances of biotype development in aphids (Riazuddin *et al.*, 2004). Instead of the production of resistant varieties, moderately resistant varieties against wheat aphid have been identified because such resistance has proved easy to locate among various wheat breeding lines (Lowe, 1987). Exploration of resistance in varieties against the aphid and its subsequent incorporation in agronomically suitable varieties through suitable breeding programme is an important IPM approach. Screening of wheat varieties

against this pest has been accomplished earlier (Khan *et al.*, 2011; Zeb *et al.*, 2011; Tabasum *et al.*, 2012). Still continuous efforts are required to identify varieties with high levels of resistance.

Materials and Methods

The present study was aimed at identifying the resistant lines of wheat genotypes against the wheat aphids, at the Agriculture Research Farm of B.R.D.P.G. College Deoria (U.P.) during *Rabi*, 2020-21.

Sixteen genotypes of wheat i.e. AAIDU WL-1, PBW-343, PBW-154, AAIDU WL-4, AAIDU WL-5, AAIDU WL-6, AAIDU WL-10, PBW-373, AAIDU WL-12, HD-2967, HD-3086, BLACK WHEAT, WHEAT-303, WB-02, AKASH-3003 and PBW-502 (check) were evaluated against aphids. Experiment was laid out in a Randomised Block Design with 3 replications. Each entry was sown in a row of 2 m length with 3 replications and line to line spacing of 20 cm. These were sown on 25th November 2020. The wheat crop was raised without any insecticidal treatments so that pest populations could build-up freely. Aphid population was recorded from 10 different plants at 45, 60, 75, 90 and 105 days after germination selected randomly of each genotype and their average were worked out. Wheat genotypes were graded into 5 grades on the basis of mean number of aphids per shoot per plant (Singh *et al.*, 2001) as given below :

Table-1 : Susceptibility rating of wheat cultivars against aphid.

Grades	Approx. No. of aphids/shoot	Rating
I	0	Immune
II	1-5	Resistant
III	6-10	Moderately resistant
IV	11-20	Susceptible
V	21 and above	Highly susceptible

Observation of yield : All the genotypes were harvested individually, followed by threshed and yield recorded in the form of kg/plot. According to the Net plot area the yields obtained as kg/plot were converted into q/ha.

Results and Discussion

Mean population of aphids on different genotypes of wheat their susceptibility rating and yield (q/ha)

Aphid population on different genotypes of wheat :

The overall results regarding mean population of aphids/shoot/plant on various genotypes of wheat at different dates of observation revealed highly significant difference among the genotypes. Significantly lower aphid load per shoot per plant was recorded in genotype PBW-154 (14.77) followed by PBW-343 (15.20), WB-02 (16.20), PBW-373 (16.34), AKASH-3003 (16.48),

HD-2967 (18.38), PBW-502 (18.65) and WHEAT-303 (19.77) had non-significant variation were categorized as susceptible genotypes on the basis of resistant rating. Rest of the genotypes in present study harboured significantly maximum aphid population per shoot per plant categorized as highly susceptible genotypes on which 25.80 to 32.80 aphid per shoot per plant recorded.

Wains *et al.* (2014) screened 464 germplasm of bread wheat against wheat aphid and found most of the germplasm have good degree of aphid resistance. There is genetic variation for aphid resistance in different accessions and selection for aphid resistant cultivars is possible. Wheat genotype PBW-373 and PBW-343 found as susceptible genotypes of wheat against wheat aphid in present study but the study of Mir *et al.* (2017) reported the same genotype as moderately resistant to wheat aphid. The difference in susceptibility rating might be due to date of sowing that influences population build-up of aphids on wheat genotypes. Devrani *et al.* (2018) evaluated twenty three genotypes of wheat in which two were recorded as resistant nineteen were moderately resistant and one showed susceptible to wheat aphids on the basis of resistance rating. Two genotypes *viz.*, HD-2967 and PBW-343 were reported as moderately resistance showed susceptible genotypes to wheat aphid in the present study. The difference in resistance rating was due to population build-up of aphids on genotypes.

Yield performance of different wheat genotypes :

A significant variation in yield (kg/plot) was observed among the genotypes under study. Maximum yield in PBW-502 i.e. 0.238 kg/plot (39.66 q/ha) which was significantly higher followed by HD-3086, AAIDU WL-1, AAIDU WL-10, AAIDU WL-12 and AAIDU WL-6 recorded 0.230, 0.212, 0.201, 0.197 and 0.184 kg/plot, respectively showed non significant variation to each other. Remaining genotypes in which grain yield recorded were comparatively lower, ranged between 0.177-0.065 kg/plot. It has been seen in present study that yield potential of genotypes did not influenced by different grades of susceptibility rating. Several highly susceptible genotypes against aphids produced better yield than susceptible ones. It revealed the genetic make up of particular genotype. Akhtar *et al.* (2003) and Khan (2005) screened different genotypes of wheat to check resistance level against aphids mainly *Sitobion avenae*, *Rhopalo siphumpadi* and *Schizaphus graminum*. They conclude that high yielding varieties were found to be more susceptible to cereal aphids. These findings did not supported by Ahmad and Nasir (2001), Saleem (2009) and Devrani *et al.* (2018) who found the genotypes had the lowest aphid population show the highest yield, while highest aphid population showed lowest yield. In the present study out of 16 genotypes screened, 8 genotypes appeared to be promising and

Table-2 : Pest susceptibility rating of wheat genotypes against aphid infestation and yield performance (q/ha) during Rabi, 2020-21.

S. No.	Name of genotype	Pooled mean population of aphids	Grade	Susceptibility rating	Yield	
					Kg/plot	q/ha
1.	AAIDU WL-1	32.80 (5.67)	V	Highly susceptible	0.212	35.33
2.	PBW-343	15.20 (3.96)	IV	Susceptible	0.132	22.00
3.	PBW-154	14.77 (3.90)	IV	Susceptible	0.125	20.83
4.	AAIDU WL-4	25.85 (5.11)	V	Highly susceptible	0.149	24.83
5.	AAIDU WL-5	25.82 (5.09)	V	Highly susceptible	0.115	19.16
6.	AAIDU WL-6	29.37 (5.43)	V	Highly susceptible	0.184	30.66
7.	AAIDU WL-10	28.48 (5.32)	V	Highly susceptible	0.201	33.50
8.	PBW-373	16.34 (4.06)	IV	Susceptible	0.086	14.33
9.	AAIDU WL-12	28.05 (5.30)	V	Highly susceptible	0.197	32.83
10.	HD-2967	18.38 (4.29)	IV	Susceptible	0.177	29.50
11.	HD-3086	26.24 (4.95)	V	Highly susceptible	0.230	38.33
12.	BLACK WHEAT	25.80 (5.10)	V	Highly susceptible	0.065	10.83
13.	WHEAT-303	19.77 (4.49)	IV	Susceptible	0.172	28.66
14.	WB-02	16.20 (4.07)	IV	Susceptible	0.167	27.83
15.	AKASH-3003	16.48 (4.06)	IV	Susceptible	0.171	28.50
16.	PBW-502	18.65 (4.36)	IV	Susceptible	0.238	39.66
	SE(m±)	(0.33)			0.018	
	CD at 0.05	(0.97)			0.060	

may be used in breeding programme and the development of host-plant resistance in wheat crop against wheat aphids.

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Vulnerability Assessment and Conservation Prioritization of Ethnomedicinal Plants in Banjar Valley, North-Western Himalaya

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Abstract

The popularity of Ayurvedic System of Medicine has been increased immensely worldwide. Indian Himalayan region is well known for great diversity of medicinal plants, but there are several interior areas which never been explored in this regard. The present study was conducted to assess the diversity, vulnerability, indigenous uses and conservation prioritization measures of ethnomedicinal plants in Banjar Valley of Kullu, North Western Himalaya. A total of 357 species of medicinal plants belonging to 98 families and 237 genera were recorded as being used by the inhabitants. The species diversity comprised of different life forms were 27 trees, 269 herbaceous, 54 shrubs, 02 climbers and 05 ferns. As per distribution and origin record of the species, 193 species were native, 03 endemic and 43 as near endemic to Indian Himalayan Region. The highest number of species was recorded in the altitudinal zone of 2801-3600 meter, the number varied along with the altitudinal gradient. Area-specific vulnerability and threat categorization of species was initiated using information on different attributes of the reported species. The presence of critically endangered, endangered and vulnerable medicinal plants indicates high anthropogenic stress on these species followed by over-exploitation, habitat degradation and changing environmental conditions which may lead to the extinction of such valuable species within a few years. Therefore, regular monitoring of populations and habitats, development of conventional protocol, establishment of species *in-situ* conditions and associated habitats and replication of this approach in other parts of Indian Himalayan Region have been recommended.

Key words : Banjar valley, indigenous uses, threat categorization, prioritization, indian himalayan region.

Introduction

The Indian Himalayan Region (IHR) is bestowed with varied natural resources and rich biodiversity. The region is comprised of five biogeographic provinces, covers approximately an area of 591 thousand km² (Rodgers and Panwar 1988) and extending from Jammu & Kashmir in the North-West to the Arunachal Pradesh in the East. IHR one of the mega hot-spot of biological diversity (Myers 2000) is a source of a great diversity of food, fuel, fodder, timber, dye and medicinal plants. It comprises about 18% of total geographical area of India and is more than 2,800 km long and 220 to 300 km wide, with altitudes from 200 to 8000 meter (Anonymous 1992). The IHR alone supports about 8,000 species of angiosperms (40% endemics), 44 species of gymnosperms (15.91% endemics), 600 species of pteridophytes (25% endemics), 1,737 species of bryophytes (32.53% endemics), 1,159 species of lichens (11.22% endemics) and 6,900 species of fungi (27.39% endemics) (Singh and Hajra 1996; Samant *et al.*, 2007 a). There are more than 816 tree species and 675 edibles species. 118 species of medicinal plants yields essential oils, 279 species of fodder, 155 sacred plants

(Samant and Pant 2003) and 121 rare-endangered plants (Samant *et al.*, 2007). Inhabitants of IHR rely on plants for staying healthy and extending the worth of their lives. According to the World Health Organization (WHO) estimates, 3.5 billion populations in the developing countries rely on plant-based medicine for primary health care. In Asia, approximately 6500 species of plants are used as household-based medicines (Ghimire and Bastakoti, 2009). With the increasing world plea and renewed global interest in increasing preference for natural substances in the health care system, the natural stock of medicinal plants of the IHR is under terrific pressure (Kala *et al.* 2006; Singh *et al.*, 2009; Rana and Samant 2011). The very survival of these resources is now under threat from rapidly expanding human population and concomitant environmental degradation occurring at a fast pace.

Medicinal plants are worn in the Ayurvedic, Unani and other traditional systems of medicine and in plant based pharmaceutical industries. The Tibetan system of medicine is also depended on Himalayan species (Samant *et al.*, 1998). Estimates indicate that at least 90% of medicinal plant species are extracted from the wild

Table-1 : Criteria used for prioritization of medicinal plants for conservation in Banjar Valley of Himachal Pradesh, India

Serial No.	Habitat	Distribution	Availability	Use Value	Trade Value	Extraction	Nativity & Endemism	Score
1.	2	<500	Low	> 10	High	Commercial	Native & Endemic	10
2.	3-4	500–1000	Moderate	5–10	Medium	Self use	Native/Endemic	6
3.	5	>1000	High	<5	Low	No use	Non-native	2

Table-2 : Threat Categorization of medicinal plants in Banjar Valley of Himachal Pradesh, India.

Threat Categorization	Critically Endangered	Endangered	Vulnerable	Near Threatened
Banjar Valley	<i>Aconitum heterophyllum</i> , <i>A. violaceum</i> , <i>Allium wallichii</i> , <i>Betula utilis</i> , <i>Dactylorhiza hatagirea</i> , <i>Jurinella macrocephala</i> , <i>Lilium polyphyllum</i> , <i>Paris polyphylla</i> , <i>Paeonia emodi</i> , <i>Picrorhiza kurrooa</i> , <i>Skimmia laureola</i> , <i>Zanthoxylum armatum</i> ,	<i>Acorus calamus</i> , <i>Angelica glauca</i> , <i>Allium humile</i> , <i>Bergenia stracheyi</i> , <i>Gentiana govaniana</i> , <i>Rheum kurroo</i> , <i>Saussurea albescens</i> , <i>Pistacia integerrima</i> , <i>Podophyllum hexandrum</i> , <i>Rheum webbianum</i> , <i>Rhododendron campanulatum</i> , <i>Taxus baccata</i> , <i>wallichiana</i> , <i>Delphinium denudatum</i>	<i>Rheum australe</i> , <i>Heracleum candicans</i> , <i>Arctium lappa</i> , <i>Saussurea heteromalla</i> , <i>Berberis asiatica</i> , <i>B. chitria</i> , <i>B. jaeschkeana</i> , <i>Rhododendron anthopogon</i> , <i>Corydalis cornuta</i> , <i>Swertia cordata</i> , <i>Polygonatum multiflorum</i> , <i>P. cirrhifolium</i> , <i>Plantago himalaica</i> , <i>Primula rosea</i> , <i>Bergenia ligulata</i> , <i>Viola pilosa</i> , <i>Valeriana jatamansi</i> , <i>V. hardwickii</i> , <i>Hedychium spicatum</i> , <i>Rosa sericea</i>	<i>Hypericum perforatum</i> , <i>H. oblongifolium</i> , <i>Allium victorialis</i> , <i>Bupleurum lanceolatum</i> , <i>Selinum tenuifolium</i> , <i>Berberis lyceum</i> , <i>Viburnum cotinifolium</i> , <i>Cassiope fastigiata</i> , <i>Hypericum uralum</i> , <i>Juglans regia</i> , <i>Nepeta discolor</i> , <i>N. longibracteata</i> , <i>Thymus linearis</i> , <i>Viscum album</i>

(Anonymous 2000); and that 69% of the material is collected through destructive harvesting, which suggests that medicinal plants are significantly threatened (Dhar *et al.*, 2000). Undue anthropogenic pressures have been identified as the main causes of demur in the population and accessibility of the medicinal plants in the Himalayan region (Samant *et al.* 1998). A number of studies have been carried out on medicinal plants of the IHR (Samant *et al.*, 2007 a; Rai *et al.*, 2000; Samant and Pal 2003; Kala 2000). However in Himachal Pradesh, studies of medicinal plants are scrappy and usually emphasis on inventory (Bhattacharya and Uniyal 1982; Chauhan 1988, 1999; Kapahi 1990; Badola 2001; Sood *et al.*, 2001; Badola and Pal 2003; Kala, 2006; Uniyal *et al.*, 2006). Although, a few studies have addressed diversity, distribution patterns, nativity, endemism, rarity and conservation prioritization of medicinal plants (Samant *et al.*, 2007 a) here. In western Himalayas, 643 medicinal plants have been recorded alone in Himachal Pradesh, out of which 269 are native, 374 non-native, 17 endemic, 131 near endemic, 12 critically endangered, 21 endangered, 27 vulnerable, two near threatened and three data deficient (Samant *et al.*, 2007a). With the increasing demand and renewed global interest in the healthcare system, the natural stock of medicinal plants of Himachal Pradesh is under tremendous pressure (Samant *et al.*, 1998). Kullu valley of the State is rich in medicinal plant diversity. There is a plenty of scope for the promotion, cultivation and conservation of medicinal plants. The study was carried out in Banjar valley in Kullu valley, Himachal Pradesh. With an integrated approach

on diverse parameters of the medicinal plants, such efforts has not been done so far in the State falling in North-western Himalayan zone of IHR. To provide the information essential to shore up further action, this paper brings together existing information with results from current field surveys.

Study Area : Banjar valley is a unique ecological landscape situated in the South of Kullu district of Himachal Pradesh which harbours a variety of ecologically diversified landscape elements and supports an array of alpine flowering plants. The valley has a large altitudinal range (*i.e.*, 1200-3600m). The area is very well known for their diverse habitats, microclimatic conditions and rich biodiversity including flora and fauna. These are mainly dominated by temperate and subalpine broad leaved and coniferous forests, alpine scrubs and alpine herbaceous vegetation, and support a large number of sensitive biodiversity elements. Climatically, the area is unique; temperature ranges between -4°C to 30°C. The forests and thatches have been facing high pressure of grazing and over exploitation of the economically important species. The climatic conditions are typically temperate, sub-alpine and alpine types with three distinct seasons- summer season (April-June), rainy season (mid-June-September) and winter season (October-March). Average annual rainfall is about 1103.2 mm/year⁻¹. July and August months receive maximum rainfall. The area witnesses heavy snow fall during December to March. The vegetation is mainly comprised of temperate, sub-alpine and alpine types.

Table-3 : Utilization pattern of medicinal plant species in different ailments/diseases in Banjar Valley.

Ailments/Diseases	No. of Species	Ailments/Diseases	No. of Species
Abcesses	4	Ear and eye complaints	22
Abdominal disease	8	Eczema	9
Abortifacient	2	Epilepsy	5
Acidity	2	Febrifuge	11
Anaemia	3	Fever	65
Analgesic	4	Gastric complaints	45
Anti-helmintic	17	Gonorrhoea	7
Anti-bacterial	5	Haemorrhoids	17
Anti-biotic	4	Headache	24
Anti-cancerous	4	Heart disease	2
Anti-fertility	8	Hepatic	6
Anti-fungal	7	Hysteria	6
Anti-inflammatory	2	Inflammation	3
Anti-septic	13	Insecticidal	7
Anti-spasmodic	6	Intestinal complaints	2
Aphrodisiac	9	Itching	4
Appetizer	14	Jaundice	16
Arthritis	2	Kidney	10
Asthma	16	Laxative	13
Astringent	15	Leprosy	6
Backache	4	Leucoderma	6
Blood pressure	2	Leucorrhoea	2
Blood purifier	22	Liver	14
Bodyache	8	Liver complaints	7
Boils	20	Malaria	11
Bone fracture	12	Menorrhoea	8
Bronchitis	24	Menstrual complaints	7
Burns	9	Nervous disorder	10
Carminative	6	Pain	20
Chest pain	2	Pimples	6
Cholera	4	Pneumonia	4
Cold	34	Poultice	7
Colic	13	Purgative	10
Constipation	5	Renal disorder	7
Contraceptive	3	Rheumatism	33
Cough	52	Ring worm infection	8
Cuts	32	Rodents killing	8
Diabetes	2	Scorpion/Snake bite	25
Diaphoretic	6	Skin ailments	43
Diarrhoea	36	Veterinary diseases	9
Diuretic	24	Sores	12
Dysentery	32	Stimulant	7
Dyspepsia	7	Stomach disorders	58
Swelling	10	Toothache	14
As tonic	34	Ulcer	14
Urinary complaints	19	Wounds	54

Methods

Surveys, data collection and analysis : The nine villages namely (Banjar, Gayagi, Jalora, Nali, Shoja, Hirb, Sidhwain, Marotan, Sajwar) and surroundings areas of the Banjar valley (1200-3600 m) were surveyed in different seasons, *i.e.* winter, summer and rainy for three

years (2007-2010) to assess the medicinal plant diversity and generate information on utilization of medicinal plants by the inhabitants of the area. Participatory Rural Appraisal (PRA) followed for information generation on medicinal plants. Also, local knowledgeable persons including *Vaidhyas* were interviewed. Information generated on the indigenous uses and commercial

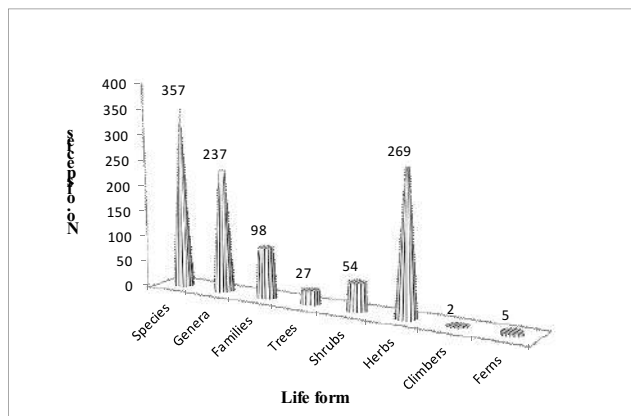


Fig-1 : Distribution of medicinal plants in Banjar Valley of Himachal Pradesh, India.

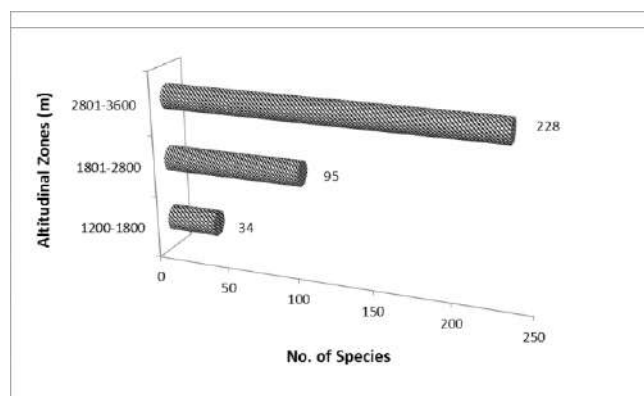


Fig-2 : Altitudinal distribution of threatened species in Banjar Valley of Himachal Pradesh, India.

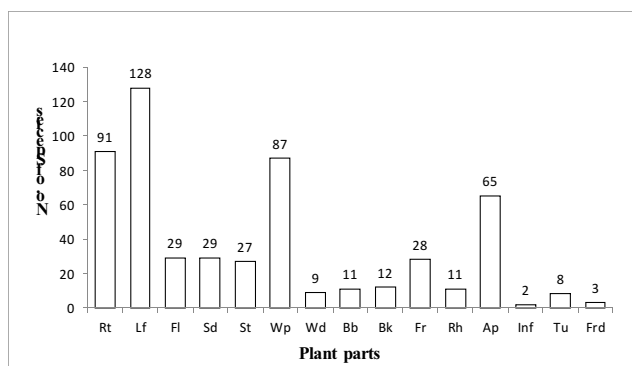


Fig-3 : Parts used in different ailments/diseases by the inhabitants of Banjar Valley in Himachal Pradesh, India
Abbreviations used: Rt=Root; Lf= Leaf; Fl= Flower; Sd= Seed; St= Stem; Wp= Whole Plant; Wd= Wood; Bb= Bulb; Bk= Bark; Fr= Fruit; Rh= Rhizome; Ap=Aerial part; Inf=Inflorescence; Tu=Tuber; Frd=Frond; Ashes=Ashes of twig

values. Among the knowledgeable persons, one person was hired to collect medicinal plants from the natural habitat(s). The specimens of each species were collected and identified (Collett 1902; Polunin and Stainton 1984, 1987; Aswal and Mehrotra 1994; Dhaliwal and Sharma 1999, 1997; Singh and Rawat 2000; Khullar 2000). Information on locality, altitudinal range, life form, habitat and other morphological characters was collected for each species. The data were compiled and analyzed for diversity and distribution pattern of the species following Samant and Dhar (1997).

Nativity, endemism, threat categorization and conservation prioritization : Endemism of a species was identified on distribution range of the species (Dhar and Samant, 1993). Species confined to the IHR were considered as endemic, and those with a distribution extending to neighbouring countries (Himalayan region of Afghanistan, Pakistan, Tibet, Nepal, Bhutan and adjacent states of the IHR) were considered as near endemics. The threat categories of the medicinal plants were identified using seven attributes (i.e. habitat preference, distribution range, availability, use value, trade value, extraction and nativity and endemic species) as per IUCN criteria and as quoted by Ved *et al.*, (2003). Species with a combination of these criteria (serial number 1, 2 and 3) were given marks accordingly. Species with score >55 were identified as critically endangered; 51-54 as endangered; 46-50 as vulnerable; 40-45 as near threatened; and <40 as least concern (Table-1).

Results and Discussion

Diversity and distribution patterns : Total, 357 species of medicinal plants belonging to 237 genera and 98 families were recorded. Of these, 27 species were trees, 54 shrubs, 269 herbs, climbers 02 and ferns 05 each (Figure 1). The families Asteraceae (39 spp.), Lamiaceae, Ranunculaceae and Rosaceae (20 spp. each), Polygonaceae and Apiaceae (15 spp. each), Gentianaceae and Fabaceae (10 spp. each), Scophulariaceae and Orchidaceae (08 spp. each), Ericaceae and Liliaceae (07 spp. each), Brassicaceae (06 spp.), Berberidaceae, Boraginaceae, Caryophyllaceae, Geraniaceae, Rubiaceae and Poaceae (05 spp. each) were rich in medicinal plants. Total 39 families were monotypic. Among the genera, *Berberis*, *Swertia* and *Nepeta* (5 spp. each) were dominant and these medicinal plants were recorded from 15 different habitats such as forests, open/alpine slopes, glacial moraines, boulders, cultivated fields, shady moist, shrubberies, riverine, grassland, damp soil/marshy, waste places, dry, epiphytic, rocky and degraded respectively (Appendix 1). Maximum richness of medicinal plants (228 spp.: herbs: 192; shrubs: 27; trees: 6; ferns: 2 and climber: 1) were

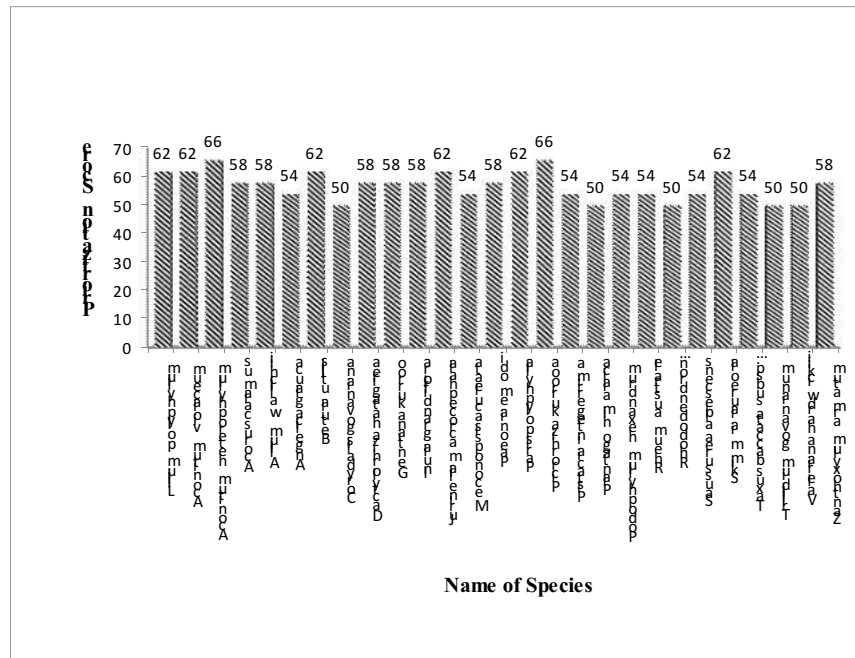


Fig-4 : Prioritization score of different prioritized medicinal plant species for the Banjar Valley.

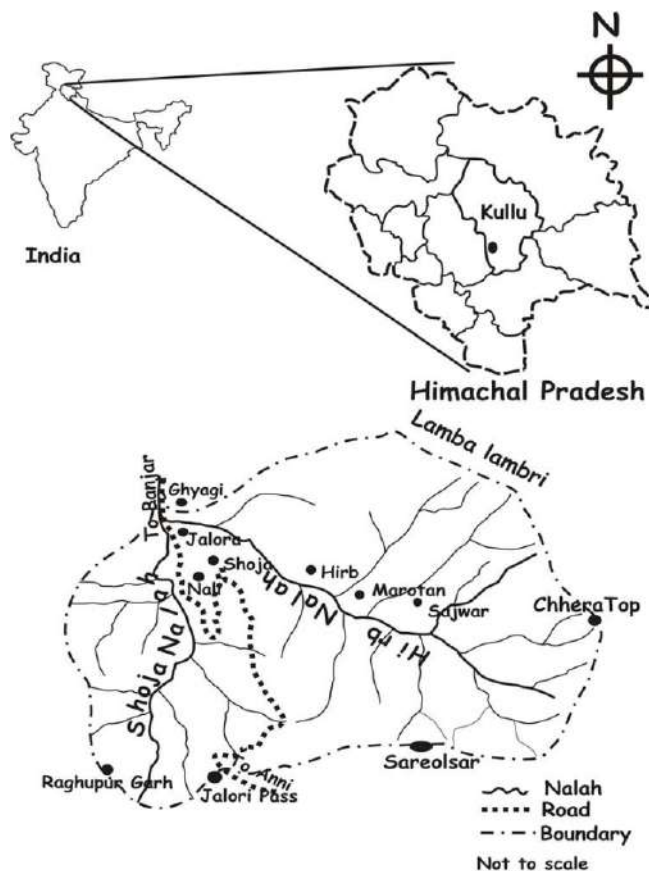
reported in the altitudinal zone, 2801-3600 followed by (95 spp.: herbs: 57; shrubs: 22; trees: 13 and fern: 3) altitudinal zone, 1801-2800 and decreased with decreasing altitude (Figure 2).

Utilization pattern : Among the parts used of medicinal plants, roots (91 spp.), leaves (128 spp.), flower (29 spp.), seeds (29 spp.), stems (27 spp.), whole plants (87 spp.), wood (09 spp.), bulb (11 spp.), bark (12 spp.), fruits (28 spp.), rhizomes (11 spp.), aerial part (65spp.), inflorescences (02 spp.), tubers (08 spp.), fronds (03 spp.) were used by the inhabitants of the Banjar valley for their own use or in trade (Figure 3). These parts of the medicinal plants were used in the treatment of different disease categories as gastro-intestinal problems, dermatological problems, respiratory problems, skeletal-muscular pain problems, reproductive/urinary systems problems, blood related problems, hepatic problems, ENT problems, anti-poisonous, oral/dental problems, nervous related problems etc. Maximum species were used for fever (65 spp.), followed by stomach problems (58 spp.), cough (52 spp.), gastric complaints (45 spp.), skin problems (43 spp.) and rheumatism (33 spp.) (Figure 5). From these medicinal plants, roots of *Angelica glauca* were used in dysentery, gastric complaints, menorrhoea, stomach disorder, vomiting and bronchitis; *Aconitum heterophyllum* were used in cold, cough, diarrhoea, fever, gall bladder, abdominal pain, gastric, piles; *Picrorhiza kurrooain* anaemia, arthritis, asthma, cold etc. *Podophyllum hexandrum* in cancer, cough, constipation, tuberculosis, gynecological disorder, skin diseases, tumors, cuts,

wounds, diarrhoea, etc. *Rheum australe* in abdominal pain, appetite, asthma etc; tubers of *Dactylorhiza hatagirea* used as anti-biotic, wound healing, bone fracture, cough, cold, cuts, sexual disability, rheumatism, blood purifier, tonic, expectorant; bark of *Taxus baccata* subsp. *wallichiana* used as anti-cancerous, blood purifier, swelling, fever, asthma, contraceptive, etc. (Appendix 1).

Nativity and endemism : 193 species were native to the Himalayan region, while 164 species were non-native, from different domains of the world. 03 species were endemic restricted to the IHR (*Angelica glauca*, *Elsholtzia flava* and *Wikstroemia canescens*) and 43 species were identified as near-endemics (Appendix 1). The number of native, endemic and near-endemic species appears to increase along an altitudinal gradient irrespective of the total species richness in the region.

Threat categorization and conservation prioritization : 12 species were identified as critically endangered, 13 as endangered, 20 as vulnerable such as *Corydalis govaniana*, *Trillidium govanianum*, *Rhododendron campanulatum*, *Plantago himalaica*, *Valeriana hardwickii*, *Angelica glauca*, *Saussurea albescens*, *Pistacia integerrima*, *Podophyllum hexandrum*, *Rheum australe*, *Meconopsis aculeata*, *Taxus baccata subsp. wallichiana*, *Allium wallichii* etc. Among these, which have been prioritized for conservation (Table 2); 45 medicinal plants of 28 species had high prioritization score, based on their demand and market potential (Figure 4). The finding recommends commercial cultivation of these species in Banjar valley (Table-2).



Map-1 : Location map of Study area.

The IHR is well known for its diversity of Medicinal plants (Jain 1991; Samant *et al.*, 2001, 2007, 2009; Singh *et al.*, 2009; Pant *et al.*, 2009; Rana & Samant 2011). However, studies on medicinal plants at catchment, watershed and valley specific are not available. Therefore, the present study provides comprehensive baseline catalogue on diversity, distribution pattern, nativity, endemism, rarity, utilization patterns, indigenous uses and part/s used of medicinal plants in Banjar valley of Himachal Pradesh, Northwestern Himalaya.

The occurrence of 357 species of medicinal plants in the area indicates that its environmental conditions, particularly, shady moist and forest habitats, are suitable for growth and development of such species. The habitats require regular monitoring to categorize the dynamics of the flora. The altitudinal range 2801-3600m has the most vegetation of medicinal plants. The occurrence of 54.1% of native species, 12.1% of near endemic species and 0.8% of endemic species shows the high significance of the area. Habitat degradation and over exploitation of these species may lead to their early extinction in the area. The over exploitation of medicinal plants parts such

as roots, rhizomes, tubers, inflorescences, fruits, oils, bark, seeds, etc. may lead to poor regeneration and extinction of these species in near future.

An area specific threat categorization of species is most important tool for short or long-term management planning. The present study represents that cultivation of such medicinal plants in the surrounding villages and other private lands may condense the extinction pressure on the wild habitats. Apart from this, identification of active ingredients would help identifying the potential species for marketing. Regular populations and habitats monitoring of native, endemic and threatened medicinal plants using ecological methods and notification of key areas as medicinal plants conservation areas (MPCAs) for *in-situ* conservation, with the involvement of the State Forest Department and inhabitants of the area have been suggested. Besides these, mass reproduction using conventional methods, establishment and maintenance of herbal gardens and medicinal plant nurseries for *ex-situ* conservation and ensuring the availability of quality planting material for cultivation, together with education and awareness programmes for large scale cultivation area recommended.

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Efficacy of Novel Insecticides Against Major Sucking Insect-Pests of Brinjal (*Solanum melongena* L.)

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Abstract

The present investigation was carried out at the Agricultural Research farm of B.R.D.P.G College Deoria (U.P.), during Rabi-2020-21 Seven insecticides including untreated check were evaluated against major sucking insect-pests in Randomized block design with three replication. Brinjal variety purple round was grown with all recommend package of practices. Insecticides were applied when pest population reached ETL. Subsequent four sprays were applied at 15 days interval. Observations were observed before spray and 3,7,10 and 15 days after spray. Results revealed that insecticides significantly reduced sucking pests population over untreated check. Among the insecticides Beta- Cyfluthrin 8.49%W/W + Imidacloprid 19.81% W/W proved best in reducing pest population and increasing yield. Other treatments viz Flubendiamide 20% W/W Thiamethoxam 25 WG and Emamectin benzoate 5% SG were also found at par effective in reducing pest population and increase fruit yield. All the insecticidal treatments were found economical but most profitable treatment was Thiamethoxam.

Introduction

Brinjal, (*Solanum melongena* L.) also known as eggplant belonging to the family Solanaceae is one of the common and popular vegetable grown throughout the world that accounts for almost 50% of the world's area under its cultivation (Alam *et al.*, 2003). The fruit contains approximately 92% moisture, 6% carbohydrates, 10% proteins, 0.5% fats and some other minerals. The composition of brinjal per 100g of edible portion contains 24 calories, 92.7 percent moisture content, 4 percent carbohydrates, 1.4g protein, 0.3g fat, 1.3g fiber, 18 mg oxalic acid, 18 mg calcium, 15 mg magnesium, 47 mg phosphorus, 0.38 mg iron, 3.0 mg sodium, 0.12 mg copper, 2.0 mg potassium, 44 mg sulphur, 52.0 mg chlorine, 0.04 mg vitamin A, vitamin B as thiamine, 0.11 mg riboflavin, 0.74 g beta carotene and 12 mg vitamin C (Gopalan *et al.*, 2007). The crop is attracted by about 140 species of insects and non insect pests belonging to 50 families. It is subjected to attack at by a number of insect pests right from nursery stage till harvesting (Regupathy *et al.*, 1997). Whitefly *Bemisia tabaci* (Aleyrodidae: Homoptera) is a serious pest ducking of a brinjal. Jassids *Amrasca biguttula biguttula* Ishida, nymphs and adults suck the sap from the lower surface of the leaves. The damaged leaves curl upwards along the margins which may turn yellowish and show burnt patches. This adversely affects plant growth and yield. Chemical Insecticides have remained the most powerful tools as are highly effective, rapid in curative action, adaptable to most situations and relatively economical. At present broad range of systemic and contact insecticides recommended for the control of brinjal pests. However short picking

interval of brinjal fruits cause residue hazard to the consumer when conventional pesticides are used repeatedly, besides killing natural enemies and eventual development of resistance. To overcome this problems, identification of safe molecules with their Insecticidal properties with lower mammalian toxicity, safety to natural enemies which fit well in IPM concept is the need of the hour. No earlier attempts have been made in past to evaluate new molecules of insecticides against sucking insect-pests in brinjal in fars region of eastern U.P. Hence, present investigation was planned.

Materials and Methods

The present investigation was carried out at the Agricultural Research farm of Baba Raghav Das Post Graduate College, Deoria (Uttar Pradesh) during Rabi (Winter season crop) 2020-21. The experiment was laid out in randomized Block Design with 8 treatments including control viz Flubendiamide 20 WG, Beta-Cyfluthrin 8.49%W/W+ Imidacloprid 19.81%W/W, thiamethoxam 25 WG, Lambda-Cyhalothrin 4.6 W/W+ Chlorantraniliprole 9.3%W/W, Emamectin benzoate 5% SG, Chlorantraniliprole 18.5 SC NSKE 5% and untreated check replicated three times in 2x2m plot size. The spacing between row to row and plant to plant was maintained at 60x50 cm, respectively. The brinjal variety Purple round was selected for the experiment. The insect pests population was recorded one day before spraying and 3, 7, 10 and 15 days and Aphid was recorded on fifteen randomly selected leaves in each plot (top, middle and lower leaves). The values of insect population were transferred using $\ln+0.5$ transformation to make the data

satisfy the normality assumption involved in statistical analysis.

Results and Discussion

Whitefly : All the insecticides proved significantly superior over untreated check at 7 days and 15 days after spray. The insecticide showed non-significant variation to each other at 3 and 7 days after spray. Overall performance of insecticides in current investigation revealed that Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81%w/w, Thiamethoxam 25% W.G and Flubendiamide 20% W.G were most effective in reducing whitefly population in brinjal. It was lambda - cyhalothrin 4.6%W/W + Chlorantraniliprole 9.3 SC followed by Chlorantraniliprole 18.5% SC were found moderately effective against whitefly. The insecticides Emamectin benzoate 5% SG and NSKE 5% was observed as comparatively least effective against Whitefly in brinjal. The efficacy of insecticides at all the interval of observations it is was observed a remarkable reduction in Whitefly at 7days after spray although the effectiveness was maintained up to 15 days after spray. Our findings are comparable to those of Raghuram *et al*, (2008) who found best results with Thiamethoxam and other newer molecules against whitefly. The effectiveness of Thiamethoxam and Imidacloprid for the control of *Bemisia tabaci* in recent time has also been reported by Shejulpati *et al*,. (2019). The superiority of Thiamethoxam was also reported by Sharma and Lal (2002) against Whitefly corroborate the present finding. Kumar *et al*,. (2017) reported that Imidacloprid was most effective followed by Emamectin benzoate, while NSKE 5% was least effective against whitefly in brinjal conform the present results. Our findings are very close to that of Aparna and Dethe (2012) who recorded that Emamectin benzoate afforded moderate control of Whitefly.

Jassid : All the insecticidal treatments evaluated against jassid in brinjal proved significantly superior over untreated check at 7 and 15 days after spray. Among the treatments Beta-Cyfluthrin 8.49%w/w +Imidacloprid 19.81%w/w and Emamectin benzoate 5% SG was found to be most effective against jassid. It was Thiamethoxam 25%WG and Flubendiamide 20%WG were found moderately effective treatment, while Lamda-cyhalothrin 4.6 w/w +Chlorantraniliprole 9.3%w/w, Chlorantraniliprole 18.5SC and NSKE 5% were observed as comparatively least effective against jassid in brinjal. It has been observed that the efficacy of all the treatments gave maximum mortality at 3 days after sprays there after slightly decreased subsequently but remained significantly effective up to 15 days after spray. The Efficacy of Imidacloprid, and Thiamethoxam already

Table-1 : Efficacy of newer molecules of insecticides against Whitefly, Jassid and Aphid during Rabi-2020-21.

Treatment	Concentr ation / amount used	Population of Whitefly /leaf (Days offer spray)					Population of Jassid /leaf (Days offer spray)					Population of Aphid /leaf (Days offer spray)				
		Before spray	3Das	7Das	10Das	15Das	Before spray	3Das	7Das	10Das	15Das	Before spray	3Das	7Das	10Das	15Das
Flubendiamide% 20% W.G	1g/Liter	0.2 (0.83)	0.15 (0.80)	0.18 (0.81)	0.19 (0.83)	0.13 (0.79)	0.2 (0.83)	0.15 (0.80)	0.18 (0.81)	0.19 (0.83)	0.13 (0.79)	26.33 (5.08)	1.41 (1.37)	1.22 (1.40)	1.68 (1.46)	0.57 (0.92)
Beta Cyfluthrin 8.49% w.P.+ imidacloprid 19.81%	1ml/ L	0.2 (0.84)	0.04 (0.73)	0.13 (0.89)	0.15 (0.80)	0.08 (0.76)	0.2 (0.84)	0.04 (0.73)	0.13 (0.89)	0.15 (0.80)	0.08 (0.76)	21.96 (4.63)	0.79 (1.20)	0.97 (1.07)	1.22 (1.40)	0.42 (0.94)
Thiamethoxam ai 25% W.G	0.5g/ Li	0.53 (1.01)	0.06 (0.75)	0.16 (0.85)	0.17 (0.82)	0.10 (0.77)	0.53 (1.01)	0.06 (0.75)	0.16 (0.85)	0.17 (0.82)	0.10 (0.77)	20.73 (4.55)	1.37 (1.34)	1.04 (1.21)	1.22 (1.41)	0.35 (0.92)
Lambda-cyhalothrin 4.6+chlorantraniliprole 9.3 w/w	1ml/Li	0.13 (1.79)	0.19 (0.83)	0.22 (0.83)	0.24 (0.85)	0.19 (0.83)	0.13 (1.79)	0.19 (0.83)	0.22 (0.83)	0.24 (0.85)	0.19 (0.83)	19.2 (3.99)	1.82 (1.50)	1.57 (1.44)	1.41 (1.37)	0.57 (1.03)
Emamectin benzoate 5% SG	2ml/Li	0.33 (0.91)	0.04 (0.73)	0.22 (0.85)	0.27 (0.87)	0.13 (0.79)	0.33 (0.91)	0.04 (0.73)	0.22 (0.85)	0.27 (0.87)	0.13 (0.79)	24.26 (4.72)	1.54 (1.42)	1.41 (1.37)	1.33 (1.29)	0.39 (0.75)
Chlorantraniliprole 18.5w/w	0.5ml/Li	0.33 (0.91)	0.19 (0.83)	0.22 (0.85)	0.19 (0.83)	0.19 (0.83)	0.33 (0.91)	0.19 (0.83)	0.22 (0.85)	0.19 (0.83)	0.19 (0.83)	28.9 (5.24)	1.53 (1.39)	1.51 (1.38)	1.35 (1.35)	0.21 (0.84)
N S K E 5%	Use as such as prepared	0.4 (0.94)	0.21 (0.84)	0.28 (0.87)	0.34 (0.91)	0.22 (0.84)	0.4 (0.94)	0.21 (0.84)	0.28 (0.87)	0.34 (0.91)	0.22 (0.84)	28.53 (5.16)	4.53 (2.14)	1.68 (1.46)	1.44 (1.34)	0.73 (0.92)
Untreated check		0.70 (1.26)	0.73 (1.21)	1.45 (1.37)	1.04 (1.23)	2.20 (1.64)	0.75 (1.11)	1.18 (1.24)	1.66 (1.43)	1.68 (1.47)	1.04 (1.21)	35.33 (5.95)	8.86 (3.04)	2.95 (1.77)	3.55 (1.96)	1.28 (1.27)
S E (m)		0.08	0.09	0.07	0.07	0.09	0.05	0.08	0.09	0.04	0.07	0.44	0.12	0.21	0.24	0.12
C.D.		N.S	N.S	0.22	N.S	0.27	0.17	0.02	0.27	0.14	0.21	N.S	0.36	N.S	N.S	N.S

Table-2 : Economics of insecticides for the control of major insect-pests of brinjal during *Rabi*, 2020-21.

Insecticide	Application dose (ml org/l)	Total cost of treatment application (Rs/ha)	Yield (q/ha)	Increase in yield over (q/ha)	Value of yield saved by insecticide (Rs/ha)	Additional income (Rs/ha)	C:B Ratio (Rs/rupee) invested
Flubendiamide 20% WG	1g/Liter	19580	197.66	67.00	201000	181420	1:10.26
Beta-cyfluthrin 8.49%w/w+imidacloprid 19.81%	1ml/ L	9200	198.33	67.67	203010	193810	1:22.06
Thiamethoxam 25% WG	0.5g/ Li	4890	195.66	65.00	195000	190110	1:39.87
Lambda-cyhalothrin 4.6 w/w + Chlorantraniliprole 9.3 w/w	1ml/Li	19400	191.33	60.67	182010	162610	1:9.38
Emamectin benzoate 5% SG	2ml/Li	11400	189.66	59.00	1777000	165600	1:15.52
Chlorantraniliprole 18.5 w/w	0.5ml/Li	9800	190.33	59.67	179010	169210	1:18.26
NSKE 5%	Use as such as prepared	4600	165.33	34.67	104010	99410	1:22.61
Untreated			130.66				

reported as effective treatments against jassid (Aktar *et al.*, 2017) confirmed the present results.

Aphid : All the insecticides proved significantly superior over untreated check at 3 days after spray. At 7, 10 and 15 days after spray the treatments showed non-significant variation to each other. Overall performance of insecticides in current investigation revealed Beta-cyfluthrin 8.49%w/w + Imidacloprid 19.81% w/w and Thiamethoxam 25% WG were most effective against aphid. It was Chlorantraniliprole 18.5 SC and Emamectin benzoate 5% SG were found moderately effective treatment. Flubendiamide 20% WG, Lamda-cyhalothrin 4.6%w/w + Chlorantraniliprole 9.3%w/w and NSKE 5% were observed as comparatively least effective against aphid in brinjal. It has been observed that the efficacy of all the treatments gave maximum mortality at 3 days after spray. There after reduced efficacy was noticed at subsequent observations. Our results are in collaboration with the results of Rudramuni *et al.* (2011) who reported Lamda-cyhalothrin combined with Triazophos as effective insecticides for the control of cotton Aphid. Walunj and Pawar and Amita and Sharma (2005) reported Imidacloprid was most effective against aphid. Our findings are also similar to that of Kumar *et al.* (2017) who reported that NSKE 5% was least effective against aphids.

Fruit yield of brinjal : An increased fruit yield was recorded in all the treated plots in comparison to untreated check. The highest yield of 138.33 q/ha was recorded in plot treated with Beta-cyfluthrin 8.49% + imidacloprid 19.81% w/w, followed by Flubendiamide 20% WG (197.66q/ha), Thiamethoxam 25 WG (195.66 q/ha) and Lambda-cyhalothrin 4.6 w/w + Chlorantraniliprole 9.3% w/w (191.33 q/ha). The NSKE 5% treated plot recorded lowest fruit yield (165.33q/h) among the

treatments evaluated. These findings are in accordance with the findings of Mahata *et al.*, (2014) who found Thiamethoxam treated plot produced best fruit yield.

Economics of various insecticidal applications : The economics of different insecticidal treatments were calculated to know the feasibility of their acceptability by farmers going to control major insect- pests of brinjal. For this purpose the yeild of marketable fruit from net plot area was converted into hectare basis. In present study application of four sprays of all the insecticidal treatments were found economical in comparison to untreated check. However, maximum additional income (Rs/ha) was recorded with Beta-Cyfluthrin 8.49% w/w + imidacloprid 19.81% w/w (193810 Rs/ha) followed by Thiamethoxam 25 WG (Rs 190110) and Flubendiamide (Rs 181420). On the basis of incremental cost benefit ratio rupees per (rupee invested) the most profitable treatment was Thiamethoxam 25% WG (1:39.8), followed by application of NSKE 5% (1:22.6), Beta-cyfluthrin8.49% + imidacloprid 19.81% w/w (1:22.00), Chlorantraniliprole 18.5 sc (1:18.26) and Emamectin benzoate 5% SG (1:15.5). The plot treated with Flubendiamide 20% WG and Lamda-cyhalothrin 4.6% w/w + Chlorantraniliprole 9.3% w/w recorded comparatively least profitable observed Rs 10.26 and Rs 9.39 per rupee invested, respectively. Various Scientist evaluated different insecticides from different parts of the world and reported their efficacy and economics accordingly a by Sarnabati and Ray (2017) found cost: benefit ratio was maximum is coragen treated plot (1:26.27), followed by imidacloprid (1:17.78) and Thiamethoxam (1:13.60) are more or less similar to present finding. The extent of cost of protection and yield obtained is proportional to the benefit achieved. The benefit or loss of particular treatment depends on their cost and corresponding yield.

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Comparative Study of Morpho-Physical Quality Characteristics in Wild and Planted Amla (*Phyllanthus emblica* Linn.) Fruits and Seeds

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Abstract

Indian gooseberry (*Phyllanthus emblica* Linn.) locally called “Amla” is one of the important fruit-yielding plants being utilized in the Indian Ayurvedic system of medicine. In Uttarakhand, the wild populations of Amla are commonly available at different locations from Tropical to Temperate zones. Due to lack of scientific investigations and mass awareness, wild Amla fruits are generally considered as substandard material for commercial use as compared to planted once. The present study was designed to investigate wild and planted Amla fruits collected from the different populations and plantation sites for estimation of its qualitative and quantitative characteristics. Basic indicators of fruits (colour, weight, diameter, length, number of fruits per kg) and seeds' quality (length, diameter, thickness and weight) were analysed to observe the natural variations and to find out the elite populations for mass multiplications. In terms of morphological parameters in fruits, there was no any significant ($P < 0.05$) variation among different wild populations. However, all the wild populations varied significantly ($P < 0.05$) in terms of average weight, length and diameter of fruits and seeds of the NA-10 variety. It indicates that only morphological parameters are not sufficient indicators to find out the elite populations and therefore, there is need to analyze the different populations in terms of anatomical features, biochemical parameters, and/or genetic variability exist in fruits and seeds.

Key words : Wild amla, fruit, morphometric traits, variation.

Introduction

Amla also known as Indian gooseberry (*Phyllanthus emblica* Linn.) is native to India and also grows in tropical and subtropical regions including Pakistan, Uzbekistan, Sri Lanka, South East Asia, China, and Malaysia (Khan, 2009). The species is common in the mixed deciduous forests of India up to 1,350 meters above sea level (m.a.s.l) in the hills of Himalaya (Naithani *et al.*, 2021). In India, Amla occupies 94 hectares area with 1089 metric tons produced in the 1st estimation and 1107 metric tons produced in the 2nd estimation within the area 95 hectares. (Anonymous, 2018). There are different varieties of Amla which are commercially cultivated in India like Francis, Chakaiya, Banarasi, NA-4, NA-5, NA-6, NA-7, and NA-10, etc. The tree is a small to medium-sized deciduous tree with a pinnate arrangement of leaves. Flowers are pale green, borne in leaf axils in clusters of 6 to 10. Amla fruits are fleshy, light green to yellowish-green in color having six vague perpendicular furrows enclosing seeds. The stone of the fruit has 6 ribbed, splitting the segments, and each containing usually 4 to 6 seeds. Amla fruits are attractive, round, and deeply ribbed. The surface of the fruit is shiny and its size varies from a small marble to large plum. It is quite hard with thin and translucent skin. The fruits are sweet and sour in taste.

Amla is the second richest source of vitamin C (950/100gm) among the fruits, after Barbados cherry

(Mishra *et al.* 2009). Amla is one of the most nutritious fruits and it is a rich source of vitamin C, ascorbic acid, protein, fat, carbohydrates, fiber, and minerals particularly calcium, phosphorus, iron, and magnesium. Besides, Amla fruit has an adequate amount of sugars, acids, and several active tannoids like nicotinic acid, phyllembelin, phyllemblic acid, gallic acid, and emblicol (Khan 2009; Dasaroju *et al.*, 2014). Through the fruits and plant parts are traditionally used for various diseases, the fruit is the most usable part of the plant. They are useful in curing many diseases like diabetes, cough, asthma, bronchitis, skin diseases, leprosy, anemia, jaundice, diarrhea, dysentery, and premature greying of hair (Hair tonic). Despite numerous health benefits, the consumption of fresh Amla fruit remains low.

Limited information is available on the physical properties of Wild Amla fruits. Also, the properties vary according to the provenances and cultivars. The main objectives of this study were to find out elite populations of wild Amla on the basis of morphometric traits and to compare physical quality of Wild Amla fruits with the planted one.

Materials and Methods

The wild populations and NA-10 Amla variety were used for the study purpose. The mature fruits were collected and analyzed as attractive, medium to large and flattened round in shape; skin is rough, yellowish-green with a pink

Table-1 : Geographical description of fruit collection sites.

S. No.	Population	Sites Codes	Collection site	Latitude	Longitude	Altitude (amsl)
1.	Wild Planted Amla	P1	Chauras	30°22'39.74" N	78°80'03.49" E	586
		P2	Chauras	30°22'57.17"N	78°80'17.44"E	559
		P3	Chauras	30°22'72.42"N	78°80'57"E	595
2.	Wild Amla	P4	Paukhal	30°36'25.9"N	78°65'97.3"E	1263
		P5	Paukhal	30°36'77.1" N	78°58'11.2" E	1269
		P6	Kandikhal	30°43'33.13" N	78°40'55.51" E	1443
		P7	Jakhand	30°33'50" N	78°65'97.3" E	1155
		P8	Kwili	30°33'74.3" N	78°63'06.5" E	1440
		P9	Hisriyakhal	30°25'95.7"N	78°66'75.3"E	1119
3.	Amla cultivar NA-10	P10	Chauras	30°22'33.17"N	78°80'05.23"E	562

Table-2 : Morphometric traits of Amla fruits from different populations.

S. No.	Sites Codes Sizes	Fruit Length (mm)			Fruit Diameter (mm)			Number of segments per fruit		
		Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
1.	P1	17.14	16.87	7.39	19.71	19.24	9.78	6.00	6.00	6.00
2.	P2	17.26	15.89	15.08	19.88	18.36	16.78	5.85	5.67	5.48
3.	P3	19.19	17.27	14.74	22.08	19.90	16.43	6.07	6.00	5.20
4.	P4	18.38	17.35	15.67	20.37	18.87	17.14	6.00	5.83	5.47
5.	P5	18.65	16.24	15.11	22.10	19.92	18.37	6.00	6.00	6.00
6.	P6	18.82	16.26	14.89	22.33	19.97	18.58	6.00	6.00	5.93
7.	P7	16.81	15.83	14.04	19.49	17.96	15.84	6.00	6.00	6.03
8.	P8	16.63	15.65	14.18	20.01	18.56	16.64	6.02	6.00	6.03
9.	P9	18.98	17.22	13.64	22.41	20.20	16.98	6.40	6.10	6.10
10.	P10	32.08	29.52	27.35	36.40	32.72	31.19	6.12	6.13	6.08
	Average	19.39	17.81	15.21	22.48	20.57	17.77	6.05	5.97	5.83
	SD	4.33	3.95	4.63	4.78	4.11	5.04	0.13	0.13	0.31
	SE (±)	1.37	1.25	1.46	1.51	1.30	1.59	0.04	0.04	0.10
	Source of Variation	F-value	p-value	F-critical	F-value	p-value	F-critical	F-value	p-value	F-critical
	Population	2002.46	6.85	2.04	2383.46	3.75	2.04	21.94	7.08	2.04
	Fruit Size	1545.49	2.46	3.15	1942.64	2.9	3.15	30.02	9.24	3.15
	Interaction	69.15	2.57	1.78	63.58	2.74	1.78	7.41	1.59	1.78
	LSD		0.48			0.48			0.176	

tinge, flesh being whitish-green. The fruits were collected from Ten different sites in Bhilangna block, district Tehri, Uttarakhand. The geographical location of different populations ranged from 30°22'33.17" to 30°43'33.13" N latitude and 78°63'06.5" E to 78°80'17.44" E longitude. The altitude of the study sites varied from 559 to 1,443 msl. The sites are denoted by site codes; (i.e., P1- Site-1, P2- Site-2, P3- Site-3, P4- Site-4, P5- Site-5, P6- Site-6, P7- Site-7, P8- Site8, P9- Site-9, and P10- Site10) and these sites codes were used in the whole investigation (Table-1).

Amla fruits of NA – 10 varieties were collected from Horticultural Research Centre (HRC), Chauras campus, Srinagar. Planted wild Amla were also collected from Forest Nursery of Dept. of Forestry and Natural Resources and Girls Hostel, Chauras campus, Srinagar.

Experimental procedure : To reduce the surface contaminations, firstly the fruits were washed properly and the surface water was wiped thoroughly by a clean cloth/blotting paper. Only good healthy and matured fruits were selected for the study. Initially, the fruits were categorized into three groups based on size through visual inspection. One group contained larger-sized fruits and another two groups contained medium and smaller-sized fruits. Since the groups were based on size, the groups were denoted as large, medium, and small fruits. All the fruits were subjected to measurement of physical properties as described below :

Determination of Physical properties of fruits and seeds : The physical analysis of fruit was done for the following parameters such as Fruit Length (mm), Fruit weight (gm), Fruit Diameter (mm), Aspect ratio (Brimpureeswaran *et al.* 2015) as :

Table-3 : Morphometric traits of Amla fruits from different populations.

S. No.	Sites Codes	Fruit Weight (gm)			Number of fruits in 1 kg		
		Large	Medium	Small	Large	Medium	Small
1.	P1	4.51	4.12	3.85	250	290	350
2.	P2	4.48	3.56	2.98	380	440	510
3.	P3	5.99	4.48	2.70	194	224	356
4.	P4	5.16	4.27	3.20	175	230	340
5.	P5	6.06	4.31	3.41	153	230	330
6.	P6	5.97	5.09	4.22	170	175	302
7.	P7	4.06	3.25	2.32	260	295	384
8.	P8	4.36	3.53	2.66	240	282	334
9.	P9	6.049	4.524	2.690	178	220	340
10.	P10	25.82	19.45	15.45	40	50	64
	Average	7.24	5.66	4.35	204.00	243.60	331.00
	SD	6.24	4.63	3.74	83.54	93.99	103.99
	SE (±)	1.97	1.46	1.18	26.42	29.72	32.88
	Source of Variation	F-value	p-value	F-critical	F-value	p-value	F-critical
	Population	5846.75	8.07	2.04	5.86	0.00049	2.39
	Fruit Size	1563.51	1.75	3.15			
	Interaction	144.75	1.53	1.78			
	LSD		0.33		118.30		

Table-4 : Morphometric traits of Amla seeds from different populations.

