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Response of INM on Growth and Seed Yield Performance of Field Pea (*Pisum sativum* L.) c.v. Arkel in Uttarakhand

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Abstract

The field experiment was conducted during *Rabi* season to determine the study was planned to see the response of integrated nutrient management on growth and yield attributing characteristics of field pea (*Pisum sativum* L.) which was compromised of eight treatments combination whereas control (T₁), NPK100% (T₂), FYM@10 t/ha (T₃), Vermicompost@10 t/ha (T₄), 100% NPK + FYM@10 t/ha (T₅), 100%NPK + vermicompost@10 t/ha (T₆), 100% NPK +FYM@10 t/ha + vermicompost @10 t/ha (T₇) and FYM @10 t/ha + Vermicompost@10 t/ha (T₈). The treatments were laid out in Randomized Block Design (RBD) with three replications of each treatment. The variety of pea used was Arkel. Observations on growth yield and yield attributing characters was recorded and analyzed statistically. All the treatments better response to growth and yield attributes over control. Among the various treatment T₇ (100% NPK +FYM@10 t/ha + vermicompost@10 t/ha) proved superior with increased plant height, number of leaves per plant, number of branches per plant, number of pods per plant, number of seed per pod and seed yield. The treatment T₇ also recorded higher value of soil available N, P₂O₅ and K₂. Next to T₇ the treatment T₅ (100% NPK + FYM @10 t/ha) showed superior response to growth attributes and seed yield.

Key words : INM, field pea, growth parameters yield attributes,

Introduction

Pea (*Pisum sativum* L.), one of the top 10 vegetable crops, is one of the most significant vegetables in the world. Pea is a staple of the global human diet and is high in the amino acids lysine and tryptophan as well as other nutrients like carbohydrates, vitamin A and C, calcium, and phosphorus. (Bhat *et al.*, 2013). Through biological nitrogen fixation in conjunction with symbiotic *rhizobium* present in its root nodules, its cultivation preserves soil fertility and is essential for promoting sustainable agriculture. (Negi *et al.*, 2006). In India it is grown mainly in Uttar Pradesh, Bihar, Punjab, Haryana, Delhi etc where it is grown for both vegetable and pulse, purposes and is highly remunerative crop. Uttar Pradesh is the major pea-growing state. Uttar Pradesh alone produces about 75% of the total pea produced in India. Chemical fertilisers are required for high crop output, but their misuse and excessive usage can be damaging to the environment, and their cost prevents them from being used to produce agricultural goods that are both affordable and lucrative. (Bobade *et al.*, 1992 and Kumari *et al.*, 2015). The increased use of chemicals under intensive cultivation has not only contaminated the ground and surface water but has also distributed the harmony existing among the soil plant and microbial population (Bahadur *et al.*, 2006). Bio fertilizer on the other hand is cost-effective and renewable source of plant nutrients to supplement the parts of

chemical fertilizer. Bio fertilizers are known to play an important role in increasing availability of nitrogen and phosphorus besides improving biological fixation of atmospheric nitrogen and enhance phosphorus availability to crop (Bhat *et al.*, 2013). For increasing the productivity of pea integrated nutrient management can be a better option over alone use of organic and inorganic. Negligible systematic study has so far been conducted on integrated use of fertilizer and organic manures specially vermicompost in pea. Hence, an attempt was made to develop integrated nutrient management package for economical productivity of pea in term of yield and growth.

Materials and Methods

The present investigation was carried out with field pea variety Arkel during the *Rabi* seasons at the Experimental Farm of the Department of Agronomy, Uttaranchal (P.G.) College of Bio-Medical Science and Hospital, Dehradun during the *Rabi* season 2016-2017. The experiment was comprised of eight treatment combination viz., control (T₁), NPK (T₂), FYM (T₃), Vermicompost (T₄), NPK + FYM (T₅), NPK +Vermicompost (T₆), NPK + FYM + Vermicompost (T₇) and FYM + Vermicompost (T₈). All the recommended cultural practices were done regularly during crop growth. The treatments were replicated three times and the experimental data were analyzed statistically in Randomized Block Design (RBD). The field pea crop was analyzed in various treatments for key

Table-1 : Details of treatment and their combinations.

Sl. No.	Symbol	Treatments Details
1.	T ₁	Control
2.	T ₂	100% NPK
3.	T ₃	FYM@10 t/ha
4.	T ₄	vermicompost@10 t/ha
5.	T ₅	100% NPK + FYM@10 t/ha
6.	T ₆	100% NPK + vermicompost@10 t/ha
7.	T ₇	100% NPK + FYM@10 t/ha + vermicompost@10 t/ha
8.	T ₈	FYM @10 t/ha + Vermicompost@10 t/ha

Table-2 : Effect of Integrated nutrient management on growth parameters of Pea (*Pisum sativum* L.) c.v. Arkel.

Treatment	Plant height (cm)	No. of leaves	Fresh shoot weight (g.)	Fresh root weight (g.)
T ₁	28.00	26.20	12.25	0.19
T ₂	43.00	40.00	13.27	0.35
T ₃	41.38	36.86	13.16	0.37
T ₄	41.78	39.91	11.62	0.33
T ₅	42.90	40.76	12.01	0.37
T ₆	38.45	36.77	13.41	0.28
T ₇	45.43	41.83	13.58	0.47
T ₈	44.39	40.13	12.83	0.38
S.Em +	2.12	1.50	0.64	0.55
CD (P=0.05)	6.45	4.57	1.97	0.16

Table-3 : Effect of Integrated nutrient management on yield parameter of Pea (*Pisum sativum* L.) c.v. Arkel.

Treatment	No. of branches/ plant	No. of pod / plant	No. of seed/ pod	Seed yield / ha
T ₁	6.46	12.4	4.99	14.22
T ₂	11.46	14.19	5.35	16.03
T ₃	13.96	15.70	5.44	16.24
T ₄	15.69	16.39	5.62	17.57
T ₅	15.27	17.86	6.03	18.22
T ₆	16.62	17.19	5.83	17.97
T ₇	16.84	19.68	6.35	19.66
T ₈	13.98	17.10	5.52	16.78
S.Em +	1.12	0.31	0.31	0.94
CD (P = 0.05)	3.41	0.96	0.96	0.28

characters *i.e.* Plant height (cm) Number of leave, fresh shoot weight , fresh root weight, Number of branches/ plant, Number of pod / plant, Number. of seed/ pod and Seed yield / ha by randomly selecting five tagged plants from each plot and averaged. The seed yield was recorded on whole plot basis and calculated as quintal per hectare (q ha⁻¹). Details of treatment and their combinations are given as in Table-1.

Results and Discussion

Growth and yield attributes : The present investigation shows that the effect of different combination of nutrients on different growth and yield attributes has been perusal of Table-2 and 3 reveals that it is evident from the present investigation that different combinations of organic manure like FYM, Vermicompost, and inorganic manure like N,P,K have differential positive effect on the growth attributes such Plant height (cm) Number of leave, fresh shoot weight, fresh root weight, Number of branches/

plant, Number of pod / plant, Number of seed/ pod and Seed yield / ha. The plant height at harvesting stages was found significant differences were observed among the treatments and the highest plant height was recorded in the treatment T₇ (NPK+ FYM + Vermicompost) (45.43cm), followed by T₅ (NPK + FYM) and lowest plant height was recorded in T₁ Control treatment (28cm). At the harvesting the maximum plant height was found in T₇ *i.e.* 105 cm, 99cm and 96cm. While the lowest plant height was recorded in T₁ *i.e.* 39 cm 37.5 cm and 37 cm. Further, it was also observed that all the other treatments were significantly better in plant height than the control treatment.

The number of leaves per plant maximum number of leaves was recorded in the treatment T₇ (NPK + FYM + Vermicompost) (13.58) and the lowest was recorded in control treatment. The treatment T₇ and T₅ showed values of 41.8 and 40.8 respectively while T₁ (12.25) give only

26.75 leaves per plant. Number of leaves per plant in all the treatments gave significantly higher values than control. Maximum fresh shoot weight was obtained in T₇ (13.58 g) followed by T₆ (13.41g). Lowest fresh shoot weight were observed in T₁ (11.62). Maximum fresh root weight found in T₇ (0.47gm) and minimum fresh root weight found in T₁ (0.19g). All the treatment shows the significant effect.

The maximum number of branches per plant was found in the treatments T₇ produced highest number of branches i.e.16.83 branches per plant, followed by T₅ i.e.15.27 and the least with T₁ i.e.6.45. At the harvesting also the number of branches per plant was recorded highest with the treatment T₇ and lowest number of branches per plant was found in T₁ control. The maximum number of pods per plant showed significant differences among the treatments T₇ was recorded the highest number of pods per plant i.e.20.23 while the least number of pods per plant was recorded in the treatment control (T₁) 11.63 per pods per plant. The maximum number of seed per pod differed significantly among the treatment in the experiment. Among the treatment the highest number of seed per pod was recorded with the treatment T₇ i.e. 6.50 seed per pod but it remained statistically at par with T₅ i.e. 6.13 seed per pod and the lowest value was recorded with the T₁ (control) i.e. 4.96 seed per pod respectively. While other treatments remained insignificant.

The data showing the seed yield are presented in the Table Among the treatments T₇ produced the maximum seed yield i.e. 20.83 q/ha followed by the treatment T₅ i.e. 19.32q/ha. While the lowest seed yield was recorded in the treatment T₁ (control) i.e.13.15q/ha. According to the investigation's table1 and 4, T₇, then T₈, achieved the greatest increase in all the growth and yield parameters, such as the plant height, No. of leave, fresh shoot weight, fresh root weight, No. of branches per plant ,No. of pod per plant , No. of seed per pod and seed yield/ hectore. However the lowest mean value of all the growth parameters and yield attributes characteristics were recorded in T₁. Similar finding was observed by Sundara *et al.* (2004) and Gupta *et.al.* (2017) they reported that the impact of vermicompost in combination with ½ dose of NPK is favourable due the probable reason behind this fact that for overall growth enzymes, hormones, as well as macronutrients, are imperative. A more adsorptive surface for nutrient absorption is also produced by vermicompost. These outcomes support the conclusion made by Patil *et al.* (2007). In accordance with Negi *et al.* (2006), the application of biofertilizers, FYM, NPK, and lime enhanced the number of pods per plant. NPK + FYM had an effect that was significantly better than any of them alone. The observation of Waseem *et al.* (2008) is

confirmed when the plant grows vigorously, which ultimately leads to an increase in the size of the pod and seed. According to Vimla and Natrajan (2000), using organic and organic fertilizers together boosted yield and yield-attributing characteristics by a significant amount when applied at the recommended dose. Similar results were obtained in the studies conducted by Jaipaul *et al.* (2011) and Mishra *et al.* (2010).

Conclusions

Based on the results of field experimentation, it may be concluded that seed yield of pea 19.66 q/ha) can be obtained from the application 100% NPK + FYM@10 t/ha + vermicompost@10 t/ha. The fertility status of the soil was also markedly improved after the crop harvest in thus treatment combination. In case the above treatment could not be taken up due to some difficulties than the application of 100% NPK + FYM@10 t/ha is the better treatment which a higher seed yield. It is concluding that the biofertilizer showed the significant difference. It is suggested that biofertilizer may be effective not only sustaining crop productivity and in soil health, but also in supplementing chemical fertilizer of crop.

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Effect of Stocking Densities on Growth Performance, Survival and Net Production of Grass Carp (*Ctenopharyngodon idella*) Fish Fingerlings during Rearing by Hapa Method and Feeding Halawana Leaves as Feed in Hill Zone of Karnataka

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Abstract

The present experiment was carried out to evaluate the effect of different stocking densities on growth performance, survival and net production performance of grass carp fish fingerlings when reared by hapa rearing method in hill zone of Karnataka. The experiment was initiated with six treatments and five replications. Each stocking density was considered as one treatment. They were T₁ (10 no's /m³), T₂ (20 no's /m³), T₃ (30 no's /m³), T₄ (40 no's /m³), T₅ (50 no's /m³) and T₆ (60 no's /m³). The fish fingerlings were stocked as per the treatments and replications. The chopped leaf of Halawana (*Erythrina variegata*) was fed as a feed for grass carp fish fingerlings. The fish fingerlings were fed during morning hours @ 100 % of their body weight. The study was carried out for a period of 120 days. After completion of the study period the fish fingerlings were completely harvested and used for calculation of survival percentage, growth performance and net production. In this studies better survival percentage of 83.05 was found in T₃ followed by T₂ (72.08%) and lowest survival was recorded in T₆ (47.91%) respectively, better growth performance interns of mean final length of 11.45cm was recorded in T₁ and lowest mean length of 8.77cm was observed in T₆ and better growth performance interns of final mean weight of 11.50g was recorded in T₁ and lowest final mean weight of 7.20 g was observed in T₆. Better net production of 2302.30 g/12m³/120 days was recorded in treatment T₃, followed by T₄ (2012.40 g 12m³/120 days) and lowest net production was observed in T₁ (747.60 g/12m³/120 days). The present study clearly indicated that, the stocking density of 30 no's/m³ of grass carp fingerlings stocked in nylon hapa and feeding chopped leaves of Halawana (*Erythrina variegata*) @ 100 % of their body weight and reared for a period of 120 days in hapa rearing method was ideal.

Introduction

The hill zone constitutes 13.36 % of the total geographical area of Karnataka. It is characterized by high rainfall (1886 mm average), undulating topography (up to 22%) and situated at an altitude of 1700 meters above Mean Sea Level. Chikkamagalur district has blessed with rich sources of water. The district has 1800 No private owned ponds and more than 12,000 No of Krishi Honda. The aquaculture sector contributes more than 45 % (82 million tonnes) to global fish production, (FAO, 2016). To improve the aquaculture production, the present seed production is not sufficient to fulfil the demand of seed requirements. To increase the availability of fish seeds it is very important to develop new technologies like seed rearing in hapa method.

The tanks are located at Agricultural and Horticultural Research Station, Kademadkal Mudigere which is located in hill zone of Karnataka. The main traditional crops of the hill zone are Coffee, cardamom, black pepper .banana and in lower area food crop like paddy. Majority of the water bodies has used for irrigation purpose during peak summer season in between the months of December to April, remaining part of the year the water sources were not used effectively. By educating

the farming community regarding utilisation of such water bodies for fish seeds rearing and motivate the rural farming community to adopt effective module as an income generation activities without affecting the regular farming practices.

Since the tanks are deeper and perineal in nature, they require advanced fish fingerlings. The fish fingerlings produced in conventional methods is not in a position to fulfil the fingerlings requirements of the hill zone. In addition to conventional method of fish fingerlings rearing, the fish fingerlings rearing in hapa methods is help in increase the fish fingerlings production and easily available to the farming community of the zone. It will help in enhance the fish production in deeper and perineal water bodies of hill zone of Karnataka.

Materials and Methods

The experiment on grass carp fish fingerlings rearing by hapa method was initiated at Agricultural and Horticultural Research Station, Kademadkal, Mudigere, Chikkamagalur district Karnataka state.

Pond preparation : The water storage tanks having an average depth of 20 ft and total water spread area of 2000 m² has selected for initiating the experiment. Before

Table-1 : Water quality parameters recorded during the experiment period.

Parameters/Treatments	Initial day (Initial day)	30 th day	60 th day	90 th day	120 day (Final day)
Water Temperature (°C)	23.00 to 26.50±0.17	22.00 to 25.50±0.21	23.50 to 26.00±0.18	21.00 to 25.00±0.20	19.00 to 23.00 ±0.21
pH	7.00 to 7.20±0.03	7.00 to 7.40±0.04	7.00 to 7.30±0.03	7.10 to 7.20 ±0.02	7.00 to 7.20 ±0.02
Dissolved oxygen (mg/l)	3.20 to 4.20±0.24	3.00 to 4.00±0.17	3.10 to 3.99±0.10	3.00 to 4.10±0.23	3.00 to 4.00±0.17
Free carbon dioxide (mg/l)	0.00 to 0.10 ±0.01	0.20 to 0.40±0.02	0.10 to 0.30±0.02	0.10 to 0.32±0.02	0.20 to 0.30 ±0.01
Total alkalinity (ppm of CaCO ₃)	95.66 to 106.00±1.20	97.00 to 110.00±1.30	96.00 to 115.00±1.45	98.00 to 120±1.54	99.00 to 123.00± 1.88
Sechhi disc reading (cm)	20.00 to 22.00±0.12	19.00 to 21.00±0.24	18.00 to 20.50±0.32	18.00 to 20.00±0.20	18.00 to 20.00±0.21

Table-2 : Growth performance in terms of mean length (cm) and mean weight (g) was recorded during the experiment period.

Treatments	Length (cm)		Weight (g)	
	Initial mean length (cm)	Final mean length (cm)	Initial mean weight (g)	Final mean weight (g)
T ₁ (10 no's /m ³)	2.80 ± 0.05	11.45 ± 1.76	2.60 ± 0.16	11.50 ± 1.90
T ₂ (20 no's /m ³)	2.80 ± 0.05	9.92 ± 2.00	2.65 ± 0.04	10.60 ± 2.20
T ₃ (30 no's /m ³)	2.90 ± 0.06	10.57 ± 1.60	2.86 ± 0.03	10.56 ± 1.90
T ₄ (40 no's /m ³)	3.20 ± 0.04	10.10 ± 1.78	2.90 ± 0.12	9.35 ± 2.20
T ₅ (50 no's /m ³)	3.30 ± 0.05	9.30 ± 1.80	3.00 ± 0.08	8.21 ± 2.40
T ₆ (60 no's /m ³)	3.50 ± 0.04	8.77 ± 1.70	3.00 ± 0.04	7.20 ± 1.90

Table-3 : Effect of different stocking densities on survival (%) and net production of grass fish fingerlings.

Treatments	Grass carp	
	Survival (%)	Net production (g)/12m ³ /120 Days
T ₁ (10 no's/m ³)	70.00 ± 1.85	747.60 ± 19.11
T ₂ (20 no's/m ³)	72.08 ± 1.80	1375.35 ± 21.00
T ₃ (30 no's/m ³)	83.05 ± 1.40	2302.30 ± 17.70
T ₄ (40 no's/m ³)	65.00 ± 1.60	2012.40 ± 18.00
T ₅ (50 no's/m ³)	58.00 ± 1.40	1813.08 ± 20.00
T ₆ (60 no's/m ³)	47.91 ± 1.60	1449.00 ± 17.00

initiation of the experiment water was completely drained out and utilised for irrigation purpose during summer season. The pond was filled during the monsoon season. The experiment was initiated in the month of August. Before one to initiation of the experiment irrigation tank was applied with agriculture limed @30g/m³, after three days of interval manure the pond with raw cow dung slurry @ 300 g/m³ as an initial dose. After grass carp fish fingerlings stocked into nylon hapa, the tank was limed @10g/m³ and liquid manured was done to the ponds @100 g/m³ in an interval of a month.

Nylon Hapa tying : Nylon hapa having a diameter of 6mts x 2mts x 1 mt has tied in the tank by the help of nylon rope.

Seed Source : Normal fish fingerlings of grass carp (*Ctenopharyngodon idella*) were brought from Inland Fisheries Division, Navile, Shivamogga.

Stocking and rearing : The fingerlings of grass carp (*Ctenopharyngodon idella*) were stocked in nylon hapa in

six treatment and five replication @10, 20, 30, 40, 50 and 60 no/m³ respectively. Each stocking density was served as a treatment. The mean initial length and weight of the grass carp was ranged from 2.80 cm to 3.50 and mean wt of 2.60 to 3.00 g respectively.

Feed and feeding : Chopped leaves of Halawana (*Erythrina variegata*) has selected as feed for the experimental fish fingerlings. The fish fingerlings were fed during morning hours @ 100 % of their body weight. The feed given was adjusted based on the growth performance of the fish fingerlings.

Water quality : Once in fifteen days partial replacement of water was carried out. The evaporation loss of water was make up by refilled the water drawn from farm ponds.

Water Sampling : Once in fifteen days water sampling was collected on each sampling day water samples was collected in morning hours and used for analysis. Temperature of the water in each treatment was noted with the help of thermometer. Water samples were also

used to analyze the pH, free carbon dioxide, dissolved oxygen and total alkalinity by following standard procedure (APHA, 1995).

Measurement and analysis : The growth performance of fish in different treatment was recorded once in fifteen days. During every sampling day minimum 50% of fish fingerlings were collected and individual length and weight of fish fingerlings was recorded. At the end of the experiment period all the fish fingerlings were collected and the individual length and weight of each fish fingerlings was recorded. The survival percentage and net production was calculated.

Results and Discussion

The experimental study was carried out for a period of 120 days in the tank located at AHRS, Kademadkal, and Mudigere. The study was carried out between the months of August to November. During the study period the water sample was collected for analysis. The water quality parameter like water temperature, dissolved oxygen, free carbon dioxide and total alkalinity were analysed. The dissolved oxygen requirement for cyprinids is more than 3.00 mg/l for a short period (Huet., 1975). The results obtained were within the permissible range.

The experimental was carried out for a period of 120 days. The fish variety used for conducting the experiment was grass carp (*Ctenopharyngodon idella*). The grass carp fish fingerlings were stocked in different stocking densities and each stocking density was treated as treatments. After completion of study period the fish fingerlings were completely harvested to calculate the survival percentage and net production.

In this studies grass carp fish fingerlings showed better survival percentage of 83.05 in T₃ followed by T₂ (72.08%) and lowest survival was recorded in T₆ (47.91%) respectively. In this experiment, the results indicated that, after certain stage of stocking density the survival percentage was decreased with increasing in stocking density of grass carps fish fingerlings. It may be due to fluctuation of dissolved oxygen availability in different treatments. Furthermore Adineh *et al.*, 2020 reported that, the fish reared at medium stocking density had better growth efficiency than those reared at high stocking density. In this experiment the results indicated that, the growth performance in terms of mean length and mean weight was decreased with increased stocking density in grass carp.

In this study better growth performance interns of mean final length of 11.45cm was recorded in T₁ and lowest mean length of 8.77cm was observed in T₆. better growth performance interns of final mean weight of 11.50g was recorded in T₁ and lowest final mean weight of 7.20 g was observed in T₆. Better net production of 2302.30 g/12m³/120 days was recorded in treatment T₃, followed by T₄, (2012.40 g 12m³/120 days) and lowest net production was observed in T₁ (747.60 g/12m³/120 days. Sharma and Chakrabarti (1998) evaluated the effect of different stocking density on growth of *Ctenopharyngodon idella* they concluded that, growth of *Ctenopharyngodon idella* decreased with increasing stocking density. The results clearly indicated that, carp fish fingerling performs better in stocking density of 30 no's /m³.

The present study clearly indicated that, the stocking density of 30 no's/m³ of grass carp fingerlings stocked in nylon hapa and feeding chopped leaves of Halawana (*Erythrina variegata*) @ 100 % of their body weight and reared for a period of 120 days in hapa rearing method was ideal for hill zone of Karnataka.

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Post-Harvest Processing Treatments, Packaging Technologies and Storage Practices to Extend the Shelf-Life of Green Leafy Vegetables

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Abstract

Green leafy vegetables received widespread recognition globally due to their numerous health benefits for humans. They are important component of a healthy diet and their sufficient daily consumption helps to prevent major diseases. Also, they are one of the most affordable and readily available sources of fibres, vitamins, minerals and essential amino acids. The decreased consumption of leafy vegetables could be attributed to their higher perishability, making them less accessible in urban fresh produce markets. The lack of adequate postharvest technologies to maintain overall quality is one of the major constraints to increase the production of leafy vegetables. To make indigenous green leafy vegetables available on the global market, proper packaging technology is required to minimise qualitative and quantitative losses during marketing and export. This paper examines the literature on nutritional ingredients, post-harvest processing treatments, packaging and storage techniques, and the effect of various packaging materials on the shelf-life of some commonly consumed green leafy vegetables.

Key words : Blanching, edible coatings, green leafy vegetables, hurdle technology, modified atmospheric packaging.

Introduction

Green leafy vegetables (GLV) piqued the interest of food scientists during the last decade as the most cost-effective source of numerous essential elements. These are the plant tender petiole, shoot and leaves consumed as a vegetable, while the plants are young and active in growth (Sahu *et al.*, 2020). They are vital for achieving daily needs for bioavailable vitamins and phytochemicals (Imathiu, 2021). They are high in folic acid, vitamin C, iron and dietary fiber while being low in calories (Kumar *et al.*, 2020). Proanthocyanidins, flavonoids, iridoids, carotenoids and saponins are antioxidant, anti-inflammatory, anticarcinogenic, and antibacterial phenolic compounds seen in green leafy vegetables (Sarkar *et al.*, 2022). Some of the commonly consumed green leafy vegetables are spinach (*Spinacia oleracea*), amaranth (*Amaranthus gangeticus*), fenugreek (*Trigonella foenumgraecum*), drumstick (*Moringa oleifera*), bathua (*Chenopodium album*), curry leaves (*Murraya koenigii*), lettuce (*Lactuca sativa*), coriander leaves (*Coriandrum sativum*) etc.

Antioxidant activity of GLV is mostly related to their phenolic content, as these chemicals have more antioxidant potential than vitamins (Hossain *et al.*, 2022). Flavonoids are abundant in GLV and more effective antioxidant than vitamins E and C (Sarker and Oba, 2020). Carotenoids such as lycopene, zeaxanthin, lutein and beta-carotene found to give variety of health benefits

due to their antioxidant ability (Bin-Jumah *et al.*, 2021). They are powerful primary and secondary antioxidants due to the presence of conjugated double bonds, which contribute to free radical scavenging and singlet oxygen quenching (Mehmood and Zeb, 2020). They are more persistent than chlorophylls after heat processing and are an efficient antioxidant (Sharma *et al.*, 2021).

Vitamins are micronutrients that are necessary for optimal human metabolism and physiology. Water-soluble vitamins, particularly vitamin C and its oxidation product dehydro-L-ascorbic acid, provide several health benefits. In human diets, fruits and vegetables contribute up to 85% of vitamin C (Mehmood and Zeb, 2020). Ascorbic acid is required for the creation and preservation of intercellular components such as dentin, cartilage and collagen (D'Aniello *et al.*, 2017). Scurvy is caused by lack of vitamin C, hence vitamin C is also known as an anti-scurvy factor (Obi *et al.*, 2020). GLV are also important sources of zeaxanthin and lutein, both of which have been identified as important eye-protective compounds (Li *et al.*, 2022). 100 g of broccoli, 60 g of spinach and 50 g of lettuce provide half of the RDA for vitamins such as B9, E and C as well as α -carotene, Fe and Ca (Randhawa *et al.*, 2015). Because of their capacity to prevent age-related ailments, green leafy vegetables are often regarded as nature's anti-aging miracles (Sahu *et al.*, 2020). The vitamin K plays a direct part in the photosynthetic process therefore, GLVs have greater amounts of vitamin K than other fruits and vegetables (Randhawa *et al.*, 2015).

GLVs and fresh fruits are gaining prominence in the dietary pyramid due to their higher concentrations of trace minerals and other beneficial substances (Randhawa *et al.*, 2015). One of the most significant barriers to increase GLV production is the lack of adequate postharvest technologies to maintain overall quality. Post-harvest losses in leafy vegetables estimated to reach greater than 30%, owing mostly to poor handling and storage conditions throughout distribution and marketing (Nyaura *et al.*, 2014). The storage strategies utilized also have an impact on GLV quality retention. The softening of tissue, loss in moisture, wilting, yellow coloration, cell material breakdown due to respiration and chlorophyll degradation are all emphasized as key related problems during leafy vegetable distribution (Amodio *et al.*, 2019) and is closely related to loss of nutritional value particularly ascorbic acid and antioxidant capacity, color, taste, flavour, fresh mass and deterioration (Cano, 2019). All of these transformations eventually make the vegetable unattractive and unsellable. Harvest and postharvest losses must be reduced as part of long-term agricultural development strategies to increase food supply. In general, leafy vegetables can be stored at temperatures below 10°C (Mampholo *et al.*, 2015). Packing green vegetables in plastic wrap will assist to decrease moisture loss at temperatures below 10°C (Khalid and Arif, 2022). However, vendors selling these vegetables are unable to keep storage temperatures below 10°C. The higher rate of respiration causes its quality to degrade more quickly. Broccoli heads are traditionally chilled to 4.4°C before being packaged in ice crates and stored in freezers to increase their shelf-life. Thus, the shelf-life of broccoli extended to 7-10 days at 4°C (Rangavajhyala *et al.*, 1998). Cooling considerably enhances the shelf-life of green vegetables by removing field heat and lowering respiration. Lettuce could be kept for 2-3 weeks in good condition at 0-2°C and a high RH of more than 95% (Makule *et al.*, 2022). Furthermore, in order to make indigenous GLV available in the global market, adequate packaging technology is required to minimize or reduce qualitative and quantitative loss during marketing and export. As a result of the above, the current review is intended to highlight different post-harvest processing methods, packaging technologies, and storage techniques that could be used to increase the shelf-life of selected GLV.

Nutritional profile of Indian varieties of selected green leafy vegetables : Green leafy vegetables are the most inexpensive and abundant sources of protein (Obeng *et al.*, 2020). *Chenopodium album* (bathua) green matter is a high-protein product. It also possesses higher concentration of phosphorous, calcium, potassium, manganese, iron and magnesium as compared to other

green vegetables (Kumar *et al.*, 2020). Similarly, spinach is rich in folic acid and iron which are important for reproduction and foetal health (Natalia *et al.*, 2019).

Physical treatments for green leafy vegetables to extend shelf-life

Blanching and heat-shock : Blanching is a technique used to reduce the acid components and bitterness that are common in leaves (Chan *et al.*, 2020). It is a wet thermal processing procedure that takes place in hot water or steam at temperatures between 75°C and 100°C for one to ten minutes. The product moves on to the dewatering and chilling stage after being blanched in hot water for the specified amount of time. In contrast, when utilizing the steam blanching method, the product is passed through a saturated steam atmosphere before being cooled with either cold air or cold-water sprays (Mehlomakulu and Emmambux, 2020). Since vegetables are seasonal and highly degradable, blanching is recognized as one of the fundamental phases in their effective processing for drying or storage, and can thus aid in conservation (Managa *et al.*, 2020). Blanching of fresh produce is generally used to reduce the activity of enzymes like lipoxygenase and peroxidase before to further processing in order to limit negative changes in flavour, odour, colour and nutritional value (Patel *et al.*, 2016). It also minimizes microbial load on the surface of fresh produce by removing intercellular gases, which lowers possible oxidative changes (Xiao *et al.*, 2018).

Managa *et al.* (2020) found that steam blanching of *Solanum retroflexum* leaves in a stainless-steel steamer pot for 5 min significantly improved the antioxidant activity and polyphenol metabolites. The anti-nutritive chemicals such as phytates, oxalates and tannins were also greatly decreased by steaming while the amount of chlorophyll increased. Similarly, blanching at 70°C for 3 to 5 minutes of common bean (*Phaseolus vulgaris*) and false sesame (*Ceratotheca sesamoides*) leaves reduced the tannin and oxalate content, and it was advised as a successful approach for removing anti-nutrients (Kandonga *et al.*, 2019). Another investigation found that blanching maintained 46.30% more ascorbic acid in moringa leaves as compared to solar-dried leaves (Fellows, 2017). Heat-shock is a high-temperature short-time (HTST) method, typically includes a brief washing step performed at temperature ranging from 45 to 70°C for less than 5 min. The leafy vegetable lettuce is mechanically and physiologically fragile, which makes it difficult to process. One of the most common post-harvest disorders reported in this product is tissue browning. The induced synthesis of phenolic compounds caused the development of browning in celery and lettuce. The heat-shock treatment was successful in reducing browning by reducing the production

of enzymes induced by wound and redirecting to the production of heat shock proteins (Rico et al., 2007). Heat-shock prevents quality deterioration as well as helps to maintain organoleptic qualities for longer duration.

Steeping preservation with hurdle concept : The hurdle technology involves a suitable combination of two or more hurdles in which every hurdle is used at an optimum level so that damages to the overall quality of food is kept to the minimum. Potential hurdles for food preservation include temperature, acidity, water activity, modified atmosphere, packaging techniques such as aseptic packaging, vacuum packaging, edible coating, etc.), radiation (preservatives, redox potential and competitive microorganisms (Singh and Singh, 2015). Hurdle technology foods are defined as “products whose shelf-life and the microbial safety are extended by use of several hurdles none of which individually would be totally lethal towards spoilage or pathogenic microbes” (Sinha et al., 2013). The application of steeping preservation with hurdle concept in case of leafy vegetables is widely exploited in cauliflower preservation. Sinha et al. (2013) and (Singh et al., 2015) applied the above concept to cauliflower and successfully extended the shelf-life by 180 days and 120 days, respectively.

Intermediate moisture leafy vegetables : One of the simplest technologies for reducing the post-harvest losses in vegetables is drying. However, in relation to rheological and sensory characteristics, rehydration of dried vegetables with a moisture content of less than 1-2% becomes difficult since it requires longer duration for rehydration resulting in inferior texture and flavour as compared to fresh products. In this respect, drying vegetables with an intermediate moisture range of 15-25% is a better alternative for enhancing organoleptic properties, shelf-life and preserving nutrients that are valuable for nutritional protection (Singh and Singh, 2015). Without affecting the sensorial and nutritional properties, a controlled multi-hurdle could be applied. The use of this method has led to the development of shelf-stable ‘intermediate moisture products’ (IMPs) which retains its qualities for 3 to 8 months without refrigeration (Sujatha et al., 2014).

Singh and Singh (2015) developed intermediate moisture amaranth (*Amaranthus caudatus*) and spinach (*Beta vulgaris* var. *bengalensis*) with an objective to extend their shelf-life. After 50 days of storage, though the ascorbic acid content of both amaranth and spinach were reported to decrease to an extent of 34% and 45-50%, respectively, the sensory scores remained acceptable up to 50 days with an overall acceptability score of 8.0 (amaranth) and 7.5 (spinach) on 9-point Hedonic scale.

Drying : Drying is the most popular process used to

enhance the shelf-life of leafy vegetables (Sonkamble and Pandhure, 2017; Zalpouri et al., 2020). Since earlier times, sun-drying has been used to obtain dehydrated vegetables (Sain et al., 2020; Jaglan et al., 2018). This method is inexpensive, but its drying efficiency is dependent on bright sunlight and requires extended drying times. Due to their unhygienic character, sun-dried vegetables are not widely accepted. The technique of osmo-air drying is a straightforward method that holds potential advantages for the preservation of vegetables over an extended period of time. Osmo-air drying exhibits a higher potential for effectively drying vast amounts of vegetables while maintaining desirable sensory qualities (Pisalkar et al., 2011). Osmo-air drying of cauliflower (*Brassica oleracea* var. *botrytis*), fenugreek (*Trigonella foenum-graecum*) leaves, bathua leaves (*Chenopodium album*), spinach (*Beta vulgaris* var. *bengalensis*) leaves, amaranth (*Amaranthus caudatus* L.) leaves and cabbage (*Brassica oleracea* var. *capitata*) leaves were carried out by Singh and Singh (2015). The combination of osmotic diffusion treatment and cabinet drying was carried out to produce convenience processed vegetables.

The theory underlying dehydration involves the elimination of moisture under controlled conditions of temperature, humidity, and airflow through the application of heat. After blanching, each layer of sliced and shredded vegetables is distributed on trays and placed in the dryer. Typically, the initial dryer temperature in a cabinet or tray dryer is set to 60-65°C for 4-5 hours, and then the temperature is lowered to 50-55° C to achieve a final moisture content of less than 2% (Singh and Singh, 2015).

Packaging techniques to enhance the shelf-life of green leafy vegetables

Hypobaric packaging and storage in rigid containers :

The basic operating scheme of hypobaric storage consists of low ambient pressure, typically below 50 kPa, continuous ventilated air exhaust, and saturated storage space humidity. This method is reported to be effective in maintaining firmness, colour, soluble solids, sensory quality, and nutrients such as ascorbic acid and chlorophyll, and for delaying microbial growth and prolonging storage life (An et al., 2009). The increased preservation by hypobaric conditions of fresh products is attributed to the modified low oxygen atmosphere, thereby reducing the respiration rate and removing harmful volatile metabolic products such as ethylene and alpha-farnesene, which can retard the progress of maturation and senescence from the atmosphere of the storage facility (Fan et al., 2016). Hypobaric storage technology has not been industrially exploited as compared to controlled atmosphere storage or modified

atmosphere packaging since it has no significant advantages over other technologies in terms of beneficial effects or costs. Rigid containers with a portable vacuum pump have recently been introduced in households to store a variety of food products, including fruits, vegetables and other fresh produce. The storage under vacuum conditions of fresh produce in containers is similar to conventional hypobaric storage as both employs low atmospheric pressure, but the difference is that there is no continuous removal of metabolic volatiles by ventilation (Park et al., 2020). An et al. (2009) applied hypobaric packaging to lettuce (*Lactuca sativa*) at different hypobaric conditions of 25.3, 50.7 and 76.0 kPa and stored at 3°C with intermittent fresh air flushing and vacuum treatment in small rigid containers of 1 L capacity. The treatments were compared with 101.3 kPa control storage conditions. Under stringent hypobaric conditions, the respiration pattern of lettuce was reported to decrease significantly, whereas only a marginal decrease in respiration was reported in milder hypobaric package conditions. However, the study pointed out that in the case of leafy vegetables, hypobaric treatment induced significant weight loss by increased moisture loss, which resulted in the opening of stomata at high pressure reduction rates.

Modified atmospheric packaging (MAP) : Modified atmospheric packaging (MAP) is a technique for preserving fresh-cut food. The technique entails changing the gaseous atmosphere surrounding an item to produce a composition other than air. Active MAP or passive MAP can be used to modify the atmosphere. Active MAP is based on the displacement or replacement of gases in the package via gas flushing or using gas scavengers or absorbers to achieve a desired gas mixture. In contrast, passive MAP uses a specific packaging film in which a desired atmosphere develops naturally due to product respiration and gas diffusion through the film (Gorris and Peppelenbos, 2020). Low quantities of oxygen and high levels of carbon-di-oxide diminish the respiration rate of produce, delaying senescence and extending the fresh product's storage life. The acceptable concentration of gases in the surrounding atmosphere for preservation varies depending on the product. Fresh-cut items, in general, are more tolerant to greater CO₂ concentrations than intact products because their diffusion barrier is lower. For example, it has been shown that lettuce is not CO₂ tolerant, while shredded lettuce may survive amounts ranging from 10 to 15% (Rico et al., 2007). O₂, CO₂, and N₂ are MAP's most regularly used gases. During product storage, O₂ is consumed, and CO₂ is produced through respiration. Nitrogen is an inert gas used in MAP as a 'filler' gas to balance volume variations and prevent package collapse. Generally, a 3-6% O₂ and 2-10% CO₂

atmosphere achieves microbiological control and increases the shelf-life of a wide range of fresh-cut items (Treesuwan et al., 2022).

The use of MAP for fresh-cut products such as GLVs requires careful selection of the package type, storage temperature, and RH for each commodity. The temperature considerably influences the rate of respiration and the permeability of gases through packing films, allowing atmospheric changes to occur inside the packaging. Furthermore, storage temperature is one of the most essential determinants in pathogen survival and proliferation. It is critical for microbiological safety to keep produce temperatures at or below four °C throughout the cold chain. Permeation is essential for extending the shelf life of fresh products. Films such as low-density polythene (LDPE), polyvinyl chloride (PVC), ethylene/vinyl acetate (EVAC), orientated polypropylene (OPP), and cellulose acetate are insufficiently permeable for strongly respiring vegetables such as mushrooms, bean sprouts, leeks, peas, and broccoli. This highly respiring product is best packed in extremely permeable microperforated sheets. Microperforated films could achieve extremely high gas transfer rates (Gorris and Peppelenbos, 2020). The diameter of micro-perforation typically ranges between 40 and 200 µm, and by varying the size and thickness of micro-perforations, gas permeability throughout a package can be adjusted to meet well-specified product requirements (Sonawane et al., 2022). However, microperforated films are relatively costly, permit moisture and odour loss, and may allow for the ingress of microorganisms into sealed packs during wet handling conditions.

The cold storage of MAP packed lettuce leaves at 97% N₂ and 3% O₂ in PP films with 940 mL m⁻² day⁻¹ OTR and 1875 mL m⁻² day⁻¹ CTR revealed that MAP preserved the brittleness and stiffness of the leaves during storage as compared to the unpacked leaves (Soltani-Firouz et al., 2021). Similarly, MAP storage of asparagus at 3.5% CO₂ and 8% O₂, broccoli at 12% CO₂ and 3% O₂, and spinach at 7% CO₂ and 4-6% O₂ extended the storage life upto 4, 7 and 7 days, respectively (Stanley et al., 2020). According to Jin et al. (2021) MAP of fresh-cut amaranth at 10% O₂, 10% CO₂ and 80% N₂ preserved the quality, inhibited the growth of *Pseudomonas fluorescens* during refrigerated storage and extended the shelf-life. Batziakas et al. (2020) studied the effect of passive MAP technology in preserving the shelf-life of spinach. Modified atmosphere of 6% O₂ and 11% CO₂ was established using a BreatheWay having microporous semipermeable membrane with OTR 5x10⁶ cc/m²/day, which was attached over a hole in PP/PE laminate bag. The passive MAP packaging of spinach retarded the rate of water loss and yellowing during storage.

Effect of packaging materials on retention of quality characteristics and extending shelf-life of green leafy vegetables :

Fresh leafy vegetables have a short shelf-life, particularly if they are stored in inappropriate conditions. Among the horticultural products, leafy vegetables are one that gets spoiled rapidly. Senescence of the leaves is caused by changes in developmental, structural, physiological and biochemical processes. Loss of fresh weight, shrivelling, flavour changes and loss of greenness associated with the deterioration of chlorophyll are some of the manifestations of senescence in harvested leafy vegetables (Ambrose et al., 2015). The temperature and humidity in which leafy greens are stored as well as packaging material used has a major effect on their quality and protection. Although packaging effectively prevents water loss, vegetables consume oxygen and produce carbon dioxide as a result of respiration, altering the gas composition within the package. Fresh leaves contain more nutrients, so it is important to keep them fresh for as long as possible. Pre-packaging in its fresh form is important for extending the shelf-life and making it available in a ready-to-use form (Suganthi et al., 2019). Packaging is important in reducing postharvest losses because it can protect fresh produce from external environmental factors that can accelerate the senescence process. Packaging, on the other hand, can aid in the protection of vegetables from heat and the preservation of quality during storage (Ahmad and Ramli, 2018). Apart from that, by slowing down the physiological process, storage temperature also can aid in maintaining the quality of leafy greens. Excessive heat can degrade the quality of green leafy vegetables by hastening the decomposition of nutrients.

Seevaratnam et al. (2012) evaluated the effect of packaging materials in retaining the quality of leafy vegetables. The dried *Alternanthera* and *Amaranthus* leaves samples packed in 300-gauge metalized polypropylene (MPP) preserved more chlorophyll, ascorbic acid and beta carotene than 300-gauge HDPE and 200-gauge PP. In another study, packaging of curry leaves and drumstick leaves in HDPE of 200 gauge followed by low-temperature storage resulted in higher retention of α -carotene, ascorbic acid, chlorophyll, lesser moisture loss and non-enzymatic browning in dehydrated vegetable leaves (Singh and Sagar, 2010). Pavani and Aduri (2018) investigated the effect of three different packaging materials such as MPP of 300gauge, HDPE of 300gauge, LDPE of 200-gauge on the retention of quality characteristics in dehydrated *Amaranthus gangeticus* and *Spinach oleracea* stored at room temperature for 45 days. The MPP, followed by HDPE, was found to be effective in preserving the freshness.

According to Suganthi et al. (2019) the aluminium foil wrapped treatment was reported to be the best in terms of preservation of colour, retention of vitamin C, protein and moisture content, as well as providing a longer shelf-life of 12 days for moringa leaves as compared to LDPE and HDPE. Similarly, Ahmad and Ramli (2018) stored curry leaves in 0.08 μ m HDPE at 5°C and achieved higher retention of ascorbic acid, chlorophyll, sensory evaluation score, antioxidant activity and a lower percentage of weight loss over a one-month storage period. The thicker HDPE provided higher barrier to oxygen and thus, prevented oxidation and other degradation processes during storage. Similarly, Ambrose et al. (2015) opined that packaging fresh and stripped curry leaf in a 20 micron PP bag with 0.1 percent vent area of 5 mm diameter vent extended the keeping quality for 4 days in ambient storage.

Conclusions

The overlapping nutritional and medicinal benefits of green leafy vegetables increased their demand globally in the last few decades. Green leafy vegetables are listed as highly perishable commodities as their moisture content is higher than 80%. The best way to preserve the nutritional value of a product is to keep it fresh, but most storage methods necessitate low temperatures, which are difficult to maintain across the distribution chain. Suitable packaging and storage techniques should be developed in future for green leafy vegetables, which can retain their nutritional quality for an extended period of time.

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Preparation of Cost Effective, Sensory and Nutritionally Evaluated Mix Grain Flour with Oat Biscuits and its Nutritional Impact on Adult Women

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Abstract

Oat based product has been increased due to increased knowledge about the many nutritional benefits of oats. Increased consumer awareness towards health has emphasized on intake of high fibre diet. Oats as a functional food having physiological benefits like hypoglycemic effect, hypocholesterolemic effect, has effect on reduction of hypertension. Oat has a well-balanced nutritional composition; it is a good source of Iron and quality protein with good amino acid balance. The unique composition of oats, combined with their subsequent processing, add to the unique organoleptic and nutrient experience accompanying the consumption of oat biscuits. However, the processing of oats into foods accepted by consumers can result in changes in their nutritional composition. Moisture and Ash and Iron has similar Homogeneity of Variance then Moisture, Protein and Calcium is having higher difference of variance then other factors. The study was carried out for determination of the highest sensorially acceptable level of the added oat flour to biscuits. Blends were carried out using concentrations of 20%, 40%, 60%, 80% oat flour and 80%, 60%, 40%, 20% (w/w) added wheat flour. Mean of post feeding BMI of adult women is higher than the pre feeding BMI of adult women. The Paired Samples Correlation adds the information that BMI of adult women, pre and post feeding scores are significantly positively correlated ($r = .989$).

Key words : Functional foods, nutrients, foshu, health.

Introduction

There has been an increasing interest in the health enhancing role of specific foods or physiologically active food components, so-called functional foods 1. Actually, all foods are functional, as they provide taste, flavor, or nutritive value. Recently, the term functional when applied to food has adopted a different connotation, which of providing an additional physiological health benefit beyond that of meeting basic nutritional needs. The term functional foods was first of all introduced in Japan during mid-1980s and refers to processed foods containing ingredients that aid specific bodily functions in addition of being providing nutrients. Today, Japan is the only country that has formulated a specific regulatory approval process for the functional foods, which is called as Foods for Specified Health Use (FOSHU), these foods are eligible to bear a seal of approval from the Japanese Ministry of Health and Welfare. Currently, 100 products are licensed in Japan as FOSHU foods. Functional foods are not recognised legally in the USA. Instead of this, there are many organizations that have given importance for this new and emerging area of the food and science of nutrition. Functional foods have been defined by The Institute of Medicine's Food and Nutrition Board as "any food or food ingredient that may provide a health benefit

beyond the traditional nutrients it contains within it." Functional foods have been made by Health-conscious baby boomers as the leading trend in the Food industry of United States.

Oats are generally regarded as a minor cereal crop when considered in terms of grain produced annually, or areas sown for production. Traditionally, most of the crop has been used as animal feed. However, UK figures on the usage of oats 5 sees slightly more of the crop (44%) going towards human and industrial uses, compared to the animal feed sector (38%). Oats have been linked to the health claims attributed to the use of β -glucans and are valuable sources of β -glucans. As harvested; oats retain their hull, which accounts about 25-30% of the seed. Oats for food use are first dehulled, because hulls are not suitable for humans' without processing although readily digested by ruminants. However, properly processed makes it useful fibre ingredient for the food industry. Oat has recently attracted its research and commercial attention mainly due to its high nutritional value. Oats is a good source of antioxidant vitamin E (tocols), phytic acid, phenolic. Oat belongs to the family *Poaceae* and genus *Avena*. *Avena sativa* L. is the species that is currently cultivated (McMullen, 2000). Among cereals, oats are unique for their high protein as well as iron contents. Oats are among the world's healthiest

grains. Oats also contain large amounts of unique soluble fibers called beta-glucans, which provide numerous health benefits. The most important beneficial effects of β -glucan are their contribution to a lowering of serum blood cholesterol as well as moderating blood glucose in diabetics. Oat products however have a high content of phytate which may interfere with the absorption of non-haem iron. The iron balance situation is critical in several groups but especially in women. Almost one third of total fatty acids present in oats are polyunsaturated which are required for good health. In recent years, demand of oat based product has been increased due to increased knowledge about the many nutritional benefits of oats. Increased consumer awareness towards health has emphasized on intake of high fibre diet. Oats as a functional food having physiological benefits like hypoglycemic effect, hypocholesterolemic effect, has effect on reduction of cancer and hypertension. Soluble fibres have been known to lower blood cholesterol levels. Oat fibre has been associated with reduced risk of heart diseases. Oat compounds provide various opportunities for incorporating oats in functional food products. There is a great need to determine the bioavailability of antioxidants from oat and other food sources and to determine various effects on human and animal health. In the stomach and small intestine, oat-soluble fibre -glucan acts primarily by increasing the viscosity of the gastric and intestinal contents, and the action is mediated via the neuro-hormonal systems involving both endocrinal and gastrointestinal hormones. Oligosaccharides produced from -glucan have been demonstrated to act as selective factors, favouring growth of at least some known probiotic bacterial strains. The favourable effect on colon function is based partly on the enhanced production of microbial mass with good water retention properties, partly by the bulking effect of the insoluble components of the fibre. Oat has a well-balanced nutritional composition. It is a good source of carbohydrates and quality protein with good amino acid balance. Colour is one of the most important sensory attribute that affect directly the consumer preference of any product. Special attention should be given to bakery products to attract the consumers' attention. The word Biscuit derived from Latin word Biscoctum means twice baked. Biscuits are one of the low cost processed foods, which are most widely consumed.

The unique composition of oats, combined with their subsequent processing, add to the unique organoleptic and nutrient experience accompanying the consumption of oat biscuits. However, the processing of oats into foods accepted by consumers can result in changes in their nutritional composition. Recent studies by Zhang *et al.* into the impact of processing and storage on fortified oat

flour with milks highlighted that ultra-high temperature pasteurisation (5–20 s at 140°C) required to ensure microbiological stability had minimal impact on vitamin content. However, prolonged storage up to 12 months resulted in the degradation of linolenic acid and vitamins A, D3 and B12. In addition, oat tocopherols and tocotrienols (in combination known as tocopherols, of which α -tocotrienol comprises 57–99 % of total oat tocopherols) suffer degradation due to elevated temperature-processing operations such as baking. The main intention is to bring health benefits to consumers. Biscuits samples with different percentages of oat whole flour were elaborated.

Materials and Methods

The method and procedure to be adopted to conduct the present study entitled "Preparation of cost effective, sensory and nutritionally evaluated mix grain flour with Oat biscuits and its nutritional impact on Adult women". Nutritional evaluation of biscuits includes protein, Iron and fiber. The sensory evaluation of biscuits obtained includes such traits as: taste and aroma, appearance and the structure of crumbs.

Area for this Research was KVK Lab. (Kasturbagram), Directorate of Soybean Research Khandwa Road, Indore.

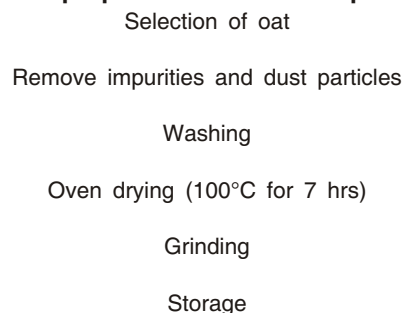
Size of the sample : 150

Age : 20-35 years adult women.

Control group : 50

Tools & Techniques : hedonic scale, proximate analysis of products, BMI.

Flow chart of preparation of Oat sample :



Ingredients for biscuits :

Amount of ingredients (in g) :

Ingredients	T ₁ (%)	T ₂ (%)	T ₃ (%)	T ₄ (%)
Oat flour	20	40	60	80
Sheat flour	80	60	40	20
Sugar ground	50	50	50	50
Hydrogenated fat	50	50	50	50
Coconut powder	10	10	10	10
Milk	25	25	25	25

Sensory evaluation :

The study was carried out for determination of the highest sensorially acceptable level of the added oat flour to biscuits. Blends were carried out using concentrations of 20% (T1), 40% (T2), 60%(T3), 80% (T4) oat flour and 80%, 60%, 40%, 20% (w/w) added wheat flour.

The panellists were from only female and from different ages, they were requested to taste each sample separately without comparing it with another sample. The samples were evaluated for desirability in appearance, colour, texture, taste, flavour and overall acceptability using a 9-point hedonic scale test.

Water was used to neutralize the taste between samples testing.

Nutritional evaluation of biscuits includes protein, Iron and Calcium. It is a good source of Iron and quality protein with good amino acid balance.

Nutritional and health impact of oat biscuits was done on parameters like Height, Weight, Body mass index (BMI) had been calculated (weight in kg/ height² in meter).

Results and Discussion

The study deals with chemical analysis of prepared Oat flour and sensory evaluation of recipes as biscuits fortified with oat flours. Therefore the results are presented and discussed under the following heads :

Nutritional evaluation :

Table-1 : ANOVA Nutritional Analysis (Generalised Linear Model).