S. No.	Sites Codes	Seed Length (mm)	Seed Diameter (mm)	Seed Thickness (mm)	Seed Weight (mg)	Number of seeds in 1gms
1.	P1	5.49	2.93	2.76	0.016	73
2.	P2	4.99	2.66	2.62	0.014	73
3.	P3	5.42	2.98	2.79	0.017	73
4.	P4	5.59	2.99	2.86	0.020	66
5.	P5	5.24	2.82	2.71	0.019	63
6.	P6	5.67	2.90	2.89	0.022	59
7.	P7	5.36	2.78	2.71	0.019	59
8.	P8	4.88	2.77	2.64	0.018	61
9.	P9	5.17	2.78	2.66	0.018	61
10.	P10	6.56	3.18	3.10	0.020	43
	Average	5.44	2.88	2.77	0.018	62.600
	SD	0.44	0.14	0.14	0.0020	8.511
	SE(±)	0.14	0.04	0.04	0.0006	2.6915
	F-value	72.58	14.26	23.83	13.73	24.47
	F-critical	2.39	2.39	2.39	2.39	3.02
	p-value	2.66	6.89	8.407	9.36	1.16
	LSD	0.16	0.11	0.089	0.0017	4.74

$$\text{Aspect ratio} = \frac{\text{Diameter of fruit}}{\text{Length of fruit}} \times 100$$

The physical analysis of seeds was done for the following parameters such as Seed weight (mg), Seed length (mm), Seed diameter (mm), Percent seed content : by following formula : (Brimapureswaran *et al.*, 2015).

$$\text{Percent Seed content} = \frac{\text{Weight of seed}}{\text{Total weight of fruit}} \times 100$$

Percent Stone content : For estimation of stone percentage, stone weight and fresh fruit weight was taken by analytical balance, and the stone percentage was calculated by following given formula : (Brimapureswaran *et al.*, 2015).

$$\text{Percent Stone content} = \frac{\text{Weight of stone}}{\text{Total weight of fruit}} \times 100$$

Moisture percentage of seed : For estimation of moisture percentage, seed fresh weight was recorded, and then kept in a hot oven at 60°C temperature till to attain constant dry weight. Moisture percentage was calculated by the following formula :

Moisture percentage

$$= \frac{\text{Fresh weight of seeds} - \text{Dry weight of seeds}}{\text{Fresh weight of seeds}} \times 100$$

Statistical Analysis : Simple and inferential statistics were applied using MS Excel 2019. The data from the morphometric traits were calculated by two-factor and single-factor ANOVA (5% level of significance) and correlation using MS Excel 2019. The data in percentage was first transformed into value through ARCSINE analysis and then transformed back into Sine for

Table-5 : Correlation between morphometric traits of Amla seeds.

	Seed Length	Seed Diameter	Seed Thickness	Seed Weight
Seed Length	1.000			
Seed Diameter	0.867**	1.000		
Seed Thickness	0.935**	0.883**	1.000	
Seed Weight	0.483**	0.433*	0.564**	1.000

Table-6 : Correlation between morphometric traits of fruits.

	Fruit Length	Fruit Diameter	Fruit weight	Number of segments per fruit
Fruit Length	1.000			
Fruit Diameter	0.985**	1.000		
Fruit weight	0.915**	0.925**	1.000	
Number of segments per fruit	0.295**	0.341**	0.296**	1.000

Level of Significance (a = $p < 0.1$, b = $p < 0.05$, * = $p < 0.02$, ** = $p < 0.01$)

All the parameters are significant at the level of significance ($p < 0.01$)

Table-7 : Sensory Test values of Score and Rating.

S. No.	Parameters	Organoleptic Scale			
		Wild Amla Fruit		Planted Amla Fruit	
		Score	Rating	Score	Rating
1.	Colour	8.2 $\pm$ 0.33	Liked very much	8.4 $\pm$ 0.22	Liked very much
2.	Taste	8.6 $\pm$ 0.22	Liked very much	8.00 $\pm$ 0.40	Liked very much
3.	Appearance	7.4 $\pm$ 0.22	Liked Moderately	7.8 $\pm$ 0.33	Liked Moderately
4.	Flavour	8.8 $\pm$ 0.18	Liked very much	8.2 $\pm$ 0.33	Liked very much
5.	Juiciness/Consistency	8.4 $\pm$ 0.22	Liked very much	8.2 $\pm$ 0.33	Liked very much
6.	Overall Acceptability	8.28 $\pm$ 0.09	Liked Moderately	8.12 $\pm$ 0.16	Liked Moderately

comparison. The mean values were compared by using the LSD method. Means of the data were separated whether they are significant or not by using Fisher's LSD (least significant difference) method at a 5% level of significance.

Results and Discussion

The seed colour of the NA-10 variety was light brown to yellowish-brown and black to dark brown in Wild Amla. According to Singh *et al.*, 2015 and Singh *et al.*, 2019; the maturity of Amla fruits can be judged externally by a change in seed colour from creamy white to brown. The number of the fruit segments in all majority populations were to be 6 which ranges from 4 to 8. Similar findings were observed by Mishra *et al.*, (2009). Number of segments in all the varieties were six but in a few varieties like Krishna and Kanchan 6-8 segments. In case of Wild Amla maximum fruit length (15.01 to 18.99 mm), diameter (17.01 to 22.99 mm), and weight (3.01 to 6.99 gm) was observed in Paukhal population however, overall, the NA-10 variety showed the maximum average fruit length (32.08 mm), diameter (36.40 mm), and weight (25.82 gm). Similar findings were recorded by Naithani *et al.*, (2020) on wild Amla collected from different populations.

The average seed length in NA-10 variety was maximum (6.56 mm) however, the minimum seed length was recorded in P8 (4.88mm). Similarly, the average

seed diameter NA-10 variety was maximum (3.18 mm) however, the minimum seed diameter was recorded in P2 (2.66 mm). The average seed thickness in NA-10 variety was maximum (3.10 mm) and minimum in P2 (2.62mm). The average seed weight in P6 was maximum (0.020 gm). Our results corresponded to Singh *et al.*, 2015; and Singh *et al.*, 2019, they studied different Amla cultivars where NA-10 variety showed maximum fruit length (33.9 mm), diameter (39.8 mm), and weight (31.45 gm). The average number of seeds per gm in P1 (76) and minimum in P10 (47) were recorded. Similar findings were reported by Kumar *et al.*, (2016) in NA-7 variety and by Brimpureeswaran *et al.*, (2015) worked on Kanchan variety which had the average fruit diameter range 30.7-36.2 mm.

Sensory quality of Wild and Planted Amla fruit based on colour, taste, appearance, flavour, juiciness/consistency, and overall acceptability varied from 7.1 to 8.9 (Fig.-1 Table-8). Based on the taste, the composite score of wild Amla fruit was 8.6 $\pm$ 0.22, and in planted once 8.00 $\pm$ 0.40 (Fig.10). The overall acceptability of wild fruit (8.28 $\pm$ 0.09) was more than planted once (8.12 $\pm$ 0.16).

Conclusions

In terms of morphological parameters in fruits, there was no any significant ($P < 0.05$) variation among different wild

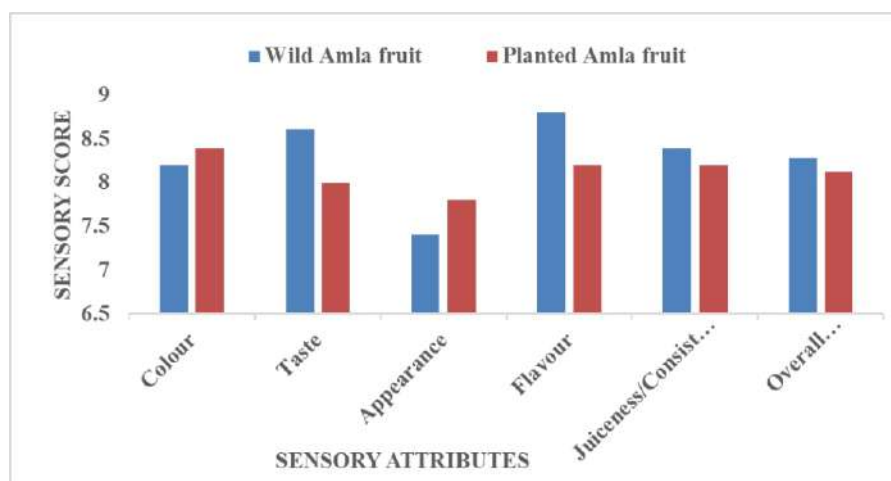


Fig-1 : Sensory test of Wild and Planted Amla Fruits.

populations. However, all the wild populations varied significantly ($P < 0.05$) in terms of average weight, length and diameter of fruits and seeds of the NA-10 variety. Therefore, it can be concluded that only morphological parameters are not sufficient indicators to find out the elite populations and therefore, there is need to analyze the different populations in terms of anatomical features, biochemical parameters, and/or genetic variability exist in fruits and seeds.

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Correlation and Path Coefficient Analysis in Bread Wheat (*Triticum aestivum* L. em. Thell)

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Abstract

The present study was conducted at Agriculture Research Farm, B.R.D. Post Graduate College (Campus), Deoria during *rabi* 2017-18 by taking 81 bread wheat genotypes from various eco-geographic regions with three checks in Augmented Block Design. Data on thirteen quantitative traits were recorded and analyzed. At phenotypic level, correlation coefficients revealed that the biological yield per plant and weight of 1000 grains had high positive correlation with grain yield per plant. Plant height was significantly correlated with yield per spike and no. of grains per spike was positively correlated with flag leaf area and length of spike was also positively correlated with plant height. Path analysis showed that most of the traits exerted positive direct effect on grain yield per plant except peduncle length, no. of grains per spike and flag leaf area. Peduncle length showed positive indirect effect on grain yield *via* biological yield per plant, number of spikelets per spike.

Key words : Bread wheat, *Triticum aestivum*, correlation coefficient, path coefficient, grain yield.

Introduction

Wheat (*Triticum aestivum* L.); a self-pollinating annual plant in the true grass family Gramineae (Poaceae) and genus *Triticum*, is the world's most famous energy rich cereal crop. It has been described as the "King of the cereals" because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade. It is a C₃ plant grown from temperate, irrigated to dry, high rain fall areas and from warm, humid to dry, cold environments. Undoubtedly, this wide adaptation has been possible due to the complex nature of the plants genome which provides great plasticity to the crop.

Its production leads all crops, including rice, maize and potatoes. Although the crop is most successful between the latitudes of 30° and 60° N and 27° and 40° S, wheat can be grown beyond these limits, from within the Arctic Circle to higher elevations near the equator. The optimum growing temperature is about 25°C with minimum and maximum growth temperatures of 3° to 4°C and 30° to 32° C, respectively. Wheat is adapted to a broad range of moisture conditions from xerophytic to littoral.

Wheat (*Triticum aestivum* L. em Thell, 2n=42) is the most important staple food crop in the world. It is currently grown on approximately 225 mha Area globally, with an average productivity of 3 t/ha. It exhibits considerable variation between different agro-ecological zones (Singh *et al.*, 2008). It supplies about 25% of protein and 20% of

the calories consumed by human beings from the daily diet.

Materials and Methods

Field Location : The field experiment under present investigation was conducted during Rabi 2017-18 at Agriculture Research farm of Baba Raghav Das Post Graduate College Deoria (U.P.). Geographically, this College is located in the east part of Uttar Pradesh, India. The site of experiment is located at 26.5°N latitude, 83.79°E longitude and 68 meter (223 feet) above the mean sea level. The climate of district Deoria is semi-arid with hot summer and cold winter nearly 80% of total rain fall is received during the monsoon (only up to September) with a few shower in the winter.

Experimental details : The experiment was conducted to evaluate 81 wheat germplasm lines in normal soil under timely sown and irrigated conditions following Augmented Block Design (A.B.D.). The entire experiment field was divided in 9 blocks of equal size and each block has the 3 checks, were randomly allocated in each block. The remaining plots of the block were used for accommodating the test genotypes which were not replicated. A test genotype was present only one block while the three checks were replicated in all the 9 blocks. Each plot consisted of two rows 3 m length with spacing of 5 cm between plant to plant and 22.5 cm between rows to rows. Recommended cultural practices were followed to raise good crops.

Generation of data : Observations on 5 randomly

[illegible][illegible]

Table-3 : Direct and indirect effects of different characters on grain yield per plant in wheat germplasm (Phenotypic).

	Tillering	Spikelets	length of spike	Peduncle length	Plant height	Biological yield	Yield/spike (g)	No. of grain/spike	1000 seed weight	Flag leaf area	Day of maturity	DFF	Grain yield/plant (g)
Tillering	0.382341	-0.09496	-0.05462	-0.00631	0.013643	-0.00518	-0.09599	0.010036	-0.00605	-0.00861	-0.01098	0.002849	0.281855
Spikelets	-0.0518	0.917976	-0.11107	-0.01799	-0.00323	-0.37719	0.033982	0.019192	-0.00647	-0.01356	-0.00971	-0.01208	0.516662
length of spike	-0.07744	-0.28867	0.330071	0.001938	-0.12301	0.033324	-0.00846	-0.01924	0.003168	-0.01431	0.006227	-0.02473	0.198785
Peduncle length	0.032649	0.170708	-0.00708	-0.10679	-0.33549	0.115822	0.093584	0.030447	0.009313	-0.01778	-0.00224	-0.02029	-0.054445
Plant height	0.016235	-0.00704	-0.10324	0.077132	0.586083	-0.27131	-0.15363	-0.03199	-0.01431	0.011987	0.003302	0.029976	0.23685
Biological yield	-0.00257	-0.34283	0.011654	-0.0111	-0.11305	0.861821	-0.03604	-0.01309	0.005371	0.005933	0.001397	-0.01548	0.568437
Yield/spike(g)	-0.12183	0.079058	-0.00757	-0.02295	-0.16384	-0.09226	0.336421	0.00852	0.006659	0.011171	0.011952	-0.00992	0.222082
No. of grain/spike	-0.02305	-0.08079	0.031159	0.013507	0.061724	0.06063	-0.01542	-0.13976	0.002809	0.009773	0.010206	0.000147	-0.12274
1000 seed weight	-0.03422	-0.06714	0.012649	-0.01018	-0.0809	0.061317	0.029699	-0.00692	0.053636	0.00304	-0.00114	0.011449	0.049794
Flag leaf area	0.043266	0.12496	0.050749	-0.01727	-0.05064	-0.06016	-0.04425	0.021399	-0.0027	-0.0708	-0.00546	0.016509	-0.05606
Day of maturity	-0.07022	-0.1138	0.028092	0.002764	0.017749	0.018022	0.060236	-0.02843	-0.00128	0.006948	0.059239	-0.0669	0.044065
DFF	0.005417	-0.0421	-0.03316	0.007452	0.047891	-0.05936	-0.01485	-0.00012	0.003846	-0.00624	-0.01989	0.187314	0.148249

R SQUARE = 0.9440 RESIDUAL EFFECT = 0.2367

Table-4 : Direct and indirect effects of different characters on grain yield per plant in wheat germplasm (Genotypic).

	Tillering	Spikelets	length of spike	Peduncle length	Plant height	Biological yield	Yield/spike (g)	No. of grain/spike	1000 seed weight	Flag leaf area	Day of maturity	DFF	Grain yield/plant (g)
Tillering	1.356516	-0.18379	-0.27475	0.115835	0.057602	-0.00911	-0.43225	-0.08177	-0.12142	0.153504	-0.24915	0.01922	0.126184
Spikelets	-0.18379	1.776746	-0.55873	0.330406	-0.01363	-0.66355	0.153016	-0.15636	-0.12996	0.24186	-0.22026	-0.08149	0.368059
length of spike	-0.27475	-0.55873	1.660438	-0.0356	-0.51936	0.058624	-0.0381	0.156746	0.063631	0.255298	0.14132	-0.16679	-0.18113
Peduncle length	0.115835	0.330406	-0.0356	1.961101	-1.41649	0.203755	0.421393	-0.24805	0.187022	0.317079	-0.05077	-0.13684	-0.03714
Plant height	0.057602	-0.01363	-0.51936	-1.41649	2.474492	-0.4773	-0.69176	0.260604	-0.28748	-0.21382	0.074939	0.202201	0.143189
Biological yield	-0.00911	-0.66355	0.058624	0.203755	-0.4773	1.516124	-0.1623	0.106661	0.10787	-0.10584	0.031704	-0.10443	0.352016
Yield/spike(g)	-0.43225	0.153016	-0.0381	0.421393	-0.69176	-0.1623	1.514851	-0.06942	0.133729	-0.19927	0.271234	-0.06688	0.035412
No. of grain/spike	-0.08177	-0.15636	0.156746	-0.24805	0.260604	0.106661	-0.06942	1.138657	0.056404	-0.17434	0.231612	0.000994	-0.06906
1000 seed weight	-0.12142	-0.12996	0.153016	0.187022	-0.28748	0.10787	0.133729	0.056404	1.077162	-0.05423	-0.0258	0.077231	-0.01591
Flag leaf area	0.153504	0.24186	0.255298	0.317079	-0.21382	-0.10584	-0.19927	-0.17434	-0.05423	1.262998	-0.12393	0.111362	0.005593
Day of maturity	-0.24915	-0.22026	0.14132	-0.05077	0.074939	0.031704	0.271234	0.231612	-0.0258	-0.12393	1.344355	-0.45128	-0.08759
DFF	0.01922	-0.08149	-0.16679	-0.13684	0.202201	-0.10443	-0.06688	0.000994	0.077231	0.111362	-0.45128	1.263505	0.076195

selected competitive plants from each of the advanced lines in each of the replication were recorded for thirteen metric traits namely Days to 50% flowering, Days to maturity, Plant height (cm), Number of effective tillers per plant (Tillering), Length of spike (cm), Number of spikelets per spike, Number of grains per spike, Weight of 1000 grains (g), Grain yield per plant (g), Flag leaf area per plant (cm²), Peduncle length per plant (cm), Grain yield per spike (g), Biological yield per plant (g). The phenotypic and genotypic correlation coefficients (r) between different characters were estimated according to Searle, (1961) and path coefficient analysis was carried out according to Dewey and Lu, (1959).

Results and Discussion

Correlation Coefficients : The estimates of phenotypic and genotypic correlation coefficients computed between 13 characters of indigenous and exotic lines of wheat under study are presented in Table-1 and 2 respectively. At phenotypic level tillering exhibited highly significant and positive correlation with Spikelets per spike (0.322654) followed by length of spike (0.321455). The spikelets per spike showed highly significant and positive correlation with biological yield (0.472024) along with length of spike (0.445814). The Days to maturity exhibited highly significant and positive correlation with days to 50% flowering (0.381263). Days to 50% flowering is highly correlated with grain yield per plant (0.148249). Length of spike (cm) had highly significant and positive correlation with plant height (0.391374) followed by 1000 grain weight (0.037028). Peduncle length (cm) showed highly significant and positive correlation with Plant height (cm) (0.568681) and number of grains per spike (0.028481). The plant height exhibited highly significant and positive correlation with yield per spike (0.36055). The biological yield per plant exhibited highly significant and positive correlation with grain yield per plant (g) (0.568437). Grain yield per spike was found highly significant and positive correlated with number of grains per plant (0.222082). Number of grains per spike exhibited highly significant and positive correlation with flag leaf area (0.140219). Weight of 1000 Grains exhibited highly significant and positive correlation with grain yield per plant (0.049794). Flag leaf area exhibited highly negative correlations for all the traits and highest for days to 50% flowering. The estimates of genotypic correlation coefficient between different characters showed close parallelism in direction with their corresponding phenotypic correlation coefficients.

Path Coefficient : Path coefficient analysis was worked out from phenotypic as well as genotypic correlations coefficients to resolve the direct and indirect effect of different characters on grain yield per plant. The results of

path coefficient analysis are presented in Table-3 and 4 respectively.

At phenotypic level, most of the characters exerted high order positive direct effects on grain yield except peduncle length (-0.10679), no of grains per spike (-0.13976) and flag leaf area (-0.0708); which showed negative direct effect on grain yield. Peduncle length exerted positive indirect effect on grain yield via no. of spikelets per spike (0.170708) and biological yield per plant (0.115822) (Table 3). However, the direct and indirect effects of rest of the characters were too low to be considered of any consequence. Keeping these results in mind a breeder can focused more on these traits in his breeding program.

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Impact of Soil Health Card Scheme in Community Development Block Bridjmanganj of District Maharajganj Eastern U.P.

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Abstract

Healthy soil constitutes the foundation of thriving ecosystem and societies are directly tied to food and nutritional security, water quality, human health, climate change adaptation and biodiversity. Soil is one of the important elements required for farming as it provides nutrients to the plant. Earth need to be nurtured with mother's care because earth give us everything for sustainable life so any kind of torture on it is sin to protect for sustainable agriculture. The present study was conducted in community development block Bridjmanganj of Maharajganj district, Eastern UP. A well-structured and pre-tested interview schedule was used for data collection. The study conducted out of 93 in habitat villages only 60 villages are benefited with the soil health card scheme. Study with regards to the impact of soil health card scheme on knowledge and adoption of recommended doses of soil nutrients and fertilizers of farmer's. Study revealed that 46.16%, 11.54% and only 1.92% card holder improved their wheat, paddy and sugarcane production from poor yield to average and high yield besides in respect to onion and potato 5.76 % soil health card holder gained an improved from their average and low production to high and average production respectively.

Key words : Soil health card, knowledge, adoption, beneficiaries, non beneficiaries

Introduction

Soil is one of the elements required for farming as it provides nutrients to the plant. Healthy soil contains all the elements for growth and development of crop. The soil deprived from one or more nutrients either reduce the production or degraded quality of crops. Therefore, proportion and quantity of micro and macro nutrients although refers to the soil health. As for as agriculture production is concerned, soil health play vital role in ensuring sustainable production with optimizing the utilization of fertilizer and reducing its waste. Shrivastava and Pandey (1999) reported most of the farmers are using continuously larger quantities of chemicals fertilizer to increase production without knowing the fertility status of the soil of their field.

Earth need to be nurtured with mother's care because earth give us everything for sustaining life so any kind of torture on it is sin to protect soil health for sustainable agriculture. As per Press Information Bureau, Government of India 23 December 2015, Gujarat has been the first state to introduce soil health card program in 2003-04.

The soil testing is a proven scientific tool to evaluate soil fertility and recommended balanced nutrition to crops, however, the soil testing programme in India has failed to create the desirable Impact on the farming community due to extremely poor coverage and delay in timely

dissemination of manure and fertilizer recommendation to farmers. (Biswas, 2002)

The Government of India launched 'Soil Health Card Scheme' on 19th February, 2015. The Department of Agriculture of different states are the main executive bodies to implement the scheme in their respective states. A Soil Health card is a printed card given to a farmer that contains the status of various plant nutrients as well as dosage of different fertilizer for the crops.

Hon'ble Prime Minister Narendra Modi said in 'Mann ki Baat' programme November 27, 2017 that "In Rabi 2016-17 the production of wheat had increased from Rs. 4000.0 to Rs. 6000 per acre which has increased the Income of the farmers". Along with this quality of the soil also improved economic savings have been achieved due to reduced.

Keeping in view the study was carried out in the community development block bridjmanganj of Maharajganj District Eastern Uttar Pradesh.

Materials and Methods

A Study example of 104 soil health card holder and non holder of 10 villages viz: (i) Phoolmanaha (ii) Hatabela hariyaana (iii) Nayansar (iv) Banjarha Sonbarsa (v) Sahabad (vi) Kamahariya Bujurg (vii) shikargarh (viii) Mainahawa (ix) Nawadihkala (x) Dharachi from Bridjmanganj block of Maharajganj District Uttar Pradesh. It was determined by multistep quota random sampling method. The respondent farmer were interviewed with the

Respondent's category wise yields of selected crops.

Crops	Paddy			Wheat			Sugarcane			Potato			Onion		
	Beneficiary (%)	Non-beneficiary (%)	Difference (%)	Beneficiary (%)	Non-beneficiary (%)	Difference (%)	Beneficiary (%)	Non-beneficiary (%)	Difference (%)	Beneficiary (%)	Non-beneficiary (%)	Difference (%)	Beneficiary (%)	Non-beneficiary (%)	Difference (%)
Poor Yield	5.77	17.31	-11.54	15.38	61.54	-46.16	1.92	3.84	-1.92	3.84	3.84	0.00	5.76	5.76	0.00
Average Yield	82.69	76.92	+5.77	80.78	34.62	46.16	7.68	5.76	1.92	21.15	26.91	-5.76	7.69	13.45	-5.76
High Yield	11.54	5.77	+5.77	3.84	3.84	0.00	-	-	-	1.92	-	1.92	53.76	-	5.76
1276Total	100.00	100.00	-	100.0	100.00	-	-	-	-	-	-	-	-	-	-

help of per-structured interview schedule patiently. Data was collected in both the mode of qualitative as well quantitative. The requested information was statistically processed as per requirement. Percentage, quartiles, test of chi-square, coefficient of correlation, test of significance.

Results and Discussion

It is apparent from table in paddy crop 82.69% and 11.54% soil health card beneficiary farmer belong average and high yield category of standard yield. Beside, 76.92% and 5.77% non-beneficiary belong to average and high category of standard yield. In case of poor yield majority of non-beneficiary farmers have leading position over beneficiary farmer. It is found that production of paddy crop of soil health card owner is higher than the yield obtained by non-beneficiary farmer.

As regard to crop production of wheat 80.78% beneficiary farmers obtained average yield while 34.62% non-beneficiary farmer obtained average yield. The high yield of wheat crop is obtained 3.84 % only by beneficiary farmer.

The table reveals that per hectare sugarcane production up to average of standard of production is obtained by 7.68 percent beneficiary as well as 5.76% non-beneficiary. On the other hand poor yield production of sugarcane the extent of beneficiaries and non beneficiary are 1.92% and 3.84% respectively.

As regard to per hectare crop production of potato 26.91% non beneficiary obtained average yield while only 21.15% beneficiary farmer obtained average yield. The high yield of potato crop obtains by beneficiary farmers only 1.92 %.

It is obvious from table in onion crop 5.76% beneficiary's farmer gain high yield and in case of average yield majority of non beneficiary 13.45% respect to 7.69% beneficiary.

Comparative advantage of 'Soil Health Card Scheme' on beneficiary over non-beneficiary farmers of selected crops. In the study area was discussed in table that the paddy, wheat and sugarcane crops majority of beneficiary in average yield production. In case of high yield production of paddy, potato and onion crops majority of beneficiary farmers.

Conclusions

Through the finding of the study it is found that 11.54%, 46.16% and only 1.92 % card owners improved their wheat, paddy and sugarcane production from poor yield to average and high yield. Besides of these in respect to crops 5.76% card holder jumped from average to high

yield category. Whereas farmer growing potato there is an improvement of 5.76 percent to the level of average yield. Consequently the scheme has significant impact on economic improvement of the farming community. Study also reveals that there are mainly three constraint namely socio- personal, socio-psychological and administrative problem which hinders the success of the scheme among farmer.

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Improving Germination Efficiency in Seabuckthorn (*Hippophae salicifolia* D. Don) Seeds through Stratification and Priming

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Abstract

Propagation through seed is the easiest method of propagation for Seabuckthorn (*Hippophae salicifolia* D. Don). However, this method is not preferred for commercial cultivation because of dioecious nature of plant and the seedling originated plants also takes about 4-5 years to start flowering. The sex of the plant cannot be distinguished until they come to flower. But the main reason for propagation through seed is that, it can be further used for propagating or establishing an orchard through vegetative propagation. Freshly harvested seeds of Seabuckthorn shows physiological dormancy and thus do not germinate right after harvesting. Such type of dormancy can be overcome by the cold treatments that are naturally provided by the habitat they are growing in and artificially, by the cold stratification treatment and priming of seeds with chemical agents such as GA₃ to get faster and synchronized seed germination. Present study was carried out to improve germination efficiency in Seabuckthorn seeds. The seeds were first cold stratified with alternate layer of moist sand and seed; kept for 7, 14, 21 and 28 days at 5 °C temperature. Further these seeds were subjected to priming with various concentrations of GA₃ (i.e., 100, 200, 300, 400, 500 ppm) for improving germination efficiency in two different conditions i.e., seed germinator and natural ventilated polyhouse. The experiment was laid out in factorial CRD for seed germinator and factorial RBD for natural ventilated polyhouse. Days taken for first germination was best in S₄G₁ (28 Days stratification x GA₃ 100 ppm), S₄G₂ (28 Days stratification x GA₃ 200 ppm) and S₄G₃ (28 Days stratification x GA₃ 300 ppm) in (9.00 days) seed germinator whereas, S₄G₅ (28 Days stratification x GA₃ 500 ppm) in (20.33 days) natural ventilated polyhouse. Germination percentage recorded best in S₁G₅ (7 days stratification x GA₃ 500 ppm) and S₂G₄ (14 days stratification x GA₃ 400 ppm) in (100.00%) seed germinator. S₂G₃ (14 days stratification x GA₃ 300 ppm) in (45.36%) natural ventilated polyhouse. Highest shoot length was recorded in S₄G₄ (28 days stratification x GA₃ 400 ppm) in (5.68 cm) seed germinator whereas S₂G₁ (14 Days stratification x GA₃ 100 ppm) in natural ventilated polyhouse. Root length of the seedling recorded best in S₁G₃ (7 Days stratification x GA₃ 300 ppm) in (1.66 cm) seed germinator and S₃G₄ (21 Days stratification x GA₃ 400 ppm) in (2.77 cm) natural ventilated polyhouse.

Key words : Seabuckthorn, stratification, priming, germination, GA₃

Introduction

Hippophae commonly called as Seabuckthorn occupies a vital position as a bio-resource in cold regions of North-Western and North- Eastern Himalayan states of India, including Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh and Sikkim. Seabuckthorn which is native of Eurasia has been domesticated in several countries including India, China, Nepal, Pakistan, Myanmar, Russia, Britain, Germany, Finland, Romania and France at a high altitude of 2500-4300 msl (Negi *et al.*, 2005). The word *Hippophae* has been derived from the Latin word “*Hippo*” meaning horse and “*Phaos*” which means “shine”. Seabuckthorn (*Hippophae species*) also called Sallow thorn belongs to the family Elaeagnaceae and is a deciduous shrub with yellow or orange fruits. Seabuckthorn has a diploid chromosome number 2n=24, and has a basic chromosome number X=12. It is also known as the wonder plant and bears small orange-yellow to red colored fruits on their two-year old thorny twigs. All the

species of the genus *Hippophae* is native to Eurasia and comprises of seven species. Out of which three species namely *Hippophae rhamnoides*, *Hippophae salicifolia*, *Hippophae tibetana* are cultivated in India (Stobdan *et al.*, 2017).

Seabuckthorn is an ecologically and economically important deciduous thorny shrub or small tree of 3-4 m in height. The berry-like fruit develops from the ovary or calyx tube connected to an ovary. Seabuckthorn berries are acidic with a mild sweet unique aroma. High amounts of vitamin-C, flavonoids, oils and oil-soluble compounds as well as minerals are present in the Seabuckthorn berry. Berries also contain many bioactive substances and are used as a medicinal purpose for treating several diseases, such as cardiovascular disease, cancer and acute mountain sickness and are available in the different forms such as liquids, pills, powders, pastes etc. The most important pharmacological functions of Seabuckthorn can be outlined as reducing inflammation, disinfecting bacteria, relieving pain, and promoting

regeneration of tissues. It has also been used in cosmetology, skin grafting and treatments of corneal wounds. Besides medicinal uses, the berries are also processed into various products such as juice and marmalade, and used for flavoring of dairy products because of their unique taste. A plant of Seabuckthorn predominantly is a dioecious species. Although, sexual polymorphism is found in some populations where plants are either hermaphrodite or monoecious or bear hermaphrodite flowers in addition to male and female flower on the same plant. The sex of seedling cannot be ascertained until they start to flower (Synge, 1974).

Hippophae salicifolia D. Don is a less known medicinal value species of *Hippophae*. Seabuckthorn is a dioecious plant whose flowers lacks nectar and fragrance with wind being the only mode of pollination. The pollen is released in large quantities when the air temperature reaches 6-10 °C. The pollen remains viable for 72 hours after dehiscence. The seed of Seabuckthorn shows epigeal form of germination (Bhowmik *et al.*, 2013). Freshly harvested seeds of Seabuckthorn shows physiological dormancy and thus do not germinate right after harvesting (Singh *et al.*, 2008) which can be overcome by the cold treatments that are naturally provided by the habitat they are growing in. Artificially, the dormancy in Seabuckthorn can be overcome by the cold stratification treatment or priming of seeds with chemical agents such as GA₃ to get faster and synchronized seed germination (Gupta, 2003). Propagation through seed is the easiest propagation method, however, this method is not preferred for commercial cultivation. It can also be propagated through vegetative propagation such as softwood cuttings, hardwood cuttings, and root cuttings and through suckers. Air layering has also been found to be useful in raising Seabuckthorn nurseries (Schroeder, 2017). Seabuckthorn being a dioecious plant have separate male and female plant. The seedling takes about 4-5 years to start flowering. The sex of the plant cannot be ascertained until they come to flower. The main reason for propagation through seed is that it can be further used for propagating or establishing an orchard through vegetative propagation. Despite its high medicinal value, it has received less attention. Therefore, with an aim to improving germination efficiency of Seabuckthorn seeds, the present study was carried out.

Materials and Methods

Experimental Details : There are two factors which consist of cold stratification and priming with GA. The experiment was laid out in factorial randomized block design with three replications. Each factor consists of different levels.

Collection and authentication of seed material : The mature healthy seeds of *Hippophae salicifolia* were collected from village Jhalla near Harsil on the way of Gangotri Dham during October when their fruits start ripening. The collected seeds were subjected to pre-sowing treatments such as stratification and priming with GA₃. Seed germination efficiency and seedling growth of Sea buckthorn seeds were evaluated.

Seed Pre-treatments : Seeds were surface sterilized by soaking in 5% sodium hypochlorite (NaOCl) solution for 10 min and subsequently rinsed thoroughly with sterilized water prior to stratification treatment.

Seed stratification : River sand with coarse texture was used as a medium for stratification. For stratification treatment seeds of Seabuckthorn were placed in between the layers of moist sand in petri-plate and then kept inside refrigerator at 5°C temperature for period of 7, 14 and 21 days. During this pre-treatment, care is taken to maintain proper moisture in the sand.

Seed Priming with GA₃ : For priming treatment, pre-stratified seed were soaked in different concentrations of GA₃ solution (100, 200, 300, 400 and 500 ppm) for a period of 24 hours. After 24 hours of soaking the 50 % of seeds were kept over Wattman filter paper in petri-dishes and then placed inside seed germinator with the temperature of 24±6 °C. The remaining 50 % seeds were sown inside natural ventilated polyhouse for germination.

Statistical Analysis : The data was analysed according to the procedure of analysis of variance for factorial completely randomized design (Snedecar and Cochran, 1988). There were 24 treatment combinations and each treatment was replicated thrice. The significant of variance among the treatments were observed by applying 'F' test and critical difference (CD) at 5 per cent level of significance was calculated to compare the treatment means for all the characters. The per cent data were transformed angularly before statistical analysis. The results are presented with the help of tables, graphs and photographs.

Observations Recorded : In this investigation, the following parameters were recorded with regard to seed germination and seedling growth:

Days taken for the first germination : The data for this parameter was recorded daily after the seeds were sown till the time of emergence of all the seedlings. The time taken from the date of sowing to the emergence of first germinated seedling was considered.

Germination percentage (%) : The germination in each treatment was recorded by visual observation every day till

Table-1 : Effect of stratification and priming on various characters of seedlings under Seed germinator.

Treatment combinations	Seed germinator			
	Days taken for first germination (Days)	Germination percentage (%)	Shoot length (cm)	Root length (cm)
S ₁ G ₀	30.33	21.33	2.97	0.47
S ₁ G ₁	17.00	96.00	2.87	0.61
S ₁ G ₂	17.67	92.00	3.71	0.48
S ₁ G ₃	16.33	98.67	3.96	1.09
S ₁ G ₄	16.00	98.67	3.96	0.69
S ₁ G ₅	13.67	100.00	4.23	0.60
S ₂ G ₀	25.33	32.00	3.30	0.50
S ₂ G ₁	15.33	94.67	4.28	0.53
S ₂ G ₂	12.33	94.67	4.34	0.72
S ₂ G ₃	14.00	97.33	4.34	0.48
S ₂ G ₄	12.67	100.00	4.63	0.51
S ₂ G ₅	13.33	68.33	2.33	0.65
S ₃ G ₀	24.67	42.67	3.09	0.39
S ₃ G ₁	12.67	97.33	4.20	0.44
S ₃ G ₂	13.33	96.00	4.46	0.73
S ₃ G ₃	14.67	93.33	5.02	0.43
S ₃ G ₄	14.67	92.00	4.00	0.42
S ₃ G ₅	12.00	97.33	4.22	0.25
S ₄ G ₀	18.67	54.67	3.70	0.17
S ₄ G ₁	9.00	96.00	4.16	0.24
S ₄ G ₂	9.00	93.33	4.33	0.34
S ₄ G ₃	9.00	88.00	3.87	0.48
S ₄ G ₄	10.00	84.00	5.69	0.46
S ₄ G ₅	9.67	89.33	3.42	0.27
Factors	C.D. at 5%	C.D. at 5%	C.D. at 5%	C.D. at 5%
Factor (S)	1.01	NS	0.25	0.01
Factor (G)	1.24	7.80	0.31	0.02
Factor (S X G)	2.48	15.60	0.62	0.03

S₁ (7 days Stratification), S₂ (14 days Stratification), S₃ (21 days Stratification), S₄ (28 days Stratification); G₀ Control (Distilled water), G₁ (GA₃ @ 100 ppm), G₂ (GA₃ @ 200 ppm), G₃ (GA₃ @ 300 ppm), G₄ (GA₃ @ 400 ppm) and G₅ (GA₃ @ 500 ppm)

there were no further germination of seedling was seen. When the plumule of the seeds emerged out of the soil surface the seeds were considered germinated. Number of seedlings were counted and finally expressed as germination percentage (%).

Seedling growth attributes : The data for this observation was recorded by selecting five seedlings randomly per replication.

Shoot length (cm) : The data for seedling height was recorded at 35 days after sowing. The height of the seedling was measured using a scale and expressed in cm. five seedlings per treatment were selected randomly for this observation.

Root length (cm) : The observation on root length was recorded 35 days after sowing. Five seedlings were selected randomly and measured with a scale.

Results and Discussion

Efficient propagation of nursery stock from seed requires

extensive knowledge of the germination methods and requirements needed for the species. Little is known about the propagation requirements for Seabuckthorn (*Hippophae salicifolia*). This deficit is due, in part, to a lack of demand for these species in the past. Extensive research work has been done on the propagation of other edible plants, specifically those of commercial value to the other industrial purpose. Information generated from the present study and the parameters taken are as follows.

Days taken for the first germination : The data presented in (Table-1 and Fig.-1) and (Table-2 and Fig. 2) reveals that, days taken for first germination was highest (30.33 days) under seed germinator and (71.00 days) under natural ventilated polyhouse when seeds were primed with distilled water (control). However, days taken for first germination was least (9.00 days) under seed germinator in S₄G₁ (28 Days stratification x GA₃ 100 ppm), S₄G₂ (28 Days stratification x GA₃ 200 ppm) and S₄G₃ (28 Days stratification x GA₃ 300 ppm) as compared to others in seed germinator, whereas (20.33 days) in S₄G₅ (28

Table-2 : Effect of stratification and priming on various characters of seedlings under natural ventilated polyhouse.

Treatment combinations	Natural ventilated polyhouse			
	Days taken for first germination (Days)	Germination percentage (%)	Shoot length (cm)	Root length (cm)
S ₁ G ₀	71.00	7.33	1.37	0.66
S ₁ G ₁	55.67	37.33	2.67	0.83
S ₁ G ₂	60.67	40.00	1.80	0.89
S ₁ G ₃	54.67	46.00	2.50	1.04
S ₁ G ₄	49.00	33.33	3.63	0.51
S ₁ G ₅	50.67	25.33	3.55	1.05
S ₂ G ₀	65.33	10.67	1.93	0.67
S ₂ G ₁	47.33	32.00	4.90	0.97
S ₂ G ₂	43.33	32.00	4.77	0.64
S ₂ G ₃	41.67	50.67	4.66	1.50
S ₂ G ₄	43.33	40.00	3.44	0.89
S ₂ G ₅	43.33	37.33	2.66	0.43
S ₃ G ₀	55.00	9.33	1.50	0.72
S ₃ G ₁	30.33	40.00	2.22	1.04
S ₃ G ₂	36.67	24.00	2.36	1.56
S ₃ G ₃	27.00	40.00	2.35	2.25
S ₃ G ₄	36.67	22.67	2.56	2.77
S ₃ G ₅	34.00	29.33	2.32	0.98
S ₄ G ₀	35.33	12.00	2.90	0.68
S ₄ G ₁	28.67	18.67	3.54	0.69
S ₄ G ₂	25.67	18.67	3.33	0.85
S ₄ G ₃	24.33	24.00	2.89	0.75
S ₄ G ₄	23.33	20.00	3.12	0.86
S ₄ G ₅	20.33	14.6	2.98	0.75

Factors	C.D. at 5%	C.D. at 5%	C.D. at 5%	C.D. at 5%
Factor (S)	0.98	2.85	0.07	0.02
Factor (G)	1.19	3.49	0.08	0.02
Factor (S X G)	2.39	6.98	0.17	0.05

Days stratification x GA₃ 500 ppm) under natural ventilated polyhouse.

Germination percentage (%) : The data presented in Table-1 and Table-2 also reveals that, mean seed germination percentage is significantly increasing when seeds treated with GA₃ concentrations up to a certain limit over control. However, germination percentage was observed to be highest (100.00 %) in treatment combination S₁G₅ (7 Days stratification x GA₃ 500 ppm) and S₂G₄ (14 Days stratification x GA₃ 400 ppm) under seed germinator whereas, (50.67 %) in S₂G₃ (14 days stratification x GA₃ 300 ppm) under natural ventilated polyhouse.

Shoot length (cm) : Perusal of the data presented in Table-1 and Table-2. indicates that, there were significant effect of stratification and gibberellic acid priming on shoot length. Shoot length of seedlings was highest (5.69 cm) in S₄G₄ (28 days stratification. x GA₃ 400 ppm) under seed germinator and (4.90 cm) S₂G₁ (14 days stratification x GA₃ 100 ppm) under natural ventilated polyhouse.

Root length (cm) : Root length was recorded maximum (1.09 cm) in S₁G₃ (7 days stratification x GA₃ 300 ppm) under seed germinator and (2.77 cm) in S₃G₄ (21 days stratification x GA₃ 400 ppm) under natural ventilated polyhouse.

The data presented in Table-1 and Table-2 reveals that, the significant decrease in the days taken for first germination with the increase in stratification days and rate of GA₃ may be due to resulting enhanced rate of cell division and metabolic activities in stratified and primed seed leads to early germination. Airi *et al.* (2009) reported that GA₃ treatments improved the mean germination time significantly in *Hippophae salicifolia*. Pipinis *et al.* (2012) also reported that cold stratification and GA₃ affect the metabolic and physiological activities of seeds which results in early germination. The increase in germination percentage when seeds were treated with GA₃ may perhaps be due to the action of GA₃ in the activation of enzymes as well as increased water absorption. It might also be because of the fact that GA₃ stimulates the

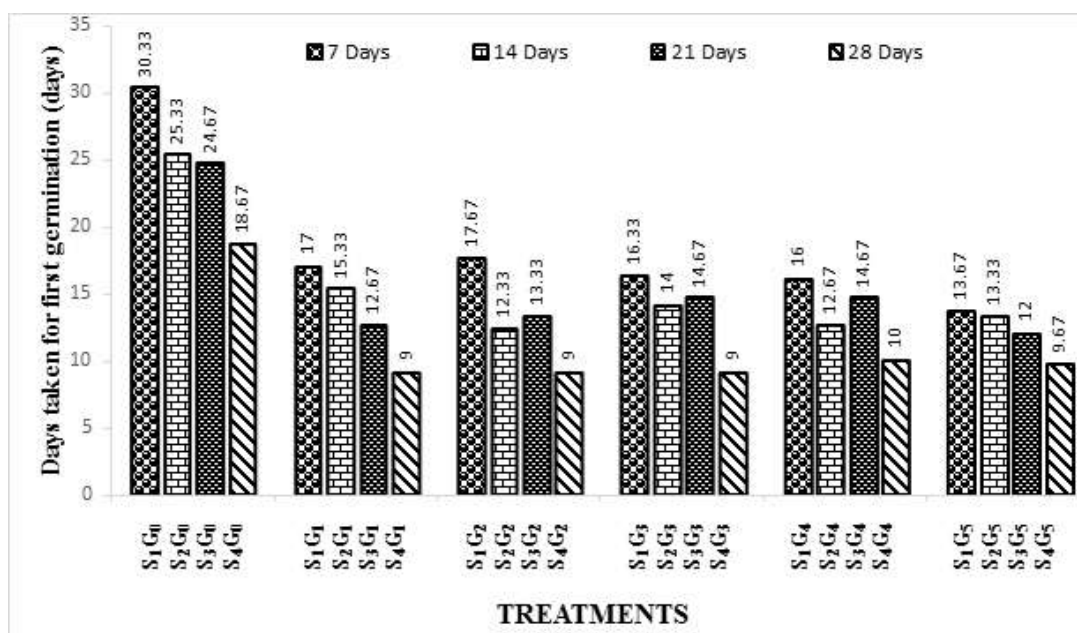


Fig.-1 : Effect of stratification and seed priming on days taken for first germination.

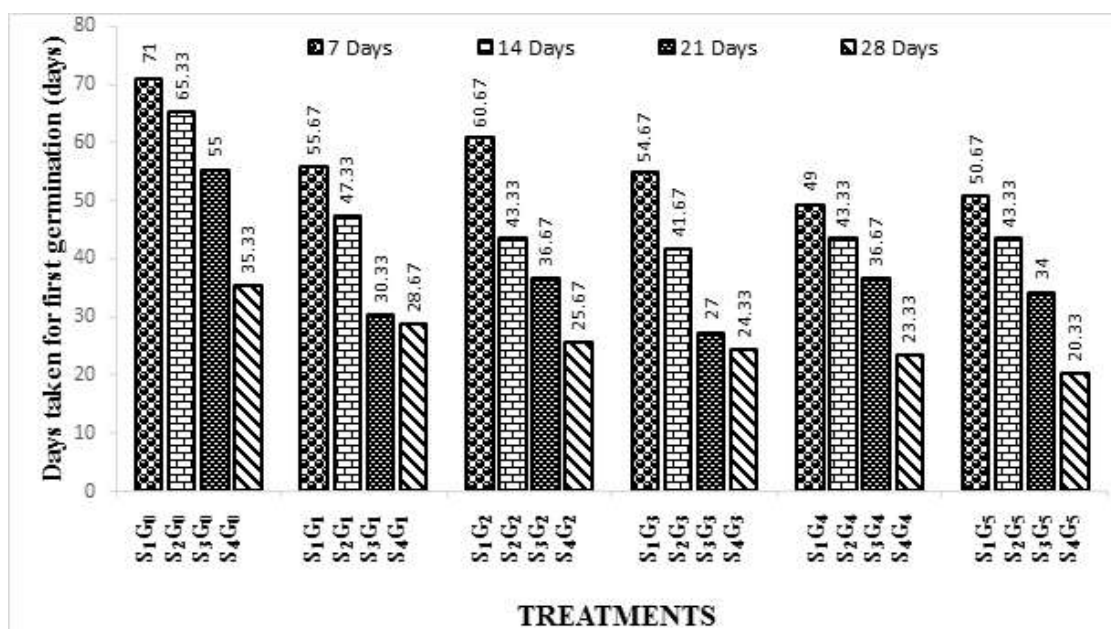


Fig.-2 : Effect of stratification and seed priming on days taken for first germination (Days).

formation of α -amylase enzyme which breaks down the insoluble form of starch into soluble sugars and also helps in radical growth by removing metabolic blocks. GA_3 in addition to cold stratification was reported to improve germination percentage in cherry seeds (Al-Absi, 2010). The increased height of shoot may be attributed to the reason that the endogenous levels of GA_3 synthesized by the seedlings might not be sufficient and external application of GA_3 might have boosted growth by increasing cell multiplication and cell elongation resulting in better plant growth. The resulting increase in root length when the seeds were subjected to stratification and

priming may be due to the effect of shoot growth which resulted in production of photosynthates which were translocated through phloem to the root zone.

Conclusions

The result obtained from the present experiment indicates that seed germination was greatly influenced by different pre-sowing treatments i.e., cold stratification and seed priming with GA_3 as compared to control. However, seeds subjected to 14 Days stratification and GA_3 300 ppm showed the best results. Thus, it can be concluded that treatment combinations S_2G_3 (14 Days stratification x GA_3

300 ppm) could be recommended for breaking the seed dormancy, enhancing seed germination and seedling growth of *Hippophae salicifolia* D. Don.

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Incidence Pattern of Gram Pod Borer in Chickpea under Agroclimatic Conditions of Eastern Uttar Pradesh

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Abstract

Field experiment entitiled "Incidence pattern of gram pod borer in chickpea under agroclimatic conditions of eastern Uttar Pradesh" were conducted during *Rabi*, 2020-21 at Agricultural Research Farm of B.R.D.P.G. College, Deoria (U.P.), India. The results revealed that the period of maximum activity was between 9th standard week to 13th standard week (March 1st week to April 1st week). The maximum mean population of moth/trap/week recorded in the 12th standard week (March 4th week) as peak population 17 when the maximum, minimum temperature and relative humidity 36 °C, 22 °C and 70% respectively, were recorded. The larval population (4.0 larvae/plant) peaked also in 12th standard week (March 4th week) coincided with full podding stage of the crop. Moth trap catches showed strong positive correlation with maximum ($r = 0.843$) and minimum ($r = 0.881$) temperature, however, negative correlation with relative humidity ($r = -0.179$) was observed. While, larval population exhibited strong positive correlation with maximum ($r = 0.946$) and minimum ($r = 0.932$) temperature, while negative association with relative humidity ($r = -0.312$).

Introduction

Chickpea (*Cicer arietinum* L.) is recognized as low priced protein food particularly in the developing countries, in order to meet their dietary requirement. Chickpea contains proteins, carbohydrates and fats at 21, 62 and 2.2% respectively and it forms an important part of Indian diet, as a vegetarian population is more in a country (Katerji *et al.*, 2001). Per capita availability of pulse in India was 43.0 gm per day and 14.4kg per annum and coming to chickpea per capita availability of chickpea was 14.6 gm per day and 5.3 kg per annum (Anonymous, 2013). Chickpea contains vitamin viz. Thiamine (0.5mg), Riboflavin (0.2mg), Niacin (1.5mg), Pantothenic acid (1.6mg), vitamin B6 (0.5 mg), Folate (557 mg), vitamin C (4.0 mg) and vitamin A (0.8 IU). India is a major pulse growing country of the world. In India chickpea grown about 9.55 million ha (m/ha) with a production 9.94 million tonnes and productivity 1041 kg/ha. The major growing States of chickpea are Rajasthan, Maharashtra, Madhya Pradesh, Uttar Pradesh, Karnataka, Gujarat, Andhra Pradesh and Jharkhand. Production and productivity of chickpea during year 2019 in Uttar Pradesh was 0.73 million ha, 7.32 million tonnes and 1272 kg/ha (Anonymous, 2019).

Coming to biotic stress, insect, nematodes, bird and vertebrates are causing damage to the crop but insect damage is more pronounced than the others. The major pests of chickpea are Cutworms and Termites during seedling stage of chickpea in certain areas, while gram pod borer, *Helicoverpa armigera* appears in vast number during vegetative and pod formation stage of chickpea

(Lal, 1996). Among insect pests, pod borer (*Helicoverpa armigera*) causes server damage to the crop have high reproduction rate wide genetic diversity across and toxic chemicals. Due to these reasons, pod borer have attained the status of national pest of India. Gram pod borer (*Helicoverpa armigera*) is a serious polyphagous pest commonly referred as Cotton bollworm, Tomato fruit borer and Tobacco budworm etc. based on the crop it feeds. A single larva can damage several chickpea pods prior to pupation and it was reported that 5 – 40 % pods were damage (Chauhan and Dahia, 1994). In India, loss due to *Helicoverpa armigera* chickpea was up to 27.95% NW plain zone, 13.2% in NE plain zone, 24.3% in central zone and 36.4% in South zone (Lateef and Reed, 1983). Larval population of *Helicoverpa armigera* are highly influenced by meteorological variables viz. temperature, relative humidity, rainfall, sunshine hours. A lot of works in past had been carried out to correlation these abiotic factors on population buildup of larval population of *Helicoverpa armigera* on different host. A definite impact of these meteorological variable on larval population has been suggested. The agro-climatic condition of this part of Eastern U.P. is quite different with scanty information. Therefore, it was fell imperative to study on these aspects so that the impact of abiotic factors on this dreaded insect pest can be established. Crop pest surveillance and its monitoring aids in successful pest management strategies. It enables the growers to get prepared for necessary management measures taken against the pest. It also enables the population buildup in that climatic condition recorded in that year. So, growers can take precaution of sowing dates and other management tactics, in order to escape from peak pest infestation.

Table-1 : Monitoring adult population of *Helicoverpa armigera* in chickpea during Rabi 2020-2021 along with Meteorological variables.

Month/week	Standard week (S.W.)	Moth catches/ trap/week	Maximum Temperature (°C)	Minimum Temperature (°C)	Relative humidity (%)
January 2 nd week	2	0	20.71	6.57	71.28
January 3 rd week	3	1	21.14	8.71	74.28
January 4 th week	4	2	18.71	6.57	80.85
February 1 st week	5	5	21.71	8.14	70.71
February 2 nd week	6	6	24.57	10.14	65.14
February 3 rd week	7	8	27.14	12.57	52.71
February 4 th week	8	9	30.57	15.14	40.71
March 1 st week	9	10	31.85	14.85	29.42
March 2 nd week	10	11	33.01	15.00	80.14
March 3 rd week	11	13	32.00	17.01	80.00
March 4 th week	12	17	36.00	22.00	70.00
April 1 st week	13	10	36.01	18.00	56.00
April 2 nd week	14	6	34.00	18.00	57.00
Correlation coefficient			0.843	0.881	-0.179

Table-4 : Weekly larval population of *Helicoverpa armigera*.

Month/Week	Standard week (S.W.)	No. of larvae (Per/plant)	Meteorological variable		
			Max. Temp. (°C)	Min. Temp. (°C)	RH (%)
Jan., 2 nd week	2	0.0	20.71	6.57	71.28
Jan., 3 rd week	3	0.0	21.14	8.71	74.28
Jan., 4 th week	4	0.2	18.71	6.57	80.85
Feb., 1 st week	5	0.4	21.71	8.14	70.71
Feb., 2 nd week	6	1.1	24.57	10.14	65.14
Feb., 3 rd week	7	1.7	27.14	12.57	52.71
Feb., 4 th week	8	2.8	30.57	15.14	40.71
Mar., 1 st week	9	3.0	31.85	14.85	29.42
Mar., 2 nd week	10	3.0	33.01	15.00	80.14
Mar., 3 rd week	11	3.5	32.00	17.01	80.00

Materials and Methods

The present study was carried out at the Agriculture Research Farm of B.R.D.P.G. college Deoria (U.P.), India. The chickpea seed variety Shulabh - 45 was sowing with row to row and plant to plant spacing 30 cm. and 10 cm, respectively. For this purpose two pheromone traps were installed in the field with the help of bamboo sticks at 2.0 meters height above the ground level. The male moths of *Helicoverpa armigera* were attracted towards the pheromone trap and slipped into plastic polythene bag through the funnel. Observations on male moth catches were recorded daily from 2nd week of January to 2nd week of April 2021. Pheromone lure was replaced by a new one at every 21 days interval. Observations on larval population were recorded at weekly interval from 10 randomly selected plants in the field.

Results and Discussion

Monitoring adult population of *Helicoverpa armigera* and

correlation between abiotic factors The data presented in Table-1 revealed that none of the moth trapped when it was installed i.e. 2nd standard week. The moth activity could be recorded for the first time in the 3rd standard week when maximum temperature was 21.14°C, minimum temperature 8.71°C and relative humidity was 74.28 per cent. After first appearance moths were regularly trapped in subsequent weeks till 14th standard week, the last observation (harvest period). Moth trap catches increased in successive weeks and reached its peak during 4th week of March (12 standard week) where 17 male moths/trap/week were recorded the meteorological variables recorded during the peak activity moth as maximum temperature 36.00°C, minimum temperature 22.00°C and relative humidity 70.00 per cent. The revealed that population of *Helicoverpa armigera* were highly positively correlated with maximum temperature (°C) as well as with minimum temperature (°C), showing correlation values of 0.843 and 0.881, respectively. A mild negative correlation was recorded between relative

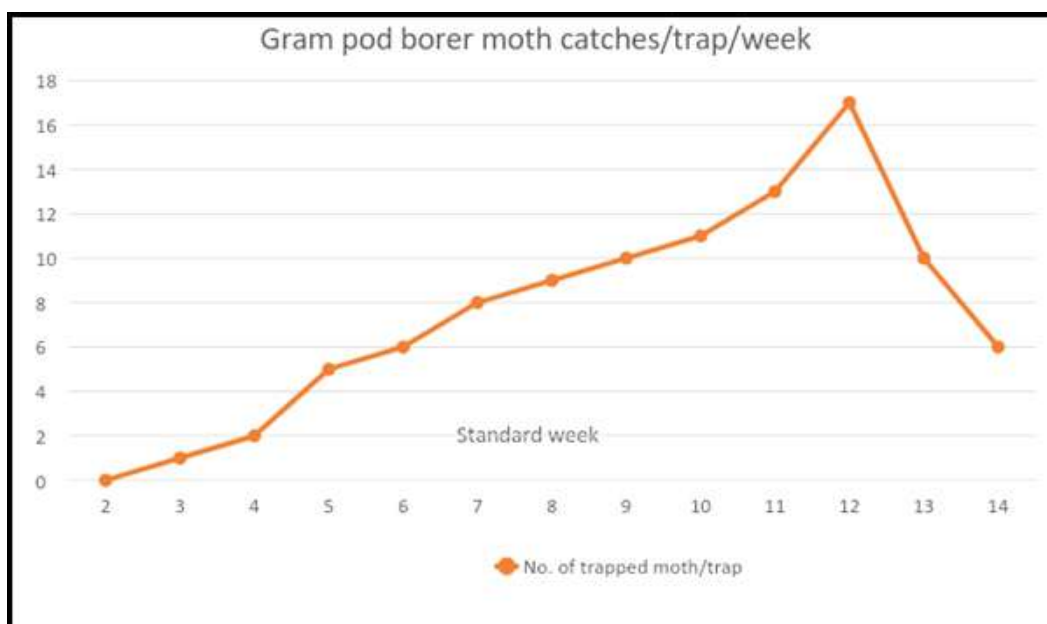


Fig-1 : Monitoring adult population of *Helicoverpa armigera* in chickpea during Rabi 2020-21.

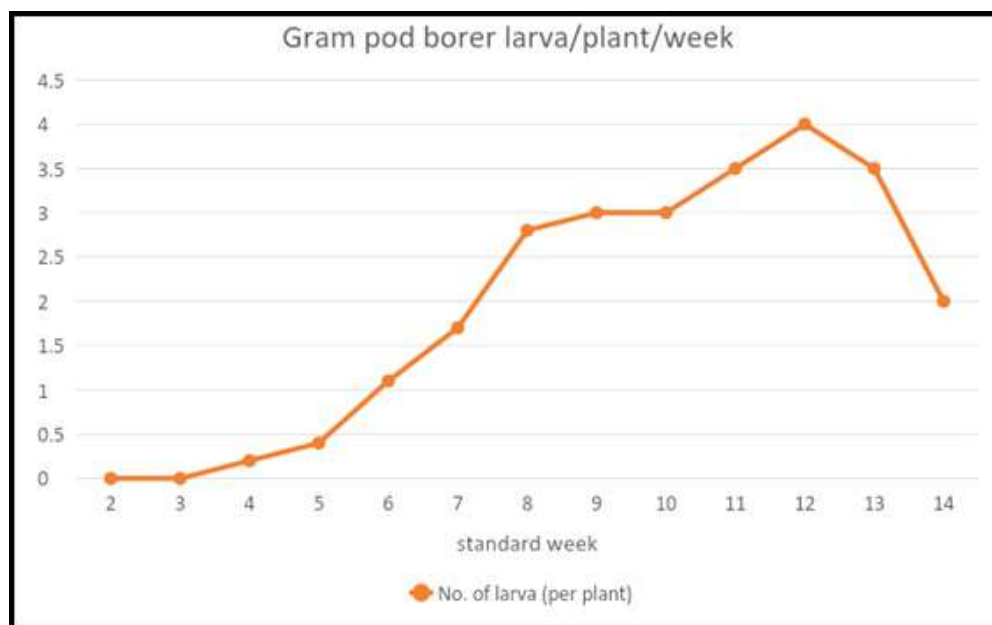


Fig-2 : Weekly larval population of *Helicoverpa armigera*.

humidity (%) and *Helicoverpa armigera* population showing correlation value of (-0.179). The present results are in partially agreement with that of Mahapatra *et al.* (2007) observed higher number of moths of *Helicoverpa armigera* trap during March and April months and similar to that of Sharma *et al.* (2012) who recorded maximum number of moth during 12th standard week. Pal *et al.* (2014) recorded peak capability of moth during 3rd to 4th week of February, Spoorthi *et al.* (2017) during 9th standard week (4th to 10th March) when maximum and minimum temperature 27.6 °C and 11.1 °C, respectively, relative humidity 75 per cent was recorded. In Madhya

Pradesh Khadse *et al.* (2018) recorded maximum number of male moths trapped were 29.92/ trap/week during 2nd standard week (January 8th to January 14th).

Incidence pattern of *Helicoverpa armigera* larvae and correlation between abiotic factors : The data presented in Table-2 revealed that the larvae of *Helicoverpa armigera* was not observed in the first two weeks i.e. 2nd and 3rd standard week when maximum temperature was 20.71 to 21.14 °C, minimum temperature 6.57 to 8.71 °C and relative humidity was 71.28 to 74.28 per cent. The incidence of larval population was commenced from 4th standard week with 0.2 larvae

per plant when maximum temperature was 18.71°C, minimum temperature 6.57°C and relative humidity was 80.85 per cent. After appearance larvae population start to increase in subsequent weeks till 12 standard week, followed by decreased subsequent. Peak population (4.0 larvae/plant) was recorded in 12 standard week (March 4th week) when there was maximum temperature 36.00°C, minimum temperature 22.00°C and relative humidity 70.00 per cent. Peak larval population was coincided with full podding stage of the crop. The results of correlation study between larval population of *Helicoverpa armigera* and abiotic factors revealed positive correlation with maximum temperature and minimum temperature and relative humidity had negative correlation (Waseem and Thakur, 2019; Kumar et al., 2019; Malik et al., 2016; Nadaf and Kulkarni, 2006 and Pandey et al., 2012) conformed the present results.

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Bolting, Quality and Bulb Yield of Onion as Influenced by Seedling Age and PGRs

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Abstract

The response of 6, 8 and 10 week old seedlings of onion cv. N-53 was studied along with foliar application of Cycocel (500 and 1000 ppm), Ethephon (2000 and 2500 ppm) and Paclobutrazol (1000 and 2000 ppm) in factorial Randomized block design replicated thrice during late *kharif* season of 2014-2015 at Research Farm of the Division of Vegetable Science, SKUAST, Jammu. The results showed maximum equatorial diameter (6.11cm), TSS (9.63°B), bulb yield/ plot (9.54 kg), total bulb yield (212.06 q/ha) in 8 week old seedlings. The minimum bolting was recorded in 8 week old seedlings (16.99%) which were statistically superior 6 and 10 week old seedlings. It is obvious from the results; application of paclobutrazol 2000ppm recorded the maximum polar diameter (4.13 cm), equatorial diameter (5.79cm), TSS (9.49°B), bulb yield/plot (8.57 kg) and total bulb yield (190.78 q/ha) along with the lowest bolting (35.99%). Interactive results between seedling age and plant growth hormones showed maximum equatorial diameter (6.80cm), TSS (11.50°B), bulb yield/plot (12.77 kg), total bulb yield (283.70 q/ha) and lowest bolting (9.64%) in the treatment having 8 week old seedlings with 2000 ppm paclobutrazol (A₂P₂).

Key words : Bolting, bulb yield, PGRs, quality, seedling age.

Introduction

Onion (*Allium cepa* L.) 2n=2x=16, is an important bulb crop belonging to *Alliaceae* family. It is cultivated in at least 170 countries of the world for being essential in food and medicine. In recent years, it has gained the importance of a cash crop because of its very high export potential. It is commonly known as "Queen of kitchen" due to its highly valued flavor, aroma and unique taste. Its cultivation is highly technical and depends on environmental conditions such as photoperiod and temperature (Steer, 1980). The factors like improper nitrogen fertilization, seedling age at the time of transplanting, hormonal imbalance of the plant, *etc.* also affect the quality and yield of onion. During early growth and development, onion requires cool temperatures (6-20°C), but during bulb initiation and development, warmer temperature (25-27°C) is required (Ansari, 2007).

Pre-initiation of flower stalk to bulb development referred as bolting, is one of the serious problem challenging onion bulb production round the world. The hollow stalk represents a single internode, elongating out of the innermost leaf base. Flower initiation however, occurs only after the emergence of certain number of leaves, depending on cultivar, followed by exposure of the plant to extreme temperatures (Brewster, 1985). Plant hormones play an interesting role in modern agriculture to improve and hasten physiological processes of plants (Ashraf *et al.*, 2010). Relatively slow growth and early cessation of cell elongation are the characteristics that

can be directly linked to scape formation. Their role as anti-gibberellins (Ouzounidou *et al.*, 2010) can be utilized in various growth process in onion such as bulbing (Levy *et al.*, 1973), bolting (Izquierdo and Corgan, 1980) and senescence (Levy *et al.*, 1972). By keeping in view the above reports, aim of work to measure the response of seedlings age and PGRs on quality, bolting and bulb yield of onion.

Materials and Methods

The present study was conducted at Vegetable Research Farm, Division of Vegetable Science and Floriculture, SKUAST, Chatha, Jammu situated at 33°55' N latitude and 74° 58' East longitudes with altitude of 296 meter above mean sea level during late *kharif* season of 2014-2015. The experiment was laid out in factorial randomized block design (FRBD) with three replications comprising of three seedling age (6, 8 and 10 week old) and seven plant hormonal treatments viz., Cycocel 500 ppm, Cycocel 1000 ppm, Ethephon 2000 ppm, Ethephon 2500 ppm, Paclobutrazol 1000 ppm, Paclobutrazol 2000 ppm and Control-distilled water spray. Transplanting was done at a spacing of 15 x 10cm between rows and plants in the plot size 2.25 x 2.0 m accommodating 300 plants per plot. Fertilization, cultural operations and plant protection measures were followed as recommended for commercial production. Three consecutive spray of each plant hormone was made in the morning hours at critical phases of onion *i.e.* 30, 60 and 90 days after transplanting.

Table-1 : Result of seedling age and PGRs on bolting, quality and bulb yield of onion.

Treatments	Polar diameter (cm)	Equatorial diameter (cm)	TSS (°B)	Bolting (%)	Bulb yield/plot (kg)	Total yield/ha (q)
Seedling age (in weeks)						
A ₁ (6 week old)	3.69	3.42	6.90	85.05	3.15	70.06
A ₂ (8 week old)	3.91	6.11	9.63	16.99	9.54	212.06
A ₃ (10 week old)	3.97	5.30	8.22	27.77	7.74	171.95
SEm+	0.11	0.09	0.20	1.10	0.39	8.62
CD (P=0.05)	NS	0.25	0.58	3.16	1.11	24.63
PGRs (ppm)						
C ₁ (Cycocel 500 ppm)	3.87	4.88	8.25	47.61	6.03	134.09
C ₂ (Cycocel 1000ppm)	3.81	5.17	8.53	52.41	7.48	166.18
E ₁ (Ethephon 2000ppm)	3.66	4.52	7.61	42.53	5.82	129.38
E ₂ (Ethephon 2500ppm)	3.85	4.38	7.20	39.98	5.30	117.77
P ₁ (Paclobutrazol 1000ppm)	3.76	5.34	9.00	38.26	7.59	168.64
P ₂ (Paclobutrazol 2000ppm)	4.13	5.79	9.49	35.99	8.57	190.78
C ₀ (Control)	3.94	4.50	7.69	46.12	6.87	153.08
SEm+	0.17	0.13	0.31	1.69	0.59	13.16
CD (P=0.05)	NS	0.37	0.89	4.82	1.69	37.62
Interaction effect of seedling age and PGRs						
A ₁ C ₁	3.83	3.24	7.47	86.33	2.77	61.50
A ₁ C ₂	3.77	3.96	7.67	94.33	3.57	79.27
A ₁ E ₁	3.57	3.10	6.47	85.33	3.07	68.17
A ₁ E ₂	3.80	2.97	5.95	81.67	2.50	55.53
A ₁ P ₁	3.63	3.43	7.07	80.67	2.97	65.93
A ₁ P ₂	3.60	3.98	7.40	79.00	3.70	82.23
A ₁ C ₀	3.63	3.27	6.27	86.00	3.50	77.77
A ₂ C ₁	3.73	6.23	9.26	21.76	8.30	185.20
A ₂ C ₂	3.58	6.30	9.34	25.32	10.43	231.87
A ₂ E ₁	3.54	5.83	8.80	16.64	7.60	168.87
A ₂ E ₂	3.96	5.73	8.53	14.12	7.40	164.43
A ₂ P ₁	3.80	6.53	11.17	11.20	11.10	246.67
A ₂ P ₂	4.37	6.80	11.50	9.64	12.77	283.70
A ₂ C ₀	4.42	5.33	8.83	20.27	9.17	203.70
A ₃ C ₁	4.04	5.17	8.02	32.73	7.00	155.57
A ₃ C ₂	4.08	5.25	8.58	37.57	8.43	187.40
A ₃ E ₁	3.86	4.63	7.56	25.63	6.80	151.10
A ₃ E ₂	3.79	4.44	7.11	24.15	6.00	133.33
A ₃ P ₁	3.86	6.07	8.77	22.90	8.70	193.33
A ₃ P ₂	4.41	6.60	9.97	19.33	9.23	205.20
A ₃ C ₀	3.76	4.91	7.97	32.10	8.00	177.77
SEm+	0.29	0.23	0.54	2.92	1.03	22.79
CD (0.05)	NS	0.65	NS	NS	NS	NS
CV (%)	13.10	7.90	10.80	11.70	26.5	26.1

The data were recorded on ten randomly selected bulbs from each replication for polar diameter (cm), equatorial diameter, TSS (°Brix), bolting percentage, bulb yield per plot and total bulb yield. Polar and equatorial diameter of bulbs (cm) was measured with the help of

digital Vernier calliper. The TSS of extracted juice was determined by a hand refractometer (RHB-62 Model). Total number of plants per plot showing emergence of flower stalk were counted and divided by the number of established plants in each plot and the percentage bolting was calculated. Bulb harvesting was done when they fully

developed, leaves started turning-yellowish colour and 50% of the plants showed neck fall. Bulbs harvested from the each experimental plot were weighted and yield per 4.5 m² was calculated. The results were later on magnified for 10,000 m², keep 30% area out for channels and bunds. The recorded data were averaged and statistically analysed (Steel and Torrie, 1981) using the statistical programme by OPSTAT.

Results and Discussion

The response of age of seedlings, plant growth regulators and their interaction on different characteristics has been given in Table-1.

Seedling age : The maximum polar diameter of bulbs (3.97 cm) was recorded in 10 week old seedlings which was non-significant as compared to 6 and 8 week old seedling. Maximum equatorial diameter of bulbs (6.11cm) was noted in 8 week old seedlings which was statistically superior to 10 and 6 week old seedlings (5.30 & 3.42cm). Similarly, the maximum TSS (9.63°B) was observed in 8 week old seedlings which was significantly higher to 10 and 6 week old seedlings (8.22 & 6.90°B), respectively. Minimum bolting was recorded in 8 week old seedlings (16.99%) which were statistically superior to 6 and 10 week old seedlings (85.05 & 27.77%), respectively. The reason of high bolting in 6 week old seedlings might be that in the thermophase plants were exposed to temperature ranging between 17-29°C which inhibits all the category of seedlings to show transition from vegetative to generative stage. Therefore, the factor responsible for bolting is length of the juvenile phase and the corresponding optimum temperature. The similar findings have also been reported by Singh and Chaure (1999).

Plant growth regulators : The exogenous application of plant growth regulators at various concentrations significantly influenced the quality, bolting and bulb yield traits of onion. Application of paclobutrazol at 1000 and 2000ppm was found statistically superior as compared to ethephon treatments. The maximum polar diameter of bulbs was noted with paclobutrazol 2000ppm (4.13cm) which was higher than rest of the treatments but statistically not significant. Maximum equatorial diameter of bulbs was recorded with paclobutrazol 2000ppm (5.79cm) which was significantly higher than rest of the treatments. Reduction in polar and equatorial diameter of bulb due to exogenous application of growth inhibitors was might be due to restricted growth and less nutrient conception that might have resulted in lower carbohydrate synthesis by the plant (Hye *et al.*, 2002). Maximum TSS (9.49°B) was recorded with paclobutrazol 2000ppm which

was statistically superior to rest of the treatments but at par with its lower concentration *i.e.* 1000ppm. Increase in TSS content due to paclobutrazol was might be due to the efficiency of this chemical to control bolting percentage of the bulbs and accumulate higher initial food reserve in the bulbs leading to maximum soluble content (Arvin and Banakar, 2002).

Least bolting percentage was recorded in paclobutrazol 2000ppm (35.99%) which was found statistically superior to rest of the treatments including control except paclobutrazol 1000ppm and ethephon 2500ppm. Such response of growth retardants might be due to the active movement of these inhibitors from the leaves into the bulb tissues at the time of bulb maturity thereby lowering down GA₃ levels and responsible for transition for vegetative to reproductive stage (Kielak and Bielinska-Czarnecka, 1987). The highest bulb yield (8.57 kg/ plot) and total bulb yield (190.78 q/ha) was obtained in paclobutrazol 2000ppm (35.99%) which was at par with paclobutrazol 1000ppm and significantly increased bulb yield than remaining treatments. Reduction in yield traits was might be due to inhibition of vegetative growth of onion that might have resulted in low carbohydrate synthesis by the plants and later reduced yield (Hye *et al.*, 2002). The similar results are findings of Natlob and El-Habar (1983).

Interactive effect of Seedling age and PGRs : As manifest from the recorded data that seedling age and different concentrations of plant growth regulators exposed significant interaction. The maximum equatorial bulb diameter (6.80cm) was recorded with paclobutrazol 2000ppm on 8 week old seedlings (A₂P₂) which was at par with cycocel 500ppm (A₂C₁), cycocel 1000ppm (A₂C₂) and paclobutrazol 1000ppm (A₂P₁). However, the interaction effect between seedling age and plant growth regulators showed non-significant results for polar diameter (cm), total soluble solids (°B), bolting percentage, bulb yield (kg/ plot) and total yield (q/ ha). The impact of paclobutrazol on yield factors was clearly due to the reduction in scape formation of the plants leading to show later stage of bolting. Such reactions of the crop directly impact yield and its attributed (Soo *et al.*, 2002).

Conclusions

The above findings, it is concluded that 8 week old seedlings followed by three successive foliar spray of paclobutrazol 2000ppm (A₂P₂) at 30, 60 and 90 days after transplanting gave maximum polar bulb diameter (cm), equatorial bulb diameter (cm) total soluble solids (°B), bulb yield (kg/ plot), total yield (q/ ha) and the lowest bolting observed in onion.

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Nutritional and Sensorial Study of Barley Flour Blended Biscuits

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Abstract

The present work was carried out to see the effect of different ratio of Wheat and Barley on the chemical and quality of Multigrain biscuits. The different proportions of Wheat flour, barley flour and all other ingredients (sugar, ammonium bicarbonate, sugar, fat, skim milk powder and baking powder) were collected from market. Multigrain biscuits were formulated by blending refined wheat flour with barley flours in the ratios of 100:0::WF:BF; 95:05::WF:BF; 90:10::WF:BF; 85:15::WF:BF; 80:20::WF:BF; 75:25::WF:BF; 65:35::WF:BF and 60:40::WF:BF. Incorporation of barley flour led to increase in mean fibre % EV, Ash%, calcium, phosphorus and iron contents of the biscuits. Whereas decreased in moisture%, carbohydrates%, protein% and fat%. In terms of sensory scores, T6 (75:25: WF: BF) was scored highest overall acceptability whereas T8 (60:40::WF:BF) scored lowest. There was a significant decline in mineral contents as well as sensory attributes. Economically, the blended biscuits were found to be cheaper and nutritious as compared to commercially available multigrain biscuits.

Key words : Barley, colour, texture, fat, protein and carbohydrates.

Introduction

Due to changing lifestyle, the people have started demanding ready to cook or ready to serve convenience foods. Among ready-to-eat snacks, biscuits possess several attractive features including wider consumption base, relatively longer shelf-life, more convenience and good eating quality (Hooda and Jood, 2005).

Bakery products are an item of mass consumption in view of its low price and high nutritive value. Consumers demand healthier bakery products and some of the popular trends in the market are the introduction of low/light, functional, natural and organic products (Jamuna and Suresha, 2012). In addition to healthier products, consumers are also purchasing products that satisfy their taste buds.

Cereals grain and their derivatives are main human food and they are a vital source of energy Evans (2001), Keser (2016) and Koehler and Weiser. (2013). The modern trend in the production and consumption of cereals, have a healthy, ecological and social influence. The entire world fights with various diseases, typical for the modern world— obesity, osteoporosis, cancer, diabetes, allergies and dental ailments. The developing countries in the globe also face difficulties in dealing with aging of the population, high energy food consumption and unbalanced diets Cencic and Chingwaru (2010). Although wheat is considered a good and cheap source of energy and other nutrients, it has a low nutritional value. Proteins in cereals are deficient in the essential amino acids lysine and threonine. Because of that, the exchange (completely or partially) of wheat with healthier cereal

grains helps improve the nutritional value of wheat products Noorfarahzilah *et. al.*, (2014).

Globally barley (*Hordeum vulgare*) is grown. It is a cereal grain, which has been used for bread production since the Neolithic Ullrich *et. al.*, (2008). Barley flour is often used as a partial substitute of wheat flour in the production of cereal-based products due to high levels of α -glucans, lignans, phenolic compounds and many essential vitamins and minerals Jukic *et. al.*, (2018).

Methods and Materials

Experimental materials : The wheat and pea was procured from the local market and all other ingredients (sugar, vegetable oil, glucose, ammonium bicarbonate, common salt sodium bicarbonate, vanilla and baking powder) were purchased from the retail market and department. The materials were transported to department.

Preparation biscuits through selected wheat and pea sprouted grains : Processing of selected grains: - The grains (wheat and barley) were washed and cleaned to remove the dirt, dust and foreign matter by winnowing.

Development and standardization of baked products (Biscuits) : First of all studies were conducted to standardize the formulation for the development of the different cereal-pulses based baked products. Biscuits were processed using the traditional creamery method described by Kamaliya and Kamaliya (2001).

Proximates analysis : Moisture, carbohydrates, Protein, Fat and Ash in samples were estimated by method as prescribed in AOAC (1984).

Table-1 : Wheat and barley flour combination of biscuits.

S.N.	Treatments	Wheat %	Barley %
1.	T1	100	-
2.	T2	95	5
3.	T3	90	10
4.	T4	85	15
5.	T5	80	20
6.	T6	75	25
7.	T7	65	35
8.	T8	60	40

Estimation of Minerals : Mineral content of biscuits were estimated through the Gopalan table values (Gopalan *et. al.* 2000). **Energy Value:** -The total energy values were estimated with using Total energy (kcal/100g) = [(% available carbohydrates x 4) + (% protein x 4) + (% fat x 9)] by the Gopalan *et. al.*, (2000).

Sensory evaluation : The organoleptic properties of nutritious wheat barley based biscuits were evaluated by the Amerine *et al.*, (1965).

Statistical analysis : The data were analyzed by variance (ANOVA) and the least significance difference to estimate the difference between means through STATA 14.0 software. The Completely Randomized Design (CRD) at 5% level of significant.

Result and Discussion

Proximate composition of wheat and barley biscuits

Moisture content : The result of present investigation clearly (table 2) indicated the data regarding moisture content of combination of wheat and barley based biscuit is of great significances for many scientific and economic reasons. Moisture contents ranged from 3.65 to 5.20 per cent. The results show that biscuits with T8 treatment had the lowest moisture content (3.65%) while biscuits with T3 treatment had the highest moisture content (5.20%). Moisture and water activity values have been increased with time and sensory scores decreased as reported by Chowdhury, (2012).

Ash content : Ash content of wheat and barley based biscuit products ranged from 1.62 to 1.77 per cent. Highest ash content in T8 treatment (1.77%) and least ash content in T2 treatment (1.62%) depicted in Table 2. The values of ash content obtained in present study were in close agreement to the value of ash content in barley Aly *et. al.*, (2021).

Calcium content : Calcium content ranged from most in T8 (22.68 mg) and least in T2 (21.70 mg) are expressed in Table-2. Results shows that supplemented of barley to the wheat improved their calcium content Lovis (2003) reported 15 mg calcium in wheat bread.

Carbohydrates content : The carbohydrates content of wheat and barley based biscuit products ranged highest in T2 treatment (65.47%) and least in T8 treatment (65.28%) are shown in Table 2. Carbohydrates revealed that there non-significant difference among the formulations. Similar work was reported by Hussain *et. al.*, (2018).

Fat content : The fat content of wheat and barley based biscuit products ranged from highest in T2 treatment (1.65%) and least in T8 treatment (1.55%) are presented in Table 2. A significant difference was observed in the fat content of wheat and barley biscuits. Similar work was reported by Hussain *et. al.*, (2018).

Iron (Fe) content:- The iron content of wheat and barley based biscuit products ranged from highest in T2 treatment (2.48 mg) and least in T8 treatment (2.14 mg) are depicted in Table 2. Similar work was carried out by El-Hadary *et. al.*, (2018) that increasing of phosphorous, Zn, Ca and Fe content in biscuits due to supplementation of malted barley flour at the level 25-35% in.

Fibre content : The fibre content of wheat and barley based biscuit products ranged from highest in T8 treatment (3.70%) and least in T2 treatment (3.17%) are presented in Table 2. The mean fibre content of wheat and barley supplemented biscuits was significantly higher than the control biscuits. Rana *et. al.*, (2021) reported similar trend of increasing of fibre content in ragi supplemented cookies.

Phosphorous (P) content : The phosphorous content of wheat and barley based biscuit products ranged from highest in T8 treatment (148.63 mg) and least in T2 treatment (117.80 mg) are represented in Table-2. All barley supplemented biscuits contained significantly higher amount of phosphorous content than that if wheat biscuits. El-Hadary *et. al.*, (2018) reported increasing trend of phosphorous, Zn, Ca and Fe content in malted barley flour supplemented level 25-35% in biscuits.

Protein content : The protein content of wheat and barley based biscuit products ranged from highest in T2 treatment (12.00%) and least in T8 treatment (11.70%) are presented in Table 2. The protein content of all the barley supplemented biscuits was significantly lower than that of control biscuits the close agreement to the value of (12.00 to 14.00%) reported by Sudha *et. al.*, (2006).

Effect of sensory score combination of the wheat and barley biscuit

The result of present investigation clearly (table-3) Different types of biscuits were developed from wheat and barley are subjected to sensory test.

Table-2 : Proximate composition of wheat and barley blended biscuits.

Treatments	Moisture %	Carbo-hydrates	Protein	Fat	Fibre	EV	Ash	Ca	P	Fe
T1	4.65	65.99	12.13	1.68	3.12	330.39	1.61	21.72	114.25	2.55
T2	4.70	65.96	12.09	1.67	3.19	329.74	1.63	21.86	118.69	2.50
T3	5.20	65.93	12.05	1.65	3.27	329.08	1.65	22.00	123.13	2.45
T4	4.70	65.91	12.00	1.64	3.35	328.42	1.67	22.14	127.57	2.40
T5	4.10	65.88	11.96	1.62	3.42	327.77	1.69	22.28	132.01	2.35
T6	4.30	65.85	11.92	1.61	3.50	327.11	1.72	22.43	136.44	2.31
T7	4.15	65.80	11.83	1.58	3.65	325.80	1.76	22.71	145.32	2.21
T8	3.65	65.77	11.79	1.56	3.73	325.14	1.78	22.85	149.76	2.16
Sem±	0.095	0.037	0.037	0.041	0.034	0.027	0.040	0.027	0.027	0.031
CD>5%	0.293	0.114	0.114	0.126	0.104	0.083	0.125	0.084	0.084	0.095
CV%	3.792	0.097	0.537	4.411	1.680	0.014	4.088	0.212	0.035	2.308
Sig	S	S	S	S	S	S	S	S	S	N

Table-3 : Sensory score combination of the wheat and barley biscuit.

Treatments	Appearance	Colour	Crispiness	Taste	Texture	Overall Acceptability
T1	7.65	7.95	7.80	8.05	8.25	7.94
T2	7.45	7.40	7.45	7.30	7.85	7.49
T3	7.65	7.35	7.85	7.45	7.90	7.64
T4	7.55	7.55	7.80	7.80	7.35	7.61
T5	7.45	7.45	7.65	7.70	7.50	7.55
T6	7.85	7.95	8.20	8.40	8.10	8.10
T7	7.15	7.70	7.20	7.15	7.30	7.30
T8	7.35	6.75	7.50	7.10	7.25	7.19
Sem±	0.040	0.030	0.033	0.037	0.040	0.034
CD>5%	0.125	0.093	0.101	0.114	0.122	0.104
CV%	0.934	0.700	0.738	0.844	0.908	0.774
Sig	S	S	S	S	S	S

Appearance : The maximum appearance was found to be in treatment T2 (7.87) whereas minimum appearance was found to be in treatment T8 (7.09). Appearance was found to be significantly lower in wheat based biscuit. The scores for appearance could be due to the Millard reaction Narender *et. al.*, (2007).

Colour : Sensory scores of wheat and barley based biscuit ranged from 6.84 to 7.80 in colour. The maximum colour was found to be in treatment T3 (7.80) whereas minimum colour was found to be in treatment T7 (6.84). Colour was found to be significantly lower in wheat based biscuit. The improved scores for colour could be due to the Millard reaction Narender *et. al.*, (2007).

Crispiness : Sensory scores of crispiness in wheat based biscuit were found to be in treatment T1 (7.37). Sensory scores of wheat and barley based biscuit ranged from 7.29 to 8.12 in crispiness. The maximum crispiness was found to be in treatment T3 (8.12) whereas minimum crispiness was found to be in treatment T7 (7.29). Crispiness was found to be significantly lower in wheat based biscuit. Similar findings were reported by Hooda and Jood (2005).

Taste : The taste is the most desirable sensory attribute in bakery and confectionery group of food products. Any manipulations that reduce the fat level of biscuit will result in diminished acceptance. The sensory scores of barley based biscuit were presented Table 3. Sensory scores of wheat and barley based biscuit ranged from 7.08 to 7.80 in taste. The maximum taste was found to be in treatment T6 (7.80) whereas minimum taste was found to be in treatment T7 (7.08). Taste was found to be non-significantly lower in wheat based biscuit. Similar work also reported by Ikuomola *et. al.*, (2017).

Texture : Sensory scores of wheat and barley based biscuit ranged from 6.74 to 8.15 in texture. The maximum texture was found to be in treatment T6 (8.15) whereas minimum texture was found to be in treatment T8 (6.74). Texture was found to be non-significantly lower in wheat based biscuit. Ikuomola *et. al.*, (2017).

Overall Acceptability : Sensory scores of wheat and barley based biscuit ranged from 7.07 to 7.87 in overall acceptability. The maximum overall acceptability was found to be in treatment T6 (7.87) whereas minimum overall acceptability was found to be in treatment T8

(7.07). Overall acceptability was found to be non-significantly lower in wheat based biscuit. Ikuomola et. al., (2017).

Conclusions

The aim of the study was to optimize the blending ratio and develop the delicious, nutritious and cheaper biscuits. Many types of snacks are available in market of which biscuits are the common in most households is an opportunist medium to be played upon to cater per cent daily requirements of nutrients. A standardization experiment thus carried out for preparation of multigrain biscuits with maximum incorporation as well as sensory acceptability was conducted. A biscuit preparation was standardized with 75 per cent replacement was the most accepted variation.

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Effect of Foliar Application of Micronutrients on Morpho-Physiological and Biophysical Parameters for Enhancing the Productivity in Bt Cotton

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Abstract

A field experiment was conducted during kharif 2019-20 to know effect of foliar application of micronutrients on morpho-physiological parameters for enhancing the productivity in Bt cotton at the Agriculture Research Station, University of Agricultural Sciences, Dharwad, Karnataka. The experiment consisted of nine treatments viz., FeSO_4 , ZnSO_4 , MgSO_4 , MnSO_4 , Boron and combination of $\text{MnSO}_4 + \text{ZnSO}_4$, $\text{MgSO}_4 + \text{ZnSO}_4$ and $\text{FeSO}_4 + \text{ZnSO}_4$ foliar spray of all these at 70 and 90 DAS. The experiment was laid out in randomized block design with three replications. Among all the treatments, foliar application on micronutrients with MgSO_4 1% + ZnSO_4 0.5% at 70 and 90 DAS recorded significantly highest plant height, monopodial, sympodial, total dry matter production, number of bolls per plant and seed cotton yield as compared to other treatments. It was on par with the treatment FeSO_4 0.5% + ZnSO_4 0.5% and treatment MgSO_4 1% and the minimum yield and yield components were recorded under control. Significantly highest photosynthetic rate ($27.5 \mu \text{mol CO}_2 \text{ m}^{-2} \text{ sec}^{-1}$) recorded in MgSO_4 1% + ZnSO_4 0.5% as compared to all treatments and Significantly highest seed cotton yield (2393 kg ha^{-1}) was recorded in foliar spray with MgSO_4 1% + ZnSO_4 0.5% as compared to control (1788 kg ha^{-1}). It is concluded that, application of foliar spray with MgSO_4 1% + ZnSO_4 0.5% at 70 and 90 DAS was more effective in increasing the yield in Bt-cotton as compared to other treatments.

Key words : Cotton, foliar spray, micro-nutrient, yield.

Introduction

Cotton (*Gossypium* spp.) popularly known as “the white gold” is an important commercial fiber crop grown under diverse agro-climatic conditions around the world. It provides fiber and raw material for textile industry along with cotton seed and plays a vital role in economy of the country. India contributes about 25 % of the world's cotton production. In India, the area about 13.4 million hectares with the production of 360 lakh bales and having productivity of 455 kg ha^{-1} , among the cotton producing major states are Gujarat, Maharashtra, Andrapradesh and Karnataka. In Karnataka, cotton is cultivated under area of 8.17 lakh hectare with production of 23 lakh bales and productivity of 522 kg ha^{-1} . (Anon., 2019-20)

Bt-cotton is a genetically engineered cotton crop that produces an insecticidal protein derived from the genome of a soil bacteria known as *Bacillus thuringiensis*, often known as Bt. many subspecies of *B. thuringiensis* are present in soils and are known to be harmful to certain insect genera while being harmless to other living organism (Kranthi, 2012).

Cotton requires sufficient quantity of macro and micro nutrients to achieve the maximum seed cotton yield. Micronutrients deficiency in cotton increases abscission of boll and finally affects the yield of cotton and are directly related to physiological process in plant and helps in increasing the production by improving the

reproduction phase Dubey *et. al.*, (2000). External supplementation of plant nutrients needs to be therefore emphasized keeping in view their role in improving yield. Essential micronutrients like Zinc, Iron, Manganese, Copper, Boron and Manganese play an important role in physiology of cotton crop and these are being a part of enzyme system or catalyst in enzymatic reactions. They are required for plant activities such as aspiration, meristmatic development, chlorophyll formation, photosynthesis, energy system, protein and oil synthesis, gossypol, tannin and phenolic compounds development. Certain micronutrients may help to secure uniform emergence, rapid seedling growth and healthy plant stand (Radhika *et. al.*, 2013).

Materials and Methods

A field experiment was conducted during kharif season of 2019-20 at Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka. The experiment was laid out in Randomized Block Design with three replications in 5.4 x 4.5 m plot size with spacing of 90 cm x 60 cm. The trial comprised of nine treatments viz, T_1 : foliar spray of FeSO_4 0.5 % at 70 and 90 DAS, T_2 : foliar spray of ZnSO_4 0.5% at 70 and 90 DAS, T_3 : foliar spray of MgSO_4 1 % at 70 and 90 DAS, T_4 : foliar spray of MgSO_4 0.5 % at 70 and 90 DAS, T_5 : foliar spray of Boron 0.2 % at 70 and 90 DAS, T_6 : foliar spray of MgSO_4 0.5 % + ZnSO_4 0.5% each at 70 and 90 DAS, T_7 : foliar spray of MgSO_4 1 % + ZnSO_4 0.5% each at 70 and 90 DAS, T_8 : foliar spray

Table-1 : Effect of foliar application of micronutrients on plant height (cm) monopodial branches, sympodial branches, total dry matter (g plant⁻¹) and Leaf area index to enhance production in Bt cotton.

Treatments		Morphological parameters				Leaf area index (dm ² plant ⁻¹)
		Plant height (cm)	Monopodial branches	Sympodial branches	Total dry matter (g plant ⁻¹)	
T1	Foliar spray of FeSO ₄ 0.5 % at 70 and 90 DAS	126.53	3.67	16.33	190.43	2.56
T2	Foliar spray of ZnSO ₄ 0.5% at 70 and 90 DAS	127.17	3.67	17.33	191.40	2.57
T3	Foliar spray of MgSO ₄ 1 % at 70 and 90 DAS	129.40	4.00	19.00	209.60	2.63
T4	Foliar spray of MgSO ₄ 0.5 % at 70 and 90 DAS	125.83	3.67	16.00	177.27	2.51
T5	Foliar spray of Boron 0.2 % at 70 and 90 DAS	127.97	3.67	17.67	199.40	2.59
T6	Foliar spray of MgSO ₄ 0.5 % + ZnSO ₄ 0.5% each at 70 and 90 DAS	126.43	3.67	16.33	189.43	2.55
T7	Foliar spray of MgSO ₄ 1 % + ZnSO ₄ 0.5% each at 70 and 90 DAS	130.40	4.33	20.33	224.50	2.75
T8	Foliar spray of FeSO ₄ 0.5 % + ZnSO ₄ 0.5% each at 70 and 90 DAS	129.63	4.33	20.00	218.13	2.72
T9	Control	122.13	3.33	15.67	153.57	2.10
	Mean	127.28	3.81	17.74	194.86	2.55
	S. Em.±	1.05	0.30	1.09	4.32	1.55
	CD at 5%	3.08	0.87	3.19	13.87	4.54

of FeSO₄ 0.5 % + ZnSO₄ 0.5% each at 70 and 90 DAS and T₉ Control. Seeds were sown by hand dibbling and the recommended dose of nitrogen, P₂O₅ and K₂O were applied by top dressing (100:50:50 kg N: P₂O₅: K₂O ha⁻¹). Observation like, plant height (cm), Number of monopodial and sympodial branches, total dry matter (g), Photosynthetic rate (μmol co₂ m⁻² sec⁻¹), Total chlorophyll content (mg/gm fresh weight), leaf area index (dm² plant⁻¹), number of bolls per plant, boll weight (g boll⁻¹) and yield (kg ha⁻¹) are recorded as per the standard procedure.

Results and Discussion

The plant height, number of monopodial and sympodial branches per plant and total dry matter production plant differed significantly due to foliar feeding of micronutrients. The data showed that the foliar application of MgSO₄ 1 % + ZnSO₄ 0.5% at 70 and 90 DAS (T₇) recorded significantly higher plant height (130.4 cm), monopodial and sympodial branches per plant (4.3 and 20.3, respectively), total dry matter production (224.5 g plant⁻¹) and leaf area index (2.75 dm² plant⁻¹) as compared to other treatments. It was on par with the treatment (T₈) FeSO₄ 0.5 % + ZnSO₄ 0.5%. T₃ MgSO₄ 1 % and (T₅) foliar spray of Boron 0.2 %. Significantly lesser plant height (122.13 cm), monopodial branches per plant (3.33), sympodial branches per plant (15.67), total dry matter production (153.57 g plant⁻¹) and leaf area index (2.10 dm² plant⁻¹) were noticed in the control (T₉) (Table 1). These results are in conformity with findings with Singh, *et al.* (2016), Patil *et al.* (2015), Shivamurthy and Biradae

(2014), and Sarour *et al.* (1988). The reason for higher morphological parameters might be due to active participation of micronutrients in plant metabolism by activating the enzymes, increasing in both cell division and cell elongation in apical meristem in growing parts leading to increased length of internodes.

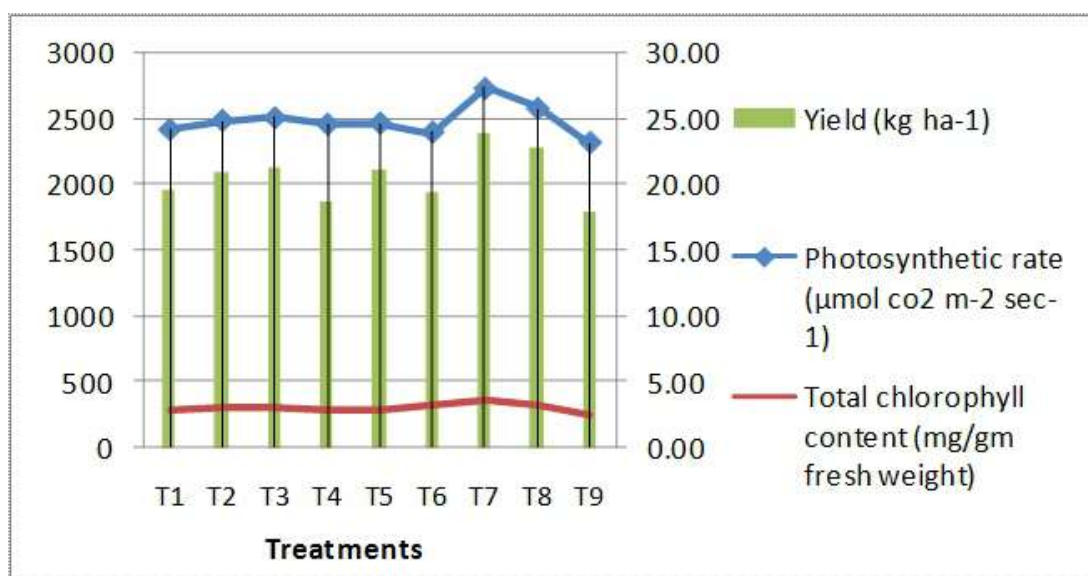
Significantly high rate of photosynthesis was recorded in MgSO₄ 1%+ZnSO₄ 0.5% (27.5 μmol co₂ m⁻² sec⁻¹) whereas lowest photosynthetic rate was recorded in control (23.10 μmol co₂ m⁻² sec⁻¹). Highest chlorophyll content was noticed in MgSO₄ 1%+ZnSO₄ 0.5% (3.60 mg/g/fr./wt.) while least chlorophyll content was recorded in control (2.51 mg/g/fr./wt.) (Table-2).

Application of MgSO₄ 1% + ZnSO₄ 0.5% recorded the highest photosynthetic rate as compared to control and other treatments. This increase in photosynthetic rate is attributed to an increase in stomatal aperture, which allows for greater Co₂ conductance (Kumar *et al.*, 2005)

The experimental results showed that foliar application of MgSO₄ 1%+ZnSO₄ 0.5% at 70 and 90 DAS (T₇) recorded significantly higher cotton yield (2393 kg ha⁻¹), higher number of bolls per plant, (46.0) and single boll weight (6.35 g boll⁻¹) compare to the other treatments and was on par with the treatment (T₈) FeSO₄ 0.5% + ZnSO₄ 0.5 %, (T₃) MgSO₄ 1% and (T₅) foliar spray with Boron 0.2 %. Significantly lower cotton yield (1788 kg ha⁻¹), least number of bolls per plant, (37.6) and boll weight (5.11 g boll⁻¹) were recorded in control (T₉) (Table-2). Foliar application of these nutrients might have

Table-2 : Effect of foliar application of micronutrients on photosynthetic rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ sec}^{-1}$), total chlorophyll content (mg/gm fresh weight), Yield (kg ha^{-1}), Number of bolls plant⁻¹ and boll weight (g boll⁻¹) to enhance production in Bt cotton.

Treatments		Yield and yield components				
		Photosynthetic rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ sec}^{-1}$)	Total chlorophyll content (mg/gm fresh weight)	Number of bolls plant ⁻¹	boll weight (g boll ⁻¹)	Yield (kg ha^{-1})
T1	Foliar spray of FeSO_4 0.5 % at 70 and 90 DAS	24.10	2.91	39.1	5.31	1954
T2	Foliar spray of ZnSO_4 0.5% at 70 and 90 DAS	24.80	3.00	41.1	5.41	2080
T3	Foliar spray of MgSO_4 1 % at 70 and 90 DAS	25.00	3.11	44.7	5.86	2120
T4	Foliar spray of MgSO_4 0.5 % at 70 and 90 DAS	24.50	2.86	37.9	5.15	1859
T5	Foliar spray of Boron 0.2 % at 70 and 90 DAS	24.60	2.94	42.4	5.55	2113
T6	Foliar spray of MgSO_4 0.5 % + ZnSO_4 0.5% each at 70 and 90 DAS	23.90	3.15	38.5	5.19	1935
T7	Foliar spray of MgSO_4 1% + ZnSO_4 0.5% each at 70 and 90 DAS	27.25	3.60	46.0	6.35	2393
T8	Foliar spray of FeSO_4 0.5% + ZnSO_4 0.5% each at 70 and 90 DAS	25.72	3.20	45.6	6.06	2276
T9	Control	23.10	2.51	37.6	5.11	1788
	Mean	24.77	3.03	41.4	5.55	2058
	S. Em.±	0.27	0.11	2.4	0.20	102.2
	CD at 5%	0.64	0.33	6.9	0.58	306.5



helped in more photosynthetic activity and better partitioning of dry matter. These results are in conformity with findings of Singh, *et al.*, (2016), Singh *et al.*, (2015) and Sankarnarayanan *et al.*, (2010) who reported that the application of MgSO_4 (1.0%) + ZnSO_4 (0.5%) micronutrients significantly increased the boll weight no of bolls per plant yield. This is due to increased plant metabolic activity, meristematic development and energy system and protein synthesis.

Conclusions

Based on the experimental results, it could be concluded that, foliar application of MgSO_4 1% + ZnSO_4 0.5 % significantly increased the plant, number of sympodial and monopodial branches per plant, total dry matter

production, photosynthetic rate, Total chlorophyll content, number of bolls per plant, boll weight and cotton yield.

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Comparative Economic Analysis of Local and Cross Breed Dairy Cows in Yadgir District of Karnataka

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Abstract

The paper analyses the comparative economics of local and cross breed cows in Yadgir district of Karnataka using the data collected from 60 farmers (30 local and 30 crossbred cow rearing farmers) by adopting multistage sampling design in the year 2020-2021. The costs incurred, returns realized, benefit cost ratios were estimated for local and crossbred cow rearing in Yadgir district of Karnataka. The total cost of crossbred cow rearing was higher (₹ 83014 per cow per annum) than local cow rearing (₹ 44313 per cow per annum). Among the total cost, feed and fodder costs accounted major share (more than 50% each) followed by labour cost and total fixed cost. The gross returns per cow per year stood at ₹ 62467 for local breed cows while it was ₹ 139034 for cross breed cows. The net returns realized per cow per year was relatively higher for crossbred cow rearing (₹ 56021) as compared to local cow rearing (₹ 18154). The crossbred cow rearing was found to be more profitable in the study area with a benefit-cost ratio of 1.67, while it was 1.40 for local cow rearing. The observed benefit cost ratio for both local and crossbred cow rearing in the study area suggests dairy farming with crossbred cow is more profitable as compared to dairy farming with local cows, therefore there is a need to provide financial assistance through enhanced scale of finance to the dairy farmers by institutional agencies.

Key words : Local cow, crossbred cow, cost and returns analysis and BCR.

Introduction

Agriculture is the principle source of employment and income in rural areas of India. The livestock sector is the sub sector of agriculture is an important activity of the rural population in India. The livestock sector occupies a vital role in the country's economy, with a share of 4.11 per cent to the total GDP of the country. Around 25.60 per cent of the total value of agricultural production is derived from this sector, of which the contribution of milk sub-sector is the highest (Anonymous, 2021).

Milk is an important primary source of income for 80 million rural households engaged in dairying in India. India ranks first in milk production, accounting for 18.5 per cent of world production, achieving an annual output of 198.40 million tons during 2019-20 as compared to 187.75 million tons during 2018-19 recording a growth of 5.68 per cent. The per capita availability of milk in India has increased from 176 grams per day in 1990-91 to 407 grams per day in 2019-20, which is more than the world average of around 305 grams per day in 2020. Although there is considerable increase in milk production over years the productivity has not been improved. One of the main reasons for such low productivity is, dairying not practiced with economic outlook.

Karnataka state has a total cattle population of about 8.46 million among which about 3.90 million are crossbreeds and about 4.56 million are local breeds. Karnataka produced 8.3 million tonnes of milk in 2019-20. The per capita availability of milk in the state is 344 gm. Among the different milk producing districts of Karnataka, Yadgir is one of the important milk producing district with a production of 89 thousand tonnes of milk in 2019-20. Karnataka has large network of dairy cooperatives and Karnataka Milk Federation (KMF) is the largest cooperative dairy federation in South India, owned and managed by milk producers of Karnataka. KMF has over 2.46 million milk producers in over 14,497 dairy cooperative societies at village level, functioning under 14 District Cooperative Milk Unions in the Karnataka state.

Anecdotal evidence suggests that dairy farming with large ruminants- especially cows and buffaloes constituting both local and crossbreeds are increasing in the district because of its higher relative profitability when compared to other activities. However, literature reviews suggest a lack of studies on cost and returns and profitability of dairy farming in general and comparative economics of local and cross breed cows in particular in Yadgir. Therefore, an attempt is made in the present study to analyse the comparative profitability of local and

Table-1 : Comparative cost of rearing local and crossbreed cow. (₹/year/animal)

Sl. No.	Particulars	Local breed cow			Crossbreed cow			Difference	
		Quantity	Price (₹)	Value (₹)	Quantity	Price (₹)	Value (₹)	Value (₹)	Per cent
A	Variable cost								
1	Dry fodder (kg)								
a	Paddy straw	1189.90	3.20	3808.00 (8.59)	1241.00	3.20	3971.00 (4.78)		
b	Bhoosa	109.50	12.00	1314.00 (2.97)	182.50	12.00	2190.00 (2.64)		
c	Jowar straw	778.40	3.58	2787.00 (6.29)	788.40	3.58	2822.00 (3.40)		
	Sub Total	2077.80		7908.00 (17.85)	2160.80		8984.00 (10.82)	1076.00	13.61
2	Green fodder (kg)								
a	Green grass	2883.50	0.75	2163.00 (4.88)	120.45	0.75	90.00 (0.11)		
b	Napier	2211.95	1.00	2212.00 (4.99)	6960.45	1.00	6960.00 (8.38)		
c	Sorghum grass	532.95	1.00	533.00 (1.20)	7500.90	1.00	7500.00 (9.04)		
	Sub Total	5628.40		4908.00 (11.07)	14581.80		14552.00 (17.53)	9644.00	196.50
3	Concentrate (kg)								
a	Tur bran	1689.95	4.00	6760.00 (15.25)	3869.00	4.00	15476.00 (18.64)		
b	Cotton cake	94.90	7.00	664.00 (1.50)	319.00	7.00	2233.00 (2.69)		
c	Pashu feed	156.95	13.00	2040.00 (4.60)	558.45	13.00	7259.00 (8.75)		
	Sub Total	1941.80		9464.00 (21.36)	4646.45		24967.00 (30.08)	15503.00	163.81
	Total feed cost (1+2+3)			22280.00 (50.28)			48504.00 (58.43)	26224.00	117.70
4	Labour (man days)			13565.00 (30.61)	96.22		21169.00 (25.50)	7604.00	56.06
5	Insemination & Veterinary cost			981.00 (2.21)			1730.00 (2.08)	749.00	76.35
6	Miscellaneous costs			588.00 (1.33)			1442.00 (1.74)	854.00	145.24
	Total variable cost			37414.00 (84.43)			72845.00 (87.75)	35431.00	94.70
B	Fixed costs								
1	Depreciation on animals			5584.00 (12.60)			8140.00 (9.80)	2556.00	45.77
2	Depreciation on cattle shed			1088.00 (2.45)			1715.00 (2.07)	627.00	57.63
3	Interest on fixed capital			226.00 (0.51)			313.00 (0.38)	87.00	38.50
	Total fixed cost			6898.00 (15.57)			10168.00 (12.25)	3270.00	47.41
	Total cost			44313.00 (100.00)			83014.00 (100.00)	38701.00	87.34

Note : Figures in the parentheses indicate percentage to total.

crossbreed cows, which helps in improving dairy development activities in the district. This can help the Karnataka Milk Federation (KMF) officials, Animal Husbandry Department, extension personnel and planners to tailor suitable strategies to orient dairy farmers

to increase herd size, milk yield, profit and facilitate for the better social impact of dairy farming.

Research Methodology

Multistage random sampling design was adopted in

Table-2 : Comparative profitability of rearing local and crossbreed cow. (₹/animal/year)

Sl. No.	Total production	Local breed cow			Crossbreed cow			Difference	
		Quantity	Price ₹/unit	Returns (₹)	Quantity	Price ₹/unit	Returns (₹)	Returns (₹)	Per cent
A.	Main product (milk in lit)	1415.75	41.71	59051.00	4339.80	31.00	134534.00	75483.00	127.83
B.	By-product (manure in tonne)	0.72	1500.00	1080.00	1.20	1500.00	1800.00	720.00	66.67
C.	Milk products			1496.00			880.00	-616.00	-41.18
D.	Sale of calves			840.00			1821.00	981.00	116.79
	Gross returns (A+B+C+D)			62467.00			139034.00	76567.00	122.57
E.	Total costs			44313.00			83014.00	38701.00	87.34
F.	Net returns			18154.00			56021.00	37867	208.59
G.	Returns per rupee of investment			1.40			1.67	-	-

selection of district, taluks, villages and farmers maintaining local and crossbreed cows. Yadgir district was purposively selected in the first stage as Yadgir is one of the districts reported to be having highest number of local and crossbreed cow population in Kalyan Karnataka region. At second stage, two taluks namely Shahapur and Shorapur were selected based on highest number of local and crossbreed cattle population. At third stage three villages from each taluka were selected based on the above criteria and finally five farmers rearing local and five farmers rearing crossbreed cows from each village were selected through snow ball sampling technique to collect the data required for the study. The data for the year 2020-21 was collected with the help of specially designed schedule.

Tabular analysis : The tabular analysis was employed for computation of cost of cow rearing and returns from cow rearing. In order to facilitate interpretation of findings, statistical measures like percentages, ratios and averages were also worked out wherever necessary.

Cost and returns from cow rearing : The total cost of rearing cow constituted fixed cost and variable cost. The fixed cost is the cost that does not vary with the level of output. The fixed cost included interest on fixed cost, which was considered 10 per cent which is the prevailing interest rate on borrowings. The depreciation worked out separately for milch animals and cattle shed keeping in view the present value and lifetime of the asset. Depreciation on milch animal was calculated by using diminishing balance method. At the end multiply already available written down value of animal by $r/100$.

$$\text{Depreciation} = \frac{\text{Value of animal} \times \text{rate of interest}}{100}$$

Depreciation on cattle shed and store was calculated by using straight line method.

$$\text{Depreciation} = \frac{\text{Original value} - \text{Junk value}}{\text{Productive life}}$$

The variable costs include three major items i.e. feed

and fodder cost, labour cost and veterinary and miscellaneous expenditure. The feed and fodder cost was comprised of dry fodder, green fodder and concentrates to animals. In case of purchased feed and fodder, the cost was worked out as product of quantity fed to animal and purchase price of respective feed. In case of home-grown feed and fodder, the relevant prices were the farm-harvest prices and if farm-harvest prices were not available, the imputed value of crop was taken at prevailing price in the village. When the concentrate feed was prepared at home, its cost was computed by taking the weighted prices of ingredients used in the concentrate. The labour cost included cost of family as well as paid labour (hired labour). The cost of hired labour was calculated considering type of work allotted and wages paid whereas, family labour costs were determined on the basis of existing wage rate of permanent farm labour.

The expenditure on breeding and health care of the animals was covered under the veterinary expense. It included, cost of artificial insemination (AI), natural service, vaccination, medicines, fee of veterinary doctor and other related expenses. The miscellaneous expenditure included expenses on repair of fixed assets, water and electricity charges, insurance premium and any other incidental charges.

The returns from cow rearing consisted of value of milk sold, values of cow dung, return from milk products and return from sale of calf. The returns from milk were calculated on the basis of the average quantities of milk yield per cow and average price received per litre of milk. Returns from cow dung were found out by taking average price at which cow dung was sold in the study areas. The returns from calf were calculated by dividing the value of calf by the age of the calf in number of days during the period of data collection.

Results and Discussion

An effort was made to estimate the comparative cost and returns of local and crossbreed cow rearing. The total cost

per cow per year was estimated, considering the quantity of feed and fodder, labour used, insemination and veterinary services, their respective market price and wages prevailed in the study area.

Comparative cost of rearing local and crossbreed cow : To understand the comparative economics of rearing local and crossbreed cow, the costs incurred for the different input factors- variable as well as fixed costs per cow per year was worked out and presented in Table-1.

With respect to inputs used for the local and crossbreed cow rearing, the utilization of dry fodder per cow per year was comparatively more in case of crossbreed cow (2160 kg) than that of local cow (2077 kg). Consumption of paddy straw, bhoosa and jowar straw in case of local cow were 1190 kg, 109 kg, and 778 kg, respectively. And in case of crossbreed cow, the consumption of these dry fodders were 1241 kg, 182 kg and 788 kg per cow per year respectively. The average green fodder utilization was more in case of crossbreed cow (14582 kg) compared to local cow (5628 kg). Consumption of green grass, napier grass and sorghum grass in case of local cow were 2884 kg, 2212 kg, and 533 kg respectively and in case of crossbreed cow, the consumption of same was 120 kg, 6960 kg and 7500 kg respectively. With respect to concentrates, comparatively more consumption was seen in the case of crossbreed cow (4646 kg) than that of local cow (1942 kg). Consumption of *tur* bran, cotton cake and pashu feed in case of local cow were 1690 kg, 95 kg and 157 kg respectively and in case of crossbreed cow, the consumption of these concentrates were 3869 kg, 319 kg and 558 kg respectively. The results showed that the crossbreed cow consumes more inputs like dry fodder, green fodder and even the concentrates like *Tur* bran, cotton cake and pashu feed than local cow.

It can also be observed from Table-1 that, among the variable costs, the cost of dry fodder, green fodder, concentrates, labour cost, veterinary services and miscellaneous cost were higher in case of crossbreed cow rearing compared to local cow rearing. Among the fixed costs there was no much difference between the local and crossbreed cow rearing.

The cost incurred in local and crossbreed cow rearing revealed that variable cost incurred was more in case of cross breed cow (₹ 72845) rearing compared to local cow (₹ 37414) rearing. Among the total cost, the variable cost accounts 84 per cent in local cow rearing as against 88 per cent in crossbreed cow rearing. The total variable cost incurred for rearing crossbreed cow was around 95 per cent higher than local cow.

The distribution pattern of variable costs under various inputs revealed that the per cow per year cost of dry fodder was more in case of cross breed cow (₹ 8984) than in local cow (₹ 7908). Cost of various dry fodders were, for paddy straw ₹3808, for bhoosa ₹1314 and for jowar straw ₹ 2787 in case of local cow and for crossbreed cow the costs were ₹3971, ₹2190 and ₹2822 respectively. Similar pattern was observed in case of green fodder consumption also, green fodder cost was more in the case of cross breed cow (₹ 14552) than in local cow (₹ 4907). The costs of green grass, napier grass and sorghum grass were ₹2163, ₹2212 and ₹ 533 in case of local cow and same was ₹ 90, ₹6960 and ₹7501 in case of crossbreed cow. The cost of concentrates was also more in case of crossbreed cow (₹ 24968) compared to local cow (₹ 9464). The cost of various concentrates were, *tur* bran (₹6760), cotton cake (₹664) and pashu feed (₹ 2040) in case of local cow, while it was ₹15476, ₹2233 and ₹7260 for crossbreed cow. Feed cost accounted for the major share of gross cost varying from 22280 (51%) in local cow rearing to 48504 (58%) in crossbreed cow rearing. The notable point in the study was that concentrates played a significant role in increasing the total feed cost in both the category. All the constituents of feed like dry fodder, green fodder and concentrates were used at a higher quantity for crossbreed cow in expectation of getting higher milk yield, as the average milk yield in the study area was 12 litres for crossbreed cow and it was 4 litres for local cow. The feed and fodder consumption is low in local cow as the local breeds are less feed consumers.

On an average 62 man days and 96 man days of labour was used per cow per year in local and crossbreed cow rearing. The cost of labour per cow per year was ₹ 13565 (31%) in case of local cow, which was ₹21169 (25%) in crossbreed cow. The labour cost was found to be higher in case of crossbreed cow rearing than in local cow rearing. This was due to the fact that crossbreed cows being more susceptible to diseases, they are devoted utmost care and management and they consume more feed and fodder. This leads to relatively more use of labours in cleaning, washing, grass collection and feeding operations in crossbreed cow farm.

Insemination and veterinary cost per cow per year was high in case of crossbreed cow (₹ 1730) compared to local cow (₹981). This is because of the reason that crossbreed cows were more sensitive to different diseases than local cows and majority of the crossbreed cow rearing farmers own a veterinary consultant. Most of the local cow rearing farmers used locally traditional breeding system to inseminate their cows by local bull at free of cost or sometimes paid cost. The miscellaneous

cost was ₹ 588 for local cow and was ₹ 1442 for crossbreed cow.