	N	Mean	Std. Deviation	Std. Error
Moisture	5	9.8600	10.48402	4.68860
Ash	5	10.0960	10.48972	4.69115
Protein	5	10.4180	10.65652	4.76574
Iron	5	10.6700	10.64370	4.76001
Calcium	5	10.1310	10.36410	4.77591
Total	20	11.3610	9.70376	2.16983

Moisture, Ash, Protein, Iron and Calcium are the factors for Nutritional Analysis of four varieties of biscuits in T₁, T₂, T₃ and T₄. Lower mean is observed in Moisture and higher in Iron. Moisture and Ash and Iron has similar Homogeneity of Variance then Moisture, Protein and Calcium is having higher difference of variance then other factors.

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Importance of Millets for Nutrition and Health

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Abstract

Millets are drought-resistant and able to survive a variety of environmental conditions. Millets crops comprising of Finger millet, Foxtail millet, Brown top millet Barnyard millet, Little millet, Proso millet, jowar, bajra and Kodo millet. They are considered as nutri- cereals. Small-seeded grains rich in proteins, minerals, and bioactive compounds, these grains have several health benefits as well as protection against chronic and degenerative conditions caused by modern living. The crops are grown in a variety of agro-ecological situations including plains, coast and hills as well as in diverse soils and varying rainfall. They are known for resilience and drought enduring capacity and are relatively less prone to major pests and diseases. The richness in calcium, dietary fiber, polyphenol and protein contents in millets make them unique among the cereals. Millets have nutraceutical properties in the form of antioxidants which prevent deterioration of human health such as lowering blood pressure, risk of heart disease, prevention of cancer and cardiovascular diseases, diabetes, chronic inflammatory disorders like type 2 diabetes, neurodegenerative diseases decreasing tumor cases etc. a burden on both developing and developed nations equally The contribution of millets to national food security and their potential health benefits, millet grain is now receiving increasing interest from food scientists, technologists and nutritionists. The coarse nature of millets makes them unpopular and underutilized in developed countries, despite their benefits and agro-economic potential. The present article research investigations about nutritional composition of millets.

Introduction

Millets are known as one of the most important cereal grains. Millets are consumed by more than 1/3rd of the world's population. It is the 6th cereal crop in terms of world's agricultural production. Millets are Jowar (Sorghum), Sama (Little millet), Ragi (Finger millet), Korra (Foxtail millet) and Variga (Proso millet). Bajra and Sama are high in fat while Ragi has the lowest fat. Millets are used as food and are widely used in rural areas. They have been cultivated for a thousand years and are used throughout the world, in the Middle ages the Romans and Gauls were consuming porridges made of millets eaten than wheat. A majority of the world's commercial millet crop is produced by China, India, Greece, Egypt and Africa. But even in rural areas some millets are used for consuming like Finger millet, Sorghum, etc and the remaining are used as animal feed. Millet are having amazing values in their nutrition content. Millets play a significant role in traditional diets in many regions. In many states of India they are using different varieties of millets respectively. All the millets are three to five times higher in their nutrition content when compared to nutritional content of widely used rice and wheat. Millets are having nutritional and also health benefits and they also help in managing health problems like diabetes mellitus, hyperlipidemia, etc. (Veena, 2003). Millets like foxtail millet are pest free and act as anti-pest agents in storage conditions for pulses like green gram. The millets do not need any fumigants. Millets have relatively a lower

position in India, among feed crops in agriculture, but they are very important from food security point at regional and farm level.

Millets on Nutritional and Health Benefits (Millet Network of India, MINI) Considering the nutritional parameters, millets are way ahead of wheat and rice. In terms of mineral content, millets have more fibre when compared to rice and wheat. Each one of the millets has more fibre than rice and wheat. Some millets have more than fifty times of fibre than of rice. Finger millet is having thirty times more Calcium than rice while all other millets have at least double amount of Calcium compared to rice (Amir Gull, et al, 2014). In their Iron content, The bran has important antioxidants and other minerals and vitamins like iron, zinc, copper, magnesium. Vitamin B such as Niacin, folacin, riboflavin, and thiamine and phosphorus are present in millets that play a key role in energy synthesis in the body. Types of Millets Sorghum Sorghum is one of the ancient cereal grain and it is a staple crop in India. Sorghum grain is completely gluten-free, and provides health benefits that make it a good addition to any diet.

Gluten, is a protein which is present commonly in grains like wheat, barley and rye that gives them the chewy, springy quality when baked into breads or pastas. Sorghum used as Wheat replacement for Breads, Pastas, etc. It is also showed that Sorghum or jowar helps in weight loss. Compared to major cereals like rice and wheat, jowar has a high proportion of calcium. It is also

packed with iron, protein and fiber. Researchers have found that a typical sorghum wax is rich in policosanols which helps in reducing the levels of cholesterol. Being a gluten-free grain, it is also much preferred by those who can't tolerate wheat-based products. (O.S.K. Reddy, 2017).

Types of Millets

1. Pearl millet : Pearl millet consists of magnesium which helps in reducing the respiratory problems in asthma patients and helps to reduce the effect of migraine. The fibre content of pearl millet helps the reduction of gall stone occurrence. The insoluble fibre present in pearl millet help in reduction of excessive bile in our system, as excessive bile in our system leads to gall stones (Shweta, 2015).

2. Little Millet : Little millet is highly nutrition and may be called little but it not less in its nutritional content. It has good source of Bvitamin, minerals like calcium, iron, zinc, potassium among others. It also provides essential fats to the body, the kind that helps in weight loss. Its high fiber content is yet another positive making it an ideal part of pongal or even kheer instead of rice. (O.S.K.Reddy, 2017).

3. Finger Millet : Finger Millet ia one among the most nutritious cereals and is a good source of natural calcium which helps for bone strengthening and helps in reducing the risk of bone fractures. It is also a good source of natural iron helping in Anaemia. Finger millet helps in different disease condition like blood pressure, heart problems, asthma and is very good food for diabetes where it helps in slow digestion and slow release of glucose in blood. Finger millet helps to increase the hemoglobin level and helps to fight malnutrition and degenerative diseases (O.S.K.Reddy, 2017).

4. Kodo millet : Kodo millet are traditional food which closely resembles the rice and helps to use in weight loss. It is easily digestible and is rich in phytochemicals and antioxidants which helps in preventing different lifestyle related diseases. Kodo millet also helps in reducing the joints and knee pain and helps in regularizing the menstruation in woman (Deshpande et al., 2015).

5. Foxtail millet : Foxtail millet helps in steady release of glucose without affecting the metabolism of the body. When people consume foxtail millet, the prevalence of diabetes is reduced and it is also known as healthy heart food due to its good source of magnesium (O.S.K. Reddy, 2017).

6. Little Millet : Little millet is highly nutrition and may be called little but it not less in its nutritional content. It has good source of Bvitamin, minerals like calcium, iron, zinc,

potassium among others. It also provides essential fats to the body, the kind that helps in weight loss. Its high fiber content is yet another positive making it an ideal part of pongal or even kheer instead of rice. (O.S.K.Reddy, 2017)

7. Proso millet : Proso millet is beneficial in preventing Pellagra condition, which is caused due to the niacin Vitamin B3. Proso millet has high content of Niacin. Pellagra is a skin disease which causes the skin to become dry, scaly and rough. Proso millet consists of protein and niacin (Vitamin B3). Traditionally it is used as recuperative food, especially post pregnancy or illness (Jana Kalinova, 2007).

8. Foxtail millet : Foxtail millet helps in steady release of glucose without affecting the metabolism of the body. When people consume foxtail millet, the prevalence of diabetes is reduced and it is also known as healthy heart food due to its good source of magnesium (O.S.K. Reddy, 2017).

Nutritional Importance of Millets

Millets have myriad of health benefits and due to high levels of insoluble dietary fibre, phytates, phytochemicals catechins, flavonoids etc., They are rich source of minerals like copper and iron. It is rich in vitamins and minerals such as copper and magnesium. Proso millet also improved glycemic responses and plasma levels (Park et al., 2008). In addition, proso millet protein concentrate has protective effects against D-galactosamin-induced liver injury in rats (Ito et al., 2008). Choi et al. (2005) and Park et al. (2008) concluded that proso millet protein could be a potential therapeutic intervention in type-2 diabetes. Devi et al. (2011) review the nature of polyphenols and dietary fiber of finger millet and their role with respect to the health benefits associated with millet. The composition of free and bound lipids in proso millet flours and brans were analysed and found that, in the free lipids, hydrocarbons, sterol esters, triacylglycerols, diacylglycerols, and free fatty acids were present. Proso millet is rich source of B vitamins, especially vitamin-B6 and folic acid.

Health Benefits of Millets

Millets are highly nutritious and renders various health benefits. The nutritional facts of small millet are listed below. Helps control Blood sugar levels when consumed on regular basis. It showed lowered triglyceride levels, LDL/VLDL Cholesterol and increase in HDL Cholesterol. It is known for its Low Glycemic index- gradual increase in blood sugar after food intake when compared to rice. Ideal food for people suffering from Diabetes & Gastric problems. Reduces risk of Heart Attack. Helps in the development of Body Tissue & Energy Metabolism. Rich in Anti-oxidants.

Table-1 : Nutrient value of millets, Nutritive value of Indian Foods, Gopalan.

Crop / nutrient	Protein (g)	Fiber (g)	Minerals (g)	Iron (mg)	Calcium (mg)
Sorghum	11	6.7	2.7	3.4	13
Finger millet	7.3	3.6	2.7	3.9	344
Foxtail millet	12.3	8	3.3	2.8	31
Kodo millet	8.3	9	2.6	0.5	27
Little millet	7.7	7.6	1.5	9.3	17
Pearl millet	10.6	1.3	2.3	16.9	38
Proso millet	12.5	2.2	1.9	0.8	14
Barnyard millet	11.2	10.1	4.4	15.2	11

Discussion

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 aminoacids, fattyacids and dietary fibre.

1. Magnesium present in millets helps in relaxes muscles of arterial wall, reducing blood pressure. Also helps in reducing the severity of asthma and frequency of migraines.

8. Millets being gluten free are the perfect food for people who suffer from celiac disease as they cannot digest and tolerate gluten.

2. When millets are consumed in large quantities, they help in reducing the triglyceride in the body thereby preventing the blood platelet clumping and also reduces coronary artery diseases.

3. Millets contain vitamins like vitamin-B which helps in easy breakdown of carbohydrate and fats. They help in reducing the homocystine level in blood preventing the bonding of cholesterol and forming deposits. Niacin help in increasing the HDL by preventing cholesterol from blood stream. They protect the blood vessels from blood hemorrhage and atherosclerosis.

4. Millets help in reducing the risk of colon cancer, as they contain both fibres and phytonutrients. Lignans which is present in millets helps from breast cancer as it is converted into mammalian lignan. 5. Millets has tryptophan which is an aminoacid 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.

6. The protein structure present in millets is similar to wheat but the only difference is that millets are no gluten grains. Due to the excellent protein source, the millets are mostly utilized by vegans or vegeterians. Millets have excellent plant protein which is better than animal protein and has no saturated fats.

7. For the proper functioning of the body, it requires many healthy nutrients and millets have many healthy nutrients. The contain minerals like iron and copper, which are required for the production of the blood cells and for improving blood oxygenation. They also contains phosphorus which help in controlling blood pressure. Thereby help in defence activity of the body against diseases.

Millets with important health benefits :

Reduces the risk of heart diseases, millets help from diabetes, improves the digestive system, helps in respiratory health, helps in fighting cancer, helps in several degenerative diseases like metabolic syndrome, improves the neurological and muscular systems, improves respiratory health etc (Manach et al., 2005). The nutrients which are present in millets are resistant starch, lipids, oligosaccharides, antioxidants such as phenolic acids, flavonoids, lignans and phytosterols which are responsible for number of health benefits (Edge *et al.*, 2005).

Sorghum is rich in dietary fibre, chemical characteristics and has unique physical characteristics which help in adding bulk to the diet, viscosity, water holding and absorption capacity, which determine the subsequent physiological behaviour. It also helps in the hunger satisfaction and helps in satiety and thereby reducing the risk of development of obesity. Its Gluten free properties help in Celiac Disease. (Dayakar Rao., *et al*, (2013)

Finger millet helps in losing weight, Ragi is having an amino acid called Tryptophan which helps in lowering of appetite and helps in weight control. Finger millet is digested at a slower rate which helps in keeping away the intake of excessive calories. And, fibres of finger millet gives fullness feeling thus controlling the excessive food consumption (ICAR - Indian Institute of Millets Research, 2017 (IIMR) Pearl millet aids in weight loss by reducing the satiety. Pearl millet with its high fibre content and

longer grains helps in slow movement of food from stomach to the intestine. Thus helps in longer duration of food intervals and helps in weight reduction. Thus millets have great potential in helping to fight Obesity. Consuming millets helps in fighting Obesity and therefore helps in fighting metabolic disorders. Millets are indeed the miracle grains, which are available at a lower cost but giving higher nutritional benefit

Magnesium in millets can help reduce the affects of migraines and heart attacks. Niacin (vitamins B3 & B6) in millets can help lower the cholesterol, Phosphorus in millets help with fat metabolism, body tissue repair and creating energy (phosphorus is an essential component of adenosine triphosphate or ATP, a precursor to energy in your body), Millet can help lower risk of type 2 diabetes, Fiber from whole grains has been shown to protect against breast cancer and whole grains have been shown to protect against childhood asthma.

Conclusions

Present scenario whole world is facing many health challenges because of fiber-less foods. Millets have multiple health benefits to include these ancient prized grains-like seed in our regular diet. Most of the civilized people have not even heard about millets and much less understand the benefits of millet nutrition. And yet, millet is one of the best-kept secrets of our ancient ancestors. Traced back to its origin in China, millets have been used throughout the ages and across many countries The aim of this study is to help the people to recognize the importance of food and to introduce the millets as a nutritious food, fulfilling the nutritional need of global population and to find ways to consume the millets nutritionally, effectively and to reduce the problems of malnutrition and other health problems. All the millet foods are having significant health Kimeera Ambati and Sucharitha KV., Millets-Review on Nutritional And Health Benefits, with their rich content of nutrients like fibre which helps in metabolic disorders like Cardiovascular diseases, Diabetes, Obesity, etc, their good protein content which helps in child growth and development, with calcium content which helps in the bone development in both children and geriatric people, with good iron content helps in ailing of anaemia and with gluten free characteristics helps the celiac disease patients and helps in gluten insensitivity. Phytosterols and policosanols are cardio-protective compounds present in the waxy layers of the millet. If these millets are ground into flour without de-hulling, then one can have multiple benefits. Millets have antioxidants, which are substances that may protect your cells against the effects of free radicals.

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Comparison of Soil Fertility Status of Pre and Post Flood Soils of South Central Laterites of Kerala and Mapping using GIS

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Abstract

A study was conducted to determine the changes in the fertility status of soils after 2018 flood in south central laterites, agro ecological unit (AEU) 9 in Alappuzha district of Kerala and maps were generated using GIS. A survey was conducted in the flood affected areas of Mulakkuzha, Ala, Cheriyanad, Venmony panchayats and Chengannur municipality and geo referenced soil samples were collected. The samples were analysed for soil texture, pH, organic carbon, available N, P, K, Ca, Mg, S and micronutrients and GIS based thematic maps were prepared. The results of the study revealed an increase in percent of soils with extremely acid pH from 0 to 20% due to flooding. Soil pH was extremely acidic in the areas of Cheriyanad, Ala, Venmony and Mulakkuzha panchayats. Organic carbon status increased after the floods from 18 to 38.7% and from 47 to 61.3% in the high and medium categories respectively. Percent of soils with medium level of available P, high level of available K, deficient levels of available Ca, Mg and B was higher after the flood whereas soils adequate in available sulphur and high levels of available P declined. The results outline the need for regular liming to control soil acidity and to alleviate Ca deficiency. The soils should be supplemented with Mg and B in addition to recommended dose of N, P and K fertilizers.

Key words : Soil fertility, post flood soils, south central laterites, GIS mapping

Introduction

Soil is the most important natural resource which is capable of supporting plant life and productivity of any region. The south central laterites (AEU 9) in Alappuzha district of Kerala covers the eastern part of Chengannur block including Mulakkuzha, Ala, Cheriyanad, Venmoney Panchayaths and Chengannur municipality was worst affected by the 2018 flood. The rise in water level in Pamba and Manimala rivers that traverses the northern part of AEU 9 of Alappuzha district resulted in the floods which created damage to this region. Soil of this region is poor in N, P, K and low in bases. These soils are very strongly acid to slightly acid with overall pH ranging from 4.5 to 6.5 which requires liming. Available nitrogen, phosphorous and potassium are medium, calcium is adequate and magnesium, sulphur are deficient. These soils are also deficient in boron with content less than 0.5 mg kg⁻¹. The poor status of these nutrients is due to the texture and heavy leaching of soils by rain. The organic carbon content is medium indicating medium level of plant available nitrogen [1]. The devastating flood caused severe damage to the soil environment and agriculture. Soil fertility and productivity have been disturbed, which needs site specific investigation on soil fertility parameters. Location specific management practices should also be recommended and plant nutrition packages should be revised. A detailed study on soil fertility of post-flood soils will help in formulating

sustainable crop management strategies in the flood affected areas.

Materials and Methods

The AEU 9 in Alappuzha district lies between 9°23'38.28" and 9°33'63.71" N latitude, 76°57'88.39" and 76°65'02.00" E longitude spread over the eastern part of Chengannur block which includes Mulakkuzha, Ala, Cheriyanad and Venmony Panchayaths and Chengannur municipality. All these panchayats selected for the present study were severely affected by flood havoc and submergence that occurred during August 2018.

The south central laterites (AEU 9) represents midland laterite terrain with typical laterite soils and short dry period. The climate is tropical humid monsoon type with mean annual temperature 26.5°C and rainfall 2827 mm. The soils are strongly acid, lateritic clay, gravelly and often underlined by plinthite. The lowlands are strongly acidic, low activity, non-gravelly clay soils with impeded drainage conditions [2]. Major crops includes coconut, banana, tapioca, betelvine, rubber, pepper arecanut, paddy and vegetables [3].

Representative geo referenced surface soil samples (0-20 cm) were collected from seventy five sites from flood affected area. The soil samples were shade dried, powdered with wooden pestle and mortar, sieved through a 2mm sieve and stored prior to analysis. With the help of

GPS, geographical coordinates of each sample site was recorded and location map depicted in Fig.-1.

Soil samples were analyzed for soil texture by Bouyoucos hydrometer method, pH (soil - water ratio of 1:2.5) using pH meter, organic carbon by wet oxidation method, available nitrogen by alkaline permanganate method, available phosphorus by colorimetric method, available potassium by neutral normal ammonium acetate extraction followed by flame photometry method, available calcium and magnesium by versenate titration method, available boron by azomethane H reagent method, available sulphur by CaCl_2 extraction and estimation using spectrophotometer and micronutrients (Fe, Mn, Zn, Cu) by extracting with 0.1 N HCl and using atomic absorption spectroscopy. GIS based thematic maps were prepared using ArcGIS 10.5.1 software following Inverse Distance Weighting method (IDW).

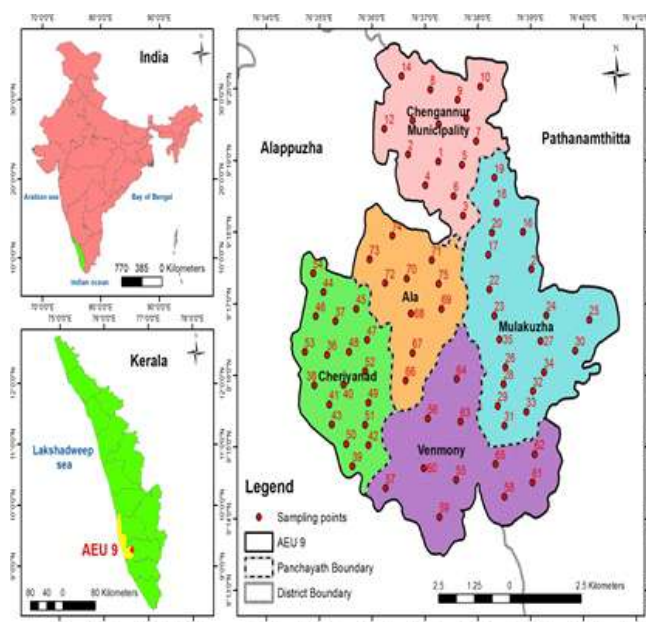


Fig.-1 : Location map of sampling sites in south central laterites (AEU 9) of Alappuzha district.

Results and Discussion

Soil texture : Sandy loam was the predominant textural class observed in 58.6% of soils in AEU 9 of Alappuzha district, followed by silty clay and sandy clay in 13.3% of soils. Clay content varied between 5.62 and 80.20 percent, silt between 11.10 and 57.80 percent and sand between 9.91 and 79.90 percent.

In post-flood soils a slight shift from sandy clay to sandy loam texture was noticed in majority of surface soil which can be attributed to the sediment deposition of sand and silt due to flood. The spatial distribution of soil texture is shown in Fig.-2.

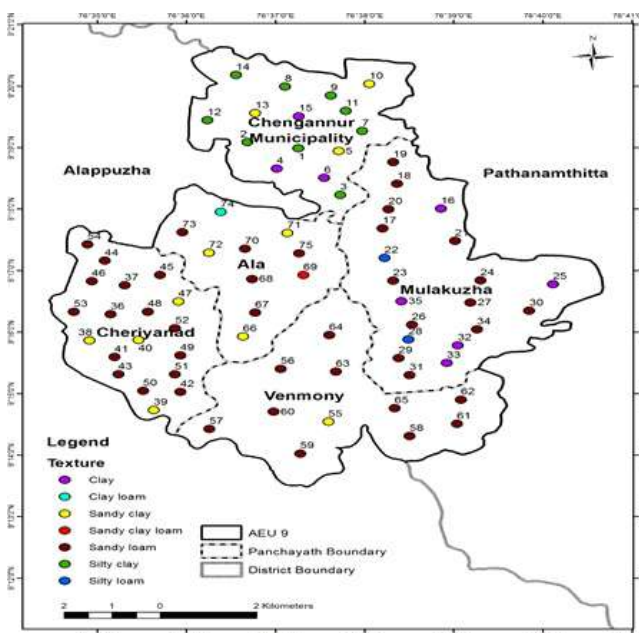


Fig-2 : Spatial distribution of textural classes in the post-flood soils of south central laterites (AEU 9) of Alappuzha district.

Soil pH : The soil pH varied from 4.10 to 6.90 with a mean value of 5.02. [4] indicated that the soils of Kerala were mostly laterites and basically acidic in reaction. Majority of soils (90.3%) were in the extremely acidic to strongly acidic category (Fig.3). Leaching of basic cations from the soil might have led to increased acidity. Soil acidity was observed to be lower in areas with sediment deposits where concentrations of basic cations like K and Ca were observed to be higher. An increase in percent of soils with extreme acid pH in post flood soils (20%) compared to pre-flood indicating leaching of basic cation from soils. This is also evident from the deficient levels of calcium (63.9%) and magnesium (100%) observed in these soils. Similar results were reported by [5].

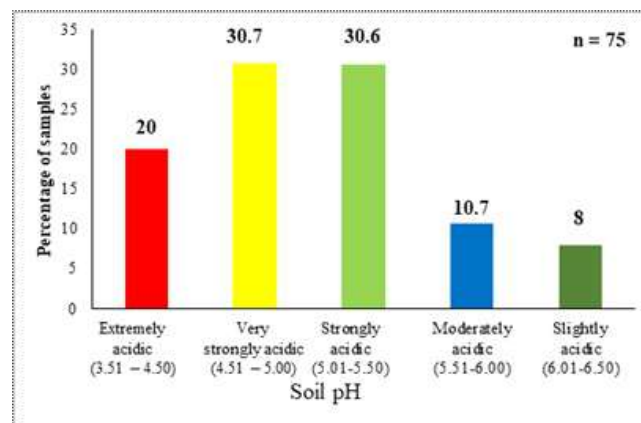


Fig-3 : Frequency distribution of soil pH in the post-flood soils of south central laterites (AEU 9) of Alappuzha district

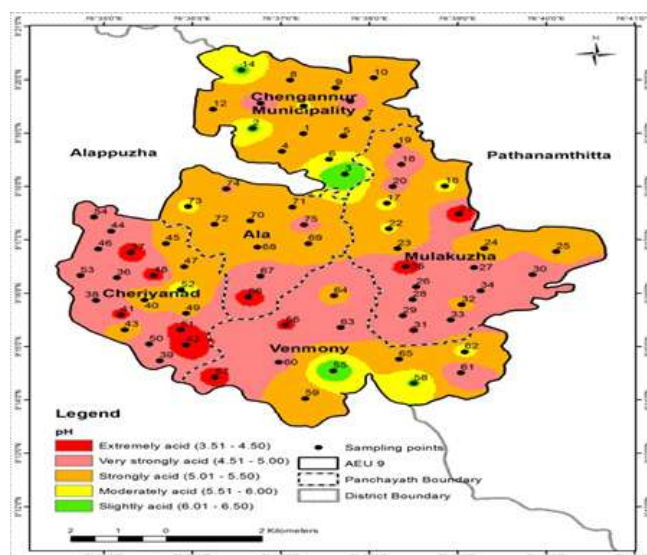


Fig-4 : Spatial distribution of soil pH in the post flood soils of south central laterites (AEU 9) of Alappuzha district.

Organic carbon : Organic carbon content ranged between 0.51 and 2.62% with a mean value of 1.42%. Majority (61.3%) of the post flood soils are having medium organic carbon status followed by 38.7% soils with high status. An increase in organic carbon content was observed due to flooding with high organic carbon status in 18% samples in pre-flood soils compared to 38.7% in post flood soils. Similarly percent of soils with medium organic carbon status increased from 47% in pre-flood to 61.3% in post-flood soils. This can be attributed to the deposition of sediments rich in organic matter under the inflow of flood water and is in compliance with the findings of [6].

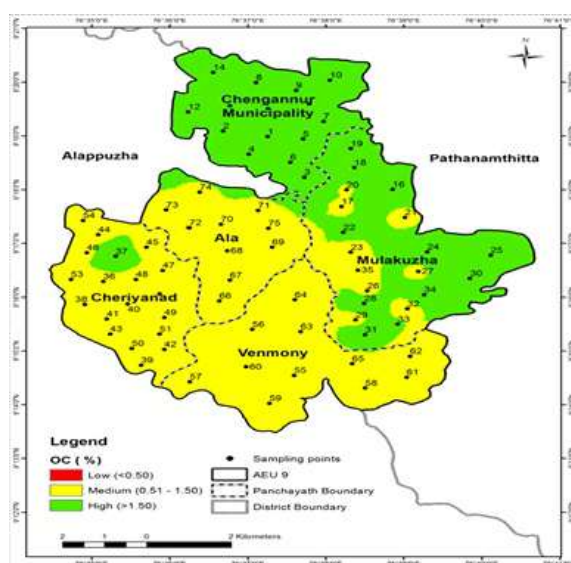


Fig-5 : Spatial distribution of organic carbon in the post flood soils of south central laterites (AEU 9) of Alappuzha district.

Available nutrient status of soil

Available nitrogen : The highest available nitrogen status of 233 kg ha^{-1} was recorded in Mulakuzha followed by Ala (219 kg ha^{-1}) and the lowest in Chengannur (156 kg ha^{-1}). Available nitrogen was low in 89.3% of the post flood soils and only 10.7% were in the medium range. Available nitrogen was found to be medium in some areas of Mulakuzha, Ala and Cheriyanad panchayats and low in other areas. The low availability of nitrogen in soil might also be due to leaching of nitrate nitrogen present in soil in the study area which received high amount of rainfall and also under the anaerobic conditions nitrogen loss would have occurred due to nitrate reduction and denitrification [7]. Slow decomposition rate of organic matter also added to the decreased nitrogen availability. Increasing soil acidity obstructs mineralization of organic matter and decreased the availability of nitrogen in soil under submerged condition .

Available phosphorus : The available phosphorous content of soil was found to be medium in 60% of the soils, high in 26.7% and low in 13.3% soils. The highest available phosphorus of 19.2 kg ha^{-1} was obtained in Mulakuzha which was followed by Chengannur (16.2 kg ha^{-1}). The lowest phosphorus availability of 10.2 kg ha^{-1} was observed in Venmony. The phosphorus availability is highly dependent on soil pH and P availability will be maximum at a pH of 6.5. It is evident from increase in soil acidity after the flood in 20% soils. Clay and organic matter deposition in the soils may have also contributed to phosphate sorption and reduction in phosphorous availability. This agree with the findings of [8] who reported that flood induced P deficiency in soil is caused by high P sorptivity.

Available potassium : The availability of potassium in soil was found to be highest in Mulakuzha (299 kg ha^{-1}), followed by Cheriyanad (280 kg ha^{-1}) and the lowest in Chengannur (177 kg ha^{-1}). Majority (53.1%) of the soils were medium in available K, 44.6% were high and 2.3% low. Available K status in soil increased in post-flood soils compared to pre-flood. Clay deposition after the flood might have contributed to this increase in the potassium status. Low activity clays such as kaolinite and iron and aluminium oxides and hydroxides are predominant in laterite soils. These tropical soils can store K even without a large content of high activity clays and avoid leaching losses [9].

Available Calcium : The highest available Ca was recorded in Chengannur (327 mg kg^{-1}) followed by Mulakuzha (259 mg kg^{-1}) and the lowest in Cheriyanad (189 mg kg^{-1}). Available Ca was deficient in 63.9% of post-flood soils and adequate in 36.1% but in pre flood

Table-1. Available nitrogen, phosphorus and potassium in the post-flood soils of south central laterites (AEU 9) of Alappuzha district.

Panchayat/ Municipality	Available nitrogen (kg ha ⁻¹)		Available phosphorus (kg ha ⁻¹)		Available potassium (kg ha ⁻¹)	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Chengannur	100-263	156 ± 44.4	9.32-44.6	16.2 ± 9.22	100 – 246	177 ± 40.6
Mulakuzha	100-627	233 ± 116	8.32-47.8	19.2 ± 11.9	112 – 492	299 ± 115
Cheriyanaad	112-526	183 ± 89.7	9.21-29.8	13.1 ± 6.31	123 – 460	280 ± 105
Venmony	138-238	189 ± 31.9	9.13-14.7	10.2 ± 1.72	112 – 380	219 ± 82
Ala	163-363	219 ± 69.3	9.02-28.0	12.3 ± 5.85	123 – 436	254 ± 101
AEU 9	100-627	197 ± 85.8	8.32-47.8	14.8 ± 8.78	100 – 492	252 ± 103

Table-2 : Available calcium, magnesium, sulphur and boron in the post-flood soils of south central laterites (AEU 9) of Alappuzha district.

Panchayat/ Municipality	Available calcium (mg kg ⁻¹)	Available magnesium (mg kg ⁻¹)	Available sulphur (mg kg ⁻¹)	Available boron (mg kg ⁻¹)
Chengannur	327 ± 130	64.5 ± 18.7	5.71 ± 1.82	0.31 ± 0.22
Mulakuzha	259 ± 95.7	69.4 ± 15.7	11.4 ± 3.94	0.12 ± 0.07
Cheriyanaad	189 ± 73.2	71.0 ± 22.3	10.5 ± 6.64	0.11 ± 0.10
Venmony	189 ± 77.8	129 ± 49.9	17.9 ± 8.37	0.20 ± 0.10
Ala	221 ± 99.0	59.7 ± 15.5	10.2 ± 7.64	0.13 ± 0.10
AEU 9	239 ± 107	76.4 ± 33.5	10.8 ± 6.65	0.10 ± 0.14

soils 25% were deficient and 75% adequate in calcium . Decrease in calcium content after flood was due to the leaching of basic cations in flood water as reported by [10].

Available Magnesium : Available Mg in soil was the highest in Venmony (129 mg kg⁻¹) followed by Cheriyanaad (71 mg kg⁻¹) and the lowest in Ala (59.7 mg kg⁻¹). Available magnesium was found to be deficient in 100% of the post flood soils whereas it was sufficient in 95% of the pre-flood soils. Magnesium being a weak competitor of exchange sites with aluminium and calcium, appears to accumulate in soil solution and is subject to leaching loss in acid soils [11] which might be the reason for lower magnesium levels in soils despite the high calcium content observed in the same areas [12].

Available Sulphur : The highest and lowest value for available Sulphur in soil were observed in Venmony (17.91 mg kg⁻¹) and Chengannur (5.71mg kg⁻¹) respectively. Available sulphur was found to be adequate in 93.3% soils . The higher levels of available sulphur might be due to the accumulation of organic matter and sediments in these soils as reported by [6].

Available boron : Chengannur recorded the highest available boron of 0.31 mg kg⁻¹ followed by Venmony (0.20 mg kg⁻¹). Cheriyanaad recorded the lowest available boron of 0.11 mgkg⁻¹ . Available B was deficient in all the soils of AEU 9 before and after the flood . This can be attributed to the higher mobility of boron in soils and also leaching losses which led to B deficiency in these soils. High intensity rainfall will lead to loss of soluble forms of boron by leaching [13].

Conclusions

From the study it is concluded that soil condition and nutrient status were slightly altered in the soils of AEU 9 in Alappuzha district after the 2018 flood. Soil acidity increased due to the leaching of basic cations and erosion by flowing flood water. This is evident from the deficient levels of calcium and magnesium observed after the flood. Organic carbon status, available K and S were increased and available P slightly decreased after the floods in the areas with sediment deposits. The results outline the need for regular liming to control soil acidity and to alleviate Ca deficiency. The soils should be supplemented with Mg and B in addition to recommended dose of N, P and K fertilizers.

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Status of Sulphur in Alluvial Soils of District Bulandshahr

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Sulphur is one of the essential nutrients that is required for the adequate growth and development of plants. Sulphur is a structural component of protein disulfide bonds, amino acid, vitamins and cofactors. Most of the sulphur in soil is present in organic matter and hence not accessible to the plants. Anionic form of sulphur is the primary source of sulphur for plants that are generally present in minimal amount in the soil. Soil fertility assessment of an area or a region is an important aspect in view of sustainable agricultural production (Rajendiran *et. al.* 2018). In recent years, adoption of high yielding varieties and use of high analysis nitrogen fertilizers led to decline in the status of sulphur in soils to below normal at which productivity of crops cannot be sustained. Inventory of available Sulphur status of the soil helps in demarcating areas where application of a particular nutrient is needed for profitable crop production (Raj kumar *et. al.* 2016). Since, no systematic information is yet available on the status of sulphur in soils of district Bulandshahr. Therefore, the present study was initiated to assess the sulphur status of soils and to relate its content with some important physico-chemical properties of soils of Bulandshahr. One hundred surface soil samples (0-15 cm depth) were collected covering all selected location of the district Bulandshahr during November and December 2021. These soil samples were analysed for their physico-chemical properties (pH, EC, organic carbon, sand, silt, clay and textural classes) by adopting standard procedure (Jackson, 1973). The Total and available sulphur were extracted with perchloric acid and 0.15% calcium chloride solution, respectively. The amount of sulphur in these extracts was determined turbidimetrically (Chesnin and Yien, 1951).

Table-1 : Physico-chemical properties and status of sulphur in soils of Bulandshahr district.

Soil characteristics	Range	Mean
pH	7.0-9.0	-
EC (dsm ⁻¹)	0.14-0.42	0.24
Organic carbon (g kg ⁻¹)	2.3-5.6	3.40
Sand (%)	12.0-51.0	40.1
Silt (%)	25.0-61.0	39.7
Clay (%)	21.0-31.0	24.9
Total sulphur (mg kg ⁻¹)	78.0-146.0	116.0
Available sulphur (mg kg ⁻¹)	7.0-18.0	13.0

Significant at 5% level, Significant 1% level

The soils of Bulandshahr district are alkaline in reaction (pH 7.0-9.0). The EC, organic carbon, sand silt, clay and textural classes of these soil varied from 0.14-0.42 dsm⁻¹, 2.3-5.6 g kg⁻¹, 12.0-51.0 %, 25.0-61.0 %, 21.0-31.0 % and sandy clay loam to sandy loam respectively. The total sulphur in soils of district Bulandshahr ranged from 78.0 to 146.0 mg kg⁻¹ with a mean value of 116.0 mg kg⁻¹. These results are fairly comparable to those reported by Singh (2015), Singh and Yadav (2017) and Singh *et. al.* (2020). Such variations might have been due to difference in local factors in relation to soil genesis, soil climate conditions including light texture and cropping system. On the whole, the low values of total sulphur in these soils may be ascribed to low organic carbon content and coarse texture of the soils. The total sulphur had significant and negative relationship with EC and organic carbon (Singh 2015). The available sulphur content in the soils ranged from 7.0 to 18.0 mg kg⁻¹ with a mean value of 13.0 mg kg⁻¹ (Table 1). Similar results were reported by Singh (2017), Singh (2018) and Singh *et.al.* (2020). The available sulphur deficiency was observed in soils of Bulandshahr district. The sulphur deficiency was found to the extent of 47.0 %.

Table-2 : Coefficient of correlation ('r' value) between selected physico-chemical properties and status of sulphur.

Soil characteristics	Total-Sulphur	Available-Sulphur
pH	+0.11	-0.13
EC (dsm ⁻¹)	-0.25	+0.46**
Organic carbon (g kg ⁻¹)	-0.40	+0.32*

The sulphur deficiency might be due to intensive cropping, limited use of organic manure and no use of sulphur containing fertilizer by the farmers. Similar results were reported by Singh *et. al.* (2020) in Agra soils, Dixit (2014) in Lalitpur soils and Singh (2017) in Allahabad soils. Available sulphur was found to have significant and positive relationship with EC and organic carbon as reported by Dixit (2014) and Singh (2015). In soils of Bulandshahr, available S constituted, on an average, of 13.0 per cent of total sulphur. Similar results were reported by Singh (2015). Available Sulphur had significant and positive relationship with total sulphur ($r=0.32^*$). Similar relationship was observed by Singh (2015), Singh (2018) and Singh *et. al.* (2020).

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Response of Different Spacing's and Varieties on Growth and Bulb Characters of Onion (*Allium cepa* L.)

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Abstract

A Field experiment was conducted during Rabi season of 2019-2020 at the field of Horticulture Research Farm, Babasaheb Bhimrao Ambedkar University, Lucknow. The treatments comprised of three varieties i.e. V₁ (Agrifound Light Red), V₂ (NHRDF-Red), V₃ (NHRDF-2) and three planting spacing S₁ (20 × 7.5cm), S₂ (20 × 10cm) and S₃ (20 × 15 cm) thus forming nine treatment combinations. These treatment combinations were laid out in a factorial randomized block design. The growth characters (Plant height, Number of leaves /plants, Neck thickness) and Bulb characters (Bulb diameter, Bulb weight, No. of scales, Bulb length). Maximum plant height was recorded in variety V₂ (NHRDF-Red) with plant spacing S₃ (20 × 15 cm) and maximum no. of leaves recorded V₃ (NHRDF-2) and spacing S₃ (20 × 15 cm). Maximum neck thickness recorded in variety V₁ (Agrifound Light Red) and spacing S₃ (20 × 15 cm). Bulb diameter (cm) has been noted maximum in variety V₂ (NHRDF-Red) and spacing S₂ (20 × 10cm). Highest bulb weight was noted in variety V₃ (NHRDF-2) and plant spacing S₃ (20 × 15 cm). Highest number of scales noted in variety V₃ (NHRDF-2) and in plant spacing S₃ (20 × 15cm). The length of bulb which was indicated maximum in variety V₂ (NHRDF-Red) and with spacing highest in S₂ (20 × 10cm).

Key words : Onion, growth, bulb character, spacing and varieties

Introduction

Onion (*Allium cepa* L., 2n=16) is very essential vegetable crop of Rabi season which belongs to Alliaceae family. Its genus is *Allium* and species *cepa*. Onion is regarded as queen of the kitchen (Selvaraj, 1976). This crop is native to Central Asia. Onion is grown throughout the entire world with some major producing countries like China, India, USA, Turkey, Pakistan, Iran, Japan, Spain and Brazil. In the world, India stands first in area (1293 Mha.) and ranks second in production (23610 M tons) after China. India exported fresh onion worth \$328 million and dried onions worth \$112.3 million in financial year 2020. Export of onion shot up 158% to Bangladesh in the April-July period of 2019-20 (ministry of commerce & industry, Government of India). The crop is very useful for human being because it has several nutritional and medicinal values. The important contents like allicin, allin, and sulphites etc. are present in onion. Onion has an anti-viral, anti-bacterial, anti-allergenic, anti-inflammatory property and due to the presence of flavonoids it reduces the chance of cancer and diabetes. The antifungal property of onion is due to presence of catechol a phenolic compound. Oil yield methyl and propyl compounds 0.02-0.03g/100g of bulb by steam distillation. Onion is used for treating problems including loss of appetite, upset stomach, and gall bladder disorder, for treating heart and blood vessel problems including chest pain (angina) and high blood pressure and for "preventing hardening of the arteries" atherosclerosis.

Mild flavour or colorful onion bulb i.e. Early Grano & Udaipur-101 is used for salad purpose and also used in processed form like flakes powder for making pickles, etc. (Bhachandani *et al.*, 1980). It also acts as a very good tonic to a nervous system and purifies blood. The beneficial compound called 'Quercetin' present in onion has shown to be powerful antioxidant. Its pungency is due to the presence of Allyl propyl disulphide, (C₆ H₁₂O₂) a volatile oil. The yield of vegetable crops can be increased by judicious use of manures and fertilizers with proper spacing, adequate water supply and cultural practices etc.

Materials and Methods

A field experiment was conducted during the Rabi season of October to April 2019-20 at Horticulture Research Farm, School of Agricultural Sciences and Technology Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar Rae Bareilly Road, Lucknow, (U.P.)-226025. The experimental field which was undertaken is geographically, situated at an elevation of 111 meter above mean sea level in the sub tropical climate of central Uttar Pradesh at 26°56' North Latitude 80°52' east longitude. According to agro-climatic conditions of Uttar Pradesh state, Lucknow falls under central plains region and receives on an average 1000 mm of Rainfall; the climate ranges from 22°C to 45°C in summer, minimum temperature ranging from 3.5°C -15°C in winter and relative humidity ranging from 60-80% in different season of the year. The soil of field was texturally

Table : Response of varieties and spacing on growth and bulb characters of onion.

Treatment	Plant height (cm)	Number of Leaves (cm)	Neck thickness (cm)	Bulb diameter (cm)	Number of scales	Bulb weight (g)	Bulb length (cm)
Effect of varieties (V)							
Agrifound Light Red (V ₁)	39.84	4.34	0.713	5.69	10.66	61.71	4.86
NHRDF-Red (V ₂)	43.69	4.27	0.506	6.97	10.1	58.41	5.29
NHRDF-2 (V ₃)	40.87	4.37	0.567	6.86	11.67	61.77	5.10
SEm±	0.338	0.024	0.032	0.312	0.231	0.638	0.275
CD(P=0.05)	1.023	0.073	0.097	0.993	0.699	1.929	0.831
Effect of spacing (S)							
20×7.5 (S ₁)	39.35	4.35	0.673	6.20	10.33	59.93	4.69
20×10 (S ₂)	39.70	4.27	0.578	7.14	10.22	60.10	5.72
20×15 (S ₃)	45.34	4.36	0.633	6.18	11.89	61.85	4.84
SEm±	0.338	0.024	0.032	0.312	0.231	0.638	0.275
CD(P=0.05)	1.023	0.073	0.097	0.993	0.699	1.929	0.831
Interaction effect (V×S)							
V ₁ S ₁	35.64	4.23	0.673	4.80	10.67	57.23	4.42
V ₁ S ₂	35.32	4.24	0.613	6.57	9.00	62.24	4.83
V ₁ S ₃	48.55	4.54	0.853	7.45	12.33	65.67	5.81
V ₂ S ₁	42.36	4.45	0.470	7.08	9.33	58.31	4.61
V ₂ S ₂	43.00	4.19	0.503	5.69	11.00	59.89	6.53
V ₂ S ₃	45.69	4.19	0.543	6.38	10.00	58.03	4.74
V ₃ S ₁	40.04	4.40	0.580	6.71	11.00	64.26	5.03
V ₃ S ₂	40.78	4.38	0.617	7.39	10.67	59.17	5.32
V ₃ S ₃	41.77	4.34	0.503	6.48	13.33	61.87	4.47
SEm±	0.586	0.42	0.055	0.540	0.401	1.105	0.476
CD(P=05)	1.771	1.561	0.162	1.593	1.211	3.341	1.4

classified as sandy clay loam and slightly alkaline in reaction. pH is ranging from about 7.5 to 8.5. The treatments comprised of three varieties (Agrifound Light Red, NHRDF-Red, NHRDF-2) and three planting spacing (20×7.5cm, 20×10cm and 20×15 cm) thus forming nine treatments combinations were laid out in a factorial randomized block design of practices. Observations recorded were growth characters; Plant height (cm), Number of leaves /plants, Neck thickness (cm) and Bulb characters; Bulb diameter (cm), Bulb weight (cm), No. of scales, Bulb length (cm). Statistical analysis of data obtained in different set of experiments was calculated following the standard procedure as stated by Panse and Sukhatme.

Results and Discussion

Effect on Growth characters : The growth parameter, were recorded periodically like plant height, number of leaves, neck thickness. Maximum plant height was recorded at 60 Days after planting in variety V₂ (NHRDF-Red). It has been found that plant spacing at 60 (Days after planting) in S₃ (20 × 15 cm) was recorded maximum height of plants. The combined effect of varieties and plant spacing clearly revealed that there was

significant effect on plant height. Among the interaction between varieties and spacing was recorded maximum plant height in V₁S₃ at 60 days after planting. The similar results were also reported by Mc-Geary (1985), Kumar *et al.* (1998) and Jilani *et al.* (2010). The number of leaves/plant was recorded at 60 days after planting. It has been recorded that the maximum number of leaves / plant was recorded in variety V₃ (NHRDF-2) and plant spacing S₃ (20 × 15cm) at 60 days after planting showed the maximum number of leaves /plant. The combination effect of the variety and plant spacing had significant effect on number of leaves /plant at all stage of plant growth. Among the interaction, the maximum number of leaves /plant has been recorded at 60 days after planting in the V₁S₃ followed by V₃S₃. This result is in conformity with the findings of Das, *et al.* (1972); Khan, *et al.* (2003); Jilani *et al.* (2010); Mc-Geary (1985); Kumar, *et al.* (1998); Singh, *et al.* (1999); Kumar, *et al.* (2001) and Bijaya Devi *et al.* (2008). The data was recorded and presented in table which indicated that significant effect of varieties and spacing on neck thickness was found at various growth stages. At 60 days after planting the variety V₁ (Agrifound Light Red) was recorded maximum neck thickness. It has been observed that plant spacing at 60 days after planting

S₃ (20 × 15 cm) was recorded maximum neck thickness. The combined effect of variety and plant spacing showed significant effect on neck thickness at all stages of plant growth. The maximum neck thickness was observed at 60 days after planting for V₁S₃. The result is quite similar to Mc-Geary (1985), Kumar, *et al.* (1998) and Jilani *et al.* (2010).

Effect on bulb characters : Bulb diameter (cm) of onion has been given in table. It is clear from the data that the maximum bulb diameter was found in variety V₂ (NHRDF-Red) with spacing S₂ (20x10 cm) and recorded maximum in the interaction as V₁ S₃. Maximum number of scales in variety V₃ (NHRDF-Red) with spacing in S₃ (20x15 cm). The combined effect on maximum number of scales was recorded in V₃S₃. This is due to wider spacing of plant, which helps to utilize more water, nutrition, air and light for better growth. These results are in close conformity with earlier reports of Singh (1977), Kumar *et al.* (1998); Kumar *et al.* (2001), Khan *et al.* (2003); and Jilani *et al.* (2010). It is clear from the table that the highest bulb weight was noted in variety V₃ (NHRDF-2) while lowest bulb weight was found in variety V₂ (NHRDF-Red). The effect of plant spacing on bulb weight was found significant and hence maximum bulb weight was found at S₃ (20 x 15 cm). The combined effect of plant varieties and spacing on bulb weight was found significant and hence maximum bulb weight was found at V₁S₃. This result corroborated the findings of Singh (1977); Kumar *et al.* (1998); Kumar *et al.* (2001); Khan *et al.* (2003) and Jilani *et al.* (2010). The data revealed that maximum bulb length was observed in variety V₂ (NHRDF-Red) with spacing S₂ (20 x 10 cm). The combined effect on maximum bulb length was recorded at V₂S₂. This is due to wider spacing of plants which help to utilize more water, nutrient, air and light for better growth. This result is in conformity with earlier reports of Singh (1977); Kumar *et al.* (1998); Kumar *et al.* (2001); Khan *et al.* (2003) and Jilani *et al.* (2010).

Conclusions

On the basis of results it may be concluded that Maximum plant height was recorded in variety V₂ (NHRDF-Red) with plant spacing S₃ (20 × 15 cm) and maximum no. of leaves recorded V₃ (NHRDF-2) and spacing S₃ (20 × 15 cm). Maximum neck thickness recorded in variety V₁ (Agrifound Light Red) and spacing S₃ (20 × 15 cm). Bulb diameter (cm) has been noted maximum in variety V₂

(NHRDF-Red) and spacing S₂ (20 × 10cm). Highest bulb weight was noted in variety V₃ (NHRDF-2) and plant spacing S₃ (20 x 15 cm). Highest number of scales noted in variety V₃ (NHRDF-2) and in plant spacing S₃ (20 x 15cm). The length of bulb which was indicated maximum in variety V₂ (NHRDF-Red) and with spacing highest in S₂ (20 x 10cm). Onion variety V₃ (NHRDF-2) was recommended for commercial exploitation in farmer fields for higher crop production.

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Estimation of Rainfall by observing historical trends using supervised data mining technique

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Abstract

Rainfall being a complete weather phenomenon, depends directly or indirectly upon many different weather aspects. It plays a key role in the process of agriculture. Also, in some places the cultivation of crop is completely dependent upon the rainfall during that period. Early estimation and prediction of rainfall helps in dealing with the uncertainties of nature.

Data mining is a process of finding out meaningful patterns after analyzing large amount of data. In this work, thirty-six years of weather data has been acquired which is collected by the world meteorological department. The collected data contains a total of 11 weather attributes for which daily values has been collected and maintained. In this work, a lazy learning approach called as k-nearest neighbor is used to analyze the data in order to predict the rainfall. The prediction model proposed in this work has been validated using cross validation technique.

Key words : Data mining, Rainfall prediction, K- nearest neighbor, weather forecasting, cross validation, Rapid miner, machine learning.

Introduction

India's growth rate is heavily dependent on agriculture sector. A good harvest simply results in more money in the hands of government to provide its welfare schemes also a depression in agriculture sector reciprocates the above scenario. Indian economy is also described as Agro-economy. Agriculture sector is also identified and marked as the sector of livelihood for more than half of the Indian population and the count becomes even more in the rural areas.

To increase the efficacy and productivity in the field of agriculture, more scientific research should be encouraged in this area. This work is dedicated towards the prognosis and estimation of rainfall by observing historical trends in the weather data using data mining techniques.

Data mining is a constructive process that involves study of data in order to find the relationship between various attributes of data set and trends that are often repetitive in nature. K- nearest neighbor is a lazy learning approach that is used to analyze thirty-six years of historical weather data. This paper includes details regarding the rainfall prediction model and its implementation using rapid miner.

K-NN stands for k-nearest neighbor where value of 'K' varies as per requirement of model. It is a supervised learning algorithm in which data has been

supplied to the prediction model and based on that data, predictions will take place. It is also categories as a non-parametric algorithm because in this machine learning approach no assumption has been made on the supplied data and used the training data at the time of actual predictions.

Some machine learning algorithm such as decision tree and artificial neural network learn from the supplied data but on the other hand K-NN does not learn from the supplied data and performs prediction and analysis at the time of actual prediction this approach is called lazy learning and such algorithms are categories as lazy learning algorithms. K-NN can be used for both classification and regression problems.

Tuple $A_1 : (a_{11}, a_{12}, a_{13}, \dots, a_{1n})$

Tuple $A_2 : (a_{21}, a_{22}, a_{23}, \dots, a_{2n})$

$$\text{dis}(A_1, A_2) = \sqrt{\sum_{i=1}^n (a_{1i} - a_{2i})^2}$$

In order to understand the working of K-nearest neighbor, Let's consider two tuples A_1 and A_2 . The difference between value of each corresponding attribute in tuple A_1 and A_2 is taken and square this difference. After the addition of all the squared difference of the corresponding attribute, square root is applied. The values of attributes are normalized wherever required before calculation of Euclidean distance.

The unknown tuple is classified based on the inference made from its nearest made from its nearest neighbor. For example, if the value of $k=1$ then the unknown tuple has assigned the class of its closest neighbor in the pattern space.

Materials and Methods

Data collection and preprocessing : Data collection for any research work can be done in two ways. One is to collect the data specifically for that research work. This type of collected data is known as Primary data. Other is to gather data which is already been collected by some other entity. This type of collected data is known as secondary data.

Table-1 : Represents data utilisation for model.

S. No.	Data Set	Description	Instances
1.	Training Data Set	(1988-2016) 31 years	7000
2.	Testing Data Set	(2017-2022) 6 years	2000

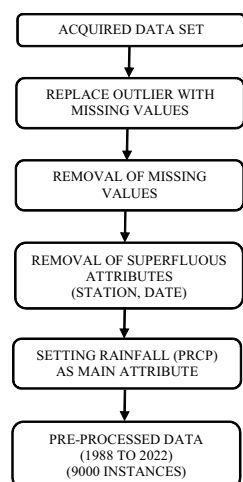


Figure-1 : Pre-processing of Acquired Data Set.