The fixed cost incurred was ₹ 6898 (16%) in case of local cow rearing and it was ₹ 10169 (12%) in crossbreed cow rearing. The total fixed cost incurred for rearing crossbreed cow was around 48 per cent higher than local cow rearing. Among the different items of fixed costs, depreciation on animal was the highest in both the cases. In case of localcow, it was ₹ 5584 and the same was ₹ 8140 in case of crossbreed cow. Higher value of depreciation was observed for crossbreed cow than local cow, this is because of the higher purchase value of crossbreed cow. The depreciation value on local cow shed was less (₹ 1088) compared to crossbreed cow shed (₹ 1715) as most of the localcow rearing farmers constructed the sheds using locally available materials like bamboo poles, mud, grass, thatch, bricks, coconut fronds, etc. Interest on fixed cost was of minor importance.

The main objective of dairy farming is to maximize the milk production; this was fulfilled by feeding the animal with the green and dry fodder as well as concentrates. Thus the feed charges formed more than half of the total cost incurred in both local and crossbreed cow rearing. Total cost per cow per year was also higher for crossbreed cow (₹ 83014) rearing than local cow (₹ 44313) rearing as more inputs were used in the crossbreed cow rearing. The additional cost incurred for rearing crossbreed cow was ₹ 38701, which was 87 per cent more as compared to local cow rearing.

Comparative profitability of rearing local and crossbreed cow : To assess the comparative profitability of rearing local and crossbreed cow, the returns realised from dairy farming in terms of milk (main product), milk products (ghee and curd) and farm yard manure are compared with total cost of rearing a cow. In addition to this, net returns realised and Benefit-cost ratio was also calculated, the findings are presented in Table-2. In dairy farming, returns were obtained in four ways; milk was the major source of returns as it is the main product in the production process. By using the dung and litters of the left over fodder on the floors of the shed, farm yard manure was prepared which was the additional source of revenue in the rearing of cows. Sale of calves and milk products were other sources of revenue in the activity of cow rearing. There exist huge differentials in the gross returns and net returns realised by local and crossbreed cow rearing. As expected, milk yield was almost 3 times higher of about 4340 litres per cow per year (11.89 litres per cow per day) in case of crossbreed cow. While coming to the unit price of milk, it was observed that price per litre of milk was higher for local breed cow (₹ 41.71) than for

crossbreed cow (₹ 31). This is due to higher sweet in the taste of localcow milk and higher content of A2 protein in milk which is considered nutritionally superior than A1 protein milk of crossbreed cows. The yield of FYM was higher in case of crossbreed cow but yield of milk products (ghee and curd) was higher in localbreed cow. The gross return obtained from crossbreed cow rearing was also very high (₹ 139034) as compared to local breed cow rearing (₹ 62467). The additional gross return obtained from rearing crossbreed cow was ₹ 76567, which was 123 per cent more as compared to local cow rearing. The net return realized per cow per year was also very high for crossbreed cow rearing (₹ 56020) as compared to only ₹ 18154 per cow per year in local cow rearing. The additional net return obtained from rearing crossbreed cow was ₹ 37867, which was 209 per cent more as compared to local cow rearing. Return per rupee of investment was also worked out to assess the profitability of dairy farming in the study area in the form of B:C ratio. The crossbreed cow rearing was found to be more profitable in the study area with a benefit-cost ratio of 1.67, while it was 1.40 for local cow rearing. It means by making a rupee investment in the crossbreed cow rearing, the respondents realised the gross returns of ₹ 1.67, thus realised the net profit of 0.67 per rupee of investment. The observed benefit cost ratio for both local and crossbreed cow rearing in the study area suggests dairy farming with crossbreed cow is more profitable as compared to dairy farming with local cow.

Conclusions

From the findings of the study following conclusion has been derived. It is observed from the study that, the total cost of crossbreed cow rearing was higher (₹ 83014 per cow per annum) than local cow rearing (₹ 44313 per cow per annum). The estimated gross returns and net returns per cow per year was relatively higher for crossbreed cow rearing as compared to local cow rearing. The crossbreed cow rearing was found to be more profitable in the study area with a benefit-cost ratio of 1.67, while it was 1.40 for local cow rearing. It can be concluded from the study that, though dairying faced some constraints, but it was a profitable enterprise. If proper remedial measures could be taken, dairy farming could be a viable commercial enterprise which in turn could play a vital role to overcome the problems of low income, unemployment, under nutrition and unfavorable balance of payment situation of the country. The studies also revealed that rearing of cross breed cow were more profitable than local breed cows. The policy maker should, therefore, extend more policy supports, which will encourage expansion of dairying and thereby, will contribute to increase milk production in the area and in the state as a whole.

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Economics of Production and Marketing of Mustard and Bengalgram as Supplementary Crops in Paddy Fallows in Kalyan Karnataka

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Abstract

An attempt has been made in this paper to examine the economic analysis of production and marketing of supplementary crops of mustard and bengalgram in Raichur district. The data collected in 2019 from 90 mustard farmers and 60 bengalgram farmers from 3 taluks in Raichur district of Kalyan Karnataka region using multistage random sampling was analysed. The cost of cultivation, returns and marketing practices etc were studied. The average cost of cultivation (Cost C) of mustard was 4185.13/acre and the cost of cultivation (Cost C) of bengalgram was ₹ 10208.04/acre. The average cost of mustard cultivation was less compared to bengalgram. The net income of mustard was ₹ 1071.93/acre and net return of bengalgram was ₹ 584.36/acre. The benefit cost ratio of mustard and bengalgram was 1.37 and 1.06 at overall level. Two marketing channels were identified in the study area were channel-I: Producer-Wholesaler-Processor and channel-II: Producer-Processor. The marketed surplus was cent percent for all categories of farmers. The producer's share in consumer's rupee was higher in channel-II (95.23%) as compared to channel-I (93.33%).

Key words : Mustard, bengalgram, costs, returns and marketing, producer's share in consumer's rupee.

Introduction

Edible oilseeds are essential part of Indian agriculture, which contributes more than 10 per cent to agriculture GDP. Oilseeds crops are the second most important determinant of agricultural economy, next only to cereals. India is the largest producer of oilseeds in the world and accounts for about 14 per cent of the global oilseeds area, 7% of the total vegetable oils production and 10% of the total edible oils consumption. In India, oilseeds accounts for 3% to the Growth National Products and 10% to the total value of all agricultural products, and employs 14 and 1 million people respectively in oilseed cultivation and processing.

India is the third largest mustard producer in the world, accounting for about 12% of the world's total mustard "seed" and about 8.5% of the world's total mustard oil. In India, mustard is grown in diverse agro-climatic conditions ranging from north-eastern/north-western hills to down south. The crop is grown sole or in mixed cropping under both rainfed or irrigated conditions. Of the total area and production under the nine oilseeds crops grown in India, mustard accounts for 22.2% of the acreage and 22.6% of the production. The average mustard yield in India is about 1145 kg/ha compared to the combined oilseeds crops average of 1135 kg/ha. Mustard is the second most important edible oilseed crop in India, among 7 edible oilseeds crops cultivated in the country. Mustard accounts for nearly 30 per cent of the total oilseeds produced in the

country. In Karnataka state, mustard is cultivated in an area of 2000 hectare with production of 1000 tons and productivity of 500 Kg/ha (www.indiastat.com, 2018). In North Eastern Karnataka (NEK) region mustard crop cultivation is practiced in paddy fallows to take the advantage of residual moisture available in the paddy field in *rabi* season.

In the sample area, mustard was mainly grown by the farmers who were migrated from Andhra Pradesh. In North Eastern Karnataka region, area under mustard and bengalgram cultivation is increasing in paddy fallows in the recent past because of non-availability of irrigation water. Along with mustard crop, bengalgram, bajra, foxtail millet are also cultivated in paddy fallows in recent past to get the supplementary income. Bengalgram is important competitive crop in the study area. Farmers used to take two crops of paddy in a year, i.e., paddy followed by paddy in this region when adequate irrigation was available. However, due to consistent drought in the recent past, it is not possible for the farmers to take two crops in a year and they restrict to only one crop in the *kharif* season and leave the land fallow in the *rabi* season. In order to supplement the income, majority of the farmers found practicing either mustard or bengalgram in paddy fallows to take advantage of the residual moisture. They are grown in the residual moisture of paddy with the minimum tillage practices, inputs and management practices.

Very few studies have been conducted in the past to

examine the production and marketing of mustard in of Raichur district North-Eastern Karnataka and so looking to above facts, a study is essential to undertake through which a detailed insight can be obtained to analyse an economic analysis of production and marketing of mustard in Raichur district of NEK region state with the following specific objectives :

To estimate the cost and returns of mustard and bengalgram crop

To study the existing marketing system of mustard crop in the study area

Materials and Methods

Study site profile : The present study was undertaken in Raichur district of Karnataka state. Raichur district is situated between 15°09' and 6°34' North latitude and 75°46' and 77°35' East longitude and in between two major rivers namely, Krishna and Tungabhadra. The geographical area of the district according to the Central Statistical Organization of the Government of India is 14,013 square kilometers. The net irrigated area of Raichur is about 0.15 lakh ha. The climate of the district is characterized by dryness for the major part of the year and a very hot in summer. The low and highly variable rainfall renders the district liable to drought.

Sampling and data collection : The multistage stratified random sampling technique was used for the present study. 90 mustard farmers and 60 bengalgram farmers who raised crops in paddy fallows were selected from three taluks of Raichur district namely Manvi, Sindhanur and Raichur. Sample mustard and bengalgram farmers were post classified into three groups vis., small farmer with 2.5 to 5 acres of land, medium farmers with 5 to 25 acres of land and large farmers with more than 25 acres of land respectively to understand the socio-economic differences across the sub groups. The information was also collected from wholesalers (8), and processors (2) involved in the marketing of mustard grain in Andhra Pradesh to study the marketing channels and marketing cost of mustard. The primary data were collected through well structured pre-tested schedule of enquiry by interview method during the agricultural year 2018-19.

Cost and returns estimation : The estimates of profitability were assessed using farm business cost concepts as detailed below :

Cost concepts : The cost of cultivation classified and recommended by, "Special expert committee on cost estimates, GOI, New Delhi", was used in this study. The cost farm business concepts were used in the study as given below :

Cost A : It includes

- (i) Value of hired human labour
- (ii) Value of hired and owned bullock labour
- (iii) Value of hired and owned machinery labour
- (iv) Value of owned and purchased seed
- (v) Value of fertilizer, chemical and manure
- (vi) Value of insecticide and pesticide
- (vii) Land revenue and taxes
- (viii) Depreciation on farm assets excluding land
- (ix) Interest on working capital
- (x) Miscellaneous expenses.

Cost B : It includes Cost A + interest on value of owned fixed capital assets. (excluding land) + rental value of owned land.

Cost C: It includes Cost B + imputed value of family labour and Supervision cost.

Benefit cost ratio :

$$\text{B:C ratio} = \frac{\text{Gross income}}{\text{Cost of cultivation (Cost } C_3 \text{)}}$$

Marketable surplus : Marketable surplus = total production – produce with held for family consumption, payment of wages in kinds, cattle feed and seed for sowing.

Marketed surplus : It is the actual quantity of produce sold in the market.

Price spread : The price spread consists of the marketing costs and margins which ultimately determine the producer's share in the price paid by the consumer. Formula for price-spread is used as :

$$P = \frac{C - M}{M} \times 100$$

Where,

P = Producer's share in the consumer's rupee

C = Price paid by ultimate consumers (Processor)

M = Marketing costs and margins.

Results and Discussion

Cost of cultivation of mustard : The item wise and group wise per acre cost of mustard cultivation was worked out and is presented in the Table 1 that, total cost of cultivation (Cost C) of mustard was worked out to be ₹ 3615.38, ₹ 4566.33 and ₹ 4373.69 in small, medium and large category farmers respectively. At the overall level, it was worked out to ₹ 4185.13. This indicated that, the cost of mustard cultivation is high in medium and large category farmers as compared to small category farmers.

Table-1 : Cost of cultivation of mustard. (₹/acre)

Sl. No.	Cost particulars	Farmer Categories			Overall
		Small farmers	Medium farmers	Large farmers	
1.	Seed	115.00 (3.18)	135.00 (2.96)	127.00 (2.15)	125.67 (3.00)
2.	Fertilizers	97.80 (2.71)	156.78 (3.43)	171.00 (3.91)	141.86 (3.39)
3.	Plant protection chemicals	470.9 (13.02)	233.08 (5.10)	276.91 (6.33)	326.96 (7.81)
4.	Hired human labour	162.00 (4.48)	387.00 (8.48)	423.00 (9.67)	324.00 (7.74)
5.	Machine labour	325.00 (8.99)	325.00 (7.12)	325.00 (7.43)	325.00 (7.77)
6.	Depreciation	26.21 (0.72)	19.17 (0.42)	18.05 (0.41)	21.14 (0.51)
7.	Land revenue	375.00 (10.37)	375.00 (8.21)	375.00 (8.57)	375.00 (8.96)
	Cost-A	1571.91 (43.48)	1631.03 (35.72)	1715.96 (39.23)	1639.63 (39.18)
8.	Interest on fixed capital (i=10%)	546.78 (15.12)	1408.82 (30.85)	1269.09 (29.02)	1074.89 (25.68)
9.	Rental value of owned land (1/6th of Gross returns)	859.02 (23.76)	1024.36 (22.43)	967.03 (22.11)	950.13 (22.70)
	Cost-B	2977.71 (82.36)	4064.21 (89.00)	3952.08 (90.36)	3664.67 (87.56)
10.	Imputed value of family labour	309.00 (8.55)	87.00 (1.91)	24 (0.55)	140.00 (3.35)
11.	Supervision charges	328.67 (9.09)	415.12 (9.09)	397.61 (9.09)	380.47 (9.09)
	Cost-C	3615.38 (100)	4566.33 (100)	4373.69 (100)	4185.13 (100)

Note : Figure in parenthesis shows the percentage to total of individual group.

Table-2 : Profitability of mustard cultivation. (₹/acre)

Sl. No.	Particulars	Farmer categories			Overall
		Small farmers	Medium farmers	Large farmers	
1.	Gross returns	5154.11	6146.13	5802.15	5700.80
2.	Costs				
	(a) Cost A	1571.91	1631.03	1715.96	1639.63
	(b) Cost B	2977.71	4064.21	3952.08	3664.67
	(c) Cost C	3615.38	4566.33	4373.69	4185.13
3.	Net returns at				
	(a) Cost A (Farm business income)	3582.20	4515.10	4086.19	4061.16
	(b) Cost B (Family labour income)	2176.40	2081.92	1850.07	2036.13
	(c) Cost C (Net farm income)	1538.73	1579.80	1428.46	1071.93
4.	Cost of production (/q)	3604.27	3841.33	3920.37	3788.66
5.	Benefit-cost ratio	1.43	1.35	1.33	1.37

At overall level, out of average cost of cultivation, share of cost A was 39.18 per cent (₹ 1639.63) and that of cost B, it was 87.56 per cent (₹ 3664.67). The maximum cost was worked out to be 8.96 per cent for land revenue (₹ 375.00). The cost incurred on plant protection chemicals (PPC) was 7.81 per cent (₹ 326.96) followed by machine labour was 7.77 per cent (₹ 325.00), hired human labour was 7.74 per cent (₹ 124.00) and seed was 3 per cent (₹ 125.67).

The cost on depreciation of implements and machinery was 0.51 per cent (₹ 21.14). The cost on interest on fixed capital accounted for 25.68 per cent (₹ 1074.89). Rental value of owned land was 22.70 per cent (₹ 950.13). Supervision charges were worked out to 9.09 per cent (₹ 380.47).

The analysis of the study indicated that, there was not much difference in total cost of cultivation for medium and large category farmers. However, this was relatively

Table-3 : Cost of cultivation of bengalgram. (₹/acre)

Sl. No.	Cost particulars	Farmer categories			Overall
		Small farmers	Medium farmers	Large farmers	
1.	Seed	777 (9.04)	810.95 (7.82)	945 (8.10)	844.69 (8.27)
2.	Fertilizers	484.45 (5.64)	723.03 (6.97)	916.40 (7.86)	707.96 (6.94)
3.	Plant protection chemicals	718.79 (8.37)	753.55 (7.27)	767.20 (6.58)	746.51 (7.31)
4.	Hired human labour	2285.23 (26.60)	2774.49 (26.75)	2665.43 (22.85)	2575.05 (25.23)
5.	Machine labour	621.60 (7.24)	659.40 (6.36)	894.60 (7.67)	725.20 (7.10)
6.	Depreciation	34.58 (0.40)	458.49 (4.42)	826.82 (7.09)	439.96 (4.31)
7.	Land revenue	375.00 (4.37)	375.00 (3.62)	375.00 (3.22)	375.00 (3.67)
	Cost-A	5785.91 (63.72)	6445.86 (62.81)	7010.26 (62.13)	6414.01 (62.83)
8.	Interest on fixed capital (i=10%)	483.70 (5.63)	1061.07 (10.23)	1235.36 (10.59)	926.71 (9.08)
9.	Rental value of owned land (1/6th of gross returns)	1605.79 (18.69)	1778.94 (17.15)	2011.69 (17.25)	1798.81 (17.62)
	Cost-B	7875.40 (86.98)	9285.87 (90.58)	10257.31 (90.21)	9139.52 (89.53)
10.	Imputed value of family labour	417.00 (4.85)	48.00 (0.46)	0.00 (0.00)	155.00 (1.52)
11.	Supervision charges	787.54 (9.17)	928.58 (8.95)	1025.73 (8.79)	917.28 (8.95)
	Cost-C	9079.94 (100)	10262.46 (100)	11283.04 (100)	10208.04 (100)

Note : Figure in parenthesis shows the percentage to total of individual group.

Table-4 : Profitability of bengalgram cultivation. (₹/acre)

Sl. No.	Particulars	Farmer categories			Overall
		Small farmers	Medium farmers	Large farmers	
1.	Gross returns	9634.71	10673.66	12070.13	10792.83
2.	Costs				
	(a) Cost A	5785.91	6445.86	7010.26	6414.01
	(b) Cost B	7875.40	9285.87	10257.31	9139.52
	(c) Cost C	9079.94	10262.46	11283.04	10208.04
3.	Net returns at				
	(a) Cost A (Farm business income)	3848.80	4227.80	5059.87	4378.83
	(b) Cost B (Family labour income)	1759.31	1387.79	1812.82	1653.31
	(c) Cost C (Net farm income)	554.77	411.20	787.09	584.36
4.	Cost of production (/q)	3197.16	3289.25	3251.60	3246.00
5.	Benefit-cost ratio	1.06	1.04	1.07	1.06

higher among these categories compared to small category farmers. Similar results were observed by Yadav Preeti (2017) that the cost of cultivation of mustard was high in medium (₹ 24527.44) and large category farmers (₹ 29506.11) compared to small farmers category (₹ 17733).

Profitability of mustard cultivation : The per acre profitability of mustard is worked out at different cost level i.e. at cost A, cost B and cost C. and is given in Table-2.

It is noticed from the Table-2 that, the mustard is profitable at all costs in all the categories. Per acre gross returns in small, medium and large category farmers was ₹ 5154.11, ₹ 6146.13 and ₹ 5802.15 respectively while it was ₹ 5700.80 at overall level. Similar findings were obtained by Sharma Shailendra (2016). The gross income was high among medium and large category farmers as compared to small category farmers.

It is observed from the Table-2 that, the net returns

Table-5 : Marketable and marketed surplus of mustard crop.

Sl. No.	Categories	Average marketable surplus (q)	Average marketed surplus (q)
1.	Small farmers (n=41)	0	231.59
2.	Medium farmers (n=36)	0	570.82
3.	Large farmers (n=13)	0	720.73
	Total	0	1523.14

Table-6 : Marketing cost and margins at different marketing channels of mustard. (₹/Quintal)

Sl. No.	Particulars	Channels	
		Channel-I	Channel-II
1.	Producers sale price	3850	4000
2.	Producers marketing cost	0	0
3.	Net amount received by farmer	3850	4000
4.	Wholesaler purchase price	3850	-
5.	Wholesaler marketing cost	85	-
6.	Wholesaler margin	190	-
7.	Wholesaler sale price	4125	-
8.	Processor purchase price	4125	4000
9.	Processor marketing cost	275	200
10.	Total price of processor	4125	4200

Table-7 : Price spread in marketing of mustard through different channels. (₹/quintal)

Sl. No.	Particulars	Channels	
		Channel-I	Channel-II
	Marketing cost		
1.	Producers	0	0
2.	Wholesalers	85 (2.06)	-
3.	Processors	-	200 (4.76)
	Total	85 (2.06)	200 (4.76)
	Marketing margin		
1.	Wholesalers	190 (4.6)	-
	Total	190 (4.6)	-
	Total cost + Total margin	275 (6.66)	200 (4.76)
	Producers rupee	3850 (93.33)	4000 (95.23)
	Processors rupee	4125 (100)	4200 (100)
	Price spread	275 (6.66)	200 (4.76)

(Note : Figures in the parenthesis indicates the percentage to processors rupee)

at cost A were ₹ 3582.20, ₹ 4515.10 and ₹ 4086.19 in case of small, medium and large category farmers respectively, while it was ₹ 4061.16 at overall level. The net returns over cost B were ₹ 2176.40, ₹ 2081.92 and ₹ 1850.07 in case of small, medium and large category farmers respectively, while it was ₹ 2036.13 at overall level. The net returns over cost C were ₹ 1538.73, ₹ 1579.80 and ₹ 1428.46 in case of small, medium and large category farmers respectively, while it was ₹ 1071.93 at overall level. The cost per quintal worked out to be ₹ 3604.27, ₹ 3841.33 and ₹ 33920.37 in case of small, medium and large category farmers respectively, while it was 3788.66 at overall level. The Benefit cost ratio was ₹ 1.43 for small category farmers, ₹ 1.35 for medium category farmers and 1.33 for large category farmers, while it was ₹ 1.37 at overall level. The analysis

of profitability indicated that, mustard cultivation in paddy fallows at all category farmers was profitable in the study area.

Cost of cultivation of bengalgram : It was seen from the Table-3 that, average cost of bengalgram cultivation was worked out to be ₹ 10208.04, at overall level. Whereas, in small, medium and large category farmers total cost of cultivation was worked out to ₹ 9079.94, ₹ 10262.46 and ₹ 11283.04 respectively. This is indicating that, the cost of bengalgram cultivation showed an increasing trend with respect to different category of farmers.

At the overall level, out of total cost of cultivation, share of cost A was 62.83 per cent (₹ 6414.01) and that of cost B, it was 89.53 per cent (₹ 9139.52). The maximum cost was worked out to be for hired human labour 25.23 per cent (₹ 2575.05). The cost incurred on seed was 8.27

per cent (₹ 844.69) followed by plant protection chemicals was 7.31 per cent, machine labour was 7.10 per cent (₹ 725.20) and fertilizer was 6.94 per cent (₹ 707.96). The cost on depreciation of implements and machinery was 4.31 per cent (₹ 439.96). Interest on fixed capital was 9.08 per cent (₹ 926.71). Rental value of owned land was 17.62 per cent (₹ 1798.81). Supervision charges were worked out to 8.95 per cent (₹ 919.28).

The analysis of per acre cost in bengalgram cultivation in all categories showed that, the cost of bengalgram cultivation for small category farmers was less compared to medium and large category farmers. However, there was not much difference in total cost of cultivation for medium and large category farmers.

By looking to the data presented in Table-1 and Table-2, we can say that cost of cultivation of mustard (₹ 4185.13/acre) is less compared to bengalgram (₹ 10208.04/acre) in the study area. This might be due to less input usage, minimum tillage and management practices followed in mustard cultivation as compared to bengalgram. The farmers who have low investment capacity can go for mustard cultivation.

Profitability of bengalgram cultivation : Per acre profitability of bengalgram was worked out at different cost level such as cost A, cost B and cost C. Per acre profitability of bengalgram was analysed and is presented in Table-4.

The data presented in Table-4 revealed that, bengalgram is profitable at all cost in all three categories. Per acre gross returns was found to be ₹ 9634.71, ₹ 10673.66 and ₹ 12070.13 in case of small, medium and large category farmers respectively while it was ₹ 10792.84 at overall level.

It is noticed from the Table-4 that, per acre net returns at cost A were ₹ 3848.80, ₹ 4227.80 and ₹ 5059.87 in case of small, medium and large category farmers respectively, while it was ₹ 4378.83 at overall level. Per acre net returns over cost B was ₹ 1653.31 at overall level. In case of small, medium and large category farmers the net returns over cost B were ₹ 1759.31, ₹ 1387.79 and ₹ 1812.82 respectively. Per acre net returns over cost C was ₹ 584.36 at overall level. In case of small, medium and large category farmers the net returns over cost C. were ₹ 554.77, ₹ 411.20 and ₹ 787.09 respectively. The cost per quintal worked out to be ₹ 3197.16, ₹ 3289.25 and ₹ 3251.60 in case of small, medium and large category farmers respectively, while it was ₹ 3246.00 at overall level. The benefit cost ratio was 1.06 at overall level.

The benefit cost ratio was 1.06 for small farmers, 1.04 for medium farmers and 1.07 for large category

farmers. The analysis of profitability indicated that, bengalgram cultivation in paddy fallow at all categories of farmers was profitable.

The economics of mustard in comparison to its competing crop is the major factor which affects its choice by the farmers. The data presented in the Table-3 and Table 4 indicated that, the returns per rupee spent (B:C ratio) for cultivation of mustard was higher than bengalgram i.e. 1.37 for mustard and 1.06 for bengalgram at overall level, which means mustard cultivation is more profitable than bengalgram cultivation in study area.

Marketable and marketed surplus of mustard : Marketable and marketed surplus of mustard are presented in Table 5. It is noticed that none of the farmers keep the produce with them and cent percent of the produce was sold after the harvest. Average marketed surplus observed was around 1523.14 quintals. The average marketed surplus of large farmers was 720.73 quintal which was the highest among the three categories of mustard growers. The average marketed surplus of small farmers was 231.59 quintals which was the lowest among three categories. The average marketed surplus of medium category farmers was found to 570.82 quintals. Regarding the marketable surplus of 3 categories of the farmers, it is to be noted that all the farmers sold their entire produce at a time to the wholesalers or to the processors, who come to buy the product to their village itself. Because mustard is not a notified commodity in regulated markets of Karnataka so there is no marketing facility in the study area to sell the produce in local market.

Marketing cost and margins at different marketing channels of mustard : The chain of marketing costs and marketing margins of mustard grain for different marketing channels is presented in Table-6. The marketing of mustard includes grain marketing which was reached from producer to consumer (Processors are ultimate consumer for mustard grain in the study area) through different channels. The mustard grain of marketing included producer, wholesalers and processors. Two channels have been identified for marketing of mustard in the study area. In channel-I, mustard growers sold their produce to the wholesalers (Producer - Wholesaler - Processor). In channel-II, the producers directly sold to the produce to processors (Producer – Processor).

The data revealed that among two channels of mustard, on an average producers got the maximum price of ₹ 4000/q, when the produce was sold in channel-II. The price realized was relatively less ₹ 3850/q, when the produce was sold in channel-I. This price difference was due to more number of market functionaries involvement in channel-II.

All the farmers have sold their produce in place of production (Local sale). Wholesalers and processors purchase the produce from farmers at their door step, thus producers did not incur any cost towards sale of their produce. However, marketing cost incurred by processors was relatively higher as compared to wholesalers. The high marketing cost and margin compared to channel-II was observed in channel-I i.e. 275 per quintal. The processors purchase price in case of channel-I was 4125 per quintal which was lower than purchase price of channel-II.

Hence, it is concluded that channel-II (Sale through processor) was found to be more remunerative than channel-I (sale through wholesaler).

Price spread in marketing of mustard through different channel : Price spread is a tool which determines actual marketing cost and marketing margin are incurred per quintal of grain distribution. The details of price spread in marketing of mustard through two marketing channels are presented in Table-7.

The analysis of total share of producers share in consumer's (Processor) rupee through sale of mustard by different marketing channels showed variations due to number of involvement of market intermediaries and charges incurred in marketing cost and margin. The data showed (Table-4.18) that the producers share in the consumer's (Processor) rupee realized was high in channel-II (sale through processor) 95.23 per cent. In channel-II marketing cost was incurred by processor itself. In the channel-I producers share in the consumer rupee was 93.33 per cent. This was due to higher marketing cost and margin incurred by the wholesalers. The price spread was higher in channel-I (6.66%) compared to channel-II (4.76%).

Therefore, it is concluded that sale of produce through channel-II (sale through processors) for oil milling producers got maximum share in the consumers rupee followed by channel-I (sale through wholesaler).

Conclusions

The cost of cultivation of mustard was ₹ 4185.13/acre which was less than bengalgram cultivation i.e. ₹ 10208.04/ acre. This might be due to less input usage, minimum tillage and management practices followed in mustard cultivation as compared to bengalgram. Both

mustard and bengalgram cultivation in paddy fallows was found to be profitable with favorable benefit cost ratios of 1.37 and 1.06 respectively. Therefore, the farmers need to be encouraged to cultivate mustard and bengalgram in paddy fallows in the study area with intensive cultivation to enhance their returns by providing information through appropriate training programmes. Mustard farmers will sell their entire commodity to wholesaler and processors of Andhra Pradesh. Out of 2 marketing channels available in the study area, channel-II (₹ 4000/q) was more profitable than channel-1 (₹ 3850) for farmers. Mustard production is limited in the study area, therefore market is not required. However, when cultivation of mustard is taken in commercial scale or large scale in future. The marketing facilities need to provide in the study area.

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Yield and Quality of Compact Cotton as Influenced by Management Practices under High Density Planting System

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Abstract

A field experiment was conducted on "Yield and quality of compact Cotton as influenced by management practices under high density planting system" at Department of Agronomy, Agricultural College, UAS, Raichur during 2016-17 and 2017-18. The result revealed that the closer row spacing of 60 cm x 10 cm produced significantly higher seed cotton yield (2875 kg ha⁻¹) over other planting geometries. Whereas, yield attributes viz., boll weight and seed cotton yield per plant (3.68 g and 30.33 g, respectively) and quality attributes viz., ginning out turn, seed index and lint index (36.74 %, 9.65 g and 5.61, respectively) were significantly higher at a wider row spacing of 90 cm x 10 cm. Among different management practices, application of 100:50:50 N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS recorded significantly higher boll weight, seed cotton yield per plant and seed cotton yield per hectare (3.67 g, 31.73 g and 2915 kg, respectively). Further, the quality parameters viz., ginning out turn, seed index and lint index (36.35 %, 9.51 g and 5.45, respectively) were higher with the same treatment and lower values of these quality attributes were recorded with the application of 60:30:30 N:P₂O₅:K₂O kg ha⁻¹. Among the different combinations, a row spacing of 60 cm x 10 cm along with application of 100:50:50 N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS recorded significantly higher seed cotton yield (3178 kg ha⁻¹) followed by combination of a row spacing of 60 cm x 10 cm along with application of 80:40:40 N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS (3031 kg ha⁻¹). Whereas, yield attributes viz., boll weight and seed cotton yield per plant and quality attributes viz., ginning out turn, seed index and lint index were higher under the combination of a row spacing of 90 cm x 10 cm along with application of 100:50:50 N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS.

Key words : Fertilizer, planting geometry, growth retardant, high density planting system.

Introduction

The concept of 'High Density Planting System' (HDPS) in cotton that is ideally suited for both rainfed and irrigated ecosystems has the potential of improving the yield by increasing the plant population by 3 to 4 folds over recommended plant population per hectare. The HDPS cotton not only provides the scope for double cropping and mechanical harvesting but also the added advantages of reducing labour cost with few picking and also farmers will not depend on seed companies for purchase of seeds for sowing every time. Adaption of HDPS along with good fertilizer management under irrigated ecosystem is a viable approach to break the current trend of stagnating cotton yield.

Compact cotton produces excessive vegetative growth under the condition of high rainfall or irrigation with higher fertilizer levels resulting in mutual shading and shedding of reproductive parts there by reducing yield. While, maximizing yield through preventing the excessive vegetative growth during excessive moisture condition, use of growth retardants is required to maintain the suitable plant height of cotton for synchronous boll bursting and mechanical harvesting and this led to the interest in use of plant growth retardants.

Keeping these points in view, field investigation under irrigated condition was carried out to know the suitable planting geometry, optimum fertilizer level and growth retardant spray to get a sustained higher yield under HDPS system.

Materials and Methods

Field experiment entitled "Yield and quality of compact Cotton as influenced by management practices under high density planting system" was conducted at Agricultural College, UAS, Raichur during 2016-17 and 2017-18 on medium black soil, neutral in nature with low available nitrogen, medium in phosphorus, rich in potassium. The climatic condition during experimental period was favorable and regular irrigation was provided to crop during both the years at later part of crop growth stages i.e, from 60 DAS to till first picking.

The experiment was laid out in split plot design with three planting geometries viz., S₁: 60 cm x 10 cm (1,66,666 plants ha⁻¹), 75 cm x 10 cm (1,33,333 plants ha⁻¹) and S₃: 90 cm x 10 cm (1,11,111. Plants ha⁻¹) as main plot treatments and six fertilizer levels with growth retardant spray viz., M₁: 60:30:30 N:P₂O₅:K₂O kg ha⁻¹, M₂: 80:40:40 N:P₂O₅:K₂O kg ha⁻¹, M₃: 100:50:50 N:P₂O₅:K₂O kg ha⁻¹, M₄: M₁+ mepiquat chloride @ 250

Table-1 : Boll weight (g), seed cotton yield (g plant⁻¹) and Seed cotton yield (kg ha⁻¹) of cotton as influenced by management practices under high density planting system.

Treatments	Boll weight (g)			Seed cotton yield (g plant ⁻¹)			Seed cotton yield (kg ha ⁻¹)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plots (S)									
S ₁	3.26 ^c	3.15 ^c	3.21 ^c	26.71 ^c	24.53 ^c	25.62 ^c	3003 ^a	2748 ^a	2875 ^a
S ₂	3.41 ^b	3.29 ^b	3.35 ^b	28.87 ^b	26.34 ^b	27.60 ^b	2836 ^b	2574 ^b	2705 ^b
S ₃	3.75 ^a	3.62 ^a	3.68 ^a	31.71 ^a	28.95 ^a	30.33 ^a	2511 ^c	2266 ^c	2388 ^c
S.Em±	0.03	0.02	0.02	0.38	0.37	0.36	32.35	29.97	23.96
Sub plots (M)									
M ₁	3.22 ^d	3.10 ^d	3.16 ^e	25.06 ^d	22.88 ^e	23.97 ^e	2513 ^e	2271 ^e	2392 ^d
iOM ₂	3.40 ^c	3.27 ^c	3.33 ^d	28.06 ^c	25.63 ^{cd}	26.85 ^{cd}	2715 ^{cd}	2471 ^{cd}	2593 ^c
M ₃	3.48 ^{bc}	3.38 ^{bc}	3.43 ^c	29.88 ^b	27.19 ^{bc}	28.53 ^{bc}	2846 ^{bc}	2586 ^{bc}	2716 ^b
M ₄	3.41 ^c	3.26 ^c	3.33 ^d	27.41 ^c	25.10 ^d	26.25 ^d	2675 ^d	2409 ^d	2542 ^c
M ₅	3.61 ^{ab}	3.50 ^{ab}	3.56 ^b	31.03 ^b	28.52 ^{ab}	29.78 ^b	2904 ^{ab}	2656 ^{ab}	2780 ^b
M ₆	3.72 ^a	3.62 ^a	3.67 ^a	33.13 ^a	30.32 ^a	31.73 ^a	3049 ^a	2782 ^a	2915 ^a
S.Em±	0.06	0.05	0.03	0.61	0.64	0.59	54.82	47.10	37.31
Interactions (S x M)									
S ₁ M ₁	3.04 ^h	2.93 ^j	2.98 ^j	23.24 ^g	21.24 ⁱ	22.24 ^h	2695 ^{c-f}	2443 ^{d-f}	2569 ^{gh}
S ₁ M ₂	3.19 ^{gh}	3.07 ^{h-j}	3.13 ^{ij}	26.04 ^{e-g}	23.81 ^{f-i}	24.93 ^{f-h}	2927 ^{b-d}	2678 ^{b-d}	2803 ^{c-f}
S ₁ M ₃	3.26 ^{f-h}	3.15 ^{g-j}	3.21 ^{hi}	27.07 ^{d-f}	24.79 ^{e-i}	25.93 ^{e-g}	3075 ^{ab}	2822 ^{a-c}	2948 ^{b-d}
S ₁ M ₄	3.21 ^{gh}	3.09 ^{h-j}	3.15 ^{ij}	25.30 ^{e-g}	23.22 ^{g-i}	24.26 ^{f-h}	2879 ^{b-d}	2605 ^{c-e}	2742 ^{d-g}
S ₁ M ₅	3.39 ^{d-g}	3.28 ^{e-i}	3.34 ^{f-h}	28.62 ^{de}	26.44 ^{d-g}	27.53 ^{d-f}	3135 ^{ab}	2890 ^{ab}	3013 ^{ab}
S ₁ M ₆	3.48 ^{c-g}	3.39 ^{d-g}	3.43 ^{d-g}	29.96 ^{cd}	27.67 ^{b-e}	28.82 ^{c-e}	3307 ^a	3050 ^a	3178 ^a
S ₂ M ₁	3.16 ^{gh}	3.04 ^{ij}	3.10 ^{ij}	24.81 ^{fg}	22.59 ^{hi}	23.70 ^{gh}	2559 ^{e-g}	2312 ^{f-i}	2436 ^{hi}
S ₂ M ₂	3.33 ^{e-h}	3.22 ^{f-i}	3.28 ^{g-i}	27.79 ^{d-f}	25.32 ^{e-h}	26.55 ^{d-g}	2765 ^{c-e}	2515 ^{d-f}	2640 ^{e-h}
S ₂ M ₃	3.42 ^{d-g}	3.32 ^{d-h}	3.37 ^{f-h}	29.84 ^{cd}	27.04 ^{c-f}	28.44 ^{c-e}	2900 ^{b-d}	2630 ^{b-e}	2765 ^{c-g}
S ₂ M ₄	3.34 ^{d-h}	3.20 ^{f-i}	3.27 ^{g-i}	27.10 ^{d-f}	24.74 ^{e-i}	25.92 ^{e-g}	2724 ^{c-f}	2453 ^{d-g}	2588 ^{gh}
S ₂ M ₅	3.55 ^{c-f}	3.44 ^{c-f}	3.49 ^{d-f}	30.62 ^{b-d}	28.16 ^{b-e}	29.39 ^{b-d}	2963 ^{bc}	2703 ^{b-d}	2833 ^{b-e}
S ₂ M ₆	3.66 ^{b-e}	3.56 ^{b-d}	3.61 ^{cd}	33.04 ^{bc}	30.19 ^{a-c}	31.62 ^{b-c}	3107 ^{ab}	2829 ^{a-c}	2968 ^{bc}
S ₃ M ₁	3.47 ^{c-g}	3.32 ^{d-h}	3.40 ^{e-g}	27.13 ^{d-f}	24.80 ^{e-i}	25.96 ^{e-g}	2283 ^g	2057 ⁱ	2170 ^j
S ₃ M ₂	3.66 ^{b-e}	3.53 ^{c-e}	3.59 ^{cd}	30.36 ^{cd}	27.78 ^{b-e}	29.07 ^{c-e}	2452 ^{e-g}	2220 ^{g-i}	2336 ^{ij}
S ₃ M ₃	3.77 ^{a-c}	3.66 ^{bc}	3.71 ^{bc}	32.72 ^{bc}	29.72 ^{a-d}	31.22 ^{bc}	2562 ^{e-g}	2306 ^{f-i}	2434 ^{hi}
S ₃ M ₄	3.67 ^{b-d}	3.50 ^{c-e}	3.58 ^{c-e}	29.81 ^{cd}	27.33 ^{b-f}	28.57 ^{c-e}	2421 ^{fg}	2169 ^{hi}	2295 ^{ij}
S ₃ M ₅	3.90 ^{ab}	3.79 ^{ab}	3.85 ^{ab}	33.86 ^{ab}	30.96 ^{ab}	32.41 ^{ab}	2612 ^{d-f}	2375 ^{e-h}	2494 ^{hi}
S ₃ M ₆	4.03 ^a	3.93 ^a	3.98 ^a	36.40 ^a	33.11 ^a	34.75 ^a	2733 ^{c-f}	2466 ^{d-g}	2600 ^{f-h}
S.Em±	0.10	0.08	0.06	1.06	1.11	1.02	94.95	81.59	64.62

ppm sprayed at 60 DAS, M₅: M₂ + mepiquat chloride @ 250 ppm sprayed at 60 DAS and M₆: M₃ + mepiquat chloride @ 250 ppm sprayed at 60 DAS as sub plot treatments with three replications.

Results and Discussion

Planting geometries : Among the different planting geometries, significantly higher seed cotton yield, (2875 kg ha⁻¹ on pooled basis) was recorded with a closer row spacing of 60 cm x 10 cm. Seed cotton yield was decreased significantly with further increase in row spacing and recorded lowest with the wider spacing of 90 cm x 10 cm (2388 kg ha⁻¹ on pooled basis). Whereas, yield attributes viz., and boll weight and seed cotton yield per plant (3.68 g and 30.33 g, respectively) and quality attributes viz., ginning out turn, seed index and lint index (36.74 %, 9.65 g and 5.61, respectively) were significantly

higher at a wider row spacing of 90 cm x 10 cm. while, other quality attributes viz., fibre length, fibre strength and micronaire were remained on par. The significant increase in the seed cotton yield under the closer row spacing of 60 cm x 10 cm was mainly due to the higher plant population per unit area even though the yield attributes were lower compared to the yield attributes recorded under wider row spacing and due to the fact that increase in plants per unit area could compensated for the decrease in yield components per plant under narrow row spacing. Similar results with respect to yield and quality parameters were also reported by Tuppad (2015), Alur (2016), Udikeri (2017) and Hiwale *et al.* (2018).

Fertilizer levels with growth retardant spray : Significant difference in seed cotton yield was noticed with different fertilizer levels with growth retardant spray. Application of higher fertilizer dose of 100:50:50

Table-2 : Ginning out turn (%), Seed index (g) and lint index of cotton as influenced by management practices under high density planting system.

Treatments	Ginning out turn (%)			Seed index (g)			Lint index		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plots (S)									
S ₁	34.57 ^c	33.88 ^c	34.22 ^c	9.17 ^b	9.08 ^c	9.12 ^b	4.85 ^c	4.66 ^c	4.75 ^c
S ₂	35.73 ^b	34.90 ^b	35.31 ^b	9.30 ^b	9.27 ^b	9.28 ^b	5.18 ^b	4.97 ^b	5.07 ^b
S ₃	37.34 ^a	36.14 ^a	36.74 ^a	9.69 ^a	9.61 ^a	9.65 ^a	5.78 ^a	5.44 ^a	5.61 ^a
S.Em±	0.19	0.21	0.20	0.05	0.05	0.05	0.02	0.03	0.02
Sub plots (M)									
M ₁	34.86 ^b	34.11 ^c	34.48 ^b	9.25 ^a	9.17 ^c	9.21 ^b	4.95 ^d	4.75 ^c	4.85 ^d
M ₂	35.82 ^{ab}	34.93 ^{a-c}	35.37 ^{ab}	9.34 ^a	9.27 ^{a-c}	9.31 ^{ab}	5.23 ^{bc}	4.99 ^{bc}	5.11 ^{bc}
M ₃	36.47 ^a	35.44 ^a	35.95 ^a	9.41 ^a	9.34 ^{a-c}	9.38 ^{ab}	5.42 ^{ab}	5.14 ^{ab}	5.28 ^{ab}
M ₄	35.07 ^b	34.29 ^{bc}	34.68 ^b	9.33 ^a	9.24 ^{bc}	9.28 ^{ab}	5.05 ^{cd}	4.83 ^c	4.94 ^{cd}
M ₅	36.18 ^a	35.25 ^{ab}	35.72 ^a	9.45 ^a	9.42 ^{ab}	9.43 ^{ab}	5.37 ^{ab}	5.14 ^{ab}	5.25 ^{ab}
M ₆	36.87 ^a	35.82 ^a	36.35 ^a	9.54 ^a	9.48 ^a	9.51 ^a	5.59 ^a	5.30 ^a	5.45 ^a
S.Em±	0.35	0.34	0.34	0.15	0.08	0.08	0.08	0.09	0.08
Interactions (S x M)									
S ₁ M ₁	33.69 ^f	33.15 ^g	33.42 ^g	9.06 ^a	8.98 ^e	9.02 ^f	4.60 ^h	4.46 ^h	4.53 ^j
S ₁ M ₂	34.52 ^{ef}	33.86 ^{e-g}	34.19 ^g	9.13 ^a	9.04 ^e	9.08 ^f	4.82 ^{gh}	4.63 ^{gh}	4.72 ^{h-j}
S ₁ M ₃	35.10 ^{d-f}	34.28 ^{d-g}	34.69 ^{e-g}	9.18 ^a	9.08 ^{de}	9.13 ^{ef}	4.97 ^{e-h}	4.74 ^{e-h}	4.86 ^{f-j}
S ₁ M ₄	33.86 ^f	33.30 ^{fg}	33.58 ^g	9.12 ^a	9.04 ^e	9.08 ^f	4.67 ^h	4.51 ^h	4.59 ^j
S ₁ M ₅	34.80 ^{d-f}	34.11 ^{d-g}	34.45 ^{e-g}	9.22 ^a	9.14 ^{c-e}	9.18 ^{d-f}	4.92 ^{e-h}	4.73 ^{e-h}	4.82 ^{f-j}
S ₁ M ₆	35.43 ^{c-f}	34.59 ^{c-g}	35.01 ^{d-g}	9.29 ^a	9.20 ^{c-e}	9.24 ^{d-f}	5.10 ^{d-g}	4.87 ^{e-h}	4.98 ^{e-i}
S ₂ M ₁	34.72 ^{d-f}	34.02 ^{e-g}	34.37 ^{e-g}	9.17 ^a	9.11 ^{de}	9.14 ^{ef}	4.88 ^{f-h}	4.70 ^{f-h}	4.79 ^{g-j}
S ₂ M ₂	35.67 ^{c-f}	34.85 ^{b-g}	35.26 ^{c-g}	9.26 ^a	9.21 ^{c-e}	9.24 ^{d-f}	5.14 ^{d-g}	4.93 ^{d-h}	5.03 ^{e-h}
S ₂ M ₃	36.30 ^{b-e}	35.36 ^{a-e}	35.83 ^{b-f}	9.33 ^a	9.28 ^{b-e}	9.31 ^{c-f}	5.31 ^{de}	5.08 ^{c-g}	5.19 ^{d-g}
S ₂ M ₄	34.93 ^{d-f}	34.21 ^{d-g}	34.57 ^{e-g}	9.25 ^a	9.18 ^{c-e}	9.21 ^{d-f}	4.97 ^{e-h}	4.78 ^{e-h}	4.87 ^{f-j}
S ₂ M ₅	36.04 ^{b-e}	35.19 ^{a-f}	35.62 ^{b-f}	9.36 ^a	9.40 ^{a-e}	9.38 ^{b-f}	5.28 ^{d-f}	5.10 ^{b-g}	5.19 ^{d-g}
S ₂ M ₆	36.72 ^{a-d}	35.75 ^{a-e}	36.24 ^{a-e}	9.45 ^a	9.41 ^{a-e}	9.43 ^{a-f}	5.49 ^{cd}	5.24 ^{b-e}	5.37 ^{c-e}
S ₃ M ₁	36.18 ^{b-e}	35.15 ^{b-f}	35.66 ^{b-f}	9.51 ^a	9.41 ^{a-e}	9.46 ^{a-f}	5.39 ^{cd}	5.10 ^{b-g}	5.24 ^{d-f}
S ₃ M ₂	37.26 ^{a-c}	36.08 ^{a-d}	36.67 ^{a-d}	9.63 ^a	9.56 ^{a-c}	9.60 ^{a-d}	5.73 ^{bc}	5.40 ^{a-d}	5.57 ^{b-d}
S ₃ M ₃	38.01 ^{ab}	36.69 ^{ab}	37.35 ^{ab}	9.73 ^a	9.65 ^{ab}	9.69 ^{a-c}	5.97 ^{ab}	5.59 ^{ab}	5.78 ^{ab}
S ₃ M ₄	36.41 ^{b-e}	35.36 ^{a-e}	35.89 ^{a-f}	9.61 ^a	9.50 ^{a-d}	9.56 ^{a-e}	5.50 ^{cd}	5.20 ^{b-f}	5.35 ^{c-e}
S ₃ M ₅	37.69 ^{ab}	36.46 ^{a-c}	37.08 ^{a-c}	9.76 ^a	9.72 ^a	9.74 ^{ab}	5.91 ^{ab}	5.58 ^{a-c}	5.75 ^{a-c}
S ₃ M ₆	38.46 ^a	37.11 ^a	37.79 ^a	9.88 ^a	9.82 ^a	9.85 ^a	6.18 ^a	5.79 ^a	5.98 ^a
S.Em±	0.60	0.58	0.59	0.25	0.13	0.13	0.13	0.15	0.13

N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS recorded significantly higher seed cotton yield (2915 kg ha⁻¹ on pooled basis), yield attributes viz., boll weight and seed cotton yield per plant (3.67 g and 31.73 g, respectively) and quality attributes viz., ginning out turn, seed index and lint index (36.35 %, 9.51 g and 5.45, respectively). While significantly lower seed cotton yield (2392 kg ha⁻¹ on pooled basis), yield attributes viz., boll weight and seed cotton yield per plant (3.16 g and 23.97 g, respectively) and quality attributes viz., ginning out turn, seed index and lint index (34.48 %, 9.21 g and 4.85, respectively) were recorded with the application of lower fertilizer dose of 60:30:30 N:P₂O₅:K₂O kg ha⁻¹. Significantly higher seed cotton yield, yield attributes and

quality attributes with increased level of fertilizer and growth retardant spray was mainly due to significant increase in yield attributing characters and effective transfer of photosynthates from source to sink. Similar result was also reported by Ikbali *et al.* (2007), Tuppad (2015) and Malakannavar (2017).

Interaction effect : Different treatment combinations influenced significantly on seed cotton yield. Combination of closer row spacing of 60 cm x 10 cm along with the application of higher fertilizer dose of 100:50:50 N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS recorded significantly higher seed cotton yield (3178 kg ha⁻¹ on pooled basis) and it was found on par with the combination of closer row spacing of

Table-3 : Fibre length (mm), fibre strength (g tex⁻¹) and micronaire value (µg inch⁻¹) as influenced by management practices under high density planting system.

Treatments	Fibre length (mm)			Fibre strength (g tex ⁻¹)			Micronaire (µg inch ⁻¹)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plots (S)									
S ₁	26.96 ^a	26.50 ^a	26.73 ^a	25.84 ^b	24.90 ^b	25.37 ^b	3.86 ^a	3.81 ^a	3.83 ^a
S ₂	27.24 ^a	26.77 ^a	27.00 ^a	26.28 ^{ab}	25.34 ^{ab}	25.81 ^{ab}	3.91 ^a	3.89 ^a	3.90 ^a
S ₃	27.40 ^a	26.94 ^a	27.17 ^a	26.84 ^a	25.99 ^a	26.41 ^a	3.98 ^a	4.00 ^a	3.99 ^a
S.Em±	0.15	0.16	0.16	0.18	0.19	0.18	0.12	0.12	0.13
Sub plots (M)									
M ₁	26.99 ^a	26.55 ^a	26.77 ^a	25.53 ^b	24.69 ^b	25.11 ^b	3.78 ^a	3.66 ^a	3.72 ^a
M ₂	27.20 ^a	26.74 ^a	26.97 ^a	25.99 ^{ab}	25.11 ^{ab}	25.55 ^{ab}	4.05 ^a	3.91 ^a	3.98 ^a
M ₃	27.30 ^a	26.84 ^a	27.07 ^a	26.63 ^{ab}	25.68 ^{ab}	26.16 ^{ab}	3.89 ^a	4.07 ^a	3.98 ^a
rM ₄	27.05 ^a	26.59 ^a	26.82 ^a	26.01 ^{ab}	25.08 ^{ab}	25.55 ^{ab}	3.82 ^a	3.69 ^a	3.75 ^a
M ₅	27.28 ^a	26.80 ^a	27.04 ^a	26.54 ^{ab}	25.64 ^{ab}	26.09 ^{ab}	4.11 ^a	3.96 ^a	4.03 ^a
M ₆	27.38 ^a	26.90 ^a	27.14 ^a	27.20 ^a	26.23 ^a	26.72 ^a	3.85 ^a	4.10 ^a	3.98 ^a
S.Em±	0.34	0.32	0.33	0.41	0.39	0.40	0.29	0.27	0.28
Interactions (S x M)									
S ₁ M ₁	26.77 ^a	26.34 ^a	26.56 ^a	25.13 ^b	24.28 ^b	24.70 ^b	3.73 ^a	3.61 ^a	3.67 ^a
S ₁ M ₂	26.96 ^a	26.51 ^a	26.74 ^a	25.52 ^{ab}	24.62 ^{ab}	25.07 ^{ab}	3.98 ^a	3.83 ^a	3.90 ^a
S ₁ M ₃	27.05 ^a	26.58 ^a	26.82 ^a	26.10 ^{ab}	25.11 ^{ab}	25.61 ^{ab}	3.84 ^a	3.95 ^a	3.90 ^a
S ₁ M ₄	26.82 ^a	26.37 ^a	26.59 ^a	25.58 ^{ab}	24.64 ^{ab}	25.11 ^{ab}	3.75 ^a	3.62 ^a	3.68 ^a
S ₁ M ₅	27.04 ^a	26.56 ^a	26.80 ^a	26.04 ^{ab}	25.10 ^{ab}	25.57 ^{ab}	4.02 ^a	3.86 ^a	3.94 ^a
S ₁ M ₆	27.13 ^a	26.64 ^a	26.89 ^a	26.66 ^{ab}	25.63 ^{ab}	26.14 ^{ab}	3.83 ^a	3.97 ^a	3.90 ^a
S ₂ M ₁	27.02 ^a	26.57 ^a	26.79 ^a	25.50 ^{ab}	24.62 ^{ab}	25.06 ^{ab}	3.77 ^a	3.65 ^a	3.71 ^a
S ₂ M ₂	27.24 ^a	26.77 ^a	27.01 ^a	25.96 ^{ab}	25.04 ^{ab}	25.50 ^{ab}	4.04 ^a	3.90 ^a	3.97 ^a
S ₂ M ₃	27.34 ^a	26.88 ^a	27.11 ^a	26.59 ^{ab}	25.61 ^{ab}	26.10 ^{ab}	3.89 ^a	4.06 ^a	3.98 ^a
S ₂ M ₄	27.08 ^a	26.62 ^a	26.85 ^a	25.98 ^{ab}	25.01 ^{ab}	25.50 ^{ab}	3.83 ^a	3.68 ^a	3.75 ^a
S ₂ M ₅	27.31 ^a	26.84 ^a	27.08 ^a	26.51 ^{ab}	25.57 ^{ab}	26.04 ^{ab}	4.10 ^a	3.96 ^a	4.03 ^a
S ₂ M ₆	27.42 ^a	26.96 ^a	27.19 ^a	27.16 ^{ab}	26.17 ^{ab}	26.66 ^{ab}	3.85 ^a	4.10 ^a	3.98 ^a
S ₃ M ₁	27.17 ^a	26.73 ^a	26.95 ^a	25.98 ^{ab}	25.18 ^{ab}	25.58 ^{ab}	3.84 ^a	3.72 ^a	3.78 ^a
S ₃ M ₂	27.40 ^a	26.9 ^a	27.17 ^a	26.51 ^{ab}	25.69 ^{ab}	26.10 ^{ab}	4.14 ^a	4.00 ^a	4.07 ^a
S ₃ M ₃	27.52 ^a	27.05 ^a	27.28 ^a	27.20 ^{ab}	26.33 ^{ab}	26.77 ^{ab}	3.94 ^a	4.20 ^a	4.07 ^a
S ₃ M ₄	27.24 ^a	26.78 ^a	27.01 ^a	26.48 ^{ab}	25.59 ^{ab}	26.03 ^{ab}	3.88 ^a	3.76 ^a	3.82 ^a
S ₃ M ₅	27.49 ^a	27.00 ^a	27.25 ^a	27.08 ^{ab}	26.25 ^{ab}	26.66 ^{ab}	4.20 ^a	4.05 ^a	4.13 ^a
S ₃ M ₆	27.60 ^a	27.11 ^a	27.36 ^a	27.80 ^a	26.91 ^a	27.35 ^a	3.89 ^a	4.25 ^a	4.07 ^a
S.Em±	0.59	0.57	0.58	0.71	0.67	0.69	0.50	0.46	0.48

60 cm x 10 cm along with the application of medium fertilizer dose of 80:40:40 N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS (3103 kg ha⁻¹ on pooled basis). Whereas significantly higher yield and quality parameters were recorded with the combination of wider row spacing of 90 cm x 10 cm along with the application of higher and medium fertilizer dose with growth retardant spray. Significantly lower seed cotton yield was observed with the combination of wider row spacing of 90 cm x 10 cm along with the application of lower fertilizer dose of 60:30:30 N:P₂O₅:K₂O kg ha⁻¹ (2170 kg ha⁻¹ on pooled basis). These results are in close conformity with the finding of Yasari and Vahed (2012), Malakannavar (2017) and Udikeri (2017).

Conclusions

Seed cotton yield with 60 cm x 10 cm spacing was maximum (2875 kg ha⁻¹) which was 5.91 and 20.39 per cent higher over 75 cm x 10 cm spacing (2705 kg ha⁻¹) and 90 cm x 10 cm (2388 kg ha⁻¹). Among different fertilizer levels with growth retardant spray, application of 100:50:50 N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS produced significantly higher seed cotton yield (2915 kg ha⁻¹) which was 17.94 per cent higher over application of 60:30:30 N:P₂O₅:K₂O kg ha⁻¹ which recorded significantly lower seed cotton yield (2392 kg ha⁻¹) amongst all other practices. Combination of 60 cm x 10 cm spacing with application of 100:50:50

N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS recorded significantly higher seed cotton yield (3178 kg ha⁻¹) and was on par with combination of 60 cm x 10 cm spacing with application of 80:40:40 N:P₂O₅:K₂O kg ha⁻¹ + mepiquat chloride @ 250 ppm sprayed at 60 DAS (3013 kg ha⁻¹) which were 31.71 and 27.98 per cent higher over combination of 90 cm x 10 cm spacing with application of 60:30:30 N:P₂O₅:K₂O kg ha⁻¹ which in turn recorded lowest seed cotton yield amongst all (2170 kg ha⁻¹).