Table-2 : Description of attributes present in the data set.

S. No.	Attribute	Type
1.	Station Code (STN)	Integer
2.	Date (DATE)	Integer
3.	Temperature (TEMP)	Numeric
4.	Dew point (DEWP)	Numeric
5.	Sea Level Pressure (SLP)	Numeric
6.	Visibility (VISIB)	Real
7.	Wind speed (WDSP)	Numeric
8.	Maximum Sustained Wind Speed (MXSPD)	Numeric
9.	Maximum Temperature (MAXT)	Numeric
10.	Minimum Temperature (MINT)	Numeric
11.	Precipitation Amount (PRCP)	Real

Dedicated resources are required to collect primary data which are costly and it is a very time-consuming process. In this research work, thirty-seven year of historical weather data has been used which is collected under the “World weather watch program” by WMO i.e. World meteorological organization (WMO). The data used in the work has been collected by NCEI (National centre environment Information). The details of attribute present in this data have been given in table-2.

Implementation : The collected data has been divided into two parts i.e., training data and testing data. As already discussed in the introduction section, K-nearest neighbor is a supervised machine learning and data from year 1988 to 2016 that contains approximately 7000 instances is used as training set and data from 2017 to 2022 that contains approximately 2000 instances is used as testing set. The proposed rainfall prediction model based on K-nearest neighbor has been implemented using Rapid Miner. The implemented version of the model is being represented in figure-1.

Results and Discussion

In this research work, a K-NN based rainfall prediction model has been proposed and implemented. The validation of the model has been done using cross validation technique shown in figure 4 and 5 respectively. The model has been tested for different values of ‘K’ and compared on the basis of Accuracy, Precision, recall, Root mean square error (RMSE). The results are compiled and shown in table-3.

Conclusion and Future Scope

K-Nearest neighbor data mining technique can be used for both classification and regression problem. In this work a rainfall prediction model has been proposed to predict rainfall using historical weather data having 9000 instances for 11 weather attributes.

The supervised machine learning technique used to design the model is k nearest neighbor. The data from the year 1988 to 2016 is used to train the proposed model having 7000 instances and data from year 2017 to 2022 is used for testing purpose having 2000 instances.

The validation of the proposed models has been carried out using cross validation method. The model has been tested out and analyzed for different value of ‘K’. The detail comparative analysis has been discussed in the result section of this paper.

The K-NN based model performs best in case of

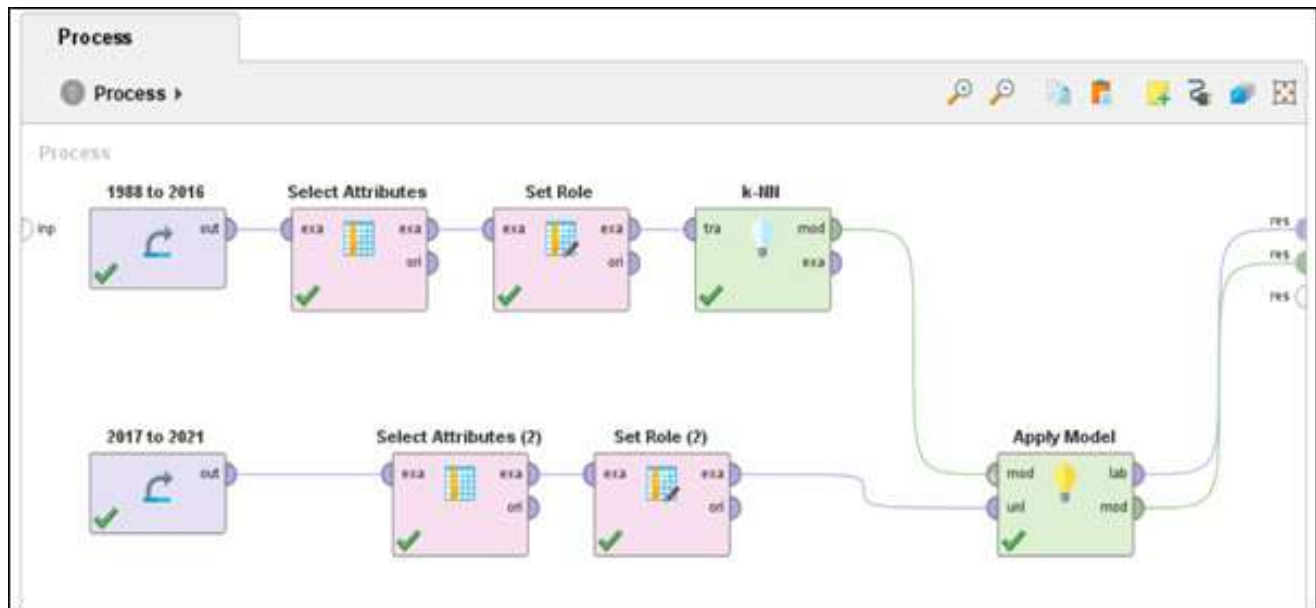


Figure-2 : Rainfall Prediction model using K-Nearest Neighbor (RPM_KNN).



Figure-3 : Results generated using rapid miner (RPM_KNN).

Row No.	prediction(PRCP)	TEMP	DEWP	SLP	VISIB	WDSP	MXSPD	MAX
1274	84.375	80.400	77.900	1001.900	2.300	0.600	1	85.300
1265	73.570	88.200	77.900	998.200	2.500	0.800	1.900	95
908	72.046	81.100	76	1001.200	2.500	0.500	1	88.500
620	54.797	73.100	72.800	1006.800	2.100	2.200	4.100	80.600
1272	53.944	82.300	75.400	998	2.300	1.700	5.100	95
1273	51.334	79.400	76.700	1000.900	2.200	1.700	2.900	93.200
907	47.975	78.500	76.200	1000.200	2.500	1.300	1.900	92.500
573	47.670	80.700	79.400	1000.600	2.200	0.800	1.900	83.700
168	45.327	80.700	73.800	998.900	2.300	1.800	2.900	101.80
1303	44.840	82.700	78.800	1001.100	2.500	1	1.900	91.800
1302	38.540	81.900	79.500	997.800	2.500	1	2.900	100.40
1244	38.483	86.600	75.300	998.700	2.500	1.800	1.900	100.20
1634	37.398	79.400	68.000	1007.400	3.300	1.900	4	80.600

Figure-4 : Predicted value of PRCP (Rainfall) in Numerical form.

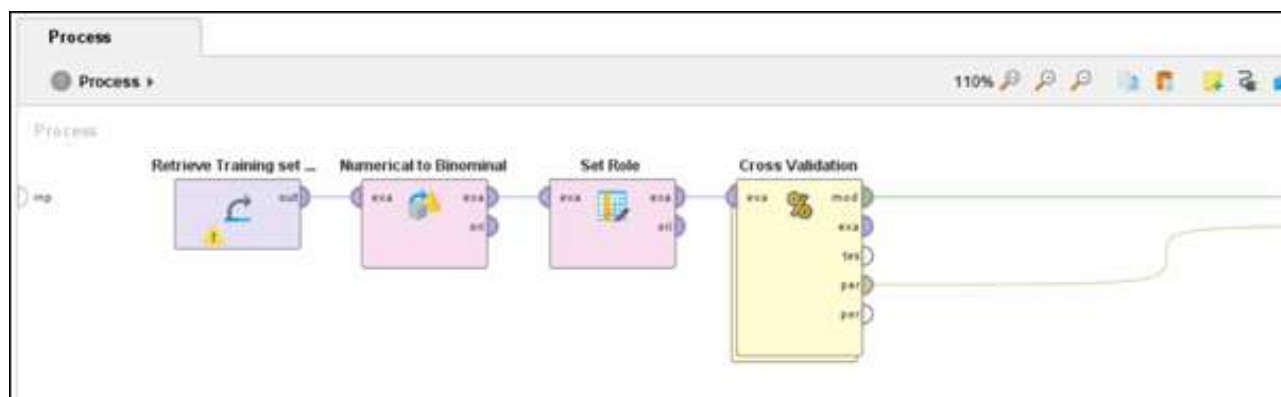


Figure-4 : Cross validation on RPM_KNN.

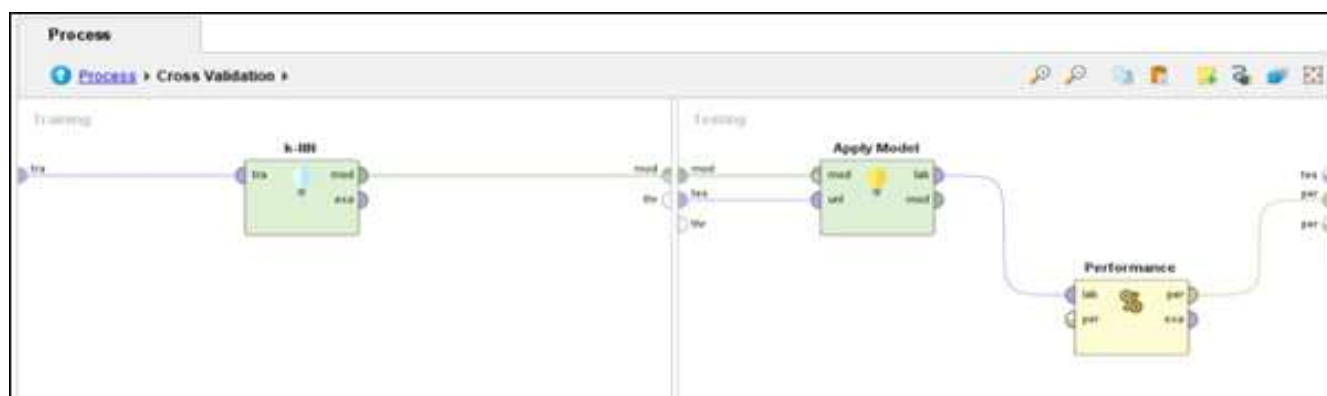


Figure-5 : Training and Testing module of Cross validation on RPM_KNN.

Table-3 : Results and analysis.

Model	Accuracy	Precision	Recall	RMSE
K-NN (K=2)	86.51	60.18	72.98	0.350
K-NN (K=4)	87.20	62.44	75.61	0.318
K-NN (K=6)	87.80	64.16	77.83	0.308
K-NN (K=8)	88.08	64.78	78.94	0.303
K-NN (K=10)	87.84	64.60	77.89	0.300

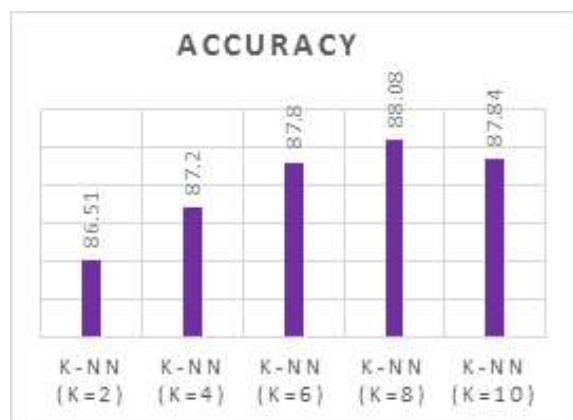


Figure-6 : Comparison : Accuracy.

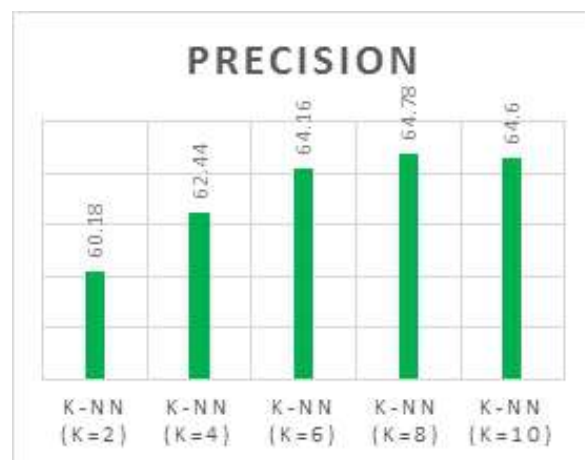


Figure-7 : Comparison: Precision.

K=8 with accuracy of 88.08 %, Precision of 64.78%, Recall of 78.94% and RMSE i.e. Root mean square error of 0.303.

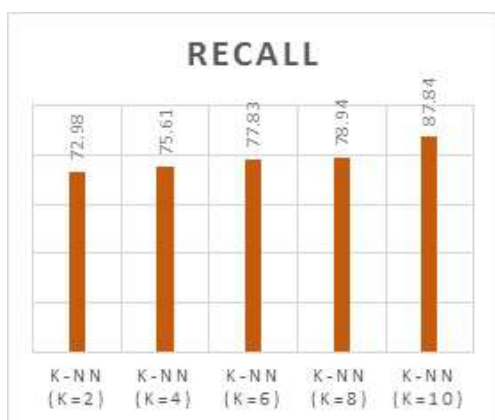


Figure-8 : Comparison: Recall.

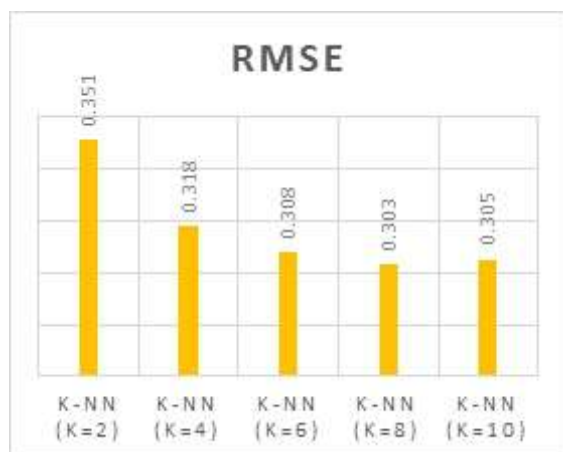


Figure-9 : Comparison : RMSE.

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Assessing Toxicity of Dichlorvos Insecticide against Bihar Hairy Caterpillar, *Spilarctia obliqua* (Walker)

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Abstract

The contact toxicity of dichlorvos (Nuvan 76 EC) was evaluated against 9d old larvae of *S. obliqua* (mean initial weight = 0.118g/larva) by topical application method using Hamilton microapplicator dispenser under laboratory conditions (temp. $27 \pm 2^\circ\text{C}$, R.H. $75 \pm 5\%$). The LD_{30} , LD_{50} and LD_{90} of this insecticide were 1.8710, 3.4271 and 15.2026 $\mu\text{g/larva}$ at 48 HAT, respectively. The LT values at the dose of 3.04 $\mu\text{g/larva}$ of this insecticide were 21.99h (LT_{30}); 45.13h (LT_{50}) and 264.75h (LT_{90}), respectively.

Key words : Contact toxicity, insecticide, bioassay, topical application method

Introduction

The Bihar hairy caterpillar, *Spilarctia* (= *Diacrisia* = *Spilosoma*) *obliqua* (Walker) (Lepidoptera: Arctiidae), is a polyphagous and intermittent pest widely distributed in India, Burma, Ceylon and China (Djou, 1939), Bangladesh, Myanmar, Nepal and Pakistan (CPC, 2004). It is sporadic in nature capable of infesting around 126 plant species belonging to more than 24 families which include various economically important crops as such cereals, gram, oilseeds, pulses, vegetables, medicinal and aromatic plants (Singh and Varatharajan, 1999; Gupta and Bhattacharya, 2008). *S. obliqua* often infests jute causing yield loss up to 30% and is known as jute hairy caterpillar (Bandyopadhyay *et al.*, 2014). Satpathy *et al.* (2014) reported infestation on sunhemp, causing substantial loss to the fibre yield. Recently, it has also become major pest of mulberry (*Morus alba*) and second most serious pest of cole crops mostly cabbage (Bhatia *et al.*, 1995; Gurung *et al.*, 2020). The female moth lays up to 1000 eggs in clusters on lower surface of the leaves. After hatching, first instar caterpillars scrap the chlorophyll content of the lower leaf gregariously whereas late instars are solitary and voracious feeder, and in severe cases complete defoliation of plants is inevitable (Hussain and Begum, 1995; Selvaraj *et al.*, 2015).

In the past five decades various chemical insecticides have been tested against *S. obliqua* by various workers like cypermethrin, deltamethrin, fenprothrin, fenvalerate, fluvalinate, endosulfan, parathion methyl and monocrotophos (Jaglan and Sircar, 1997). Injudicious and uncontrolled use of insecticides led to the development of resistance in insects in different crop ecosystems. Chemical control of this pest through

conventional insecticides is difficult due to dense hairs on larval body surface along with the development of resistance (Dhingra *et al.*, 2007).

Materials and Methods

Insects rearing : A rearing culture of *S. obliqua* was maintained in the laboratory ($25 \pm 2^\circ\text{C}$, $70 \pm 5\%$ RH, and 16:8 h light: dark photoperiod) by standard rearing technique (Thakur and Srivastava, 2019). Egg masses were collected from the fields of different crops and widely grown castor, *Ricinus communis* plants at Norman E. Borlaug Crop Research Centre (NEBCRC) of the University and kept in a petri dish (9 cm dia.) lined with a moist filter paper to avoid dried conditions. Upon hatching, neonate larvae were transferred to plastic tubs (dia. 35 cm, ht. Approx 15 cm), containing fresh soft castor leaves with a water soaked cotton swab wrapped around petiole which protect it from drying. Hygienic conditions were provided to the growing larvae and fresh food was supplied daily. Egg masses obtained from laboratory reared adults which were used for further experiments.

Insecticides : Dichlorvos was obtained from Insecticides, India.

Testing of insecticides : The dosage and duration-mortality response of insecticides were assayed against 9d old larvae of *S. obliqua* by topical application method (Pineda *et al.*, 2004). Serial dosages of this insecticide were first prepared in acetone. Then, a Hamilton microapplicator syringe was used to apply test solution on dorsal surface of *S. obliqua* larva. The control larvae were treated with acetone alone. The treated larvae were transferred to plastic transparent boxes containing fresh castor leaves for feeding. Three replicates with 5 larvae in each replicate were used for each treatment. The

Table-1 : Dosage-mortality response of dichlorvos (Nuvan 76EC) against the larvae of Bihar hairy caterpillar, *Spilarctia obliqua* (Walkar) by topical application method.

Insecticides (Trade name)	HAT*	LD values (µg/larva)			Heterogeneity χ^2	Regression equation $Y=a+bx$	Fiducial limits at LD ₅₀ (µg)	
		LD ₃₀	LD ₅₀	LD ₉₀			Lower	Upper
Dichlorvos (Nuvan 76EC)	48	1.8710	3.4271	15.2026	0.8007685	$y = 4.156+0.313x$	1.9803	4.7296

*HAT = Hours after treatment; Larval age = 9d; Average larval weight=0.118g/larva; No. of larvae per treatment (n) = 15; Temp. = 27°C, R.H. = 80%, Time = 8.00AM

Topical application was made using Hamilton microapplicator syringe mounted with automatic dispenser.

Table-2 : Duration - mortality response of dichlorvos (Nuvan 76EC) against the larvae of Bihar hairy caterpillar, *Spilarctia obliqua* (Walkar) by topical application method.

Insecticides (Trade name)	Dose (µg/ larva)	LD values (µg/larva)			Heterogeneity χ^2	Regression equation $Y=a+bx$	Fiducial limits at LD ₅₀ (h)	
		LD ₃₀	LD ₅₀	LD ₉₀			Lower	Upper
dichlorvos (Nuvan 76EC)	3.04	21.99	45.13	264.75	9.325482	$y = 3.126+0.739x$	24.75	61.76

Larval age = 9d; Average larval weight=0.118g/larva; No. of larvae per treatment (n) = 15; Temp. = 27°C, R.H. = 80%, Time = 8.00AM

Topical application was made using Hamilton microapplicator syringe mounted with automatic dispenser.

observation on mortality was recorded at 48 hours after treatments and the data was corrected using Abbott's formula (Abbott, 1925). The data so obtained was subjected to probit analysis for obtaining regression equation and computing LD and LT values following Finney (1971).

The observations recorded on mortality were corrected using Abbott's formula (Abbott, 1925) as given under-

$$\text{Abbott's corrected mortality (\%)} = \frac{T - C}{100 - C} \times 100$$

Where, T = mortality in treatments (%)

C = mortality in control (%)

Results and Discussion

It is evident from fig.-1 that the three higher doses of dichlorvos (9.12, 7.60 and 6.08 µg/larva) resulted into the complete (100%) mortality of treated larvae within 72HAT while in remaining lower doses except the lowermost (1.52 µg/larva) complete mortality was achieved at 96HAT. The data presented in the table 1 shows that the LD₃₀, LD₅₀ and LD₉₀ of dichlorvos were 1.8710, 3.4271 and 15.2026 µg/larva, respectively.

The LT values at the dose of 3.04 µg/larva of dichlorvos were 21.99h (LT₃₀); 45.13h (LT₅₀) and 264.75h (LT₉₀), respectively in topical application method (Table 2).

There is no published review available on dose mortality response (LD values) of dichlorvos against *S. obliqua* by topical application method. However, few

references are available on toxicity (LC values) and field efficacy of this insecticide against *S. obliqua* and other caterpillars. For instance, Gupta and Yadav (2012) assessed the relative contact toxicity of seventeen conventional and non-conventional insecticides belonging to different groups of chemicals against 3-4 day old larvae of *S. obliqua* at 24, 48 and 72 h. Deltamethrin on the basis of 'relative toxicity value' was 920, 3400 and 13750 times more toxic than dimethoate at 24, 48 and 72 h, respectively. The order of relative toxicity (LC₅₀ value at 24 HAE) was: deltamethrin (0.0001%) > ð-cyhalothrin (0.0001%) > alphamethrin (0.002%) > cypermethrin (0.009%) > fenvalerate (0.025%) > chlorpyrifos (0.0009%) > quinalphos (0.0130%) > Prophenophos + Cypermethrin (0.005%) > dichlorvos (0.009%) > triazophos (0.035%) > methomyl (0.026%) > prophenophos (0.027%) > monocrotophos (0.024%) > endosulfan (0.042%) > phenthoate (0.022%) > Chlorpyrifos + Cypermethrin (0.057%) > dimethoate (0.092). All the five synthetic pyrethroids as well as chlorpyrifos, quinalphos, prophenophos + cypermethrin, dichlorvos, triazophos, methomyl, prophenophos, monocrotophos were more toxic than dimethoate. In 2008, Rao determined the LC₅₀ (µg/larva) values of lufenuron, emamectin benzoate, novaluron, indoxacarb, profenofos, endosulfan, chlorpyrifos, deltamethrin, quinalphos, spinosad, cypermethrin, dichlorvos, acephate and fenvalerate as 0.0068, 0.0069, 0.030, 0.21, 0.213, 0.645, 0.93, 0.95, 1.02, 1.14, 3.31, 5.12, 5.3 and 5.49 µg/larva, respectively. Using the LC₅₀ value of cypermethrin as the control, dichlorvos, acephate and fenvalerate were found to be the least toxic insecticides and LC₉₀ value of dichlorvos was 18.62 µg/larva against Kurnool (Andhra

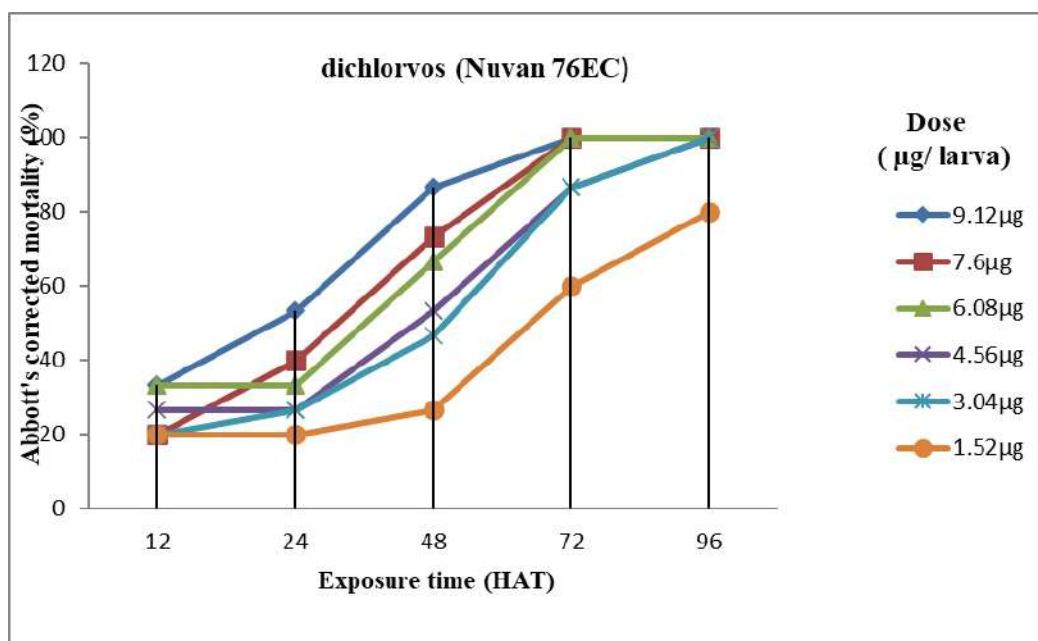


Figure-1: Contact toxicity of dichlorvos (Nuvan 76EC) against 9d old larvae of Bihar hairy caterpillar *Spilarctia obliqua* (Walker) by topical application method.

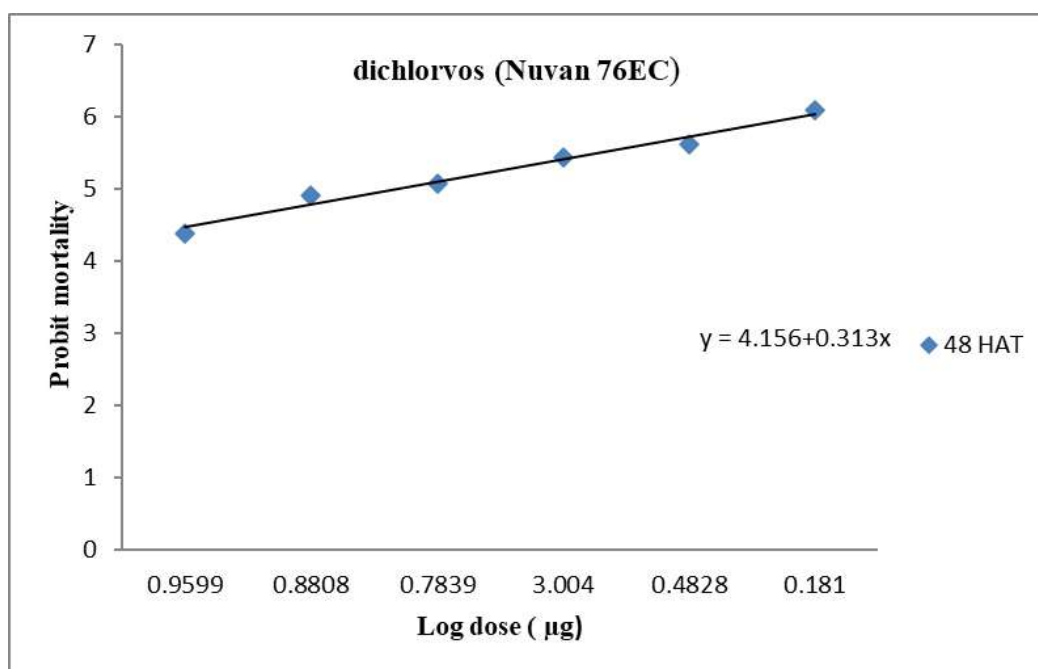


Figure-2: Dose-mortality response of dichlorvos (Nuvan 76 EC) against 9d old larvae of Bihar hairy caterpillar *Spilarctia obliqua* (Walker) by topical application method.

Pradesh) population of *S. litura*. The LC_{50} value of dichlorvos insecticide tested by Chen *et al.*, (2000) against 2nd instar larvae of *S. litura* by Potter's tower sprayer was 481.79 $\mu\text{g/ml}$.

Muthusamy *et al.*, (2011) assessed that high mortality was observed in lambda-cyhalothrin treatment (LD_{50} : 6.198 ppm, LD_{90} : 38.6 ppm), followed by dichlorvos (LD_{50} : 1.167 ppm, LD_{90} : 14.512 ppm) as compared to temephos (LD_{50} : 24.72 ppm, LD_{90} : 7958.6) against 3rd

instar larvae of *Amsacta albistriga*. Abrol and Singh (2003) reported that carbaryl + fenvalerate = dichlorvos + fenvalerate > malathion + fenvalerate > fenvalerate + deltamethrin > dichlorvos = carbaryl + deltalrethrin = malathion = dichlorvos + deltamethrin = malathion + deltamethrin > endosulfan > carbaryl significantly reduced the fruit damage by *Leucinodes orbonalis* recording only 14.9, 16.4, 18.3, 20.0 and 21.6% as compared to control (69.8%), respectively. Dichlorvos + fenvalerate combination gave the highest yield of 263.45 q/ha.

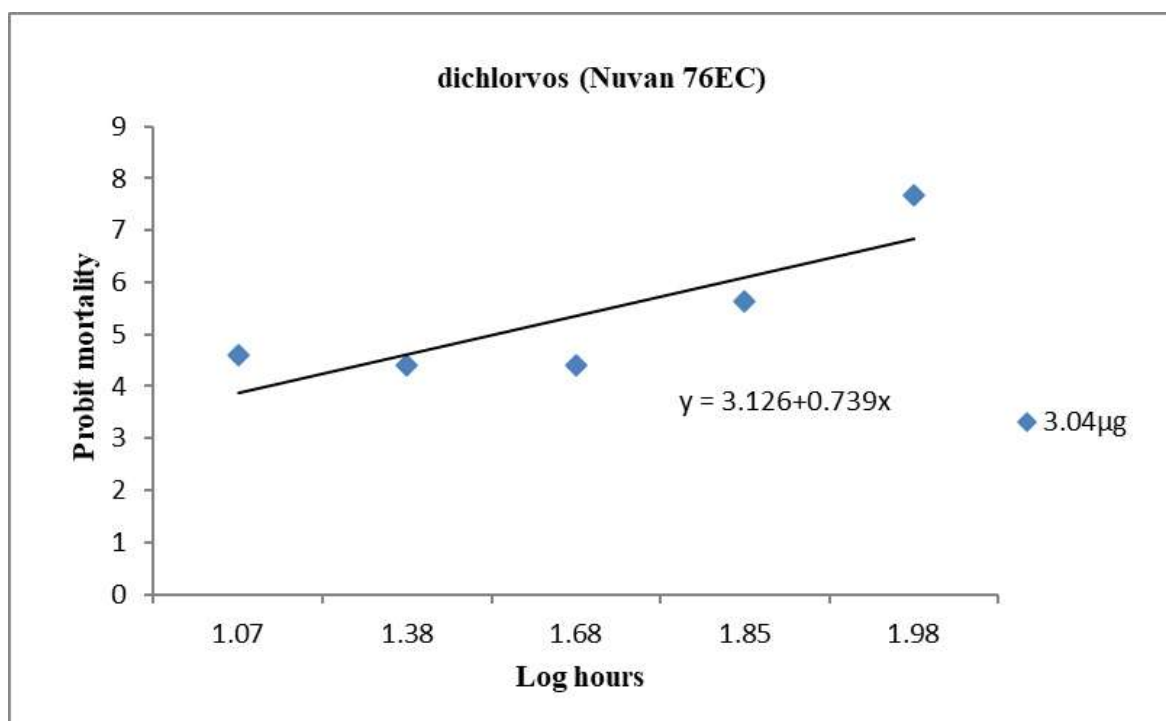


Figure-3: Duration-mortality response of dichlorvos (Nuvan 76 EC) against 9d old larvae of Bihar hairy caterpillar *Spilarctia obliqua* (Walker) by topical application method.

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Effect of Rock Phosphate, Poultry Manure and Phosphate Solubilizing Bacteria on Economic Feasibility of Chickpea (*Cicer arietinum* L.)

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Abstract

A field experiment was conducted during Rabi season of 2021-22 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan) to examine the effect of rock phosphate, poultry manure and phosphate solubilizing bacteria on economic feasibility of chickpea (*Cicer arietinum* L.). The experiment was laid out in Randomized Block Design with three replications. The experiment comprises nine treatment combinations of phosphorus source (SSP, RP and PM with and without PSB) including one control. The result revealed that application of 100% P through SSP (T₃) remained higher availability of phosphorus in soil up to 40 days whereas combined application of 50% P through RP + 50% P through PM + PSB (T₉) maintained longer (up to 90 days) availability of phosphorus in soil. The maximum gross return (₹ 123505 ha⁻¹), net profit (₹ 91657 ha⁻¹) and BC ratio (2.88) were observed under application of 50% P through RP + 50% P through PM + PSB (T₉). It was concluded that application of 50% P through RP + 50% P through PM + PSB (T₉) decrease cost and increase return of chickpea (*Cicer arietinum* L.).

Key words : Chickpea, gross return, economic, net profit, phosphorus.

Introduction

Pulses are wonderful gifts of nature, because of their ability of biological nitrogen fixation (15-35 kg ha⁻¹), deep root system and mobilization of insoluble soil nutrients bringing qualitative changes in soil physical properties, they are known as soil restorers. Therefore, pulses have emerged as a viable option to improve soil health, conserve natural resources and sustain the agricultural productivity. In view of increased cost of fertilizers and present energy crisis, the current emphasis is on integrated use of different sources of plant nutrients such as organic manure and biofertilizers in combination with chemical fertilizers.

The chemical fertilizers, no doubt, are important source, which can meet the nutrient requirement, but their imbalance and continuous use has led to environmental problems and deterioration of soil health. Further, availability of fertilizer at economic prices is another problem. Under these circumstances, a system comprising balanced use of fertilizer along with low cost biofertilizer needs to be evolved.

Biofertilizers play an significant role in nutrient supply to crops in a more eco-friendly and sustainable manner. Inoculation of seeds with microbes culture is a

very low cost method of nitrogen fertilization in legume and increasing availability of nitrogen by biological fixation of atmospheric nitrogen. Phosphate solubilizing microorganisms convert the insoluble phosphates into soluble forms by acidification, chelation, exchange reactions and production of gluconic acid. Poultry manure contain plant nutrients including N, P, K, Ca, Mn, Zn and Cu as well as other nutrients the uptake of which has a positive effect on plant nutrition, photosynthesis, the chlorophyll content of the leaves and improves the nutrient content of the different plant component. It is very cheap and easily available source of nutrients. Whereas, rock phosphate and different organic sources of phosphorus nutrient in acid play vital role in the future agriculture scenario of our country, simply because, they are cheap, abundantly available in natural way and will be efficient if they are used in scientific way. The present study therefore aimed to evaluate the effect of rock phosphate, poultry manure and phosphate solubilizing bacteria on economic feasibility of chickpea (*Cicer arietinum* L.).

Materials and Methods

Experimental site : The experiment conducted at Instructional Farm, Rajasthan College of Agriculture,

Table-1 : Effect of rock phosphate, poultry manure and phosphate solubilizing bacteria on economics of chickpea crop.

Treatment		Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	BC ratio
T ₁	: Control	77098	50248	1.87
T ₂	: PSB	83640	56590	2.09
T ₃	: 100% P through SSP	107937	78837	2.71
T ₄	: 100% P through RP	88622	60176	2.12
T ₅	: 100% P through PM	96361	61511	1.77
T ₆	: 50% P through RP + 50% P through PM	118685	87037	2.75
T ₇	: 100% P through RP + PSB	106378	77732	2.71
T ₈	: 100% P through PM + PSB	110358	75308	2.15
T ₉	: 50% P through RP +50% P through PM+ PSB	123505	91657	2.88
SEm±		4850	4850	0.17
CD (5%)		14540	14540	0.51

Udaipur . It is located in region of Rajasthan Agro Climatic Zone IV-a, which includes the Sub-Humid Southern Plain and Aravalli Hills. The mean annual rainfall of Udaipur is 637 mm from the South-West monsoon, which arrives in the final week of June and lasts till September. The maximum and minimum temperatures, according to statistics, were 22.49 and 33.34 °C, and 3.77 and 14.67 °C, respectively. The maximum and minimum relative humidity readings were 54.43 and 90.57 percent, respectively, and 18.27 and 52.14 percent. The soil of the experimental site was clay loam in texture with 272.35 kg ha⁻¹, 21.62 kg ha⁻¹ and 368.50 kg ha⁻¹ available nitrogen, phosphorus and potassium, respectively with 8.28 pH.

Treatment details : The experiment was laid out in Randomized Block Design with three replications. The experiment comprises nine treatment combinations of phosphorus source (SSP, RP and PM with and without PSB) including one control.

Treatments Details

T1	Control
T2	PSB
T3	100% P through SSP
T4	100% P through RP
T5	100% P through PM
T6	50% P through RP + 50% P through PM
T7	100% P through RP + PSB
T8	100% P through PM + PSB
T9	50% P through RP + 50% P through PM + PSB

Note: P = Phosphorus, PSB= Phosphate Solubilizing Bacteria, SSP=Single Super Phosphate, RP=Rock Phosphate, PM=Poultry Manure

Economic analysis : For calculation of economics, the average treatment yield along with prevailing market rates for inputs and outputs were used. Hence, to evaluate the effectiveness and profitability of the treatments comprehensive. The course of investigation were subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Fisher (1950). The critical difference for the treatment

comparison was economics including net return (₹ ha⁻¹) was calculated so that most effective and remunerative treatment could be recommended.

BC Ratio =

$$\frac{\text{Net return (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)} + \text{Cost of treatment (₹ ha}^{-1}\text{)}}$$

The data collected during worked out, whereas the F test

was found significant at 5 per cent level of significance.

Results and Discussion

The results (Table-1) showed that highest gross return (₹123505 ha⁻¹) and highest net returns (₹ 91657 ha⁻¹) was recorded with the application of 50% P through RP + 50% P through PM + PSB (T₉). Similarly, the perusal of data (Table-1) showed that maximum BC ratio (2.88) was obtained with the application of 50% P through RP +50% P through PM+ PSB (T₉) followed by 50% P through RP + 50% P through PM (T₆). The lowest BC ratio (1.87) was found under T₁ (Control).

Economics is the main parameter which finally decides the adoption of any recommended practices or technology at farming situations by the farmers. It should be technically and economically viable. Application of 50% P through RP + 50% P through PM + PSB (T₉) recorded highest net return (₹ 91656) and B C ratio (2.88). This might be due to higher seed and haulm yield of chickpea. The are in conformity with findings of Saravanan and Panneerselvam, (2014), Gurdeep *et al.* (2015), Waheed *et al.* (2015), Billah *et al.* (2020).

Conclusions

On the basis of experimental results of the present investigation conducted during *Rabi* 2021-22, it was concluded that application of 50% P through RP + 50% P through PM + PSB (T₉), had significant effect with respect to economic feasibility as compared to control.

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Effect of Planting Geometry on Yield and Profitability of Potato in Sandy Loam Soil of Jharkhand

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Abstract

An On Farm Trial was carried out at farmers field of Giridih district of Jharkhand to find out the suitable planting geometry with appropriate plant density of potato tubers for obtaining optimum yield of potato. Potato cultivar Kufri Kanchan were planted in two different methods viz. planting tubers on single row on ridges spaced at 60 X 20 cm (TO1) and paired-rows (15 cm apart) on ridges spaced at 60 X 20 cm (centre to centre) (TO2) along with farmers practice of single row of seed tubers weighing 40-50g on ridges 45 cm apart at 15 cm plant to plant spacing. Paired-row planting geometry produced highest tuber yield (28.40 t/ha) and it was almost 18.65% higher than that in single-row planting at 60 X 20 cm spacing (19.08 t/ha) and about 37.34 % more than that obtained in single-row planting at 45 X 15 cm spacing (16.47 t/ha).

Key words : Moisture inhibition, paired – row planting geometry, potato profitability

Introduction

Potatoes are a staple food in India with Consumption of 47.5 million tonnes and are also used in a variety of dishes and the crop is a major source of income for farmers in India. In India area under potato cultivation is 1.7 million hectares producing 53.3 million tonnes with export of 5.8 million tonnes of potato tubers. Area under potato cultivation in Jharkhand is 0.3 million hectares producing 650,000 tonnes out of which 100000 tonnes is exported. The future of the potato crop in Jharkhand is bright. The state has a favourable climate for potato cultivation, and there is a growing demand for potatoes in the domestic market. The average yield of potatoes in Jharkhand is 11.7 tons per hectare, which is below the national average of 21.5 tons per hectare. With proper investment and management, Jharkhand could become a major potato-producing state in India.

The spacing between potato plants can affect the amount of sunlight and water that each plant receives. This, in turn, can affect the size and number of tubers that each plant produces. The depth at which potato tubers are planted can also affect tuber production. If the tubers are planted too shallow, they may be exposed to the sun and dry out. If they are planted too deep, they may not be able to get enough oxygen. The height of the ridges in which potato tubers are planted can also affect tuber production. If the ridges are too low, the tubers may be exposed to frost or waterlogging. If the ridges are too high, the tubers may not be able to get enough sunlight.

Planting aspect highly influences the plant development and tuberization primarily by affecting soil moisture and temperature. Planting of seed tubers on ridges is widely followed method with some modifications from place to place. Almost in all the districts of Jharkhand state only 8-10 per cent area is irrigated and an extensive area is under rainfed agriculture. Using the most valuable water resource, the growers practice dense planting of almost all the crops. In view of poor socio-economic condition of the farmers and desirable edaphic factors like sandy loam structure and high organic matter content a comparative study among planting geometry involving farmers' traditional system, scientifically recommended system and a slightly modified system as per growers' tendency was conducted.

Materials and Methods

Present investigation was conducted on farmer's field in participatory mode during rabi, 2018-19 and 2019-20. The experiments consisted of assessment of three technology options related to planting methodology in potato. Among the treatments, farmers' traditional practice (FP) i.e., planting of single row of seed tubers weighing 40-50g on ridges 45 cm apart at 15 cm plant to plant spacing was compared with recommended method i.e. single row on ridges spaced at 60 X 20 cm (TO1) and 15 cm apart paired-rows on ridges spaced at 60 X 20 cm (centre to centre) (TO2). Seed rate in all treatments was kept constant (2.5 t/ha) by selecting tubers of 40-50 g in single-row methods and those of 20±5g in paired-row method. Caring of consumers and producers' preference

Table-1 : Performance of potato cv. Kufri Kanchan in different planting geometry pooled over two years.

Parameters	Technology assessed			SEm	CD (0.05)
	FP	TO1	TO2		
Plant Height (cm)	33.84	35.46	32.13	0.33	0.69
No.of shoots/hill	3.5	4.2	3.1	0.22	0.46
Soil moisture in centre of ridge (%)	26.3	24.4	22.8	0.28	0.59
No. of tubers/plant	5.73	6.65	4.65	0.15	0.32
Tuber weight (g)	30.80	35.79	31.96	1.16	2.44
Yield (t/ha)					
A - grade	4.72	4.98	5.98	0.34	0.70
B - grade	4.56	5.67	7.80	0.54	1.12
C - grade	4.52	4.71	7.73	0.17	0.36
D - grade	2.67	3.72	6.89	0.35	0.73
Tubers of equal market value (A+B+C)	11.50	14.35	18.77	0.65	1.46
Total	16.47	19.08	28.40	0.76	2.60
B : C ratio	2.52	3.57	4.65	-	-

Notes : 1. FP= Single row per ridge at 45x15 cm spacing; TO1= single row per ridge at 60x20 cm spacing (Recommended); TO2= 15 cm apart paired rows per ridge at 60x20 cm spacing.

2. Labour charges have been excluded from cost of cultivation. A-grade tubers : > 80g, B-grade : 50-80g, C-grade : 25-50g and D-grade : < 25g

over red cultivars, Kufri Kanchan was selected for the experiments. Rest of cultural practices for raising the crop were uniform for all the plots. Each treatment was replicated in 10 farmers' field of Giridih district of Jharkhand in 100 m² area. The organic matter content of soils of experimental plots varied from 0.7- 0.8 per cent. Data were recorded on plant height (cm), number of shoots per hill, Soil moisture in centre of ridges (%), number of tubers per plant, tuber weight (g), yield of A, B, C and D grade tubers (t/ha) and total tuber yield (t/ha). Benefit/cost (B:C) ratio was also worked out to assess the profitability of various planting geometry.

Perusal of pooled data of two years given in Table 1 showed that potato planting in single row geometry at recommended spacing of 60 X 20 cm (TO1) was significantly superior in relation to plant height (35.46 cm) as compared to paired row planting (32.13 cm). Similarly, maximum number of shoots per hill was also recorded in single row planting at 60 X 20 cm spacing (4.2) as against 3.1 in paired row planting. Impaired haulm growth and biomass production in paired row planting was probably due to increasing competition between plants for nutrients. Similar observations were also recorded by Ahire *et al.* (2000) in Maharashtra. However, Singh *et al.* (2010) did not find significant difference in number of shoots under triple row, paired row and single row planting geometry with or without drip irrigation system.

Soil moisture content in the centre of ridge is one of the most important parameter contributing to the plant growth and tuber yield. Vertical as well as horizontal movement of soil moisture decides level of irrigation water to be used. There is a close relation between soil moisture tension and other physical properties of soil like capillary conductivity, thermal conductivity, clay and organic matter

content. Organic matter content and texture of the soil primarily govern bidirectional moisture movement in the soil. Sandy loam with high organic matter generally exhibits more soil moisture imbibition. Maximum soil moisture content in the centre of ridge was recorded in single row planting system at 45 X 15 cm spacing (FP) (26.3%) followed by single row planting at 60 X 20 cm spacing (24.4%). Paired row planting at 60 X 20 cm (TO2) exhibited least value for this edaphic parameter (22.8%) because of comparatively thicker ridges accommodating 15 cm apart two rows in this treatment. Even though, horizontal and vertical movement of sufficient moisture provides favourable edaphic environment around the rhizosphere for nutrient uptake and tuberization.

Number of tubers per plant is one of the major yield contributing characters in potato. Closer spacing between plants inversely influenced the number of tubers per plant. Significantly higher number of tubers per plant was recorded in single row planting at 60 X 20 cm (6.65) followed by single row planting at 45 X 15 cm (5.73). Paired row plant geometry resulted in comparatively lower number of tubers per plant viz., 4.65. Similar results have also been reported by Ahire *et al.* (2000), Singh *et al.* (2010) and Sharma *et al.* (2014).

Significantly higher tuber weight was observed in single row planting geometry at 60 X 20 cm spacing (35.79g). However, there was non-significant difference in tuber weight of single row planting at 45 X 15 cm and paired row planting geometry. Plant population per unit area was negatively associated with number of tubers per plant and tuber weight. The result of present study was supported by Ahire *et al.* (2000), Singh *et al.* (2010) and Mangeni *et al.* (2015).

Results indicated that paired-row planting of potato

exhibited significantly higher tuber yield (28.40 t/ha). Tuber yield in paired row planting was almost 18.65 % higher than that in single-row planting at 60 X 20 cm spacing (19.08 t/ha) and about 37.34 % more than that obtained in single-row planting at 45 X 15 cm spacing (16.47 t/ha). Singh et al. (2010) have also reported higher total tuber yield in triple row and paired row planting geometry as compared to single row planting. However, Ahire et al. (2000) and Patel et al., (2005) reported higher total tuber yield in single row planting (18.49 t/ha and 39.3 t/ha, respectively) as compared to paired row planting geometry (19.66 t/ha and 32.6 t/ha, respectively). Yield of A, B, C and D grade tubers and tubers with equal market value (>25g) were also significantly higher in case of paired-row planting as compared to any of single row planting systems (Table-1). On the contrary, Singh et al. (2010) observed higher yield of larger grade tubers in single row spacing as compared to paired row or triple row systems. It appeared that plant population was major factor of increased tuber yield in case of paired-row planting.

Regarding profitability of technology in terms of B:C ratio, it was found that paired row planting geometry resulted in maximum B:C ratio (4.65) as compared to single row planting at 60 X 20 cm (3.57) & single row planting at 45 X 15 cm (2.52). Results corresponding to present investigations have also been reported by Singh et al., (2010) in potato.

The specific features of planting of seed tubers in 15 cm apart paired rows at 60 X 20 cm spacing are utilization of undersized tubers of 20±5g, maintenance of more number of plants per unit area, economy of resources like land, water and inputs with higher tuber yield and lucrative return. The resource conserving features of paired row planting geometry encourage the subsistence farming community in Giridih district of Jharkhand.

Planting of potato in 15 cm apart paired rows per ridge at 60 X 20 cm spacing was significantly superior treatment in relation to yield of tubers with equal market value, total tuber yield and B/C ratio. This treatment exhibited 18.65 and 37.34 % higher tuber yield than single row planting at 60 X 20 cm and 45 X 15 cm spacing, respectively. This technology had special utility to use

under-sized seed tubers in close planting taking advantage of high moisture imbibition capacity of organic-rich sandy loam soils and saving irrigation water up to 33% by irrigating more number plants in limited area with profitable tuber yield and remuneration. Furthermore, production of B and C grade tubers in higher quantity because of closer spacing in paired row planting method offers opportunity of increasing yield of medium size tubers in seed crop.

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Effect of Potassium on Tuber Yield and Incidence of Late Blight in Potato

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Abstract

Present investigation through On Farm Trial was conducted on farmer's field in participatory mode in sandy loam soils of Giridih district of Jharkhand during Rabi, 2020-21 and 2021-22 with an objective to assess effect of Potassium on Potato tuber var. Kufri Pushkar. The experiment consisted three levels of potassium viz. 10, 80 and 120 kg/ha with same nitrogen and phosphorus doses of 150 kg/ha and 80 kg/ha respectively in all the treatment i.e Farmers Practice, Technology Option 1 and Technology option 2. The trial was conducted in 10 different locations with similar farming situation (land, soil, moisture acidity and microclimate). The results indicated that application of 120 kg of potassium produced highest yield (263.68 q/ha), net return (Rs.237416/ha) and B:C ratio (3.79). This yield was 46.04 % higher over control and 72.92 % more net return than farmers practice which could be due to significantly higher yield and low infestation (6.7 %) of late blight of potato.

Key words : Levels of potassium, late blight, tuber yield, and economics of potato,

Introduction

Potato is a highly versatile crop grown in varying environmental conditions viz. plains, hills, and plateau in India. It is grown under short days in the plains in autumn season and under long days during summers in hills. The pattern of growth, duration of crop as well as the yield varies according to the environment. Potato is an important crop of Giridih district of Jharkhand grown almost on one fourth of total irrigated area during Rabi season. The major hurdles for farmers in regard to potato cultivation in this area are lack of quality seed, inappropriate doses of fertilizers due to economic condition of farmers and inadaptability of plant protection measures. Farmers generally grow red tuber varieties viz., Kufri Lalima, Kufri Sindhuri, Kufri Red etc. with application of partial doses of nitrogen and phosphorus only whereas application of potassium is entirely ignored in lack of knowledge and extension works. Potassium is essential element which improves the tuber yield by increasing the size of tuber in potato. It increases leaf area and its duration and helps in use of nitrogen more efficiently (Reddy et al, 1986; Saika et al, 1987). Potato responds well to potassic fertilizers (Grewal and Sharma, 1978) and it removes large amount of potassium followed by nitrogen, phosphorus and sulfur from soil (Tandon, 1991). Potassium increases resistance of the potato plants to water stress (Handique and Manivel, 1992; Manivel et al., 1995) frost (Saini, 1978; Tiwari et al., 1980; Grewal and Singh, 1980) and diseases (Huber and Arny, 1985; Chettri et al., 2002). Therefore, intervention on potassium levels

effects of potassium levels is indispensable for optimum tuber yield and plant protection.

Materials and Methods

Looking upon the farmers preference of potato over other vegetables present investigation was conducted on farmer's field in participatory mode during Rabi, 2020-21 and 2021-22 under On Farm Trial activity of KVK, Giridih. The trial consisted of three levels of potassium viz. 10, 80 and 120 kg/ha along with nitrogen and phosphorus doses at 150 kg/ha and 80 kg/ha respectively as farmers practice of farmers of that community. Each treatment was replicated in 10 farmers' field on 400 sq m area in a randomized block design. Observation parameter for the trial that were recorded on degree of incidence of late blight (%), plant height (cm), number of tubers per plant, tuber weight (g), tuber yield (q/ha) and economics of Potato cultivation. Statistical analysis for observed data was done (ANOVA) for getting final outcome in respect of yield and other parameters.

Results and Discussion

Data recorded clearly showed that potassium levels had a linear response of the crop to the levels of potassium from 10 kg/ha to 120 kg /ha (Table-1). Maximum tuber yield was obtained with potassium at 120 kg /ha (263.68 q/ ha) followed by that with potassium at 80 kg/ha (220.04 q/ha) and 10 kg/ha (180.60 q/ha). The control plot with potassium application at the rate of 10 kg/ha by local farmers had only 180.60 q/ha tuber yield. Similar increasing trend was also found for tuber weight, number

Table-1 : Effect of Different Levels of Potassium on Late Blight Incidence, Plant Growth and Tuber Yield in Potato.

Technology Assessed	Plant infected with late blight (%)	Plant height (cm)	Av. No. of tubers/plant	Av.tuber weight (gm.)	Tuber yield/ha	% increased over check
Farmers' practice (NPK 150:80:10 Kg/ha)	13.4	35.12	3.61	38.4	180.60	-
NPK 150:80:80 Kg/ha	10.4	36.64	4.18	43.0	220.04	21.83
NPK 150:80:120 Kg/ha)	6.7	40.42	4.14	49.31	263.68	46.00
CD (0.05)	1.24	1.53	0.31	2.65	7.55	-

Table-2 : Effect of Different Levels of Potassium on economics of Potato.

Technology Assessed	Cost of Cultivation, Rs./ha	Gross Return, Rs./ha	Net Return, Rs./ha	C:B ratio
Farmers practice (NPK 150:80:10 Kg /ha)	83400	220693	137293	2.64
NPK (150:80:80 Kg/ha	84370	268888	184518	3.22
NPK (150:80:120 Kg /ha)	85000	322416	237416	3.79
CD (0.05)			5455	-

of tubers per plant and plant height with significant difference between plots with and without potassium application. Pronounced effects of potassium levels on tuber yield of potato have also been reported by Upadhyay *et al.* (1987), Sharma and Sharma (1988), Trehan and Sharma (1998), Singh and Raghav (2000) and Chettri *et al.* (2002), Bishwoyog and Swarnima (2016), Haddad *et al.* (2016), Zelelew *et al.* (2016) and Bista and Bhandari (2019). Effect of potassium on tuber yield of Potato is also reported by Yakimenko and Naumova (2018) and Otieno & Mageto (2021). Potassium application plays significant role in increasing yield of potato tubers which is either due to formation of large sized tubers or increasing number of tubers per plants or both by helping in accumulation of carbohydrate. There is low replenish and high loss of Potassium by leaching in soil and shows widespread deficiency in intensively potato growing areas. Therefore, careful attention should be given in Potassium fertilization to maximize the quality and yield of potato tuber. Higher tuber yield was associated with low infestation of late blight indicating higher tuber yield at higher level of potassium dose possibly because low damage of the crop by late blight (Huber and Army, 1985; Chettri *et al.*, 2002 and Kowalska and Drozdzyński, 2018) although more biomass development in terms of plant height, leaf area, leaf area duration etc. At higher level of potassium, it might be the secondary cause of high tuber yield as was confirmed by Reddy *et al.* (1986) and Saika *et al.* (1987). It was also reported by Nelson (2008) that potassium fertilizer can hold to grow seedling that are more resistant to fungal disease and some insect pest. The beneficial influence of higher level of potassium on tuber yield might also be indirectly through increased nitrogen uptake efficiency of the Crop (Sharma and Sharma, 1990; Trehan and Grewal, 1991). Based on cost benefit ratio application of 120 kg of potassium was found the most beneficial. It was evident from the above findings that higher potassium levels increased the tuber yield in potato by enhancing the

resistance of the plants to late blight, biomass and photosynthetic efficiency and uptake of nitrogen. With regards to morphological appearance of tubers those harvested from plots with higher potassium levels (80 kg/ha and 120 kg/ha) were lustrous in colour, smoothed surface and bulky in Size.

Based on findings of above experiments it is obvious that application of 120 kg potassium per hectare along with 150 kg of nitrogen and 80 kg phosphorus that generally farmers use could be effective in controlling foliar diseases viz., late blight and increasing the tuber yield in potato for remunerative tuber yield and to avoid losses due to epidemic diseases in Giridih district of Jharkhand. Table 2 clearly shows that the economics of potato cultivation with higher dose of Potassium (120 kg K /ha) could fetch maximum net return (Rs.237416/ha) and CB ratio (3.79) as compared to other treatments.

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Himalayan Climate Tree Rudraksha (*Elaeocarpus ganitrus* Roxb.) : A god gift for human beings-A Review

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Abstract

Rudraksha (*Elaeocarpus ganitrus* Roxb.) is a valuable and magical tree in Himalayan region in India and Nepal also in in Gangatic plain belong to the family Elaeocarpaceae. Rudraksha beads have been traditionally used in India and other Asian countries. Rudraksha beads are catalogued depending on the number of "Mukhis" or faces. A single Rudraksha tree bears beads in all different faces or mukhis at the same time. The higher Mukhis or faces are very rare. The environment and location of Rudraksha tree plays a major role in the bead formation and the type of beads according to Mukhis. Himalayan beads seem powerful due to the suitable environment of Himalayan region. Therefore, it is a certainty that climate and specifically the location of Rudraksha tree play a key role in their growth and quality of bead development. Different parts (Beads, Bark and Leaves) of Rudraksha have several traditional uses and ayurvedic properties. Therefore, Rudraksha have a remarkable position in Hinduism and Ayurveda, the indigenous system of medicine. Ayurvedic texts categories Rudraksha fruits as thermogenic, sedative, cough alleviator and are useful for the treatment of bronchitis, neuralgia, cephalalgia, anorexia, migraine, manic conditions and other brain disorders, that is Rudraksha have several spiritual and medicinal values. Hindu mythology believes that, anyone who wears Rudraksha beads get the mental and physical prowess to get spiritual illumination. Present review provides a scientific basis for properties and uses of *Elaeocarpus ganitrus* Roxb.

Key words : Rudraksha , *Elaeocarpus ganitrus*, Mukhis, Spiritual and pharmacological properties

Introduction

Rudraksha (*Elaeocarpus ganitrus* Roxb.) have somatic chromosome number ($2n=50$) is an evergreen tree raise in tropical and subtropical regions at the eminence raising from seacoast to 2000 meters above the sea level [1]. Rudraksha cultivate in the area from the Gangetic plain in foothills of the Himalayas to south-East Asia, Indonesia, New Guinea to Australia, Guam and Hawaii. Rudraksha tree flourish on mountains and hilly regions of Nepal, Indonesia, Java, Sumatra and Burma [2].

Systematic Position :

Kingdom - Plantae

Division – Phanerogams

Subdivision – Angiospermae

Class – Dicotyledonae

Order – Oxalidales

Family – Elaeocarpaceae

Genus – Elaeocarpus

Species – ganitrus

Botanical Name – *Elaeocarpus ganitrus* (Roxb.)

Common Name – Rudraksha

The word Elaeocarpus is derived from Greek word "Elaeo" means Olive and "Carpus" means fruits i.e Olive

like fruits. *Elaeocarpus ganitrus* usually known as Rudraksha in Sanskrit and Rudraki in Hindi.

The word Rudraksha is derived from two words Rudra and Aksha. Rudra means Lord Shiva and Aksha means eyes. That is one who is capable of looking at and doing everything. Rudraksha also called blueberry beads are covered by an outer shell of blue colour on fully ripening [3]. According to ancient scriptures and legends, Lord Shiva wanted to kill demon named Tripura to free the Devas from him in order to defeat him, lord Shiva needed a weapon named Kalagni. Lord Shiva kept his eyes closed for many years to acquire this weapon. When he opened his eyes, drops of tears fell on the surface on earth. These drops created MahaRudraksha.

According to "Shiv Purana" Lord Shiva once went into deep meditation for the health and prosperity of all living being. When he awakens, he opened his eyes and tear drops fell on the earth. These tear drops carved out the form of seeds that later on emerges as the Rudraksha tree.

"Rudraksha Daan (donation) is the best donation among all" [1]. *Elaeocarpus ganitrus* is a large evergreen broad-leaved tree. The tree of Rudraksha is about 50-200 feet long and possess cylindrical trunk with a greyish white and rough textured bark. The diameter of trunk is up to 1.22 Meter the morphological and organoleptic examination [4,5] demonstrates that Rudraksha leaves

are simple, shining green on the upper side with a dull leathery on the dorsal side. Inflorescence racemose, the flowers of Rudraksha are hermaphrodite, white with bristling 5 petals. Petals are sepaloid with entire lobed or fimbriate margins. Stamens 11-80, Stamens without awns but with a seta at tip. Ovary with 3-9 loculi each with 4-6 ovules. Fruit – Drupes or Berry. Seed or Bead—Stone [6,7,8]. Fig.-1.

The Rudraksha trees are very tall and endure small white colored sweet-smelling flowers on blooming in the rainy season. These flowers turn into black berry like fruits, which on ripening yield brownish red colored seeds. The tree is annual i.e. grows throughout the year. Rudraksha is germinating in subtropical climate area with temperature ranges of 25-30 degree centigrade. These trees start giving fruit after 7 years. Fruits appear in June and grow up by August-October. The bead formation and the type of bead formed depends on the environment and location of Rudraksha tree, e.g. The Himalayan beads looks larger, heavier and more powerful due to the environment they grow in.

Rudraksha has been adored in almost all ancient ayurvedic texts for its extra ordinary medicinal properties. It is ethnomedicinally important tree and possesses ameliorating pharma logical properties which have been used for the treatment of various ailments.



Fig.-1

Traditional, Medicinal and Scientific Values of Rudraksha :

Different parts (beads, bark and leaves) of Rudraksha are used for the treatment of diverse ailments as well as may be worn either on arm, wrist or other parts of the body. The several traditional (Fig. 2.) medicinal and scientific values of Rudraksha are as following [9,10,11]

For improving memory power: Milk boiled with four or six faced Rudraksha seed is excellent remedy for mental disorders. This also assists in enhancing memory.

For Blood Pressure: Five mukhi Rudraksha keeps blood pressure normal. Rudraksha is a best medication for curing H.B.P. (High blood pressure).

Sure, shot remedy for conceiving baby: One

rudraksha and one karsa (10 gm) of Sarpa'kshi (Ophiorrhizamungos) can be cooked together and pestled in the milk of one colored cow. Consumption of it during the menstrual period will bestow even a sterile woman conceive - Damara Tantra.

Alleviator of heaviness, tongue cracks and tastelessness: Gargling with Rudraksha decoction is beneficial in heaviness, tongue cracks and tastelessness.

Curing all brain disease: All brain disorders can be recovered with four faced Rudraksha remedy.

Neutrizer of brain fever: Consumption of overnight kept water of Rudraksha in earthen pot on an empty stomach can get rid of brain fever.

For Hysteria and Coma: Elaeocarpus ganitrus is also a good assistance for panic conditions of hysteria and coma in woman.

For Frequent fever: Rudraksha is also good for children's who suffers from frequent fever.

Imparts calmness to mind: It cools down the body temperature and brings calm to mind.

Controlling anxiety: A person grieves from anxiety should keep big size Panchmukhi Rudraksha with themselves and during nervousness; they should hold them tightly in their right palm for ten minutes. It will assist them to get back their confidence. To Ward off evil spirits and omens : The Rudraksha fruits were employed to defend from evil spirits in traditional Indian medicinal system.

As blood purifier and general tonic: Rudraksha can be taken as a medicament for blood purification and powers the body substance. Regular consumption as a quath in conjunction with honey purifies blood and works as general tonic.

Curing breathing problems or cough: A quath made by mixing beads of Rudraksha, bark of adusa and harad, in equal amount can be consumed with honey. The concoction of ten-faced Rudraksha with milk mitigates recurrent cough.

For getting good sleep: Rudraksha shall be keep under pillow and preparation of its bead in the milk shall be applied on the eye lid for getting better sleep. Rectifier of chicken pox or small pox: Equal proportion of black pepper and *Elaeocarpus ganitrus* should crushed together and taken with stale water alleviate the problem of small pox.

Burn Pox or Marks alleviator: The five-faced Rudraksha is the foremost remedy for burn or pox marks on face. It can be used as a panacea for skin diseases, ringworms, sores, pimples and boil also.

Different types of Rudraksha Beads and their benefits associated with number of Mukhis and ruling God: [9,10]

Rudraksha 's Shape	Mukhi	Ruling God	Therapeutic potentials and other Benefits
	1 Mukhi	Shiva	Medicament for diseases like mental anxiety, heart problems, eye problems, TB, paralysis, bone pain, etc. Enlightens the super-consciousness and provides improved concentration.
	2 Mukhis	Ardhnareshwar	Implausible treatment of ailments like chronic asthma, renal failure, impotency, stress, anxiety, depression, eye problems, negative thinking, mental chaos, lack of concentration, hysteria, intestinal disorder etc. Blesses the wearer with 'UNITY'.
	3 Mukhis	Agni	Sure, shot remedy for the diseases like depression, schizophrenia, blood pressure, jaundice, mental disability, fever or weakness, directive of the menstrual cycle/ menstrual stress, mood swings, etc.
	4 Mukhis	Brahma	Provides medication for diseases like blood circulation, asthma, memory lapse, cough respiratory strip problems, and brain linked illness, etc. The wearer bestows power of creativity, enhances memory power and intelligence.
	5 Mukhis	Kalaagni	For treating medical conditions like blood pressure, diabetes, piles, stress, displeasure, mental disability, as well as neurotic, heart and maladjustment problems etc.
	6 Mukhis	Kartikeya	Counter measure for the ailments like gynecological problems, epilepsy etc. Defends from emotional trauma of wordy sorrows and imparts wisdom, learning and knowledge.
	7 Mukhis	Mahalaxmi	Extraordinarily works for treating diseases like asthma, impotency, pharyngitis, respiratory confusion, foot related diseases, pains and aches etc. Beneficial for peoples who are suffering from finance and mental set-up.
	8 Mukhis	Ganesh	Provides cures for medical conditions like stomach ache, skin diseases, stress, anxiety etc. Get rid of all obstacles and affords success in all undertakings
	9 Mukhis	Durga	Works as a mystical therapeutic agent for treating strange diseases. Wearer is harbored with lot of energy, powers, dynamism and fearlessness.
	10 Mukhis	Vishnu	Alleviates discomforts like mental insecurity, hormonal inequality in the body, whooping cough etc. It does a job like a shield on one's body and kicks evils away.
	11 Mukhis	Hanuman	Provides relief from body pain, backache and recovers from chronic alcoholism and liver diseases. Blesses wearer with wisdom, right judgement, fearlessness and success.
	12 Mukhis	Sun	Medically it is more valuable for ameliorating discomforts of bone diseases, osteoporosis, rickets, mental disability, anxiety etc. Wearer gains the strength of sun to rule and to move continuously with brilliant radiance. Boosts self image and motivation.
	13 Mukhis	Indra	Used for treating muscle dystrophies. It gives honor and fulfills all the earthly desires.

Different types of Rudraksha Beads and their benefits associated with number of Mukhis and ruling God: [9,10]

Rudraksha 's Shape	Mukhi	Ruling God	Therapeutic potentials and other Benefits
	14 Mukhis	Hanuman	It provokes the sixth sense organ by which the wearer foresees the forthcoming happenings.
	15 Mukhis	Pashupati	Skin diseases, recurring miscarriage, still birth etc can be cured.
	16 Mukhis	Hari And Shankar	Taken as a curative agent for the diseases like leprosy, cor-pulmonale, tuberculosis, lung diseases etc.
	17 Mukhis	Lord Viswakarma	Excellent for handling conditions like memory lapse, body functional disorders etc.
	18 Mukhis	Bhairav	Prevent ailments like loss of power, mental inharmonization etc.
	19 Mukhis	Vishnu Narayan	Exterminate the disorders of blood, spinal cord etc.
	20 Mukhis	Narayan	Taken as nullifier for problem of eyesight and snake bites.
	21 Mukhis	Ganesh	Possesses built-in medical healing and it eradicates every form of diseases.
	Gauri Shankar	Shiva and Parvati Two Naturally Joined Rudraksha	Works for the medication of problems related to sex and behaviour.
	Trijuti/ Tribhagi	Brahma Three Naturally Joined Rudraksha	Trijuti Rudraksha is supreme for keeping internal as well as external body disorders at bark.

Epilepsy management: Pulverized bark of Rudraksha tree and pulp of fruit or the bead can be used.

For curing Piles: Rudraksha bead in combination with triphala churna and guggul or with root of kaneer is beneficial for treating piles.

Counter measure for jaundice, liver related problems or stomach ache: Rudraksha, chitrak, harad, devdaru, giloy, daruhaldi, dharangi and punarnava shall be taken in equal proportion and

regular consumption of it as a quath is an important medicine.

Nullifying poisonous effects caused by bites of insects: Panchamukhi Rudraksha can be grinded with lemon juice on a stone and the application of this paste on the affected spot will subside pain.

Conclusions

Rudraksha (*Elaeocarpus ganitrus* Roxb.) is an evergreen tree and grows in the Himalayan region climate. Therefore birth place or motherland of Rudraksha in mountains of

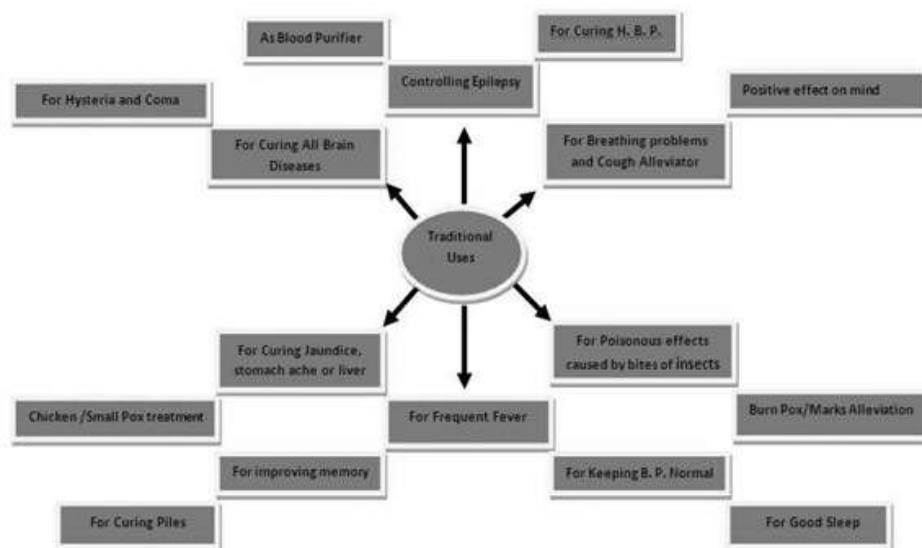


Fig.-2

Himaylas. It has important position in Hindu religion and in Ayurveda. Fruits (beads) of the plant are wearing by Hindu mystics as necklaces and in their daily worship for purpose of counting prayers and various magical properties are recognized to them. Rudraksha used in folk medicine in treatment of stress, anxiety, depression, palpitation, nerve pain, epilepsy, migraine, lack of concentration, asthma, hypertension, arthritis and liver diseases. All over the world scientific research is getting momentum to evaluate the pharma logical activities, side effects and medicinal uses of *Elaeocarpus ganitrus* against different diseases on the basis or various *in vitro*, experimental and clinical researches. Therefore, Rudraksha is the king of herbal medicine working effectively and positively and have many spiritual and medicinal values both as defensive and remedial. Hence, Himalayan climate tree Rudraksha (*Elaeocarpus ganitrus* Roxb.) is a God gift for human beings.

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Impact of Climate Smart Production Technologies and Practices in Soybean (*Glycine max* L.) through Frontline Demonstrations in Dhar District of Madhya Pradesh

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Abstract

A study was carried out to analysis the yield gaps and economics in soybean (*Glycine max* L.) through frontline demonstrations by Krishi Vigyan Kendra, Dhar, Madhya Pradesh at tribal farmers' fields of Dhar district for productivity enhancement and livelihood security. The highest yield (1770 kg/ha) of soybean was recorded in recommended practice whereas the minimum yield (1244 kg/ha) was recorded in farmers' practice under rainfed conditions during the year 2020-21. An increase of 42.52% in yield with demonstration over farmer's practice was recorded. The technological gap (430 kg/ha), extension gap (526 kg/ha) and technological index (19.54%) was recorded under frontline demonstrations. The maximum average gross monetary returns (Rs. 79668/ha), net monetary returns (Rs. 49038/ha and profitability (2.60) was recorded under demonstration over farmer's practice gross monetary returns (Rs. 55980/ha), net monetary returns (Rs. 31530/ha and profitability (2.29) during 2020-21. The maximum yield was recorded in demonstration plots over local check due to adoption of innovative knowledge and full package of practices.

Key words : Extension gap, technology transfer, yield, front line demonstrations, technology index and economics

Introduction

Soybean [*Glycine max* (L.) Merill] is one of the important rainfed leguminous oilseed crops of central India particularly in Madhya Pradesh. Soybean ranks first amongst oilseed crops in the world as well as in India. It is also widely grown in Maharashtra and Rajasthan as a sole or intercrop with pigeon pea, maize and cotton (Singh *et al.*, 2002). In India, it is cultivated on an area of about 12.81 million hectares, which is likely to produce more than 12.90 million tonnes with productivity 1007 kg/ha during the year 2020-21 (Anonymous, 2021). Madhya Pradesh (6.50 million hectare), Maharashtra (4.36 million hectare) and Rajasthan (1.13 million hectare) constitute the major niche for the cultivation of soybean crop. Soybean is a major legume crop having two major quality characters viz. protein and oil. Soybean is known as 'miracle bean' rich in protein (40%) and moderate in oil (18-22%). Soybean has become popular because of its wider adaptability for soil, climate and food composition value. Madhya Pradesh is known as "Soya State of India". It has the potential to bridge the gap between the supply and demand of edible oil and protein. The crop has shown enormous growth in area and production in India during recent past and has come out as one of the noteworthy *kharif* crop in Central India.

Soybean is a major *kharif* oilseed crop for income generation and livelihood of tribal farmers in Dhar district of Madhya Pradesh. Majority of soybean area i.e. 3.10

lakh hectares which is about 75% of the total cultivable area of Dhar district mostly grown under rainfed conditions but due to non-availability of quality seed of improved varieties and poor adoption of scientific cultivation practices in the district, productivity (1200 kg/ha) of soybean is far below the potential yield (2000 kg/ha). For the sustainable production of soybean, numbers of technologies are available but farmers' perception towards adoption of good agricultural practices is very poor and they are still practicing the unscientific methodologies. To sustain production of soybean, several steps were taken. In this regard, to sustain the potential production and consumption system, the Indian Institute of Soybean Research, Indore had sanctioned the project "Frontline Demonstrations on oilseeds under Tribal sub Plan" to RVSKVV, Gwalior. The basic strategy of the Mission is to promote and extend improved technologies along with capacity building of farmers.

In view, the aim of frontline demonstrations is to identify the production constraints of the technology and extension gap in soybean through various extension methods and technologies. To boost the production and productivity of soybean with implementation of latest and specific technologies in tribal areas of the state, Krishi Vigyan Kendra, Dhar has promoted and extended improved technologies with quality seed, balance use of fertilizers, nutrient management, integrated pest management, land configuration along with capacity building of tribal farmers.

Materials and Methods

A study was carried out in *kharif* during 2020-21 by the KVK, Dhar of Madhya Pradesh. The demonstrations were conducted in tribal farmers' fields of four different tribal villages of Sardarpur block of Dhar district. Farmers were trained to follow the package and practices for soybean cultivation as recommended by the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) and need based critical inputs and technical support were provided to the beneficiaries by KVK (Table 2). In case of local check, the traditional practices were kept by using existing variety (JS 335). An area of 20 hectare was covered with plot size 1.0 acre under front line demonstration with active participation of 50 farmers during 2020-21. High yielding improved variety RVS 2001-4 (duration 95-105 days) which has two to three bold seeds in a pod and resistant to Yellow Mosaic Virus (YMV) depending on the environmental condition were grown with recommended practice. Before conducting trials, a baseline survey was conducted to know the basic needs of farmers and a list of farmers was prepared through group meeting and interface. As per the needs, specific skill training was imparted to the targeted farmers.

Frequent visits to farmers' fields with the extension functionaries was arranged at demonstration plots to disseminate the message at large scale. The beneficiaries were timely facilitated by KVK scientists to perform field operations during the course of training and visits. The traditional practices were carried out as farmers used to do earlier. The yield obtained from demonstrations and potential yield of the crop was compared to estimate the yield gaps which were further categorized into technology index and technology gap. The data were recorded from both FLD plots as well as control plots. Finally the extension gap, technology gap, technology index along with the benefit cost ratio were worked out with the help of formula as given by Samui *et al.*, (2000) as described below :

Technology gap = Potential yield - Demonstration yield

Extension gap = Demonstration yield - Farmer's yield

Technology index (%)

$$= \frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \times 100$$

Results and Discussion

Results pertaining to the demonstrations indicated that the improved cultivation practices comprised with the use of improved variety (RVS 2001-4), line sowing, balanced application of fertilizers and control of pest at economic threshold level following integrated pest management

practices increased the yield and profitability. The maximum number of branches (5.6) and pods per plant (61) were recorded in demonstrations as compared to farmers' practice (branches 4.2) and pods (45) during the study, respectively (Table-5). Yield parameters enhanced with inclusion of improved package of practices under demonstrations over existing farmers practice as shown in Table 3. Results revealed that performance of soybean productivity was comparatively much higher in the demonstrated plots than the farmers' practice. The demonstration plot with high yielding variety recorded an average yield of 1770 kg/ha whereas plots with local variety produced average yield of 1244 kg/ha. The demonstration plots registered 42.52% more yield over local practices. Similarly, yield enhancement in different crops in front line demonstrations were documented by Singh *et al.*, (2019) and Yadav *et al.*, (2020). The results clearly indicated the positive effects of FLDs over the existing practices toward enhancing the productivity of soybean (Table-3).

The extension gap was also recorded in an increasing trend. The extension gap 526 kg/ha of study also emphasizes that there is need to educate the farmers through various means for adoption of improved practices to reverse the trend of wide extension gap. The trend in technology gap (430 kg/ha) reflects the farmers' cooperation in carrying out such demonstrations with encouraging results in subsequent years. The performance study of the technology demonstrated was found to be better than the farmers' practice under the same environment. The farmers were trained and motivated by seeing the results in terms of productivity and income. They are now embracing the climate resilient soybean variety *i.e.* RVS 2001-4 by adopting good agricultural practices. The feasibility of technology is confirmed by the lower value of technology index. As such fluctuation in technology index (19.54%) may be attributed to the dissimilarity in soil fertility status, weather conditions, non-availability of water and insect pest attack in the crop during the study period in certain region.

The maximum average gross monetary returns (Rs. 79668/ha), net monetary returns (Rs. 49038/ha and profitability (2.60) was recorded under demonstration over farmer's practice gross monetary returns (Rs. 55980/ha), net monetary returns (Rs. 31530/ha and profitability (2.29) during 2020-21. The maximum yield was recorded in demonstration plots over local check due to adoption of innovative knowledge and full package of practices. Hence, favourable benefit cost ratio proved the economic viability of the interventions and convinced the farmers on the utility of interventions. These results are in conformity with Saikia *et al.*, (2018), Singh *et al.*, (2019) and Yadav *et al.*, (2020).

Table-1 : Comparison of practices between demonstration and local control (farmers' practice) in soybean.

Particulars	Demonstration	Farmers' Practice
Farming situation	Rainfed	Rainfed
Variety	RVS 2001-4	JS-335
Time of sowing	18 June to 05 July	18 June to 05 July
Method of sowing	Line sowing	Line sowing
Seed rate	75 kg/ha	120 kg/ha
Fertilizer as per STV	NPK 25:60:40:20 kg/ha	NPK 18:46:00 kg/ha
Seed treatment and inoculation	With Carboxin 17.5 + Thiram 17.5 @ 2.5 ml/kg of seed and inoculation with Rhizobium and PSB @ 5 g/kg of seed	Nil
Weed management	Post-emergence herbicide (Imazethapyr 10% SL)	Hand weeding
Plant protection	Need based application of insecticide (Betacyfluthrin+ Imidacloprid, Thiacloprid)	Profenofos+cypermethrin
Time of harvesting	02-08 October	02-10 October

Table-2 : Critical inputs and technological packages distributed under front line demonstrations of soybean.

Year	No. of demonstrations	Variety	Technology demonstrated	Need based input distributed
2020-21	50	RVS 2001-4	Improved variety, seed treatment, inoculation, NM, WM and IPM	Improved seed (75 kg/ha), soil testing, seed treatment with Carboxin 17.5+Thiram 17.5 @ 2.5 ml/kg of seed and inoculation with Rhizobium and PSB @ 5 g/kg of seed, Imazethapyr 10 % SL @ 1 lit/ha, Betacyfluthrin+ Imidacloprid for white fly and caterpillar, Thiacloprid for girdle beetle, on and off campus trainings, field day and exposure visits

Table-3 : Productivity, technology gap, extension gap and technology index under recommended and farmer practices.

Year	Variety	No. of demonstrations	Seed yield (kg/ha)			% increase over control	Technology gap (kg/ha)	Extension gap (kg/ha)	Technical index (%)
			Potential	FLD	FP				
2020-21	RVS 2001-4	50	2200	1770	1244	42.52	430	526	19.54

Table-4 : Comparative study of economics of demonstrations and farmer practices.

S. No.	Village covered	Block	No. of farmers	Area (ha)	Cost of cultivation (Rs./ha)		Gross monetary return (Rs./ha)		Net return (Rs.)		B:C ratio		Additional returns (Rs./ha)
					Demo.	FP	Demo.	FP	Demo.	FP	Demo.	FP	
1.	Bagpipliya, Moregaon, Bhilkhedi and Nayapur	Sardarpur	50	20	30630	24450	79668	55980	49038	31530	2.60	2.29	17508

*Rate of soybean in the Mandi (APMC) of Dhar was Rs 4500/q during 2020-21.

Table-5 : Yield attributing characters.

S. No.	Year	Crop	Yield attributing characters					
			Pods/plant		Branches /Plant		Seed weight (100 seed)	
			Demonstration	FP	Demonstration	FP	Demonstration	FP
1.	2020-21	Soybean	61	45	5.6	4.2	11.95	10.45

Conclusions

It is concluded that the technology gap can be reduced to a considerable extent by sowing of high yielding climate resilient soybean variety viz. RVS 2001-4 and adoption of scientific methods of cultivation to increase productivity of soybean. It was observed that potential yield can be achieved by imparting scientific knowledge to the tribal farmers, providing the quality seed material, timely availability of critical inputs and their proper utilization. Horizontal expansion of improved technologies may be achieved by organizing such demonstrations and

implementation of various extension activities like training programme, field days, exposure visit *etc.* at the farmers' fields. The trend of technology gap reflected the farmers' cooperation in carrying out demonstrations with encouraging results in subsequent years. Moreover, extension institutes like Krishi Vigyan Kendra in the district may play the lead role in providing proper technical support for welfare of the farming community through organizing different educational and extension activities and also may reduce the extension gap for better oilseed production and productivity in the district.

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Character Association and Path Coefficient Analysis for Seed Yield and Yield Contributing Traits in Sesame (*Sesamum indicum* L.)

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Abstract

The present investigation was conducted to estimate the character association and path analysis in thirty-five sesame genotypes for yield and yield contributing traits. The values of genotypic correlation, in general, were higher as compared to the corresponding phenotypic correlation, indicated that there was a high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. Seed yield per plant was found to be significantly and positively correlated with number of capsules per plant, number of branches per plant, biological yield per plant, number of seeds per capsule, days to maturity, 1000 seed weight and harvest index at both the genotypic and phenotypic levels. The phenotypic path coefficient analysis revealed that biological yield per plant and harvest index exhibited high and positive direct effect on seed yield per plant. The characters, number of capsules per plant, height to first capsule, number of seeds per capsule, number of internodes per plant, length of capsule, oil content and 1000 seed weight had low to very low positive direct effects on seed yield per plant. Hence, biological yield per plant, harvest index, number of capsules per plant, number of seeds per capsule and 1000 seed weight had positive significant correlation and direct effect with seed yield per plant. Thus these traits may be good selection criteria for seed yield.

Key words: Character association, path coefficient analysis, sesame

Introduction

Sesame (*Sesamum indicum* L., Family Pedaliaceae), also called til and gingelly, is one of the oldest cultivated oilseed crops. The name sesame derives from the Arabic word "simsim". Sesame is an important oilseed crop successfully grown in tropical and sub-tropical climates. Sesame is usually rich in oil (50 %) and protein (18-20 %), 13.5% carbohydrate and 5% ash. Approximately 78% of the sesame seed produced in India is allocated for oil extraction, while around 2.5% is used for planting purposes. The remaining portion is utilized in confections and for religious Hindu ceremonies. Sesame seeds and oil are also used extensively in India. In most parts of the country, sesame seeds mixed with heated jaggery, sugar, or palm sugar are made into balls and bars similar to peanut brittle or nut clusters and eaten as snacks. Sesame seed oil has long shelf life due to the presence of lignans (sesamin, sesamol, sesamolin), which have remarkable antioxidant functions, resisting oxidation. Sesame is mainly cultivated for its seeds and oil. It had earned the poetic label "Queen of Oilseeds" as its oil and protein are of very high in quality. Globally, the sesame is grown in an area of 12 million ha with a production of 6.3 million tonnes and productivity of 508.1 kg/ha (FAOSTAT, 2021). In India, area and production under sesame were 1.722 million ha and 0.816 million tonnes, respectively with an average productivity of 474 kg/ha (Anon., 2021).

Yield is the outcome or end product that is obtained from the combined effects of various morphological, physiological, and biological components. To formulate an effective selection technique for increasing the yield, the association analysis among yield and yield contributing characters are important. The magnitude and direction of the association of yield components with yield will help us to programme our selection technique. Phenotypic and genotypic correlation coefficient and the yield components and their contribution in path analysis provide information on their relative importance in determining the yield (Dewey and Lu, 1959). Path analysis is standardized partial regression analysis, which further permits the partitioning of correlation coefficient into components of direct effect and indirect effect of independent variable on dependent variable (Wright, 1921) with this background, the present investigation is contemplated with the following objectives 1. To assess the genotypic and phenotypic correlation in the sesame genotypes. 2. To differentiate the yield traits and assess their direct and indirect effects for selection in sesame.

Materials and Methods

A field experiment was conducted at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during *summer* season of 2022 in randomized block design with

three replications by using thirty-five genotypes of sesame (*Sesamum indicum* L.) by involving sixteen quantitative characters. Each entry was accommodated in a single row of 3 m in length with a spacing of 30 x 10 cm. Phenotypic and genotypic correlation coefficients were worked out to study the interrelationship between various pairs of characters as suggested by Al-Jibouri *et al.* (1958). The path coefficient analysis was conducted using the formula established by Dewey and Lu (1959).

Results and Discussion

The phenotypic and genotypic correlation coefficients for 16 characters in sesame genotypes were calculated and their significance was tested at 5% and 1% levels of significance. The results are presented in Table 1. In general, genotypic correlation coefficients were higher in magnitude than the phenotypic correlation coefficient. This indicated that although there is strong inherent association between the various pairs of characters studied the low phenotypic correlation would result from the masking and modifying effects of the environment plays a significant role in influencing the association of characters at the gene level. The characters, seed yield per plant was found to be significantly and positively correlated with number of capsules per plant, number of branches per plant, biological yield per plant, number of seeds per capsule, days to maturity, 1000 seed weight, harvest index at both the genotypic and phenotypic levels. Similar results for one or more of these characters were also reported by Khairnar and Monpara (2013), Hika *et al.* (2014), Abate *et al.* (2015), Bamrotiya *et al.* (2016), Saxena and Bisen (2016) and

Patel *et al.* (2023). Further, the seed yield per plant also registered positive but, non-significant correlation with width of capsule, plant height, length of capsule, number of internodes per plant, days to 50 per cent flowering and protein content. Seed yield per plant expressed non-significant and negative correlation with oil content and height to first capsule.

The yield components displayed diverse patterns of association among each other. Days to 50 percent flowering had highly significant and positive association at both genotypic and phenotypic levels with days to maturity and height to first capsule and significant and positive association with plant height at genotypic level. Days to maturity had highly significant and positive association with plant height, number of capsules per plant, biological yield per plant and significant and positive association with number of branches per plant, height to first capsule and number of internodes per plant at both genotypic and phenotypic levels. The plant height exhibited highly significant and positive correlation with number of capsules per plant, height to first capsule,

number of internodes per plant at both genotypic and phenotypic levels. Number of branches per plant had showed highly significant and positive correlation with number of capsules per plant and significant and positive correlation with biological yield per plant at both genotypic and phenotypic levels. Number of capsules per plant exhibited highly significant and positive correlation with biological yield per plant at both genotypic and phenotypic levels. Number of internodes per plant had significant and positive correlation with biological yield per plant at both genotypic and phenotypic levels. Length of capsule exhibited highly significant and positive correlation with number of seeds per capsule and significant and positive correlation with width of capsule at genotypic level. Width of capsule showed highly significant and positive correlation at genotypic level with number of seeds per capsule, biological yield per plant and significant and positive correlation at phenotypic level with number of seeds per capsule and biological yield per plant. Number of seeds per capsule exhibited significant and positive correlation at genotypic level with biological yield per plant. Significant and positive relationships among these pairs of characters indicated that the improvement in one will bring the improvement in another which, in turn automatically leads to increase in seed yield.

Path coefficient analysis was carried out to study the direct and indirect effects of different yield contributing characters on seed yield. The results of various causes influencing yield are presented in Table (2) and Fig (1). The phenotypic path coefficient analysis revealed that the biological yield per plant, harvest index exhibited high and positive direct effects on seed yield per plant and was found to be the most important yield component. The similar results for one or more characters were also obtained by Khairnar and Monpara (2013), Singh *et al.* (2020), Abate *et al.* (2021), Ahmed *et al.* (2022). The characters, number of capsules per plant, height to first capsule, number of seeds per capsule, number of internodes per plant, length of capsule, oil content and 1000 seed weight had low to very low positive direct effects on seed yield per plant. Days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, width of capsule, and protein content showed negative direct effect on seed yield per plant. As far as indirect effects are considered, the trait days to maturity, number of capsules per plant and number of branches per plant had high indirect effect on seed yield through biological yield per plant.

Path coefficient analysis revealed that the residual effect (0.2114) was low in magnitude indicated that the characters studied contributed 78 per cent of yield. It indicated that all necessary characters which contribute for seed yield per plant are included in this study.

Table-1 : Phenotypic (rp) and Genotypic (rg) correlation coefficients among different characters in sesame.

Characters	DFF	DM	PH	NBP	NCP	HTFC	NIP	CL	CW	NSPC	1000 SW	OC	PC	HI	BYP
SYP	r_g	0.0418	0.4941**	0.2773	0.5999**	0.7700**	-0.1436	0.1681	0.2760	0.2934	0.5095**	0.4873**	0.1348	0.4360**	0.5472**
	r_p	0.0481	0.4658**	0.2605	0.5823**	0.7472**	-0.1373	0.1564	0.2653	0.2699	0.4692**	0.4159*	0.1433	0.4270**	0.5370**
DFF	r_g		0.7480**	0.3609*	0.1036	0.3090	0.5535**	0.2060	0.1428	-0.0478	-0.4006*	0.1427	-0.1496	-0.2144	0.3086
	r_p		0.6534**	0.3266	0.0896	0.2658	0.4457**	0.1793	0.1363	-0.0519	-0.3296	0.1156	-0.1219	-0.1700	0.2570
DM	r_g			0.6617**	0.4173*	0.6780**	0.4369**	0.4084*	-0.0281	0.0803	-0.1846	0.2569	-0.1072	-0.0731	0.6055**
	r_p			0.5974**	0.3663*	0.6394**	0.3715*	0.3917*	-0.0291	0.0804	-0.1422	0.2215	-0.1079	-0.0625	0.5543**
PH	r_g				0.2593	0.4674**	0.6181**	0.5576**	-0.0731	-0.0585	-0.1663	0.1680	-0.1872	-0.0255	0.2972
	r_p				0.2438	0.4533**	0.5622**	0.5299**	-0.0797	-0.0472	-0.1621	0.1544	-0.1760	-0.0221	0.2760
NBP	r_g					0.7452**	-0.0220	-0.0799	-0.2265	0.1546	0.2618	0.0774	0.2107	0.1907	0.4191*
	r_p					0.6917**	-0.0084	-0.0805	-0.2011	0.1450	0.2134	0.0385	0.2124	0.1728	0.4111*
NCP	r_g						0.0768	0.1888	-0.0391	0.0116	0.1439	0.0235	0.0613	0.3165	0.4619**
	r_p						0.0624	0.1894	-0.0421	0.0097	0.1217	0.0315	0.0589	0.2976	0.4430**
HTFC	r_g							0.0389	-0.2920	0.1453	-0.5015**	0.1014	-0.1623	-0.3191	0.1120
	r_p							0.0340	-0.2538	0.0889	-0.4429**	0.0891	-0.1488	-0.2819	0.0872
NIP	r_g								0.0593	0.2892	-0.1706	0.2388	-0.2001	-0.2724	0.3975*
	r_p								0.0551	0.2593	-0.1422	0.2315	-0.1978	-0.2587	0.3725*
CL	r_g									0.3555*	0.5007**	0.1844	0.2071	0.0796	0.2158
	r_p									0.2960	0.4266*	0.1724	0.2010	0.0789	0.1965
CW	r_g										0.4437**	0.2131	0.1004	-0.2467	0.4889**
	r_p										0.3443*	0.1434	0.3060	-0.1826	0.4080*
NSPC	r_g											-0.0793	0.1781	0.1179	0.3569*
	r_p											-0.0746	0.1519	0.1302	0.3031
1000 SW	r_g												0.0171	0.2256	0.3130
	r_p												0.0236	0.1833	0.2775
OC	r_g													0.0256	-0.0332
	r_p													0.0238	-0.0360
PC	r_g													0.0857	0.0506
	r_p													0.0851	0.0597
HI	r_g														-0.4891**
															-0.5023**

* ** Significant at 5 and 1% levels, respectively [DFF: Days to 50% flowering; DM: Days to maturity; PH: Plant height (cm); NBP: No. of branches per plant; NCP: No. of capsules per plant; HTFC: Height to first capsule; NIP: No. of internodes per plant; CL: Length of capsule; CW: Width of capsule; NSPC: No. of seeds per capsule; 1000SW: 1000 Seeds weight (g); OC: Oil content (%), PC: Protein content (%), BYP: Biological yield per plant (g); HI: Harvest index (%); SYP: Seed yield per plant (g)].

Table-2 : Phenotypic path analysis of seed yield per plant and other component characters in sesame.

Characters	DFF	DM	PH	NBP	NCP	HTFC	NI	CL	CW	NSPC	1000 SW	OC	PC	HI	BYP	SYP
DFF	-0.0735	-0.0287	-0.0232	-0.0006	0.0386	0.0622	0.0059	0.0036	0.0002	-0.0265	0.0005	-0.0026	0.0028	-0.1478	0.2372	0.0481
DM	-0.0480	-0.0440	-0.0425	-0.0023	0.0929	0.0518	0.0129	-0.0008	-0.0002	-0.0114	0.0009	-0.0034	0.0025	-0.0543	0.5117	0.4658**
PH	-0.0240	-0.0263	-0.0711	-0.0016	0.0659	0.0784	0.0174	-0.0021	0.0001	-0.0130	0.0006	-0.0036	0.0041	-0.0192	0.2547	0.2605
NBP	-0.0066	-0.0161	-0.0173	-0.0064	0.1005	-0.0012	-0.0026	-0.0053	-0.0004	0.0171	0.0001	-0.0043	-0.005	0.1503	0.3794	0.5823**
NCP	-0.0195	-0.0281	-0.0322	-0.0044	0.1453	0.0087	0.0062	-0.0011	0.0001	0.0098	0.0001	-0.0037	-0.0014	0.2587	0.4089	0.7472**
HTFC	-0.0327	-0.0163	-0.0400	0.0001	0.0091	0.1395	0.0112	-0.0067	-0.0003	-0.0356	0.0003	-0.0048	0.0035	-0.2451	0.0805	-0.1373
NIP	-0.0132	-0.0172	-0.0377	0.0005	0.0275	0.0475	0.0329	0.0015	-0.0008	-0.0114	0.0009	0.0023	0.0046	-0.2249	0.3438	0.1564
CL	-0.0100	0.0013	0.0057	0.0013	-0.0061	-0.0354	0.0018	0.0264	-0.0009	0.0343	0.0007	0.0011	-0.0047	0.0686	0.1814	0.2653
CW	0.0038	-0.0035	0.0034	-0.0009	0.0014	0.0124	0.0085	0.0078	-0.0030	0.0276	0.0006	0.0012	-0.0072	-0.1588	0.3766	0.2699
NSPC	0.0242	0.0063	0.0115	-0.0014	0.0177	-0.0618	-0.0047	0.0113	-0.0010	0.0803	-0.0003	0.0022	-0.0079	0.1132	0.2797	0.4692**
1000 SW	-0.0085	-0.0097	-0.0110	-0.0002	0.0046	0.0124	0.0076	0.0046	-0.0004	-0.006	0.0039	0.0003	0.0029	0.1594	0.2561	0.4159**
OC	0.0134	0.0103	0.0176	0.0019	-0.0372	-0.0466	0.0053	0.0019	-0.0002	0.0122	0.0001	0.0144	-0.0006	-0.1005	-0.0333	-0.1412
PC	0.0090	0.0047	0.0125	-0.0014	0.0086	-0.0208	-0.0065	0.0053	-0.0009	0.0273	-0.0005	0.0003	-0.0234	0.0740	0.0551	0.1433
HI	0.0125	0.0027	0.0016	-0.0011	0.0432	-0.0393	-0.0085	0.0021	0.0005	0.0105	0.0007	-0.0017	-0.0020	0.8694	-0.4636	0.4270**
BYP	-0.0189	-0.0244	-0.0196	-0.0026	0.0644	0.0122	0.0123	0.0052	-0.0012	0.0243	0.0011	-0.0005	-0.0014	-0.4367	0.9230	0.5370**

* ** Significant at 5 and 1% levels, respectively, Phenotypic residual effect= 0.2114

[DFF: Days to 50% flowering; DM: Days to maturity; PH: Plant height (cm); NBP: No. of branches per plant; NCP: No. of capsules per plant; HTFC: Height to first capsule; NIP: No. of internodes per plant; CL: Length of capsule; CW: Width of capsule; NSPC: No. of seeds per capsule; 1000SW: 1000 Seeds weight (g); OC: Oil content (%); PC: Protein content (%); BYP: Biological yield per plant (g); HI: Harvest index (%); SYP: Seed yield per

Correlation analysis indicated that the characters viz., number of capsules per plant, number of branches per plant, biological yield per plant, number of seeds per capsule, days to maturity, 1000 seed weight, harvest index are inter correlated among themselves. Therefore these traits are to be given priority during selection for improvement of yield. Path analysis revealed that the trait biological yield per plant and harvest index had very high direct effect on seed yield. The present study revealed that the trait biological yield per plant, harvest index, number of capsules per plant, number of seeds per capsule and 1000 seed weight should be given more importance during selection programme for improving seed yield in sesame.

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Weed Management Practices Affect Weed Dynamics in Wheat (*Triticum Aestivum* L.)

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Abstract

A two-year field experiment was conducted at the Agronomy Farm, SK Rajasthan Agriculture University, Bikaner, Rajasthan, in arid climatic conditions in the *rabi* seasons of 2016–2018 with the effect of crop establishment and weed management on weed and yield of wheat and its residual effect on succeeding green gram in north western Rajasthan. Metsulfuron methyl 4.0 g ha⁻¹ 30 DAS + one hand hoeing 45 DAS and 2,4-D 0.5 kg ha⁻¹ 30 DAS + one hand hoeing 45 DAS were efficiently curbed the density and dry matter of broad leaved, narrow leaved and sedge weeds and attained the maximum weed indices *i.e.* weed control efficiency, weed control index, weed index, reduction in weed density and dry matter, agronomic management index, weed persistence index, crop resistance index, per cent management index and herbicide efficiency index. Maximum reduction in density and dry matter of weeds were in Metsulfuron methyl 4.0 g ha⁻¹ 30 DAS + one hand hoeing 45 DAS and 2,4-D 0.5 kg ha⁻¹ 30 DAS + one hand hoeing 45 DAS over weedy check treatment during 60 DAS and at harvest stage.

Key words : 2,4-D, metsulfuron, weed control efficiency, weed control index and agronomic management index.

Introduction

Wheat (*Triticum aestivum* L.) is the one of most important energy giving food across the globe (Meena *et al.* 2016). Wheat is second most important cereal crop after rice of India and grown under diverse agro-climatic conditions (Jat *et al.* 2005). Globally it contributes about 49 per cent of food grain production. In India, wheat is grown on 30.6 m ha with total production of 107 mt and average productivity of 3400 kg ha⁻¹ (IASRI, 2019). Infestation of weeds both annual and perennial is the important constraints in the low productivity of wheat. Weeds compete with crops for water, soil, nutrients, light and space; finally reduce crop yields (Das, 2008). Verma *et al.* (2008) reported infestation of weed throughout crop growth period caused 43.63 per cent reduction in grain yield of wheat. Weed is one of the major biotic constraints in wheat production.

Herbicides play an important role for weed control in close spaced crops like wheat, where manual or mechanical weeding is difficult (Yaduraju and Das, 2002). Chemical weed control preferred practices among farmer because not availability of labor at critical time, due to increase nuclear family migration of labor toward cities for wages so manual weeding became costly Singh *et al.* (2015). Manual weeding is laborious, time consuming, energy intensive and only possible on small scale and effective on annual weeds (Patro and Ray, 2016). Metsulfuron herbicide control mostly broad leaved weeds

and its directly inhibit the acetohydroxy acid synthase (AHAS) or acetolactate synthase (ALS) enzyme, which catalyses the synthesis of three branched amino acid, *e.g.* leucine, isoleucine and valine (Das, 2008). 2,4-D at 500 g ha⁻¹ alone or with one hand weeding is effective technique for minimize the BLWs weeds. 2,4-D is an “auxin mimic” or synthetic auxin. This type of herbicide kills the target weed by mimicking the plant growth hormone auxin (indole acetic acid), and when administered at effective doses, causes uncontrolled and disorganized plant growth that leads to plant death. It is believed to acidify the cell wall which allows the cells to elongate in an uncontrolled manner (Tu *et al.* 2001). Hence present investigation was carried out to “Weed Management Practices Affect Weed Dynamics in Wheat (*Triticum Aestivum* L.)

Materials and Methods

Field Experiment Site and Details : A field experiment was carried out during two consecutive *rabi* seasons of 2016–2017 and 2017–2018 at the Agronomy farm, (SK Rajasthan Agriculture University, Bikaner, India) to effect of crop establishment and weed management on weed and yield of wheat and its residual effect on succeeding green gram in north western Rajasthan. Strip plot design with four replication was used to the field experiment. The treatments consisting of four tillage, *i.e.*, Stale seed bed technique with shallow tillage, Stale seed bed technique with glyphosate 2.0 kg ha⁻¹, deep and conventional tillage,

and seven weed management, i.e., weedy check, weed free, one hand weeding at 30 DAS, 2,4-D 0.5 kg ha⁻¹, metsulfuron 4.0 g ha⁻¹, 2,4-D 0.5 kg ha⁻¹ + one hand weeding at 45 DAS, metsulfuron 4.0 g ha⁻¹ + one hand weeding 45 DAS. Stale seed bed using shallow tillage system included harrow carried out three week prior to planting, irrigated and left for weed germination. In SSB using glyphosate included harrow carried out three week prior to sowing, there after apply irrigation and left to weed germination. Two week after weed germination takes place therefore weeds killed by glyphosate and shallow tillage irrespective plot. Deep tillage plots were ploughed by tractor drawn disc plough followed by planking. Conventional tillage plots were ploughed by tractor- drawn two cultivator followed by planking. Weed management treatment post emergence herbicide applied with nap sack sprayer fitted with flat fan nozzle. Planting date was the same among main plots. Wheat variety Raj- 3077 was sown on 26th November in 2016, 29th November in 2017. Sowing was done manually by using a 100 kg ha⁻¹ seed rate with a rows spaced of 22.5 cm apart and 3.0 cm depth. The area of each plot was 13.5 m².

Soil Analysis : A field study was conducted during *rabi* seasons of 2016-17 and 2017-18 at Agronomy Farm (28.01°N latitude and 73.22°E longitude at an altitude of

234.7 M above mean sea level) of SKRAU, Bikaner. The soil was loamy sand, low in organic carbon (0.08 per cent) and available N (78 kg ha⁻¹) and medium in available P₂O₅ (22 kg ha⁻¹) and available K₂O (210 kg ha⁻¹) with pH 8.3.

Meteorological Observation and Cumulative Pan Evaporation :

The periodical mean weekly weather parameters for the period of the experimentation recorded at the meteorological observatory of the Agriculture research station, SKRAU, Bikaner. Daily and monthly mean values of climatic parameters namely, maximum and minimum temperatures, relative humidity, and rainfall were observed in observatory; however, cumulative pan evaporation was calculated daily with the open pan evaporimeter method. The maximum temperatures during 2016 and 2017 of the crop-growing period were 41.1 and 40.07°C; however, corresponding values for minimum temperatures were 4.1 and 3.8°C. The annual rainfall at the experimental site during the crop-growing period was no rainfall received during the first year of the experiment, but in the next years, 8 mm rainfall was received. The maximum and minimum relative humidity during the crop-growing period was 91.3 per cent and 15.9 per cent in 2016 and 82.4 per cent and 12.00 per cent in 2017, respectively.