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Yield and Quality Parameters of Cotton as Influenced by Genotypes and Plant Densities under High Density Planting System

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Abstract

A field experiment on “Yield and quality parameters of cotton as influenced by genotypes and plant densities under high-density planting system” was conducted at Department of Agronomy, Agricultural College, UAS, Raichur during 2016-17 and 2017-18. Among the different compact cotton genotypes, G₁: SCS-1206 recorded significantly higher boll weight (3.73 g), seed cotton yield per plant (25.98 g) and seed cotton yield per hectare (2886 kg). Whereas, significantly higher ginning out turn (35.29 %), seed index (9.33 g) and lint index (5.10) was observed With the genotype G₃: Suraj and other quality parameters viz., fibre length, fibre strength and micronaire values did not differ significantly. Among the different plant densities, a closer row spacing of S₁: 60 cm x 10 cm recorded significantly higher seed cotton yield (2896 kg ha⁻¹) over the rest of the row spacings. Whereas, other yield parameters viz., boll weight (3.88 g), seed cotton yield per plant (26.16 g) and quality parameters viz., ginning out turn (35.50 %), seed index (9.04 g) and lint index (4.98) were significantly higher at wider row spacing of 90 cm x 10 cm. Among the different combinations, the genotype G₁: SCS-1206 grown at S₁: 60 cm x 10 cm spacing recorded significantly higher seed cotton yield (3096 kg ha⁻¹) and it was found at par with the combination of the same genotype G₁: SCS-1206 with S₂: 75 cm x 10 cm spacing (2949 kg ha⁻¹) and genotype G₃: Suraj with S₁: 60 cm x 10 cm spacing (2923 kg ha⁻¹). Cotton grown under the conventional system with Bt cotton hybrid ATM at a recommended spacing of 90 cm x 60 cm recorded significantly lower seed cotton yield (2314 kg ha⁻¹), and significantly higher yield boll weight (4.28 g) and seed cotton yield per plant (140.80 g) when compared with the all the treatment combinations of cotton grown under HDPS.

Introduction

Cotton is one of the most important cash crop in India and plays a major role in the agricultural economy of the country. Among the various factors responsible for low yield of cotton in the country, low plant population and use of low potential varieties are of primary importance. Under these conditions adaption of HDPS in cotton is more relevant to India in general and Karnataka in particular. The ongoing cotton breeding research in various cotton research centers in the country and at UAS, Raichur has led to evolution of promising compact cotton genotypes which have the advantage of short sympodial branches with reduced inter-nodal length giving morphological feature of compressed habit and clustered boll habit. Plant density is the most active factor and plays a pivotal role in crop management practices. Hence, plant density is the enduring topic for crop production improvement. Amongst the crop management option, the suitable genotypes and optimum plant density are the major part of crop cultivation that visualized now than ever before for yield and quality fibre production. Increase in plant density increased the economic and biological yield per unit area (Parlawar *et al.*, 2017 and Khargkharate *et al.*, 2017).

Keeping these points in view, field investigation under irrigated condition was carried out to know the suitable potential genotype and optimum planting

geometry to get a sustained higher yield under HDPS system.

Materials and Methods

A field experiment on “Yield and quality parameters of cotton as influenced by genotypes and plant densities under high-density planting system” was conducted at Department of Agronomy, Agricultural College, UAS, Raichur during 2016-17 and 2017-18 on medium black soil, neutral in nature with low available nitrogen, medium in phosphorus, rich in potassium. The climatic condition during experimental period was favorable and regular irrigation was provided to crop during both the years at later part of crop growth stages *i.e.* from 60 DAS to till first picking.

The experiment was laid out in split plot design with three compact cotton genotypes viz., G₁: SCS-1206, G₂: DSC-99, G₃: Suraj as main plot treatments and three planting geometries viz., S₁: 60 cm x 10 cm (1,66,666 plants ha⁻¹), S₂: 75 cm x 10 cm (1,33,333 plants ha⁻¹) and S₃: 90 cm x 10 cm (1,11,111 plants ha⁻¹) as sub plot treatments along with conventional system of cotton cultivation with Bt cotton hybrid ATM at a recommended spacing of 90 cm x 60 cm (18,518 plants ha⁻¹) as uneven control.

Results and Discussion

Table-1 : Boll weight (g), seed cotton yield (g plant⁻¹) and seed cotton yield (kg ha⁻¹) of cotton as influenced by genotypes and planting geometries under high density planting system.

Treatments	Boll weight (g)			Seed cotton yield (g plant ⁻¹)			Seed cotton yield (kg ha ⁻¹)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plots (G)									
G ₁	3.80 ^a	3.66 ^a	3.73 ^a	26.42 ^a	25.55 ^a	25.98 ^a	2962 ^a	2811 ^a	2886 ^a
G ₂	3.35 ^b	3.29 ^b	3.32 ^c	22.90 ^c	21.32 ^c	22.11 ^c	2584 ^b	2388 ^b	2486 ^b
G ₃	3.64 ^a	3.54 ^a	3.59 ^b	24.97 ^b	23.82 ^b	24.40 ^b	2842 ^a	2666 ^a	2754 ^a
S.Em±	0.05	0.05	0.03	0.27	0.33	0.16	55.58	52.77	53.73
Sub plots (S)									
S ₁	3.36 ^c	3.25 ^b	3.30 ^b	23.18 ^c	21.61 ^c	22.40 ^c	2974 ^a	2819 ^a	2896 ^a
S ₂	3.49 ^b	3.44 ^b	3.46 ^b	24.47 ^b	23.39 ^b	23.93 ^b	2841 ^b	2675 ^b	2758 ^b
S ₃	3.95 ^a	3.80 ^a	3.88 ^a	26.64 ^a	25.68 ^a	26.16 ^a	2573 ^c	2371 ^c	2472 ^c
S.Em±	0.03	0.11	0.06	0.35	0.46	0.26	42.38	43.68	42.87
Interactions (G x S)									
G ₁ S ₁	3.58 ^{bc}	3.41 ^{a-c}	3.50 ^{bc}	25.06 ^{b-d}	23.63 ^{bc}	24.35 ^{cd}	3156 ^a	3035 ^a	3096 ^a
G ₁ S ₂	3.71 ^{bc}	3.69 ^{ab}	3.70 ^{ab}	25.94 ^{bc}	25.40 ^{ab}	25.67 ^{bc}	3020 ^{ab}	2879 ^{ab}	2949 ^{ab}
G ₁ S ₃	4.12 ^a	3.89 ^a	4.00 ^a	28.26 ^a	27.6 ^a	27.93 ^a	2711 ^{cd}	2518 ^{cd}	2615 ^{cd}
G ₂ S ₁	3.06 ^e	3.01 ^c	3.03 ^d	21.15 ^f	19.37 ^d	20.26 ^f	2761 ^{cd}	2579 ^{cd}	2670 ^{cd}
G ₂ S ₂	3.27 ^{de}	3.19 ^{bc}	3.23 ^{cd}	22.77 ^{ef}	21.13 ^{cd}	21.95 ^e	2621 ^d	2428 ^d	2525 ^d
G ₂ S ₃	3.73 ^b	3.66 ^{ab}	3.70 ^{ab}	24.77 ^{cd}	23.44 ^{bc}	24.11 ^d	2368 ^e	2157 ^e	2263 ^e
G ₃ S ₁	3.44 ^{cd}	3.32 ^{a-c}	3.38 ^{bc}	23.34 ^{de}	21.82 ^{cd}	22.58 ^e	3005 ^{ab}	2842 ^{ab}	2923 ^{ab}
G ₃ S ₂	3.47 ^{b-d}	3.43 ^{a-c}	3.45 ^{bc}	24.68 ^{c-e}	23.64 ^{bc}	24.16 ^d	2882 ^{bc}	2717 ^{bc}	2799 ^{bc}
G ₃ S ₃	4.02 ^a	3.86 ^a	3.94 ^a	26.89 ^{ab}	26.00 ^{ab}	26.45 ^b	2639 ^{cd}	2438 ^d	2539 ^d
S.Em±	0.08	0.18	0.10	0.60	0.79	0.45	73.40	75.65	74.25
Control	4.32	4.24	4.28	143.45	138.14	140.80	2419	2208	2314
S.Em±	0.09	0.17	0.08	1.37	0.88	0.77	77	78	75
CD (P=0.05)	0.28	0.50	0.24	4.08	2.49	2.29	228	230	222

Genotypes : Among the different compact cotton genotypes, G₁: SCS-1206 recorded significantly higher seed cotton yield (2886 kg ha⁻¹ on pooled basis) and significantly lower seed cotton yield was recorded with genotype G₂: DSC-99 (2486 kg ha⁻¹). This difference in seed cotton yield was mainly attributed to significant difference in yield components viz., boll weight and seed cotton yield per plant were significantly higher with the genotype G₁: SCS-1206 (3.73 g and 25.98 g respectively on pooled basis) over rest of the two genotypes. Among the quality parameters, significantly higher ginning out turn (35.29 %), seed index (9.33 g) and lint index (5.10) were recorded with the genotype G₃: Suraj and lower was recorded with the genotype G₂: DSC-99 (33.97 %, 8.28 g and 4.26, respectively). Whereas, other quality parameters viz., fibre length, fibre strength and micronaire values were remained non significant. The differences in yield and quality parameters were mainly due to differences in genetic potential of the genotypes. Similar results were also reported by Killi *et al.* (2016), Udikeri and Shashidhara (2017), Ajaykumar *et al.* (2017), Parlawar *et al.* (2017), Kumar *et al.* (2017) and Sankarnarayanana *et al.* (2018).

Planting geometry : Difference in seed cotton yield due to different plant densities was evident. Among different row spacings, a closer spacing of S₁: 60 cm x 10 cm recorded significantly higher seed cotton yield (2896 kg ha⁻¹ on pooled basis) when compared with the medium row spacing of S₂: 75 cm x 10 cm (2758 kg ha⁻¹ on pooled basis) and wider row spacing of S₃: 90 cm x 10 cm (2472 kg ha⁻¹ on pooled basis). Whereas, yield attributes viz., boll weight and seed cotton yield per plant (3.88 g and 26.16 g, respectively on pooled basis) were significantly higher under wider row spacing of S₃: 90 cm x 10 cm. Which was mainly due to more ground area available for individual plants. Significantly higher seed cotton yield in closer row spacing was attributed to higher plant population per unit area even though the yield attributes were lower when compared to recorded under medium and wider row spacings and increase in the number of plants per unit area could be compensated for decrease in yield components per plant under narrow spacing. Significantly superior seed cotton yield observed was mainly due to higher number of harvested bolls and higher plants population per unit area as supported findings of Alur (2016), Venugopalan *et al.* (2016), Anbarasi and

Table-2 : Ginning out turn (%), seed index (g) and lint index of cotton as influenced by genotypes and planting geometries under high density planting system.

Treatments	Ginning out turn (%)			Seed index (g)			Lint index		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plots (G)									
G ₁	34.94 ^{ab}	34.52 ^a	34.73 ^a	8.57 ^b	8.52 ^b	8.54 ^b	4.61 ^b	4.50 ^b	4.55 ^b
G ₂	34.24 ^b	33.69 ^b	33.97 ^b	8.31 ^b	8.26 ^b	8.28 ^b	4.33 ^b	4.20 ^c	4.26 ^c
G ₃	35.45 ^a	35.14 ^a	35.29 ^a	9.35 ^a	9.32 ^a	9.33 ^a	5.14 ^a	5.05 ^a	5.10 ^a
S.E.m±	0.20	0.19	0.17	0.19	0.14	0.16	0.09	0.03	0.07
Sub plots (S)									
S ₁	34.10 ^b	33.60 ^c	33.85 ^c	8.52 ^b	8.46 ^b	8.49 ^b	4.41 ^c	4.29 ^c	4.35 ^c
OS ₂	34.83 ^b	34.45 ^b	34.64 ^b	8.65 ^b	8.61 ^b	8.63 ^b	4.63 ^b	4.53 ^b	4.58 ^b
S ₃	35.71 ^a	35.29 ^a	35.50 ^a	9.05 ^a	9.03 ^a	9.04 ^a	5.03 ^a	4.93 ^a	4.98 ^a
S.E.m±	0.24	0.25	0.23	0.11	0.11	0.11	0.05	0.05	0.03
Interactions (G x S)									
G ₁ S ₁	34.16 ^{cd}	33.69 ^{cd}	33.93 ^{cd}	8.34 ^{de}	8.28 ^{cd}	8.31 ^{de}	4.33 ^{ef}	4.21 ^{fg}	4.27 ^e
G ₁ S ₂	34.89 ^{b-d}	34.46 ^{a-c}	34.68 ^{bc}	8.48 ^{de}	8.43 ^{cd}	8.46 ^{de}	4.54 ^{de}	4.42 ^{ef}	4.48 ^d
G ₁ S ₃	35.76 ^{ab}	35.40 ^{ab}	35.58 ^{ab}	8.88 ^{b-d}	8.85 ^{bc}	8.87 ^{b-d}	4.95 ^b	4.85 ^{bc}	4.90 ^{bc}
G ₂ S ₁	33.48 ^d	32.85 ^d	33.17 ^d	8.06 ^e	7.99 ^d	8.03 ^e	4.06 ^g	3.91 ^h	3.99 ^f
G ₂ S ₂	34.20 ^{cd}	33.63 ^{cd}	33.92 ^{cd}	8.22 ^e	8.17 ^d	8.20 ^e	4.27 ^{fg}	4.14 ^{gh}	4.21 ^e
G ₂ S ₃	35.04 ^{a-c}	34.59 ^{a-c}	34.81 ^{a-c}	8.64 ^{c-e}	8.60 ^{b-d}	8.62 ^{c-e}	4.65 ^{cd}	4.54 ^{de}	4.60 ^d
G ₃ S ₁	34.65 ^{b-d}	34.26 ^{b-d}	34.46 ^{b-d}	9.15 ^{a-c}	9.11 ^{ab}	9.13 ^{a-c}	4.85 ^{bc}	4.75 ^{cd}	4.80 ^c
G ₃ S ₂	35.39 ^{a-c}	35.25 ^{ab}	35.32 ^{ab}	9.25 ^{ab}	9.22 ^{ab}	9.24 ^{ab}	5.06 ^b	5.02 ^b	5.04 ^b
G ₃ S ₃	36.32 ^a	35.90 ^a	36.11 ^a	9.64 ^a	9.62 ^a	9.63 ^a	5.50 ^a	5.39 ^a	5.44 ^a
S.E.m±	0.42	0.44	0.40	0.18	0.19	0.18	0.08	0.08	0.06
Control	36.58	36.03	36.31	9.89	9.83	9.86	5.43	5.35	5.39
S.E.m±	0.61	0.57	0.57	0.23	0.20	0.21	0.11	0.14	0.11
CD (P=0.05)	1.81	1.70	1.68	0.68	0.59	0.62	0.33	0.43	0.31

Rajendran (2017), Khargkharate *et al.* (2017), Parlwar *et al.* (2017) and Devi *et al.* (2018). Among the quality parameters, significantly higher ginning out turn (35.50 %), seed index (9.04 g) and lint index (4.98) were recorded under wider spacing of 90 cm x 10 cm. whereas, other quality parameters remained non significant. Similar reports were also reported by Alur (2016) and Kumar *et al.* (2017).

Interaction effect : Interaction effect of compact cotton genotypes and planting geometries were found significant. Among the different combinations, interaction of genotype G₁: SCS -1206 with a row spacing of S₁: 60 cm x 10 cm recorded significantly higher seed cotton yield (3096 kg ha⁻¹ on pooled basis) when compared to rest of treatment combination. However, it remained at par with the combination of G₁: SCS-1206 with a row spacing of S₂: 75 cm x 10 cm (2949 kg ha⁻¹ on pooled basis) and genotype G₃: Suraj with a row spacing of S₁: 60 cm x 10 cm (2923 kg ha⁻¹ on pooled basis). Further, boll weight and seed cotton yield per plant were higher with the combination of genotype G₁: SCS-1206 with a row spacing of S₃: 90 cm x

10 cm (4.00 g and 27.93 g, respectively). Among the quality parameters, significantly higher ginning out turn (36.11 %), seed index (9.63 g) and lint index (5.44) were recorded with the combination of genotype G₃: Suraj with a row spacing of S₃: 90 cm x 10 cm and lower was recorded with the combination of genotype G₂: DSC-99 with a row spacing of S₁: 60 cm x 10 cm (33.17 %, 8.03 g and 3.99, respectively). Whereas, other quality parameters remained non significant. cotton grown under conventional system with Bt cotton hybrid ATM at a recommended spacing of 90 cm x 60 cm recorded significantly lower seed cotton yield (2314 kg ha⁻¹ on pooled basis) when compared with all the treatment combinations of cotton grown under HDPS except with the combination of genotype G₂: DSC-99 with a row spacing of S₂: 75 cm x 10 cm (2525 kg ha⁻¹ on pooled basis) and genotype G₂: DSC-99 with a row spacing of S₃: 90 cm x 10 cm (2263 kg ha⁻¹, on pooled basis). Decrease in yield under conventional system of cotton cultivation when compared to HDPS was attributed to the increase in area per plant has not compensated for increase in yield per plant per unit area. The quality

Table-3 : Fibre length (mm), fibre strength (g tex⁻¹) and micronaire value (µg inch⁻¹) of cotton as influenced by genotypes and planting geometries under high density planting system.

Treatments	Fibre length (mm)			Fibre strength (g tex ⁻¹)			Micronaire (µg inch ⁻¹)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plots (G)									
G ₁	27.68 ^a	27.56 ^a	27.62 ^a	24.04 ^a	24.36 ^a	24.20 ^a	3.90 ^a	3.80 ^a	3.85 ^a
G ₂	27.49 ^a	27.26 ^a	27.38 ^a	23.83 ^a	23.91 ^a	23.87 ^a	3.79 ^a	3.70 ^a	3.74 ^a
G ₃	27.97 ^a	27.84 ^a	27.90 ^a	23.98 ^a	24.20 ^a	24.09 ^a	3.85 ^a	3.74 ^a	3.79 ^a
S.E.m±	0.18	0.25	0.16	0.26	0.27	0.15	0.18	0.18	0.17
Sub plots (S)									
S ₁	27.30 ^a	27.11 ^a	27.20 ^a	23.64 ^a	23.81 ^a	23.73 ^a	3.80 ^a	3.72 ^a	3.76 ^a
S ₂	27.78 ^a	27.63 ^a	27.70 ^a	23.88 ^a	24.07 ^a	23.97 ^a	3.85 ^a	3.74 ^a	3.79 ^a
S ₃	28.06 ^a	27.93 ^a	27.99 ^a	24.33 ^a	24.59 ^a	24.46 ^a	3.90 ^a	3.77 ^a	3.84 ^a
S.E.m±	0.24	0.35	0.27	0.30	0.32	0.25	0.29	0.22	0.23
Interactions (G x S)									
G ₁ S ₁	27.30 ^a	27.10 ^a	27.20 ^a	23.80 ^a	24.07 ^a	23.93 ^a	3.85 ^a	3.77 ^a	3.81 ^a
G ₁ S ₂	27.70 ^a	27.63 ^a	27.67 ^a	23.97 ^a	24.27 ^a	24.12 ^a	3.91 ^a	3.81 ^a	3.86 ^a
G ₁ S ₃	28.03 ^a	27.95 ^a	27.99 ^a	24.37 ^a	24.73 ^a	24.55 ^a	3.95 ^a	3.81 ^a	3.88 ^a
G ₂ S ₁	27.10 ^a	26.90 ^a	27.00 ^a	23.53 ^a	23.53 ^a	23.53 ^a	3.75 ^a	3.68 ^a	3.71 ^a
G ₂ S ₂	27.48 ^a	27.23 ^a	27.36 ^a	23.73 ^a	23.80 ^a	23.77 ^a	3.78 ^a	3.67 ^a	3.72 ^a
G ₂ S ₃	27.90 ^a	27.65 ^a	27.78 ^a	24.23 ^a	24.40 ^a	24.32 ^a	3.85 ^a	3.74 ^a	3.80 ^a
G ₃ S ₁	27.50 ^a	27.32 ^a	27.41 ^a	23.60 ^a	23.83 ^a	23.72 ^a	3.80 ^a	3.72 ^a	3.76 ^a
G ₃ S ₂	28.15 ^a	28.02 ^a	28.08 ^a	23.93 ^a	24.13 ^a	24.03 ^a	3.85 ^a	3.73 ^a	3.79 ^a
G ₃ S ₃	28.25 ^a	28.18 ^a	28.22 ^a	24.40 ^a	24.63 ^a	24.52 ^a	3.90 ^a	3.76 ^a	3.83 ^a
S.E.m±	0.42	0.60	0.47	0.52	0.55	0.44	0.42	0.39	0.40
Control	28.61	28.45	28.53	24.97	25.37	25.17	3.96	3.87	3.92
S.E.m±	0.42	0.57	0.45	0.47	0.51	0.38	0.38	0.36	0.36
CD (P=0.05)	1.23	1.68	1.33	1.41	1.50	1.13	1.11	1.06	1.08

parameters values recorded under conventional system remained higher and on par with the wider row spacings irrespective of genotypes of cotton grown under high density planting system. The results are in line with the findings of Tuppad (2015), Udikeri and Shashidhara (2017) and Parlawar *et al.* (2017).

Conclusions

In this research work, among the different compact cotton genotypes, the genotype SCS-1206 recorded significantly higher seed cotton yield (2886 kg ha⁻¹ on pooled basis). Among the different planting geometries, a closer spacing of 60 cm x 10 cm recorded significantly higher seed cotton yield (2896 kg ha⁻¹ on pooled basis) and among the different combinations, interaction of genotype SCS -1206 with a row spacing of 60 cm x 10 cm recorded significantly higher seed cotton yield (3096 kg ha⁻¹ on pooled basis) when compared to rest of treatment combination. Cotton grown under conventional system with Bt cotton hybrid ATM at a recommended spacing of 90 cm x 60 cm recorded significantly lower seed cotton yield (2314 kg ha⁻¹ on pooled basis). Thus, cotton cultivation under high density planting system with suitable compact cotton is economically viable technology for farmers of India as an

alternate means for getting higher yield compared to convention cultivation.

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Soil-Site Suitability and Evaluation of Some Cotton Growing Vertisols of Marathwada Region of Maharashtra State

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Abstract

Six representative soil pedons from different thematic mapping were evaluated from Marathwada region of Maharashtra. The soil sites were examined for soil site properties such as climate, depth, texture, structure and drainage. Physico-chemical properties such as pH, EC, Organic carbon, CEC, CaCO₃ content, available micro nutrient content, bulk density, Hydraulic conductivity, sand, silt, clay were also studied which are the major factors for a successful higher crop production. Morphological analysis showed that surface structure was weak and sub surface was sub angular to angular blocky. Soil colour indicated dark grayish brown to very dark gray in colour, Drainage was moderately well of all soils except P5 and P6 which were imperfect drained, respectively. Soils were clayey in texture and clay per cent ranged from 50.1 to 62.9, sand ranged from 9.7 to 21.6 and silt varied from 25.1 to 32.9, the bulk density range from 1.27 to 1.56 Mg m⁻³. Hydraulic conductivity ranged from 0.1 to 5.3 cm hr⁻¹, pH range (7.8 to 8.7) showed that soils were moderately to strongly alkaline in reaction. Organic carbon content ranged from 1.95 to 10.04 g kg⁻¹, CaCO₃ ranged from 2.87 to 19.0 %, CEC ranged from 38.2 to 78.2 cmol (p⁺) kg⁻¹ based on field morphology and laboratory characterization, the soil of the study area belonged to orders of Vertisols. The all cotton growing soils were classified as the qualified for great group *Haplusterts* except P6 *SodicHaplusterts*. The soils were classified as *TypicHaplustepts* at great group level. Soil profile when correlated with yield, it was concluded that *TypicHaplustepts* belonging to order Vertisols were the best soils for cotton growing that order.

Key words : Classification, soil site, characteristics, vetrisols.

Introduction

Variation in soil properties from place to place arise from differences in parent material, climate, topography, biosphere and the age of ground surface. Even if the parent material does not vary, the variation in physiography in a given area significantly affects the soil properties and, in turn, nutrient availability. In Maharashtra, most of the soils have developed over basaltic parent material and are heavier in texture. These soils are classified as Vertisols and associated soils (very deep to very shallow) as per USDA soil classification system. A survey in Maharashtra showed that black soil having depth of ~ 60 cm constituting 45 percent of an area in 1910 was reduced to 18 percent after 50 years. The remaining 27 per cent almost got turned to shallow soils category [1]. It was also reported by Bhaskaret al. [2], the shallow, medium deep and deep soils covered 36.2, 38.1 and 25.7 per cent area, respectively in the state. Thus shallow soil covers larger area as compared to deep soils.

Cotton is an important cash crop grown widely in the tropical and sub-tropical areas of the world. Currently

India stands first in total production among the leading cotton producing countries in the world, followed by China and USA. The crop productivity in India (500 kg lint ha⁻¹) is, however, far lower as compared to China (1484 kg lint ha⁻¹) and USA (939 kg lint ha⁻¹) (USDA 2017). In India, cotton is cultivated mainly (~65%) in the black soils (Vertisols and vertic-intergrades) under rainfed conditions. These soils are distributed across Central India and are locally known as 'Black Cotton Soils', since cotton is being grown here for centuries. However, it has been observed that the crop productivity in these soils has been dwindling (Mandal et al. 2005) and it might be further worsening. Cotton is an important cash crop grown widely in the tropical and sub-tropical areas of the world. Currently India stands first in total production among the leading cotton producing countries in the world, followed by China and USA. The crop productivity in India (500 kg lint ha⁻¹) is, however, far lower as compared to China (1484 kg lint ha⁻¹) and USA (939 kg lint ha⁻¹) (USDA 2017). In India, cotton is cultivated mainly (~65%) in the black soils (Vertisols and vertic-intergrades) under rainfed conditions. These soils are distributed across

Table-1 : Morphological properties of some cotton growing Vertisols of Marathwada region of Maharashtra.

Soil series	Depth (cm)	Horizon	Matric colour		Structure			SS/PF pressure faces	Soil Consistency	Slop %
			Dry	Moist	Size	Grade	Type			
Latur P1	Ap	0-25	10 YR 3/2	10 YR 3/2	m	2	Sbk	—	vh, vfi, vs, vp	1-3
	Bw1	25-60	10 YR 3/2	10 YR 3/2	m	2	Sbk	—	vh, vfi, vs, vp	
	Bw2	60-90	10 YR 3/1	10 YR 3/1	m	2	Sbk	PF	vh, vfi, vs, vp	
	Bssk	90-120	10 YR 3/1	10 YR 3/1	m	2	Sbk	SS	vfi, vs, vp	
Beed P2	Ap	0-15	10 YR 3/2	10 YR 3/3	m	2	sbk	-	vh, vfi, vs, vp	1-3
	A	15-27	10 YR 3/2	10 YR 3/3	m	2	sbk	-	vh, vfi, vs, vp	
	Bw	27-60	10 YR 3/2	10 YR 3/1	m	2	sbk	PF	vh, vfi, vs, vp	
	Bssk	60-100	10 YR 3/1	10 YR 3/1	m	2	sbk/abk	SS	vh, vfi, vs, vp	
Govindpur P3	Ap	0-15	10 YR 3/1	10 YR 3/2	m	2	sbk	-	sh, vfi, vs, vp	2-3
	A	15-30	10 YR 3/1	10 YR 3/1	m	2	Sbk	-	fi, vs, vp	
	Bw	30-60	10 YR 3/1	10 YR 3/1	m	2	sbk	PF	vfi, vs, vp	
	Bssk	60-105	10 YR 3/1	10 YR 3/1	m	2	sbk/abk	SS	vfi, vs, vp	
Wadgaon P4	Ap	0-15	10 YR 3/3	10 YR 3/3	m	2	Sbk	—	sh, fi, vs, vp	1-3
	A	15-33	10 YR 3/2	10 YR 3/3	m	2	Sbk	—	fi, vs, vp	
	Bss1	33-65	10 YR 3/2	10 YR 3/3	m	2	Sbk	PF	vfi, vs, vp	
	Bssk	65-100	10 YR 3/2	10 YR 3/2	m	2	Sbk	SS	vfi, vs, vp	
Babulgaon P5	Ap	0-20	10 YR 3/1	10 YR 3/1	m	2	Sbk	—	vh, vfi, vs, vp	1-3
	Bw1	20-45	10 YR 3/1	10 YR 3/1	m	2	Sbk	—	vh, vfi, vs, vp	
	Bw2	25-90	10 YR 3/1	10 YR 3/2	m	2	Sbk	PF	vh, vfi, vs, vp	
	Bssk	90-110	10 YR 3/2	10 YR 3/2	m	2	Sbk	SS	vh, vfi, vs, vp	
Hadgaon P6	Ap	0-15	10 YR 5/1	10 YR 4/1	m	2	sbk	-	vfi, vs, vp	0-3
	A	15-40	10 YR 4/2	10 YR 4/1	m	2	sbk	-	vfi, vs, vp	
	Bw	40-65	10 YR 4/2	10 YR 4/1	m	2	sbk	PF	fi, vs, vp	
	Bssk	65-105	10 YR 4/2	10 YR 4/2	m	2	sbk/abk	SS	fi, vs, vp	

Central India and are locally known as 'Black Cotton Soils', since cotton is being grown here for centuries. However, it has been observed that the crop productivity in these soils has been dwindling (Mandal et al. 2005) and it might be further worsening. Cotton is an important cash crop grown widely in the tropical and sub-tropical areas of the world. Currently India stands first in total production among the leading cotton producing countries in the world, followed by China and USA. The crop productivity in India (500 kg lint ha⁻¹) is, however, far lower as compared to China (1484 kg lint ha⁻¹) and USA (939 kg lint ha⁻¹) [3]. In India, cotton is cultivated mainly (~ 65%) in the black soils (*Vertisols and verticintergrades*) under rain fed conditions. These soils are distributed across Central India and are locally known as 'Black Cotton Soils', since cotton is being grown here for centuries. However, it has been observed that the crop productivity in these soils has been dwindling [4] and it might be further worsening due to the introduction of long staple Bt cotton (that is primarily developed for irrigated farming) owing to its high sensitivity towards moisture stress [5]. These dwindling trends in crop yield and crop failures often force the farmers to adopt alternate crops and systems for their

sustenance. The decline in productivity and crop loss may be due to several factors (both biophysical and socioeconomic) of which biophysical constraints often predominate. The biophysical factors limiting crop production includes (i) unfavorable soil conditions (both physical and chemical) such as high CaCO₃, development of sodicity and poor soil structure [6,7], and poor soil fertility status [8], (ii) meteorological factors such as erratic rainfall, humidity variations during various phenological stages and its implications on pests and diseases [9], evapotranspiration variations on the soil water balance [10], solar radiation and its interception [9], and (iii) the nature of various soil management practices [11]. The crop performance in Vertisols under rainfed farming primarily depends on soil-site parameters such as depth, texture, drainage as conditioned by climate, and topography. Therefore, exhaustive assessment of soil-site characteristics for predicting the crop performance of an area forms a routine task in land evaluation. Van Wadnbeke and Rossiter [12] defined that land evaluation is the ranking of soil units on the basis of their inherent capabilities, under the prevailing management and socio-economic scenarios to produce

Table-2 : Soil site Characteristics of some cotton growing Vertisols Marathwada region of Maharashtra.

Location	Latitude	Longitude	MAR (mm)	MAT (°C)	Topography	Drainage	Slope %
Beed P1	18°95"48	75°75"80	699.4	25.15	Plateau	M. Well	1-3
Govindpur P2	18°63"96	76°78"70	736.2	25.8	Subdued Plateau	M. Well	2-3
Wadgaon P3	18°28"68	76°09"97	708.4	25.8	Subdued Plateau of inter hill	Imperfect	1-3
Latur P4	18°41"96	76°61"85	743.5	26.7	Plateau	M. Well	1-3
Babulgaon P5	19°24"93	75°61"37	743.5	26.7	Plateau	Imperfect	1-3
Hadgaon P6	19°16"34	75°45"89	905.6	28.3	Plateau	M. Well	0-3

Table-3 : Physical properties of some cotton growing Vertisols of Marathwada region of Maharashtra.

Pedon	Horizons	Depth (cm)	SHC cm hr ⁻¹	Bulk density (Mg m ⁻³)	Particle size distribution (%) (< 2mm)			Textural class
					Sand	Silt	clay	
Latur P1	Ap	0-25	1.0	1.30	21.6	28.4	50.1	c
	Bw1	25-60	1.4	1.31	18.03	30.27	51.7	c
	Bw2	60-90	1.1	1.40	16.1	30.8	53.1	c
	Bssk	90-120	0.9	1.42	15.8	28.3	55.8	cl
Beed P2	Ap	0-15	2.3	1.48	16.8	30.1	53.1	c
	A	15-27	2.8	1.51	14.6	29.8	55.6	c
	Bw	27-60	1.1	1.53	20.6	27.6	51.8	cl
	Bssk	60-100	0.2	1.53	16.1	25.1	58.9	cl
Govindpur P3	Ap	0-15	4.7	1.36	17.2	31.6	51.2	c
	A	15-30	5.3	1.41	16.1	31.1	52.7	cl
	Bw	30-60	1.9	1.39	15.8	29.1	55.1	cl
	Bssk	60-105	0.9	1.29	14.2	27	58.8	cl
Wadgaon P4	Ap	0-15	2.5	1.29	19.8	28.1	52.2	c
	A	15-33	2.7	1.32	17.9	28.4	53.7	c
	Bss1	33-65	0.9	1.36	16.2	28.2	55.6	c
	Bssk	65-100	0.4	1.27	14.9	27.8	57.3	cl
Babulgaon P5	Ap	0-20	1.0	1.39	21.2	26.7	52.1	c
	Bw1	20-45	2.1	1.48	20.3	26.5	53.2	cl
	Bw2	25-90	0.4	1.42	19.4	26.2	54.4	cl
	Bssk	90-110	0.1	1.41	10.1	32.9	56.8	cl
Hadgaon P6	Ap	0-15	0.5	1.52	15.8	27.1	57.1	c
	A	15-40	1.0	1.54	12.8	28.7	59.2	c
	Bw	40-65	0.4	1.56	16.7	31.8	51.2	c
	Bssk	65-105	1.9	1.55	9.7	28.3	62.1	c

optimum returns per unit area time. An effective resource planning should, therefore, be efficiently implemented for wider applicability.

The clay content in soil generally increased with depth indicating movement of clay from surface to sub surface layers. Very high profile water storage capacity was observed in *VerticHaplustepts* and high profile water storage capacity was observed in *TypicHaplustepts*[13].

Taxonomic and pedogenic classification and characterization of these soils is one of the importance for land use planning and soil resource management under

the existing subtropical climatic conditions. The present investigation was undertaken to characterize and evaluation of cotton growing Vertisols of Marathwada region of Maharashtra. There is an urgent need for location specific research attention on delineation of available N,P and K status of soils and their deficiency and toxicities affecting the crop growth. Such study is felt necessary now more than ever before. Hence, estimation of soil fertility status of Vertisols of Marathwada region was undertaken. For effective planning and better utilization of soil resources, information relating to soil-site suitability for cultivation of cotton is necessary.

Table-4 : Chemical properties of some cotton growing Vertisols of Marathwada region Maharashtra.

Pedon	Horizo	Depth (cm)	pH	EC (dSm ⁻¹)	OC (g kg ⁻¹)	CaCO ₃ (%)	CEC (cmolp + kg ⁻¹)
Latur P1	Ap	0-25	8.1	0.291	6.82	2.8	55.8
	Bw1	25-60	8.0	0.287	6.24	3.8	52.1
	Bw2	60-90	8.3	0.337	4.29	3.0	62.5
	Bssk	90-120	8.3	0.345	3.51	5.0	40.5
Beed P2	Ap	0-15	8.0	0.270	6.24	4.1	59.2
	A	15-27	7.8	0.286	5.85	3.5	62.1
	Bw	27-60	8.1	0.231	5.62	8.6	62
	Bssk	60-100	7.9	0.261	3.31	11.2	59.1
Govindpur P3	Ap	0-15	8.1	0.254	9.94	4.8	45.4
	A	15-30	8.5	0.288	6.24	7.6	47.1
	Bw	30-60	8.3	0.346	5.24	9.0	51.6
	Bssk	60-105	8.4	0.560	2.92	11.0	41.3
Wadgaon P4	Ap	0-15	8.0	0.233	9.75	9.5	48.9
	A	15-33	7.9	0.269	7.21	11.0	51.5
	Bss1	33-65	7.9	0.204	5.46	15.8	56.3
	Bssk	65-100	8.1	0.290	4.09	19.0	40.3
Babulgaon P5	Ap	0-20	8.2	0.470	10.04	4.8	77.5
	Bw1	20-45	8.1	0.238	8.77	4.0	76.1
	Bw2	25-90	8.0	0.203	6.82	6.5	78.2
	Bssk	90-110	8.3	0.221	3.90	11.5	68.2
Hadgaon P6	Ap	0-15	8.4	0.635	6.24	7.5	45.5
	A	15-40	8.7	0.444	5.07	14.1	47.3
	Bw	40-65	8.4	0.591	3.51	7.8	66.2
	Bssk	65-105	8.5	0.600	1.95	18.9	38.2

Materials and Methods

The study area was chosen cotton growing Vertisols of the district of Osmanabad, Latur, Beed and Nanded in Marathwada region of Maharashtra State, India. The geology at the area is essentially basalts of the Deccan trap. Six sites on different thematic mapping were selected and nomenclature the soils of the study area as, P1 to P6 are *TypicHaplusterts*. The profiles were exposed and examined on each selected site. The morphological characteristics such as structure, texture, consistence, pores, roots, nodules, effervescence, coarse fragment and other feature like deep cracks were observed as seasonal dry and wet periods produced short-term cycles of soil surface crack area density (crack density). Horizon wise soil samples were collected as per the guidelines given by Anonymous [14]. In addition, the site characteristics such as location, slope, and climate were also studied. Soil samples were collected for each profile horizon-wise, air dried, processed and passed through 2 mm sieve for laboratory analysis. Physical properties like particle size distribution was determined as per the International pipette method [15]. Bulk density was determined by dry Clod waxing technique [16], Hydraulic conductivity was determined by Constant head method,

pH and EC were measured in 1:2.5 soil-water suspension and Cation exchange capacity (CEC) was determined by I NaOAc at pH 8.2 [16]. Exchangeable Ca²⁺ was determined by KCl-triethanolamine method followed by EDTA titration and Organic carbon was determined by Walkley and Black, [17]. Calcium carbonate equivalent was determined by acid neutralization method [16]. Available zinc, copper, iron and manganese were extracted by 0.005 M DTPA solution [18] and analyzed with the help of Atomic Absorption Spectrophotometry.

Results and Discussion

Soil-site characteristics of cotton growing Vertisols of Marathwada region of Maharashtra : The characteristic of the six 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) (°C) and topography etc. are given in (Table 1). The soils of pedon P1, P5 and P6. Plateau in topography to be slightly undulating that of pedon P2 and P3 were Subdued Plateau. The slope and drainage were recorded to be 1-3 % except pedon P2, medium and Imperfect of all pedon. The variation in morphological characteristic of six profiles indicated that the soil vary in depth and colour

Table-5 : Available macro nutrient status of some cotton growing Vertisols of Marathwada region of Maharashtra.

Pedon	Horizon	Depth cm	Available macro nutrient			Available micronutrient (mg kg ⁻¹)			
			N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)	Fe	Mn	Zn	Cu
Latur P1	Ap	0-25	213.2	21.20	465.8	5.52	15.66	0.91	2.83
	Bw1	25-60	194.3	6.50	438.9	5.10	12.13	0.68	3.10
	Bw2	60-90	140.1	2.80	382.7	4.37	8.17	0.49	2.01
	Bssk	90-120	90.7	1.80	337.5	3.18	6.42	0.46	0.59
Beed P2	Ap	0-15	259.9	18.20	318.2	6.13	21.89	1.23	2.61
	A	15-27	125.4	2.80	404.7	4.20	14.39	0.92	3.11
	Bw	27-60	94.9	1.20	350.3	3.17	12.94	0.92	2.16
	Bssk	60-100	74.4	1.00	272.6	3.00	8.39	0.49	1.67
Govindpur P3	Ap	0-15	128.5	16.30	403.8	5.91	12.81	0.93	4.13
	A	15-30	134.8	8.90	427.1	4.76	13.80	1.11	4.12
	Bw	30-60	97.2	3.10	348.2	3.93	2.36	0.81	4.23
	Bssk	60-105	87.8	2.00	382.5	3.51	3.09	0.61	2.22
Wadgaon P4	Ap	0-15	206.9	27.10	583.8	6.20	15.42	1.39	3.90
	A	15-33	334.8	11.20	472.1	5.53	12.83	0.91	4.10
	Bss1	33-65	128.5	1.60	461.2	4.18	6.40	0.61	2.56
	Bssk	65-100	63.9	1.40	382.3	3.81	7.51	0.51	1.75
Babulgaon P5	Ap	0-20	225.8	16.10	618.2	7.21	13.18	0.47	3.32
	Bw1	20-45	100.4	3.20	512.7	5.16	15.54	0.90	4.11
	Bw2	25-90	81.5	2.10	348.7	4.71	10.59	0.81	2.42
	Bssk	90-110	69.6	1.60	317.2	3.58	5.63	0.68	1.56
Hadgaon P6	Ap	0-15	103.5	10.60	519.9	5.17	14.18	0.90	2.13
	A	15-40	222.7	4.60	303.9	3.90	12.37	0.81	1.98
	Bw	40-65	65.9	2.20	229.6	4.13	8.87	0.82	1.72
	Bssk	65-105	62.7	1.20	294.1	3.29	4.98	0.51	1.67

considerably depending upon the topographic situation. The morphological characteristics showed considerable variation in the nature and degree of horizon development reported by Raina [19]. The morphology of the Vertisols indicated that the soils were deep to very deep (1.00 m to more than 1.2m). 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. Slickensides were well developed and were tilted to an angle 45-60 degree from horizontal.

Morphological properties of cotton growing Vertisols of Marathwada region of Maharashtra : The peds broke into small sub angular blocky to angular blocky peds. The soils were very dark grey to dark yellowish brown (10YR 3/1.5 to 10YR 4/4). The surface horizons of all the pedons generally had sub angular blocky structure and slightly hard to hard (dry) and friable to moderately friable (moist) condition and very sticky and very plastic in wet condition of consistency (Table 2). In pedons 1, 2, 3 and 4, the effervescence (with 10% HCl) was slight where as in pedons 6, it was strong to violent to which attributed process of diffuse powdery form of CaCO₃. Calcium carbonate was observed throughout the depth of all soils. 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 by considering the sand, silt and clay per cent. The data indicated that all the soils were clayey in texture. Per cent clay ranged from 50.1 P1 (Latur) to 62.9 P6 (Hadgaon), whereas the sand per cent ranged from 9.7 P6 (Hadgaon) to 21.6 P1 (Latur) and that of silt per cent ranged from 25.1 P2 (Beed) to 32.9 P5 (Babulgaon). 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 [20].

Physical properties of cotton growing Vertisols of Marathwada region : The data on physical characteristics of soils were presented in Table-3. The surface and sub surface soil had lower bulk density value of (P4) 1.27 to (P6) 1.56 Mg m⁻³.

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 [21]. 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 Vertisols [22]. The mass of soil unit⁻¹ of volume including pore space is the bulk density [23].

Table-6 : Soil site suitability classes and yield of some cotton growing Vertisols of Marathwada region Maharashtra.

Pedons	Sys et. al., (1991) and NBSS and LUP (1994)	Soil site suitability classes (with limitation) FAO (1983)		
	Cotton	Yield (q/ha)	Optimum yield (25 q ha ⁻¹)	Suitability class
Latur P1	S2	15.48	62	S2
Beed P2	S2 (h,o)	10.53	42.12	S2
Govindpur P3	S3 (o)	11.04	44	S2
Wadgaon P4	S2 (k,o)	19.87	79.5	S1
Babulgaon P5	S1	—	—	No Sowing
Hadgaon P6	S2 (k,h)	13.01	52.04	S2

* Latter in parentheses show limitation as, dt-soil depth, s- slop, o-organic carbon, k-CaCO₃, h-hydraulic conductivity and p- pH.

* Suitability class – S1- Highly suitable, S2- Moderately suitable, S3- Marginally suitable, N1- Currently not suitable & N2- Un suitable.

*The yield was notated in mean of 5 years (—Not regular sowing).

The hydraulic conductivity ranged from 0.1 cm hr⁻¹ (P5) to 5.3 cm hr⁻¹ (P2). 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.

Chemical properties of some cotton growing Vertisols of Marathwada region Maharashtra : The chemical properties of soil are presented in table 4. The pH data indicated that the soil were generally moderate to strongly alkaline in reaction with pH varying between 7.8 (P2) to 8.7 (P6).

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 Kaushalet *al.*, [24]. 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, intrusion followed by evapotranspiration resulting in the salt accumulation at the subsurface horizon. Similar to this observation of Rajankar [25] 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 studied soils. This content ranged from 1.95 (P6) to 10.04 (P5) g kg⁻¹. This might be due to the sieving effect and adsorption of fine organic particles and water soluble organic matter respectively by soil particles. The calcium carbonate content varied from 2.8 % (P1) to 19.0 % (P4). 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 properties of soil and may prevent root penetration [26]. The high cation

exchange capacity is attributed to the high amount of clay. The CEC ranged from 38.2 cmol^(P+) kg⁻¹ (P6) to 78.2 cmol^(P+) kg⁻¹ (P5) Babhulgaon. The cation exchange capacity of these black soils is attributed to its smectitic clay mineralogy [27]. Since soils under study had low to moderate organic carbon status, clay fraction appeared to influence largely the CEC value.

Nutrient status of some cotton growing Vertisols of Marathwada region Maharashtra : The available N, P and K ranged from 62.70 to 334.80, 1.00 to 27.10 and 229.6 to 618.2 kg ha⁻¹, respectively in different pedons and in general, their content decreased with the depth (Table 5). The variation in available N content in soil could be attributed to the differences in their physiographic, differential cultivation and management practices of this soil a 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 the [28]. The available N was optimum in Ap horizons of P4 (Babhulkar) and low in Bw horizons of P6 (Hadgaon). Available P was optimum in surface horizon of P4 and low to deficiency in other pedons and K was above optimum at P5 (Babulgaon) and low in Bw-horizons P6 (Hadgaon).

Singh *et al.* [29] reported that medium ranges N in litchi growing soil. In soil available P more than 50 per cent samples were observed in adequate amount at both the depth of soil P and K was above optimum at P5 and low in P6 whereas, available soil K 15.60 and 32.10 per cent ranges were inadequate range in both the cultivars. It might be due to basaltic parent material (weathered rock and alluvium) which are basic in nature.

The diethylenetriaminepenta 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 0.46 mg kg⁻¹ which was also reported by Sharma *et al.* [30].

The 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 mg kg⁻¹ as per the criteria given by Lindsay and Norvell [18].

Soil site suitability on cotton growing Vertisols of Marathwada region of Maharashtra : Cotton being a long duration crop with deep rooting system shows significant yield decline in Vertisols with low moisture storage. Higher yields could however be obtained in deeper soils. It tolerates fairly wide range of soil pH conditions i.e acidity and alkalinity [31]. The field studies show that cotton is successfully grown in deep soils with good drainage [2,32-34]. A depth of 100 to 120 cm has been observed to be optimum, whereas < 50 cm depth was considered uneconomical to grow cotton [2].

Based on these criteria and limitations, the soil-site suitability of P1 to P6 pedons was worked out (Table 6).

The overall suitability class for cotton showed that soil of P5 (Babulgaon) are highly suitable (S1) for growing cotton due to depth and landform. The Pedons P1 to P4 are marginally suitable (S2) and Hadgaon P6 are moderately suitable for cotton cultivation with moderate limitation of calcareousness. Average yield of cotton kg ha⁻¹ was calculated on 5 years data. It was found from the result that soils with similar suitability showed wide variation in yield of cotton. From the data it was correlated that the Typic Haplusteres (P5) belonging to Vertisols were best soils for cotton growing.

Conclusions

The soils of study area were very dark grey to dark yellowish brown in colour, sub-angular blocky to angular blocky in structure, very sticky very plastic in consistency, clay to clay loam in texture and classified as all pedons are *Typic Haplustert* sand except P6 *Sodic Haplusterts* at great group level. The soils were slightly to moderately alkaline, low to moderate in organic carbon content and calcareous in nature. The soil site suitability evaluation indicated that most of the soils have good potential to grow the cotton crop. The soils of *Typic Haplusterts* were highly suitable and soils of except P6 *Sodic Haplusterts* were marginally suitable for cotton crop. 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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Impact of Sheep Penning in Mulberry Garden on Soil Health, Leaf Quality and Economic Traits of Silkworm, *Bombyx mori* L.

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Abstract

Studies were conducted to find out the impact of sheep penning in mulberry garden on soil health and its influence on mulberry leaf quality and economic traits of silkworm, *Bombyx mori* L. in comparison to application of recommended doses of chemical and biofertilizers. The practice of annual sheep penning clubbed with regular application of biofertilizers after each leaf harvest registered significantly improved soil fertility besides reduction in PH and EC values, increase in nutritional values of mulberry leaf and superior economic traits of silkworm than the practice of application of recommended doses of fertilizers. Further, repeated applications of inorganic manures in the mulberry garden resulted to adverse impact on all the above parameters. Thus, a holistic approach should be made for creating awareness among the sericulture farmers and popularizing sheep penning strategies for sustainable production of cocoon and to fetch more profit through sericulture.

Key words : Mulberry, chemical fertilizers, biofertilizers, sheep penning, soil nutrients, microbial, populations, leaf quality, silkworm, economic traits

Introduction

Mulberry, *Morus alba* L. the food plant of the silkworm *Bombyx mori* L. is a perennial crop and once planted can be maintained for many years. The quality of leaf fed with the silkworm plays vital role on its growth and development and economic traits including cocoon yield and silk ratio. Therefore, practices of application of chemical fertilizers, NPK @ 28:11:11 kg per acre after each leaf harvest and farm yard manure @ 8 MT/ac /year to replenish the soil nutrients for sustainable production of quality mulberry leaves (Sakthivel *et al.*, 2014). However, continues use of chemical fertilizers in mulberry ecosystem pollutes the soil and ground water, alters physical and chemical properties of soil, depletes the naturally available essential nutrients besides deleterious effect on beneficial micro and macro-organisms which play vital role on soil health and plants growth (Devi and Sakthivel, 2018). Dandin *et al.* (2003) suggested that application of biofertilizers viz. *Azospirillum* and *Phosphobacteria* @ 2 kg each /ac/crop could compensate the reduction of 50% of chemical fertilizers N & P in mulberry garden. However, promotion of organic farming in mulberry garden is inevitable in order to avoid deleterious effect of chemicals on soil health (Sakthivel *et al.*, 2018).

Sheep penning is one of the traditional methods of enhancing soil fertility. Penning is a fascinating cooperative effort between shepherds and farmers.

Penning is an important traditional practice in Tamil Nadu, India and more than 57% of farmers follow the practice at least once in 2 years. This practice involves camping of sheep in the crop fields over night or days of nights in agriculture field after the crop harvest i.e., prior to next crop (Nandhini and Suganthi, 2018). After penning, urine and fecal matter added to the soil is incorporated to a shallow depth by ploughing or digging. Being perennial in nature and continuous crop, sericulture farmers devoid of such practice in mulberry gardens due to risk of grazing. Therefore, an attempt is made to implement sheep penning in mulberry gardens immediately after completion of leaf harvest and pruning of stem and prior to sprouting of plants. A study was also carried out to find out the impact of adopting sheep penning by the sericulture farmers on soil health, mulberry leaf quality and economic traits of silkworm in order to add the sheep penning as one of the components of organic farming in mulberry ecosystem.

Materials and Methods

The studies were conducted in potential sericulture cluster of Rasipuram block, Namakkal district of Tamil Nadu. A total number of 18 farmers who holding 5-6 years old V1 mulberry variety with good water source and proper maintenance of the garden in the same location were selected. They were grouped into six with three farmers in each group based on manuring practices and among them sheep penning was implemented with 9 farmers. Penning of sheep @ 1000 numbers per acre

Table-1 : Influence of sheep penning on chemical properties of soil in mulberry ecosystem

Treatments	pH	EC (dS m ⁻¹)	Organic carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
T ₁	7.56	0.43	0.39	142.00	12.80	216.21
T ₂	7.61	0.40	0.49	172.20	18.64	232.32
T ₃	7.46	0.33	0.54	195.83	21.72	250.44
T ₄	7.25	0.28	0.54	196.20	19.98	258.54
T ₅	7.08	0.22	0.75	233.00	27.86	256.65
T ₆	8.20	0.58	0.35	126.46	11.36	198.34
CD (P=0.05)	0.076	0.041	0.030	16.53	2.68	13.49

Table-2 : Nutrient content of mulberry leaves as influenced by sheep penning.

Treatments	Moisture content (%)	Leaf moisture retention capacity (%)	Total Protein (%)	Total carbohydrates (%)	Leaf yield (MT/ha/year)
T ₁	60.84	67.28	18.53	28.00	47.26
T ₂	62.25	73.96	18.26	30.60	46.64
T ₃	71.19	89.10	21.10	34.95	55.75
T ₄	70.63	92.36	19.32	36.85	53.80
T ₅	73.35	92.19	21.96	38.06	59.18
T ₆	59.26	53.66	15.78	25.44	38.38
CD (P=0.05)	8.59	12.31	3.80	3.96	12.16

were allowed for penning for two nights, immediately after pruning of plants. Penning was done annually during the month of September prior to commencement of North-East monsoon for three years during 2018-2020. Green manuring with dhaincha (*Sesbania aculeata* Pers.) was done with all the farmers invariably once in a year in the month of March with the onset of summer rain. Based on the manuring practices, the treatments were categorized into six as detailed below :

T₁ : Farmers applying recommended doses of chemical fertilizers NPK @ 28:11:11 kg/ac/each crop (i.e., six times in a year) and FYM @ 8 MT /ac/year in two splits doses.

T₂ : 50% reduction in recommended doses of N&P and recommended doses of Azospirillum 2kg and Phosphobacteria 2 kg/ac/each crop and FYM @ 8 MT /ac/year in two splits.

T₃ : Sheep penning + 50% reduction in recommended doses of NPK/each crop.

T₄ : Sheep penning + 50% reduction in recommended doses of NPK/alternate crops.

T₅ : Sheep penning + 50% reduction in recommended doses of NPK and Azospirillum 2kg and Phosphobacteria 2 kg/ac/each crop.

T₆ : Farmers using only chemical fertilizers irrespective of recommendations (control farmers).

Soil samples from the mulberry gardens of each group were collected in bimonthly intervals separately after each silkworm rearing, i.e., after completion of each shoot harvest and before application of manures for next

crop, covering six crops / year for the period of three years. The samples were collected from a depth of 0-30 cm by digging 1x1x1 feet cubic pits. The soil from the sides of the pit was scraped out and collected at 4-5 locations. The soil collected from various pits of a garden was mixed thoroughly, spread over a plastic sheet, divided into four equal parts and one set of opposite quarters was discarded. The remaining two parts were mixed well and the process repeated for 2-3 times and reduced to 500-700 gram.

Soil pH, electric conductivity, organic carbon, available nitrogen, available phosphorus and available potassium were analyzed following standard methods (Jackson, 1973). The soil samples from each category of farmers were mixed together to form a composite sample for isolation of microbes by dilution plate technique (Waksman, 1922) and different microflora were recorded and the population in terms of colony forming units (CFU) per gram soil was calculated. The quality parameters of mulberry leaf viz., moisture content (%), leaf moisture retention capacity (Dandin and Jolly, 1986), total protein (Lowry *et al.*, 1951) and total carbohydrate (Dubois *et al.*, 1956) were estimated using standard procedures. Leaf yield was recorded for every crop at 60th day after each pruning by harvesting leaves from randomly selected 20 plants from each garden.

In order to find out the effect of manuring practices on rearing parameters of silkworm, all the farmers were uniformly supplied with the commercial double hybrid FC1 x FC2 silkworms after second moult and allowed to rear further as per the recommended package of

Table-3 : Influence of sheep penning on economic traits of silkworm.

Treatment	Larval duration (D:H) III-IV instars	Weight of matured larva (g)	Single cocoon weight (g)	Single shell weight (g)	Silk Ratio (%)	Average cocoon yield per 100 layings
T ₁	18.16	3.49	1.617	0.354	21.89	59.621
T ₂	18.20	3.52	1.605	0.353	21.99	63.500
T ₃	18.21	4.73	1.883	0.449	23.84	80.050
T ₄	18.19	4.40	1.819	0.429	23.58	77.567
T ₅	18.18	4.75	1.917	0.455	23.73	83.525
T ₆	18.18	3.25	1.565	0.301	19.23	48.750
CD (P=0.05)	-	0.061	0.026	0.011	3.33	9.16

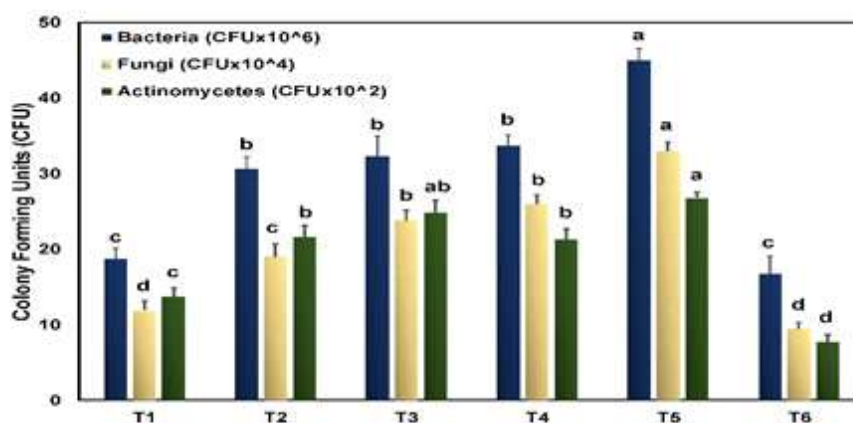


Fig-1 : Influence of sheep penning on microbial population of soil in mulberry ecosystem.

practices (Dandin *et al.*, 2003) till cocooning and entire rearing were monitored by periodical visits. Data on larval periods (days), matured larval weight (g), single cocoon weight (g), single shell weight (g), silk ratio (%), average cocoon yield (kg/100 dfls) were recorded at each rearing. Analysis of variance (ANOVA) for soil chemical properties of soil, microbial population, quality parameters of mulberry and rearing performance of silkworm were analyzed by using STATISTICA version 6.

Results and Discussion

Chemical properties of soil : The data on the chemical properties of soil in mulberry ecosystem as influenced by sheep penning showed notable variations in pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), available phosphorus (P), and available potassium (K) (Table 1). The Soil pH was in desirable range 7.08 (T5), 7.25 (T4) and 7.46 (T3) with treatment of sheep penning and also use of biofertilizers with only 50% chemical fertilizers, 7.61 (T2) but increased (9.13) adversely with only chemical fertilizer (T6) which was closely followed by T1 (8.56) on application of recommended doses of chemical fertilizers. The value of electrical conductivity was found less than 0.8 dS/m in all the treatments which were found safe for mulberry crop. However, highest EC

(0.058) was recorded with the gardens received only chemical fertilizers (T6) and it was followed by T1 (0.43) and T2 (0.40). Sheep penning exhibited significantly decreased EC 0.33 (T3), 0.28 (T4) and 0.22 (T5).

Sheep penning resulted in significantly higher percentage of organic carbon content, 0.54% (T3 & T4) and 0.75% (T5) over control (0.35) where as one time application of FYM with 100% NPK (T1) was found on par (0.39) with control (T6). The quantities of available form of all three major soil nutrients viz. nitrogen (kg/ha), phosphorus (kg/ha) and potassium (kg/ha) were found comparatively higher in all the treatments with sheep penning (T3-T5) however, Sheep penning with the combination of biofertilizers and 50% reduced application of recommended doses of NPK (T5) exhibited highest values 233.00, 27.86 and 256.65 respectively. The gardens received continuous doses of inorganic fertilizers (T6) registered lowest values of NPK (126.46, 11.36 and 198.34).

Impact on biological properties of soil : The soil microbial population in mulberry garden was significantly influenced by the practice of sheep penning and application of different doses of inorganic fertilizers alone or with biofertilizers (Table 2). The sheep pent gardens were exhibited highest population of all soil microbes but

significantly maximum bacterial counts (43.19), fungal (25.43) and actinomycetes (25.43) were recorded from the sheep pentgarden applied with recommended doses of biofertilizers and 50% reduction in chemical fertilizers (T5). However, repeated application of chemical fertilizers without any organic inputs (T6) exhibited very poor count in population of bacteria (13.66), fungi (9.18) and actinomycetes (9.21) and found to be highly injurious to these soil microbes. Reduced application of inorganic manure with regular application of biofertilizers & FYM exhibited considerable amount bacterial count 31.33 (T2) than the sheep penned garden without application of biofertilizers which received 50% doses of chemical fertilizers (28.07, T3).

Impact on mulberry leaf quality : In respect of leaf quality, leaf moisture (%), moisture retention capacity, total protein and total carbohydrate contents in leaf were found differed significantly in relation to sheep penning and different manuring practices in mulberry garden (Table 3). The leaves harvested from all the gardens pent with sheep (T3, T4 & T5) were registered its superior values of moisture content (71.19, 70.63 & 73.35%), moisture retention capacity (89.10, 92.36, 92.19%), protein content (21.10, 19.32 & 21.96%) and carbohydrate content (34.95, 36.85 & 38.06%) comparable to all unpent mulberry gardens whereas the gardens received repeated doses of chemical fertilizers alone (T6) exhibited least values viz. 15.78%, 25.44%, & 38.38% of respective parameters. Considerable increase in leaf yield (55.75, 53.80 & 59.18 MT/ha/year) was recorded with all sheep pent gardens (T3, T4 & T5) comparable to unpent gardens (47.26: T1 & 46.64: T2) whereas the leaf quality and yield (38.38) affected significantly due to repeated applications of inorganic manures (T6).

Impact on rearing parameters of silkworm : Varied manuring practices and sheep penning in mulberry garden significantly influenced the economic traits of silkworm and cocoon yield except that of larval duration which exhibited no differences among the treatments (Table-4). Feeding silkworms with the leaves harvested from the sheep pent gardens (T3, T4 and T5) resulted to improved economic traits of silkworms viz. more weight of matured larvae (4.73, 4.40 & 4.75 g), highest values in single cocoon weight (1.883, 1.819 and 1.917 g), single shell weight (0.4449, 0.429 & 0.455 g), silk ratio (23.84, 23.58 & 23.73 %), average cocoon yield (80.050, 77.567 & 83.525 kg / 100 dfls) when compared to unpent gardens (T1 & T2) with the values 3.49, 1.617, 0.354, 21.89 & 59.621 and 3.52, 1.605, 0.353, 21.99 & 63.500 respectively. The gardens received repeated application of chemical fertilizers (T6) which yielded least values in respective economic traits (3.25, 1.565, 0.301, 19.23 & 48.750).

The dropping of sheep and goats contain higher nutrients than farmyard manure and compost. On an average, the manure contains 3 per cent N, 1 per cent P and 2 per cent K₂O (Sakthivel *et al.*, 2014). Sheep penning with application of biofertilizers lowers the pH and EC which may be due to the accumulation of organic acids from microbial metabolism or from the production of fulvic and humic acids decomposition (Albannell *et al.*, 1988). The increase in organic carbon content could be attributed to contribution of litter and urine to the soil in the form of residues and oxidation of these organic matters by microbes. The highest content of available nutrients in the sheep pent garden as well as application of biofertilizers might be due to improvement of physical and chemical properties and better nitrogen fixing capacity of Azospirillum and P solubilization. Similar influence of organic based inputs in mulberry garden was reported by Sashidhar *et al.*, (2009).

Positive relationship with organic inputs and mulberry leaf quality was reported by Sakthivel *et al.*, (2014). In mulberry, leaf moisture content (LMC) and moisture retention capacity (MRC) are the two important factors that maintain the nutritive levels of leaves, which in turn improves the palatability of leaves for silkworm. This could be attributed to more moisture content and increased fertile value of the soil in the sheep pent gardens. In the present study, increase in dosages of chemical fertilizers resulted to decrease in leaf quality which could be attributed to the deleterious effect of repeated applications of chemicals on physical and biological properties of soil. Such adverse effect of repeated applications of inorganic fertilizers in mulberry ecosystem on soil health was reported by Devi and Sakthivel (2018). The beneficial effect of organic resources obtained from sheep penning resulted in sustainable improvement in growth attributes, leaf yield and quality due to proper decomposition, mineralization, solubilizing effects and availability of sufficient nutrients as observed in T5. This corroborates the findings of Sashidhar *et al.*, (2009) in mulberry particularly in relation to the use of two types of biofertilizers, vermicompost and integrated nutrient management packages.

Shankaret *et al.*, (1992) observed that use of organic fertilizers or combined application of composted sericulture wastes along with fertilizers, registered highest silk productivity. Increase in these parameters were influenced by different sources of organic manures and inorganic fertilizers which were applied to mulberry might have increased the crude protein content in leaves which in turn influenced the silk productivity and cocoon yield. The results on the influence of varied sources of organics on mulberry and its influence on the

performance of silkworm are discussed in the light of earlier works. The economic traits of silkworm including cocoon yield and silk percentage were increased considerably when worms fed on mulberry grown by the practice of sheep penning because of the rich foliar constituents of mulberry showed marked positive influence on rearing parameters. Similarly, significant improvement in mulberry leaf yield, quality and cocoon yield in relation to application of various organic fertilizers in mulberry garden was reported by Sakthivel *et al.*, (2018).

Present investigation indicated that repeated application of chemical fertilizers either indiscriminately or even as per the recommendations in mulberry ecosystem resulted with adverse impact on soil health as it affected the physical, chemical and biological properties of soil. Sheep penning practice in mulberry garden with the application of recommended doses of biofertilizers exhibited considerable improvement in soil health, mulberry leaf quality as well as yield which reflected positively on cocoon yield and silk percentage when compared to all other treatments. Thus, it could be concluded that a holistic approach should be made for creating awareness among the sericulture farmers and popularizing sheep penning strategies for sustainable production of cocoon and to fetch more profit through sericulture.

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Quality Evaluation of Wood Apple (*Limonia acidissima* L.) RTS and Beverage During Storage

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Abstract

The present investigation conducted during 2019-20 and 2020-21 at laboratory Department of Horticulture, Collage of Agriculture, Gwalior M.P. The study was aims to prepare RTS and evaluated its shelf life conditions with 2 levels and 3 replications. The RTS prepared from wood apple pulp and blended with medicinal herbs. RTS was filled in sterilized bottles and stored at ambient condition for 3 months. The quality parameters were tested for fresh as well as in storage at 30,60,90 days. During storage evaluation was conducted for acidity, total sugar, pH, moisture content, TSS, and sensory parameters of products e.g. colour, flavor, texture. colour change in storage time. In present study observed that TSS and acidity were increased, ascorbic acid, non- reducing sugar decrease with increasing storage period and RTS & beverage found suitable for consumption up to 3 months.

Key words : RTS, wood apple, storage, chemicals, nutrients.

Introduction

Wood apple is botanically known as (*Limonia acidissima* L.) belongs to the family Rutaceae. Wood apple is one of the most important underutilized indigenous fruit of India and a very hardy fruit crop found all over the plains of Southern Maharashtra, West Bengal, Uttar Pradesh, Chhattisgarh and Madhya Pradesh. Wood apple is nutrient rich fruit which contains high amount of protein and low amount of sugar, carbohydrates, compared to other underutilized fruit crops. Wood apple in the form of chutneys or sherbet is useful in treating hiccups (Ratnayake *et al.*, 2009). A homemade drink popularly known as “*Sarbat*” is prepared from the wood apple fruits. Wood apple RTS beverage prepared from 10 per cent pulp, 13 per cent total soluble solids with 0.25 per cent acidity was found to be best during organoleptic quality. The manufactured RTS was bottled in sterilized glass bottles (200 mL capacity) and stored at ambient temperature. The storage ability of RTS the TSS, acidity, reducing and total sugars and browning were increased, whereas ascorbic acid, non-reducing sugar and organoleptic quality was decreased with increased storage period. Kumar and Deen 2017, prepared nectar from fruit of Barhal or Monkey Jackfruits and results revealed that 20% juice, 13% TSS and 0.3% acidity for nectar was found excellent. Singh *et al.* (2000) prepared a ready to serve beverage from wood apple pulp using fully ripened fruit, where pulp was extracted using water for dilution at 0.5, 1.0 and 2.0 times using sieves. The pulp

was heated to 60 °C for 30 min. Acceptable RTS beverage from wood apple can be prepared by using pulp 10 %, TSS 15 °Bx and acidity 0.30% (citric acid) and preserved by pasteurization+sodium benzoate (100 ppm) remained in good condition up to 3 months. Lande *et al.* (2010).

Materials and Methods

In the present study fresh and uniform size of wood apple fruits were purchased from the local market of Gwalior (M.P.), these fruits were selected by taking into consideration of various factors such as soundness, firmness, cleanliness, size, maturity, weight, shape and free from foreign matters. Unripe and ripe fruits of wood apple were classified and use for preparation of various value added products e.g. RTS, Beverage. The fruits of wood apple were graded to select fruits according to treatment having uniform maturity and fruits were first washed to remove the dirt. The fruits of wood apple were broken into small pieces with the help of small hammer and scoop out the pulp with the help of spoon, after that cook with water until very soft and gently grind.

Wood apple R.T.S. and beverage preparation : Fruit juice concentrates, singly or in blended form, are products with great potential on account of their wide acceptability in fruit based beverages. Pulp as well as amount of sugar, citric acid, potassium meta-bisulphite and water required to prepare the finished RTS in different proportions according to desired recipes. One liter of RTS of each recipe were prepared by mixing the calculated amount of pulp, sugar, citric acid and water in different proportions.

Table-1 : Nutrients characters of fresh wood apple pulp, RTS and beverage (g/100g).

Nutrients	Crude protein (g)	Crude fiber (g)	Crude fat (g)	Carbohydrate (g)	Total mineral (g)	Calcium (g)	Phosphorous (g)	Ascorbic acid (mg)
Fresh pulp	I	6.53	0.80	3.73	18.33	1.60	0.23	0.69
	II	6.90	0.90	4.03	18.0	1.97	0.24	0.63
RTS	I	1.53	0.83	2.93	16.0	0.97	0.12	0.10
	II	1.60	0.77	3.07	15.67	1.00	0.12	0.11
Beverage	I	1.60	0.87	3.00	17.00	1.03	0.14	0.13
	II	1.63	0.83	3.13	16.67	1.13	0.15	0.14

Table-2 : Chemical characters change in RTS and beverage during storage.

Chemical characters	TSS	pH	Titrateable Acidity	Total Sugar	Non-enzymatic browning
RTS 1 year	1	10.00	3.10	0.60	11.33
	30	11.33	3.0	0.73	12.37
	60	13.00	2.97	0.90	12.97
	90	14.10	2.93	1.27	13.0
RTS 2 year	1	10.00	3.10	0.57	11.80
	30	12.33	3.0	0.73	11.93
	60	13.20	2.93	0.87	12.43
	90	13.70	2.80	1.07	13.53
Beverage 1 year	1	15.33	3.17	0.77	11.87
	30	16.0	3.10	1.13	12.43
	60	17.33	3.03	1.30	12.90
	90	17.83	3.03	1.70	13.03
Beverage 2 year	1	15.0	3.13	0.77	12.10
	30	17.0	3.03	1.17	12.23
	60	17.67	2.97	1.60	12.30
	90	18.0	2.90	1.83	13.33

Flowchart of preparation of wood apple RTS and beverage illustrated in Figure 1.

Nutra-chemical Estimation :

Crude protein (g) : Determined as per AOAC (2000) method.

$$\text{Protein (\%)} = \frac{(A - B) \times N \times 14007 \times 6.25}{W}$$

Crude fiber (g) : Determination as per AOAC (1984).

Crude fiber in ground sample (%) =

$$\frac{\text{Loss in weight on ignition (W2 - W1) - (W3 - W1)}}{\text{Weight of the sample}} \times 100$$

Crude fat (g) : Determined by Chloroform-Methanol Method of AOAC (1984).

$$\text{Total fat (\%)} = \frac{\text{residue weight} \times 4}{\text{sample weight}} \times 100$$

Total mineral (Ash) content (g) : Ash represents the inorganic residue as total minerals, determined as per AOAC (2000).

$$\text{Total mineral content (Ash) (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Carbohydrate (g) : Carbohydrate estimated by the phenol sulphuric acid method.

Calcium (g) : Calcium was estimated by the method of Sadasivam and Manickam (2008).

Phosphorous (g) : The phosphorus was estimated Colorimetrically by using vanadomolybdate as indicator (Koeing and Johnson, 1942).

Total Soluble Solids (%) : Measured by using digital hand refractometer (Atazo, Japan) at room temperature and results were expressed in degree Brix (°B).

Titrateable Acidity (%) : The titrateable acidity was determined by titrating 10 ml aliquot against 0.1 N sodium hydroxide solution using phenolphthalein as indicator by method suggested by AOAC (1980) and expressed in percent.

Ascorbic acid : Estimated by using 2, 6-Dichlorophenol-indophenol visual titration (Ranganna, 1986). Ascorbic acid in terms of mg per 100g pulp weight was calculated by using following formula :

$$\begin{aligned} \text{Ascorbic acid (mg/100g)} \\ = \frac{\text{Dye factor} \times \text{titre reading} \times \text{dilution}}{\text{Weight} \times \text{Volume of sample}} \times 100 \end{aligned}$$

Table-3 : Sensory evaluation of products.

Sensory	Colour	Flavor	Taste	Texture	Overall acceptability	
RTS 1 year	1	7.5	7.0	8.0	8.0	7.6
	30	7.5	7.0	7.8	7.8	7.3
	60	7.2	6.8	7.3	7.8	7.0
	90	7.0	6.6	7.2	7.7	7.0
RTS 2 year	1	7.8	7.5	7.6	7.8	7.5
	30	7.5	7.2	7.4	7.5	7.4
	60	7.2	7.1	7.2	7.4	7.3
	90	7.0	7.0	7.0	7.3	7.2
Beverage 1 year	1	8.5	8.0	8.2	8.0	8.0
	30	8.3	7.7	8.0	7.8	8.0
	60	8.0	7.4	7.8	7.5	7.8
	90	7.9	7.2	7.6	7.3	7.6
Beverage 2 year	1	8.2	7.8	8.0	8.1	7.5
	30	8.1	7.6	7.5	8.0	7.3
	60	7.8	7.3	7.2	8.0	7.2
	90	7.7	7.0	7.0	7.9	7.1

Total Sugar : Estimated by the standard method of AOAC (1980).

pH : pH, each sample was agitated (using a magnetic stirrer) for 1 minute until a stable reading was obtained.

Sensory evaluation : The quality of wood apple products was judged by offering the sample to the panel of 5 judges in each trial separately. Score card method for sensory evaluation of products as suggested by Pal and Gupta (1985) was adopted as details below.

Characters	Score
Color	9
Flavor	9
Texture	9
Taste	9
Overall acceptability	9

Overall acceptability was determined by a trained sensory panel (minimum of 5 members) on a 9-point hedonic scale as prescribed by Nelson and Trout (1964).

Results and Discussion

Nutritional analysis of fresh wood apple revealed that it contains 6.53g and 6.90g crude protein, 0.80g and 0.90g crude fiber, 3.73g and 4.03g crude fats, 18.33g and 18.0g carbohydrates, 1.60g and 1.97g total minerals, 0.23g and 0.24g calcium, 0.69g and 0.63g phosphorous and 3.0mg and 2.8mg ascorbic acid per 100g of pulp for first & second year respectively. Similarly, these levels of nutritional composition of wood apple pulp was also reported and reviewed by Hemalatha and Parameshwari

& Mani and Mitra. When compared with fresh wood apple pulp, RTS and beverages found to be less nutritious containing 1.53g and 1.60g crude protein in RTS and 1.60g and 1.63g crude protein in beverage also, 0.83g and 0.77g crude fiber in RTS and 0.87g and 0.83g crude protein in beverage, 2.93g and 3.07g crude fats in RTS and 3.0g and 3.13g crude fat in beverage, 16.0g and 15.67g carbohydrates in RTS and 17.0 & 16.67g carbohydrates in beverage, 0.97g and 1.0g total minerals in RTS and 1.03g and 1.13g total minerals in beverage, 0.12g and 0.12g calcium in RTS and 0.14g and 0.15g calcium in beverage and 0.10g and 0.11g phosphorous in RTS, 0.13g and 0.14g phosphorous in beverage and 0.37mg and 0.39mg ascorbic acid in RTS and 0.42mg and 0.43mg ascorbic acid in beverage per 100 g of product for first & second year respectively (Table-1). The nutritional level of products is increased due to the addition of other ingredients.

pH value 3.10, 3.0, 2.97 and 2.93 for first year and 3.10, 3.0, 2.93 and 2.80 for second year in RTS and 3.17, 3.10, 3.03 and 3.03 for first year and 3.13, 3.03, 2.97 and 2.90 for second year in beverage decreased at 0, 30, 60 and 90 days of storage respectively. Decrease in pH can be attributed to increase in acidity 0.60%, 0.73%, 0.90% and 1.27% in first year and 0.57%, 0.73%, 0.87% and 1.07% in second year in RTS and 0.77%, 1.13%, 1.30% and 1.70% in first year and 0.77%, 1.17%, 1.60% and 1.83% in second year in beverage at 0, 30, 60 and 90 days of storage respectively (Table-2). Remarkable increase in percent acidity was observed during 90 days of storage period, irrespective of recipe used. Maximum acidity was reported in RTS and pickle at 90 days of storage. The increased acidity is due the fermentation of sugars to acids with course of time, which also prevents the growth of harmful bacteria and moulds increasing the

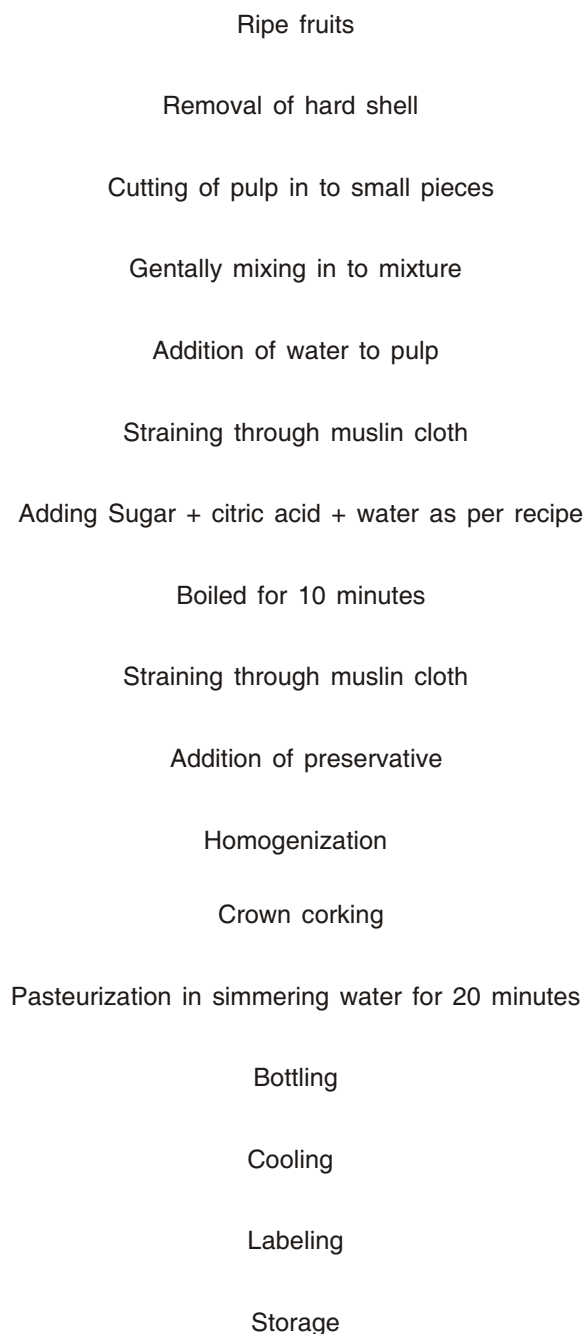
self-life of products. Similar results were obtained by Kumar and Deen. The physico-chemical changes of karonda products like jam, jelly, chutney, squash and R.T.S beverage during the storage period of 8 months. T.S.S and pH of the products increased where as acidity content and ascorbic acid content decreased, but the change in pH, T.S.S and ascorbic acid content were non-significant but change in acidity was significant. Jadhav *et al.*,. Total sugar content in products gradually increased as 11.33%, 12.37%, 12.97% and 13.0% for first year and 11.80%, 11.93%, 12.43% and 13.53% for second year in RTS and 11.87%, 12.43%, 12.90% and 13.03% for first year and 12.10%, 12.23%, 12.30% and 13.33% for second year in beverage at 0, 30, 60 and 90 days of storage respectively (Table-2). The increase in sugar would be attributed to conversion of starch and other insoluble carbohydrate into sugars. Slight chemical changes also observed during storage like pH decreased with increasing storage period and TSS increase with increase storage period from 10, 11.33, 13.0 and 14.10 for first year and 10, 12.33, 13.20 and 13.70 for second year and 15.33, 16.0, 17.33 and 17.83 for first year and 15.0, 17.0, 17.67 and 18.0 for second year in beverage at 0, 30, 60 and 90 days of storage respectively. Similar also observed by Kumar and Deen 2017.

The organoleptic evaluation shows, gradual reduction in mean score for overall acceptability after 90 days of storage. Consistency remains same and the taste declined, flavor change was observed, reduction in appearance and taste of product in storage occurred after 90 days of storage. Hence, maximum storage at 90 days at room temperature may give better acceptability. Over the storage month sensory evaluation of products revealed fewer amounts of change in colour, flavor, texture, test, and overall acceptability (Table-3). Browning of products with time is the possible cause of slight colour and flavor change. Significant increased sourness of products with storage time might be one of the possible reasons for flavor changes and reduction in overall acceptability. Similarly Premi *et al.* observed that freshly made wood apple products showed high overall acceptability which reduced with time of storage.

When compared with fresh wood apple pulp, the RTS and Beverage found to nutritious. The organoleptic evaluation shows, gradual reduction in mean score for overall acceptability after 90 days of storage. Consistency remains same and the taste declined, flavor change was observed, reduction in appearance and taste of RTS and beverage in storage occurred after 90 days of storage. Hence, maximum storage at 90 days at room temperature may give better acceptability. Over the storage month sensory evaluation of RTS and beverage revealed fewer

amounts in change in colour, flavor, texture, test, and overall acceptability.

Figure-1 : Flow chart for preparation of wood apple R.T.S. and beverage :



Conclusions

A wood apple fruit has high nutritive property. Wood apple RTS and beverage are nutrient rich and tasty product and their organoleptic evaluation revealed that wood apple RTS and beverage can be consumed up to 90 days of storage without major organoleptic and Nutra- chemical changes and is a good source of protein, fiber, calcium and phosphorous among other fruits. Overall acceptability

of wood apple RTS and beverage observed very good and its consumption also found safe for human health.

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Survey and Surveillance of Pigeonpea Fusarium Wilt in Different Districts of Rajasthan

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Abstract

Wilt of pigeonpea incited by *Fusarium udum* Butler was an important disease problem in Dholpur and Alwar during survey conducted in major pigeonpea growing districts of Rajasthan in *kharif* 2012 and 2013. The disease incidence and disease intensity (%) varied from 0 to 40.71 and 0 to 28.93 with an overall average of 17.01 and 11.93, respectively in Alwar district. In Dholpur district the disease incidence and disease intensity (%) was higher than Alwar, varied from 38.41 to 54.88 and 25.35 to 28.86 with an overall average of 45.34 and 26.75, respectively. There was no disease incidence (%) in Ajmer, Banswara, Bundi, Dausa and Udaipur districts. The maximum disease incidence observed in plants at maturity, i.e. in month of October and November (in short duration variety), than at seedling stage. The incidence of disease was more severe in fields with sole crop while low incidence was observed in fields having mixed / intercrops. The wilted plants of pigeonpea were observed in patches with yellowing of leaves, leaf epinasty and marginal necrosis of leaves resulting in complete wilting. Discoloration of vascular tissues and dark brown coloured bands on stem were also observed in wilted plants at later stages of disease development. Partial wilting in plants was also seen.

Key words : Pigeonpea, *Fusarium udu*, survey, incidence

Introduction

Pigeonpea [*Cajanuscajan* (L.) Mills.], a pulse crop of Indian origin is a major source of protein in world's vegetarian diet. In India South East Asia and in remaining world, it is consumed as "Dal", "Varan" or "Sambhar" and is an important item in the vegetarian menu. Besides India, Uganda and Kenya in Africa, the West Indies, Puerto Rico and the Dominican Republic in the Caribbean region and Burma in Asia are the major pigeonpea producing countries. The maximum production of pigeonpea is from south Asia, 90% of which belongs to India (5). Major cause of low productivity is the losses due to diseases. More than 63 fungal, 3 bacterial, 19 viral or alike pathogens and 10 nematodes are reported to infect the crop at various growth stages (9). Among diseases, wilt and sterility mosaic diseases are important. Recent surveys have indicated that major losses in the pigeonpea are due to wilt which is caused by *Fusarium udum* Butler. Losses varying from 0.2 to 100 per cent have been estimated in India (4). Kannaiyan *et al.* recorded maximum mean losses to the tune of 22 per cent from Maharashtra (7). The disease is known in India with description of wilt of pigeonpea by Butler (1). Though the disease goes unnoticed in early stages, the symptoms of yellowing and drying of leaves and finally death of few branches or of entire plant are the conspicuous symptoms manifested during flowering or grain development. If wilted plants are uprooted and longitudinally split, a clear vascular browning in tap root extending to upper stem is seen. Infection of the plants in early stage leads to

infection of roots, stem cortex and reaching up to vascular bundles where the pathogen multiplies and blocks water and nutrient flow to upper region which leads to yellowing, drying and finally death of the plant.

Fusarium wilt is quite prevalent in parts of Rajasthan causing severe losses to the crop every year. Therefore, it was very important to undertake the studies to find out the causes for disease development and its suitable control measures. Though the disease has been investigated in other parts of country, yet the importance of the study cannot be ignored because of the climatic conditions of Rajasthan state.

Materials and Methods

Survey and surveillance : Survey in twelve major pigeonpea growing districts of Rajasthan was undertaken during the year 2012 and 2013 in *kharif* for per cent disease incidence and intensity of wilt caused by *Fusarium udum* Butler at flowering and podding stages of the crop. The selection of villages and fields was done randomly. In each district observations of sole pigeonpea crop were recorded in fields in villages on road side. At each location the data for stage of crop, disease incidence (%), disease intensity (%) and other observations were gathered with the help of farmers of the area. The per cent disease incidence was calculated as per formula given below :

Per cent disease incidence

$$= \frac{\text{Number of infected plants}}{\text{Total number of plants observed}} \times 100$$

Similarly, to calculate the per cent disease intensity following arbitrary disease rating scale and formula was used.

Disease rating	Description
1	No apparent symptoms or disease, plant healthy
2	Chlorosis and early wilting of seedlings looking apparently healthy
3	Chlorosis, stunting, defoliation of lower leaves and late wilting
4	Chlorosis, defoliation, stunting, but no wilting
5	With complete wilting

Per cent disease intensity

$$= \frac{\text{All ratings}}{\text{Maximum rating} \times \text{Total number of plants observed}} \times 100$$

District	Place (Village/ town) of survey
Ajmer	Beawar, Kishangarh, Sali, Saradhana
Alwar	Behrod, Govindgarh, Navgaon, Rajgarh, Ramgarh, Thanagazi, Tijara
Banswara	Bhanwarkara, Ghatol, Ratapan
Bharatpur	Deeg, Dhandholi, Gandholi, Graphpura, Kanuwa
Bundi	Indole, Tabra
Dausa	Dausa, Lalsot
Dholpur	Baipur, Bari, Indrawali, Marena, Pahari, Rajakhera, Rupasara
Jaipur	Bairat, Dhand, Durgapura
Kota	Ummedganj
Sawaimadhopur	Isarda, Kalyanpur, Karmotha
Tonk	Banthali, Diggi, Malpura
Udaipur	Jhadol, Kotra, Salumbar

Results and Discussion

Survey in major pigeonpea growing districts of Rajasthan viz., Ajmer, Alwar, Banswara, Bharatpur, Bundi, Dausa, Dholpur, Jaipur, Kota, Swaimadhopur, Tonk and Udaipur was carried out at different intervals of time with a view that Fusarium wilt may appear at any stage of growth of the plants, and to study host parasite relationship being a prerequisite factor. The wilted plants of pigeonpea were observed in patches in affected fields in Alwar and Dholpur districts, first described by Butler (1). Dark brown coloured bands on stem of wilted plant at later stages of disease development were observed, similar symptoms were recorded by Nene *et al.* (10). There was no disease incidence (%) in Ajmer, Banswara, Bundi, Dausa, and Udaipur districts. The maximum disease incidence observed in plants at maturity i.e. in month of October and November (in short duration variety), than at seedling stage. The disease incidence (%) and disease intensity (%) was maximum in Dholpur which varied from 38.41 to 54.88 and 25.35 to 28.86 with an overall average of 45.34 and 26.75, respectively, followed by Alwar, Jaipur, Sawaimadhopur, Kota, Tonk and Bharatpur (Table-1. and Fig.-1)).

Wilt was found as a major disease of pigeonpea in different districts of Rajasthan state, as reported by Chauhan and Kumar (2) in Uttar Pradesh, Pandeet *et al.* (11) in Andhra Pradesh and Pawar *et al.* (12) in Maharashtra in India. The maximum disease incidence observed in plants at maturity rather than seedling and flowering stages. This may be due to the effect of

Fig. 1 Disease incidence of Fusarium wilt of pigeonpea in Rajasthan

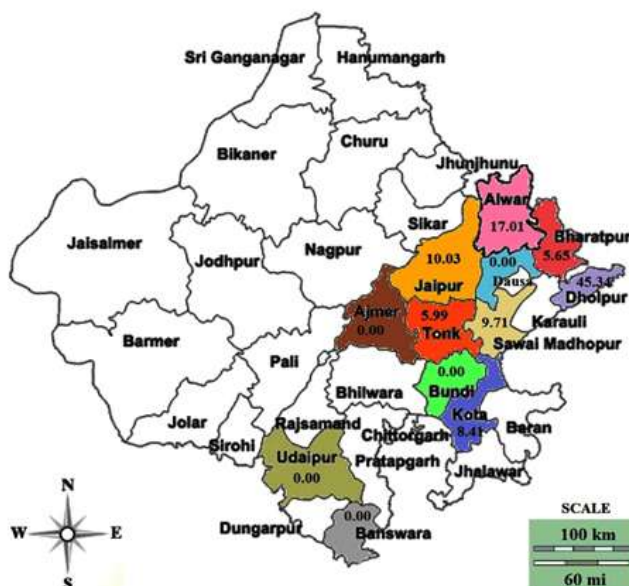


Table-1 : Per cent incidence and intensity of wilt of Pigeonpea induced by *Fusarium udum* Butler in Rajasthan during survey in kharif 2012-13.

District / Village	Mean disease incidence (%)	Mean disease intensity (%)	Soil type	Cropping pattern	Stage of crop
Spreading type					
Ajmer	—	—	Sandy loam	Sole	F
Beawar	—	—	Clay loam	PM:PP (2:1)	Se & F
Kishangarh	—	—	loamy Sand	PM:PP (2:1)	F
Sali	—	—	Clay loam	Sole & PM:PP (1:1)	F
Saradhana	—	—			
Average	—	—			
Alwar	12.45	9.34	Sandy loam	Sole	F & P
Behrod	—	—	Clay loam	PM:PP (2:1)	F
Govindgarh	37.50*	28.93*	Sandy loam	Sole	Se, F & P
Navgaon	40.71	28.19	Clay loam	Sole & PM:PP (3:1)	Se & F
Rajgarh	—	—	Sandy loam	Sole & PM:PP (4:1)	Se, F & P
Ramgarh	—	—	Loamy sand	Sole	F
Thanagazi	28.39	17.03	Sandy loam	Sole & PM:PP (2:1)	F
Tijara	17.01	11.93			
Average	—	—			
Banswara	—	—	Clay loam	PM:PP (2:1)	F
Bhanwarkara	—	—	Sandy loam	PM:PP (2:1)	F
Ghatol	—	—	Sandy clay loam	Sole & PM:PP (2:1)	F
Ratapan	—	—			
Average	—	—			
Bharatpur	12.01	7.20	Sandy loam	Me:PP (4:1)	F & P
Deeg	16.25	10.64	Clay loam	PM:PP (3:1)	Se & F
Dhandholi	—	—	Sandy loam	PM:PP (2:1)	F
Gandholi	—	—	Loamy sand	S:PP (3:1)	F
Graphpura	—	—	Clay loam	PM:PP (4:1)	Se & F
Kanuwa	5.65	3.57			
Average	—	—			
Bundi	—	—	Sandy loam	Sole	F & P
Indole	—	—	Sandy clay loam	Sole	F & P
Tabra	—	—			
Average	—	—			
Dausa	—	—	Sandy loam	Sole & S:PP (4:1)	F
Dausa	—	—	Loamy sand	CP:PP (5:1)	F
Lalsot	—	—			
Average	—	—			
Dholpur	41.46	28.86	Sandy loam	Sole & PM:PP (2:1)	F & P
Baipur	52.01	27.18	Loamy sand	Sole & PM:PP (2:1)	F
Bari	45.67	25.37	Sandy loam	Sole	Se, F & P
Indrawali	45.79	25.64	Sandy loam	Sole	F & P
OMorena	38.41	27.06	Sandy loam	Sole & S:PP(2:1)	Se
Pahari	54.88	27.78	Loamy sand	Sole	Se & F
Rajakhera	39.12	25.35	Sandy loam	Sole	F
Rupasara	45.34	26.75			
Average	—	—			
Jaipur	15.78	14.20	Clay loam	PM:PP (3:1)	F & P
Bairat	—	—	Sandy loam	PM:PP (3:1)	F & P
Dhand	14.30	12.87	Loamy sand	Sole & CP:PP (2:1)	Se, F & P
Durgapura (ARS)	10.03	9.02			
Average	—	—			
Kota	8.41	7.06	Clay loam	Sole	F & P
Ummedganj	8.41	7.06			
Average	—	—			
Sawaimadhopur	17.53	10.52	Sandy loam	S:PP (2:1)	F
Isarda	11.59	6.96	Sandy loam	S:PP (2:1)	F & P
Kalyanpur	—	—	Sandy loam	Sole	F
Karmotha	9.71	5.83			
Average	—	—			
Tonk	11.37	7.79	Silty clay loam	S:MU:PP(2:1:1)	Se & F
Banthali	6.61	4.96	Sandy loam	Sole	F
Diggi	5.99	4.25	Silty clay loam	PM:PP(3:1)	F
Malpura	—	—			
Avergae	—	—			
Udaipur	—	—	Clay loam	Sole	F
Jhadol	—	—	Red clay	BG:PP(1:1)	F & P
Kotra	—	—	Clay loam	Sloe	F
Salumbar	—	—			
Average	—	—			

PP = Pigeonpea (*Cajanus cajan* (L.) Millsp.), PM = Pearl millet (*Pennisetum americanum* (L.) Leeke), S = Sorghum (*Sorghum bicolor* (L.) Moench), MU = Mung (*Vigna radiata* (L.) Wilczek), Me = Mesta (*Hibiscus sabdariffa* var. *altissima*), CP = Chickpea (*Cicer arietinum* L.), BG = Black Gram (*Vigna mungo* (L.) Hepper), Se = Seedling, F = Flowering, P = Podding, *Mean of three replications, — No disease incidence / intensity %.

physiological state of plants. Kannaiyan and Nene observed the influence of wilt at different growth stages and found that *Fusarium udum* caused 100% yield losses at red pod stage (6). The variation in disease incidence in different districts may be due to differing pathogenic types present in soil (13), varying soil conditions (11); (9) and genetic variability in host (8), (3) and (15).

The incidence of disease was found reduced in fields where pigeonpea crop was grown mixed or intercropped with pearl millet, sorghum or other *kharif* crops. Sole crop of pigeonpea expressed more incidence than the intercrop with sorghum, soybean or cotton (12).

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Effect of Plant Density and Sources of *Simarouba glauca* DC. on Productivity and Yield of Soybean under Agroforestry System

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Abstract

Simarouba glauca is fast growing tree species with multipurpose benefits and suitable for plantation programme under various agro-climatic conditions. Field experiment was conducted during Kharif from 2005 to 2019 with the different plant densities at Main Agricultural Research Station, University of Agricultural Science, Dharwad to know the feasibility of cultivation of Soybean in *Simarouba glauca*. There were four treatment combinations comprising intercrop of Soybean sown in different spacing's with *Simarouba glauca* and soybean alone as control. Results revealed that, sole soybean recorded significantly higher grain yield. Soybean in association with *Simarouba glauca* planted at 5 m x 5 m spacing recorded higher grain yield. The maximum height and diameter of breast height were recorded under 5 m x 3 m spacing and 5 m x 5 m spacing (8.11 m and 19.83 cm respectively) when compared to other spacings. The basal area and volume of the trees were registered significantly higher in 5 m x 5.0 m spacing compared to other spacings tried. The grain yield of soybean grown during the initial years was significantly higher in the 5 m x 5 m spacing when compared to other spacings. The soybean yield was decreased gradually in the narrow spacings and the old age of plantation due to the lack of light, moisture, nutrients and crown shade.

Key words : *Simarouba glauca*, agroforestry system, soybean crop, densities

Introduction

Simarouba glauca belongs to family simarubaceae, commonly known as "The Paradise Tree" or "King Oil Seed Tree", is a versatile multipurpose evergreen tree having a height of 7-15 m with tap root system. It is mainly found in coastal hammocks throughout South Florida. In India, it is mainly observed in Andhra Pradesh, Karnataka and Tamil Nadu etc. It can adapt a wide range of temperature, has the potentiality to produce 2000-2500 kg seed/ha/year (Joshi and Hiremath, 2000); can grow well in marginal lands/wastelands with degraded soils and therefore considered as a major forest tree. All parts of *Simarouba* are useful in some way or the other. However, in the present context the seeds are economically very important as they contain 60-75% oil, which can be used in the manufacture of vegetable fat and/or margarine. From 1950 onwards, in El Salvador and other Central American countries the oil is marketed for edible purposes under the trade name of Manteca Vegetal "Nieve" and the oil is well accepted. It is a new crop having multi utilities that can be tapped for production of biofuel in India and Central America. As the kernel has high non-edible oil content, this can be an appropriate candidate for production of biodiesel (*simarouba* oil methyl ester).

Agroforestry is a cultivation of woody perennials with arable crops. It is an alternate land use system (Baumer, 1991) to meet the demand of food and fuel for ever growing population. In agroforestry system appears to be

the most appropriate technology for cultivated soils and fuel, timber wood from the alley components serves as an insurance against total crops failure due to aberrant weather and other conditions. The increased productivity of field crop under the tree canopy was believed to be due to improved soil fertility (Young, 1989) and ameliorative influences of shade in a hot dry environment reducing temperature and evaporation (Bunderson *et al.*, 1990). It has been reported that *S. glauca* based agroforestry systems are profitable than that of mono-cropping systems (Mohanty *et al.*, 2017). Even though it is being widely adopted as tree component in different types of agroforestry systems, the effect on *S. glauca* growth due to intercropping of understory crop under different plant densities still need to be explored. Hence, efforts made to assess growth performance and productivity of *S. glauca* under agroforestry system.

Materials and Methods

A field experiment was initiated during the year 2005 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka to study the growth and productivity of *S. glauca* under agroforestry system. The study area fell under the Northern Transitional Zone of Karnataka between 15° 29' 16" N Latitude, 74° 58' 91" E Longitude with altitude of 2268 ft msl. The site had medium black soil with pH 6.85 and available Nitrogen 245 kg/ha, Phosphorous 19.6 kg/ha and Potassium 285 kg/ha. The mean annual rainfall was

Table-1 : Influence of different spacings on growth performance and Seed Yield of Simarouba glauca.

Sources		Ht (m)	DBH (cm)	Crown area (m ² /tree)	Volume (m ³ /tree)	Seed yield (kg/tree)
Sources	KALI (K)	7.72	19.28	16.31	0.022	4.79
	GOURI (G)	7.63	18.80	16.33	0.021	4.89
	SEm+	0.14	0.46	0.11	0.002	0.14
	CD (0.05)	NS	NS	NS	NS	NS
Spacings	S ₁ – 5 x 3 m	8.11	18.40	15.43	0.020	4.57
	S ₂ – 5 x 4 m	7.71	18.90	16.47	0.024	4.79
	S ₃ – 5 x 5 m	7.21	19.83	17.01	0.028	5.15
	SEm+	0.19	1.56	1.14	0.003	0.18
Interaction	CD (0.05)	0.50	4.56	3.46	0.009	0.58
	K x S ₁	7.56	18.48	15.81	0.020	4.53
	K x S ₂	7.36	19.25	16.41	0.025	4.67
	K x S ₃	7.35	20.10	16.93	0.029	5.13
	G x S ₁	6.85	18.32	15.05	0.023	4.60
	G x S ₂	7.09	18.54	16.52	0.019	4.90
	G x S ₃	7.07	19.56	17.09	0.031	5.15
	SE m+	0.24	1.78	1.25	0.009	0.25
	CD (0.05)	NS	NS	NS	NS	NS

Table-2 : Effect of different spacings on soybean grain yield under *S. glauca* plantation.

Treatments Spacings	Soybean Grain Yield (kg/ha)							
	2005-06	2007-08	2009-10	2011-12	2013-14	2015-16	2017-18	2019-20
5 x 3.0 m + FC	604.6	505.2	419.0	347.5	284.5	138.2	108.3	70.1
5 x 4.0 m + FC	617.4	537.4	447.2	417.1	323.2	167.8	115.7	82.3
5 x 5.0 m + FC	641.4	581.2	505.5	446.9	352.5	217.4	155.5	91.8
Field Crop only	750.8	740.3	735.4	748.2	749.8	741.2	745.6	747.6
SEm±	28.1	29.6	46.4	60.2	63.5	79.2	81.2	82.8
CD (0.05)	84.3	88.8	139.2	180.6	190.5	237.6	243.6	248.4

786.2 mm recorded in 58 rainy days. The highest mean maximum temperature ranges from 37.2°C to 27.1°C and the highest mean minimum temperature ranges from 21.5°C to 13.0°C.

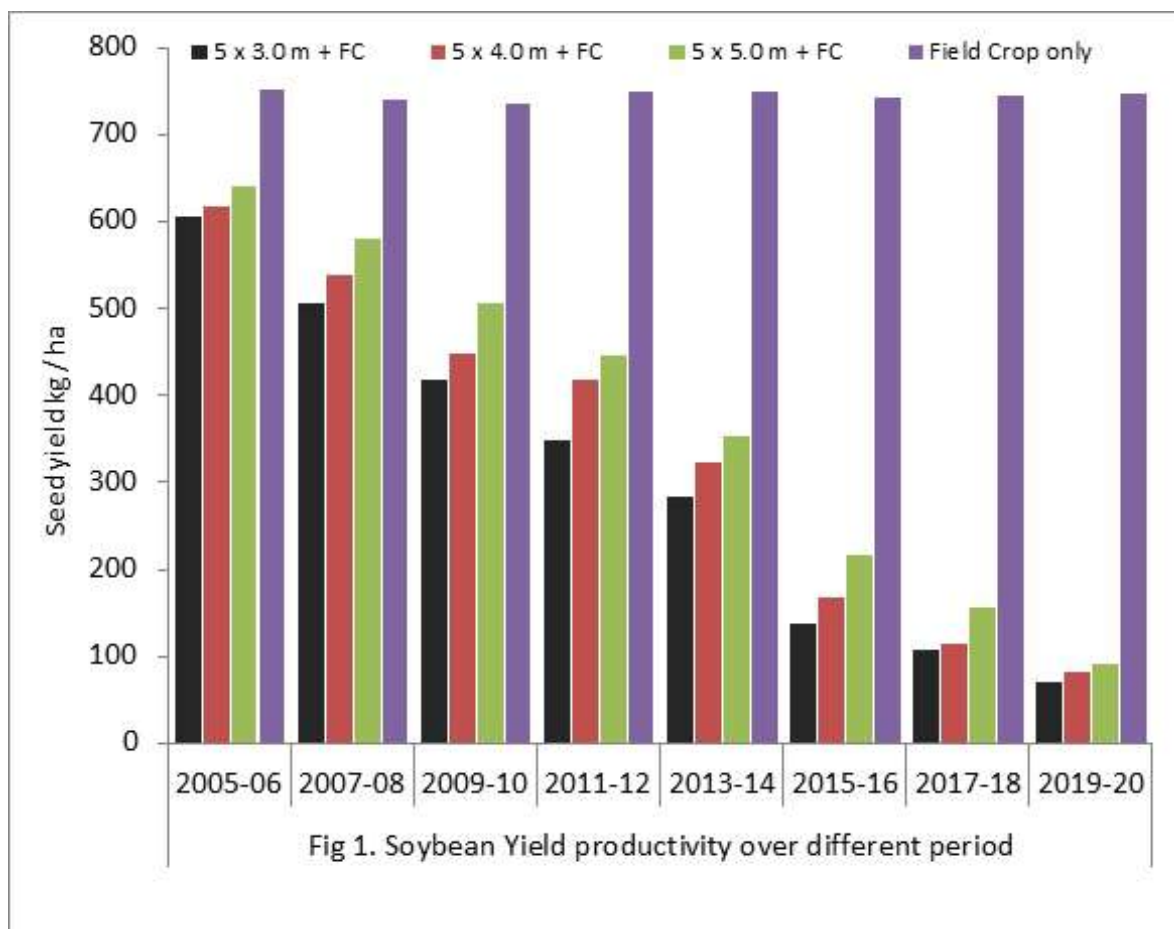
S. glauca was subjected to sources (Kali and Gouri) with different spacings viz., 5x5 m, 4 x 5 m and 3x5 m. The experiment was laid out in the Factorial Randomized Block Design with three replications. The field crop Soybean (Var: JS-335) was sown during the Kharif season between two alleys. Protective irrigation was provided in the initial years. Silvicultural practices and soil working were followed for the *S glauca* trees every year. The total volume was determined by using following formula; Total Volume = Total height x Basal area x Form factor (Chaturvedi and Khanna, 1984) and expressed in m³. Observations on growth parameters viz., height, diameter at breast height and field crop yield were recorded regularly and the results were presented in the tables.

Results and Discussion

The growth parameters of the *S. glauca* were presented in the Table-1. The results reported that, evaluation of *Simarouba glauca* clones revealed that, significant height

was recorded under 5 x 3 m spacing (8.11m) whereas maximum diameter at breast height and volume was recorded under 5 x 5 m spacing (19.83 cm and 0.028 m³/tree) as compared to other spacings. Significantly higher crown area (17.01 m²/tree) was recorded under 5 x 5 m spacings and least in 5 X 3 m spacing. Among the varieties (Kali and Gouri) and interaction effects of varieties were non-significant, but remarkable difference was observed in spacing treatments. The performances of both the varieties were on par with respect to seed yield. The seed yield of Gouri variety (4.89 kg/tree) is higher than Kali variety (4.79 kg/tree). However the seed yield of Simarouba (5.15 kg/tree) was significantly higher in wider spacing of 5 x 5 m as compared to narrow spacings (4.57 kg/tree). These results are in agreement with the findings of Patil and Gaikwad (2011) in *Simarouba glauca* plantation. Similarly, opined by Bhaskar *et al.*, (2019) effect of interspacings on *Simarouba glauca* based agroforestry system. These findings also revealed significant variation in the growth parameters with respect to different plant densities (Karatangi and Patil (2017).

The basal area and volume of the trees estimated by using the formula and were significantly higher in 5 x 5 m spacing when compared to other spacings which was



mainly due to better competition for above and below ground resources such as sunlight and soil nutrients. These results are in line with the findings of Prajapati *et al.*, (2020) reported that, the volume and biomass per tree were higher in trees from sole *Melia dubia* plantation at 4 × 4 m spacing. The variation in the productivity of tree species is mainly depends on the genotype of the species and environment. The present study revealed that varying plant densities significantly affected the tree growth. The height of the tree species decreased with increasing density, conversely diameter at breast height and height were inversely related with changing density. The reduced growth parameters and decreased wood volume in *Simarouba glauca* in narrow spacing was mainly accompanied due to better translocation of photosynthates to cambium region (Vikrant *et al.*, 2009). The overall divergence in the volume was due to the tree density / numbers in narrow spacing's which directly affected total yield in field crops of soybean. This reveals that growth is the cumulative result of age and spacing (Nissen *et al.*, 2001). This could also be due to more plants per unit area with efficient utilization of nutrients compare to other densities. The results are in accordance with Harris *et al.*, (2007) competition on tree stand, growth and structure of different plant densities in subtropical

Eucalyptus grandis plantations. The significant variation in the diameter, height and volume of the *S. glauca* species which could be due to the competition for limiting factor such as moisture, light and nutrients and also morphology of the species. (Thakur *et al.*, 2019).

In between the alleys of *S. glauca*, soybean crop was sown during the Kharif season. Field crop yield differed significantly when grown in different spacing of agroforestry system (Table 2). Soybean grain yield (750.8 kg/ha) recorded significantly higher when they are grown solely as compared to agroforestry systems. In the initial years, soybean grain yield (641.4 kg/ha) was significantly higher in the wider spacing (5 x 5 m) when compared to narrow spacings (5 x 3 m) (Fig.1). *Simarouba* plantation, the yield of soybean grain yield was severely affected in the narrow spacings viz., 5 x 3 m. These results are in agreement with the findings of Prajapati *et al* (2020) growth and yield parameters of *Simarouba* planted at various spatial configurations, either in silvi-pasture systems or sole plantations, differed significantly due to intercropping of sorghum sudan grass. These results are in line with the findings of Bhaskar *et al.* (2019) opined finger millet in association with trees planted at wider spacing recorded higher grain and Thakur *et al.*, (2019) indicated the significant difference in *Melia dubia* tree

height and diameter at breast height due to intercropping of *Cymbopogon* spp. The research work exploring intercropping system of *M. dubia* have shown its potential scope for commercial use in plywood in addition to timber industry. There is also need to make farmers aware about the scope and technique of cultivation of this multipurpose tree along with supply of good quality planting material.

Conclusions

Due to multiple uses in timber wood and timber industry along with its fast growth and adaptability to varied agro-climatic conditions of the country, *S. glauca* also known as the money spinning tree for seed collection to use in bio diesel production. Overall, the present investigation pointed out that there were significant differences observed in growth and yield attributes of both *S. glauca* and field crops. The growth parameters of *S. glauca* were higher under agroforestry system, which confirm the harmful effect on intercrops of soybean yield due to lack of light, moisture and nutrients under plantation. Therefore, it can be substantiated from this result that agroforestry has positive effect on soybean grain yield for initial up to 6 year. The maximum increment in wood biomass was also higher in two spatial configurations under Agroforestry system at 5 x 5 m and considered better species for block plantations.

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Evaluation of Provenance Variations of *Dalbergia latifolia* Roxb. for Seed and Seedling Variables

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Abstract

The present investigation was carried out at Forest Nursery, Main Agricultural Research station Dharwad and Karnataka to identify the best seed source of *D. latifolia* across its distribution areas in Karnataka for further collection of seeds for afforestation or breeding purpose. The seed sources were collected from nine different Agro-climatic zones of Karnataka. The seeds of various source exhibited significant variability in size, weight, germination and growth characters. Seed length, seed width and seed weight were positively correlated to each other but seed size had no effect on germination per cent under Nursery condition. Initial growth parameters and biomass viz., germination per cent, germination vigour, shoot length, root length and root and shoot dry weight of seedlings were significantly higher in Northern dry zone followed by Eastern dry zone, Southern dry zone and North eastern transition zone. The estimates of variability with regard to genetic parameters for seed traits in this study also showed a wide range of variation. The variation among source is commonly used as an estimate of total genetic variation and to calculate the degree of genetic control for a particular trait. Seeds collected from provenance of Dharwad followed by Mysore, Bidar and Bangalore were superior seed sources compared to seeds from other parts of Karnataka in all the traits considered for the study.

Key words : Rosewood, seedling vigor index, seed source.

Introduction

Dalbergia latifolia is a premier timber species, also known as the Indian rosewood belongs to the family Leguminosae or Papilionaceae. It is native to low-elevation tropical monsoon forests of south east India. It is well known for producing very hard and durable wood with a long straight bole, which makes it highly valued on the international market. Its wood usually comes from seeds and successful tree planting depends on healthy seeds of good genetic quality. The source and type of dormancy may be revealed experimentally by removing or treating various parts of the fruit or seed separately. Most species with orthodox seed are able to be stored for long periods at room temperature with minimal losses in seed viability. The physical characteristics of the seeds collected from various sources show polymorphism in physical measurements and weight. Rose wood is an important species with lot of variability, which can be exploited for its improvement farming systems in different agro-climatic requirements, evolving the superior seeds. Genetic differences associated with the place of origin have been several times as great as that among individual trees within the population.

However, it becomes necessary to conduct seed source testing prior to a more intensive breeding work and effect of agro-ecological zones viz., North Eastern Transition Zone, North Eastern Dry Zone, Northern Dry Zone, Central Dry Zone, Eastern Dry Zone, Southern Dry

Zone, Southern Transition Zone, Northern Transition Zone and Hilly Zones of Karnataka on seed quality. The loss from using the wrong sources can be great and even disastrous [3]. The success of a plantation program largely depends on production of quality seedlings without increasing costs. Hence, interest in producing quality seedlings by application of improved and modern nursery technique has increased in recent years. It is essential to evaluate the performance of different seed sources under nursery conditions to study the effect of seed source and for further selection of best source. Therefore, various afforestation programs are carried out by forest departments to restore the population of this species but owing to its slow growth, establishment is difficult. The supply of good quality planting stock is of prime importance and this can be achieved through standardization of a suitable nursery technology. Hence to investigate the importance of these factors to determine the suitable seed source to influence better germination and quality seedling production in *Dalbergia latifolia*.

Materials and methods

The experiment was carried out in the Nursery laboratory at the Main Agricultural Research Station, Dharwad during 2020-21, University of Agricultural Sciences, Dharwad, Karnataka to extensive survey was under taken across nine different agro-climatic zones of Karnataka viz., North Eastern Transition Zone, North Eastern Dry

Table-1 : Studies on Seed attribute of *D. latifolia* collected from different seed sources under laboratory condition.

Seeds Provenances/Zones	Seed Source	Seed length (mm)	Seed thick (mm)	Seed Width (mm)	Seed Test wt (g)
North Eastern Transition Zone	Bidar	7.19	4.95	6.14	33.21
INorth Eastern Dry Zone	Raichur	6.67	4.10	5.58	27.80
Northern Dry Zone	Dharwad	7.43	4.95	6.44	34.70
Central Dry Zone	Davangere	6.76	4.44	5.78	31.35
Eastern Dry Zone	Bangalore	7.19	4.70	6.19	32.72
Southern Dry Zone	Mysore	7.28	4.95	6.24	33.71
Southern Transition Zone	Shimoga	6.94	4.70	6.14	29.77
Northern Transition Zone	Belgaum	7.04	4.31	6.24	31.72
Hilly Zone	Sirsi	7.11	4.21	6.34	33.71
SEm±		0.01	0.009	0.01	0.06
CD(0.05)		0.02	0.03	0.02	0.18
CV (%)		1.00	0.5	1.00	2.00

Table-2 : Seed germination parameters of *D. latifolia* as influenced by different seed sources under Nursery condition.

Seeds Provenances/Zones	Seed Source	MDG	GR	Peak value	GV	Germination (%)
North Eastern Transition Zone	Bidar	2.91	4.37	5.62	16.78	61.86
North Eastern Dry Zone	Raichur	2.27	4.48	4.46	13.76	51.55
Northern Dry Zone	Dharwad	3.43	5.27	6.55	21.97	67.02
Central Dry Zone	Davangere	2.63	3.97	5.31	15.06	56.71
Eastern Dry Zone	Bangalore	2.42	4.59	5.00	14.28	63.92
Southern Dry Zone	Mysore	3.07	4.79	6.03	18.13	62.89
Southern Transition Zone	Shimoga	2.11	4.18	4.23	13.04	59.80
Northern Transition Zone	Belgaum	2.22	4.28	4.38	13.56	56.71
Hilly Zone	Sirsi	2.11	3.97	4.28	12.72	60.83
SEm ±		0.30	0.02	0.05	0.17	0.26
CD (0.05)		0.07	0.60	0.13	0.5	0.76
CV (%)		3.0	2.0	3.0	4.0	2.00

Where; MDG-Mean daily germination, GR-Germination rate, PV-Peak value GV-Germination value

Zone, Northern Dry Zone, Central Dry Zone, Eastern Dry Zone, Southern Dry Zone, Southern Transition Zone, Northern Transition Zone and Hilly Zones that spread over different districts. The study area fell under the Northern Transitional Zone of Karnataka between 15° 29' 16" N Latitude, 74° 58' 91" E Longitude with altitude of 2268 ft msl. The individual tree with about 40 cm diameter at breast height was identified based on their phenotypic characteristics and tree identity was also maintained. The seeds were removed from pods manually and dried properly before subjecting to various activities. Seed parameters such as seed length, seed width, seed thickness and 1000 seed test weight were recorded for each seed sources.