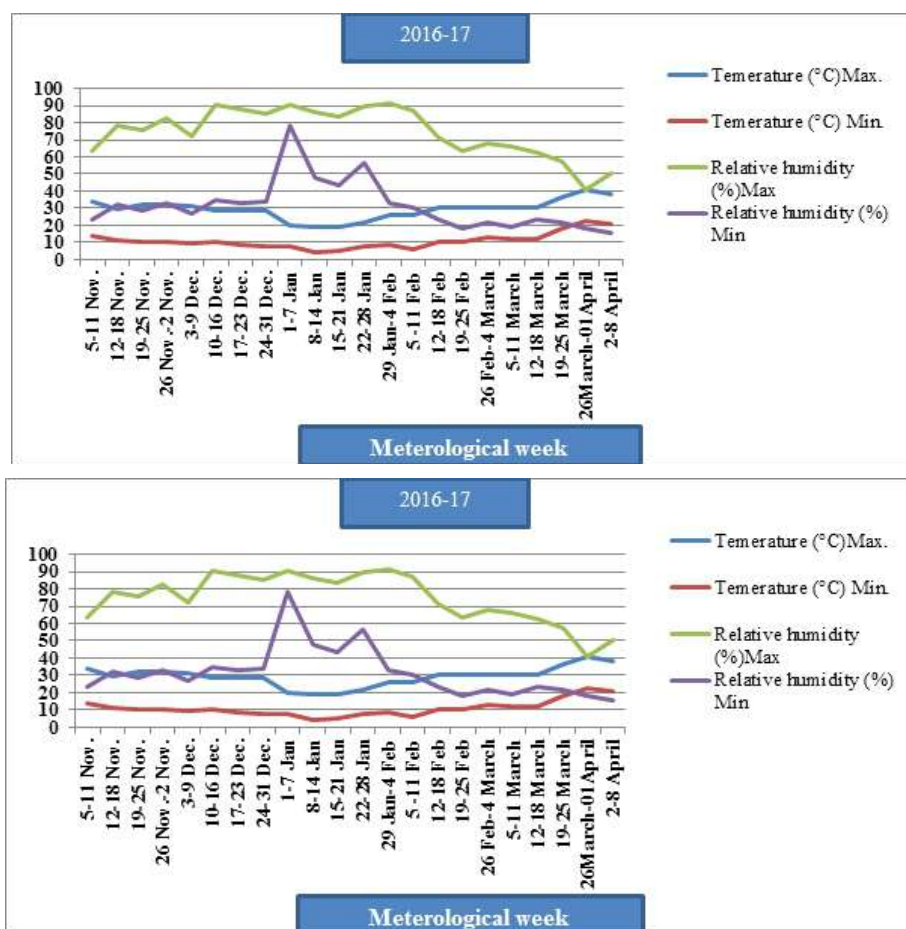


Figure-1 : Weather parameters during the crop growing period.

Water and fertilizer application : Water application by sprinkler system apply six to seven irrigation was applied by sprinkler method. A recommended dose of fertilizer 120 kg N ha⁻¹, 60 kg P₂O₅ ha⁻¹ and 40 kg K₂O ha⁻¹ was given through urea, DAP and MOP as a basal dose.

Analyses of Yield : The observations on yield were also recorded as per the standard method. Harvesting was done on 30 March 2017 and 05 April 2018. The seed and straw yield were recorded from the net plot area of each treatment.

Analysis of weed Studies : Weed density and dry matter:

Weed density (no. m⁻²) and dry matter of weeds (g m⁻²) were recorded by putting quadrat of 0.25 m² at two random samples in each plot.

Weed control index (WCI) : was calculated by using following formula given by Misra and Tosh, 1979.

$$WCI = \frac{WDMc - WDMt}{WDMc} \times 100$$

WDMc: weed dry matter in control plot, WDMt: Weed dry matter in treated plot

Weed control efficiency (WCE): Weed control efficiency is as derived by weed density per unit area and formula given by Mani *et al.* 1973.

$$WCE = \frac{WDc - WDt}{WDc} \times 100$$

WDc: Weed density in control plot and WDt: weed density in treated plot

Weed Index (WI) : Weed index is a derived parameter from the crop yields obtained across the treatments of weed control. (Gill and Vijaya Kumar, 1969).

$$WI = \frac{Y_{wf} - Y_t}{Y_{wf}} \times 100$$

Weed Persistence Index (WPI) : This index indicates the resistance in weeds against the tested treatments and confirms the effectiveness of the selected herbicide, and the same was computed using the given formula as suggested by Mishra and Mishra, 1997.

$$WPI = \frac{\text{Weed weight in treated plot}}{\text{Weed weight in control plot}} \times \frac{\text{Weed count in plot control}}{\text{Weed weight in treated plot}} \times 100$$

Weed management index (WMI) : This index is the ratio of yield increase over the control because of weed management and percent control of weeds by the respective treatment it was computed as per following formula :

$$WMI = \frac{\text{per cent yield increase over control}}{\text{per cent control of weeds}}$$

Crop resistance index (CRI) :

$$CRI = \frac{\text{Crop weight in treated plot}}{\text{Crop weight in control plot}} \times \frac{\text{Weight in control plot}}{\text{Weed weight in treated plot}} \times 100$$

Agronomic management index (AMI) :

$$AMI = \frac{\text{Per cent yield over control} - \text{per cent control of weed}}{\text{Per cent control of weeds}}$$

Herbicide efficiency index : This index represents the potential of a particular herbicide for controlling the weeds along with their phyto-toxicity effect on the crop (Krishnamurthy *et al.* 1975).

$$HEI = \frac{\text{Yield in treated plot} - \text{Yield of control plot}}{\text{Yield in treated plot}} \times 100$$

Integrated Weed Management Index

$$IWM = \frac{\text{Agronomic Management Index} + \text{Weed Management Index}}{2}$$

Results and Discussion

Regular weed surveillance during the course of experimentation showed that wheat was heavily invaded by broad leaved weeds since the crop emergence. The prominent weed species found to infest the experimental crop were *Chenopodium album*, *Rumex dentatus*, *Cyperus rotundus* and *Cynodon dactylon*.

Effect of weed management on weeds indices : Application of herbicides significantly influenced the density and dry matter of weeds. The maximum weed density and dry matter were recorded in weedy check followed by 2,4-D 0.500 kg ha⁻¹, Metsulfuron 4.0 g ha⁻¹, 2,4-D at 0.5 kg ha⁻¹ + one hand hoeing and Metsulfuron 4.0 g ha⁻¹ + one hand hoeing, respectively. Highest reduction of density and dry matter of weeds in Metsulfuron 4.0 g ha⁻¹ + one hand hoeing followed by 2,4-D at 0.5 kg ha⁻¹ + one hand hoeing and Metsulfuron 4.0 g ha⁻¹, respectively. These results corroborate the findings of Singh *et al.* (2016). Weed index is an ideal parameter to describe yield loss caused by weed infestation in comparison with weed free plots (Suria *et al.*, 2011). It reflects the effectiveness of applied herbicide in securing yield loss against weed competition and a lower value of weed index means high herbicide efficiency. Regarding weed index, main effect of weed control treatments and wheat cultivars was significant (p=0.05). Application of 2,4-D at 0.5 kg ha⁻¹ + one hand hoeing and 2,4-D at 0.5 kg ha⁻¹ + one hand

Table-1 : Effect of tillage and weed management on total density (no. m⁻²) and dry matter of weed (g m⁻²) in wheat (pooled data of two years).

Treatments	Weed persistence index		AMI	HEI	Crop resistance index		WMI	IWMI
	60 DAS	At harvest			60 DAS	At harvest		
Tillage								
SSB using shallow tillage	-	-	-	-	-	-	-	-
SSB using glyphosate at 2.0 kg ha ⁻¹	-	-	-	-	-	-	-	-
Deep tillage	-	-	-	-	-	-	-	-
Conventional tillage	-	-	-	-	-	-	-	-
Weed Management								
Weedy check	-	-	-	-	-	-	-	-
Weed free	-	-	0.08	-	-	-	1.08	0.50
One hand hoeing at 30 DAS	0.31	0.33	-0.08	5.92	9.31	9.46	0.92	0.45
2,4-D at 0.5 kg ha ⁻¹ 30 DAS	0.56	0.62	-0.02	1.64	3.24	3.45	0.98	0.56
MSM at 4.0 g ha ⁻¹ 30 DAS	0.40	0.41	0.15	4.46	5.97	6.94	1.15	0.56
2,4-D at 0.5 kg ha ⁻¹ 30 DAS+ One hand hoeing at 45 DAS	0.42	0.06	-0.02	47.44	61.21	128.27	0.98	0.49
MSM at 4.0 g ha ⁻¹ 30 DAS + One hand hoeing at 45 DAS	0.45	0.06	0.01	56.53	70.73	157.41	1.01	0.50

*Transformed to $\sqrt{x}$ 0.5, ** original values and *** SSB – Stale Seed Bed Technique, MSM-Metsulfuron.

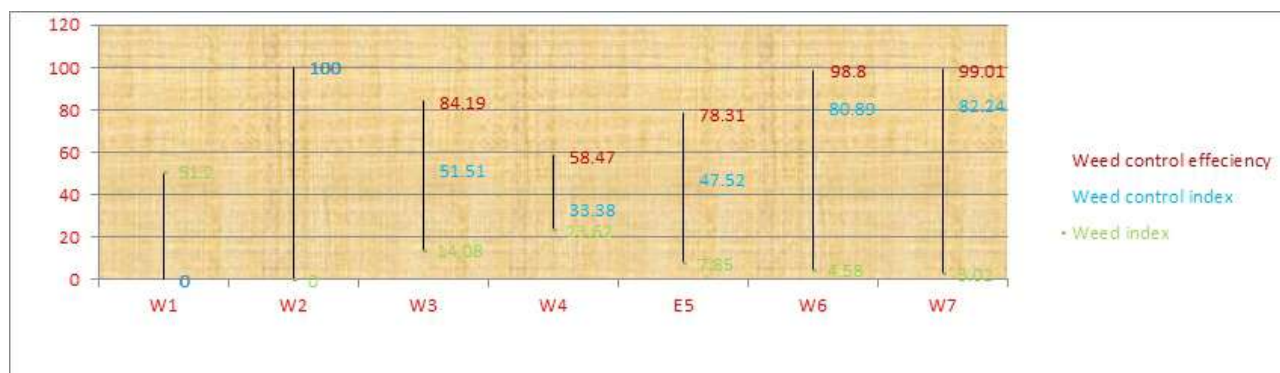


Figure-2 : Effect of tillage and weed management on weed control efficiency, weed control index and weed index (pooled data of two years). W1-Weedy check, W2- Weed free, W3- One hand weeding 30 DAS, W4- 2,4-D 0.5 kg ha⁻¹ at 30 DAS, W5- Metsulfuron 4.0 g ha⁻¹ at 30 DAS, W6- W4- 2,4-D 0.5 kg ha⁻¹ at 30 DAS+ one hand hoeing and W7- Metsulfuron 4.0 g ha⁻¹ at 30+ one hand hoeing.

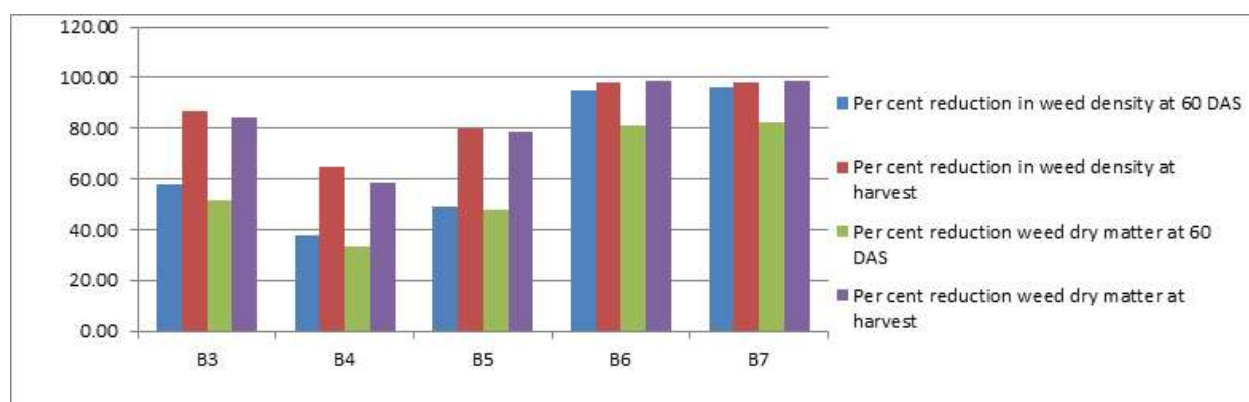


Figure-3 : Effect of tillage and weed management on reduction of density and dry matter of weeds in wheat at 60 DAS and at harvest (pooled data of two years).

hoeing recorded lowest weed index than rest of the applied treatments. Weed persistence and herbicide efficiency indices express the tolerance of weeds to different herbicide treatments as well as their efficiency to eradicate the weeds. A lower WPI and higher HEI

value is required for efficient weed management. Regarding HEI, only the effect of herbicide treatment was significant and 4.0 g ha⁻¹ + one hand weeding and 2,4-D at 0.5 kg ha⁻¹ + one hand hoeing produced significantly higher HEI than rest of the herbicides. These

Table-2 : Effect of tillage and weed management on reduction of density and dry matter of weeds in wheat at 60 DAS and at harvest (pooled data of two years).

Treatments	Reduction in weed density (%)		Reduction in weed dry matter (%)	
	60 DAS	At harvest	60 DAS	At harvest
Weed Management				
Weedy check	-	-	-	-
Weed free	100	100	100.00	100.00
One hand hoeing at 30 DAS	57.82	51.51	86.98	84.19
2,4-D at 0.5 kg ha ⁻¹ 30 DAS	37.66	33.38	65.04	58.46
MSM at 4.0 g ha ⁻¹ 30 DAS	48.94	47.52	79.82	78.33
2,4-D at 0.5 kg ha ⁻¹ 30 DAS+ One hand hoeing at 45 DAS	95.11	80.89	97.96	98.80
MSM at 4.0 g ha ⁻¹ 30 DAS+ One hand hoeing at 45 DAS	96.05	82.24	98.23	99.01

*Transformed to $\sqrt{x}$ 0.5, **, original values and *** SSB – Stale Seed Bed Technique, MSM-Metsulfuron.

results corroborate the findings of Khaliq *et al.* (2011) who documented the lower WPI and higher HEI efficiency indices due to herbicide application in wheat. These findings are in conformity with those reported Meena *et al.* 2019. Metsulfuron 4.0 g ha⁻¹ + one hand weeding and 2,4-D at 0.5 kg ha⁻¹ + one hand hoeing were significantly control the weeds and gave weed control efficiency and weed control index 99.01, 98.8 and 82.24, 80.89 per cent, respectively comparable with that of weed free treatments. This is possible might be due to depletion of density and dry matter of weeds. These findings are in conformity with those reported Chhipa *et al.* (2005) and Bharat and Kachroo (2007). The weed-persistence index (WPI) indicates the resistance in weeds against the tested treatments and confirms the effectiveness of the selected herbicides. Metsulfuron 4.0 g ha⁻¹ + one hand weeding and 2,4-D at 0.5 kg ha⁻¹ + one hand hoeing were lower the weed-persistence index (WPI) as compare to alone . Metsulfuron 4.0 g ha⁻¹ and 2,4-D at 0.5 kg ha⁻¹ at harvest stage. (Khaliq *et al.* 2014 and Meena *et al.* 2019). The crop-resistance index (CRI) indicates the relationship between a proportionate increase in crop biomass and a proportionate decrease in weed biomass in the treated plots. The Metsulfuron 4.0 g ha⁻¹ + one hand weeding and 2,4-D at 0.5 kg ha⁻¹ + one hand hoeing higher crop-resistance index followed by one hand weeding and alone metsulfuron 4.0 g ha⁻¹. Weed management index resulted with metsulfuron 4.0 g ha⁻¹ 4.0 g/ha followed by Metsulfuron 4.0 g ha⁻¹ + one hand hoeing, 2,4-D at 0.5 kg ha⁻¹ + one hand hoeing and 2,4-D at 0.5 kg ha⁻¹ which may be owing to the better control of weeds resulting in higher weed control efficiency under these treatments. The result confirms the findings of Gupta *et al.* (2013). Agronomic management index and integrated weed management index were recorded highest with weed free, Metsulfuron 4.0 g ha⁻¹ + one hand hoeing and 2,4-D at 0.5 kg ha⁻¹ + one hand hoeing. These findings are in conformity with those reported Singh *et al.* 2017.

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Profitability Assessment of Baby Corn (*Zea mays* L.) as Influenced by Seed Priming and Moisture Conservation Measures under Upland Rainfed Situation

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Abstract

A field experiment was conducted during *rabi*, 2019-20 and 2020-21 at the PG experimental plot of the department of agronomy, BNCA to assessed seed priming and moisture conservation measures on profitability of baby corn grown under rainfed upland situation. The soil of the experimental site was acidic (pH 4.64), sandy loam in texture, medium in organic carbon (0.64%), low in available N (232.06 kg ha⁻¹), P₂O₅ (13.84 kg ha⁻¹) and K₂O (115.27 kg ha⁻¹). The experiment was laidout in factorial randomized block design with 4 levels of seed priming methods viz. S₀: No priming; S₁: Seed priming with 1% urea solution; S₂: priming with 1% potash solution (MOP); S₃: priming with 3 times diluted cow urine and 3 levels of soil moisture conservation measures viz. M₀: No mulching; M₁: use of bio mulch; M₂: use of black polythene mulch. Results revealed that, the higher and significant baby corn yield without husk (22.59 q ha⁻¹) with 305.61 q ha⁻¹ of green fodder yield alongwith harvest index (6.00), production efficiency (25.67 kg⁻¹ day⁻¹ ha⁻¹) and nutrient use productivity (9.41 kg⁻¹ ha⁻¹ kg⁻¹) were recorded under the treatment where black polythene mulching was used as soil moisture conservation measure. The economic parameters like gross return (Rs. 372782 ha⁻¹), net return (Rs. 213372 ha⁻¹), B:C (2.34) ratio and economic efficiency (Rs. 2425 ha⁻¹ Day⁻¹) were recorded superior where seeds were primed with 1% potash (MOP) solution whereas, the use of black polythene mulch recorded a gross return (Rs. 399972 ha⁻¹), net return (Rs. 231132 ha⁻¹), B:C (2.37) ratio and economic efficiency (Rs. 2627 ha⁻¹ Day⁻¹).

Key words : Baby corn, seed priming, moisture conservation measures, economic efficiency, Economic efficiency.

Introduction

Maize (*Zea mays* L.) considered as the third most important cereal crop in the world following wheat and rice. Maize is classified into different groups or types based on the endosperm of kernels among which baby corn is grown for vegetable purpose. Baby corn is the young finger-length fresh maize ear harvested within 2 or 3 days of silk emergence but prior to fertilization (Muthukumar *et al.*, 2005). Baby corn is a delicious and vegetable with lots of nutrients. Thavaprakash *et al.*, (2005) reported that 100 g of baby corn contained 89.1% moisture, 0.2 g fat, 1.9 g protein, 8.2 mg carbohydrate, 0.06 g ash, 28.0 mg calcium, 86.0 mg phosphorus, and 11.0 mg of ascorbic acid. There are also some other benefits of baby corn such as utilization of husk, silk, and stover as green fodder for feeding ruminants and only 13 to 20% of fresh ear weight is for human consumption. After harvest of babies, economic potential is further enhanced, since it supplies green, soft, succulent, nutritious, palatable fodder with higher digestibility. The success of crop production is mainly influenced by weather, soil nutrient status and other agronomical practices. There are some other practices to enhance the field establishment like seed priming with different nutrients where seed priming is a process known for its controlled hydration of seeds to a particular level that will only permit the pre-germinative metabolic activity, but prevents actual

emergence of the radical (Farooq *et al.*, 2005). Seed priming practices before sowing can only induce a better physiological status in seeds and sometimes on yield but its effect on soil nutrient status seems to be non-significant.

Among different moisture conservation practices, mulching is one of the popular operations practiced in farmer's field. Mulch is simply a protective cover of a material that is spread on top of the soil. It is generally used to conserve soil moisture along with different soil nutrients to improve the soil around plants. Mulching also prevent weeds from growing and protect the roots of plants. The plastic mulch favourably influences the soil moisture regime by controlling evaporation loss from the soil surface, improves infiltration, soil water retention capacity, reduce weed emergence and decreases bulk density.

Materials and Methods

The field experiment entitled "Effect of seed priming and moisture conservation measures on productivity and profitability of Baby corn (*Zea mays* L.) under rainfed upland situation" was conducted in the PG experimental field of the department of Agronomy, Biswanath College of Agriculture during two consecutive *rabi* seasons *i.e.* 2019-20 and 2020-21. The site was located in 26°7'26"N latitude and 93°13'30"E longitude having an elevation of

86.70 m above mean sea level. The topography of the land was uniformly plain upland. The experimental site falls in the Sub-tropical climatic region, and enjoys Monsoon type of climate. Summer is hot and humid; with an average temperature of 29°C. Summer rain is heavy, which is a boon for providing natural water to the fields and winters extend from the month of October to February, and are cold and generally dry, with an average temperature of 16°C. The total rainfall received during crop growth period was 175 mm. The weekly mean maximum temperature ranged from 23.54°C to 33.24°C and the weekly mean minimum temperature ranged from 5.53°C to 23.30°C. The weekly average relative humidity during morning hours ranged from 90.00 percent to 95.86 percent while evening relative humidity ranged from 51.86 percent to 75.00 percent. The experimental field was sandy loam in texture with a pH of 4.64 and organic carbon content was 0.65%. The soil was low in available nitrogen content (232.06 kg/ha), low in available phosphorus (13.84 kg/ha) and low in available potassium (115.27 kg/ha).

The experiment was laid out in Factorial Randomised Block Design with three replications and two treatment factors *viz.* Seed priming with four levels i.e., S₀: No priming, S₁: Seed priming with 1% urea solution, S₂: Seed priming with 1% MOP solution and S₃: Seed priming with 3 times diluted cow urine and moisture conservation measures with three levels i.e., M₀: No MCM, M₁: Use of bio-mulching and M₂: Use of black polythene mulch. The baby corn variety “golden baby” was sowed on first fortnight of October and immature cobs were harvested from the mid of December. Fertilizer dose of 120:60:60 N:P₂O₅:K₂O kg ha⁻¹ with full dose of nitrogen, phosphorus and potash were applied in the furrows before sowing. Intercultural operations were carried out as per the requirement of crop. Baby corn was evaluated in terms of the periodic soil moisture content which was recorded weekly from the time of sowing till harvesting with the help of digital soil moisture meter.

Results and Discussion

Weight of cob with and without husk : The effect of seed priming was found to be statistically non-significant in respect of weight of cob (with and without husk) which might be due to the early effect of priming on germination and emergence of baby corn. The results are in conformity with the findings of Afzal *et al.* (2013). Whereas, significantly higher weight of cob (with husk) was recorded under use of black polythene mulch (55.01 g cob⁻¹) over straw mulch and control. The lowest weight of cob (35.21 g cob⁻¹) with husk was noticed under no mulch treatment. Similarly, significantly higher weight of cob (without husk) was recorded under black polythene mulch

(8.13 g cob⁻¹) and the lowest weight of cob (without husk) was noticed under no mulch treatment (5.84 g cob⁻¹). (Table-1).

Yield of cob with and without husk : The effect of seed priming failed to show any significant difference in respect of yield of cob (with husk and without husk). Among the moisture conservation measures, statistically superior results were recorded for yield of cob (without husk) under bio-mulching treatment (88.97 q ha⁻¹) (Table-1). Again, for cob yield (without husk), significantly superior results were recorded under black polythene mulch (22.59 q ha⁻¹) over straw mulch and control. The lowest cob yield without husk (17.95 q ha⁻¹) was noticed under no mulch treatment. The significant increase in cob was due to higher number of cobs plant⁻¹, higher cob weight and cob girth. The presence of a cover applied in mulching on the soil preserves the humidity of soil, promoting a microclimate favourable to microbial life, which has the direct consequence of improving the physiochemical properties of the soil which in turn improve the yield and yield attributing traits of baby corn. According to some findings, plastic film mulching may greatly improve crop yields due to increased soil moisture (Li *et al.*, 2000, Wang *et al.*, 2009), reduced soil evaporation (Wang *et al.*, 2009, Wang *et al.*, 2011), and increased topsoil temperatures (Wang *et al.*, 2011, Zhou *et al.*, 2009).

Green fodder yield : The effect of seed priming was found to be statistically non-significant in respect of green fodder yield which again might be due early effect of seed priming on initial phase of crop growth. Similar results were recorded by Tian *et al.* (2014). Whereas, significantly higher green fodder yield (305.61 q ha⁻¹) was recorded under use of black polythene mulch over straw mulch and control. The lowest green fodder yield (289.91 q ha⁻¹) was noticed under no mulch treatment. Higher green fodder yield is due to the higher plant height and more vegetative growth under black polythene mulch over bio-mulching and control (Table-1). The results are in conformity with the findings of Kwabiah *et al.* (2013).

Harvest Index : The effect of seed priming failed to show any significant difference in respect to harvest index. Similar findings were recorded by Murungu *et al.* (2004). The significant effect of moisture conservation measures was observed for harvest index of baby corn. Significantly higher harvest index was recorded under black polythene mulch (6.00%) over straw mulch and control. The lowest harvest index (4.78 %) was noticed under no mulch treatment (Table-1).

Production efficiency : The effect of seed priming was found to be statistically non-significant in respect of production efficiency whereas, the significant effect was observed for moisture conservation measures. A

Table-1 : Effect of different treatments on yield attributes and yield of babycorn.

Treatments	Baby corn wt (g) With husk	Yield (q ha ⁻¹)			Green fodder yield (q ha ⁻¹)	Harvest index	Production efficiency (Kg ⁻¹ Day ⁻¹ ha ⁻¹)	Nutrient use efficiency (Kg ⁻¹ ha ⁻¹ kg ⁻¹)
		Without husk	With husk	Without husk				
Seed Priming (S)								
S0: No priming	46.74	7.05	81.86	19.04	294.49	5.06	21.64	7.93
S1: Seed priming with 1% urea solution	44.07	6.84	83.05	20.22	304.58	5.22	22.98	8.43
S2: Seed priming with 1% potash solution	46.13	7.29	84.90	20.73	309.16	5.26	23.55	8.64
S3: Seed priming with 3 times diluted cow urine	45.59	6.18	82.76	20.72	299.39	5.42	23.54	8.63
SE(d)	0.78	0.95	1.92	0.63	5.78	0.23	1.11	0.86
C.D.(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Moisture Conservation measures (M)								
M0: No MCM	35.21	5.84	85.28	17.95	289.91	4.78	20.40	7.48
M1: Use of bio-mulching	39.18	6.54	88.97	19.99	293.70	5.22	22.72	8.33
M2: Use of black polythene mulch	55.01	8.13	70.67	22.59	305.61	6.00	25.67	9.41
S.E(d)	0.24	0.13	4.26	0.54	5.01	0.69	0.62	0.73
C.D.(P=0.05)	0.51	0.27	8.84	1.13	10.39	1.35	1.28	1.27
Interaction (S×M)								
SE(d)	NS	NS	NS	NS	NS	1.04	1.23	1.15
CD (P=0.05)	9.40	12.73	12.79	6.59	14.54	NS	NS	NS

Data represented average of two years of experiments.

Table-2 : Effect of different treatments on economics of babycorn.

Treatments	Cost of cultivation (Rs. ha ⁻¹)	Gross return (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	B:C	Economic efficiency (Rs. ha ⁻¹ day ⁻¹)
Seed Priming (S)					
S0: No priming	159340.00	344498.00	185158.00	2.16	2104.07
S1: Seed priming with 1% urea solution	159390.00	364216.00	204826.00	2.29	2327.57
S2: Seed priming with 1% potash solution	159410.00	372782.00	213372.00	2.34	2424.68
S3: Seed priming with 3 times diluted cow urine	159340.00	370678.00	211338.00	2.33	2401.57
SE(d)	-	1849.56	1325.34	0.40	425.19
C.D.(P=0.05)	-	NS	NS	NS	NS
Moisture conservation measures (M)					
M0: No MCM	155340.00	327232.00	171892.00	2.11	1953.32
M1: Use of bio-mulching	154840.00	358590.00	203750.00	2.32	2315.34
M2: Use of black polythene mulch	168840.00	399972.00	231132.00	2.37	2626.50
S.E(d)	-	1601.77	1365.09	0.08	354.56
C.D.(P=0.05)	-	3321.87	2987.80	0.22	745.90
Interaction (S×M)					
SE(d)	-	3203.54	1986.56	0.03	213.65
CD (P=0.05)	-	NS	NS	NS	NS

Data represented average of two years of experiments.

significantly higher production efficiency was recorded under black polythene mulch (25.67 kg day⁻¹ ha⁻¹) over straw mulch and control. The lowest production efficiency (20.40 kg day⁻¹ ha⁻¹) was noticed under no mulch treatment (Table-1). The results are in conformity with the findings of Mahajan *et. al.* (2003).

Fertilizer use efficiency : The effect of seed priming was found to be statistically non-significant in respect of fertilizer use efficiency. Afzal *et. al.* (2013) revealed that seed priming has no significant effect on fertilizer use efficiency. On the other hand, a significant effect of moisture conservation measures was observed on

fertilizer use efficiency. Significantly higher fertilizer use efficiency was recorded under black polythene mulch (9.41 kg ha⁻¹ kg⁻¹) over control. The lowest fertilizer use efficiency (7.48 kg ha⁻¹ kg⁻¹) noticed under no mulch treatment (Table-1).

Economics : In the present study, seed priming could not bring any significant effect on the economic indices of baby corn but treatment where seed priming was done with 1 % potash (MOP) solution recorded the higher gross return (Rs. 372782 ha⁻¹), net return (Rs. 213372 ha⁻¹), benefit-cost ratio (2.34) and economic efficiency (Rs. 2425 ha⁻¹ day⁻¹) over the other seed priming treatments.

Similar result was observed by Tanwar *et.al.* (2013) and Baldev *et. al.* (2018)

Among the moisture conservation measures, the use of black polythene mulch recorded higher gross return (Rs. 399972 ha⁻¹), net return (Rs. 231132 ha⁻¹), benefit-cost ratio (2.37) and economic efficiency (Rs. 2627 ha⁻¹ day⁻¹) which shows that per day monetary return was more remunerative over the other mulching treatments. The no mulch treatment recorded lowest gross return (Rs. 327232 ha⁻¹), net return (Rs. 171892 ha⁻¹), benefit-cost ratio (2.11) and economic efficiency (Rs. 1953 ha⁻¹ day⁻¹). The use of black polythene mulch recorded the highest cost of cultivation which was due to increased cost of polythene mulch. Maximum gross return was recorded under black polythene mulch which was due to higher baby corn and green fodder yield obtained under this treatment, hence ultimately resulted in higher gross return (Table-2). The results are in conformity with the findings of Ling *et. al.* (2013).

Conclusions

From the above experimentation, it was found that seed priming had failed to bring any significant effect for yield and economic parameters. However, seed priming with 3 times diluted cow urine had recorded superior yield performance among all the other seed priming treatments whereas seed priming with 1% potash (MOP) solution recorded higher profitability over other treatments. Again, among the different moisture conservation measures, the use of black polythene mulch showed significant performance for all the yield and economic parameters than the rest of the treatments. The higher benefit cost ratio and other economic readings shows that cultivation of baby corn with such practices could be highly beneficial as on-farm income generation activity for smallholders where there are market facilities available.

Hence, the findings support that baby corn is highly profitable with any of the seed priming treatments *i.e.*, 1% urea solution, 1% potash solution or 3 times diluted cow urine and mulching with black polythene mulch.

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Joint Forest Management (JFM) in Keonjhar Forest Division, Odisha : A study on Assessment and Impacts on local livelihood

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Abstract

Joint Forest Management (JFM) could be described as management of the state forest lands jointly by the state and the local community with joint sharing of benefits. The objectives of this paper were to analyze the socio-economic status and livelihood dependency of Joint Forest Management based villages in Telkoi and Banspal Block of Keonjhar district of Odisha. A total of 100 respondents were chosen randomly from two blocks and ten villages to participate in the experiment. Pre-structured questionnaires, personal interviews, secondary information and group discussions with villagers were used to collect data and statistically analysis done. Agriculture is the most important activity followed by NTFPs collection and livestock rearing for their livelihood as majority of the people owned their own farm land and during off season they depends on the forest and worked as labour in JFM activities as well. People living around the forest worked 211 days in a year in various income generating activities like agriculture, NTFPs collection, labour (wage earning), family occupation etc. Factors influencing the share on NTFP income were determined by correlation and regression analysis. Agriculture (Rs 12749.18) contributed the most to the overall income of the respondents followed by NTFPs collecting (Rs 8370.50) > labour (Rs 4038.63) > family occupation (Rs 1390.34) > livestock rearing (Rs 1917.12) and other sector (Rs 3814.10). The percentage contribution of various NTFPs to net return are Sal (*Shorea robusta*) leaves generated 30.37 % followed by siali (*Bauhinia vahlii*) leaves (21.74 %), cane culms (*Calamus* spp.) (19.02 %), mahua (*Madhuca longifolia*) (2.26 %), honey (4.52 %), sal seeds (4.58 %), mushroom (2.15 %), amla (*Phyllanthus emblica*) (2.98 %), harida (*Terminalia chebula*) (1.88 %), bahada (*T. bellerica*) (1.00 %), tamarind (*Tamarindus indica*) (6.28%) and char (*Buchanania lanzan*) (3.22%). The highest net return (Rs 2542/-) was obtained from the sale of sal leaves as plates, out of the total income of Rs 8370.50 from NTFPs. After agriculture, forest produces were the main source of income. It also provides various employment opportunities for the forest dwellers. So the economic status of the people had been increased. From this study it was concluded that villages Haldipani and Malanda were highly dependent on forest for their livelihood compared to other villages who were less dependent upon forest produce.

Key words : Forest, forest produce, Joint Forest Management, NTFPs, socioeconomic traits

Introduction

Joint forest management (JFM) in India has been instrumental in changing the socioeconomic lives of forest dependent communities (FDCs) from being forest-centered to one based on the money economy. JFM has resulted in the elite capture of forest resources, and enabled regeneration of degraded forests though the evidence on the quality of regeneration is mixed (Sundar, B.2017). JFM is the management of the state forest lands in cooperation with the state and the local community having mutual distribution of benefits. The programme has its emergence in the National Forest Policy (MoEF, 1988), which forecasted “creating a huge people’s movement with the engagement of the woman, for attaining the objectives and to reduce pressure on existing forest”. JFM enclosed nearly 29.80 per cent of the entire forest area of the country (Singh et al., 2011). Around 59.31 per cent of the forest land was regulated by the government in the country and 28.91 per cent was chosen for the utilization

by communities and native groups (RRI, 2011). Various studies reveal the impacts of JFM on livelihoods of the rural people (Nayak et.al., 2022, Jana et al 2012, Jana et al 2014 and Jana et al 2015). The concept of livelihoods integrates ecological, economic and social wellbeing of people. One important source of income from forest of the households under JFM are Non timber forest Products (NTFPs).

Odisha Govt. was the architect to accept a policy of JFM even prior to the execution of National Forest Policy of 1988 (w.e.f. 2.10.1988) in India while recognizing the need for community involvement in forest protection and brought about a step to engage the people in safeguarding the Reserved forests adjacent to their villages with allotting certain roles and in exchange granting specific concessions for satisfying their bonafide requirement of small timbers and firewood through Resolution No. 10F (Pron) – 47/88/17240/ FFAH dated 1.08.1988 and looked for community involvement for protection, management and regeneration of the forest

wealth expanding the opportunity of social empowerment and employment generation of the forest-fringe dwellers.

The individuals living nearby the Keonjhar forests depend on it for their earnings. Most of them generally collect forest products for sale as well as for their own consumption. The involvement of local communities in planting management and in the protection of forestry is extremely important to monitor and creates jobs for local people. The JFM managed forests is capable of meeting local subsistence needs, such as fuel wood, fodder, other non-wood products, forest, small wood and wood, etc., and simultaneously to prevent the forest from degrading which offers local, national and global environmental benefits (Nayak et. al.,2022)

Materials and Methods

The research was conducted in Keonjhar District, Odisha during 2021-22. Some ranges like Telkoi and Champua are mostly high hills and possessing a very good forest cover were selected which is one-third of the total number of ranges in the division on the grounds of their dependency on the forest for their sustenance, 20% of villages were selected from a range. Total ten villages i.e., four villages from Telkoi block and six from Champua block selected for the study. From the village, all the households were selected randomly and a total number of 100 families belonging to 10 villages from 2 forest ranges of Keonjhar Forest Division were selected. The data were collected personally through a structured questionnaire which was prepared by consulting different experienced ones and reference to literature. The data were incorporated and put in the Excel software. Descriptive statistics (Mean, standard deviation, percentage) as well as correlation-regression analysis were utilized to describe the socio-economic status of the NTFP collectors for instance age, caste, literacy, family size, marital status, occupation, land holding, livestock and annual income in the study area. The income generated in various sectors and the employment generated from diverse NTFP was examined on Microsoft excel and the outcome of socio-economic profile of the study area.

Results and Discussion

In the study area, the vast majority of respondents (87.00%) were engaged in agricultural activity on their own or rented land (Table-1). Agriculture was found to be the primary source of income. 75.00% of respondents were involved in the collection of NTFPs. Other source of employment were labour (54.00%) followed by livestock rearing (42.00%), family occupation (33.00%) and others (18.00 %).

Table-1 : Involvement of respondents in different income generating sectors.

Sl. No.	Different sectors	No. of respondents	Percentage (%)
1.	Agriculture	87	87.00
2.	NTFPs Collection	75	75.00
3.	Labour	54	54.00
4.	Livestock rearing	42	42.00
5.	Family occupation	33	33.00
6.	Others	18	18.00

Perusal of data in Fig-1. showed that in composition of employment i.e. agriculture contributed the most to job creation in different sectors with 65 days/HH/year (30.81%) followed by NTFPs collection with 53 days/HH/year (25.12%), labour with 47 days/HH/year (22.27%), family occupation with 19 days/HH/year (9.01%), livestock rearing with 12 days/HH/year (5.68%) and others (services) with 15 days/HH (7.11%).

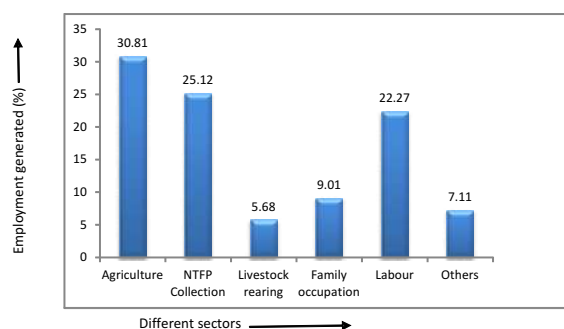


Fig-1 Composition of employment in different sectors.

Different activities like Agriculture, NTFPs collection, labour (wage earning) and family occupation were identified as the primary livelihood and income-generating activities in the study area. People living in and around the forest worked 211 days in a year in the various income generating activities. This gave the similar findings of Nayak et al.,(2022), found poor and landless households receive more employment per year in forest-related activities in Khordha Division, odisha under JFM which was similar to the findings of the present study. The average annual household income during 2020 was affected due to corona pandemic situation. As indicated in Table 2, income was created in the study area from a variety of activities including Agriculture, NTFPs collection, labour, family occupation, livestock husbandry and other (service). The agricultural sector generated the highest average annual income of Rs 14243.18 (37.43%) followed by NTFPs which contributed Rs 8370.50 (21.98%), labour which contributed Rs 7375.63 (19.38%), livestock rearing contributed Rs 2875.12 (7.53%), others (service) contributed Rs 3814.10 (10.02%) and family occupation contributed least i.e. Rs 1390.34 (3.66%).

Table-2 : Composition of average annual household income (in INR) derived from different sector (household/year).

Sl. No.	Different sectors	Income generated in INR (Income/HH/year)	Percentage
1.	Agriculture	14243.18	37.43
2.	NTFP Collection	8370.50	21.98
3.	Labour	7375.63	19.38
4.	Others (Services)	3814.10	10.02
5.	Livestock rearing	2875.12	7.53
6.	Family occupation	1390.34	3.66
	Total	38068.87	100.00

The annual income generated per household from various sectors in the current study area Rs 38068.87/-. Palhanian (2018) reported that engagement as labourers in different Govt. activities and household works is the third important income generating activities in the study area followed by livestock rearing and family occupation with total income Rs 121430/-in Himachal Pradesh. NTFPs are the second most important source of total annual income in rural households after agriculture. Agriculture ensured them food security while also generating significant revenue from the sale of surplus grains and the residual crops and grains. They also used their cattle to carry out agricultural tasks in the field, such as ploughing.

Sal leaves account for 9 days/HH/year of total employment created by NTFPs. The collection of siali leaves was the next primary employment generation activity accounting for 8 days/HH/year followed by the collection of Sal seeds (6 days/HH/year), mahua (6 days/HH/year), tamarind (5 days/HH/year), amla (4 days/HH/year), cane culm (3 days/HH/year), honey (3 days/HH/year), bahada (3 days/HH/year), mushroom (2 days/HH/year), harida (2 days/HH/year) and char seed (2 days/HH/year) which contributed 11.32%, 11.32%, 9.43%, 7.54%, 5.66%, 5.66%, 5.66%, 3.78%, 3.78%, 3.78% and 3.78% of NTFPs respectively.

Sal leaves, siali leaves, and cane culm might be recognized as primary income producing occupations in the study area based on employment generation activity from NTFPs collection. Sarker *et al.*, (2008) found that when a single person from each household with a family size of five or less is given the option to collect NTFPs, they gain employment for 35-40 days per year. If a family has more than five members, two people are usually assigned to collect NTFPs; they work for a total of 70-80 days per year which is in parallel with the findings of the present study.

Table-3 : Contribution of different NTFPs in employment generation.

Sl. No.	Name of the NTFPs	Employment generated (days/HH/year)	Percentage(%)
1.	Sal leaf	9	16.97
2.	Siali leaf	8	15.09
3.	Sal seed	6	11.32
4.	Mahua	6	11.32
5.	Tamarind	5	9.43
6.	Amla	4	7.54
7.	Cane culm	3	5.66
8.	Bahada	3	5.66
9.	Honey	3	5.66
10.	Harida	2	3.78
11.	Mushroom	2	3.78
12.	Char seed	2	3.78
	Total	53	100.00

Figure 2 data showed that the net return generated from the NTFPs collected by the respondents was calculated based on the amount collected and sold at price/ bundle/ pana or kg. From the data found that sal leaves (Rs 2542/-), siali leaves (Rs 1820/-), cane culm (Rs 1592.50/-), mahua (Rs 190/-), honey (Rs 378/-), sal seeds (Rs 384/-), mushroom (Rs 180/-), amla (Rs 250/-), harida (Rs 157.50/-), tamarind (Rs 525/-), char (Rs 270/-) and bahada (Rs 82.50/-). The total income per household from NTFPs is estimated to be Rs 8370.50/- per year. The net returns are in decreasing order at sal leaf > siali leaf > cane culm > tamarind > sal seed > honey > char > amla > mahua > mushroom > harida > bahada. Mondal *et al.*, (2018) investigated in the Sonamukhi region of West Bengal, India and found that the contribution of several NTFPs such as mushroom (Rs. 1500/-), mahua (Rs. 500/-) and kusum fruit (Rs. 100/-) per annum.

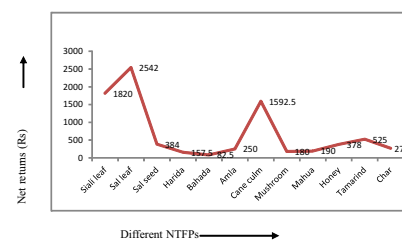
**Fig-2 : Net returns (Rs) from different NTFPs.**

Table-4 depicted the seasonal distribution of respondents' engagement in JFM activities. Road building, soil and water conservation, trimming and thinning operations, nursery and planting were among the primary JFM activities.

The efficiency of JFM-based communities was evaluated based on their reliance on the forest for a living as well as their participation in JFM activities. It showed

Table-4 : Seasonal calendar of involvement in JFM activities.

Months	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Activities												
Road construction												
Soil and water conservation												
Pruning and thinning operation												
Nursery												
Planting												

that the performance of the studied village as per their livelihood dependency. From two Blocks Telkoi Block have higher average performance (10.74) as compared to Banspal Block (9.50). Haldipani village has high performance 14.92 followed by Malanda(14.70), Kundheihata (12.75), Gundula (9.60), Gobindpur (9.40), Guptaganga (8.75), Bandhanjori (8.52), Panasanasa (7.25), Gonasika (7.12) and Kalima (6.99).

Conclusions

In the Keonjhar Forest Division the various income-generating sectors included NTFPs collection, livestock rearing, agriculture, family occupation, labour and other services related to livelihood reliance. Agriculture (87%) was the most important activity among respondents followed by NTFPs collecting (75%), livestock rearing (42%), labour (54%), family occupation (33%) and others like services (18%). The agriculture sector generated the most employment opportunities (30.81%) in terms of the number of days per household per year, followed by NTFPs collection (25.12%), labour (22.27%), family occupation (9.01%), other services (7.11%) and livestock rearing (5.68%). Forest-fringe residents worked in a variety of income-generating activities for 211 days each year. Among the major sectors, agriculture generated the highest average annual income (Rs 14243.18/-), accounting for 37.43% of the annual income of Rs 38068.87/- per HH/year followed by NTFPs collection which contributed 21.98% (Rs 8370.50/-). Among the selling of various NTFPs, collection of Sal leaves produced the most employment generating activities accounting for 9 days/HH/year of total employment generated by NTFPs followed by Siali leaves collection which contributed 8 days/HH/year. The highest net return (Rs 2542/-) was obtained from the sale of sal leaves as plates, out of the total income of Rs 8370.50 from NTFPs. After agriculture, forest produce was the main source of income. It also provides various employment opportunities for the forest dwellers. So the economic status of the people had been increased.

From this study it was concluded that villages Haldipani and Malanda were highly dependent on forest for their livelihood compared to other villages who were less dependent upon forest produce.

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Augmenting Farmers' Income through Food Processing and Value Addition

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Abstract

The present research review analyses and discuss about the potential of food processing and value addition in enhancing farmers' income. Food processing sector has the potential to enhance farmer's income in India by adding significant value to the agricultural and horticultural produce. By engaging farmers in processing activities, providing better storage and transportation and creating market linkages, it is possible to generate avenues for enhancing income for the farmers. The post-harvest/in transit wastage account for approximately 40 per cent of the total food wastage in India compared to 28 per cent globally and result in significant erosion of farmer income. The impact is more so in high-value crops, such as fruits and vegetables, keeping farmers away from reaping benefits. Well-developed storage (e.g. cold storage) and transportation facilities help farmers reduce these losses by preserving food for extended period of time. Farmers engaged in the production of low-value crops can add value and increase household income through primary and secondary processing creating higher value products. This is a proven method globally. By including more farmers and expanding the product range, near-farm processing activities can be very fruitful for a large number of farmers. The Government of India has approved more than 63 near-farm agri-processing clusters under its Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters (SAMPADA Yojana). Farmers can be directly connected to food manufacturers (secondary/ tertiary processors) and sell their produce (fresh/ primary production) to large food manufacturers. The future market potential of food processing is likely to generate greater demand for crop produce, creating a new market for processable varieties for farmers. Food processing companies can enter into end-to-end arrangements for direct engagement with farmers, including their education leading to the enhancement of farmers' knowledge of advancing technologies, cultivation of processable crops and manufacturing of higher value-added product lines.

Key words : Food processing, value addition, farmers' income, agricultural produce, post-harvest, food manufacturers, SAMPADA yojna.

Introduction

Agriculture plays a vital role in the global economy, with farmers being the backbone of food production. However, many farmers face challenges in terms of low income and limited market opportunities. To address these issues, an emerging trend in recent years has been the emphasis on food processing and value addition. This research paper explores how food processing and value addition can significantly augment farmers' income, create new avenues for growth, and contribute to sustainable agricultural practices.

Increasing Shelf Life and Market Opportunities : Food processing involves transforming raw agricultural produce into value-added products such as packaged goods, beverages, dairy products, and snacks. By processing their produce, farmers can extend the shelf life of perishable goods, reducing post-harvest losses and enabling them to access markets beyond their immediate vicinity. Processed food products are more convenient for consumers, thereby opening up opportunities for farmers to reach larger consumer bases, both locally and globally.

This expanded market access can result in higher demand and increased profitability for farmers.

Value Addition and Price Premiums : Value addition refers to enhancing the quality, nutritional value, and presentation of agricultural products through various processing techniques. By adding value to their produce, farmers can command higher prices and earn price premiums. For example, processing fruits into jams, jellies, or dried fruit snacks adds value and allows farmers to sell their products at higher rates compared to selling raw fruits. Similarly, value addition in the form of packaging, branding, and labeling can help differentiate products in the market and create a niche for farmers, enabling them to capture higher margins.

Diversification and Product Innovation : Food processing and value addition also provide an opportunity for farmers to diversify their product offerings and explore new markets. By investing in processing facilities or partnering with food processing companies, farmers can expand their range of products beyond raw commodities. This diversification helps reduce dependency on volatile commodity prices and allows farmers to tap into consumer trends and preferences. Moreover, it encourages product

innovation, encouraging farmers to develop unique and specialized offerings that cater to niche markets, such as organic, gluten-free, or plant-based products.

4. Employment Generation and Rural Development :

Food processing and value addition activities often require a significant workforce, leading to employment generation, particularly in rural areas. Establishing processing units or cooperatives can create job opportunities for local communities, contributing to rural development and reducing migration to urban centers. This decentralization of economic activities can have a positive impact on local economies, improving infrastructure, education, healthcare, and overall living standards.

Reduced Food Waste and Sustainability : Food processing and value addition can contribute to sustainable agricultural practices by reducing food waste. By utilizing surplus or imperfect produce that may not meet the aesthetic standards of fresh markets, farmers can minimize post-harvest losses and maximize their overall yield. Additionally, food processing techniques such as canning, freezing, or dehydrating help preserve nutritional value and minimize spoilage, ensuring that food reaches consumers in a safe and consumable state. This sustainable approach not only benefits farmers economically but also address global concerns regarding food security and resource conservation.

Objective : In this review, we discuss if there are the potential of food processing and value addition in enhancing farmers' income.

Materials and Methods

Narrative review of literature. The search of the articles was done in databases of Google Scholar, Science Direct, etc. without restriction in period of publication. The descriptors used in the search strategy were: Food processing, value addition, farmers' income, SAMPADA yojna.

Results and Discussion

Food processing has the immense potential to enhance the farmers' income in India by adding significant value to the agricultural produce. The sector has also grown at a faster CAGR of 9.5 per cent as compared to agriculture's five-year CAGR of 3.4 per cent. KPMG in India in its recent report – "Indian Food Processing Industry Growth opportunities post the COVID-19 pandemic" estimates that, going forward, this sector will reach USD535 billion by 2025 at a CAGR of 15 per cent, which indicates significant potential for increasing farmers' income through processing. The sector also aims to add 9 million jobs by 2024. Thus, the sector can potentially be the

solution India needs to double farmer's income. In the past, efforts have been made to increase farmers' income by increasing food production and introducing new ways to increase productivity, providing incentives through better crop prices and subsidies, and via public investment in agriculture and facilitating agricultural institutions. While these efforts have increased our agriculture produce by 3.7 times since independence, it has not translated into a corresponding increase in farmers' income. Majority of the farmers (small and marginal - accounting for 82 per cent of all farmers) still have not seen any significant rise in their income. Being at the lowest end of the value chain without any bargaining power, these farmers continue to bear losses arising due to several reasons, including lack of post-harvest storage and transportation and processing facilities. Globally all major economies have advanced food processing ecosystems with high levels of processing (70-80 per cent against 10 per cent in India) and correspondingly higher value added per worker in agriculture. India, despite being the leader in production of several agricultural commodities, lags behind several countries in terms of value added per worker in agriculture.

Farmers will have to be integrated into the food processing value chain, not as producers but as entrepreneurs engaged in primary and secondary processing activities that are profit generating . An effort needs to be made to ensure that the benefits reach the intended beneficiaries -small and marginal farmers. A policy intervention or action plan is the need of the hour.

Country	Value added per worker in Agriculture (USD)
Canada	112,867
United States	93,728
United Kingdom	51,960
Germany	42,622
United Arab Emirates	30,180
Brazil	13,750
China	4,191
India	1,998

Thus, the need of the hour for the country is to expedite its move towards value addition in agriculture through food processing. India's food processing sector generated a much higher gross value added (GVA) (USD5,367 at current prices) per employee per worker than that generated in agriculture (USD1,981) in 2019. This increased GVA per worker, if distributed to the players in the value chain, including farmers, can be their potential earnings. To accomplish this, small and marginal farmers will have to be integrated into the food processing value chain, not as producers but as entrepreneurs

engaged in primary and secondary processing activities that are profit generating.

Some of the ways in which food processing results in addition to farmers' income include: Reduction of post-harvest losses through efficient storage and transportation:

The post-harvest/in transit wastage account for approximately 40 percent of the total food wastage in India compared to 28 percent globally and result in significant erosion of farmer income. The impact is more so in high-value crops, such as fruits and vegetables, keeping farmers away from reaping benefits. Well-developed storage (e.g. cold storage) and transportation facilities help farmers reduce these losses by preserving food for extended periods of time. This also allows monetisation of the crop when the prices are higher. For achieving the desired results, the storage and transportation facilities need to be accessible and affordable. A cluster approach with shared infrastructure is one such model with demonstrated success.

Near farm processing : Farmers engaged in the production of low-value crops can add value and increase household income through primary and secondary processing creating higher value products. This is a proven method globally. In many African countries, farmers process sorghum into beer or cassava into gari or snack foods and have formed very successful smallscale businesses . In India, demonstrated examples include papad, pickle and chutney-making, which have become a major source of income for many farmers, including women in rural areas. By including more farmers and expanding the product range, near farm processing activities can be very fruitful for a large number of farmers. The Government of India has approved more than 63 near farm agri-processing clusters under its Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters (SAMPADA Yojana).

Value chain linkages : Farmers can be directly connected to food manufacturers (secondary/ tertiary processors) and sell their produce (fresh/ primary production) to large food manufacturers. A recent study involving farmers of Krishnagiri cluster in Tamil Nadu, showed that farmers who are linked with the processing industry were able to gain on an average additional income of about 49 per cent in comparison to the farmers who operate in the non-processing industry region.