The experiment was laid out in completely randomized design with three replications of 100 seeds of each source. Nursery beds (10 m × 1 m) were prepared by mixing soil media containing soil, sand and FYM in 2:1:1 ratio. The seeds were sown in the standard nursery raised bed and regular watering was done. Further, same seeds were used for assessing germination and growth traits of seedling. Observations on daily germination were recorded up to 25 days from date of sowing. Germination

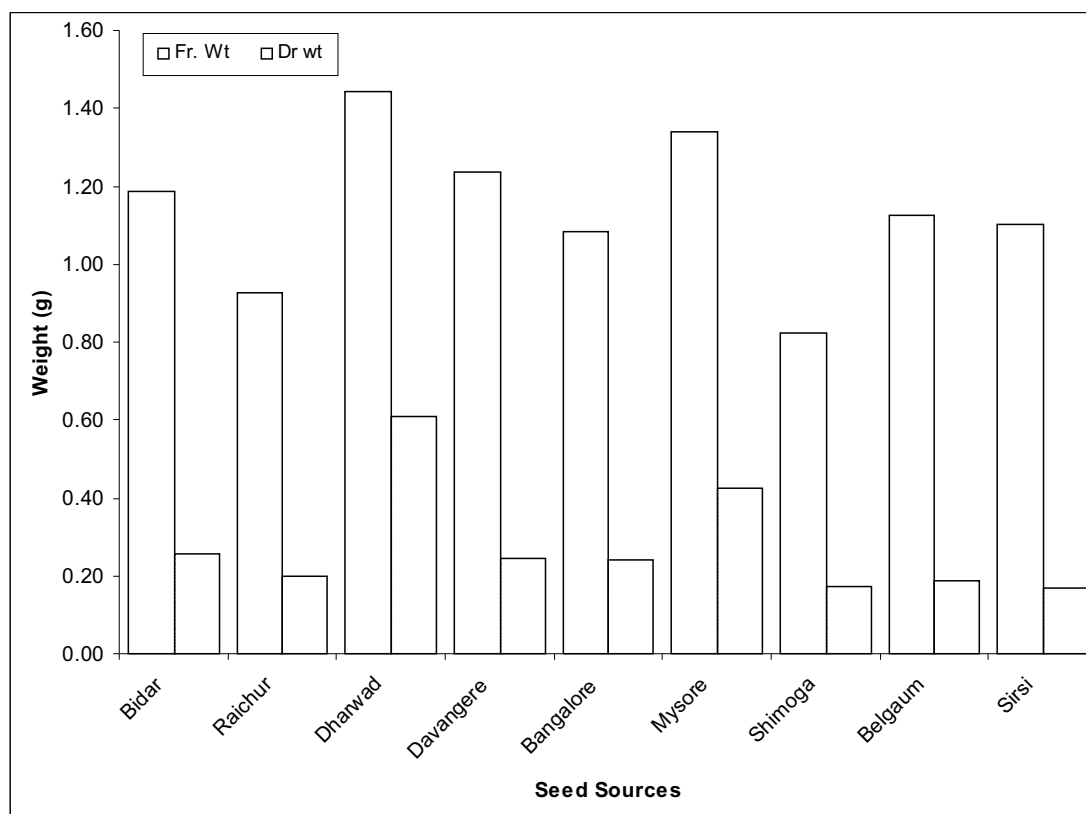
percentage, peak value, mean daily germination, germination rate and germination value were recorded for each seed source. After 25 days of germination, shoot length, root length, seedling fresh weight and seedling dry weight were recorded. For dry weight estimation, the seedlings were dried in oven at 60 ± 1°C temperature for 48 hours. The data relating to each parameter observed was analyzed statistically using MSTAT-C program as applicable to Completely Randomized Design. The level of significance used in F test was P = 0.05.

Results and Discussion

Data from the Table-1 revealed that physical parameters of seeds showed significant differences for among seed sources. The seeds collected from Northern dry zone and Southern dry zone were recorded longest, thickest and had higher mass as well as seed width compared to other seed sources. Seed length amongst various seed sources varied from 6.67 mm to 7.43 mm, seed thickness from 4.10 mm to 4.95 mm and seed width from 5.58 mm to 6.44 mm. The test weight ranged between 27.80 g to 34.70 g. These variations could be due to the fact that, this species grows over a wide range of climatic conditions

Table-3 : Performance of different seed sources on seedling length and seedling vigor index of *D. latifolia*.

Seeds Provenances / Zones	Seed source	Shoot length (cm)	Root length (cm)	Total seedling length (cm)	SVI
North Eastern Transition Zone	Bidar	11.75	6.21	18.52	1181
North Eastern Dry Zone	Raichur	9.80	5.01	15.27	812
Northern Dry Zone	Dharwad	13.49	6.78	20.90	1444
Central Dry Zone	Davangere	10.64	5.96	17.11	1001
Eastern Dry Zone	Bangalore	10.60	5.94	17.05	1124
Southern Dry Zone	Mysore	11.70	6.38	18.64	1209
Southern Transition Zone	Shimoga	9.63	4.42	14.49	893
Northern Transition Zone	Belgaum	9.70	4.44	14.58	853
Hilly Zone	Sirsi	9.43	4.18	14.03	880
SEm±		0.07	0.06	0.13	11.97
CD(0.05)		0.22	0.16	0.38	34.95
CV (%)		2.00	3.00	4.00	5.00

Fig.-1 : Biomass production of *D. latifolia* seedlings as influenced by different seed sources.

as well as soil types and altitudes. The size and shape, test weight and width of seeds variables are depending on the structure and form of the ovary and environmental conditions under which plant is growing. The findings of the present study also get support from [3] and [4] in *Dalbergia sissoo*.

Analysis of variance (ANOVA) revealed that the results were statistically significant for all the germination attributes (Table-2). Overall germination per cent was on/or above the 50 per cent. Significantly higher seed germination per cent was found in Northern dry zone

(67.02 %) followed by Eastern dry zone (63.92 %), Southern dry zone (62.89 %) and North eastern transition zone (61.86 %) were owing to higher peak value of germination, mean daily germination, germination rate and germination value among sources. Where, as germination per cent was recorded significantly lowest in North eastern dry zone followed by Central dry zone and Northern transition zone when compared with other seed sources. *D. latifolia* seeds have low germination percentage owing to the seed dormancy which is attributed to the presence of metabolic blocks in the

mature embryo or due to the presence of inhibitors in the seed coat [5]. It is evident from the result that seeds sources from Dharwad followed by Bangalore, Mysore and Bidar were found to be superior with respect to germination percentage. They found that the variation observed in the seed characters may be attributed to adverse environment and differences in their distribution range this in turn affect the germination of seeds. Similar findings were revealed by several workers [1] in *Simarouba gluaca*, [4] in *Azadirachta indica* and [9] in *Sapindus emarginatus*

The values of seedling biomass significantly among the different geographical sources were furnished in figure-1 shows that biomass production was significantly higher in seed sources of Dharwad followed by Mysore and Bidar among the seed sources. However, Davangere followed by Belgaum, Sirsi and Bangalore sources were found on part with each other for this trait. Similar, results were observed by various authors [2] in seeds of *Shorea robusta* and [10] in *Pongamia pinnata*.

Seedlings of Dharwad followed by Bidar and Mysore seed sources were showed significantly higher seedling length (13.49 cm, 11.75 cm, 11.70 cm) and seedling vigour index (1444, 1209 and 1181) respectively when compared to other seed sources. Among all seed sources, Raichur followed by Belgaum, Sirsi and Shimoga were performed significantly least for all the seedling characters. Total seedlings length ranged between 14.49 cm to 20.90 cm, shoot length between 9.63 cm to 13.49 cm, root length between 4.42 cm to 6.78 cm and seedling vigour index from 853 to 1444 (Table 3). The analysis of the above observations reveals perceptible inters source differences with respect to seed and germination attributes. This variation is mainly attributed to genetic and environmental factors which effect on seedlings growth. The results are in consonance with that of several workers [6] in *Albizzia lebbeck*, [7] *Acacia albida* and [8] in *Jatropha curcas*.

Conclusions

This study identifies the better quality seed sources viz., Dharwad followed by Mysore, Bidar and Bangalore of *D. latifolia* based upon seed and seedling traits for those regions of Karnataka which were sampled. On a short

term basis, breeding zones may be set up in these environmentally homogeneous areas. However, this may be preliminary as only seedling traits have been considered. Hence, seed source screening provides a great opportunity to the tree breeder to screen and capture natural variation for success of afforestation, besides providing information on the raw material for breeding and evolving improved quality planting stock among seed sources.

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Effect of Different Sowing Dates in Varieties on Growth and Yield of Hybrid Fodder Dual Purpose Maize (*Zea mays*) Crop in Doon Valley Condition in Uttarakhand

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Abstract

The experiment was laid out in split plot design with three replication having main plot/ factor of three sowing date ($SD^1 = 24^{th}$ february, $SD^2 = 6^{th}$ march, $SD^3 = 16^{th}$ march) and sub plot of varieties ($V1 = \text{Nutra Shakti777}$, $V2 = \text{Derby-1209}$, $V3 = \text{Nutra Early}$, $V4 = 2026 \text{ Maize}$, $V5 = \text{MH 108099}$, $V6 = 456 \text{ Maize}$). The subplot size was $5\text{m} \times 3\text{m}$. Experimental result indicate that plant height (151.91cm), dry matter accumulation (493.44gm), no of leaves (12.13), no of ears (1.62), yield attributes such as ear length (22.56cm), grain rows /ear (13.73), grains/row (24.29), 1000 grain test weight (215.83gm), shelling percentage (39.77%) and yield as ear yield (6547.85kg/ha), grain yield (2467.78kg/ha), stover yield (6507.76kg/ha), total biological yield (11332.07kg/ha) were observed in $SD^1 = 24^{th}$ february. Among 6 different varieties, plant height (169.03cm), dry matter accumulation (453.27gm), no of leaves (12), no of ears (1.60), yield attributes such as ear length (23.13cm), grain rows /ear (13.33), grains/row (24.85), 1000 grain test weight (202.56gm), shelling percentage (41.12%) and yield as ear yield (6048.75kg/ha), grain yield (2536.39kg/ha), stover yield (5679.17kg/ha), total biological yield (11431.83kg/ha) was recorded by variety $V1 = \text{Nutra Shakti777}$. It is concluded from the result that sowing in the month of february and variety Nutra Shakti 777 gave a higher grain yield and yield traits of maize.

Key words : *Zea mays*, varieties; sowing dates; grain yield; growth parameters.

Introduction

Maize (*Zea mays*) is a staple food in many parts of the world, with the total production of maize surpassing that of wheat and rice. Maize is also known as king of cereals due to its high production potential and adaptability. Overall in the global statically data, India falls under 6^{th} in global maize production, while Asian production of maize is dominated by china, followed by India whereas USA is 1^{st} in global ranking. Maize does well in wide range of climatic conditions; it is grown in the tropical as well as temperate region. February is best month for sowing of maize within the time of 20^{th} february in the time period of zaid season. In case of late sowing due to warm air, there is possibility of silk and pollen grain dry which hinders grain formulation. Optimum temperature for good germination of maize seed requires range from 15°C to 25°C . The month of february is the best months for sowing of maize as it's fulfill all the criteria for zaid season maize. Grain of maize has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil and 1.5% minerals. Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains. Maize oil is used as the best quality edible oil. Green parts of the plant and grain are used as livestock and poultry feed, respectively. Stover and dry leaves are used as good fuel.

Plant variety is usually affected by crop environment, which influence crop growth and yield. Maize varieties have great impact on yield. Hybrid varieties produce more

than double than local varieties. Cultivation of hybrid varieties along with proper date of sowing can increase production of maize. Selection of proper date of sowing in the maize field is important to ensure maximum utilization of climate and environment by the crop and to reduce unnecessary loss. Optimizing of sowing date depend on the variety is among the most important agronomic practices to increase crop production. Two important components of maize cropping systems are plant variety and planting date. Proper selection of these components can help in improving maize yields. The release of genetically superior hybrids, reduction of row spacing, higher plant densities, increased use of chemical fertilizers, improved cultural practices and better weed and pest management can be attributed largely to optimum output of yield and growth of crop (Dwyer *et al.*, 1991). Yield can be increased to a greater extent through high yielding varieties, appropriate time of planting and with good agronomic practices. Planting dates and varieties selection are the major factors affecting maize production in addition to soil fertility, temperature regimes and irrigation. For optimization of yield, planting at an appropriate time is very critical. Maize that are cultivated in all around season is influenced by the environmental changes (temperature, rainfall etc.), different varieties associated with different sowing dates and the wider the deviation from the optimum sowing date the greater will be yield loss. Considerable yield and its parameter

Table-1 : Effect of sowing dates and varieties on maize yield and yield parameter.

Treatments	Plant height (cm)	No of leaves (plant ⁻¹)	Dry matter accumulation (g plant ⁻¹)	Ear Length (cm)	1000-grains weight	Grain yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)
Date of Sowing (D)							
SD ¹ = 24 th Feb, 2021	151.91	12.13	493.44	22.56	215.83	2467.78	11332.07
SD ² = 6 th March, 2021	125.06	11.07	342.90	20.29	147.72	1032.57	6816.82
SD ³ = 16 th March, 2021	150.13	11.46	396.65	22.50	210.72	1911.81	11150.76
SEm±	16.777	0.450	91.485	1.050	1.608	723.707	2383.995
CD at 5%	48.448	1.301	264.193	3.033	4.642	2089.94	6884.558
Varieties (V)							
V1 = Nutra Shakti 777	159.67	12.00	453.27	23.13	202.56	2536.39	11431.83
V2 = Derby-1209	144.09	11.76	441.97	22.60	197.56	1956.39	11101.53
V3 = Nutra Early	139.15	11.56	435.54	22.60	186.00	1569.03	9321.64
V4 = 2026 Maize	141.43	11.87	429.09	20.32	185.78	1212.92	7746.11
V5 = MH 108099	130.56	10.96	337.05	21.20	189.89	1735.97	8921.94
V6 = 456 Maize	139.32	11.18	369.07	20.86	186.78	1813.61	10076.25
SEm±	4.47	0.32	39.93	0.40	2.31	338.84	1157.57
CD at 5%	12.91	0.93	115.32	1.15	6.67	978.51	3342.84

decline or increase as a result of sowing too early or too late has been reported in maize (Waqar Ali *et al.* 2018).

Materials and Methods

The experiment was conducted at the Agriculture research farm of Dolphin institute of Bio-medical and natural science, Manduwala, Dehradun, and Uttarakhand (DIBNS) during zaid season of 2021 to research on influence of different sowing dates in varying maize varieties grown under agro-climatic zone of Dehradun. The experimental site is located in valley of Dehradun near Selaqui (30.361 / North latitude and 77.874 / East longitude). The land is 640 m above the sea level. The experiment was conducted considering two factors; 3 date of sowing (10 days interval) and six different varieties of maize, where the design of split plot design (SPD) having 3 replication was applied. The experiment was two factors sowings dates were assigned to the main plot and varieties of maize to subplot. The soil sample from the experimental site was sampled and analyzed for Physico-chemical properties. The pH of the soil was (5.61) which is acidic in nature, EC was (0.05 dSm⁻¹) which is normal, the organic matter content (0.51%) and Available Phosphorous (kg ha⁻¹), Potassium (kg ha⁻¹) is (4.48), (52.0) respectively.

The detail of factors and treatments are given below:

1st Factors (sowing dates) :

SD¹ = 24th Feb, 2021

SD² = 6th March, 2021

SD³ = 16th March, 2021

2nd Factor treatment (varieties):

V1 = Nutra Shakti 777

V2 = Derby-1209

V3 = Nutra Early

V4 = 2026 Maize

V5 = MH 108099

V6 = 456 Maize

The data was recorded at different stages of maize at seed germination, 30 DAS, 60 DAS, 90 DAS and 120 DAS considering wide parameters such as plant height(cm), no of leaves, dry matter accumulation(gm plant⁻¹) , ear length(cm),1000-grains weight,Grain yield (kg ha⁻¹),Biological yield(kg ha⁻¹) .

Plant height (cm) : Total no of 5 tagged plants were measured for the height data record. The plant height of the five plants to be averaged from each experimental unit and expressed in cm.

Number of leaves per plant : Green leaves from each tagged plants were counted and was averaged to obtain number of leaves per plant at different data recording stages.

Dry matter accumulation (g plant⁻¹) : Dry matter accumulation was recorded by 3 randomly uprooted plants from plots and sundried for 10 – 15 days. After the sundried process the weights were recorded by using electronic balance having the data of whole plant with root and only roots. The dry matter accumulated was averaged and expressed as g plant⁻¹.

Ear Length (cm) : The 5-10 ears were selected randomly at the time of the harvest and after the removing of husk their length were measured from the base to the tip and averaged out of the samples.

1000-grains weight : Thousand grains from sun-dried grain produce were taken from each experimental unit and weighed to get 1000-grains weight.

Grain yield (kg ha⁻¹) : After separating ear sheath, shelling was done using traditional technique with hand. The grain yield was expressed in kg/ha from the each separate plot.

Biological yield (kg ha⁻¹) : The weight of total harvested produce from net plot of each treatment (ear + stover) were recorded and expressed as biological yield kg ha⁻¹.

Results and Discussion

Sowing dates plays a major role in crop management system for optimum productivity and good crops response. Crop reacts severely to different sowing dates as temperature and environment is widely affected. In the context of zaid season the result showed that sowing early has very positive effect on growth and development of the maize crop in all the parameters. The result showed that all the parameters were significantly affected.

The data was recorded at different stages of maize at seed germination, 30 DAS, 60 DAS, 90 DAS and 120 DAS considering wide parameters such as plant height(cm), no of leaves, dry matter accumulation(gm plant⁻¹), ear length(cm), 1000-grains weight, Grain yield (kg ha⁻¹), Biological yield(kg ha⁻¹) was recorded optimum by SD1 = 24th Feb, 2021 and minimum was observed in SD2 = 6th March, 2021.

While in case of varieties the data recorded of plant height(cm), no of leaves, dry matter accumulation (gm plant⁻¹), ear length(cm), 1000-grains weight, Grain yield (kg ha⁻¹), Biological yield(kg ha⁻¹), the quality variety is seen by V1 = Nutra Shakti 777 followed by V2 = Derby-1209 where the least performance variety was seen by V4 = 2026 Maize. The result in the context of data is shown in table-1

Use of optimum variety of maize and favorable date of sowing results into high productivity of maize in terms of commercial as well as fodder sector. Appropriate date of sowing and variety with favorable agro climatic zone produces high productivity and yield. The rapid changing climate which is major defects of any given environment, resulting into high loss. To evaluate favorable date of sowing and variety in the agro climatic zone of Dehradun for minimizing loss from the stress occurred by climatic condition. The study was carried out influenced by date of sowing and varieties for optimum condition for growth and development of maize crop in zaid season. The SD¹ = 24th Feb, 2021 is the optimum sowing date for all the parameters where the appropriate developments stages collides with favorable temperature, where the main

reproductive stages of maize SD¹ = 24th Feb, 2021 was in better temperature for reproduction. Overall SD¹ = 24th Feb, 2021 had performed optimum in all the parameters than other dates of sowing followed by SD³ = 16th March, 2021 and then by SD² = 6th March, 2021, as temperature and climate plays major role in it. As the sowing date shifted further towards final sowing date the temperature became much favorable (rainfall and cool down of climate) resulting into high yield then SD² = 6th March, 2021.

Conclusions

The following conclusion was achieved on the basis of result :

The most suitable date of sowing is seen in SD¹ = 24th Feb, 2021 in all the parameters recorded in above study.

The variety V1 = NutraShakti777 performed well than other varieties in agro-climatic zone of Dehradun.

Overall, the SD1 = 24th Feb, 2021 with V1 = NutraShakti777 is best scenario or condition for optimum growth and development of maize crop.

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Drying Kinetics of Aloe Vera (*Aloe vera barbadensis miller*) in Solar Cabinet Dryer

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Abstract

In the present investigation, aloe vera dried in solar cabinet dryer and compared with open sun drying method. It was observed that time required for reduction of aloe vera gel moisture content from 98.45 per cent (wb) to 8.82 per cent (wb) in solar cabinet dryer is two days while in open sun is three days. The average drying rate in open sun drying and solar cabinet drying of aloe vera was found 1.47, 1.34 and 1.19 g/100g dm/ h in OSD₁, OSD₂ and OSD₃ respectively and 3.96, 2.7 and 2 g/100g dm/ h in CSD₁, CSD₂ and CSD₃ respectively. The moisture diffusivity varied in the range of $1.59 \times 10^{-9} \text{ m}^2/\text{s}$ to $1.54 \times 10^{-9} \text{ m}^2/\text{s}$ in open sun drying and $1.88 \times 10^{-9} \text{ m}^2/\text{s}$ to $2.56 \times 10^{-9} \text{ m}^2/\text{s}$ in solar cabinet drying of aloe vera samples. Among the twelve thin layer drying model, best ranked thin layer drying model applicable to the variation of moisture ratio with drying time of aloe vera samples in open sun drying were two term model whereas in cabinet drying was diffusion approach model.

Key words : Aloe vera, solar cabinet dryer, thin layer drying models.

Introduction

The name aloe vera comes from Arabic word 'Alloeh', means shining bitter substance (Karkala and Bhushan, 2014). It has a wide role in ancient system of medicine like ayurveda, siddha, Unani and homoeopathy (Baby and Justin, 2010). Aloe vera plant is tropical succulent plant belong to family Liliaceae and are cultivated in tropical and sub tropical regions. Aloe vera has thick flesh leaves covered with spikes and bear yellow flowers. The gel is protected from evaporation by thin layer of a substance composed by resin and aloin. There are more than 300 species of aloe vera in the world but only 4 or 5 species commonly used in medicines. The regions which face the problem like lack of rain, low ground water and soil degradation etc. cultivation of aloe vera would be beneficial as it requires minimum water and return from it would be more than Rs. 50,000 yearly per acre. The aloe vera production in India is estimated around 1, 00,000 ton and annual (Anonymous, 2006) consumption of aloe vera by pharmaceutical industries 200 tonnes (Pandhair, 2008). In Rajasthan, organization 'Hahnemann charitable mission society' has promoted approximately 700 acres land under aloe vera cultivation and also helps in its marketing. There is around 125 ha of aloe vera ranch in the bordering territory of the preparing unit inside the Ogna backwoods local region of Udaipur (Gwarpatha prasanskaran kendra). This is the principal such preparing unit in immature innate zone of the Rajasthan for occupation fortifying, financial strengthening and protection of forest. The accomplishment of aloe vera preparing unit has supported the business among the inborn agriculturists of this territory. There are many aloe industries developed and potential use of aloe product

involves some type of processing like heating, dehydration and grinding (Ramachandra and shrinivasa, 2008). Aloe vera has attracted much attention and increasing demand for cure and cosmetics, there is good expectation for its large-scale production, processing and marketing (Chang *et al.*, 2006).

American food and drug administrative accredited aloe vera for its great medicinal value. Concentrates of aloe vera is a demonstrated skin healer which help to alleviate skin wounds influenced by consuming, skin disturbances, cuts, creepy crawly nibbles and its bactericidal properties ease tingling and skin swellings. Aloe vera is an effective detoxifier, germicide and tonic for the sensory system. It likewise has resistant boosting hostile to oxidant and against viral properties. As a general wellbeing tonic aloe vera is a valuable wellspring of vitamins A, C, E, B-assemble vitamins and folic corrosive. Aloe vera gel contains essential fixings including 19 of the 20 amino acids required by the human body (Rajeswari *et al.*, 2012). Aloe vera rich in mucilage formed of galacturonic and glucuronic acids linked to sugars such as glucose, galactose and arabinose. Other polysaccharides are present which contain high contents of uronic acids, fructose and other hydrolysable sugars. When aloe vera used as supplement absorption of vitamins C and E increases and their concentration in blood plasma was prolonged. Aloe vera used as a nutritional supplement is gaining popularity because it's potential to support human health (Nindo *et al.*, 2010). Daily supplementation of aloe vera is effective against various disorder and diseases like stroke, heart attacks, leukemia, anemia, hypertension, AIDS, radiation burns and digestive disorders (Banjare *et al.*, 2014).

Solar energy includes in prime energy source to our planet and all other energy sources are derived from it. The energy incident per year over India's land area is about 5,000 trillion kWh with most parts receiving 4-7 kWh per sq.m per day. The studies have revealed that even if we utilize less than 1 per cent of the total land area available that can generate a solar power of 3,400 TWh/yr (Desai, 2014). From energy reliability aspect solar is the most secure of all sources and non-polluting hence helps in reducing the greenhouse effect. The ultimate way to reduce the energy consumption of fossil fuel and its precious conservation is the widespread use of solar energy wherever possible. Low-temperature applications will be advantageous for rural electrification and other energy needs for power like heating and cooling in both rural and urban areas.

Drying of crop products by solar energy is of engrossment in the plain region where solar energy available in abundance. Drying may be required for several reasons. First and most often reason to remove water from the fresh crop to extend its shelf life. The dried product is later rehydrated, prior to use, in order to produce a food closely resembling the fresh crops for example use of dried fruits and vegetables. Secondly, a crop may require drying so that it can be further processed for example grains are dried so that they can be ground into flour. Thirdly, fresh crops are dried so that a new product distinctly different from its original form can be produced (Pardhi and Bhagoria, 2013). The drying need to lower the water activity and reduce the development of microorganisms, spoilage, longer period storage and reduce weight (Okas *et al.*, 1992). In sun drying most of the crops and cereals are lost because of fungal and micro bacterial attacks due to non-uniform drying, damage by animals, birds and rodents, degradation in quality due to direct exposure to solar radiation, rain, contamination by dirt and debris. Generally, farmers do this by open-air drying but this method is too unhygienic and time-consuming. Therefore, drying crop products by solar energy play an important role in the preservation of agricultural products (Tiwari *et al.*, 2013). Also open sun drying system has time consuming, labour intensive and product required to cover at night. This could be easily prevented by proper drying, which enhances storage of crops and grains over the long period. The advancement of open sun drying is solar drying system in which raw products are dried in a closed system in which inside temperature is higher than outer surrounding (Rajkumar, 2007). The use of high temperature dryer is economically feasible, uniformity in drying, time saving and no chance of micro bacterial attack on product. Major advantage includes protection against flies, pests, rain, dust and animals. To get the

benefit from the energy provided by the sun several attempts have been made to harness solar energy for drying mainly to preserve agricultural products. Solar cabinet drying is the most widespread method of food preservation in most part of India and world because of solar irradiance being very high for the most of the year. This technique is more beneficial to the small scale farmers who can't afford the electricity or other fuel for drying (Tiwari, 2016). The high initial investment for solar dryers remains a barrier to farmer in developing country due to low income however, if it is manufactured by locally available material such as wood, glass, polyethylene plastic etc. it will be economically affordable.

Materials and Methods

Selection of raw material and sample preparation :

The fresh aloe-vera (*Aloe barbadensis* Miller) leaves were visually analyzed as per size, ripeness and colour and according to homogeneous mature leaves were selected for preparing dried aloe vera. The aloe vera leaves were washed under tap water to remove adhering impurities. Leaves were washed within 2-4 h after harvesting. The biological activity lost if washing of leaves is delayed up to 24 h (Mulay *et al.*, 2014). A yellow-colour liquid (acibar) was extracted by cutting the base of the leaves and allowing them to drain vertically for an hour. The yellow fluid secretion from the harvested leaves was completely removed for its processing and purity of product (Chandegara and Varshney, 2013). The upper and lower skin of leaves were carefully removed with the help of a knife and mucilaginous mass made up of parenchymatous tissue cut pieces according to three different lengths. The epidermis was then separated from the gel, which was manually cut into three different sizes of 2, 5 and 10 cm. The care must be taken to avoid contamination of yellow sap within the fillet.

Drying of aloe vera gel

Open sun drying : Sun drying was done by spreading the aloe vera slices samples in a single layer in the dish. A 0.35 m height from the ground was maintained in order to avoid contamination of dust (Navale *et al.*, 2015). The initial mass of the samples was recorded on digital electronic weighing balance platform with an accuracy of ± 0.01 g. The samples were weighed regularly at an interval of 1 h and simultaneously the temperature, solar radiation and air flow were measured. Drying experiments were conducted between 9.00 a.m. to 18.00 p.m.

Solar cabinet drying : The drying experiments were carried in the cabinet type solar dryer. The dryer operated on principle of natural convection solar dryer having 15kg capacity was used for drying of aloe vera gel. The solar collector system was facing south tilted at an angle of 45°

from the horizontal is connected to food cabinet trays. The collector is covered with a transparent glass at the top surface. The inlet air comes in through the collector channel heated and naturally rises through the food cabinet and exits through the shutter of the chimney. The flowing air picked up moisture from the wet product in the chamber which was exhausted to the surrounding by natural convection. The samples were spread evenly in thin layers on the drying tray and then place on the shelf of the drying cabinet. During each trial, the mass of the aloe vera gel on the tray was measured.

Analysis of drying data : The drying mechanism simultaneous depends on heat and mass transfer phenomena and factors dominating each process determine the drying behavior of the product (Vega *et al.*, 2007). The drying rates were computed from the experimental data and drying characteristics curves.

Moisture content : The moisture content of aloe vera gel was measured as per cent wet basis (% wb) and per cent dry basis (% db) by oven method. Moisture content was determined by the standard method AOAC 934.06 (AOAC, 1990) using an oven and an analytical balance with an accuracy of ± 0.0001 g. The samples were placed in hot air oven at $100 \pm 0.5^\circ\text{C}$ for 18 h. The moisture content as the percentage by mass of the samples was calculated by following equation (Scala *et al.*, 2013). Triplicate samples were used for determination of moisture content and average values were recorded.

$$\text{M.C. (\% wb)} = \frac{M_1 - M_2}{M_1} \times 100 \quad \text{Eq. 2.1}$$

$$\text{M.C. (\% db)} = \frac{M_1 - M_2}{M_1} \times 100 \quad \text{Eq. 2.2}$$

Where,

M_1 = Initial mass of aloe vera gel before drying, g

M_2 = Final mass of aloe vera gel in after drying, g

Equilibrium moisture content : The equilibrium moisture content of dried aloe vera gel sample was determined by drying of samples until it reached to bone dry condition (Prabhanjan *et al.*, 1995).

Moisture ratio : The moisture ratio during drying experiments was calculated using the following equation (Togrul and Pehlivan, 2003 and Yaldiz *et al.*, 2001).

$$\text{Moisture ratio (MR)} = \frac{M - M_e}{M_0 - M_e} \times 100 \quad \text{Eq. 2.3}$$

Where,

MR = Moisture ratio

M = Moisture content at any time, t

M_0 = Initial moisture content, %

M_e = Equilibrium moisture content, %

However, the moisture ratio (MR) was simplified because of the relative humidity of the drying air continuously fluctuated during solar drying processes (Sunil *et al.*, 2013). Hence, moisture ratio was calculated by the following equation :

$$\text{Moisture ratio (MR)} = \frac{M}{M_0} \quad \text{Eq. 2.4}$$

Drying rate : Drying rate during experiments was calculated using the following equation (Doymaz, 2006).

$$\text{Drying rate} = \frac{M_{(t-dt)} - M_t}{dt} \quad \text{Eq. 2.5}$$

Where,

M_t = Moisture content at time t, %

$M_{(t+dt)}$ = Moisture content at t + dt (kg water/kg dry matter), %

t = Drying time, min

Estimation of moisture diffusivity : In drying diffusivity used to indicate the flow of moisture. In falling rate period of drying moisture is transferred mainly by molecular diffusion. Diffusivity is influenced by shrinkage, case hardening during drying, moisture content and temperature of the material. The moisture diffusivity of the samples was estimated by using the simplified mathematical Fick's second diffusion model (Crank, 1975). Aloe vera gel slice was considered to be infinite plate shape (Pisalkar *et al.*, 2014).

$$\text{MR} = \frac{M - M_e}{M_0 - M_e} = \frac{8}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{2n} \exp \left(-\frac{(2n-1)^2 \pi^2 D_{eff} t}{4H^2} \right) \quad \text{Eq. 2.6}$$

For long drying periods above equation can be further simplified to the first term of the series.

$$\ln \frac{M - M_e}{M_0 - M_e} = \ln \frac{8}{\pi^2} - \frac{\pi^2 D_{eff} t}{4H^2} \quad \text{Eq. 2.7}$$

Where,

D_{eff} = effective diffusivity, m^2/s

H = half thickness of sample, m

n = positive integer,

t = time, s

The effective diffusivity is typically calculated by plotting experimental drying data in terms of $\ln(\text{MR})$ versus drying time. From Equation 2.7, a plot of $\ln(\text{MR})$ versus the drying time gives a straight line with a slope of :

Table-1 : Mathematical models applied to drying curves.

Sr. No.	Model	Name of model	Reference
1.	MR = exp(-a.t)	Lawis / Newton	Sarsavadia et al.,1999
2.	MR = exp(-a.tn)	Page	Page, 1949, Diamante and Munro, 1993
3.	MR = exp(a.t)n	Modified Page	Yaldiz et al., 2001
4.	MR = a.exp(-b.t)	Henderson and Pabis	Henderson and Pabis, 1961, Chninman, 1984, Doymaz, 2006
5.	MR = a.exp(-b.t)+c	Logarithmic	Yaldiz and Ertekin, 2001
6.	M.R. = a.exp(-b.t)+c.exp(-d.t)	Two term	Rahman et al., 1998
7.	M.R.= a.exp(-b.t) + (1- a)Exp(-b.a.t)	Two term exponential	Sharaf-Elden et al., 1980
8.	M.R.=a.exp(-b.t) + c.exp(-d.t)+e.exp(-f.t)	Modified Henderson and Pabis	Karathanos, 1999
9.	M.R.=1+ a.t+b.t ²	Wang and Singh	Wang and Singh, 1978
10.	MR = a.exp(-c.t)+(1- a)exp(-c.b.t)	Diffusion approach	Kassem, 1998
11.	M.R.= a.exp(-c.t.n)+b.t	Midilli and Kucuk model	Midilli et al., 2002
12.	M.R. = a.exp(-b.t) + (1-a)exp(-c.t)	Varma et al model	Verma et al.,1985

$$\text{Slope} = \frac{{}^2D_{eff}}{4H^2} \quad \text{Eq. 2.8}$$

Mathematical modeling of drying kinetics of aloe vera gel : The well known thin layer drying models related dimensionless moisture ratio as the dry basis moisture content versus drying time into a dimensionless moisture ratio versus drying time. The experimental moisture ratio versus drying time data was fitted in thin layer drying models widely used to describe the drying characteristics of most food products and the best model was selected to describe the solar cabinet and open sun drying processes of aloe vera.

In the thin layer drying model equations a, b, c, f and n are the model coefficients and t is drying time. Non-linear regression method was utilized to fit the data to the selected drying models. For mathematical modeling of drying curves, the thin layer drying equations in following Table 2.1 were assessed to decide the best model for illustrating the drying behavior of aloe vera during drying process by solar drying. The regression analysis was performed using Excel software.

The correlation coefficient (R^2) was used as the primary criterion for choosing the best model that fit the experimental data. In addition to the coefficient of determination, the best fit of the experimental data was also selected based on various statistical parameters such as the reduced chi-square (χ^2) as the mean square of the deviations between the experimental and predicted values for the models and root mean square error analysis (RMSE). To get the best fit of the experimental data, the coefficient of determination was higher and the χ^2 and R_{MSE} were lower (Akpınar *et al.*, 2006, Sunil *et al.*, 2013 and pattali, *et al.*, 2014). The statistical parameters were calculated by using the following relationships :

$$R^2 = \frac{\sum_{i=1}^N (MR_{pre,i} - \sqrt{MR_{pre,i}})^2}{\sum_{i=1}^N (MR_{exp,i} - \sqrt{MR_{exp,i}})^2} \quad \text{Eq. 2.9}$$

$$\chi^2 = \frac{\sum_{i=1}^N (MR_{exp,i} - MR_{pre,i})^2}{N - n} \quad \text{Eq. 2.10}$$

$$\text{and } R_{MSE} = \sqrt{\frac{1}{N} \sum_{i=1}^N (MR_{pre,i} - MR_{exp,i})^2} \quad \text{Eq. 2.11}$$

Where,

$MR_{exp,i}$ = i^{th} experimentally observed moisture ratio

$MR_{pre,i}$ = i^{th} predicted moisture ratio values

N = Total number of observations

n = Number of constants in the model

R_{MSE} = Root mean square error

Results and Discussion

Drying of aloe vera gel : Aloe vera gel was dried in solar cabinet dryer and compared with the open sun drying method. Gel production yield was calculated considering the average weight of aloe vera leaves to be 100 per cent (25 kg). The leaf peel represented 34.48 per cent (8.62 kg) of the total, while the gel was 63.58 per cent (15.88 kg), with 1.98 per cent (0.5 kg) loss due to handling.

Open sun drying : Open sun drying of aloe vera was conducted at temperature range 25-35°C (mean 30°C). During the experiment, the observations were recorded at a regular interval of time. The overall 9 hours of drying during daytime was considered. Table-1 show number of days and drying hours required for different size aloe vera gel samples in open sun drying (OSD).

Table-1 : Total drying hours required to dry aloe vera gel in open sun drying.

Sr. No.	Type of sample	Size of aloe vera, cm	Drying hours, h	Days
1.	OSD ₁	2	24	3
2.	OSD ₂	5	26	3
3.	OSD ₃	10	27	3

Solar cabinet drying : The samples of aloe vera gel were placed in different trays of solar cabinet dryer at the temperature range of 35-55°C (mean 45°C) with corresponding average solar radiation 592 W/m² and average ambient temperature of 30°C. During the drying process, the observations were recorded at an interval of 1 hour. The drying process was continued for 9 hours per day. Total drying hours required for drying of aloe vera in the thin layer in different size are depicted in Table-2.

Table-2 : Total drying hours required to dry aloe vera gel in solar cabinet dryer

Sr. No.	Type of sample	Size of aloe vera, cm	Drying hours, h	Days
1.	CSD ₁	2	15	2
2.	CSD ₂	5	16	2
3.	CSD ₃	10	17	2

Drying characteristics of aloe vera gel in open sun drying and solar cabinet dryer : The drying behavior was investigated for aloe vera gel samples dried in solar cabinet dryer and compared with open sun drying. The different drying characteristics in terms of moisture content, drying rate and moisture ratio were studied. The initial mass of the aloe vera gel at the time when subjected to drying process was 100 g and was found to reduce to 1.70 g in CSD in the time span of 15-17 hour, whereas the equal loss of mass in OSD was observed in 24-27 hour. The variation in moisture content of aloe vera samples with drying time and drying rate were calculated and presented in Fig. 3.1. The moisture content reduced from 6351.61 per cent db (98.48 % wb) to 9.61 per cent db (8.8 % wb) in 24 h, 9.67 per cent db in 26 h and 9.67 db per cent in 27 h of drying in open solar drying sample of OSD₁, OSD₂ and OSD₃ respectively and in solar cabinet dryer moisture content reduced from 6352 per cent db to 9.67 per cent db in 15 h, 9.68 per cent db in 16 h and 9.7 per cent db in 17 h of drying sample in CSD₁, CSD₂ and CSD₃ respectively.

It reveal that the drying rate of OSD₁ varies from 0.054 to 5.516 g per 100 g dry matter per h and in CSD₁ varies from 0.021 to 7.598 g per 100 g dry matter per h. The average drying rate of OSD₁ was found to be less as compared with CSD₁ which were 1.47 and 3.69 g / 100 g dry matter / hour dried in open solar drying and solar cabinet dryer respectively. The average moisture ratio (MR) of OSD₁ and CSD₁ dried in open solar drying and solar cabinet dryer was found to be 0.421 and 0.549 respectively. The drying rate of OSD₂ varies from 0.093 to 5.405 g per 100 g dry matter per h when aloe vera was dried in open solar drying and CSD₂ variation from 0.019 to 7.627 g per 100 g dry matter per h when dried in solar cabinet dryer. The average drying rate for drying of OSD₂ and CSD₂ was found to be 1.34 and 2.6 g per 100 g dry

matter per h dried in open solar drying and solar cabinet dryer respectively. The average moisture ratio of OSD₂ and CSD₂ dried in open solar drying and solar cabinet dryer was found to be 0.42 and 0.38 respectively. It revealed that the drying rate of OSD₃ varies from 0.020 to 5.247 g per 100 g dry matter per h when aloe vera gel were dried in open solar drying and CSD₃ variation from 0.018 to 7.096 g per 100 g dry matter per h dried in solar cabinet dryer. The average drying rate for drying of OSD₃ and CSD₃ was found to be 1.19 and 2 g per 100 g dry matter per h dried in open solar drying and solar cabinet dryer respectively. The average moisture ratio of OSD₃ and CSD₃ dried in open solar drying and solar cabinet dryer was found to be 0.35 and 0.188 respectively. It was observed that drying rate of aloe vera was high at higher moisture content and it decreased as moisture content reduced. At the initial stage of aloe vera gel drying moisture content of aloe vera gel was high and more moisture was evaporated from the upper surface of aloe vera. As the drying process proceeded the moisture on the surface decreased and hence drying rate reduced with the drying time as well as moisture content. It was also observed that size of aloe vera gel affect the drying rate, as size decreased drying rate increased. The drying curves mostly exhibited a falling rate period similar results were also obtained by researcher Akpinar, 2010; Clary *et al.*, 2005; Zhang and xu, 2003; zhang *et al.*, 2005.

Moisture diffusivity : The moisture diffusivity value of aloe vera was affected by temperature as well as the size of aloe vera gel. Drying in solar cabinet dryer gave highest diffusivity values comparative to open sun drying. It was also found that at a higher in moisture content in aloe vera sample lowered the moisture diffusivity and at lowered moisture content moisture diffusivity was higher. The moisture diffusivity varied in the range of 1.59×10^{-9} m²/s to 1.54×10^{-9} m²/s and 1.88×10^{-9} m²/s to 2.56×10^{-9} m²/s for open sun drying and solar cabinet drying of aloe vera samples. At higher size of aloe vera gel decreased the moisture diffusivity. The moisture diffusivity in open sun drying was 1.59×10^{-9} m²/s, 0.94×10^{-9} m²/s and 1.54×10^{-9} m²/s in OSD₁, OSD₂ and OSD₃ respectively, whereas in the solar cabinet dryer was 1.88×10^{-9} m²/s, 2.33×10^{-9} m²/s and 2.56×10^{-9} m²/s respectively. The extensive range of moisture diffusivity are within of 10^{-08} to 10^{-12} m²/s for drying of food materials (McMinn and Magee, 1999).

Thin layer drying model : It is revealed that, in open sun drying all the models showed the good fit having R² values were found between 0.90-0.99 except modified Henderson and Pabis model for OSD₂ had observed very low R² value 0.42. Two term model was best fitted descriptive model for aloe vera samples OSD₁, OSD₂ and OSD₃. The two term model gave better predictive value than other models and satisfactorily drying characteristics

of aloe vera. The drying constants for the best fit two term equation for OSD₁ ($a=0.783$, $b=0.002$, $c=0.266$ and $d=0.012$), OSD₂ ($a=0.691$, $b=0.002$, $c=0.366$ and $d=0.010$) and OSD₃ ($a=0.881$, $b=0.003$, $c=0.164$ and $d=0.013$) The coefficient of determination (R^2) was found to be more than 0.99 and the mean square deviation ($??^2$) was 0.009, 0.002 and 0.0008 revealed the best fit equation and good correlation between attributes of moisture ratio and drying time of aloe vera sample of OSD₁, OSD₂ and OSD₃ respectively.

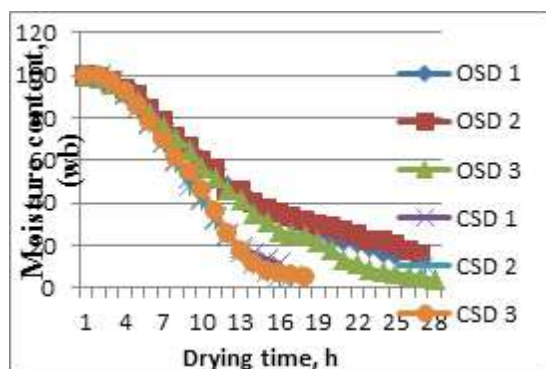


Fig-1 : Variation of moisture content of aloe vera during drying.

It reveals that, in cabinet type solar drying all the models showed the best fit having R^2 values were found between 0.90-0.99 except modified Henderson and Pabis model for CSD₂ had observed R^2 value 0. The diffusion approach was best fitted for aloe vera samples CSD₁, CSD₂ and CSD₃. Experimentally determined and predicted moisture ratio values were fitted to above model and for different aloe vera samples. The drying constants for the best fit two term equation for CSD₁ ($a=-0.117$, $b=0.104$ and $c=0.052$), CSD₂ ($a=-0.160$, $b=0.078$ and $c=0.0760$) and CSD₃ ($a=-0.159$, $b=0.071$ and $c=0.0789$) The coefficient of determination (R^2) was found to be more than 0.99 and the mean square deviation ($??^2$) was 0.008, 0.008 and 0.0005 revealed the best fit equation and good correlation between attributes of moisture ratio and drying time of aloe vera sample of CSD₁, CSD₂ and CSD₃ respectively.

Conclusions

The time required for reduction of aloe vera gel in solar cabinet dryer less than open sun drying method. The average drying rate in open sun drying and solar cabinet drying of aloe vera was found 1.47, 1.34 and 1.19 g/100g dm/ h in OSD₁ OSD₂ OSD₃ respectively and 3.96, 2.7 and 2 g/100g dm/ h in CSD₁, CSD₂ and CSD₃ respectively. The moisture diffusivity varied in the range of $1.59 \times 10^{-9} \text{ m}^2/\text{s}$ to $1.54 \times 10^{-9} \text{ m}^2/\text{s}$ in open sun drying and $1.88 \times 10^{-9} \text{ m}^2/\text{s}$ to $2.56 \times 10^{-9} \text{ m}^2/\text{s}$ in solar cabinet drying of aloe vera samples. Among the twelve thin layer drying model, best ranked thin layer drying model applicable to

the variation of moisture ratio with drying time of aloe vera samples in open sun drying were two term model whereas in cabinet drying was diffusion approach model.

Nomenclature

AOAC	-	Association of official analytical chemists
CSD	-	Cabinet solar drying
CSD ₁		Cabinet solar drying of aloe vera sample having size 2 cm
CSD ₂		Cabinet solar drying of aloe vera sample having size 5 cm
CSD ₃		Cabinet solar drying of aloe vera sample having size 10 cm
db	-	Dry basis
exp	-	Expected value
MC	-	Moisture content
MR	-	Moisture ratio
OSD	-	Open solar drying
OSD ₁	-	Open solar drying of aloe vera sample having size 2cm
OSD ₂	-	Open solar drying of aloe vera sample having size 5cm
OSD ₃	-	Open solar drying of aloe vera sample having size 10cm
pre	-	Predicted value
R^2	-	Coefficient of determination
R_{MSE}	-	Root mean square error analysis
SR	-	Solar radiation
T1	-	Average temperature of solar cabinet dryer, °C
T2	-	Ambient temperature, °C
T3	-	Chimney exhaust temperature, °C
wb	-	Wet basis
²	-	Chi-square

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Adoption Behaviour of Farmers on *Melia dubia* based Agroforestry system in Kalyana Karnataka Region

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Abstract

Survey was conducted in Kalyana Karnataka region and data were collected from 38 farmers in six districts with an objective to study perception of farmers towards adoption of *Melia dubia* based agroforestry system in Kalyana Karnataka region. Out of 38 respondents selected, 24 respondents comprising of more than 60 per cent were farmers *i.e.*, whose livelihood depends on farming only, while, rest (12 respondents) comprising 28.95 per cent were non-farmers (businessmen). The survey revealed that, with respect to adoption of *Melia dubia*, 63.16 per cent respondents adopted intercrops in between definite row proportion of *Melia dubia*, while, 26.31 per cent respondents cultivated as sole plantation and 10.53 per cent farmers had *Melia dubia* as hedge plantation. Out of 28 respondents who adopted arable crops with *Melia dubia*, 16 respondents adopted horticultural plantation crops like pomegranate, papaya and lime which covered 60.85 per cent of total area while, 5 respondents adopted tree species like sandalwood. In respect of *Melia dubia* plant density under intercropping system with arable crops, 44.74 per cent respondents adopted 501 to 1000 trees per ha, which covered 52.16 per cent total area followed by 28.95 per cent respondents adopted 73 to 500 trees per ha. Only two respondents were in adoption of higher plant density (2001 to 2500 tree ha⁻¹), which covered 5.93 per cent of total area.

Key words : Survey, respondents, *Melia dubia*, adoption, intercrops

Introduction

The rainfed ecosystems are ecologically more fragile, characterized with inadequate and ill distributed rainfall, scarcity of moisture, low organic carbon, fluctuation of water table, higher temperature and consequent higher evaporation and highly susceptible soils to erosion process. Therefore, the productivity of agriculture has declined and crop production has become more vulnerable due to climate change in spite of breakthroughs in crop varieties and crop husbandry. These days, tree based land use system is projected as a panacea for all problems in rainfed ecosystem. In fact, tree based land use system is an age old traditional practice followed by millions of farmers wherein farmers retain the useful trees on the farmland mainly to get fodder for animals, fuel wood, timber, fruits and other minor forest products singly or together. That apart, trees are also extending many ecosystem services, such as shade, protection and demarcation of land boundaries and congenial living habitat (Chittapur and Patil, 2017).

Agroforestry is a collective term for all land use systems and technologies where woody perennials (trees, shrubs, palms, bamboos *etc.*) are deliberately used on the same land management unit as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems, there are both ecological and economical interactions between the components. Agroforestry

system includes both traditional and modern land use system, where trees are managed together with crops, vegetables, fruit trees and/or livestock production on both irrigated and rainfed conditions where it produces multiple products and ecosystem services like soil and water conservation in the short run and carbon sequestration in the long run, decrease in deforestation, creation of microclimate and conservation of biodiversity (Lundgren, 1982).

Broadly, there are three categories of agroforestry systems found on farm; first one is the age old traditional agroforestry systems, second one consisting of modules developed through the formal scientific research and the third one is borne out of research but later modified further, evolved and adopted by the farmer himself (Nair, 1996). The second and third categories of agroforestry systems are oriented towards integration of only a few tree species which are of economical importance, fast growing, input responsive and high yielding. The traditional agroforestry land use systems, however, are complex in structure and function with both complementary and competitive effects (Muturi *et al.*, 2005). However, these need to be ascertained whether the traditional agroforestry systems are ecologically more desirable, economically viable and socially preferred. Often these land use systems have significant species diversity and density variation of useful plants which are managed through planting or selection and management

of naturally regenerated plants on the farm land by farmers (Schroth *et al.*, 2004).

There are many tree species are found to be suitable for agroforestry system but recently *Melia dubia* gaining more importance and most preferred. *Melia dubia* belongs to Meliaceae family, is a promising tree highly suitable for farm forestry and agroforestry for generating higher income in the semi-arid regions. Planting of *Melia dubia* fetches handsome price in the market, assured buyback with low maintenance expenditure. This also aid the planet by preventing temperature rise and checking gas emission into the atmosphere as the trees are naturally endowed to absorb maximum carbon dioxide. It is good for land rehabilitation and afforestation planting purposes. Its cultivation provides the economic upliftment of farmers (Kannan *et al.*, 2013). Hence the cultivation and utilization of trees is an economically viable, ecologically empathetic, environmentally ameliorative and aesthetically acceptable.

Hence, agroforestry can be adopted to meet the requirements of people and species like *Melia dubia* is being promoted which is fast growing and can fulfill their needs such as timber, fuel wood and also fodder, thereby farmers become self-reliant and economically stable. Apart from these benefits, the cultivation of *Melia dubia* increases the organic matter content of soil due to accumulation of litter which in turn enhances soil fertility. In recent years, farmers in Kalyana Karnataka region are growing *Melia dubia* in their farm lands to fulfill their livelihood needs and contributing to increasing the green cover. Still many farmers are reluctant towards adoption of agroforestry system. Hence, a survey was conducted in Kalyana Karnataka region and data were collected from 38 farmers in six districts with an objective to investigate performance of *Melia dubia* on farmers' field. In general, the management of *Melia dubia* plantation during later years (from second or third year onwards) with most of the farmers rested with organic eco-system.

Materials and Methods

Survey on perception of farmers towards adoption of *Melia dubia* based agroforestry system in Kalyana Karnataka region was conducted in 38 farmers field in Kalyana Karnataka region (UAS, Raichur, jurisdiction) by developing questionnaire.

Results and Discussion

Distribution of farmers according to adoption of *Melia dubia* : Data pertaining to distribution of farmers according to adoption of *Melia dubia* is depicted in Table-1.

Data were collected from 38 farmers who adopted *Melia dubia* in 67.48 ha. Out of 38 farmers, 24

respondents were farmers whose livelihood depends only on farming which covered 35.28 ha. It means that more than 60 per cent respondents were farmers followed by 28.95 per cent businessmen. These businessmen adopted *Melia dubia* with purpose of getting higher income only.

Distribution of respondents according to age of *Melia dubia* species : Data pertaining to distribution of respondents according to age of *Melia dubia* species is depicted in Table-2.

Melia dubia tree was recently introduced in Kalyana Karnataka region, only some people have known about the tree. Out of 38, 13 respondents planted *Melia dubia* in last two years which was major part of respondent. Out of total area adopted, 21.00 ha area was under *Melia dubia* plantation in last two years. Less than 3.0 per cent farmers adopted *Melia dubia* in 8 years back.

Distribution of respondents according to type of soil in which *Melia dubia* was adopted : Data pertaining to distribution of respondents according to type of soil in which *Melia dubia* was adopted is depicted in Table-3.

About 84.21 per cent respondents cultivated *Melia dubia* in red soils under irrigated condition, which covered 88.74 per cent of total area. It indicated that farmers who were having irrigation facilities have adopted *Melia dubia* in their field.

Distribution of respondents according to type of ecosystem in which *Melia dubia* was adopted : Data pertaining to distribution of respondents according to type of ecosystem in which *Melia dubia* was adopted is depicted in Table-4.

Looking into the importance of *Melia dubia* through wider publicity and farmers who have irrigation facilities started adopting *Melia dubia* in their field. In present study also, out of 38, 32 respondents adopted *Melia dubia* under irrigated condition which covered 88.74 per cent of total area.

Distribution of respondents according to type of *Melia dubia* based agroforestry system adopted : Data pertaining to distribution of respondents according to type of *Melia dubia* based agroforestry system adopted is depicted in Table-5.

About 63.16 per cent farmers adopted intercrops in *Melia dubia* based agroforestry system which covered 66.39 per cent of total area. Ten respondents cultivated *Melia dubia* as sole crop, which covered 23.53 per cent of total area.

Distribution of respondents according to type of intercrops adopted in *Melia dubia* based agroforestry system : Data pertaining to distribution of respondents

Questionnaire
Survey on performance of *Melia dubia* on farmer's field in Kalyana Karnataka region

Name	Village								Hobli & Taluka							
Total area	Irrigated								Rainfed							
Soil type																
Area under <i>Melia dubia</i>	No of trees/ha								Year of plantation							
Sole	Inter crop															
Spacing																
Area under other trees																
Insect incidence & Control measures																
Disease incidence & Control measures																
Multi use																
Benefits																
Pest control																
Disease control																
Ill effect	Yes	NO	Yes	NO	Yes	NO	Yes	NO	Yes	NO	Yes	NO	Yes	NO	Yes	NO
	I year		II year		III year		IV year		V year		VI year		VII year		VIII year	
Shade																
Poor germination of crops near vicinity																
Low moisture																
Difficulty in agril operation due to rooting																
Yield																
Constraints in adoption																
Does your family size affect your tree planting options:	(1) No								(2) Yes							
Occupation?	(1) Employed	(2) Farmer	(3) Civil Servant/Teacher	(4) Business Man/Woman	(5) Other											

according to type of intercrops adopted in *Melia dubia* based agroforestry system is depicted in Table-6.

With respect to adoption of intercrops in *Melia dubia*, 63.16 per cent respondents adopted intercrops in between definite row proportion of *Melia dubia*, while, 26.31 per cent respondents cultivated as sole plantation and 10.53 per cent farmers had *Melia dubia* as hedge plantation. In inter cropping adoption, 16 respondents adopted horticultural plantation crops like pomegranate, papaya and lime which covered 42.10 per cent of total area while 5.26 percentage of respondents adopted intercropping with field crops due to very poor awareness about the concept.

Distribution of respondents according to plant density of *Melia dubia* adopted : Data pertaining to distribution of respondents according to plant density of *Melia dubia* adopted is depicted in Table-7.

Regarding *Melia dubia* plant density, 44.74 per cent respondents had 501 to 1000 trees ha⁻¹, which covered 52.16 per cent of total area followed by 28.95 per cent respondents with 73 to 500 trees ha⁻¹. Only two respondents adopted higher plant density (2001 to 2500 trees ha⁻¹), which covered 5.93 per cent of total area. Farmers opined that higher plant density have more advantages than closer density. Similar results were also

observed by Pradeep (2015) who reported that planting geometry of *Melia dubia* at 24 m x 5 m was significantly superior in terms of its tree height (10.73 m), biomass (44.41 t ha⁻¹), bole height (3.96 m), GBH (62.40 cm), collar diameter (78 cm), canopy spread towards north-south (8.40 m), towards east-west (5.46 m), volume (0.097 m³) and biomass (44.41 t ha⁻¹) as compared to other planting geometry. Kirankumar and Patil (2017) conducted experiment on growth and productivity of *Melia dubia* under different planting densities at AICRP on Agroforestry, UAS, Dharwad and results revealed that the planting densities of 833 trees ha⁻¹ and 1000 trees ha⁻¹ showed optimum performance over the individual tree performance as well as total stand performance. The planting density of 2500 trees ha⁻¹ exhibited significant stand volume compared to other planting density.

From the studies, it was observed that many of the plantations were of different types of planting systems identified as monocultures (very few), mixed block plantations, bund planting, etc. In case of small land holdings, majority of the farmers practiced border planting. The spacing followed varied with individual land holding, type of intercropping, availability of water and requirement of the farmer. Generally, while establishing plantations, six months old seedlings were planted in pits

Table-1 : Distribution of respondents according to adoption of Melia dubia based agroforestry system

Category	No of respondents	Percentage	Area (ha)	Percentage
Farmers	24	63.16	35.28	52.28
Businessmen	11	28.95	27.80	41.19
Employ	03	07.89	04.40	06.52
Total	38	100.00		100.00

Table-2 : Distribution of respondents according to the age of Melia dubia species on their fields.

Category	No. of respondents	Percentage	Area (ha)	Percentage
2 years	13	34.21	21.00	31.12
3 years	08	21.05	17.08	25.32
4 years	06	15.79	8.00	11.85
5 years	05	13.16	9.80	14.52
6 years	05	13.16	9.20	13.63
8 years	01	02.63	2.40	03.56
Total		.0		.00

Table-3 : Distribution of respondents according to type of soil in which Melia dubia was adopted.

Category	No of respondents	Percentage	Area (ha)	Percentage
Black soil	06	15.79	07.60	11.26
Red soil	32	84.21	59.88	88.74
Total	38	100.00		100.00

Table-4 : Distribution of respondents according to type of ecosystem in which Melia dubia is adopted with corresponding area.

Category	No of respondents	Percentage	Area (ha)	Percentage
Rainfed	06	15.79	07.60	11.26
Irrigated	32	84.21	59.88	88.74
Total	38	100.00		100.00

Table-5 : Distribution of respondents according to type of Melia dubia based agroforestry system adopted with the corresponding area.

Category	No of respondents	Percentage	Area (ha)	Percentage
Sole	10	26.31	15.88	23.53
Hedge	04	10.53	06.80	10.08
Intercropping	24	63.16	44.80	66.39
Total	38	100.00		100.00

Table-6 : Distribution of respondents according to type of intercrops adopted in Melia dubia based agroforestry system with the corresponding area.

Type of intercrops	No of respondents	Percentage	Area (ha)	Percentage
Without intercrops	10	26.31	15.88	23.53
Field crops	02	5.26	07.40	10.97
Vegetable and Flower crops	05	13.16	06.20	9.19
Horticulture plantation	16	42.11	31.40	46.53
Trees (Sandalwood tree)	05	13.16	06.60	9.78
Total	38	.00	67.48	100.00

Table-7 : Distribution of respondents according to plant density of Melia dubia adopted.

No of plants ha ⁻¹	No of respondents	Percentage	Area (ha)	Percentage
73-500	11	28.95	16.28	24.13
501-1000	17	44.74	35.6	52.76
1001-1500	05	13.16	06.00	08.89
1501-2000	03	07.89	05.60	08.30
2001-2500	02	05.26	04.00	05.93
Total		100.00		100.00

(0.216 m³). The average spacing adopted for an inter crop was 3.3 m x 3.3 m, 4.0 m x 3.3 m and under hedge planting, wider spacing from 9 m to 30 m to 3 m to 4.5 m. Most of the farmers expressed that a pit size of 60 cm x 60 cm (0.216 m³) with a spacing of 3.3 m x 3.3 m is ideal for attaining better growth within a short period.

Most of farmers are using sarees for protecting fruits under high temperature to avoid sunburn, which is common practice in the region that cost around Rs 1.00 lakh ha⁻¹. To avoid such problem, farmers have adopted *Melia dubia* plantation as an inter crops in pomegranate, papaya and lime. These opinions are in conformity with the findings of Kulkarni (2017) who conducted participatory research to know the performance of *Melia dubia* in agroforestry system and reported that *Melia dubia* showed positive effect on quality of pomegranate fruits by reducing scorching effect through sunlight. Incidence of bacterial blight was also not noticed in new plantations but anthracnose (2 to 7 %) was noticed in few gardens. Kannan *et al.* (2013) opined that *Melia dubia* is a promising tree and highly suitable for farm forestry and agroforestry for generating higher income in the semi-arid regions. Nuthan *et al.* (2009) conducted survey in Kanakapur district, Southern Karnataka state and opined that *Melia dubia* being a fast growing tree gives early returns and also serves as insurance to the farmers during crop failure. The wood is easily available to both farmers and wood industries at cheaper rates. Being a fast growing tree, it can be cultivated in all types of soil and requiring a low supply of water.

Conclusions

This study highlights that farmers must be informed about advantages or benefits of leguminous and non leguminous tree species and their main effect on soil fertility through tree planting campaigns, trainings and workshops. *Melia* species would fetch best market value in irrigated areas. Primary and secondary marketing

points near to villages need to establish to facilitate the farmers who want to promote agroforestry.

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Optimization of Nutrients for Productivity Enhancement of Groundnut (*Arachis hypogaea* L.) in Northern Dry Zone of Karnataka

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Abstract

The field experiment on “optimization of nutrients for productivity enhancement of groundnut (*Arachis hypogaea* L.) in northern dry zone of Karnataka” was conducted for the two years during rabi 2013-14 and 2014-15 at Agriculture Extension Education Centre, Lingsugur under University of Agricultural Sciences, Raichur, Karnataka with an objective was to optimize nutrient requirement for groundnut crop. Experiment was laid out in randomized block design with seven treatments replicated thrice. Among the different nutrient combinations, application of packager of practices (PoP) + MgSO₄ @ 20 kg ha⁻¹ + Boron 2.5 @ kg ha⁻¹ + Multinutrient spray (3 ml per litre of water) recorded significantly higher pod yield of groundnut (1855 kg ha⁻¹) when compared with all the treatments except application of PoP + MgSO₄ @ 15 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray (1828 kg ha⁻¹) and PoP + MgSO₄ @ 20 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ (1765 kg ha⁻¹). Application of package of practice alone recorded significantly lower pod yield of groundnut (1586 kg ha⁻¹) which was on par with application of PoP + MgSO₄ @ 15 kg ha⁻¹ (1602 kg ha⁻¹), PoP + MgSO₄ @ 20 kg ha⁻¹ (1639 kg ha⁻¹) and PoP + MgSO₄ @ 15 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ (1698 kg ha⁻¹). Pod weight, kernel weight and haulm yield were followed similar trend. As for economics was concern, maximum gross returns, net returns and benefit cost ratio was realized with application of PoP + MgSO₄ @ 20 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray (3 ml per litre of water) followed by PoP + MgSO₄ @ 15 kg ha⁻¹ + Boron 2.5 @ kg ha⁻¹ + Multinutrient spray (1828 kg ha⁻¹). Balanced application of combinations of macro, secondary and micronutrients is very much essential to boost the productivity and profitability of groundnut cultivation in redsoil in northern dry zone of Karnataka.

Key words : Groundnut, nutrients, sustainability, significant, chlorophyll, cell division

Introduction

Groundnut (*Arachis hypogaea* L.) is an important legume used as oilseed as well as a food crop in India and grown in most of the states on all soil types, under tropical to subtropical climates. It is unpredictable, heavy feeder legume and is cultivated worldwide on almost all types of soil. It contains about 50 per cent oil, 25-30 per cent protein, 20 per cent carbohydrate and 5 per cent fiber and ash which makes groundnut a rich source of nutrition. It is a valuable cash crop cultivated by millions of small farmers throughout the world, because of its economic and nutritional value (Nandi *et al.* 2020). Groundnut is the world's fourth most important source of edible oil and third in vegetable protein and being grown in area of 24.59 million ha with an annual production of 38.20 million tons with the productivity of 1550 kg ha⁻¹ (Anon, 2015). In Karnataka, it is cultivated in an area of 1.30 m ha with production being 1.14 m t and productivity 589 kg ha⁻¹. The current average yield level of 1305 kg ha⁻¹ is deplorably low as compared to 3568 kg ha⁻¹ in China and 4699 kg ha⁻¹ in USA (FAO, 2012). Lower productivity was attributed to several reasons including imbalanced fertilization, damage caused by pest and disease. In spite

of recommended application of fertilizer (NPK – nitrogen, phosphorus, potassium) the yield does not reach the potential level (Meki Chirwa *et al.*, 2017). One of the major constraints for low yield of groundnut relates to deficiency of secondary and micronutrients. Intensification of agriculture, usage of straight fertilizers, rising crop requirements due to increasing productivity levels have heightened the secondary and micronutrients demand in soil fertility management and are increasingly becoming major constraints to achieve agricultural production.

Since it is an exhaustive crop and depending upon the yield it removes large amount of macro and micronutrients. On an average, to produce 2.0 to 2.5 t ha⁻¹ of economic yield, the groundnut requires 160-180 kg of N, 20-25 kg of P, 80-100 kg of K, 60-80 kg of Ca, 15-20 kg S, 30-45 kg Mg, 3-4 kg Fe, 300-400 g Mn, 150-200 g Zn, 140-180 g B, 30-40 g Cu and 8-10 g Mo (NRCG, 1993). The Potassium, calcium, magnesium, phosphorus and sulphur, among macro-nutrients are to be looked carefully because these elements are involved in the kernel filling and oil synthesis and are required in higher quantity. Magnesium is a component of chlorophyll and it serves as a cofactor in most of the enzymes that activate phosphorylation processes. The deficiency of Mg is a

problem of acid and sandy soils, as under high rainfall it is leached out more easily. Like K, the groundnuts are very efficient in extracting Mg from the soil, hence it rarely shows deficiency symptoms. However, the Mg deficiency in groundnut occurs in acid soils of Karnataka, Tamil-Nadu, part of A.P. and Eastern and North Eastern Hill Regions (Singh and Basu, 2005). Boron is an essential element which has received maximum attention over last 15 years. The deficiency symptoms appear especially on leaves, stems and reproductive parts. It is very useful in the production of legume seed with proper seed setting, improved seed quality, dry matter accumulation in roots, shoots, leaves and helps in the absorption of nitrogen to a certain extent (Singh *et al.*, 2007). Keeping these points in view, the present investigation was carried out to study the optimization of nutrients in groundnut with objective is to augment the crop productivity.

Materials and Methods

Field experiments were conducted for the two years during 2013-14 and 2014-15 at Agriculture Extension Education Centre under University of Agricultural Sciences, Raichur, Karnataka with an objective is to optimize nutrient requirement for groundnut crop. Eight multilocation trials were conducted in Kalyana Karnataka region to know the yield stability of best treatment at different locations. Experiments were conducted for two years laid out in randomized block design with seven treatment combinations and replicated thrice. Initial soil samples were collected from experiment block and analyzed for their nutrient contents. Experimental soil was sandy loam in texture having pH (7.89), electrical conductivity (1:2.5) dSm^{-1} (0.33), organic carbon (0.66 %), nitrogen (311.5 kg ha^{-1}), phosphorus (41.39 kg ha^{-1}) and potassium ($316.57 \text{ kg ha}^{-1}$), exchangeable calcium ($17.45 \text{ c mol (p+) kg}^{-1}$), exchangeable magnesium ($3.62 \text{ c mol (p+) kg}^{-1}$) and available boron (0.29 ppm). The report indicated that soil is deficit in magnesium and boron. Based on the outcome, an experiment was formulated during 2013-14 and 2014-15 in redsoils of Kalyana Karnataka region. The treatments consisted of T₁: Package of practice (PoP- 25:75:37.5 Kg N, P₂O₅: K₂O ha^{-1}), T₂: Package of practice with MgSO₄ (15 kg ha^{-1}), T₃: Package of practice with MgSO₄ (20 kg ha^{-1}), T₄: Package of practice with MgSO₄ (15 kg ha^{-1}) and boron (2.5 kg ha^{-1}), T₅: Package of practice with MgSO₄ (20 kg ha^{-1}) and boron (2.5 kg ha^{-1}), T₆: Package of practice with MgSO₄ (15 kg ha^{-1}), boron (2.5 kg ha^{-1}) and multinutrient spray ($3 \text{ ml per litre of water}$) and T₇: Package of practice with MgSO₄ (20 kg ha^{-1}), boron (2.5 kg ha^{-1}) and multinutrient spray ($3 \text{ ml per litre of water}$). Soil pH and EC (1:2.5) was measured using digital pH and EC meters (Jackson,

1973), Organic carbon content by wet oxidation method of Walkley and Black (1934), Available nitrogen by Subbaiah and Asija, 1956, available phosphorus using Olsen extractant by colorimetric method, available potassium using ammonium acetate by flame photometer, and calcium, magnesium and sulphur using calcium chloride as described by Jackson (1973) and boron using Azomithine H method as outlined by Berger and Trough, 1939. The observation on yield parameters were collected at physiological maturity stage and pods and haulm yields were recorded at maturity. The per cent oil content was analysed under magnetic resonance at MARS, Raichur, UAS, Raichur. The economical parameters like gross returns, net returns and benefit cost ratio were worked out after marketing of the produce. Data were subjected for analysis as per the Panse and Sukhatme (1978).

Results and Discussion

Yield parameters, yield and oil : The pooled data of two years pertaining to yield and yield parameters were presented in the Table-1.

The pod yield of groundnut was significantly influenced by soil and foliar application of various nutrients. Among the different nutrient combinations, application of PoP + MgSO₄ @ 20 kg ha^{-1} + Boron @ 2.5 kg ha^{-1} + Multinutrient spray ($3 \text{ ml per litre of water}$) recorded significantly higher pod yield of groundnut (1855 kg ha^{-1}) when compared with all the treatments except application of PoP + MgSO₄ @ 15 kg ha^{-1} + Boron @ 2.5 kg ha^{-1} + Multinutrient spray (1828 kg ha^{-1}) and PoP + MgSO₄ @ 20 kg ha^{-1} + Boron @ 2.5 kg ha^{-1} (1765 kg ha^{-1}). Application of package of practice alone recorded significantly lower pod yield of groundnut (1586 kg ha^{-1}) which was on par with application of PoP + MgSO₄ @ 15 kg ha^{-1} (1602 kg ha^{-1}), PoP + MgSO₄ @ 20 kg ha^{-1} (1639 kg ha^{-1}) and PoP + MgSO₄ @ 15 kg ha^{-1} + Boron @ 2.5 kg ha^{-1} (1698 kg ha^{-1}). The per cent increase in groundnut pod yield in PoP + MgSO₄ @ 15 kg ha^{-1} + Boron @ 2.5 kg ha^{-1} + Multinutrient spray over package of practice alone was 16.96. The significant increase in pod yield of groundnut was attributed to significant improvement in pod weight per plant. Application of PoP + MgSO₄ @ 20 kg ha^{-1} + Boron @ 2.5 kg ha^{-1} + Multinutrient spray ($3 \text{ ml/litre of water}$) recorded significantly higher pod weight ($50.7 \text{ g plant}^{-1}$) when compared with all the treatments except PoP + MgSO₄ @ 15 kg ha^{-1} + Boron @ 2.5 kg ha^{-1} + Multinutrient spray ($49.9 \text{ g plant}^{-1}$).

The significant increase in pod yield of groundnut as a result of application of magnesium and boron along with RDF and foliar spray of multinutrients were attributed to better pod weight and kernel weight per plant. Significantly higher haulm yield (1923 kg ha^{-1}) was

Table-1 : Pod weight, Kernel weight, oil content, pod yield and haulm yield of groundnut as influenced by different combination of nutrients.

Sl. No.	Treatments	Pod weight (g plant ⁻¹)	Kernel weight (g plant ⁻¹)	Pod yield (Kg ha ⁻¹)	Haulm yield (Kg ha ⁻¹)	Oil Content (%)
T ₁	Package of practice (PoP)	33.2	21.6	1586	1649	44.9
T ₂	PoP + MgSO ₄ @ 15 kg ha ⁻¹	37.2	24.2	1602	1667	45.1
T ₃	PoP + MgSO ₄ @ 20 kg ha ⁻¹	38.4	24.9	1639	1706	44.8
T ₄	PoP + MgSO ₄ @ 15 kg ha ⁻¹ + Boron @ 2.5 kg ha ⁻¹	40.5	28.4	1698	1770	44.4
T ₅	PoP + MgSO ₄ @ 20 kg ha ⁻¹ + Boron 2.5 @ kg ha ⁻¹	45.3	31.7	1765	1824	45.0
T ₆	PoP + MgSO ₄ @ kg ha ⁻¹ + Boron @ 2.5 kg ha ⁻¹ + Multinutrient spray (3 ml/litre of water)	49.9	34.9	1828	1901	45.6
T ₇	PoP + MgSO ₄ @ 20 kg ha ⁻¹ + Boron @ 2.5 kg ha ⁻¹ + Multinutrient spray (3 ml/litre of water)	50.7	35.5	1855	1923	45.3
S.E.m.±		0.93	0.62	38	16	0.13
CD at 5%		2.86	1.91	118	49	0.40

Table-2 : Economic analysis of groundnut as influenced by different combination of nutrients.

Sl. No	Treatments	Cost of Cultivation Rs. ha ⁻¹	Gross returns Rs. ha ⁻¹	Net returns Rs. ha ⁻¹	B:C
T ₁	Package of practice (PoP)	20000	55533	35533	2.78
T ₂	PoP + MgSO ₄ @ 15 kg ha ⁻¹	20600	56082	35482	2.72
T ₃	PoP + MgSO ₄ @ 20 kg ha ⁻¹	20800	57388	36588	2.76
T ₄	PoP + MgSO ₄ @ 15 kg ha ⁻¹ + Boron @ 2.5 kg ha ⁻¹	20850	59442	38592	2.85
T ₅	PoP + MgSO ₄ @ 20 kg ha ⁻¹ + Boron 2.5 @ kg ha ⁻¹	21050	61775	40725	2.93
T ₆	PoP + MgSO ₄ @ kg ha ⁻¹ + Boron @ 2.5 kg ha ⁻¹ + Multinutrient spray (3 ml/litre of water)	21525	63992	42467	2.97
T ₇	PoP + MgSO ₄ @ 20 kg ha ⁻¹ + Boron @ 2.5 kg ha ⁻¹ + Multinutrient spray (3 ml/litre of water)	21725	64925	43200	2.99

recorded in the treatment T₇: PoP + MgSO₄ @ 20 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray when compared with all the treatment except PoP + MgSO₄ @ 15 kg ha⁻¹ + Boron 2.5 @ kg ha⁻¹ + Multinutrient spray (1901 kg ha⁻¹). Significantly lower haulm yield of groundnut was recorded with application of package of practice only (1649 kg ha⁻¹) which was at par with application of PoP + MgSO₄ @ 15 kg ha⁻¹ (1667 kg ha⁻¹). Other treatments were intermediary in their effect. The significant improvement in productivity of groundnut might be due to role of magnesium and boron and other nutrients which had role in combating the deficiency of nutrient which has been reported to help in seed formation, seed filling and weight. The increased growth and yield with the soil application of magnesium and boron in combination attributed to complementary effect of these nutrients on growth parameters, nutrient utilization efficiency and yield Chaudhary *et al.* (2015), Patil *et al.* (2015), Ravikumar *et al.* (2019) and Nandi *et al.* (2020).

Boron being essential for N fixation, which ensured better N supply to the crop and also improved in dry matter accumulation in plant. This may be ascribed to the enhanced root development which improved nutrient uptake and growth as reported by (Layek *et al.*, 2014 and Meki Chirwa *et al.*, 2017). The oil content in groundnut

kernel was significantly influenced by application of various nutrient combinations. Significantly higher oil content was observed in treatment PoP + MgSO₄ @ kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray (45.6 %) followed by PoP + MgSO₄ @ 20 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray (45.3 %) which were significantly superior over all treatments. Significantly lower oil content was observed with application of package of practice (49.1 %). Significant improvement in former treatments mainly ascribed to better transformation of photosynthates from source to sink in presence balanced nutrients including secondary and micronutrients Kulkarni and Uppari (2015).

Economic analysis : The data pertaining to economic analysis were presented in the Table-2. Maximum gross returns of Rs. 64925 ha⁻¹ was realized with the treatment PoP + MgSO₄ @ 20 kg ha⁻¹ + Boron 2.5 @ kg ha⁻¹ + Multinutrient spray (3 ml/litre of water) followed by PoP + MgSO₄ @ 15 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray (Rs. 63992 ha⁻¹). The treatment package of practice produced minimum gross returns of Rs. 55533 ha⁻¹. Similarly, net returns were higher with application of PoP + MgSO₄ @ 20 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray (Rs. 43200 ha⁻¹) followed by PoP + MgSO₄ @ kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray (Rs. 42467 ha⁻¹). Minimum net returns were realized

with PoP + MgSO₄ @ 15 kg ha⁻¹ (Rs. 35482) due to higher input cost with lower pod yield. As for the benefit cost ratio was concern, higher B:C ratio was realized with PoP + MgSO₄ @ 20 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray (2.99) followed by PoP + MgSO₄ @ 15 kg ha⁻¹ + Boron @ 2.5 kg ha⁻¹ + Multinutrient spray (2.97). Lower benefit cost ratio was observed with treatment PoP + MgSO₄ @ 15 kg ha⁻¹ (2.72). Similar results were also reported by Patil *et al.* (2015) and Ananthkumar *et al.* (2016) in groundnut crop.

Conclusions

The experiment results showed that application of PoP + MgSO₄ @ 20 kg ha⁻¹ + Boron 2.5 @ kg ha⁻¹ + Multinutrient spray (3 ml/litre of water) or PoP + MgSO₄ @ kg ha⁻¹ + Boron 2.5 @ kg ha⁻¹ + Multinutrient spray (3 ml/litre of water) recorded significantly higher pod yield, haulm yield, pod weight, kernel weight and oil content when compared with all the treatment combinations which reflected on higher economic returns. So, either of these two treatments can be used to get higher productivity and profitability of groundnut under red soils of Kalyana Karnataka region.

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Assessment the Impact of ICT (What's App) Tools in Agricultural Extension

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Abstract

In present scenario agriculture being highly skill oriented and technical intensive sector needed to high priority. Farmers are on social media platforms virtually every day, and that's going to drastically influence their opinion whether they realize it or not. It is so important that you make sure your brand is showcased positively and provides valuable content your audience can enjoy and actually put to good use. Present study was conducted in Rajgarh district of Madhya Pradesh State. Information regarding weather forecasting, crop production, horticulture, dairy farming, postharvest management/ value addition and other agricultural related information were disseminated. The total no. of 30 farmers from each block was selected for conducting the study. The questionnaire was developed for assessment of Impact of information provided on What's app groups during the assessment period. Results of study revealed that, the right information at right time should useful for planning in agriculture activities and other developmental programme at remote places of district. What's app (ICT tools) group is also useful for real time scientist farmer interaction to increase the farm income.

Key words : *ICT, Agromet advisory bulletin, what's app group and agricultural extension persons.*

Introduction

Social media is a powerful & successful tool for connecting with and educating a mass of people and farmers are recognizing the value of these platforms. Farmers are actively engaging with social media sites with the purpose of delivering useful, informative content material where people can virtually participate in the world of agriculture. It has the ability to connect with farmers and agribusiness people from around the world over large geographical distances. In present scenario agriculture being highly skill oriented and technical intensive sector needed to high priority. Farmers are on social media platforms virtually every day, and that's going to drastically influence their opinion whether they realize it or not. It is so important that you make sure your brand is showcased positively and provides valuable content your audience can enjoy and actually put to good use. It develops a sort of compatibility without having to directly interact with any individual person.

Introduction to ICT in the field of agriculture has brought many changes in traditional methods of extension. It enables the circulation of requisite information at the right time. The revolution in ICT has made access to the information easy and cost effective to the farming society. ICTs now include computer-based applications and such communication tools as social media, digital information repositories (online or offline), and digital photography and video, as well as mobile phone (Balaji *et al.*, 2007). TheWhat's app service through message is being used to deliver the needful

agricultural information and specially to improve farmers' proficiency & agricultural technical knowledge with decision making ability, so that, they may enable to increase their production and productivity to fulfil market demands with securing better quality life and income in present competitive agrarian economy. The advisory was sent to registered farmers covering the broad category of information like, crop production, crop protection, vegetable and fruit production, dairy farming, weather forecasting, extension activities, postharvest management and other agricultural or allied information. Keeping in view the importance of Agromet Advisory Bulletins the constraints in farmer's field, the present study was conducted with following objectives :

To study the profile of beneficiaries of Agromet Advisory Bulletins.

To study the Knowledge, usefulness and adoption of Agromet Advisory Bulletins among Rajgarh farmers.

To assess the impact of Agromet Advisory Bulletins on dissemination to farmers.

Materials and Methods

Present study was conducted in Rajgarh district of Madhya Pradesh State. The district was selected purposively because this district was comes under Malwa Plateau Zone. Study was carried out with farmers and Agromet Advisory Bulletins (which were delivered through KVK in the year 2020-21 was procured from IMD Delhi. In three blocks (Rajgarh, Sarangpur, Zirapur) were selected. Information regarding weather forecasting, crop

Table-1 : Distribution of total number of Farmers in whatsapp group.

S. No.	Name of Block	No of Farmers	No of Agromet Advisory Bulletins (2020-21)
1.	Rajgarh	30	92
2.	Sarangpur	30	92
3.	Zirapur	30	92
Total	03	90	-

Table-2 : Area wise advisories under Agromet Advisory Bulletins issued during 2020-21.

S. No.	Area	Number	Percent (%)
1.	Agronomy Crop	20	22.16
2.	Horticultural Crop	15	16.86
3.	Plant protection	20	22.16
4.	Weather Forecasting	20	22.16
5.	Live stock	10	10.84
6.	Covid-19	03	02.89
7.	Others	04	3.61
Total	07	92	100

Table-3 : Distribution of the Respondents according to understanding of the Agromet Advisory Bulletins.

Particular	Farmers (n=90)		In service personnel (n=25)		Input supplier (n=15)	
Highly understandable	38	41.30	22	88.00	08	53.33
Medium understandable	32	34.78	03	12.00	04	26.66
Low understandable	10	10.87	00	00	03	20.00
Not understandable	10	10.87	00	00	00	00.00

Table-4 : Distribution of Respondents according to need and time base information.

Particular	Farmers (n=90)		In service personnel (n=25)		Input supplier (n=15)	
	No.	Percent	No.	Percent	No.	Percent
Needful & Timely	60	66.67	12	48.00	06	40.00
Needful but Not timely	23	25.56	07	28.00	04	26.66
No Needful but timely	03	3.33	04	16.00	03	20.00
No Needful & Not timely	04	4.44	02	8.00	02	13.33

Table-5 : Distribution of the Respondents according to applicability of Agro-met Advisory Bulletins.

Particular	Farmers (n=90)		In service personnel (n=25)		Input supplier (n=15)	
Fully Applicable	40	44.44	14	56.00	06	40.00
Medium Applicable	21	23.33	07	28.00	04	26.66
Partially Applicable	20	22.22	01	04.00	00	00.00
Not Applicable	9	10.00	03	12.00	05	33.33

production, horticulture, dairy farming, postharvest management/ value addition and other agricultural related information were disseminated. The total no. of 30 farmers from each block was selected for conducting the study. The questionnaire was developed for assessment of Impact of information provided on What's app groups during the assessment period. The compiled data were depicted in the tables for ready reference.

Results and Discussion

Agromet Advisory Bulletins was started with the object of passing the Agriculture information to maximum numbers of farmers in shortest, low cost and also timely advice without any distortion of the Bulletins. Initially, Agromet Advisory Bulletins were sent in local language font (Hindi) and English on their blockwise what'sapp group. A total number 92 Agromet Advisory Bulletins was sent

pertaining to different discipline related with agriculture in 2020-21. (Table-1).

A total number Agromet Advisory Bulletins 92 was sent pertaining to different discipline related with agriculture in 2020-21. Area wise Advisories in Agromet Advisory Bulletins were sent in the field of Weather Forecasting 22.16% followed by Agronomy (Crop Production) 22.16%, Horticultural crops 16.86%, Plant Protection 22.16 %, Livestock 10.84%, Covid-19 2.89 % and Rest of 3.61% SMS includes information others agriculture related information. (Table-2)

The result obtained indicated that messages were medium to high understandable for large majority i.e 40.00% to 47.50% of farmers category. It was highly understandable for 88% and 53.33% whatsapp group member of in service personnel and input supplier category, respectively. No members of any category of

what'sapp group were reported that messages were not understandable for them (Table-3). These findings were nearby to finding reported by Parganiha and Shrivastava (2012).

Agromet Advisory Bulletins provided a agricultural information's ranging from weather forecasting, advice related to Agronomy Crop, Horticultural Crop, Plant protection, their land preparation to harvesting & storage and also about livestock, allied enterprises but needfulness and timeliness of the messages was very important. The data presented in Table-4 indicated that messages were needful and timely for 66.67 per cent of the what'sapp group members of the farmer's category and about 48 and 40 percent for in-service personnel and input supplier, respectively. The message was not needful and not timely for them was reported less numbers of farmers (4.44%), in-service personnel (8.00%) and Input Supplier (13.33%). (Table-4) This finding was similar to finding reported by Kasana *et al.*, (2015).

As far as applicability of message is concerned, the data presented in Table-5 indicates that message was fully applicable for about 44.44% of what's app group members of farmer's category. Medium and partially applicable were reported by 23.33% & 22.22% of members of farmer's category, respectively. It was also

found that message was fully applicable for in-service personnel (56.00%) and input supplier (40%).

Conclusions

The results of study were revealed that the use of ICT in agriculture was very much useful for dissemination of information to large group in real time. The right information at right time should useful for planning in agriculture activities and other developmental programme at remote places of district. What's app (ICT tools) group is also useful for real time scientist farmer interaction to increase the farm income.

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Resource Use Efficiency of Sorghum and Chickpea Production in Watershed and Non-Watershed Area of Nek Region

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Abstract

Watershed is a land planning and management unit, which includes the physical, biological, technical, economic, socio-cultural, managerial and other water resources as well as other connected elements. Watershed is a systemic unit. Of the state economy in Karnataka, agriculture is essential and 70% of the dry land is arable. Research was thus performed to evaluate the cost and return of the major *rabi* crops as a result of watershed. The main major crops cultivated in the NEK area were sorghum and chickpea. In the Non-watershed, sorghum was farmed on 119 acres and on 79.25 acres. This paper was study about the impact of watershed on resources use efficiency used for the production of sorghum and chickpea. For the analysis Cobb-Douglas production function was used and a comparative study made between watershed area and non-watershed area for correct interpretation. It was clear from the study that manure, human labour, and machine labour are significant at 5 and 1 per cent level of significant in sorghum. While in chickpea fertilizer and human labour are significant at 5 and 1 per cent level of significance.

Key words : production function, manure, human labour, fertilizer, significant

Introduction

In recent years, India has looked to watershed development as a way to realize its hopes for agricultural development in *rainfed* and *semi-arid* areas. Watershed development is one of the popular approaches among development planners and agricultural scientists because it promises a win to win situation for natural resource conservation and agricultural productivity are concerned. It is often assumed that watershed development will also have favorable implications for poverty alleviations of the people of the catchment area. In order to achieve this objective, the emphasizes should not only be afforestation, but also be on other activities like water and soil conservation, training, community development activities, *etc.* Some of the components of the project that are suggested to be undertaken based on the requirement of different states includes agro-forestry/farm forestry, water and soil conservation, training and extension, biodiversity conservation and ecotourism, community development activities, income generation activities through SHGs with marketing strategy, involvement of NGOs, training of all stakeholders, dovetailing of project activities with other government departments schemes; monitoring and evaluation and impact analysis after project completion. Most of the watershed projects in India are implemented with the twin objectives of soil and water conservation and enhancing the livelihoods of the rural poor people. Different types of treatment activities carried

out in a watershed include soil and moisture conservation measures in agricultural lands (contour/ field bunding and summer ploughing), drainage line treatment measures (loose boulder check dam, minor check dam, major check dam, and retaining walls), water resource development/ management (percolation pond, farm pond, and drip and sprinkler irrigation), crop demonstration, horticulture plantation and afforestation. The aim has been to ensure the availability of drinking water, fuel wood and fodder and raise income and employment for farmers and landless labourers through improvement in agricultural production and productivity. Today watershed development has become the main intervention for natural resource management. In Karnataka agriculture plays a key role in the state's economy, and 70 percent of dry land is arable. The state depends on dry land for more than half of its food production. This precious resource has been subjected to poor soil and water management practices. This led to deterioration of soil fertility, decrease in crop yield, deforestation, decline in the biomass production, depletion of underground and surface water bodies, distraction of natural vegetation, these will intern affect the natural environment. In view of the above situation, more emphasis is given for dry land farming in the state by way of developing dry land areas on watershed basis and attempts have been made by both central and state Governments to draw several programs on watershed development with internal as well as external assistance. Sujala watershed project designed by Government of

Table-1 : Production function estimates for chickpea cultivation.

Variable	Parameter	Watershed	Non-Watershed
		Regression co-efficient	Regression co-efficient
Intercept	A	1.321	1.061
Seed	X ₁	0.742 (0.481)	0.790 (0.440)
Manure	X ₂	0.986 (0.566)	0.848 (0.524)
Fertilizer	X ₃	0.671* (0.334)	0.749* (0.354)
PPC	X ₄	0.813 (0.651)	0.983 (0.663)
Human labour	X ₅	0.740** (0.260)	0.843* (0.421)
Machine labour	X ₆	0.199 (0.134)	0.160 (0.091)
Bullock pair	X ₇	0.084 (0.062)	0.114 (0.088)
R ²		0.82	0.73

Note : *Significant @ 5 per cent, **Significant @ 1 per cent
The figures in the parentheses indicate the standard error of the variable

Table-2 : Production function estimates for sorghum cultivation.

Variable	Parameter	Watershed	Non-Watershed
		Regression co-efficient	Regression co-efficient
Intercept	A	2.963	1.689
Seed	X ₁	0.095 (0.063)	0.081 (0.054)
Manure	X ₂	0.612* (0.301)	0.459 (0.312)
Fertilizer	X ₃	0.116 (0.419)	-0.226 (0.163)
Human labour	X ₄	0.315** (0.059)	0.071 (0.042)
Machine labour	X ₅	0.107** (0.024)	0.913* (0.432)
Bullock labour	X ₆	0.066 (0.051)	0.019 (0.016)
R ²		0.76	0.83

Note : *Significant @ 5 per cent, **Significant @ 1 per cent
The figures in the parentheses indicate the standard error of the variable

Karnataka with assistance of World Bank. Sujala project is a community driven watershed development project initiated by Government of Karnataka and implemented by the Watershed Development Department with tripartite cost-sharing arrangements. The World Bank through International Development Association provides major portion of funds provided as a loan to Government of India. The Government of Karnataka finances some portion of the budget and the watershed communities contribute some portion. The project is being implemented in the selected 2531 micro watersheds located in 11 project districts viz., Bidar, Kalaburagi, Yadgir, Raichur, Koppal, Vijayapura, Gadag, Davangere, Tumkur and Chamarajanagara of which major districts were from North Eastern Region of Karnataka.

North-Eastern Karnataka region having geographical area of 1.76 million hectares and annual rainfall of the region varies from 633.2 to 806.6 mm. North-Eastern Karnataka receives about 55 per cent of rainfall from South-West and North- East monsoons. The climatic endowments are favourable for the production of different crops throughout the year if the water is made available. The present study was conducted in watershed areas of Bidar, Kalaburgi, Raichur and Yadagir districts

were chosen in consonance with the main objective of the study to assess the Impact of watershed project implemented in these four districts. Hence, with an objective of resources use efficiency of major rabi crops grown in NEK region was carried out in this study.

Research Methodology

The primary data were collected from both watershed and non-watershed farmers regarding all aspects of social change related to general characteristics, cropping pattern, crop yield, land utilization, sources of income of farm households, returns from the crops and livestock, farming systems adopted and input utilization on major crops cultivated etc., by using pre-tested, well-structured schedule through survey method. .

Secondary data : Secondary data regarding total geographical area of the district, demographic features and agro-climatic features were collected from the various sources viz., reports of the Sujala-III watershed project, State statistical abstracts and Central groundwater board reports.

Production function analysis : The Cobb-Douglas type of production function was employed to study the effect of various inputs on major crops output on account of its well

Table-3 : Allocative efficiency of chickpea cultivation.

Variable	Parameter	Watershed			Non-watershed		
		MVP	MFC	MVP:MFC	MVP	MFC	MVP:MFC
Seed	X ₁	2.43	1	2.43	1.378	1	1.378
Manure	X ₂	1.891	1	1.891	1.771	1	1.771
Fertilizer	X ₃	1.471	1	1.471	0.789	1	0.789
PPC	X ₄	0.432	1	0.432	0.615	1	0.615
Human labour	X ₅	1.966	1	1.966	1.834	1	1.834
Machine labour	X ₆	0.368	1	0.368	1.756	1	1.756
Bullock labour	X ₇	1.492	1	1.492	1.428	1	1.428

Note : MVP: Marginal Value Product, MFC: Marginal Factor Cost

Table-4 : Allocative efficiency of sorghum cultivation.

Variable	Parameter	Watershed			Non-watershed		
		MVP	MFC	MVP:MFC	MVP	MFC	MVP:MFC
Seed	X ₁	3.507	1	3.507	1.569	1	1.569
Manure	X ₂	2.945	1	2.945	4.654	1	4.654
Fertilizer	X ₃	0.356	1	0.356	-1.431	1	-1.431
Human labour	X ₄	1.861	1	1.861	0.265	1	0.265
Machine labour	X ₅	1.458	1	1.458	0.861	1	0.861
Bullock labour	X ₆	1.665	1	1.665	0.167	1	0.167

Note : MVP: Marginal Value Product, MFC: Marginal Factor Cost

known properties like its computational simplicity that justify its wide application in analyzing production relationship and it being a homogenous function provided a scale factor enabling one to measure the returns-to-scale. The estimated regression coefficients represented the production elasticities.

The form of Cobb-Douglas production function used in the present study is as follows.

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4}X_5^{b_5}X_6^{b_6}X_7^{b_7}e^u \quad \dots(1)$$

Where,

Y = Gross returns (/acre)

a = Intercept

X₁ = Seed cost (/acre)

X₂ = FYM cost (/acre)

X₃ = Chemical fertilizers cost (/acre)

X₄ = Plant protection chemicals (/acre)

X₅ = Human labour cost (/acre)

X₆ = Machine labour cost (/acre)

X₇ = Bullock labour cost (/acre)

e^u = Random error term

b_i's = Output elasticities of respective factor inputs, i = 1, 2...7

The Cobb-Douglas production function was converted into log linear form and parameters

(coefficients) were estimated by employing Ordinary Least Square Technique (OLS) as given below.

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7 + u \log e \quad \dots(2)$$

Allocative efficiency : Allocative efficiency exists when resources are allocated within the farm according to market prices and it implies the proper level of input used in production. Marginal value product for each input is computed in order to decide whether a particular input is used rationally or irrationally on the criteria of coverage of its acquisition cost by the respective input.

Marginal value product for each input was calculated by using the elasticity coefficient of each input obtained from the production function of respective input and the geometric mean levels of each variable by using the formula,

$$MVP \text{ of } i^{\text{th}} \text{ input} = b_i P_y (Y/X_i)$$

Where,

Y = Geometric mean of input

X_i = Geometric mean of ith input

b_i = Regression co-efficient of ith input

P_y = Average price per unit of output

The allocative efficiency in the use of each resource was estimated by calculating the ratio of marginal value product (MVP) to the marginal factor cost (MFC). Based on the ratio of value of marginal products to their factor

prices, the decision whether particular input used was rationally or irrationally was decided based on the following criteria

If MVP to MFC ratio were

>1, then the resources were under utilized

=1, then the resources were optimally utilized

<1, then the resources were over utilized

Results and Discussion

Production function estimates for chickpea cultivation

: The co-efficient of multiple determination (R^2) of the production function in chickpea (Table-1) crop production in watershed was 0.82 and 0.73 under non-watershed area indicating the 82 per-cent and 73 per cent of variation was explained by the variables used in the production function analysis in watershed and non-watershed areas respectively.

The variables like fertilizer and human labour were positively significant, indicating one-unit increase of these variables lead to increase of 0.671 and 0.74 unit of returns under watershed areas. Similarly, under non-watershed area the regression co-efficient of fertilizer (0.749) and human labour (0.843) were positively significant. Further, the other co-efficient of seed, manure, plant protection chemical, machine labour and bullock pair were positive but statistically non-significant under both watershed and non-watershed areas. The results obtained are in line with the results obtained from Dalviet *et al.* (2018) and Singh *et al.* (2018).

Production function estimates of sorghum cultivation

: The production function for sorghum cultivation under watershed and non-watershed area was worked out and presented in Table 2. The results of the table indicated that significant co-efficient (0.76) of multiple determination (R^2) indicated that 76 per cent of variation in return was explained by six variables included in the production function. However, the co-efficient of multiple determinations (R^2) under non-watershed area was (0.83) indicating 83 per-cent of variation in sorghum returns was explained by comparable variables used in watershed areas for production function analysis.

The regression co-efficient of human labour (0.315) and machine labour (0.107) were positive and highly significant ($p < 0.01$) and manure (0.612) at 5 per cent level of significance, indicating greater influence on return of sorghum returns. Other variables namely seed, fertilizer and bullock pair and their regression co-efficient were positive but statistically non-significant in watershed areas. Whereas in non-watershed areas, only machine labour (0.913) was positive and significant at 5 per-cent level, while other variables were positive but

non-significant except fertilizer (-0.226) which was negative and non-significant indicating the further more investment on fertilizer may lead to decrease in return.

Hence, it can be inferred that in overall among all major crops, it was noticed that the resources used for the major crop cultivation under watershed area were utilized efficiently than non-watershed area due to watershed intervention the soil health condition was better and water availability was also improved in watershed area. Therefore, the resources in watershed area were efficiently utilized.

Allocative efficiency of chickpea cultivation

: The Allocative efficiency of chickpea cultivation in watershed and non-watershed area as indicated in the Table-3. The MVP to MFC ratios of seed, manure, fertilizer, human labour and bullock pair were found to be more than one, indicating underutilization of these resources in chickpea production under watershed area. While, PPC and machine labour were excess utilized as their MVP to MFC ratios were less than one. However, in case of non-watershed fertilizer and plant protection chemicals were excess utilized remaining all were underutilized. Hence, it can be suggested that respondents of watershed and non-watershed area should re-allocate the resources to obtain higher return from production of chickpea.

Allocative efficiency of sorghum cultivation

: The Allocative efficiency of sorghum production in watershed and non-watershed area is indicated in the Table 4. The MVP to MFC was less than unity for fertilizer (0.356) indicated excessive utilization of fertilizer in sorghum cultivation in watershed area. While, the MVP to MFC ratios of remaining variables viz., seed (3.507), manure (2.945), human labour (1.861), machine labour (1.458) and bullock pair (1.665) was more than unity indicated underutilization of these resources, hence there is a scope of increasing these resources for higher gross return from sorghum production in watershed area.

Whereas, under non-watershed area, the MVP to MFC ratio of seed (1.569) and manure (4.654) was more than unity indicating there is greater scope for using additional unit of these resources to increase gross return from sorghum production. Similarly, the ratios of fertilizer (-1.431), human labour (0.263), machine labour (0.861) and bullock pair (0.167) were less than one indicating excessive use of these resources.

Conclusions

From the above results, it would be inferred that resources under watershed area were used near to optimal level in sorghum and chickpea cultivation. While, under

non-watershed area resources need to be re-allocate for better return from crop production.

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Effect of Chemicals and Bio Agents on Seedling Growth of Chilli Hybrid UARChH 43

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Abstract

The experiment was conducted to know the effect of chemicals and bio agents on seedling growth of chilli hybrid UARChH 43 during *Kharif*, 2019-20 at glasshouse, GPB block, College of Agriculture, University of Agricultural Sciences, Raichur. Lab experiment was undertaken in CRD (Completely Randomized Design) with seven treatments and four replications. Results revealed that, for superior seedling characteristics, treatment of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g/kg) + Phosphorus solubilizing bacteria (5g/kg) + 19:19:19 NPK, stands best method. Application of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g/kg) + Phosphorus solubilizing bacteria (5g/kg) + 19:19:19 had positively influenced the seedling emergence (78.00 %). Supplication of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g/kg) + Phosphorus solubilizing bacteria (5g/kg) + 19:19:19 NPK had increased the shoot length (10.140 cm), root length (13.085 cm), seedling length (21.505 cm) and seedling dry weight (2.686 mg). Treatment of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g/kg) + Phosphorus solubilizing bacteria (5g/kg) + 19:19:19 NPK, waste decomposer (5 ml/lit) and waste decomposer (5ml/lit) + IBA (2ml/lit) showed significantly higher seedling vigour index I (1704.56). Using of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g/kg) + Phosphorus solubilizing bacteria (5g/kg) + 19:19:19 NPK, waste decomposer (5ml/lit) and waste decomposer (5ml/lit) + GA₃ (2ml/lit) shown significantly higher seedling vigour index II (236.15).

Key words : Chilli, seedling characteristics, chemicals and bio agents.

Introduction

Chilli (*Capsicum annum* L.) an important crop being called as vegetable or spice or commercial crop and can be grown across the country in most of the states. It has its origin at South America. Around 400 different varieties of chillies are cultivated throughout the globe. The hottest variety being "Carolina Reaper" developed by a grower Ed Currie of West Indies having the maximum pungency of about 2.2 million Scoville Heat Units. The pungent principle is due to presence of Capsaicin (C₁₈H₂₇NO₃) synthesized in the epidermal cells of placenta of the fruit and possesses anti-inflammatory and antioxidant activities (Roy *et al.*, 2016).

According to 2019-20 first advance estimates, India being the world's largest producer, consumer and exporter of chillies has occupied an area of 7.33 lakh hectares (18.11 lakh acres) with a production of 17.64 lakh tonnes and productivity of 2400 kg ha⁻¹ (971 kg per acre). In India, major chilli producing states are Andhra Pradesh, Telangana, Madhya Pradesh, Karnataka and West Bengal accounting for 35, 17, 12, 11 and 6 per cent of all India production respectively. Karnataka stands first in production (673.81 million tonnes). While, in productivity it ranks eighth in position with an average yield of 1150 t ha⁻¹ of dry chilli per hectare during 2019-20. Indian chilli is considered to be world famous for two important commercial qualities of colour and pungency

levels. It is mainly exported to Asian countries like Vietnam, Thailand, Sri Lanka, Bangladesh and U.A.E. (Peer *et al.*, 2020).

However, the quality and yield of chilli is low due to cultivation of chilli under erratic spacing as well as with the application of erroneous levels of fertilizers or bio agents. There are few studies conducted by various authors in considering diversity of chilli varieties or hybrids to standardize the optimum level of fertilizers and spacing. In recent scenario of commercial crop cultivation, use of eco-friendly bio-products has emerged as one of the important strategies for sustainable agriculture. (Kumar *et al.*, 2000).

The scope to increase the productivity of chilli to its potential would substantiate the need for promotion of chilli cultivation technology in the farmer's field. Hence, greater emphasis should laid on educating the farmers particularly on sustainable agricultural productivity with substantial and judicious use of monitoring and non-monitoring inputs. One way by which extension scientist can contribute to this task, is to find out better ways and means of promoting improved chilli cultivation technology among the group of clientele. Since, change in knowledge and attitude preceded adoption of an innovation, it is therefore, always important to find out the most effective and economic techniques of changing farmers knowledge and attitude towards agricultural

innovations in general and chilli cultivation technology in particular.

Looking to importance of the organics in chilli, the experiment with the title “effect of chemicals and bio agents on seedling growth of chilli hybrid UARChH 43” was carried out to know the effect of different organics in chilli seedlings.

Materials and Methods

The experiment was carried out to know the effect of chemicals and bio agents on seedling growth during Kharif, 2019-20 at glasshouse, GPB block, College of Agriculture, University of Agricultural Sciences, Raichur. Laboratory experiment was conducted in CRD with seven treatments and four replications.

Seven different treatment combinations such as T₀: control, T₁: *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g/kg) + Phosphorus solubilizing bacteria (5g/kg) + 19:19:19 NPK, T₂: waste decomposer (5ml/lit), T₃: T₂ + rapid (2ml/lit), T₄: T₂ + harit sanjeevani (2ml/lit), T₅: T₂ + IBA (2ml/lit), T₆: T₂ + GA₃ (2 ml/lit), T₇: rapid (2 ml/lit) + nimbicide (4ml/lit). The treatments was done based on the followed procedure.

Protrays are shallow, small depressions are made at center of plugs. Treated seeds are sown in each cell and covered with coco peat containing 100 per cent moisture. Water was sprinkled by rose can. Drenching the trays with fungicide (melathion 1ml/lit) as a precautionary measure against seedling mortality is done. The seedlings were ready for transplanting in 40 days to the main field. (<https://en.TNAU Agritech portal.org>).

Five normal seedlings were randomly selected from each treatment. The shoot length and root length was measured on 40th day after sowing from the base of the primary leaf to the base of the hypocotyl and mean shoot length and root length was expressed in centimeters (Anon, 2013).

To measure seedling length, five normal seedlings were randomly selected from each treatment. The seedling length was measured on 40th day after sowing from the tip of shoot to tip of the root was measured and mean length was calculated and expressed in centimeters (Anon, 2013).

For seedling dry weight, five normal seedlings used for measuring seedling length. 40 days old seedlings were taken in butter paper and dried in a hot-air oven maintained at 80° C temperature for 24 hours. Then five seedlings were removed and allowed to cool in a desiccator for 30 minutes before weighing in an electronic balance. The average weight was calculated and expressed as seedling dry weight in milligrams (Anon, 2013).

To measure seedling vigour index I and II five normal seedlings used for measuring seedling vigour index I and II (40 days old seedlings). Seedling vigour index was determined by multiplying percentage germination and mean seedling length (Abdul-Baki and Anderson, 1973).

Seedling vigour index I = Germination (%) × Seedling length (cm)

Seedling vigour index II = Germination (%) × Seedling dry weight (mg)

Data of five random plants of various characters were analyzed statistically to find out the significance of variation among the treatments. The analysis of variance (ANOVA) was performed by F-test, while, the significance of difference between the pairs of treatment means were evaluated by the Duncan's Multiple Range Test (DMRT) test at 5% and 1% level of probability (Gomez and Gomez 1984).

Results and Discussion

In the present study, the chemicals and bio agents showed significant effect on seedling emergence (cm). The seedling emergence happens to be one of the most important characteristics of seed to be commercially used. Seedling emergence is a biological process depending on several factors. Significantly highest seedling emergence was in treatments of *Pseudomonas fluorescens* (5g / kg) + *Trichoderma harzianum* (5g / kg) + Phosphorus solubilizing bacteria (5g / kg) + 19:19:19 NPK and waste decomposer (5 ml / lit) + IBA (2 ml / lit) to the extent of 78 % followed by 77 % seedling emergence in treatment rapid (2 ml / lit) + nimbicide (4 ml / lit). Whereas, lowest seedling emergence was noted in the treatment waste decomposer (5 ml / lit) + harit sanjeevani (2 ml / lit) i.e., only 65 % (Table 1). The significant increase in seedling emergence may be due to *Trichoderma harzianum* which induces formation and accumulation of reactive oxygen species (ROS) which acted as signal molecules that increased seedling emergence *Pseudomonas fluorescens* suppress plant diseases by protecting the seeds and roots from fungal infections. This are similar to findings of Alam *et al.* (2014) recorded lowest seedling emergence (61.33 %) in control and highest seed seedling emergence (93.33 %) in the seed treatment with *Trichoderma harzianum*.

Shoot length varied significantly due to chemicals and bio agents treatments. The shoot length recorded significantly higher treatment of *Pseudomonas fluorescens* (5g / kg) + *Trichoderma harzianum* (5g / kg) + Phosphorus solubilizing bacteria (5g / kg) + 19:19:19 NPK (10.14 cm) followed by rapid (2 ml / lit) + nimbicide (4 ml / lit) (9.70 cm) and lowest was observed in treatment waste

Table-1 : Mean table values for seedling characteristics of chilli hybrid UARChH 43.

Treatments	Seedling emergence %	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Seedling dry weight (mg)	SVI I	SVI II
T ₀ : control	68.00	9.47	11.45	20.93	2.43	1442	160
T ₁ : <i>Pseudomonas fluorescens</i> (5g / kg) + <i>Trichoderma harzianum</i> (5g/kg) + Phosphorus solubilizing bacteria (5g / kg) + 19:19:19 NPK	78.00	10.14	13.08	21.50	2.68	1704	236
T ₂ : Waste decomposer (5ml / lit)	69.00	7.87	12.80	20.67	2.57	1423	184
T ₃ : T ₂ + Rapid (2 ml / lit)	70.00	7.48	12.26	19.59	2.34	1395	187
T ₄ : T ₂ + Harit Sanjeevani (2 ml / lit)	65.00	7.32	9.74	18.26	2.22	1195	130
T ₅ : T ₂ + IBA (2 ml / lit)	78.00	8.52	10.77	20.91	2.65	1704	165
T ₆ : T ₂ + GA ₃ (2 ml / lit)	75.00	9.25	12.25	21.50	2.78	1683	236
T ₇ : Rapid (2 ml / lit) + Nimbicide (4 ml / lit)	77.00	9.70	11.60	21.31	2.93	1659	216
S.Em ±	2.09	0.30	0.43	0.35	0.29	2.17	2.01
C.D at 1%	0.90	0.62	0.89	0.73	N/S	0.85	0.79

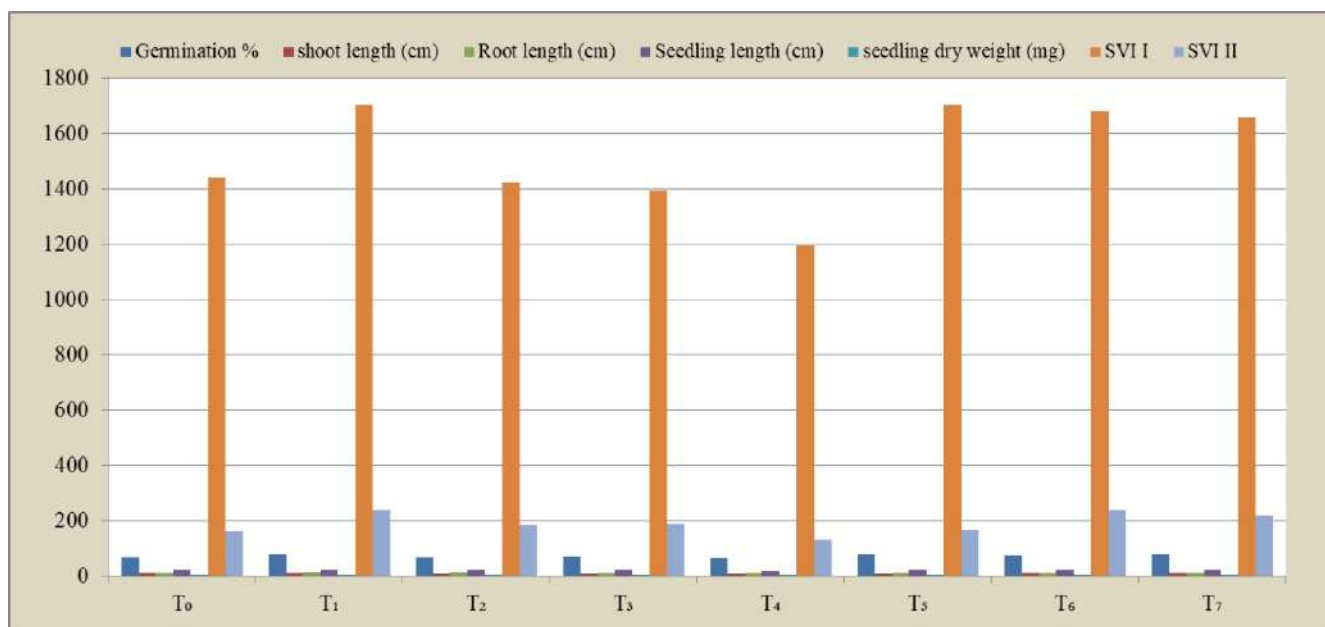


Fig.-1 : Seedling characteristics of chilli hybrid UARChH 43 under the influence of different organics.

T₀ : controlT₁ : *Pseudomonas fluorescens* (5g / kg) + *Trichoderma harzianum* (5g / kg) + Phosphorus solubilizing bacteria (5g / kg) + 19:19:19 NPK,T₂ : waste decomposer (5 ml / lit)T₃ : T₂ + rapid (2 ml / lit)T₄ : T₂ + harit sanjeevani (2 ml / lit)T₅ : T₂ + IBA (2 ml / lit)T₆ : T₂ + GA₃ (2 ml / lit)T₇ : rapid (2 ml / lit) + nimbicide (4 ml / lit)

decomposer (5 ml / lit) + harit sanjeevani (2 ml / lit) (7.32 cm) The chemicals and bio agents showed significant effect on shoot length (cm). (Table-1. and Fig-1.).

The length of the shoot determines the plant height and biomass and these two traits inter determine overall yield of the crop. The significant increase in shoot length may be due to *Pseudomonas fluorescens* which has

potential for promoting plant growth by suppressing pathogenic microorganisms, synthesizing growth stimulating plant hormones and promoting increased plant disease resistance. The present results corroborated the findings of Gore *et al.* (2007) who observed that foliar application of bio agents was effective in enhancing growth of chilli.

The treatment of *Pseudomonas fluorescens* (5g / kg) + *Trichoderma harzianum* (5g / kg) + Phosphorus solubilizing bacteria (5g / kg) + 19:19:19 NPK showed significantly higher root length (13.08 cm) followed by waste decomposer (5 ml / lit) (12.80 cm) and lowest was observed in treatment waste decomposer (5 ml / lit) + harit sanjeevani (2ml / lit) (9.74 cm) (Table-1. and Fig-1.). The significant increase in root length may be due to *Trichoderma* which is capable of acting as biostimulants of root growth by promoting root development through phytohormones, and thus improve nutrient assimilation, increasing resistance to biotic factors. These are similar to the findings of Muthu *et al.* (2011).

The treatment of *Pseudomonas fluorescens* (5g / kg) + *Trichoderma harzianum* (5g / kg) + Phosphorus solubilizing bacteria (5g / kg) + 19:19:19 NPK (21.50 cm) showed higher seedling length followed by rapid (2 ml / lit) + nimbiocide (4 ml / lit) (21.31 cm) and lowest was observed in treatment waste decomposer (5 ml / lit) + harit sanjeevani (2 ml / lit) (18.26 cm) (Table-1 and Fig-1). Seedling length varied significantly due to chemicals and bio agent's treatment. The significant increase in seedling length is due to increased root length and shoot length. Similarly, a study conducted by Ananthi *et al.* (2014), they observed that, bio-priming of chilli seeds with *T.harzianum* at 60 per cent for 3 hrs gave the highest values for mean seedling length (63 cm) compared to non-primed seed.

Out of seven treatments many showed non-significant effect on seedling dry weight (mg). The treatment of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g/kg) + Phosphorus solubilizing bacteria (5g/kg) + 19:19:19 NPK showed higher seedling dry weight (2.93 mg) followed by waste decomposer (5 ml/lit) + GA₃ (2 ml/lit) (2.78 mg) and lowest was observed in treatment waste decomposer (5 ml / lit) + harit sanjeevani (2 ml / lit) (2.22 mg) (Table-1 and Fig.-1). The increase in seedling length was be due increase in assimilate allocation to roots for maintaining root growth, turgor maintainance. Similarly, Ananthi *et al.* (2014) reported that, *P. fluorescens* treatment at 60 per cent for 12 h could increase the rate of germination (10.8 per cent), the germination percentage (95 per cent), mean root length (82 mm), mean shoot length (70 mm), biomass production (4.7 mg seedling⁻¹) and SV I (1,406) compared to non-primed seed (SVI = 855).

Seedling vigour index I was significantly highest in treatment of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g/kg)+Phosphorus solubilizing bacteria (5g/kg) + 19:19:19 NPK and waste decomposer (5 ml/lit) + IBA (2 ml/lit) (1704) followed by waste decomposer (5 ml / lit) + GA₃ (2 ml / lit) (1683). The lowest

seedling vigour index I was in treatment waste decomposer (5 ml/lit) + harit sanjeevani (1195) (Table-1 and Fig.-1). Seedling emergence and seedling length was the major factors for deciding the seedling vigour index I. Further, Seedling vigour index II is helpful in monitoring and ensuring the survival and growth of seedlings after germination. Seedling vigour index II was significantly highest in the treatment of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g / kg) + Phosphorus solubilizing bacteria (5g / kg) + 19:19:19 NPK and waste decomposer (5 ml / lit) + GA₃ (2 ml / lit) (236) followed by rapid (2 ml / lit) + nimbiocide (4 ml / lit) (216) and the lowest seedling vigour index II was recorded in treatment waste decomposer (5 ml / lit) + harit sanjeevani (2 ml / lit) (130) (Table-1 and Fig-1). This may be due to accumulation of more dry matter in plant tissues. However, these are similar to the findings of Alam *et al.* (2014). Further, seedling vigour index II is helpful in monitoring and ensuring the survival and growth of seedlings after germination. Seedling vigour index II was significantly highest in the treatment of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g / kg) + Phosphorus solubilizing bacteria (5g / kg) + 19:19:19 NPK and waste decomposer (5 ml / lit) + GA₃ (2 ml / lit) (236) followed by rapid (2 ml / lit) + nimbiocide (4 ml / lit) (216) and the lowest seedling vigour index II was recorded in treatment waste decomposer (5 ml / lit) + harit sanjeevani (2 ml / lit) (130) (Table-1 and Fig.-1). This may be due to accumulation of more dry matter in plant tissues. However, these are similar to the findings of Alam *et al.* (2014).

Conclusions

Therefore, based on the study on determining the effect of chemicals and bio agents on seedling growth of chilli, it can be concluded that, for superior seedling characteristics, treatment of *Pseudomonas fluorescens* (5g/kg) + *Trichoderma harzianum* (5g / kg) + Phosphorus solubilizing bacteria (5g / kg) + 19:19:19 NPK stands best method for better seedling emergence and further growth and development of chilli plants.

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