The future market potential of food processing (USD535 billion) is likely to generate greater demand for crop produce, creating a new market for processable varieties for farmers. Food processing companies can enter into end-to-end arrangements for direct

engagement with farmers, including their education leading to the enhancement of farmers' knowledge of advancing technologies, cultivation of processable crops and manufacturing of higher value-added product lines. Food processing has the potential to enhance farmer's income in India by adding significant value to the agricultural produce. By engaging farmers in processing activities, providing better storage and transportation and creating market linkages, it is possible to generate avenues for enhancing income for the farmers.

We are also witnessing greater consumer preference for processed food in the post COVID- 19 world. The sector is expected to see enhanced private sector investment creating opportunities for integrating farmers into the value chain of large producers. An effort needs to be made to ensure that the benefits reach the intended beneficiaries - small and marginal farmers. A policy intervention or action plan is the need of the hour.

A brief perspective about the Governments' initiatives towards augmenting farmers' income by promoting food processing and value addition is mentioned below :

MoFPI is implementing a Centrally Sponsored Scheme-PM Formalisation of Micro Food Processing Enterprises Scheme (PMFME) for providing financial, technical and business support for setting up/upgradation of 2 lakh micro food processing enterprises through credit linked subsidy during five years from 2020-21 to 2024-25 with an outlay of INR 10,000 cr.*

One District One Product (ODOP) has been approved for 713 districts of 35 States/ UTs under PMFME scheme.*

27,003 Loans have been sanctioned in the country under credit linked subsidy component of PMFME Scheme.*

Food Processing is recognized as a Special Focus Sector in the National Manufacturing Policy.*

Under Mission Organic Value Chain Development in North East Region (MOVCDNER), Farmers are provided subsidy of INR 31000/ ha / 3 years under PKVY and INR 32500/ ha/ 3 years under MOVCDNER for various organic inputs including organic fertilisers. *

Under National Food Security Mission (NFSM), financial assistance is provided for promotion of Bio-Fertilizer (Rhizobium/ PSB) @50% of the cost limited to Rs.300 per ha.*

Total of 1138 agristartups are supported under the programme with financial assistance of INR 70.30 cr

under Innovation and Agri-Entrepreneurship Development” programme. *

The Government is implementing Agricultural Marketing Infrastructure (AMI), a sub-scheme of Integrated Scheme for Agricultural Marketing (ISAM) under which assistance is provided for construction/ renovation of godowns/ warehouses in the rural areas in the States to enhance the storage capacity for agriculture produce. Under the scheme, Government provides subsidy at the rate of 25% and 33.33% on capital cost of the project based on the category of eligible beneficiary. Assistance is available to Individuals, Farmers, Group of farmers/growers, Agri-preneurs, Registered Farmer Produce Organizations (FPOs), Cooperatives, and state agencies etc. The scheme is demand driven. *

Food and agro-based processing units can avail loans under Priority Sector Lending. *

It will ensure a greater flow of credit to entrepreneurs for setting up food processing units and attract investment in the industry.

Government has set up a special fund called “Food Processing Fund” of approximately USD 265 Mn in National Bank for Agriculture and Rural Development (NABARD) for extending affordable credit to designated food parks and the individual food processing units in the designated food parks. *

Ministry of Food Processing Industries is also keen on developing an integrated and comprehensive National Food Processing Policy, for which a draft has already been circulated among the stakeholders to receive suggestions and recommendations. * It aims to build India’s National Food Grid and National Cold Chain Grid apart from the retail markets at every nook and corner of the country.

The Union Cabinet of India has announced a new central sector scheme of Agriculture Infrastructure Fund. Under the scheme, INR 1 lakh cr will be provided by banks and financial institutions to feasible projects for post-harvest management infrastructure and community farming assets. The financial support will be in the form of medium - long term debt financing facility and all loans under this financing facility will have interest subvention of 3% per annum up to a limit of INR 2 cr. *

The Cabinet Committee on Economic Affairs of the Government of India has approved the setting up of Animal Husbandry Infrastructure Development Fund (AHIDF). AHIDF will incentivize investments in infrastructure for dairy and meat processing and value addition infrastructure and establishment of animal feed plant in the private sector. Farmer Producer Organizations (FPOs), MSMEs, Section 8 companies, private companies and individual entrepreneurs with a minimum 10% margin money will be the eligible beneficiaries of the scheme. The remaining 90% would be the loan component which will be provided by scheduled banks. A total amount of INR 15000 cr. has been approved for the Animal Husbandry Infrastructure Development Fund (AHIDF). *

Conclusion

Food processing and value addition present a promising avenue for augmenting farmers’ income while creating a more sustainable and resilient agricultural sector. By extending shelf life, accessing new markets, commanding price premiums, diversifying products, generating employment, and reducing food waste, farmers can enhance their economic viability and contribute to rural development. However, it is essential to provide farmers with the necessary training, infrastructure, and market linkages to fully capitalize on these opportunities. By supporting and promoting food processing and value addition, we can empower farmers, strengthen the agricultural value chain, and ensure a more prosperous and inclusive future for rural communities.

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Effect of Supplementation of Moringa Leaf Powder on Comparative Economics of Pratapdhan Chicken under Organic Management System

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Abstract

A study was undertaken to evaluate the effect of supplementation of Moringa leaf powder on comparative economics of Pratapdhan chicken under organic management system. Three hundred and sixty, 4 week old pratapdhan chicks divided into 6 groups with and each group having 60 birds. The dietary treatments consists of the basal diet as control (T₁), feed of organic origin (T₂), T₂ + supplementation of Moringa leaf powder @ 2.5% (T₃), T₂ + supplementation of Moringa leaf powder @ 5% (T₄), T₂ + supplementation of Moringa leaf powder @ 7.5 % (T₅) and T₂ + supplementation of Moringa leaf powder @ 10% (T₆). Statistical analysis of data revealed significant effect on comparative economics of Pratapdhan chicken due to supplementation of Moringa leaf powder. Feed efficiency for egg production was significantly higher in T₁ and T₆ as compared to other treatment group. The total cost per birds was significantly lowest in T₄ and T₅. The highest total cost per birds was found in control group. The return per bird was significantly higher in T₄ and T₅ as compared to rest of the treatment groups. Significantly highest B:C ratio was found in T₄ and T₅ as compared to other treatment groups. It may be concluded that supplementation Moringa leaf powder improves comparative economics of Pratapdhan chicken under organic management system.

Introduction

Feed is a major component affecting net return from the poultry enterprise. Various strategies like feed supplements and additives are being used to ensure more net return and to minimize expenditure on feed. Feed contributes 65-70% of total cost of poultry production in poultry. Economical poultry production largely depends on optimum utilization of feed, improved body weight, prevention of diseases, increase egg production and reduce mortality rate.

Incorporation of herbal feed additives with feed is mainly aimed to improve digestibility and availability of various nutrients, thereby, rising economic gains by decreasing the input cost. Herbs could be anticipated to serve as feed additives due to their suitability and preference, reduced threat of virulence and minimum health problems.

Plants like Moringa have been used as feed stuffs for poultry as a supplement as partial substitute for the conventional cakes, cereal grains and forages. All plants parts of *Moringa oleifera* have been used for various ailments, like treatments of inflammation in various infectious diseases as well as to treat cardiovascular, gastrointestinal, hematological and hepato-renal disorders. It is also used to enhance immune response and to improve intestinal health of broiler birds. There has been an increased interest in the utilization of *Moringa oleifera* in improving poultry performances. *Moringa oleifera* has been known since ancient times, but very limited

information is available in India on the effect of these medicinal plants on nutrient utilization efficiency in poultry. Keeping the aforesaid facts in view, the present investigation was planned to explain the possibilities of utilization of Moringa leaf powder on comparative economics of Pratapdhan chicken under organic management system.

Materials and Methods

Three hundred and sixty, 4 week old pratapdhan chicks divided into 6 groups with and each group having 60 birds (20 birds in each replication). The ration was prepared with maize, groundnut cake, de-oiled rice barn, dicalcium phosphate etc. Control The dietary treatments consists of the conventional feed as control (T₁), feed of organic origin (T₂), T₂ + supplementation of Moringa leaf powder @ 2.5% (T₃), T₂ + supplementation of Moringa leaf powder @ 5% (T₄), T₂ + supplementation of Moringa leaf powder @ 7.5 % (T₅) and T₂ + supplementation of Moringa leaf powder @ 10% (T₆).

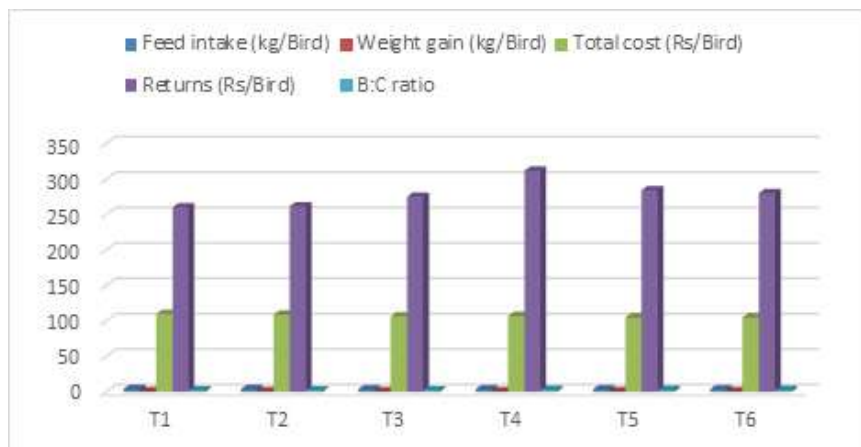
Economics of Pratapdhan chicken in the present study was carried out by considering the prices of inputs prevalent at the time of experiment in the market. Inputs consist of cost of birds, cost of feed, cost of Moringa leaf powder other expenses. Net profit per bird was calculated from the sale of the birds in the local market on live body weight basis. Similarly net profit per kg body weight was calculated for all treatment groups.

Statistical Analysis : Data collected during the current research work was subjected to statistically analyzed by

Table-1 : Economics of supplementation of Moringa leaf powder on Pratapdhan chicken.

System	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	SEm±
Feed intake (kg/Bird)	4.01±0.28 ^a	3.97±0.38 ^a	3.87±0.05 ^{ab}	3.89±0.08 ^{ab}	3.81±0.31 ^b	3.81±0.05 ^b	0.19
Weight gain (kg/Bird)	1.04±0.07 ^b	1.05±0.10 ^b	1.10±0.01 ^b	1.25±0.03 ^a	1.14±0.10 ^{ab}	1.12±0.01 ^b	0.05
Total cost (Rs/Bird)	110.25±7.74 ^a	109.25±10.54 ^a	106.75±1.33 ^b	107.25±2.37 ^{ab}	105.25±8.64 ^b	105.25±1.57 ^b	5.33
Returns (Rs/Bird)	261.00±18.96 ^b	262.25±26.46 ^b	275.75±3.75 ^b	312.50±8.45 ^a	284.75±26.34 ^{ab}	280.75±4.65 ^b	14.38
B:C ratio	2.37±0.17 ^d	2.40±0.25 ^{cd}	2.58±0.04 ^{bc}	2.91±0.09 ^a	2.71±0.28 ^b	2.67±0.04 ^{bc}	0.14

Means with the same superscript in a particular row do not differ significantly ($P<0.05$) from each other.

**Fig-1 : Economics of supplementation of Moringa leaf powder on Pratapdhan chicken.**

analysis of variance described by Snedecor and Cochran (1989).

Results and Discussion

The data pertaining to economics of Pratapdhan chicken in different treatment groups are presented in Table-1 and graphical representation depicted in Figure-1.

The feed intake was 4.01±0.28, 3.97±0.38, 3.87±0.05, 3.89±0.08, 3.81±0.31 and 3.81±0.05 kg per birds, respectively in T₁, T₂, T₃, T₄, T₅ and T₆. The feed intake was significantly ($P<0.05$) higher in T₁ and T₂ as compared to rest of the treatment groups except T₃ and T₄. The difference in feed intake between T₁, T₂, T₃ and T₄ as well as between T₃, T₄, T₅ and T₆ was found non-significant.

Weight gain (kg/bird) was 1.04±0.07, 1.05±0.10, 1.10±0.01, 1.25±0.03, 1.14±0.10 and 1.12±0.01, respectively in T₁, T₂, T₃, T₄, T₅ and T₆. Weight gain (kg/bird) was significantly ($P<0.05$) higher in T₄ as compared to rest of the treatment groups except T₅. The difference between T₄ and T₅ as well as between T₁, T₂, T₃, T₅ and T₆ were found non-significant.

The total cost (feeding and miscellaneous) was (Rs/bird) 110.25±7.7, 109.25±10, 106.75±1.3, 107.25±2.3, 105.25±8.64 and 105.25±1.5, respectively in T₁, T₂, T₃, T₄, T₅ and T₆. The total cost per bird was significantly lowest in T₃, T₅ and T₆ as compared to rest of the treatment groups except T₄. The difference between

T₁, T₂ and T₄ as well as difference between T₃, T₄, T₅ and T₆ was found non-significant.

The returns (Rs/bird) were 261.00±18.96, 262.25±26.46, 275.75±3.75, 312.50±8.45, 284.75±26.34 and 280.75±4.65, respectively in T₁, T₂, T₃, T₄, T₅ and T₆. The returns (Rs/bird) were highest in T₄ as compared to rest of the treatment groups except T₅. The difference between T₄ and T₅ as well as difference between T₁, T₂, T₃, T₅ and T₆ was found non-significant.

The benefit cost ratio was 2.37±0.17, 2.40±0.25, 2.58±0.04, 2.91±0.09, 2.71±0.28 and 2.67±0.04 in treatment groups T₁, T₂, T₃, T₄, T₅ and T₆, respectively. Significantly ($P<0.05$) highest BC ratio was found in T₄ as compared to rest of the treatment groups. Significantly lowest BC ratio was found in T₁ as compared to rest of the treatment groups except T₂. The data on economics of supplementation of Moringa leaf powder revealed that the supplementation of Moringa leaf powder up to 5% level increases the benefit cost ratio while, further increase in level of Moringa leaf powder decreases the benefit cost ratio. BC ratio in control groups was at par with group fed on feeds of organic origin.

The data on economics of supplementation of Moringa leaf powder revealed that the supplementation of MLP up to 5% level increased the benefit cost ratio while, further increase in level of MLP decreases the benefit cost ratio. BC ratio in control groups was at par with group fed on feed of organic origin. The results of the present

investigation are in agreement to the finding of Ayssiwede *et al.* (2011) who studied effects of MOLM inclusion (0, 8, 16 and 24%) in groundnut cake meal in the diets on growth performance, carcass and organ characteristics and economics in growing indigenous Senegal chickens. Significantly better growth performances, feed costs and economic margins were recorded in growing chickens fed diet containing 8% of MOLM making these dietary treatments the most economically profitable. Portugaliza *et al.* (2012) showed that the supplementation with MOALE was responsible for better health in terms of efficient conversion of feed into body meat. These gains were also reflected in higher revenue generation/ better returns of the total investment in feed.

Zanu *et al.* (2012) conducted an experiment to evaluate the effects of partial replacement of fish meal with Moringa leaf meal on broiler chickens. The graded level 0, 5, 10, and 15% Moringa leaf meal (MLM) were studied in broiler and the cost benefit analysis showed that incorporation of MLM resulted in reduced feed cost. However, the net revenue from birds fed diets containing MLM reduced as a result of poor weight gain. The results concluded that *Moringa oleifera* leaf meal when partially used to replace fish meal may hamper growth rate of broiler chickens.

In contrast, Onunkwo and George (2015) reported no significant differences on growth performance and economic parameters in broilers fed with *Moringa oleifera* leaf meal. Similarly, Pagua *et al.* (2014) noted that the addition of Moringa leaf powder on broiler diets did not found significant influence on feed cost per kg of broiler produced and income over feed and chick cost.

Conclusion

Supplementation of the Moringa leaf powder as feed

additives 5% could be important to comparative economics of Pratapdhan chicken under organic management system.

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Characterization of Mungbean (*Vigna radiata* (L.) Wilczek) Genotypes through Plant Morphological Characters

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Abstract

An experiment was carried out at the Pulses Research Station, Junagadh Agricultural University, Junagadh, to characterize fifty mungbean genotypes based on plant morphological characters. Based on plant growth type, the genotypes were grouped as erect (3 genotypes), semi erect (46 genotypes) and spreading (1 genotype). Based on plant growth habit, the genotypes were grouped as determinate (48 genotypes) and indeterminate (2 genotypes). Based on plant height, the genotypes were grouped as short (<50 cm) (29 genotypes) and medium (50-70 cm) (21 genotypes). Based on hypocotyl: anthocyanin coloration, the genotypes were grouped as present (29 genotypes) and absent (21 genotypes). In all the 50 genotypes, leaflet lobes was absent. Based on the leaf shape, the genotypes were grouped as deltoid (2 genotypes) and ovate (48 genotypes). Based on leaf colour, the genotypes were grouped as light green (24 genotypes), green (22 genotypes) and dark green (4 genotypes). Based on leaf vein color, the genotypes were grouped as green (11 genotypes), green with purple splashes (10 genotypes) and purple (29 genotypes). Based on petiole color, the genotypes were grouped as green (8 genotypes), green with purple splashes (40 genotypes) and purple (2 genotypes). Based on leaf size, the genotypes were grouped as small (7 genotypes), medium (37 genotypes) and large (6 genotypes). Based on stem pubescence, the genotypes were grouped into absent (3 genotypes) and present (47 genotypes). Based on, stem color the genotypes grouped into green (8 genotypes) and green with purple splashes (42 genotypes). Based on time of flowering, the genotypes were grouped as early (< 40 days) (5 genotypes), medium (40-50 days) (43 genotypes) and late (> 50 days) (2 genotypes). Based on flower color of petal, the genotypes were grouped into yellow (34 genotypes) and light yellow (16 genotypes). Pod pubescence was present in all fifty genotypes. Among 50 genotypes, pod color of premature pod was green (29 genotypes), while it was green with pigmented structure (21 genotypes). Based on pod curvature, the genotypes were grouped into two groups as straight (24 genotypes) and curved (26 genotypes). Based on pod position, the genotypes were grouped into two groups as above canopy (24 genotypes) and intermediate (26 genotypes). Based on the pod color of mature pods, genotypes were grouped into two groups as black (4 genotypes) and brown (46 genotypes). Among 50 genotypes, mature pod length was short (25 genotypes), while it was medium (25 genotypes). Seed color was green in all the genotypes. Based on seed shape drum (22 genotypes) and oval shaped (28 genotypes). On the basis of seed size, the genotypes categorized in medium seed size (3-5 gm) (24 genotypes) and large seed size (> 5 gm) (26 genotypes). Based on seed coat luster, the genotypes grouped as shiny (45 genotypes) and dull (5 genotypes).

Key words : Mungbean, characterization, plant, morphology.

Introduction

The mungbean (*Vigna radiata* L.) is a member of the legume family (Fabaceae) with the chromosome number $2n=22$. The mungbean is cultivated for its edible seeds and sprouts across Asia. It contains about 55% - 65% carbohydrate and are rich in protein, fat, vitamins and minerals. It is composed of about 20% - 25% protein, among which globulin (60%) and albumin (25%) are the primary storage proteins. The crop is also grown for hay, green manure and as cover crop (4). Besides being rich source of proteins and amino acids, they maintain soil fertility through the process of nitrogen fixation in symbiotic association with Rhizobium bacteria present in their nodules. Thus, they play a vital role as nitrogen fixing manufactories, which help in sustain productivity of soil.

It is one of the important pulse crop cultivated in

India ranking third having about 70% of the world area and 45% of production. In India, pulses are grown in nearly 28.34 million hectare area with production status of nearly 23.15 million tonnes at an average productivity level of 817 kg/ha. Mungbean is grown in about 5.13 million hectares with the total production of 3.09 million tonnes with a productivity of 601 kg/ha and contributing 10 % to the total pulse production. Mungbean is mostly grown in the state of Rajasthan (30.81%), Maharashtra (19.51%), Karnataka (15.35%), Andhra Pradesh (12.79%), Orissa (7.41%), Tamil Nadu (4.97%), and Uttar Pradesh (2.09%). In Gujarat during 2020-21, mungbean is cultivated in an area of 154.69 lakh ha with the production of 110.14 lakh tonnes and productivity of 712 kg/ha (2).

Morphological descriptors are the base for characterization of plant genotypes on the basis of

external appearance. Further, characterization of mungbean varieties is required for their description under plant variety for Distinctness, Uniformity and Stability is the basis for protection for a new plant variety under Indian Law (Protection of Plant Varieties and Farmer's right Act, 2011). Proposed new varieties are compared against a set of relevant characteristics prescribed according to (14). This investigation was undertaken to study mungbean genotypes on the basis of morphological traits to select the most promising germplasm for cultivation and use in improvement programme

Materials and Methods

The field experiment was conducted at the Pulses Research Station, Junagadh Agricultural University, Junagadh during summer 2022 to characterize the 50 genotypes of mungbean (*Vigna radiata* (L.) Wilczek) viz., GJM 1001, GJM 1002, GJM 1003, GJM 1004, GJM 1005, GJM 1006, GJM1007, GJM 1008, GJM 1009, GJM 1010, GJM 1011, GJM 1012, GJM 1016, GJM 1017, GJM 1020, GJM 1021, GJM 1022, GJM 1024, GJM 1025, GJM 1026, GJM 1027, GJM 1028, GJM 1104, GJM 1105, GJM 1108, GJM 1110, GJM 1111, GJM 1112, GJM 1113, GJM 1116, GJM 1117, GJM 1118, GJM 1102, GJM 1103, GJM 1703, GJM 1710, GJM 1714, GJM 1810, GJM 1812, GJM 1813, GJM 1806, GJM 1809, GJM 1822, GJM 1823, GJM 1825, GJM 1826, GJM 1832, GJM 1834, GM 4 and K 851, based on plant morphological characters. They were sown at 45×10 cm distance. The experiment was carried out in field as per Randomized Block Design with three replications. All the necessary cultural practices were carried out during crop standing. The observations were recorded on 5 randomly selected plants for each replication at different crop growth stages. The data obtained from field experiment conducted in RBD were analyzed as per standard method suggested by (9).

Results and Discussion

Plant morphological characters : Based on the plant morphological characteristics, the genotypes were categorized into different groups (Table-1). Based on plant growth type, the genotypes were grouped as erect in three genotypes, semi erect in forty six genotypes and spreading in one genotype. Based on plant growth habit, the genotypes were grouped as determinate in forty eight genotypes and indeterminate in two genotypes. Based on plant height, the genotypes were grouped as short (<50 cm) in twenty-nine genotypes and medium (50-70 cm) in twenty one genotypes. The plant height ranged 34.99 cm (GJM 1117) to 69.33 cm (GJM 1008) with a mean of 48.71 cm. Based on hypocotyl: anthocyanin coloration, the genotypes were grouped as present in twenty nine genotypes and absent in twenty one genotypes.

The genotypes GJM 1009, GJM 1017, GJM 1104, GJM 1110, GJM 1111, GJM 1116, GJM 1117, GJM 1102, GJM 1103, GJM 1703, GJM 1710, GJM 1825, GJM 1826, GJM 1832 and GJM 1834 were having similar plant morphology viz., semi-erect plant growth type, determinate growth habit, short plant height and present hypocotyl anthocyanin coloration.

The genotypes GJM 1008, GJM 1022, GJM 1027, GJM 1108, GJM 1813, GJM 1806 and GJM 1823 was having plant morphology viz., semi-erect plant growth type, determinate growth habit, medium plant height and absent hypocotyl: anthocyanin coloration, but differing in short plant height (GJM 1002, GJM 1112, GJM 1118, GJM 1714, GJM 1810, GJM 1812, GJM 1809, GJM 1822, GM 4 and K 851), in present hypocotyl: anthocyanin coloration (GJM 1025, GJM 1026 and GJM 1028) and in spreading plant growth type (GJM 1004).

The genotype GJM 1012 was having erect plant growth type, indeterminate plant growth habit, medium plant height and present hypocotyl: anthocyanin coloration, while the genotype GJM 1011 varied from above genotypes with respect to semi-erect plant growth type.

The genotypes GJM 1003 and GJM 1006 were having semi-erect plant growth type, determinate plant growth habit, medium plant height and present hypocotyl: anthocyanin coloration, but differing in absent hypocotyl: anthocyanin coloration (GJM 1002). Similar findings and grouping of genotypes based on plant morphological characters are reported by (3, 5, 6, 7, 8, 10, 11, 13) in mungbean.

Leaf morphological characters : In all the 50 genotypes, leaflet lobes was absent. Based on the leaf shape, the genotypes were grouped as deltoid in two genotypes and ovate in forty eight genotypes. Based on leaf color, the genotypes were grouped as light green in twenty four genotypes, green in twenty two genotypes and dark green in four genotypes. Based on leaf vein color, the genotypes were grouped as green in eleven genotypes, green with purple splashes in ten genotypes and purple in twenty nine genotypes. Based on petiole color, the genotypes were grouped as green in eight genotypes, green with purple splashes in forty genotypes and purple in two genotypes. Based on leaf size, the genotypes were grouped as small in seven genotypes, medium in thirty seven and large in six genotypes.

The genotypes GJM 1011, GJM 1021, GJM 1024, GJM 1028, GJM 1113, GJM 1802, GJM 1825 and GJM 1832 were having similar leaf morphology viz., absent leaflet lobes, ovate leaf shape, light green leaf color, purple leaf vein color, green with purple splash petiole color and medium leaf size.

Table-1 : DUS descriptors of 50 Mungbean genotypes.

Sr. No.	Genotypes	Plant Growth Type	Plant Growth Habit	Plant Height	Hypocotyl Color	Leaflet Lobes	Leaf Shape	Leaf Color	Leaf Vein	Petiole Color	Leaf Size	Stem Color	Stem Pubescence	Time of Flowering	Flower Color	Premature Color	Pod Pubescence	Pod Curvature	Pod Position	Pod Length	Pod Color	Seed Color	Seed Shape	Seed Weight	100 Seed Lusture	Seed								
1	GJM 1001	5	1	7	2	1	1	1	2	2	5	2	9	9	5	3	2	9	1	2	3	1	2	3	5	1								
2	GJM 1002	5	1	3	1	1	1	3	1	1	5	2	9	9	3	5	1	9	1	2	3	1	2	1	5	1								
3	GJM 1003	5	1	7	2	1	1	1	1	1	5	2	9	9	5	3	1	9	1	1	3	1	2	1	5	1								
4	GJM 1004	7	1	3	1	1	1	3	1	1	5	2	9	3	5	3	1	9	3	1	3	1	2	1	5	1								
5	GJM 1005	5	1	7	2	1	1	3	3	2	7	2	9	5	5	3	1	9	1	2	3	1	2	3	5	1								
6	GJM 1006	5	1	7	2	1	1	3	3	2	7	2	9	5	5	3	1	9	1	2	5	1	2	3	7	1								
7	GJM 1007	5	1	7	2	1	1	3	3	3	5	2	9	5	5	3	2	9	3	1	3	1	2	1	7	2								
8	GJM 1008	5	1	7	1	1	1	3	3	3	3	2	9	5	5	3	1	9	3	1	5	1	2	1	5	1								
9	GJM 1009	5	1	3	2	1	1	1	3	2	5	2	9	3	5	3	1	9	1	2	3	1	2	3	5	1								
10	GJM 1010	5	1	7	2	1	1	1	3	2	3	2	9	5	5	5	1	9	3	2	3	1	2	3	5	1								
11	GJM 1011	5	3	7	2	1	1	3	3	2	5	2	9	5	3	3	2	9	1	1	5	1	2	3	5	1								
12	GJM 1012	3	3	7	2	1	1	2	3	2	3	1	9	5	5	3	1	9	3	1	5	1	2	1	5	1								
13	GJM 1016	3	1	3	1	1	1	1	1	1	5	1	9	5	3	3	1	9	3	1	5	1	2	1	5	1								
14	GJM 1017	5	1	3	2	1	1	2	3	2	5	2	9	5	3	3	2	9	1	2	3	1	2	3	7	1								
15	GJM 1020	5	1	7	2	1	2	1	3	2	5	2	9	5	5	5	2	9	1	1	5	2	1	5	1	1								
16	GJM 1021	5	1	7	2	1	1	1	3	2	5	2	9	5	5	5	2	9	1	2	5	1	2	1	7	1								
17	GJM 1022	5	1	7	1	1	2	1	3	2	5	2	9	5	3	3	2	9	1	1	3	1	2	3	7	1								
18	GJM 1024	5	1	7	2	1	1	3	3	2	7	2	9	5	5	5	2	9	3	2	3	1	2	1	7	1								
19	GJM 1025	5	1	7	2	1	1	1	2	2	5	2	9	5	5	3	2	9	3	1	5	1	2	3	5	1								
20	GJM 1026	5	1	7	2	1	1	1	3	2	5	2	9	5	3	3	2	9	3	1	3	1	2	1	5	1								
21	GJM 1027	5	1	7	1	1	1	3	3	2	5	2	9	5	7	5	1	9	3	1	5	1	2	1	5	1								
22	GJM 1028	5	1	7	2	1	1	3	3	2	5	2	9	7	5	3	1	9	3	1	5	1	2	1	7	2								
23	GJM 1104	5	1	3	2	1	1	1	2	2	5	2	9	5	3	3	1	9	1	1	5	1	2	1	5	1								
24	GJM 1105	5	1	3	1	1	1	1	1	2	5	1	9	5	3	3	1	9	3	2	3	1	2	1	5	2								
25	GJM 1108	5	1	3	1	1	1	1	1	2	7	1	9	5	3	3	1	9	3	1	5	1	2	1	5	1								
26	GJM 1110	5	1	3	2	1	1	1	3	2	5	2	9	7	3	3	2	9	1	1	5	1	2	1	7	1								
27	GJM 1111	5	1	3	2	1	1	1	2	2	5	2	9	5	5	5	2	9	1	2	3	1	2	3	7	1								
28	GJM 1112	5	1	3	1	1	1	1	3	2	5	2	9	5	3	3	2	9	1	1	3	1	2	3	5	1								
29	GJM 1113	3	1	3	1	1	1	3	3	2	5	2	9	5	3	3	2	9	3	1	5	1	2	1	5	1								
30	GJM 1116	5	1	3	2	1	1	1	3	2	3	2	9	5	3	3	2	9	3	1	3	1	2	1	5	1								
31	GJM 1117	5	1	3	2	1	1	1	3	2	3	2	9	5	5	3	2	9	3	1	3	1	2	1	5	1								
32	GJM 1118	5	1	3	1	1	1	3	1	2	5	2	9	5	3	3	1	9	3	2	5	1	2	1	7	1								
33	GJM 1102	5	1	3	2	1	1	3	3	2	5	1	9	5	5	3	1	9	3	2	5	1	2	1	7	1								
34	GJM 1103	5	1	3	2	1	1	2	1	2	5	2	9	3	3	3	1	9	1	1	5	1	2	1	5	2								
35	GJM 1703	5	1	3	2	1	1	2	1	2	7	2	9	5	3	3	2	9	1	2	5	1	2	3	5	2								
36	GJM 1710	5	1	3	2	1	1	2	3	2	5	2	9	1	5	3	2	9	1	2	5	1	2	3	5	1								
37	GJM 1714	5	1	3	1	1	1	1	3	2	7	2	9	5	3	3	1	9	3	2	3	2	3	5	2	2								
38	GJM 1810	5	1	3	1	1	1	1	3	2	3	2	9	5	3	3	1	9	3	1	5	1	2	1	7	1								
39	GJM 1812	5	1	7	1	1	1	3	2	2	5	2	9	5	3	3	2	9	1	2	5	1	2	1	7	1								
40	GJM 1813	5	1	7	1	1	1	3	2	2	7	2	9	5	5	3	2	9	1	2	5	2	3	7	1	1								
41	GJM 1806	5	1	3	1	1	1	3	1	1	5	2	9	5	3	3	1	9	3	2	5	1	2	1	7	1								
42	GJM 1809	5	1	3	1	1	1	1	1	1	5	2	9	5	3	3	1	9	3	2	3	1	2	1	7	1								
43	GJM 1822	5	1	7	1	1	1	3	2	2	5	2	9	5	5	3	1	9	3	2	3	2	3	7	1	1								
44	GJM 1823	5	1	3	1	1	1	1	3	2	5	2	9	5	5	3	1	9	1	2	3	1	2	3	7	1								
45	GJM 1825	5	1	3	2	1	1	3	3	2	5	2	9	5	5	3	1	9	1	2	5	1	2	3	5	1								
46	GJM 1826	5	1	3	2	1	1	1	3	2	5	2	9	5	3	3	2	9	1	2	5	1	2	3	7	1								
47	GJM 1832	5	1	3	2	1	1	3	3	2	5	2	9	5	3	3	1	9	1	2	3	1	2	3	7	1								
48	GJM 1834	5	1	3	1	1	1	1	3	2	5	2	9	5	3	3	2	9	1	2	5	1	2	3	7	1								
49	GM 4	5	1	3	1	1	1	3	1	1	5	1	9	5	5	5	1	9	1	1	3	1	2	1	5	1								
50	K 851	5	1	7	1	1	1	1	2	2	5	1	9	5	5	3	1	9	3	1	3	1	2	1	5	1								
40	Erect-3 Determinate 1																									Present - straight - Intermediate - Small - Brown - Green - Shiny -								
																									9	1	ate - 2	3	1	2	Medium	Shiny -		
																									Curved - 3	Above Canopy - 1	Drum - 3	Large - 7	Dull - 2					
																									Semi Erect-5	Indeterminate 3	Medium - 7	Absent - 1	Green - 2	Green - 5	Pigment - 2			
																									Dark Green-2	Purple - 3	Purple - 3	Purple - 7	Late - 7					

The genotypes GJM 1009, GJM 1020, GJM 1026, GJM 1110, GJM 1112, GJM 1123, GJM 1826 and GJM 1834 were having leaf morphology viz., absent leaflet lobes, ovate leaf shape, green leaf color, purple leaf vein color, green with purple splashes petiole color and medium leaf size, but differing in green with purple splashes leaf vein color in GJM 1001, GJM 1025, GJM 1104, GJM 1111 and K 851 genotypes and green leaf vein color in GJM 1105 genotype.

The genotypes GJM 1002, GJM 1004, GJM 1806 and GM 4 having similar leaf morphology viz., absent leaflet lobes, ovate leaf shape, light green leaf color, green leaf vein color, green petiole color and medium leaf size, but differing in green leaf color in GJM 1003, GJM 1016 and GJM 1809 and dark green in GJM 1703.

The genotype GJM 1020 was absent leaflet lobes, deltoid leaf shape, green leaf color, purple leaf vein color, green with purple splashes petiole color and medium leaf size. While, the genotype 1022 differed from above genotype with respect to large leaf size.

The genotypes GJM 1017 and GJM 1710 was absent leaflet lobes, ovate leaf shape, dark green leaf color, purple leaf vein color, green with purple splashes petiole color and medium leaf size. While, the genotype 1012 differed from above genotype with respect to small leaf size.

The genotypes GJM 1103, GJM 1812 and GJM 1822 were having absent leaflet lobes, ovate leaf shape, light green leaf color, green with purple splashes leaf vein color, green with purple splashes petiole color and medium leaf size, but differing in small leaf size (GJM 1117) and large leaf size (GJM 1813) groups. Similar findings and grouping of genotypes based on leaf morphological characters are reported by (1, 3, 5, 6, 7, 8, 10, 11) in mungbean.

Stem morphological characters : Based on stem pubescence, the genotypes grouped into absent in three genotypes and present in all remaining forty seven genotypes. Based on, stem color eight genotypes grouped into green stem color and forty two into green with purple splashes.

The genotypes viz., GJM 1001, GJM 1002, GJM 1003, GJM 1004, GJM 1005, GJM 1006, GJM1007, GJM 1008, GJM 1009, GJM 1010, GJM 1011, GJM 1012, GJM 1017, GJM 1020, GJM 1021, GJM 1022, GJM 1024, GJM 1025, GJM 1026, GJM 1027 GJM 1028, GJM 1104, GJM 1110, GJM 1111, GJM 1112, GJM 1113, GJM 1116, GJM 1117, GJM 1118, GJM 1103, GJM 1810, GJM 1812, GJM 1813, GJM 1809, GJM 1822, GJM 1823, GJM 1825, GJM 1826, GJM 1832 and GJM 1834 were having similar stem morphology viz., present stem pubescence and green

with purple splashes stem color, while the genotypes GJM 1016, GJM 1105, GJM 1108, GJM 1102, GJM 1806, GM 4 and K 851 varied from the above genotypes with green stem color.

The genotypes GJM 1710, GJM 1714 having similar stem morphology viz., absent stem pubescence and green with purple splashes stem color, while the genotype GJM 1703 varied from above genotypes with respect to green stem color. Similar findings and grouping of genotypes based on leaf morphological characters are reported by (3, 6, 8, 11, 13) in mungbean.

Flower morphological characters : Time of flowering varied with the genotypes ranging from 38 days (GJM 1004) to 53 days (GJM 1110) with an average of 42.09 days. Based on time of flowering, the genotypes were grouped as early (< 40 days) with five genotypes, medium (40-50 days) with forty three genotypes and late (> 50 days) with two genotypes. The flower color of petal varied among different mungbean genotypes (Table 1). Based on, flower color of petal, the genotypes were grouped into yellow in thirty four genotypes and light yellow in sixteen genotypes.

Of all the genotypes evaluated, GJM 1028 and GJM 1110 genotypes were late in flowering with light yellow flower color of petal (GJM 1028) and yellow flower color of petal (GJM 1110), while GJM 1002, GJM 1004, GJM 1009, GJM 1012, GJM 1703 genotypes were early in flowering with light yellow flower color of petal (GJM 1002, GJM 1004 and GJM 1012) and yellow flower color (GJM 1009 and GJM 1703) and GJM 1001, GJM 1003, GJM 1005, GJM 1006, GJM1007, GJM 1008, GJM 1010, GJM 1011, GJM 1016 GJM 1017, GJM 1020, GJM 1021, GJM 1022, GJM 1024, GJM 1025, GJM 1026, GJM 1027, GJM 1104, GJM 1105, GJM 1108, GJM 1111, GJM 1112, GJM 1113, GJM 1116, GJM 1117, GJM 1118, GJM 1102, GJM 1103, GJM 1710, GJM 1714, GJM 1810, GJM 1812, GJM 1813, GJM 1806, GJM 1809, GJM 1822, GJM 1823, GJM 1825, GJM 1826, GJM 1832, GJM 1834, GM 4 and K 851 genotypes were medium in flowering with light yellow flower color of petal (GJM 1006, GJM 1010, GJM 1020, GJM 1021, GJM 1024, GJM 1111, GJM 1117, GJM 1102, GJM 1813, GJM 1822, GJM 1825 and GM 4) and yellow flower color of petal (GJM 1001, GJM 1003, GJM 1005, GJM1007, GJM 1008, GJM 1011, GJM 1016 GJM 1017, GJM 1022, GJM 1025, GJM 1026, GJM 1027, GJM 1104, GJM 1105, GJM 1108, GJM 1112, GJM 1113, GJM 1116, GJM 1118, GJM 1103, GJM 1710, GJM 1714, GJM 1810, GJM 1812, GJM 1806, GJM 1809, GJM 1823, GJM 1826, GJM 1832, GJM 1834 and K 851). Similar findings and grouping of genotypes based on flower morphological characters are reported by (3, 6, 7, 8, 10, 11, 12, 13) in Mungbean.

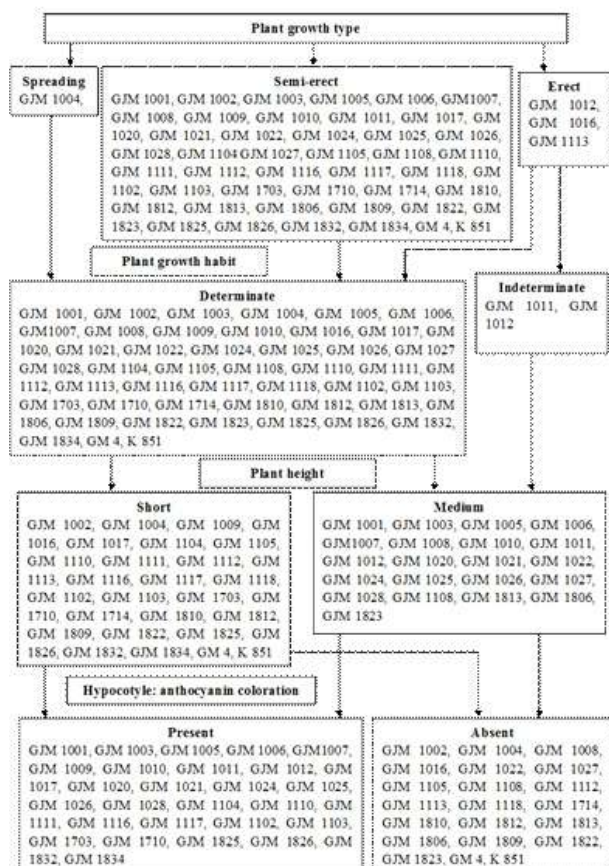


Figure-1 : Mungbean genotypes identification keys on the basis of plant morphological characters.

Pod morphological characters : All the 50 mungbean genotypes evaluated did not show any variation for pod pubescence. Pod pubescence was present in all fifty genotypes. The pod color of premature pod varied among the mungbean genotypes. Among 50 genotypes, pod color of premature pod was green in twenty nine genotypes, while it was green with pigmented structure in twenty one genotypes.

Based on pod curvature, the genotypes were grouped into two groups as straight in twenty four genotypes and curved in twenty six genotypes. Based on pod position, the genotypes were grouped into two groups as above canopy in twenty four genotypes and intermediate in twenty six genotypes. Based on the pod color of mature pods, genotypes were grouped into two groups as black in four genotypes and brown in forty six genotypes. The pod length at maturity varied among the mungbean genotypes. The mean mature pod length of the genotypes was 7.96 cm. Significantly the highest mature pod length was observed in GJM 1110 (8.95 cm) followed by GJM 1016 (8.77 cm), GJM 1020 (8.55 cm), GJM 1806 (8.55 cm) and GJM 1703 (8.51) and the lowest was observed in GJM 1112 (7.18 cm). Among 50

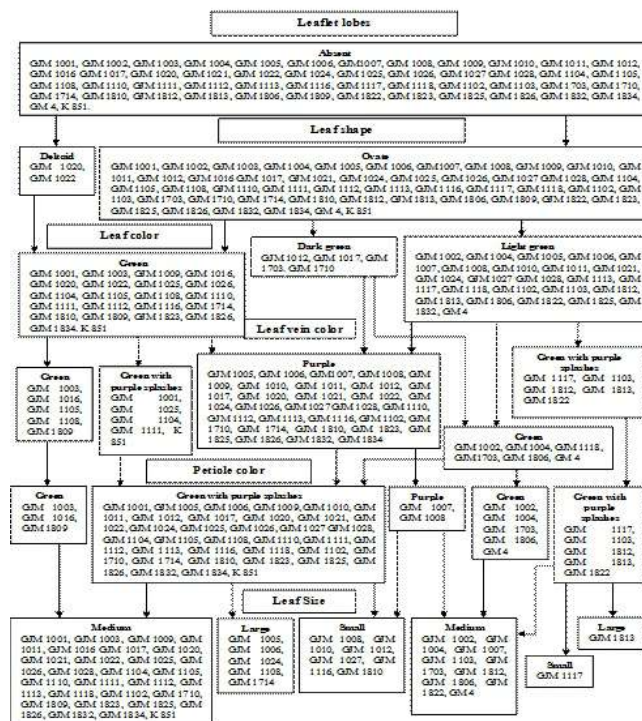


Figure-2 : Mungbean genotypes identification keys on the basis of leaf morphological characters.

genotypes, mature pod length was short in twenty five genotypes, while it was medium in twenty five genotypes.

The genotypes viz., GJM 1001, GJM 1002, GJM 1005, GJM 1009, GJM 1017, GJM 1111, GJM 1823, GJM 1832 were having similar pod morphology viz., green pod color of premature pod, present pod pubescence, straight pod curvature, intermediate pod position, short pod length of mature pod and brown pod color, while the genotypes GJM 1006, GJM 1021, GJM 1812, GJM 1825, GJM 1826 and GJM 1834 varied from the above genotypes with respect to medium pod length of mature pod.

The genotypes viz., GJM 1008, GJM 1012, GJM 1016, GJM 1025, GJM 1027, GJM 1028, GJM 1113, GJM 1703 and GJM 1810 were having similar pod morphology viz., green with pigmented structure pod color of premature pod, present pod pubescence, curved pod curvature, above canopy pod position, medium pod length of mature pod and brown pod color, while the genotypes GJM 1004, GJM 1007, GJM 1026, GJM 1116 and GJM 1117 varied from the above genotypes with respect to short pod length of mature pod.

The genotypes GJM 1002, GJM 1010, GJM 1105, GJM 1108 and GJM 1803 having similar pod morphology viz., green pod color of premature pod, present pod pubescence, curved pod curvature, intermediate pod position, short pod length of mature pod and brown pod

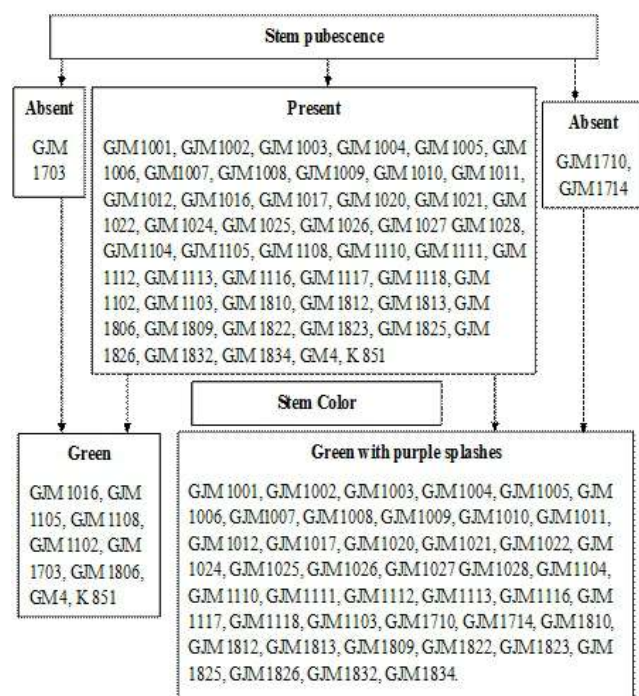


Figure-3: Mungbean genotypes identification keys on the basis of stem morphological characters.

color, but differing in black pod color in GJM 1714 and GJM 1822 genotypes and above canopy in GJM 1004 and K 851 genotypes.

The genotype GJM 1813 was having similar pod morphology viz., green with pigmented structure pod color of premature pod, present pod pubescence, straight pod curvature, intermediate pod position, medium pod length of mature pod and black pod color, while the genotype GJM 1020 varied from the above genotype with respect to above canopy pod position. Similar findings and grouping of genotypes based on pod morphological characters are reported by (3, 6, 7, 8, 10, 11, 12, 13) in mungbean.

Seed morphological characters : All the 50 mungbean genotypes evaluated did not show any variation for seed color. Seed color was green in all fifty genotypes. Based on seed shape, the genotypes were grouped as drum in twenty two genotypes and oval shaped in twenty eight genotypes. On the basis of seed size, twenty four genotypes categorized in medium seed size (3-5 gm) and twenty six in large seed size (> 5 gm). The seed size ranged from 5.83 g (GJM 1812) to 4 g (GJM 1009) with a mean of 4.87 g. Based on seed coat luster, the genotypes were grouped as shiny in forty five genotypes and dull in five genotypes.

The genotypes viz., GJM 1006, GJM 1017, GJM 1022, GJM 1111, GJM 1117, GJM 1813, GJM 1822, GJM 1823 and GJM 1826 were having similar seed morphology viz., green seed color, drum seed shape,

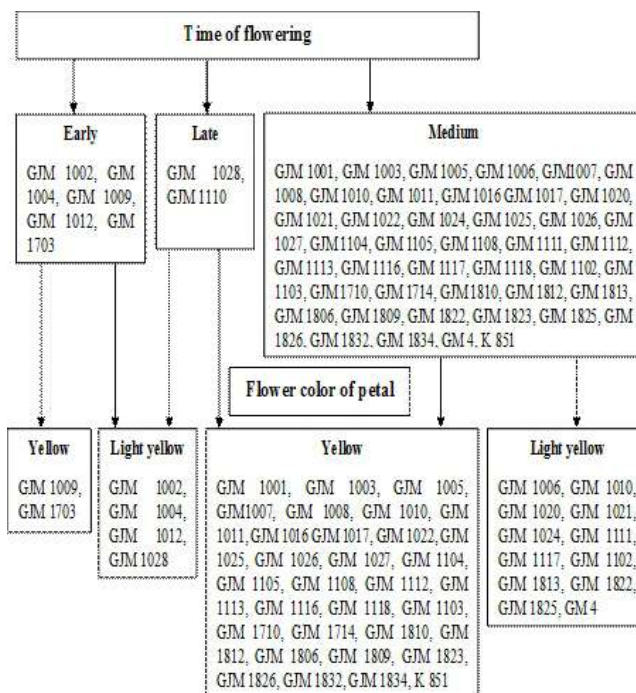


Figure-4: Mungbean genotypes identification keys on the basis of flower morphological characters.

large seed size and shiny seed coat luster. While, the genotypes GJM 1001, GJM 1005, GJM 1009, GJM 1010, GJM 1011, GJM 1025, GJM 1112, GJM 1710 and GJM 1825 differed from above genotype with respect to in medium seed size and the genotypes GJM 1021, GJM 1024, GJM 1108, GJM 1110, GJM 1118, GJM 1102, GJM 1103, GJM 1810, GJM 1806, GJM 1809 and GJM 1812 differed with respect to oval seed shape.

The genotypes GJM 1105 and GJM 1703 were having similar seed morphology viz., green seed color, oval seed shape, medium seed size and dull seed coat luster, while the genotype GJM 1714 varied from the above genotypes with respect to drum seed shape and the genotypes GJM 1007 and GJM 1028 varied with respect to large seed size.

The genotypes GJM 1002, GJM 1003, GJM 1004, GJM 1008, GJM 1012, GJM 1016, GJM 1020, GJM 1026, GJM 1027, GJM 1104, GJM 1105, GJM 1113, GJM 1116, GM 4 and K 851 were having seed morphology viz., green seed color, oval seed shape, medium seed size and shiny seed coat luster, but differing in dull seed coat luster in GJM 1007, GJM 1028, GJM 1105 and GJM 1703. Similar findings and grouping of genotypes based on seed morphological characters are reported by (3, 6, 7, 8, 10, 11, 13) in mungbean.

Conclusions

From the above results, it can be concluded that plant

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Impact of Cluster Frontline Demonstrations (CFLDs) on Groundnut and Sesame Production, Adoption and Economic Impact in Anakapalli District of Andhra Pradesh

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Abstract

Krishi Vigyan Kendra, a farm science centre and an innovative institution located in Anakapalli district of Andhra Pradesh which was established in the year 2017 which covers 13 plain mandals and 7 tribal mandals catering the needs of farmers since then. The present study was undertaken to assess Cluster Frontline Demonstrations (CFLDs) which were carried with improved cultivars and scientific package of practices conducted during 2016-17 and 2017-18 in total of 100 demonstration plots on Groundnut and Sesame. The present study reveals Production, Productivity, Profitability and Transfer of Technologies in the district. The study was conducted with the randomly selected 60 farmers for each crop. The yield was recorded for all the years of the study both in control and demonstration plots. The parameters viz., frequency, mean, percentage, impact in adoption and yield increase were worked out. The interventions of KVK had paved the way for increased productivity of Groundnut and Sesame crops. The results revealed that average yield of groundnut increased by 12.17% and that of sesame was 40.62 % under cluster frontline Demonstrations. The average adoption rate increased by 4.40 % in Groundnut and 3.5 in Sesame crops. It was observed that the benefit cost ratio (B: C) of recommended practice (CFLDs) were 2.93 and 2.22 as compared to 2.50 and 1.71 in farmer's practice. Therefore, the results clearly indicates that the use of improved varieties and package of practices with scientific intervention under frontline demonstration programme contribute to increase the production and profitability of oilseed farmers' (groundnut and sesame) in Andhra Pradesh State.

Key words : Improved cultivars, scientific package, production and profitability.

Introduction

Agriculture is the backbone of Indian economy. Major portion of the Indian workforce is involved in Agriculture directly or indirectly. It is extremely important since it gives the bulk of our population a means of subsistence and significantly boosts both our national GDP and productive employment. Agriculture practice necessitates being creative, environmentally conscious, relying on farmers' experience, and utilizing current scientific advancements. The major goal of technology transfer is to raise the socioeconomic levels of rural farmers by improving their knowledge and abilities. Groundnut and sesame are cultivated in an area of 6.61 and 0.39 hectares, respectively in Andhra Pradesh. In Anakapalle district they are cultivated in 394 and 1625 hectares, respectively. The productivity of groundnut is 650 kg/ha. which is below the nations average i.e. 661 kg/ha. The average yield of sesame (405 kg/ha) in India is low when compared with other countries in the world. In Andhra Pradesh sesame is cultivated in 0.39 lakh ha area with 0.14 lakh tones production with an average yield of 343 kg/ha (Anonymous, 2019). Farmers need right information, at

right time, from right source for right decision making in order to increase their farm income. Also, the information need of the farmers is diverse and they also searching different sources for getting information on agriculture and scientists of KVKs were found as one of the important sources of knowledge of the farmers in Nagaland (Jamir and Sharma, 2018). It was observed that 88.33 per cent of the respondents perceived that the extension services implemented by Krishi Vigyan Kendra were useful to more useful for them regarding the dissemination of knowledge (Sarnaik et al., 2020). Hence, KVK Kondempudi planned CFLDs of groundnut and sesame with a goal of increasing the productivity of the oilseed crops and befitting farmers of the district. The main role of KVKs in the context of agricultural extension is more of 'Informative than emancipatory extension and thus performs the duty of front-line extension. Cluster front line demonstrations (CFLDs) is one of the responsibilities of KVKs and it's a novel approach to provide a direct interface between researcher and farmer for the transfer of technologies developed by them and to get direct feedback from farming community. A considerable time has passed after the initiation of CFLDs and it is time to take stock of the

situation, especially on the performance appraisal. Therefore, the questions arise whether there is an impact of CFLDs on the beneficiary farmers' adoption of improved cultivars, scientific package of practices and ultimately on the level of agricultural development in the district. So, keeping these aspects in view, a study entitled "Impact of Cluster Frontline Demonstrations (CFLDs) on Groundnut and Sesame Production, adoption and economic impact in Anakapalli District of Andhra Pradesh" has been conducted.

The objectives of the present study were to analyze the Cluster Frontline Demonstrations (CFLDs) on Groundnut and Sesame Production, economic impact and adoption levels in the district.

Materials and Methods

The present investigation was undertaken in Anakapalli district of Andhra Pradesh. The study was conducted in 5 KVK operational villages i.e Gowripatnam, R. Narsapur, Mediwada, Buchayyapeta and Bangarumetta with a selected randomly sampling of 12 farmers from each village thus making a sample size of 60 members. Selected farmers were the beneficiaries of KVK CFLDs and need based inputs were also provided to the beneficiaries. The farmers followed the full package of practices recommended by KVK, Kondempudi for groundnut like improved variety TCGS-1157 (Nityaharitha), seed treatment with rhizobium, Gypsum application, nutritional weed management and timely protection measures and for sesame practices like improved YLM – 66 Variety Seed, treatment, Line Sowing, weed management and ICM. For comparison the farmers' practices were followed by using existing varieties and their known practices. The yield data of demonstration plots as well as control plots were collected immediately after harvesting to assess the impact of CFLDs on the yield of crops. However, structured and pre-tested interview schedule was used to elicit the information from beneficiary farmers about adoption, varietal replacement and horizontal spread of technologies in adopted villages. The personal interview was conducted with the beneficiary farmers to assess the impact of practices by the farmers. The following formulae

were used to assess the impact of interventions on the different parameters of crops.

1. Impact on yield (% Change)

$$\frac{\text{Yield of demonstration plot (ha}^{-1}) - \text{Yield of control plot (ha}^{-1})}{\text{Yield of control plot (ha}^{-1})} \times 100$$

1. Impact on adoption(% Change)

$$\frac{\text{No. of adopters after demonstration} - \text{No. of adopters before demonstration}}{\text{No. of adopters before demonstration}} \times 100$$

$$3. \text{ Benefit Cost Ratio} = \frac{\text{Total income}}{\text{Total costs}}$$

The simple statistical tools like frequency, percentage, mean was adopted to interpret the data in a meaningful way.

Results and Discussion

The results in table-1 and fig.-1 indicate that there is a considerable impact of around 9.93% and 40.62 % on the yields of groundnut and sesame, respectively through interventions of KVK by CFLDs. Thus, it is evident from the results that under the CFLDs, the yield of groundnut and sesame was comparatively much higher than the farmers practices.

The table-2 and fig.-2 indicates that the B: C cost ratio paddy was 2.93 which was earlier 2.50 before CFLDs for groundnut and 2.22 for sesame which is earl 1.71 after the CLDs interventions of KVK and contributed positively in enhancing the income levels of farmers.

It is evident from the table 3 and fig. 3 that under the CFLDs of KVK there is an increase of 4.4 folds of adoption in groundnut and 3.5 folds in sesame, respectively. Thus, through CFLDS of groundnut and sesame with more scientific interventions of KVK, the change yield and income had been changed contributed positively in enhancing the adoption level of farmers.

Conclusions

The present study on impact analysis of CFLDs on Oilseeds of KVK, Kondempudi revealed that it made the

Table-1 : Impact of Cluster Frontline Demonstrations on yield of Groundnut and Sesame. N : 60

S. No.	Crop	KVK Technological intervention	Framers practice (q ha ⁻¹)	Demonstration plot (q ha ⁻¹)	Impact (% change)
1.	Groundnut	Improved variety TCGS- 1157 (Nityaharitha), seed treatment with rhizobium, Gypsum application, nutritional weed management and timely protection measures.	15.6	17.5	9.93
2.	Sesame	Improved variety (YLM – 66), Seed treatment, Line Sowing, Weed management and ICM.	3.2	4.5	40.62

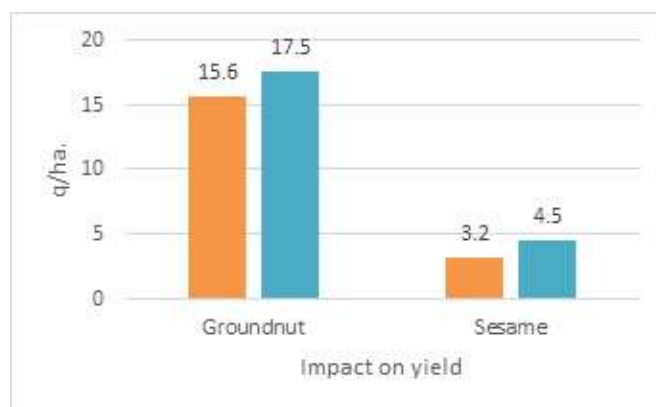


Fig.-1 : Impact of Cluster Frontline Demonstrations on yield of Groundnut and Sesame.

Table-2 : Economic impact of Cluster Frontline Demonstrations on Groundnut and Sesame. N : 60

S.No.	Crop	Item	Avg. yield (Q/ha)	Cost of cultivation (Rs./ha)	Net Returns (Rs./ha)	B:C ratio
1.	Groundnut	Farmers method	15.6	26750	66,850/-	1:2.50
		Improved variety TCGS-1157 (Nityaharitha), seed treatment with rhizobium, Gypsum application, nutritional weed management and timely protection measures.	17.5	26750	78,250/-	1:2.93
2.	Sesame	Farmers method	3.2	15000	10600	1:1.71
		Improved variety (YLM-66), Seed treatment, Line Sowing, Weed management and ICM.	4.5	16250	19750	1:2.22

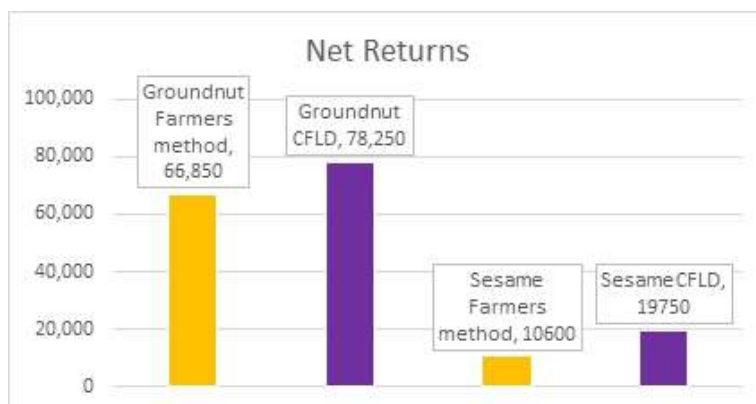


Fig.-2: Economic impact of Cluster Frontline Demonstrations on Groundnut and Sesame.

Table-3 : Impact of Cluster Frontline Demonstrations on extent of adoption of Groundnut and Sesame.

S. No.	Crop	Number of adopters			
		Before Demonstration	After Demonstration	Change in no. of adopters	% Change
1.	Groundnut	12	65	53	4.4 folds
2.	Sesame	18	81	63	3.5 folds

commendable difference in the productivity of Groundnut and sesame crops by its series of interventions like improved varieties, seed treatment with rhizobium, Gypsum application, nutritional weed management and timely protection measures through CFLDs. Krishi Vigyan Kendra contributed positively in enhancing the income

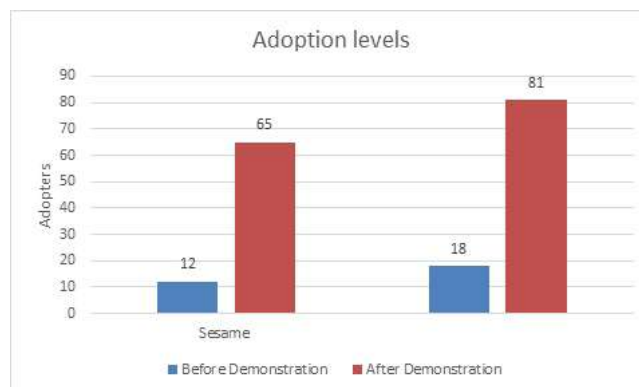


Table-5 : Reasons for non-adoption.

Technology	Reasons for non - adoption
Improved varieties	Lack of availability and market information
Seed treatment	Lack of technical knowledge
Gypsum application	Lack of technical knowledge
Nutrient management	Lack of knowledge on chemical compositions of fertilizers
IPM	Lack of information about IPM practices.
Line Sowing	Complex and time consuming
weed management	Lack of knowledge on weedicides

level and adoption levels of farmers in various aspects of agricultural production technologies. KVK practices created great awareness and motivated the other farmers to adopt appropriate production technologies. Indeed, the efforts of the KVK seemed to have a positive effect in enhancing the farmers' technical knowledge on agricultural production technologies.

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Nitrogen Fractions, Organic Carbon Status and Chemical Properties in the Soils of Coastal Region of Gujarat

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Abstract

The present research work was carried out in surface soils of Coastal region under Junagadh Agricultural University, Junagadh, Gujarat, India during 2021-2023. Total 100 soil samples were collected using the GPS location of Coastal region and then after nitrogen fractions, Organic Carbon status and Chemical properties were evaluated. The status of Total N (0.017 to 0.071 %), Available N (159.9 to 561.6 kg ha⁻¹), Ammonical N (13.42 to 66.42 mg kg⁻¹), Nitrate N (5.67 to 46.38 mg kg⁻¹), Organic Carbon (0.21 to 1.56%), pH (7.5 to 8.9) and EC (0.12 to 3.04 ds m⁻¹) were recorded in soils. About 36 soil samples were tested as low class (< 250 kg ha⁻¹), 63 soil samples were under medium class (250-500 kg ha⁻¹) and 1 soil sample falls in high total nitrogen fertility class (> 500 kg ha⁻¹). The high nutrient index values of 2.9, 2 and 1.9 for total nitrogen were reported in soils of the bhanvad, Jam Khambhaliya and dwarka taluka, respectively. In general, available nitrogen also influenced positive significant relationship with total nitrogen, available N, ammonical nitrogen, nitrate nitrogen and organic carbon.

Key words : Surface soil, Ammonical, GPS, nutrient index, EC and available nitrogen.

Introduction

Nitrogen in soil exists in two major forms: (i) organic and (ii) inorganic nitrogen. The inorganic forms (NH₄⁺, NO₃⁻ and NO₂⁻) are very important from crop nutrient point of view, because plant root takes up nitrogen from the soil mostly as NO₃⁻ and to some extent as NH₄⁺-N. The NO₂⁻ form is unstable and is usually present in soil in lesser extent. Organic N form constitute up to 90% of total N in the plow layer of mineral soils and only about 1-4% in mineralized as plant-available N (NH₄⁺ and NO₃⁻ form). Mineralization of organic nitrogen is seldom sufficient to achieve the maximum yield possible with modern cultivars, so additional nitrogen from mineral fertilizer or organic sources (e.g., animal manures, bio fertilizer and legume residue) is needed. Only a small proportion of total N is present in the available forms (NH₄⁺ and NO₃⁻) in the soil. Nitrogen occupies unique position among the elements essential for plant growth because it is required in large amounts by most of the agricultural crops. The total nitrogen in soils generally varies from 0.02 to 0.44 % with overall mean 0.05%. Due to tropical climate, the Indian soils are poor in total N, which varies from 0.04 to 0.12 %. Plant available nitrogen release from soil organic nitrogen or applied in fertilizer is highly susceptible to loss from soil plant system through leaching and denitrification. Knowledge of different forms of nitrogen and factors affecting their distribution throughout the root zone

penetration is essential to improve the nitrogen nutrition of the crops growing with diversified root system. The knowledge of the various forms of phosphorus present in a soil and condition under which these became available to the plants is a prerequisite in assessing the availability of phosphorus in the soil and crop response to applied P Fertilizers (Fueki and Konno, 2002). Since the different forms of soil phosphorus have different solubility under different soils environmental conditions; the availability in the soil and the uptake of phosphorus by crops should largely depend upon the different factors prevailing in and through the soils (Narayanasamy and Biswas, 2000). Thus, knowledge of the dynamics of P in soil is helpful in understanding the soil processes influencing the availability of this nutrient and its uptake by plant. Today, there is a serious issue with soil fertility. because a wide variety of chemical fertilizers are used in Saurashtra Region. Additionally, a negative effect on the physical, chemical, and biological properties of the soil (Ganvit *et al.* 2023). Crop productivity is largely determined by it and therefore soil fertility and soil nitrogen were still considered synonymous to each other in many areas. Soil fertility refers to the ability of soil to supply nutrients and its proper assessment before planting crops in the adoption of appropriate measures to compensate for deficit and ensure good crop production (Paragi *et al.* 2022). When measurements describing nitrogen dynamics in the soil system are included in routine soil nitrogen testing, on

which fertilizer nitrogen recommendations should be based, accurate diagnosis of nitrogen status will be possible. The characteristics of the soil profile, which are influenced by different factors and processes of soil formation, suffer from a significant impact on soil fertility and crop productivity (Dash *et al.*, 2019). The soil nitrogen system is most dynamic in nature and its content is affected by number of soil and climate factors. Because of tropical climate, Indian soils are low in nitrogen which varies from 0.03 to 0.1 per cent. A soil survey is an inventory of a landscape's soil physical characteristics, including topography, soil texture, soil structure, parent material, internal drainage, depth to groundwater, degree of erosion and salinity (Kachhiyapatel *et al.* 2022). Keeping in view the above said context the current study was conducted to determine the spatial distribution of nitrogen fractions and chemical properties in surface soil and their relationship to their forms. In this occasion, a study on GPS based soil testing was done to evaluate the potassium fractions in soils of different talukas of Gujarat, India.

Materials and Methods

The soils were found predominantly black cotton soil and very wide variation in physical properties such as light to heavy texture in soil taxonomy, and moderate sub angular blocky structure by USDA, morphologically the profile of these soils have A-C horizon characteristics (Tripura, 2018). The ten surface soil samples were collected from 10 each talukas Coastal region of Gujarat (Table 1 and Fig. 1). After being air-dried and ground to pass through a 2-mm sieve and stored in gunny bags. Soil sample processed (<2 mm) and analysed for characteristics

following standard procedures. Total nitrogen was determined by the modified Kjeldahal method (Jackson, 1973). Available nitrogen was determined by the alkaline permanganate method as described by (Subbiah and Asija, 1956). Ammonical nitrogen was determined by the Richardson's method (Richardson, 1938). Nitrate nitrogen was determined after Olsen's extraction for ammonia (Olsen, 1929). The Coastal region has a tropical wet and dry climate with three different seasons, including a monsoon season from July to October, a hot summer from March to June and a mild winter from November to February. The region experiences harsh weather conditions, with temperatures ranging from 28 °C to 43 °C in the summer and 10 °C to 25 °C in the winter.

Statistical Analysis : The data generated by analysis of soil samples was statistically analysed as per the following parameters given by Panse and Sukhatme (1985). Also, Correlation and Regression were calculated as described by Steel and Torrie (1980).

Results and Discussion

Available Nitrogen : The present study shows in Table-1 that the available nitrogen ranged between 159.9 to 561.6 kg ha⁻¹ with a mean value of 285.1 kg ha⁻¹. The data revealed from the bar diagram that the lowest mean value of available nitrogen (246.9 kg ha⁻¹) was obtained from the samples of Jodiya taluka on the other hand it was low and not sufficient to support crop requirement (Fig.2). The highest mean value was 351.9 kg ha⁻¹ in samples of Bhanvad taluka followed by Jam khambhaliya (325.8 kg ha⁻¹), Dwarka taluka (307.2 kg ha⁻¹) and kalyanpur (279.18 kg ha⁻¹) presented in Fig.-3. The contribution of available nitrogen ranged from 2.38 % to 2.79 % toward total

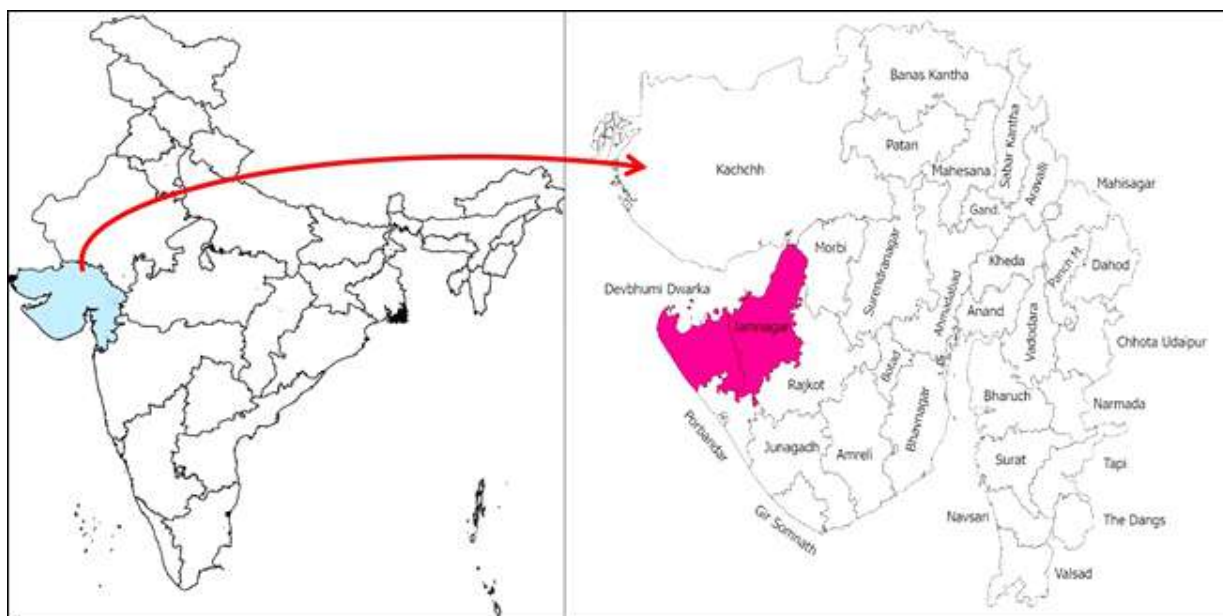


Fig.-1. Map of Soil Survey Coastal region of Gujarat.

nitrogen (Table-1). Similar low to medium range of nitrogen were reported by Vijaykumar and Haroon (2013) at Theni district, Tamilnadu and Mishra and Kumar (2020) at different tehsils of Mirzapur, Uttar Pradesh.

Total Nitrogen : The distribution of total nitrogen mean basis is shown in Table-1 and range of total nitrogen was 0.017% to 0.072 % with mean value of 0.039 %. The data revealed that the lowest mean value of total nitrogen (0.034%) was obtained from the samples of Rajkot taluka it may due to intensive cultivation followed by farmers and less contribution of organic carbon in these soils. the highest mean value of total nitrogen (0.048 %) was found in samples of Dwarka taluka. It may be due to continuously use nitrogen containing fertilizer in that areas. According to the correlation coefficient among forms, available K were strongly positively correlated with each other's. except pH and EC (Table 3). This indicated the increasing availability of nitrogen among other forms further indicating that the available N is governed by organic carbon and other forms of nitrogen. The results are in accomplished with Vekaria *et al* (2015) studied in the soils of Saurashtra region. Only a small fraction, usually about 2 % gets mineralised due to microbial activity in a growing season. Very little amount of nitrogen is also present in ionic forms viz, ammonium, nitrate and nitrite (Singh *et al.* 2005).

Ammonical Nitrogen : The overall value of ammonical nitrogen in the Coastal region was found 13.41-66.40 mg kg⁻¹ or equivalent to 0.074 to 0.368 Cmol kg⁻¹ (Table-1) with mean value of 32.84 mg kg⁻¹. Similar results have been reported by Misal *et al* 2020 The findings indicated that the minimum value of ammonical nitrogen 28.79 mg kg⁻¹ was obtained from the samples of Dhrol taluka which be might due to the lowest organic carbon however the data revealed that maximum ammonical nitrogen 40.30 mg kg⁻¹ was found in the samples of Jam jodhpur followed by Kalavad (36.53 mg kg⁻¹), Jamnagar (35.76 mg kg⁻¹), Bhanvad (34.27 mg kg⁻¹), Dwarka (33.72 mg kg⁻¹) and Kalyanpur (30.53 mg kg⁻¹) talukas on the overall mean basis (Fig.3). The ammonical form of nitrogen positive correlated with organic carbon and nitrate nitrogen (Table 3). The results obtained for correlation among forms are agree with to that obtained by Saha *et al.* (2000) as they found strong positive correlation between NH₄-N and NO₃-N indicates their inter-relationship in N-transformation in soils.

Nitrate Nitrogen : The distribution of nitrate nitrogen is presented in Table-1. It ranging recorded 5.6 to 46.4 mg kg⁻¹ with mean value of 19.3 mg kg⁻¹. The data revealed that lowest mean value of nitrate nitrogen (14.88 mg kg⁻¹) was obtained from the samples of Jodiya taluka and the highest mean value of nitrate nitrogen (24.78 mg kg⁻¹) was

found in samples of Dwarka taluka and it might due to high total nitrogen in Dwarka taluka. Organic carbon positive correlated with nitrate nitrogen. similar results were obtained by Rajani *et al.* (2010) in the soil of Junagadh, Gujarat.

Organic Carbon : The organic carbon ranged from 0.21-1.56% in the coastal region, with a mean value of 0.48%. The highest value of organic carbon was found in Bhanvad taluka soils, with a mean of 0.67% and followed by Jam khamabhalaya (0.63%), Kalyanpur (0.55%), Jam jodhpur (0.53%), Kalvad (0.47%) and Lalpur (0.46%) while the lowest value of 0.42% was found in Jamnagar taluka soils (Fig.-3). The higher status of organic carbon in some soils might be due to higher forest areas in that region which accumulated organic carbon. Simple correlation between selected organic carbon and all form of nitrogen. Similar results were reported by Tripura, (2018).

Status of chemical properties (pH & EC) : In general, the pH values of the soils for the coastal region were ranged from 7.5 to 8.9 with mean value of 8.2 (Table-1). The data revealed that the lowest mean value of pH (7.5) were obtained from the samples of Jamnagar and Bhanvad Talukas and the highest mean value of pH (8.2) was found in the samples of Dwarka and Jam jodhpur (Fig.2). Similar results were also obtained by Polara, *et al.*, (2004) for soils of Kutchh region and also reported for Jafrabad and Rajula talukas of Amreli district by Maliwal and Timbadia (2000), for Charu district of Rajasthan (Verma *et al.*, 2003). The overall mean value of EC of soil samples was 0.56 dS m⁻¹, which was varied widely from 0.12-3.04 dS m⁻¹ (Table-1). In North Saurashtra region the lowest mean value of EC found in Lalpur Taluka with 0.20 dS m⁻¹ and the highest mean value of EC found in Dwarka Taluka with 0.61 dS m⁻¹. The wide variation in EC could be due to the influence of seawater or shallow water table or poor quality of ground water prevailing in a particular location. The data of EC value indicate the potential danger of salinity development in this area.

Use the idea of nutrient index, the amount of nitrogen that is readily available in coastal region soils : The formula given by Parker *et al.* (1951) was used to calculate the Nutrient Index value. In light of this, the 100 soil samples under investigation may be divided into three categories: Available Nitrogen i.e. low (<250 kg ha⁻¹), medium (250-500 kg ha⁻¹) and high (>500 kg ha⁻¹) categories as given fertility classes by Rajani *et al.* (2010).

Nutrient index value

$$= \frac{\text{No. of Samples (Low)} \times 1 + \text{No. of Samples (Medium)} \times 2 + \text{No. of Samples (High)} \times 3}{\text{Total Number of Samples}}$$

Table-1: Range and mean of different forms of Nitrogen (N), Organic Carbon status and Chemical properties in different taluka of Coastal Region.

Name of Talukas	Total Nitrogen (%)	Available Nitrogen (kg ha ⁻¹)	Ammonical Nitrogen (mg kg ⁻¹)	Nitrate Nitrogen (mg kg ⁻¹)	Organic Carbon (%)	pH	EC (ds m ⁻¹)
Dwarka	0.023-0.067 (0.048)	138.6-379.8 (307.2)	15.29-48.67 (33.72)	7.16-36.29 (24.78)	0.21-0.66 (0.44)	8.0-8.4 (8.2)	0.41-3.04 (1.12)
Bhanvad	0.020-0.071 (0.040)	280.8-561.6 (351.9)	19.27-57.98 (34.27)	12.67-36.97 (21.21)	0.27-0.87 (0.67)	7.5-8.7 (8.0)	0.13-0.35 (0.27)
Kalyanpur	0.017-0.064 (0.037)	225.0-345.6 (279.18)	16.31-56.92 (30.53)	6.37-37.95 (18.75)	0.24-1.08 (0.55)	7.6-8.9 (8.1)	0.24-1.69 (0.42)
Jam Khambhaliya	0.020-0.055 (0.039)	264.6-468.0 (325.8)	19.43-58.78 (30.12)	10.95-41.76 (19.56)	0.36-1.56 (0.63)	7.8-8.4 (8.1)	0.33-1.79 (0.62)
Jamnagar	0.018-0.051 (0.034)	202.9-325.0 (249.9)	19.28-61.29 (35.76)	9.18-39.26 (20.65)	0.24-0.63 (0.42)	7.5-8.5 (8.0)	0.28-0.80 (0.42)
Jam jodhpur	0.022-0.070 (0.043)	199.5-359.4 (257.6)	23.09-64.29 (40.30)	11.00-30.61 (19.88)	0.30-0.81 (0.53)	7.7-8.6 (8.2)	0.17-0.74 (0.47)
Jodiya	0.028-0.048 (0.037)	159.9-338.8 (246.9)	14.58-46.28 (29.84)	8.37-26.97 (14.88)	0.36-0.60 (0.46)	7.5-8.7 (8.1)	0.29-1.09 (0.47)
Dhrol	0.023-0.058 (0.038)	196.0-452.6 (266.4)	13.42-56.72 (28.79)	5.67-35.67 (15.10)	0.33-0.57 (0.44)	7.6-8.7 (8.1)	0.34-2.95 (1.07)
Lalpur	0.022-0.062 (0.036)	187.4-387.0 (249.9)	18.37-48.56 (29.89)	7.28-35.67 (15.80)	0.24-0.63 (0.46)	7.7-8.4 (8.1)	0.12-0.23 (0.20)
Kalavad	0.017-0.058 (0.037)	202.9-306.1 (254.3)	19.68-66.42 (36.53)	9.37-46.38 (19.05)	0.33-0.66 (0.47)	7.8-8.6 (8.1)	0.19-0.70 (0.44)
Overall	0.017-0.071 (0.039)	159.9-561.6 (285.1)	13.42-66.42 (32.84)	5.67-46.38 (19.31)	0.21-1.56 (0.48)	7.5-8.9 (8.2)	0.12-3.04 (0.56)

Note : Values in parenthesis are mean of 10 samples.

Table-2 : Taluka wise percentage and the number of soil samples falling in low, medium and high fertility classes for available nitrogen.

Sr. No.	Name of Talukas	Low	Medium	High	Nutrient index	Nutrient index class
1.	Dwarka	(1)	(9)	(0)	1.9	Low
2.	Bhanvad	(0)	(9)	(1)	2.9	Low
3.	Kalyanpur	(2)	(8)	(0)	1.8	Low
4.	Jam Khambhaliya	(0)	(10)	(0)	2.0	Low
5.	Jamnagar	(6)	(4)	(0)	1.4	Low
6.	Jam jodhpur	(6)	(4)	(0)	1.4	Low
7.	Jodiya	(4)	(6)	(0)	1.6	Low
8.	Dhrol	(6)	(4)	(0)	1.4	Low
9.	Lalpur	(7)	(3)	(0)	1.3	Low
10	Kalavad	(4)	(6)	(0)	1.6	Low
	Overall Coastal region	(36)	(63)	(1)	1.62	Low

Note : Values in parenthesis are number of soil samples.

The nutrient index values for total nitrogen are presented in Table-4 and Table-2 the overall 100 soil sample of coastal region had nutrient index values of 2.33 for available nitrogen. It was referred to in medium class based on the nutrient index value. About 36 soil samples were tested as low class (< 250 kg ha⁻¹), 63 soil samples were under medium class (250-500 kg ha⁻¹) and 1 soil sample falls in high total nitrogen fertility class (> 500 kg ha⁻¹). The high nutrient index values of 2.9, 2 and 1.9 for total nitrogen were reported in soils of the bhanvad, Jam

Khambhaliya and dwarka taluka, respectively. Similar low to medium range of nitrogen were reported by Vijaykumar and Haroon (2013) at Theni district, Tamilnadu and Mishra and Kumar (2020) at different tehsils of Mirzapur, Uttar Pradesh.

Conclusions

The investigation's findings that the soils in the coastal region had low levels of nutrients overall basis. Most of the soil N was not in available forms. About 36 soil samples

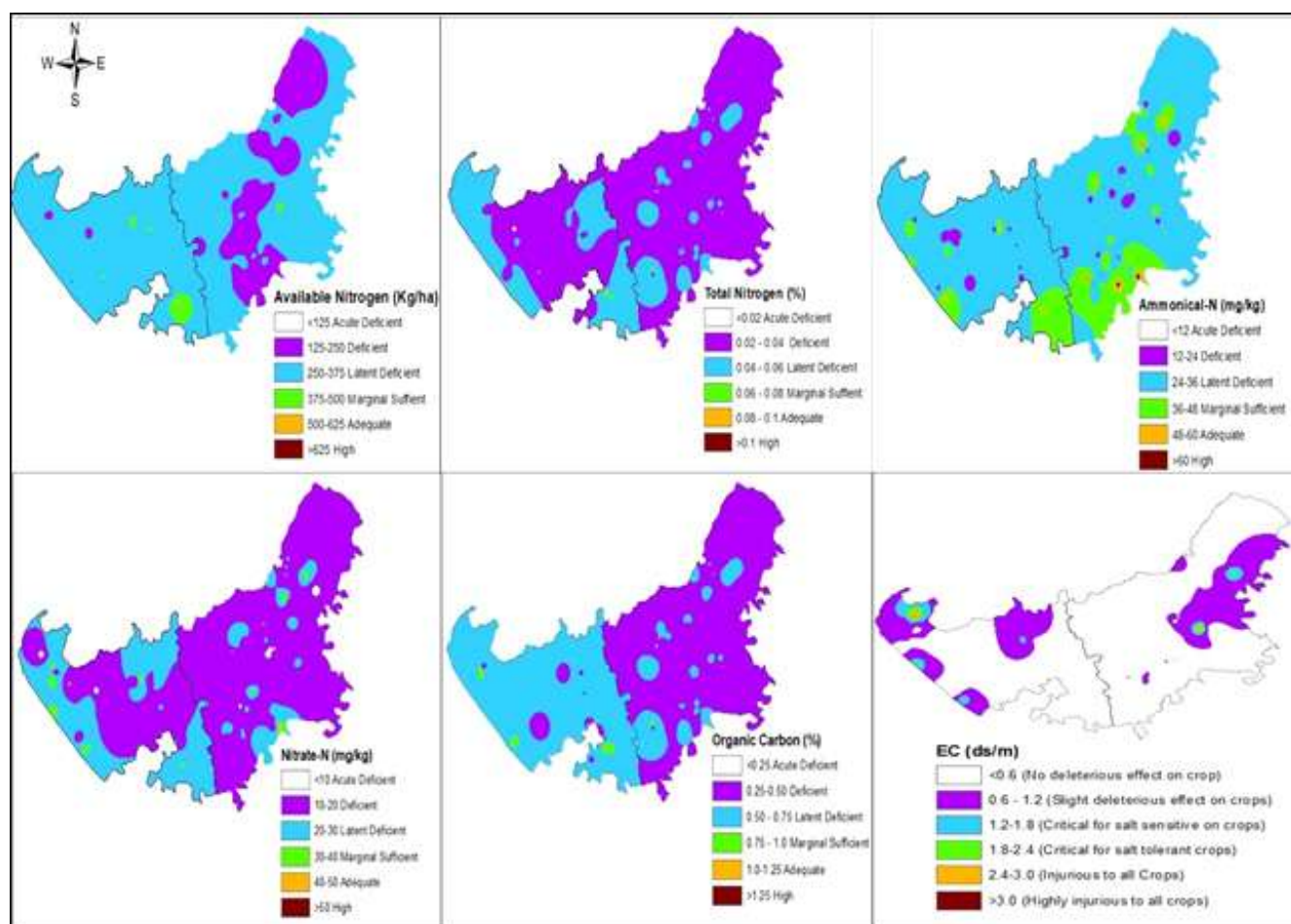
Table-3 : Simple correlation among different Fractions of nitrogen, organic carbon and chemical properties in surface soils of Coastal region (n=100).

	Total N	Available N	Ammonical N	Nitrate N	Organic Carbon	pH	EC
Total N	1						
Available N	0.469**	1					
Ammonical N	0.284**	0.683**	1				
Nitrate N	0.303**	0.597**	0.832**	1			
Organic Carbon	0.533**	0.978**	0.638**	0.608**	1		
pH	-0.02902	0.016061	-0.01681	0.013484	0.038452	1	
EC	0.174358	0.076766	-0.06843	-0.01336	0.096215	-0.10833	1

Note : ** at 1% level of significance.

Table-4 : Classification of nutrient value index.

Sr. No.	Nutrient index class	Value	Interpretation
1.	Low	=1.67	Low fertility status of area
2.	Medium	1.67-2.33	Medium fertility status of area
3.	High	=2.33	High fertility status of area

**Fig-2 : Overall distribution of Nitrogen fraction, Organic Carbon status and EC in Coastal region of Gujarat.**

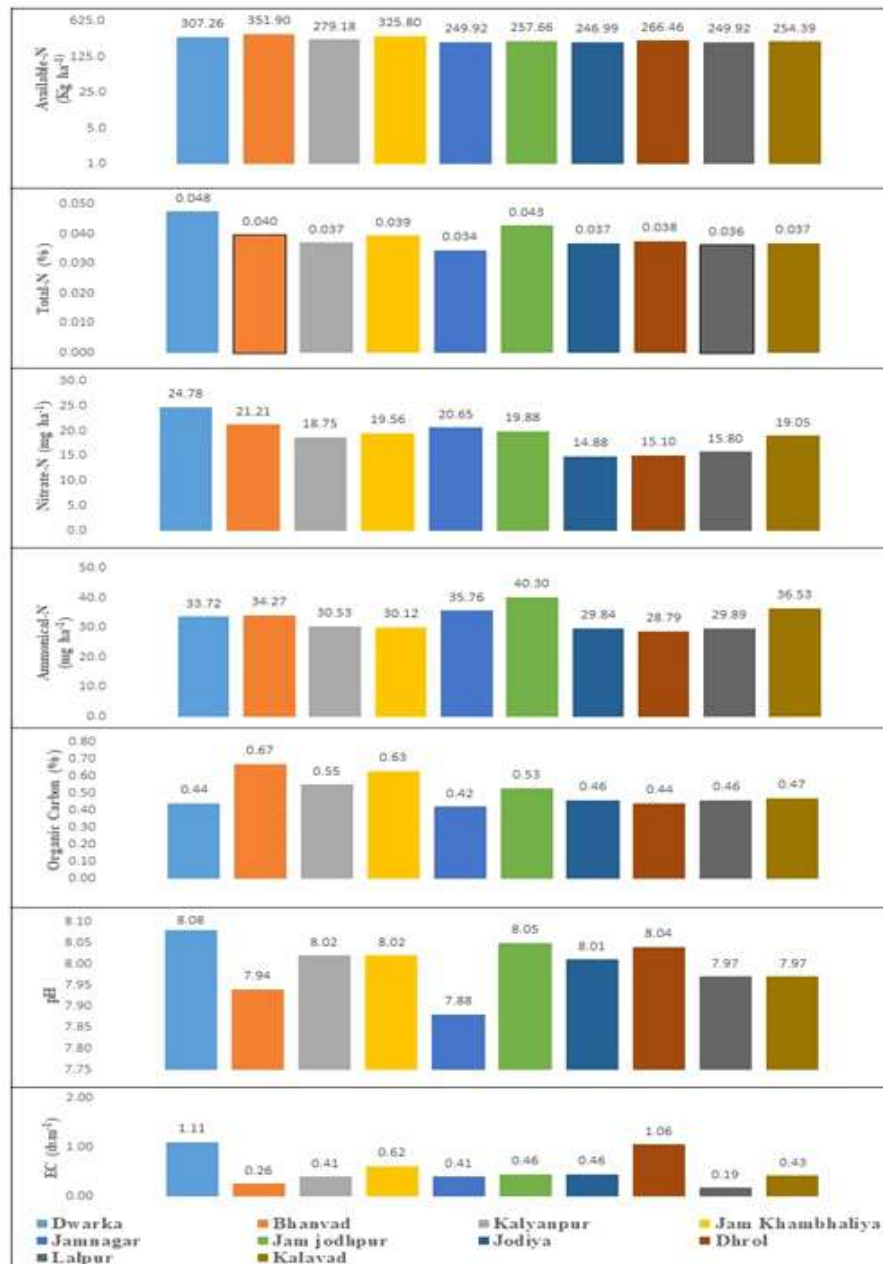


Fig.-3 : Taluka wise distribution of Nitrogen fraction, Organic Carbon status and EC on mean value basis.

were tested as low class ($< 250 \text{ kg ha}^{-1}$), 63 soil samples were under medium class ($250\text{-}500 \text{ kg ha}^{-1}$) and 1 soil sample falls in high total nitrogen fertility class ($> 500 \text{ kg ha}^{-1}$). The high nutrient index values of 2.9, 2 and 1.9 for total nitrogen were reported in soils of the bhanvad, Jam Khambhaliya and dwarka taluka, respectively. A significant highly positive relationship was obtained among these fractions.

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A Role of Graph with Pagerank Algorithm

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Abstract

The pages and hyperlinks of the World-Wide Web may be viewed as nodes and links in a directed graph. The graph has many a billion nodes, several billion links, and appears to grow exponentially with time. The in-degree and out-degree distributions of links in the graph are seen. The PageRank as another way of characterizing structure of the Web graph is considered. The PageRank algorithm works on the basic theory that the more important and useful a page is; the more other pages will link to it. Therefore, a page that has many other pages linking to it is more important, and will appear higher in the search results. PageRank algorithm used in some search engines to order their query responses. The PageRank values correspond to a unique eigenvector typically computed by applying the power method and an iterative technique based on matrix multiplication. Each algorithm's complexity is derived with respect to the number of blocks contained in the coarsest equitable partition and compared to the PageRank algorithm's complexity. The practical lower bound on the PageRank algorithm's execution time was previously only suggested using experimental results. Finally, these results motivate several avenues of future research related to graph isomorphism.

Key words : Page rank, graph isomorphism, coarsest equitable partition, eigen value vector, average rank.

Introduction

The PageRank algorithm is used in certain search engines to rank query responses. The algorithm produces a unique eigenvector, PageRank vector, whose entries equal the probability each node is visited by an object that randomly traverses the graph. The PageRank algorithm uses the PageRank vector, which is guaranteed to exist, to order a graph's vertices, such as a UAV swarm's nodes, according to their probability of being randomly visited. A graph is a useful construct for expressing relationships between a set of objects, such as the radio connectivity among nodes in an unmanned aerial vehicle (UAV) swarm. Some analysis tools use a measure of node centrality to rank a graph's vertices, such as a UAV swarm's nodes, by their relative importance. To reduce the time needed to obtain a swarm's PageRank vector if the swarm contains nodes having equal PageRank values. In the context of UAV swarms, the PageRank vector can be used to identify where to inject a message to ensure it is efficiently disseminated among the swarm's nodes by a rumor-routing protocol. In social network analysis, a PageRank vector can be used to find group members that are useful for efficiently spreading information or misinformation. The PageRank vector can also be used to find roadblock locations for capturing fleeing suspects. The PageRank vector is computed by the PageRank algorithm and is useful for analyzing the

probable behavior of some object traversing a network's nodes, such as some information or misinformation distributed by a rumor-routing protocol in a UAV swarm.

Pagerank with unmanned vehicle swarms : An unmanned aerial vehicle (UAV) swarm is a heterogeneous network of mobile vehicles whose sensors can collect multi-dimensional data. UAV swarms may collaborate, e.g., by cooperatively searching a geographic area for objects matching some search criteria. Thus, more robust methods of ordering nodes are typically needed to obtain a canonical node ordering. One robust method of ordering a network's nodes based on relative importance is the PageRank algorithm used in some search engines to order query responses, e.g., the web pages matching a user's search criteria. The PageRank algorithm perturbs the adjacency matrix corresponding to the original network such that the resulting matrix specifies the probability of visiting each node from any other node. Therefore, the matrix yields a unique dominant eigenvector whose entries correspond to the probability of visiting each node. The PageRank algorithm orders the nodes, e.g., the query responses, based on this eigenvector's entries, which correspond to the stationary distribution of the Markov chain defined by the perturbed adjacency matrix. Thus, the PageRank algorithm finds a unique vector, the PageRank vector, where a node's PageRank value

also determines its position in the node ordering. This ordering corresponds to the order nodes are likely to be visited by an object that randomly selects the next node to visit, e.g., a user who randomly surfs web pages or message distributed using a rumor-routing protocol. In the context of an unmanned aerial vehicle (UAV) swarm, the PageRank vector can be used to determine where to inject a message in the swarm to ensure the message is quickly transmitted to each node by a rumor-routing protocol. For instance, the PageRank vector can identify which group members are likely to disseminate information or misinformation most efficiently. In general, the PageRank algorithm is applicable to any scenario that requires assessing the probable behavior of an object traversing the nodes in some network. Certain networks, however, yield a PageRank vector containing duplicate entries, which cannot induce a canonical vertex ordering. This occurs most often in networks that are not randomly constructed, i.e., networks having some pattern of regularity among its links between nodes. The issue can be resolved in some applications, e.g., search engines, by sorting on additional keys, such as web page addresses. A second method is to apply an application that produces canonical isomorphs, e.g., nauty, and order the canonical isomorph's nodes using its PageRank vector. Networks containing nodes that yield equal PageRank values define an interesting duality. First, such networks motivate using application, such as nauty, to find a canonical PageRank vector. Second, if a non-canonical PageRank vector suffices, which is often the case, such graphs also simultaneously suggest methods for decreasing the time needed to obtain the PageRank vector. These latter methods also eliminate some numerical errors in the PageRank vector. The three algorithms constructed that leverage these ideas to improve the PageRank algorithm's performance if a network contains nodes that must have equal PageRank values.

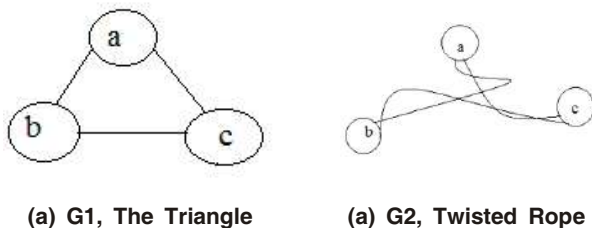


Fig.-1: Two Graph Isomorphs : The Triangle and Twisted Rope.

Table-1 : Two Adjacency Matrix Isomorphs: The Triangle and Twisted Rope.

(a) A1, The Triangle

	a	b	c
a	0	1	1
b	1	0	1
c	1	1	0

(b) A2, Twisted Rope

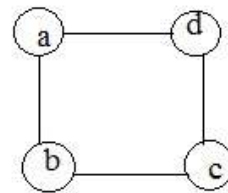
	a	b	c
a	0	1	1
b	1	0	1
c	1	1	0

A Formal Definition : A pair of graphs, G1 and G2, are isomorphs if and only if a permutation, $\bar{o}$, exists satisfying (1), where for each edge in E1, an equivalent edge exists in E2. For example, applying the permutation, $\bar{o} = [2,1,3, 4]$, to the square's vertices illustrated in Figure 8(a) confirms the square is an isomorphs of the hourglass shown in Figure 2(b). In other words, each graph contains four vertices, where each vertex is adjacent with two other vertices, such that the edges define a cycle graph of length four, denoted C4.

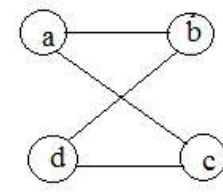
$$(V1) = V2 \text{ s.t.}$$

$$G1=G2 \quad e_i\{v_r, v_s\} \in E_1 \quad v_r \quad V_1 \quad v_s \quad V_1$$

$$e_j=\{ (v_r), (v_s)\} \in E_2 \quad (v_r) \quad V_2 \quad (v_s) \quad V_2 \dots(1)$$



(a) G1, The Square



(a) G2, The Hourglass

Fig.-2 : Two Isomorphs : The Square and Hourglass.

Equivalently, two adjacency matrices, A_1 and A_2 , are isomorphs if and only if a permutation matrix, P , exists satisfying (2), where P^T denotes the matrix transpose, and $\cdot$ denotes matrix multiplication. A permutation matrix, P , is a row permutation, $\cdot$, of the identity matrix, I , a square matrix whose diagonal entries equal one that otherwise equals zero. Thus, the row permutation orders I 's rows based on the given permutation vector, $\cdot$. The transpose of the permutation matrix, P , denoted P^T , is equivalent to applying $\cdot$ as a column permutation to I , i.e., ordering I 's columns with respect to $\cdot$.

$$A_1 = A_2 \quad P \text{ s.t. } A_2 = P.A.P^T \quad \dots(2)$$

The Pagerank Algorithm

Another significant application of the eigen decomposition to graph theory is the PageRank algorithm used in certain search engines to order query responses, such as the web pages matching a user's search criteria. For example, the mansion graph shown in Figure 3(a) yields the PageRank vector listed in Table 2(a), which is a unique eigenvector that always exists, as described in this section. Sorting the PageRank vector's entries yields the vector listed in Table 2(b), which is reflected in Figure 3(b). The PageRank vector is unique up to isomorphism. Since every entry contained in the mansion graph's PageRank vector is distinct, every mansion graph isomorph yields a vertex ordering equivalent to the vertex ordering shown in Table 2(b). For example, the isomorph shown in Figure 3(c) yields the sorted PageRank vector shown in Table 2(c), which is equivalent to the ordering shown in Table 2(b) and reflected in Figure 3(b).

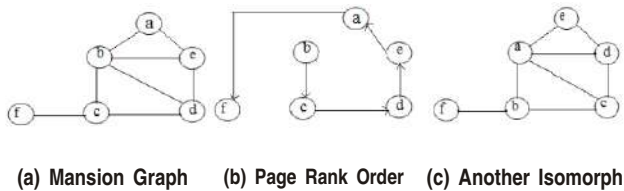


Fig-3 : Mansion Graph.

Table-2 : Mansion Graph's PageRank Vector.

(a) PageRank Vector		(b) PageRank Order		(c) Isomorph's Order	
a	0.126	0.236	b	0.236	a
b	0.236	0.195	c	0.195	b
c	0.195	0.182	d	0.182	c
d	0.182	0.180	e	0.180	d
e	0.180	0.126	a	0.126	e
f	0.182	0.080	f	0.080	f

Conversely, if the PageRank vector contains duplicate entries, it cannot induce a canonical ordering. That issue can be resolved in some applications, e.g., search engines, by sorting on more keys, e.g., web page addresses. Alternatively, ties in PageRank value can be broken by the vertex order in a canonical isomorph produced by applications such as *nauty*. For example, the house graph depicted in Figure 4(a) yields the PageRank vector listed in Table 3(a). The house graph's canonical isomorph yielded by *nauty* is shown in Figure 4(b) and corresponds to applying the permutation, [3, 4, 1, 2, 5], where the vertex $i \rightarrow j$ denotes vertex v_i , v_j , labeled r , is mapped to vertex,

labeled s . The two graphs are isomorphs, thus, their PageRank vectors are also related by the same vertex permutation, as reflected in Tables 2(a) and (b), where the canonical isomorph induces the canonical vertex ordering listed in Table 3(c) and shown in Figure 4(c).

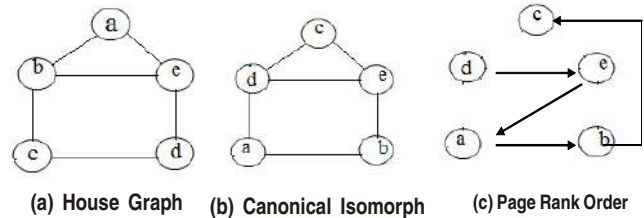


Fig-4 : House Graph.

The algorithms are used to eliminate a certain class of numerical errors that may be present in the PageRank vector. More importantly, two of these algorithms dramatically reduce the time needed to compute the PageRank vector of certain graphs. To obtain this vertex order, the PageRank algorithm perturbs the adjacency matrix and builds a strictly positive stochastic matrix in which each entry reflects the probability of visiting a vertex from another vertex. Thus, the eigenvector orders a graph's vertices based on PageRank values yielded by its perturbed adjacency matrix. PageRank values are unique up to isomorphism, i.e., vertices have the same PageRank value across all input graph isomorphs. Hence, vertices contained in the same block of the orbit partition also must have equal PageRank values.

Table-3 : House Graph's PageRank Vector.

(a) House Graph		(b) Canonical Isomorph		(c) PageRank Order	
a	0.168	1 $\rightarrow$ 3 $\Leftrightarrow$ a $\rightarrow$ c	0.168	0.244	d
b	0.244	2 $\rightarrow$ 4 $\Leftrightarrow$ b $\rightarrow$ d	0.244	0.244	e
c	0.172	3 $\rightarrow$ 1 $\Leftrightarrow$ c $\rightarrow$ a	0.172	0.172	a
d	0.172	4 $\rightarrow$ 2 $\Leftrightarrow$ d $\rightarrow$ b	0.172	0.172	b
e	0.244	5 $\rightarrow$ 5 $\Leftrightarrow$ e $\rightarrow$ e	0.244	0.168	c

Computing the pagerank vector

Power method iteration : There are many ways to find the PageRank vector, e.g., by applying MATLAB's 'eig' function for finding eigen decompositions. Another method is the power method, where PageRank matrix, S , is multiplied by the current PageRank vector, x_i , yielding the revised estimate of the PageRank vector, x_{i+1} . The vector, x_{i+1} , is normalized by applying an arbitrary norm, e.g., $x_{i+1} = x_{i+1} / \|x_{i+1}\|_1 = x_{i+1} / \sum x_{i+1}$. Thus, each iteration simply requires computing a normalized dot product, where

$$x_{i+1} = S \cdot x_i, \quad \dots(3)$$

followed by

$$\mathbf{x}_{i+1} = \mathbf{x}_{i+1} / \mathbf{x}_{i+1} \quad \dots(4)$$

The initial entries in $\mathbf{x}$ can equal an arbitrary value, such that $\mathbf{x}_1 (i) \in [0.0, 1.0]$ and $\mathbf{x}_1 = 1$, e.g., $\mathbf{x}_1 = \mathbf{1}^{n,1} / n$. The power method terminates after some number of iterations is performed or some numerical tolerance, $\hat{O}$, is obtained, e.g., $|\mathbf{x}_{i+1} - \mathbf{x}_i| < \hat{O}$, $\hat{O} = 0$. The power method derives its name from the observation the i^{th} iteration can be expressed by the product of the i^{th} power of $\mathbf{S}$, denoted $\mathbf{S}^i$, and the initialization vector, $\mathbf{x}_0$, where

$$\begin{aligned} \mathbf{x}_1 &= [\mathbf{S} \cdot \mathbf{x}_0] / [\mathbf{S} \cdot \mathbf{x}_0] \\ \mathbf{x}_2 &= [\mathbf{S} \cdot \mathbf{x}_1] / [\mathbf{S} \cdot \mathbf{x}_1] = [\mathbf{S} \cdot (\mathbf{S} \cdot \mathbf{x}_0)] / [\mathbf{S} \cdot (\mathbf{S} \cdot \mathbf{x}_0)] \quad \dots(5) \\ \mathbf{x}_i &= [\mathbf{S}^i \cdot \mathbf{x}_0] / [\mathbf{S}^i \cdot \mathbf{x}_0] \end{aligned}$$

Finally, $\mathbf{S}$'s left eigenvector, $\mathbf{y}$, is obtained by computing $\mathbf{y}_{i+1} = \mathbf{y}_i^T \cdot \mathbf{S}$, followed by the requisite normalization, $\mathbf{y}_{i+1} = \mathbf{y}_{i+1} / \mathbf{y}_{i+1}$.

Pagerank : An algorithm for ranking vertices

The PageRank algorithm consists of two key steps, applying a perturbation to the graph's adjacency matrix that yields a strictly positive stochastic matrix and determining the dominant eigenvector of the stochastic matrix by computing an iterated dot product. The eigenvector's entries correspond to the probability the corresponding vertices will be visited by an object that randomly selects its destination. The entire PageRank algorithm is listed in Figure-5, where the stochastic PageRank perturbation is applied on lines 2–6. Since the power method terminates based on the numerical differences with respect to the last eigenvector estimate, the two vectors, $\mathbf{s}$ and $\mathbf{x}$, are initialized on lines 8 and 9, along with an iteration counter, z , on line 10. The power method loop is entered on line 12 and the eigenvector estimate, $\mathbf{x}$, is copied to the vector, $\mathbf{s}$, on line 14. The eigenvector is revised on line 16, where $\mathbf{x} = \mathbf{S} \cdot \mathbf{x}$. Normalizing by the column sum norm on line 16, or 1-norm, $\|\mathbf{x}\|_1$, ensures $\mathbf{x}$ sums to one, i.e., that $\mathbf{x}$ is a probability distribution. The norm choice is arbitrary, e.g., the Euclidean, or spectral norm, $\|\mathbf{x}\|_2$, could be used. The power method terminates after the tolerance, $\hat{O}$, is obtained and the upper bound on the number of power method iterations is $t = \log \frac{1}{\hat{O}}$. The PageRank perturbation requires (n^2) time, where $n = |V|$, since each entry in $\mathbf{A}$ is scaled and shifted. Given a tolerance, $\hat{O}$, and scaling factor, β , the lower and upper bounds on the power method's complexity are $(n^2 \cdot \log n)$, and $O(n^2 \cdot t)$, respectively, where $t = \log \frac{1}{\hat{O}}$. If the graph is stored using sparse matrices, the lower and

upper bounds can be reduced to $(m \cdot \log n)$ and $O(m \cdot t)$, respectively, where $m = |E|$, the number of edges contained in the graph. A common modification of the PageRank algorithm uses a personalization vector, $\mathbf{v}$, containing user-specified probabilities. A potential application is "to decrease the effect of spamming done by the so-called link farms". The personalization vector, $\mathbf{v}$, is used to modify the perturbation on line 6 in Figure 5, which becomes

$$\mathbf{S} = \beta \cdot \mathbf{A} \cdot \mathbf{D}^{-1} + (1 - \beta) \cdot \mathbf{v} \cdot \mathbf{1}^{1,n} \quad \dots(6)$$

```

1.  getPageRank ( $\mathbf{A}$ ,  $n$ ,  $\beta$ ,  $\mathbf{v}$ )
2.  # construct degree matrix
3.   $\mathbf{d}_i = \sum_{j=1}^n \mathbf{A}_{:,i}$ 
4.   $\mathbf{D} = \text{diag}(\mathbf{d})$ 
5.  # apply PageRank perturbation
6.   $\mathbf{S} = \beta \cdot \mathbf{A} \cdot \mathbf{D}^{-1} + (1 - \beta) \cdot \mathbf{v} \cdot \mathbf{1}^{1,n}$ 
7.  # initialize vectors and counter
8.   $\mathbf{x} = \mathbf{1}^{n,1} / n$ 
9.   $\mathbf{s} = \mathbf{0}^{n,1}$ 
10.  $z = 0$ 
11. # iterate power method
12. while ( $\|\mathbf{s} - \mathbf{x}\|_2 > \hat{O}$ )
13. # save PageRank vector
14.  $\mathbf{s} = \mathbf{x}$ 
15. # update PageRank vector
16.  $\mathbf{x} = \mathbf{S} \cdot \mathbf{x}$ 
17. # normalize PageRank vector
18.  $\mathbf{x} = \mathbf{x} / \|\mathbf{x}\|_1$ 
19. # increment loop counter
20.  $z = z + 1$ 
21. end while
22. return  $\mathbf{x}$ 
23. end PageRank
```

Figure 5. PageRank : An Algorithm for Ordering Vertices

Eliminating equitable pagerank differences

Vertices that are contained in the same block of the coarsest equitable partition of an arbitrary graph must have equal PageRank values. However, the PageRank values may differ if the values are computed using finite-precision arithmetic, where such differences induce an invalid vertex ordering. Such differences may occur even after many iterations of the power method have been performed to obtain the PageRank vector. The following example is based on the tree shown in

Figure 6 that yields the adjacency matrix listed in Table 6 and the coarsest equitable partition, $\{[a, c, g, i], [b, h], [d, f], [e]\}$.

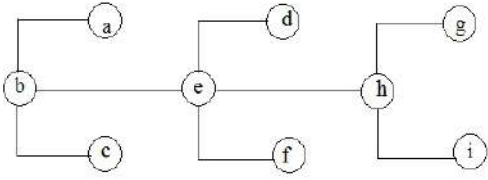


Fig.-6. 9-Vertex Tree: A Graph Yielding a 4-Block Equitable Partition

Table-4. A 9-Vertex Tree's Adjacency Matrix.

	a	b	c	d	e	f	g	h	i
a	0	1	0	0	0	0	0	0	0
b	1	0	1	0	1	0	0	0	0
c	0	1	0	0	0	0	0	0	0
d	0	0	0	0	1	0	0	0	0
e	0	1	0	1	0	1	0	1	0
f	0	0	0	0	1	0	0	0	0
g	0	0	0	0	0	0	0	1	0
h	0	0	0	0	1	0	1	1	0
i	0	0	0	0	0	0	0	1	0

This tree's PageRank vector for $\alpha = 0.85$ is listed in Table 5(a), where sorting its entries in descending order in Table 5(b). Since the tree's coarsest equitable partition is $\{[a, c, g, i], [b, h], [d, f], [e]\}$, vertices $\{a, c, g, i\}$ should have the same PageRank value. The PageRank vector listed in Table 5(a) initially confirms this expected behavior, since vertices $\{a, c, g, i\}$ have an equal PageRank value up to the fourth decimal place, 0.0682. However, close inspection shows the PageRank values of vertices g and i are $1.388 \cdot 10^{-17}$ greater than the PageRank values of vertices a and c . The difference occurs in the last bit of the double-precision format specified by the IEEE 754 standard. The value, $1.388 \cdot 10^{-17}$, is small in magnitude and induces a false order on vertices $\{a, c, g, i\}$, where vertices g and i erroneously receive a higher PageRank value than vertices a and c . In this example, rounding to four decimal places ensures vertices contained in the same block have equal PageRank values. However, simply rounding the PageRank vector cannot guarantee such vertices have equal PageRank values. In particular, the computed PageRank values of vertices contained in each block may be above or below the rounding point and thus may receive different rounded PageRank values.

Averagerank : An algorithm for eliminating equitable differences

Fortunately, differences in the computed PageRank

values of vertices contained in the same block of the coarsest equitable partition can be easily eliminated. The algorithm listed in Figure 7 sets the PageRank value of each block's vertices to the average of their computed values without internally modifying the PageRank algorithm. First, the PageRank vector is determined on line 3 using the PageRank algorithm. The coarsest equitable partition on line 5 is obtained using any method described, e.g., 1-D Weisfeiler-Lehman stabilization. PageRank values differences among vertices in the same block are eliminated on lines 6–11 by setting their PageRank values to their corresponding average PageRank value. The median could be used in lieu of the average, but determining the median PageRank value requires $(n \log n)$ time, whereas determining the average PageRank value only requires (n) time.

1. find Equitable Page Rank (A, n, α, ϵ)
2. # computes the PageRank vector
3. $x \leftarrow \text{getPageRank}(A, n, \alpha, \epsilon)$
4. # compute the coarsest equitable partition
5. $B \leftarrow \text{findCoarsestPartition}(A, n)$
6. # assign average PageRank value of equitable vertices
7. foreach, i block $b \in B$
8. foreach vertex, $v_j \in b_i$
9. $x(v_j) \leftarrow \frac{1}{|b_i|} \sum_{v_j \in b_i} x(v_j)$
10. end foreach
11. end foreach
12. return x
13. end EquitablePageRank

Figure 7. Average Rank: An Algorithm for Ensuring Equitable Page Rank Values

Excess dot products and equitable vertices

The Average Rank algorithm eliminates differences in PageRank value between vertices contained in the same block of the coarsest equitable partition and *increases* the PageRank algorithm's execution time. Conversely, the method described, the Product Rank algorithm ensures vertices in the same block have equal PageRank values and *decreases* the PageRank algorithm's execution time. For example, the house graph shown in Figure 8 yields the coarsest equitable partition, $\{[c, d], [a], [b, e]\}$, shown in Figure 8(b). Since vertices b and e are contained in the same block, it suffices to obtain one of their associated dot products

and assign its value to their associated PageRank vector entries during each power method iteration. Multiplying the house graph's PageRank matrix listed in Table-7 with the initial PageRank vector, the normalized all-ones vector shown in Table 8(a), yields the updated PageRank vector shown in Table 8(b). More significantly, the intermediate product sums yielded by vertices b and e are $0.455 \cdot 0.2 + 0.030 \cdot 0.2 + 0.455 \cdot 0.2 + 0.030 \cdot 0.2 + 0.313 \cdot 0.2$ and $0.455 \cdot 0.2 + 0.313 \cdot 0.2 + 0.030 \cdot 0.2 + 0.455 \cdot 0.2 + 0.030 \cdot 0.2$, respectively. Inspection reveals ordering the intermediate products yields the same sorted list, $0.030 \cdot 0.2 + 0.030 \cdot 0.2 + 0.313 \cdot 0.2 + 0.455 \cdot 0.2 + 0.455 \cdot 0.2$. Vertices c and d also yield the same intermediate products up to isomorphism, since vertices c and d are also contained in the same block of the coarsest equitable partition. Hence, a second dot product can be eliminated during each power method iteration. The ProductRank algorithm described, this technique to decrease the PageRank algorithm's execution time.

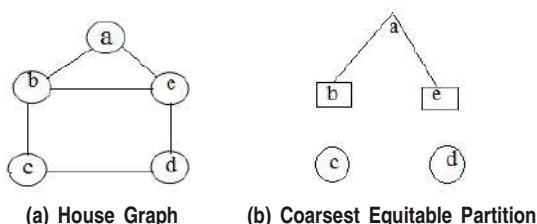


Fig-8: House Graph and Its 3-Block Coarsest Equitable Partition.

Table-5 : House Graph's Adjacency and Degree Matrix

	a	b	c	d	e
a	0	1	0	0	1
b	0	0	1	0	1
c	0	1	0	1	0
d	0	0	1	1	0
e	1	1	0	1	0

Table-6 : House Graph's Stochastic PageRank Matrix, $S, \alpha = 0.85$

	a	b	c	d	e
a	0.030	0.313	0.030	0.030	0.313
b	0.455	0.030	0.455	0.030	0.313
c	0.030	0.313	0.030	0.455	0.030
d	0.030	0.030	0.455	0.030	0.313
e	0.455	0.313	0.030	0.455	0.030

Table-7: Initial PageRank Power Method Iterations of the House Graph

(a) $x_0 = 1^{5 \times 1/5}$ (b) $x_1 = s, x_0 \Sigma(S, x_0)$ (c) $x_2 = s, x_1 \Sigma(S, x_1)$ (d) $x_3 = s, x_2 \Sigma(S, x_2)$

a	0.2	a	0.143	a	0.175	a	0.164
b	0.2	b	0.257	b	0.237	b	0.246
c	0.2	c	0.172	c	0.176	c	0.172
d	0.2	d	0.172	d	0.176	d	0.172
e	0.2	e	0.257	e	0.237	e	0.246

Conclusions

PageRank algorithm, is related to the concept of computing resources exist, can obtain a canonical order, where the first method only uses the PageRank algorithm. For example, the mansion graph yields a PageRank vector that induces a canonical vertex order. Thus, their PageRank vectors contain at least two equal entries and cannot induce a canonical ordering. For example, the canonical isomorph that is yielded by applying nauty to house graph, where its PageRank vector induces the canonical vertex ordering illustrated. However, finding a canonical isomorph may require exponential time, therefore, the latter approach only succeeds if it is applied to sufficiently small and irregular graphs. For instance, nearly every random graphs and random trees is sufficiently irregular, even if their coarsest equitable partition is not discrete.

The most theoretical contribution constructed herein, where it is shown that vertices contained in the same block of a graph's coarsest equitable partition must have equal iterated dot products. Since a PageRank vector can be obtained by applying the power method, which simply computes an iterated dot product, vertices contained in the same block yield equal PageRank values, as described. The relationship between the PageRank vector and the coarsest equitable partition are showed. Both of the proofs suggest many methods of improving the PageRank algorithm's performance. The first improvement is obtained by the Average Rank algorithm listed, which uses the average block Page Rank values.

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Effects of Invasive *Prosopis juliflora* on Soil chemical properties of Sathya Mangalam Tiger Reserve, Tamil Nadu, India

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Abstract

Prosopis juliflora belongs to the family Fabaceae (Leguminosae), subfamily Mimosoideae. *Prosopis* is a shrub/tree native to Mexico, Central and Northern America. *Prosopis* spread to Africa, Asia and Australia from its native ranges. In India, *Prosopis* was first introduced to Tamil Nadu during 1960's to generate the firewood and to improve livelihood condition of rural peoples of the state, and continued to establish in other states in different times. The Sathyamangalam Tiger Reserve (STR) in the foothills of the Nilgiris is one of the most famous preferred breeding landscapes for the Elephants in the Western Ghats and Eastern ghat meeting point, and it is known for its landscape beauty, varied of forest ecosystems and wildlife diversity. Unfortunately, during the last decades, there has been a drastic reduction in the diversity of the natural vegetation. The available niches have been occupied by invasive exotic species especially *Prosopis juliflora*. The present part of the study deals with the impact assessment of *Prosopis juliflora* on soil physical and chemical properties in Sathyamangalam Tiger Reserve (STR), Tamil Nadu. The study conducted at Bhavanisagar Forest range (STR) total 60 representative soil samples collected and analyzed from the depth of 0-30cm and 30-60cm from three different stratified areas Viz., 1. Natural Forest 2. *Prosopis juliflora* invaded and 3. *Prosopis juliflora* eradicated areas and effectively managed area. The parameter assessed are soil physical and chemical properties. Regarding soil physical properties bulk density, particle density and total porosity of the soil in the study area, the natural forest significantly performed well as compared to *Prosopis juliflora* invaded and eradicated sites. In soil physico chemical properties, in case of soil pH, the soil samples analyzed exhibited slightly acidic in nature, in all the three different sites. Regarding chemical properties organic carbon, available soil nitrogen, available soil phosphorus and available soil potassium of natural forest area was significantly higher than *Prosopis juliflora* eradicated and invaded area. The *Prosopis juliflora* eradicated and managed area slightly improving its fertility status as compared to *Prosopis juliflora* invaded areas. An effective strategy has been made by Tamil Nadu Forest Department for restoration of indigenous flora to support well habit ground for Black buck and Elephant population.

Introduction

Invasive alien plants are non-native organisms and they have the potential to cause, harm to the environment, economics and human health. Invasive alien species are one of the most significant drivers of environmental transformation worldwide. An invasive plant an alien species which establishes in natural or semi natural ecosystems, an agent of change and threatens native biological diversity. According to the World Conservation Union, invasive plants are generally considered to be the second greatest threat to biodiversity after habitat destruction (Buckley and Roughgarden, 2004). Invasive plant species can have a significant impact on the native community and ecosystem, and also may have the significant impact on biodiversity and global change (Sakai *et al.*, 2001). Van Wilgen *et al.*, (2001) reported that 180 exotic species invaded the total area of 10 million hectares in South Africa and millions of dollars were being spent on their management. India also is facing a serious

problem related to invasive plants. The worst alien invasive species are viz., *Ageratum conyzoides*, *Chromolaena odorata*, *Eichhornia crassipes*, *Eupatorium adenophorum*, *Ipomoea carnea*, *Lantana camara*, *Mikania micrantha*, *Mimosa invisa*, *Parthenium hysterophorus* and *Prosopis juliflora*. The invasive species in their new ecosystems become Predators (Drenovsky, 2012), Competitors (Vittorio, 2007), Parasites (Holmes, 2008) and Hybridizers (Corbin and D'Antonio, 2004). Invasive plants cause diseases to native plants and displacement of native species (Anderson, 2005), pose a considerable threat to endangered species (Sharma *et al.*, 2005). Dominant understorey cause increasing in allelopathy inhibit both the germination and growth of other plant interaction results in degradation of habitat and entire ecosystem due to predation by the invasive plant, consequential in community level changes of the ecosystem over the long-term. Invasive plants are often better competitors to native plant-pollinator mutualisms (Day *et al.* 2003). *Prosopis* is a xerophyte which, in its

native habitats, has been a desert plant. As long as it was confined to its natural habitat, *P. juliflora* was a great resource, especially to the economically weak inhabitants, who could beneficially use each and every part of that tree (Pasiecznik et al. 2001; Walter 2004; Walter & Armstrong 2014). But when *P. juliflora* was introduced in other regions of the world in a hope to derive similar benefits from it, things began to go awry. *Prosopis juliflora* started spreading and multiplying much faster than the rate at which it could be used. By now it has become one of the world's 100 most dominant invasives (Becker et al. 2016; Walter & Armstrong 2014). *Prosopis juliflora* belongs to the family Fabaceae (Leguminosae), subfamily Mimosoideae. *Prosopis* is a shrub/tree native to Mexico, Central and Northern America. *Prosopis* spread to Africa, Asia and Australia from its native ranges. In India, *Prosopis* was first introduced to Tamil Nadu during 1960's to generate the firewood and to improve livelihood condition of rural peoples of the state, and continued to establish in other states in different times. The Sathyamangalam Tiger Reserve (STR) in the foothills of the Nilgiris is one of the most famous preferred breeding landscapes for the Elephants in the Western Ghats and Eastern ghat meeting point, and it is known for its landscape beauty, varied of forest ecosystems and wildlife diversity. Unfortunately, during the last decades, there has been a drastic reduction in the diversity of the natural vegetation. The available niches have been occupied by invasive exotic species especially *Prosopis juliflora*.

Materials and Methods

Study area : The study area is situated with Nilgiris in the south, Sathyamangalam in the north, Bhavanisagar in east and Segur plateau in west. Geographically, the study site lies at 11° 50' N latitude and 77°07' E longitude to 11° 56' N and 77° 02' and at an altitude ranging from 352 to 412 MSL. The study was conducted at Bhavanisagar Range of Sathyamangalam Tiger Reserve, Tamil Nadu, during August 2016 to May 2017. Sathyamangalam forest division is the largest in the state of Tamil Nadu, extending over 1455.76 km² and the Bhavanisagar range consists of 241.92 km² of forest area. The study area accounts to 35.82 km². The Forest types found in the study area are viz., Southern Tropical dry mixed deciduous forest (5A/C3), Southern Sub-Tropical hill forest (8A/C1) and Riparian Forest along the Moyar River.

Location : The study area is situated with Nilgiris in the south, Sathyamangalam in the north, Bhavanisagar in east and Segur plateau in west. Geographically, the study site lies at 11° 50' N latitude and 77°07' E longitude to 11° 56' N and 77° 02' and at an altitude ranging from 352 to 412 MSL

Prevailing weather condition of the study area : The climate of the study area is characterized by warm, temperate to sub-tropical rainy season with good tropical sunshine. The maximum temperature during the study period ranged from 33.9°C and the minimum temperature ranged from 21.6°C. The minimum temperatures were recorded during December and January and the maximum temperatures were recorded during March-April. The total rainfall received during the study period (year 2015-2016) was 330 mm and the number of rainy days was 28 days. The average annual rainfall of the area was less than 717 mm for the last ten years.

Geology : The soil derived from parent rock varies considerably with climatic conditions. The parent rock has an influence on the properties of the desired soil considerably. Metamorphic igneous rock types such as charnockites and granite gneiss are varying from acid to ultra-basic ones present widely. The soils belong to Irugur series, Sathyamangalam series, Chikkarampalayam series and Kodivery series. The soils of the study area were red soil, laterite soil, black cotton and alluvial soils. The physical properties of soil often acquire greater importance than the chemical ones. The soils are generally deficient in plant nutrients and are normal with their pH value ranging from 6.0 – 6.5. Different sites of soil samples of study area were collected.

Stratification of the study area : The study area was stratified as follows,

- (A) *Prosopis juliflora* eradicated and effectively managed area (Site-I)
- (B) *Prosopis juliflora* invaded area (Site-II)
- (C) Natural forest area (Site-III, *Prosopis juliflora* non-invaded area)

A brief description of each of the sites has been made here as follows :

***Prosopis juliflora* eradicated and effectively managed area (Site-I) :** In the study area *Prosopis juliflora* was eradicated and effectively managed in Sathyamangalam Tiger Reserve the invasive species are *Prosopis juliflora*, *Lantana camara* and *Opuntia*. Among these weed species, *Prosopis juliflora* was causing considerable threat to biodiversity of Tiger Reserve. There was a strong notion amongst foresters, researchers and environmentalists to eradicate *Prosopis juliflora* from the forests. Followed by this situation also in the Tiger Reserve tends towards eradicating *Prosopis juliflora* tree stems from forest followed with mechanical method, and work was carried out in May 2014 to June 2015 funded by TBGP (Tamil Nadu Biodiversity conservation and Greening Project). The main goal of the Programme was

eradication of *Prosopis juliflora* and effective management of sites for development its potential indigenous floral community in the study area. The area of *Prosopis juliflora* removed was around 75 ha.

The average rainfall of the site is 600-650 mm. The main Forest type of the site is Southern tropical dry mixed deciduous forest (consist of scrubs and thorn forest) (5A/C3) and Riparian Forest along the Moyar River (Management plan of Sathyamangalam Tiger Reserve). The main native species present in this Site viz., *Acacia planifrons*, *Albizia amara*, *Randia dumetorum*, *Azadirachta indica*, *Chloroxylon swietenia*, *Sapindus emarginatus*, *Erythroxylon monogynum* etc. This Site is Located in Bhavanisagar range of Sathyamangalam Tiger Reserve. The landscape of site lies at 11° 50'94½ N latitude and 77°06'42½ E longitude and at an altitude ranging from 340 - 352m MSL.

***Prosopis juliflora* invaded area (Site-II) :** In Site-II with *Prosopis juliflora* invaded area, which consists of *Prosopis juliflora* covering predominant species in site. *Prosopis juliflora* disrupts ecosystem by displacing the indigenous species through rapid reproduction and expansion. The re-establishment of this species seems to be beyond control within a decade. The conversion of *Prosopis juliflora* invaded fields back to original condition would be very difficult and very costly (in terms of money, time and logistic resources).

The main native species coexisted with *Prosopis juliflora* are viz., *Acacia planifrons*, *Albizia amara*, *Catunaregam spinose*, *Azadirachta indica*, *Albizia lebbeck*, *Gyrocarpus americanus*, *Limonia acidissima*, *Diospyros montana*, *Diospyros melanoxylon*, *Albizia odoratissima*, *Chloroxylon swietenia*, *Randia dumetorum* etc. The standard parameters results obtained from Site-II is compared with site-I and site-III. Average Rainfall of the site is 600-650 mm. The main forest type of the site is Southern Tropical Dry Mixed Deciduous Forest (consist of scrubs and thorn forest) (5A/C3) (Management plan of Sathyamangalam Tiger Reserve). Site located in Bhavanisagar range of Sathyamangalam Tiger Reserve. The landscaped site lies at 11° 52'17½ N latitude and 77°06'69½ E longitude and at an altitude ranging from 360 – 380 MSL (Table-1).

Natural forest area (Site-III) : In Site-III with Natural Forest area, site consist of an area unaffected by *Prosopis juliflora*, the fully covered with indigenous species. This Natural Forest area rich in supporting vast diversity of flora, fauna. The average rainfall of the site is 800-850 mm. Main Forest type of the site is Southern Sub Tropical Hill Forest (8A/C1) (Management plan of STR). The main species present in this Site viz., *Acacia planifrons*, *Albizia amara*, *Albizia lebbeck*, *Albizia odoratissima*,

Anogeissus latifolia, *Chloroxylon swietenia*, *Diospyros melanoxylon*, *Hardwickia binate*, *Sapindus emarginatus*, *Randia dumetorum*, *Terminalia crenulata*, *Terminalia arjuna*, *Terminalia chebula*, *Phyllanthus emblica*, *Sapindus emarginatus* etc., (Plate 3) located in Bhavanisagar range of Sathyamangalam tiger reserve. The landscaped site lies at 11° 56'36½ N latitude and 77°00'59½ E longitude and at an altitude ranging from 390 - 410 MSL.

Research Methodology

Collection of soil samples for analysis : At the beginning, a general visual field survey of the area was carried out to have a general view of the variations in the study area. Representative soil sampling sites were then selected from laid sample plots. The present part of the study deals with the impact assessment of *Prosopis juliflora* on soil physical and chemical properties in Sathyamangalam Tiger Reserve (STR), Tamil Nadu. The study conducted at Bhavanisagar Forest range (STR) during the year 2016, total 60 representative soil samples collected and analyzed from the depth of 0-30cm and 30-60cm from three different stratified areas Viz., 1. Natural Forest 2. *Prosopis juliflora* invaded and 3. *Prosopis juliflora* eradicated areas and effectively managed area and the obtained result was averaged. During collection of samples; dead plants, furrow, old manures, wet spots, areas near trees and compost pits were excluded. This was done to minimize differences, which may arise because of the dilution of soil organic matter due to mixing through cultivation and other factors.

The soil samples were collected from representative sites then air-dried, mixed well and passed through a 2 mm sieve for the analysis of soil physical and chemical properties. The sample for the analysis of organic carbon was passed through a 0.2 mm sieve. Geo-reference points of the study area were recorded.

Soil Analysis : The soil samples collected from different sites were analyzed for different physical and chemical properties. The soil analysis is done for three months viz., September (2016), December (2016) and March (2017) in order to study the soil properties of different sites. Standard analytical procedures were followed for the analysis of the soil physicochemical properties.

Soil physical properties

Bulk density (Mg m^{-3}) : Bulk density or apparent density is the ratio of the mass of the soil to that of its total volume, which includes any air space and organic materials in the soil volume. It is determined by the oven dry weight of a unit volume of soil, expressed in Mg m^{-3} . The bulk density of the soil is measured by taking an undisturbed block of

soil with a cylindrical metal core (Gupta and Dakshinamoorthy, 1981). The bulk density was calculated using the volume of the core and the weight of the soil by using the formula,

Bulk density = Oven dry soil weight / volume of soil solids and pores

Particle density (Mg m^{-3}) : Particle density and total porosity are measured in Cylinder method (Gupta and Dakshinamoorthy, 1981).

Particle density = oven-dry soil weight / volume of soil solids

Total porosity : Porosity is that portion of the soil volume occupied by pore spaces. This property does not have to be measured directly since it can be calculated using values determined for bulk density and particle density. Finding the ratio of bulk density to particle density and multiplying by 100 calculates the percent solid space, so subtracting it from 100 gives the % of soil volume that is pore space.

% solid space = (bulk density / particle density) x 100

Total porosity (%) = 100 - (% solid space)

Soil physicochemical and chemical properties : Regarding analysis of soil physicochemical and chemical properties, viz., soil reaction (pH), Electrical conductivity, Organic Carbon, Nitrogen, Phosphorous, and Potassium the standard procedures are followed.

Results and Discussion

The study on Ecological Impacts and Restoration Implications of *Prosopis juliflora* invaded areas and soil properties of Sathya Mangalam Tiger Reserve was conducted from August-2016 to -2017 and the results of this investigation are discussed in the following sections.

Soil physical properties

Bulk density (Mg m^{-3}) : With respect to the bulk density of study area, *Prosopis juliflora* invaded area (Site-II) recorded highest value of mean bulk density of 1.15 Mg m^{-3} , it was followed by *Prosopis juliflora* eradicated and effectively managed area (Site-I) (1.12 Mg m^{-3}), and the value of 1.08 Mg m^{-3} was recorded in natural forest area (Site-III). The oven dry weight of a unit volume of soil inclusive of pore spaces is called bulk density. The bulk density of a soil is always smaller than its particle density. The bulk density of sandy soil is about 1.6 Mg m^{-3} , whereas that of organic matter is about 0.5 Mg m^{-3} . Bulk density normally decreases, as mineral soils become finer in texture. The bulk density varies indirectly with the total pore space present in the soil and gives a good estimate of the porosity of the soil. Bulk density is of greater importance than particle density in understanding the

physical behavior of the soil. Generally, soils with low bulk densities have favorable physical conditions. Bulk density is soil mass divided by unit volume. In its natural state, a soil's volume includes solids and pores, therefore, a sample must be taken without compaction or crumbling to correctly determine bulk density. Bulk density increases with depth and tends to be high in sands and compacted pan horizons and tends to be low in soils with abundant organic matter. Tillage operations loosen soils and temporarily lower bulk density, while compaction processes raise bulk density. High bulk densities correspond to low porosity. Natural soil-forming processes that increase aggregation reduce bulk density, but excessive tillage and raindrop impact on bare soil destroy aggregation and increase bulk density. Bulk density of mineral soils commonly ranges from 1.1 to 1.5 Mg m^{-3} in surface horizons.

The results of bulk density analysis of the soil samples collected from different sites revealed that the mean values ranged from 1.08 Mg m^{-3} to 1.15 Mg m^{-3} . The site-III was significantly performing low bulk density (1.08 Mg m^{-3}), however, soil with low bulk density is most suitable for plant root growth and regeneration (Marshall and Holmes, 1992) and followed lower bulk density was recorded by site-I (1.12 Mg m^{-3}) because better improvement of soil bulk density after eradication of *Prosopis juliflora* from the site. The higher bulk density of 1.15 Mg m^{-3} was observed in site-II, since bulk density increases with compaction and tends to increase with depth. In site-II the presence of *Prosopis juliflora* caused the slightly higher bulk density when, compare to other sites. Similarly, the study by Kahi et al., (2009), has observed that soil bulk density under the open area was 1.28 Mg m^{-3} , followed by under area canopy of *Acacia tortilis* was 1.16 Mg m^{-3} and under canopy area of *Prosopis juliflora* recorded was 1.18 Mg m^{-3} .

Particle density (Mg m^{-3}) : With reference to particle density of study area, *Prosopis juliflora* eradicated and effectively managed area (Site-I) registered highest particle density of 2.45 Mg m^{-3} , followed by *Prosopis juliflora* invaded area (Site-II) (2.42 Mg m^{-3}) and least particle density was observed in natural forest area (Site-III) (2.40 Mg m^{-3}). The weight per unit volume of the solid portion of soil is called particle density. Generally, particle density of normal soils is 2.65 Mg m^{-3} . Organic matter has a density of 0.8 Mg m^{-3} . The particle density is higher if large amount of heavy minerals such as magnetite; limonite and hematite are present in the soil. With increase in organic matter of the soil the particle density decreases. Particle density is also termed as true density. Particle density plays an important role in our understanding and determination of other physical properties including bulk density and porosity. Particle

Table-1 : Standard analytical procedures followed for soil analysis.

Sl. No.	Estimation	Method	Author
A. Soil physical properties			
1.	Bulk density	Core sample method	Gupta and Dakshinamoorthy (1981)
2.	Particle density	Cylinder method	
3.	Total porosity	Cylinder method	
B. Soil physico-chemical properties			
1.	Soil reaction (pH)	Potentiometry method 1:2.5 soil water suspension	Jackson (1973)
2.	Electrical conductivity (Ec)	Conductometry method 1:2.5 soil water suspension	
C. Soil chemical properties			
1.	Soil organic carbon	Wet chromic acid digestion	Walkley and Black, (1934)
2.	Available nitrogen	Alkaline permanganate method	Subbiah and Asija, (1956)
3.	Available phosphorus	Bray 1 method	Bray and Kurtz, (1945)
4.	Available potassium	Neutral normal NH ₄ OAc, using Flame photometry	Stanford and English, (1949)

density is the volumetric mass of the solid soil. It differs from bulk density because the volume used does not include pore spaces. Particle density represents the average density of all the minerals composing the soil.

Regarding particle density of soil, the mean values ranged from 2.40 Mg m^{-3} to 2.45 Mg m^{-3} . Among the soil samples analyzed, the site-I significantly had higher particle density (2.45 Mg m^{-3}), it was followed by site-II with the particle density of 2.42 Mg m^{-3} . And the least (2.40 Mg m^{-3}) particle density was observed in Site-III. correspondingly, Habtamu (2014) reported that the highest (2.30 Mg m^{-3}) particle density recorded on the surface layer of cultivated land might be due to its high sand content and the presence of heavy minerals of Fe and Mn. Similar findings were also reported by Belay (2003).

Total porosity (per cent) : Regarding the total porosity of the study area, Natural Forest area (Site-III) recorded the highest mean value of total porosity of 55.00 per cent, and it was followed by 54.28 per cent of *Prosopis juliflora* eradicated and effectively managed area (Site-I), and the lowest was recorded in *Prosopis juliflora* invaded area (Site-II) 52.11 per cent. Porosity or pore space refers to the volume of soil voids that can be filled by water and/or air. It is inversely related to bulk density. Porosity is calculated as a percentage of the soil volume. Porosity is that portion of the soil volume occupied by pore spaces. High bulk densities correspond to low porosity. Loose, porous soils have lower bulk densities and greater porosities than tightly packed soils. Porosity varies depending on particle size and aggregation. It is greater in clayey and organic soils than in sandy soils. A large number of small particles in a volume of soil produces a large number of soil pores. Fewer large particles can occupy the same volume of soil so there are fewer pores and less porosity. Pores of all sizes and shapes combine

to make up the total porosity of a soil. Porosity, however, does not indicate anything about the size of pores.

In case of total porosity of the soil, the mean values ranged from 52.11 per cent to 55.00 per cent. Among the soil sample analyzed, site-III recorded highest total porosity (55.00 per cent) of soil, with natural forest vegetation which leads to high infiltration rate when compared to site-I and site-II. Since, the bulk density of site was 1.08 Mg m^{-3} causing the better porosity. In site-I, it was 54.28 per cent and in site-II, it was 52.11 per cent because, the bulk density was 1.12 and 1.15 Mg m^{-3} for site-I and site-II respectively. Correspondingly, Tiedmann and Klemmedson (1977) noted that roots of *Prosopis juliflora* extend downward and laterally and affect the total porosity and soil moisture regime under the canopy.

Soil physicochemical properties

Soil reaction (pH) : With respect to soil pH of the study area, *Prosopis juliflora* invaded area (Site-II) recorded the highest mean value of 6.32, followed by *Prosopis juliflora* eradicated and effectively managed area (Site-I) (6.31), and the least value was recorded by natural forest area (Site-III) with a soil pH of 6.21. The soil pH influences the rate of nutrient release through its influence on decomposition, carbon exchange capacity and solubility of materials. Further, soil pH influences plant growth by way of improving the soil physical condition and nutrient availability, whereas, high or low pH of the nutrient medium has an adverse effect on plant growth (Sannappa and Manjunath, 2013). In the study area the pH of the soil, the mean value ranged from 6.21 to 6.32. Among the soil samples analyzed exhibited the slightly acidic pH was observed in all the three different sites. This kind of slightly acidic soil not affects the vegetation growth in all the sites. This result was contrary, with the report documented by Bhojvaid and Timmer (1998) that indicated a remarkable reduction of soil pH under the tree canopy of *Prosopis*

Table-1 : Physical properties of soil in study area.

Sl. No.	Sites	Bulk density (Mg m ⁻³)				Particle density (Mg m ⁻³)				Total porosity (%)			
		Interval	Sep	Dec	Mar	Mean	Sep	Dec	Mar	Mean	Sep	Dec	Mar
1	Site-I	1.09	1.15	1.12	1.12	2.44	2.45	2.46	2.45	54.20	54.34	54.30	54.28
2	Site-II	1.13	1.16	1.15	1.15	2.40	2.44	2.42	2.42	52.46	52.56	51.32	52.11
3	Site-III	1.06	1.09	1.09	1.08	2.38	2.40	2.42	2.40	54.00	56.00	55.00	55.00
	SD	±0.21	±0.14	±0.10		±0.16	±0.07	±0.10		±7.35	±6.82	±8.11	

Site-I is the *Prosopis juliflora* eradicated and effectively managed area, Site-II is the *Prosopis juliflora* invaded area, Site-III is the Natural Forest area, SD-Standard deviation.

Table-2 : Soil physico-chemical properties of soil in study area.

Sl. No.	Sites	Soil pH				Electrical conductivity (dSm ⁻¹)				Soil organic carbon (%)			
	Interval	Sep	Dec	Mar	Mean	Sep	Dec	Mar	Mean	Sep	Dec	Mar	Mean
1	Site-I	6.35	6.20	6.40	6.31	0.12	0.11	0.12	0.11	4.56	4.58	4.57	4.58
2	Site-II	6.36	6.42	6.20	6.32	0.11	0.11	0.11	0.11	5.30	5.36	5.36	5.34
3	Site-III	6.32	6.10	6.22	6.21	0.14	0.14	0.14	0.14	6.22	6.32	6.30	6.12
SD	±0.59	±0.51	±0.70		±0.03	±0.04	±0.04		±0.80	±0.76	±0.85		

Site-I is the *Prosopis juliflora* eradicated and effectively managed area, Site-II is the *Prosopis juliflora* invaded area, Site-III is the Natural Forest area, SD-Standard deviation.

Table-3 : Macro nutrients analysis of soil in study area.

Sl. No.	Sites	Available Nitrogen (kg ha ⁻¹)				Available Phosphorus (kg ha ⁻¹)				Available Potassium (kg ha ⁻¹)			
	Interval	Sep	Dec	Mar	Mean	Sep	Dec	Mar	Mean	Sep	Dec	Mar	Mean
1	Site-I	283.12	298.52	302.32	294.65	12.47	14.56	16.24	14.51	130.45	142.50	145.52	139.49
2	Site-II	335.22	348.12	320.49	334.61	14.25	16.12	15.21	15.19	142.12	152.45	146.20	146.92
3	Site-III	386.10	356.45	346.23	362.92	16.12	15.21	15.19	16.52	159.25	155.12	162.78	158.38
SD		±35.97	±5.89	±18.20		±1.86	±1.45	±2.51		±46.95	±49.66	±52.99	

Site-I is the *Prosopis juliflora* eradicated and effectively managed area, Site-II is the *Prosopis juliflora* invaded area, Site-III is the Natural Forest area, SD- Standard deviation.

juliflora than *Prosopis juliflora* free areas. Studies by Singh (1995), noted that reduction in soil pH under the *Prosopis juliflora* tree canopy was observed modifying the alkaline soil to acidic. Since *Prosopis juliflora* tending to use the restoration of soil affected with alkaline soil.

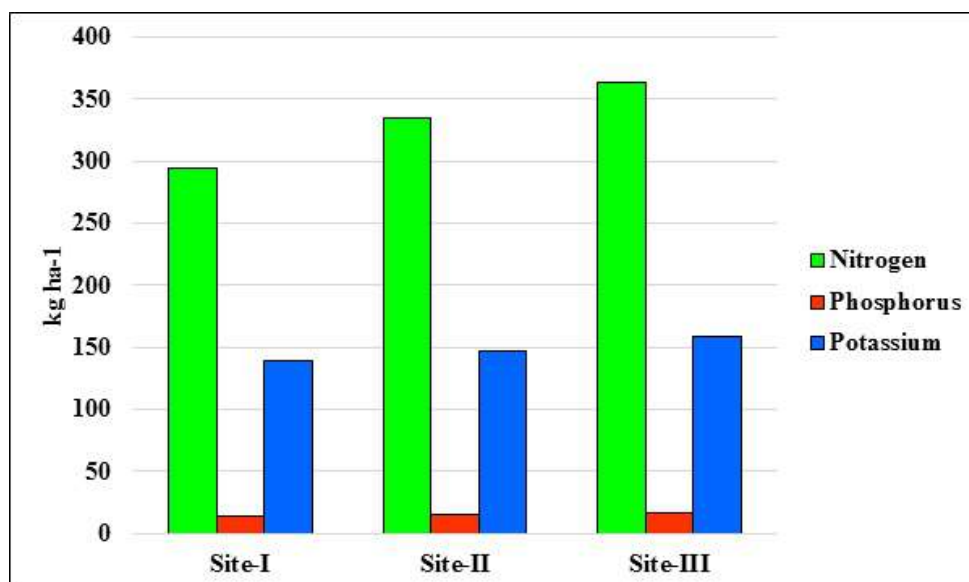
Electrical conductivity (dsm⁻¹) : Regarding Electrical conductivity of the study area, Site-III recorded maximum mean value of EC 0.14 dsm⁻¹, it was followed by Site-I (0.11 dsm⁻¹), and the lowest Electrical conductivity was observed in Site-II with a value of 0.11 dsm⁻¹. The electrical conductivity shows the total amount of soluble salts present in the soil. It is the most common measure of soil salinity. In the study area, the electrical conductivity mean values ranged from 0.11 dsm⁻¹ to 0.17 dsm⁻¹. The lowest EC (0.11 dsm⁻¹) was observed in the site-II, with was non saline soil. Site-I gradually had increases EC (0.119 dsm⁻¹) after eradication of *Prosopis juliflora*, it was represented non saline and site-III (0.14 dsm⁻¹) with natural forest was also represented the non-saline soil.

Soil with electrical conductivity values lesser than 0.4 dsm⁻¹ are considered as non-saline (Rickard 1995). Similarly, as stated by Basavaraja *et al.*, (2007), that *Prosopis juliflora* significantly reduced EC content of soil

as compared to *Prosopis juliflora* non-invaded area. Since *Prosopis juliflora* tree used for restoration of saline soil

Chemical properties of soil

Organic carbon (per cent) : With regard to organic carbon content of study area, natural forest area (Site-III) registered maximum Organic carbon of 6.12 per cent, it was followed by *Prosopis juliflora* invaded area (Site-II) with 5.34 per cent, and least Organic carbon value was observed in *Prosopis juliflora* eradicated and effectively managed area (Site-I) (4.58 per cent). The level of soil organic matter determines the multiplication of microorganisms and makes the system more dynamic. In the soil samples collected the organic carbon content mean value ranged from 4.58 per cent to 6.12 per cent. Since, all three sites exhibited high range of organic carbon. The overall mean values of all the samples showed that the soils of site-III recorded higher value of organic carbon content was 6.28 per cent. This might be due to the presence of high floral diversity and richness in this site. The higher accumulation of soil organic carbon in the forest soils than the other land use soils may be due to the continuous accumulation of decayed and partially decomposed plant and animal residues in the surface soils as reported by Lechisa Takele *et al.*, (2014). The high



Site-I is the *Prosopis juliflora* eradicated and effectively managed area, Site-II is the *Prosopis juliflora* invaded area, Site-III is the Natural Forest area

Fig.-1 Macro nutrients status of the study area.

floral diversity contributes organic matter to the soil in the form of leaf litter which directly influences the organic carbon content of the soil. A soil sample of site-II (5.34 per cent) has recorded higher than site-I (4.58 per cent). In site-I, the *Prosopis juliflora* canopy density was reduced by *Prosopis juliflora* eradication. Similarly, Kahi *et al.*, (2009) reported that organic carbon under the canopy of *Acacia tortilis* was 1.37 per cent, under *Prosopis juliflora* which was 1.23 per cent and in open area, it was 1.09 per cent. Varyingly, Aggarwal (1998) reported no effect of *Prosopis juliflora* on the organic matter under the crowns of *Prosopis juliflora* trees.

Macro nutrients status and analysis of soil in study area

Available nitrogen (kg ha⁻¹) : The soil available nitrogen in the study area revealed that, natural forest area (Site-III) registered maximum available nitrogen of 362.92 kg ha⁻¹, followed by *Prosopis juliflora* invaded area (Site-II) which has registered 334.61 kg ha⁻¹, and *Prosopis juliflora* eradicated and effectively managed area (Site-I) recorded the minimum available nitrogen of 294.65 kg ha⁻¹. Nitrogen is the kingpin of the nutrients and is an important factor affecting decomposition. The availability of nitrogen is due to the regular addition of plant residues on the soil and decomposition. The organic compounds are converted into inorganic nitrogen by certain bacteria, which can be absorbed by the plants (Sannappa and Manjunath, 2013). Regarding soil available nitrogen content of soil samples, the mean value ranged from 294.65 kg ha⁻¹ to 362.92 kg ha⁻¹. Since, all three sites recorded medium range of available nitrogen. A comparison of mean values of all the soil samples

analyzed for available nitrogen showed that the site-III recorded the highest value of 362.92 kg ha⁻¹. The higher availability of nitrogen was due to the regular addition of plant residues on the soil and due to decomposition, which might be the reason for the higher nitrogen content in this area.

Since site-II was covered with *Prosopis juliflora* vegetation and site-I, had reduced vegetation by *Prosopis juliflora* eradication effect this might cause less deposition of nitrogen in site-I. The available nitrogen recorded was 334.61 kg ha⁻¹ in site-II higher than site-I, because *Prosopis juliflora* has the ability to fixing atmospheric nitrogen (Aronson *et al.*, 1992). Similarly, Kahi *et al.*, 2009 reported that 0.08 per cent total nitrogen under the canopy of *Prosopis juliflora*, 0.13 per cent was under the canopy of *Acacia tortilis* and 0.06 per cent of total nitrogen in open area.

Available phosphorus (kg ha⁻¹) : With respect to the soil available phosphorus of study area, natural forest area (Site-III) registered highest available phosphorus of 16.52 kg ha⁻¹, it was followed by *Prosopis juliflora* invaded area (Site-II) with a value of 15.19 kg ha⁻¹ and least available phosphorus was observed in *Prosopis juliflora* eradicated and effectively managed area (Site-I) (14.51 kg ha⁻¹). Available phosphorus was an inevitable for the vital growth processes in plants. It was observed that phosphorus was found in all terrestrial systems in the form of organic and inorganic matter, while organic phosphorus forms are the major available source of phosphorus. Soil organic matter has the inorganic form of phosphorus transformed into an insoluble form in many soils (Brown *et al.*, 2004). The amount of phosphorus indicates the

character of soil to allow specific plants to grow at a particular site, which is also useful to identify the vegetation type of the area.

The available phosphorus content of the samples collected from different sites varied with the mean value ranging from 14.51 kg ha^{-1} to 16.52 kg ha^{-1} . Since, all three sites recorded medium range of available phosphorus. Among the mean values of available phosphorus content of the samples, the soils of site-III recorded higher value (16.52 kg ha^{-1}) since natural forest covered with high vegetation might be the reason for the higher phosphorus content in the soil. Regarding site-II phosphorus accounts to 15.19 kg ha^{-1} higher than site-I (14.51 kg ha^{-1}), because *Prosopis juliflora* has the ability to obtain nitrogen and phosphorus by symbiotic relationships with nitrogen fixing bacteria and mycorrhizae, where similar findings were also stated by Aggarwal, (1998).

Available potassium (kg ha^{-1}) : With respect to the soil available potassium of study area, natural forest area (Site-III) registered maximum available potassium of $158.38 \text{ kg ha}^{-1}$, it was followed by *Prosopis juliflora* invaded area (Site-II) ($146.92 \text{ kg ha}^{-1}$) and least available potassium was observed in *Prosopis juliflora* eradicated and effectively managed area (Site-I) with value of $139.49 \text{ kg ha}^{-1}$. The mineral potassium (available K) was found in soluble form in all parts of plants and is responsible for the carbohydrate and protein formations. Potassium activates the enzymes of the plants, which in turn help in the metabolism of the plants, starch synthesis, nitrate reduction and also plays a role in sugar degradation. Potassium performs very vital processes like regulating transpiration and respiration, influencing enzyme action and synthesis of carbohydrates and proteins, etc. (Brady, 2006). The decrease of K is caused by leaching and drainage, which results in the destruction of vegetation as reported by Basumatary and Bordoloi (1992).

The soil analysis on available Potassium content of all the sites varied and the mean values ranged from $139.49 \text{ kg ha}^{-1}$ to $158.38 \text{ kg ha}^{-1}$. Since, all three sites recorded medium range of available potassium. Among the mean values of available potassium content of all the soil sample, the soil of site-III, recorded higher value ($158.38 \text{ kg ha}^{-1}$) which might be due to the high floral diversity of the site. In case of site-II ($146.92 \text{ kg ha}^{-1}$) it was higher than site-I ($139.49 \text{ kg ha}^{-1}$). This might be due to the opened canopy from the site caused due to leaching of Potassium from the site-I. Similarly, Ali El-Keblawy and Al-Rawai (2007) stated that potassium content of soil was increased under *Prosopis juliflora* invaded area than *Prosopis juliflora* non-invaded area.

Summary and Conclusion

Regarding physical properties bulk density, particle

density and total porosity of soil in the study area, the natural forest (Site-III) was significantly performed well as compare to *Prosopis juliflora* invaded area (Site-II) and eradicated area (Site-I). In soil physicochemical properties in case of soil pH, the soil samples analyzed exhibited the slightly acidic in nature in all the three different sites. Regarding chemical properties organic carbon, available soil nitrogen, available soil phosphorus and available soil potassium of natural forest area (Site-III) was significantly higher than *Prosopis juliflora* eradicated (Site-I) and invaded area (Site-II). The forest in Bhavanisagar range was a recovery forest and lost habitat is slowly rejuvenating. It forms a part of the Nilgiris Biosphere Reserve and is one of the rich biodiversity areas of Western Ghats. Invasive alien species causing the serious threat to Tiger reserve, where *Prosopis juliflora*, *Lantana camara* and *Opuntia delinii* were invaded in plain and hilly regions of tiger reserve respectively. Besides these, they created a harmful effect on native environments that include displacement of native species, degradation or elimination of habitat welfare factors, alternation in soil properties, degradation of wildlife forage, adversely altered fire regime and posed a considerable threat to endangered species.

An effort was made to study the impact of *Prosopis juliflora* eradication and effective management for improvement of indigenous floral species which shows positive impacts towards rich faunal base and soil conditions of the Sathyamangalam Tiger reserve. Hence there was an improvement towards shrub and herbaceous layer composition in the *Prosopis juliflora* eradicated area showing positive trend than *Prosopis juliflora* invaded area. The assessed natural forest area (site-III) was higher in floral and faunal diversity than *Prosopis juliflora* invaded and eradicated sites. Since the area supports the enormous number of the herbivorous population like Black buck, spotted deer and the Cattle from villages are the main zoophily agents for *Prosopis juliflora* seeds. If this situation continues for few decades, the tiger reserve will be under great threat by invasive alien species. So, in future more advanced ecological studies are needed to conclude this complex situation. There was immediate need of standard framework and strong modern controlling strategies (mechanical eradication, prescribed burning and chemical control) to tackle the *Prosopis juliflora* invasion towards biodiversity of Tiger Reserve. The Sathyamangalam Tiger Foundation has initiated the eco-development committees, with involvement community participation. Community-based *Prosopis juliflora* eradication in Tiger reserve will be the sustainable management strategies to ensure the ecological balance and livelihood enhancement of the local tribal community. This study will

help to conclude that eradication of *Prosopis Juliflora* has a positive impact towards biodiversity and will serve as baseline data base pertaining to the management of invasive habitats by suitable management plans in Sathyamangalm Tiger Reserve.

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Population Dynamics of Citrus Nematode, *Tylenchulus semipenetrans* on Lemon (*Citrus limon* L.)

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Abstract

An experiment was conducted to find out the population dynamics of citrus nematode, *Tylenchulus semipenetrans* on lemon (*Citrus limon* L.). The population parameters of citrus nematode were studied in relation to mean temperature and relative humidity. The study was conducted at Horticulture farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur from July to December, 2022. Soil and root samples were collected in the first week of July, August, September, October, November, December, 2022 and brought to the laboratory for further processing. Soil samples were processed through Cobb's and sieving and decanting technique while roots were stained with 0.1% acid fuchsin-lactophenol solution as described by Mc Beth *et al.*, 1941. Observation viz., nematode population per 200 cc soil, females / 5 g roots, egg masses / 5g roots and eggs & larvae per egg mass was recorded. Nematode population per 200cc soil found highest in months of September (1159.50), while minimum was found in December (314.50). Females / 5 g roots were recorded maximum in month of August (135.00) and after this decline in the populations till December (69.40). Similar trend were found in egg masses/ 5 g roots and eggs & larvae/ egg mass. Minimum population was recorded during the month of December. Temperature and relative humidity both ecological factors are positively correlated to the nematode population. Nematode population increased during high humidity and warm temperature and the population would decline significantly in winters as the temperatures and R.H. decreased. Management practices should be applied in months of July and August to prevent the nematode population when they are present in higher number.

Key words : Population dynamics, lemon, citrus nematode, *tylenchulus semipenetrans*.

Introduction

Citrus limon (L.) is a tree with evergreen leaves and yellow edible fruits belong to the Family-Rutaceae. Citrus is the third largest fruit crop which is grown commercially in large areas of Rajasthan, Maharashtra, Andhra Pradesh, Karnataka, West Bengal, Sikkim, Punjab and Assam in arid & semi-arid regions to humid tropical regions of India. Presently, area under citrus is 1.09 mha with a production of 14.50 million tonnes and average productivity of 11.80 tonnes/ha in India (Agristat, 2020). In Rajasthan, lime & lemon occupy an area of 2.69 thousand ha with 14.47 thousand MT production and productivity of 5.66 tonnes/ha (Horticulture Statistics at a Glance 2018). Nutritional facts of citrus per 100 g is Calories 60, Fat N/A, Sodium N/A, Fiber 3 g, Sugar 12 g, Protein 1g, Vitamin A 14 mcg and Vitamin C 70 mcg. The main raw material of *C. limon* is the fruit, particularly the essential oil and juice obtained from it. The *C. limon* fruit stands out as having well-known nutritional properties, its valuable biological activities are underestimated in modern phytotherapy and cosmetology (Goetz, 2014). These chemical components are the reason for the important position of *C. limon* in the food and cosmetics industries (Abad-García *et al.*, 2012; García-Salas *et al.*, 2013; Russo *et al.*, 2015). *C. limon* fruit juice (lemon juice) has traditionally been used as a

remedy for scurvy before the discovery of vitamin C (Mabberley, 2004).

In India out of seventy species within 37 genera of plant parasitic nematodes have been reported in association with citrus roots (Reddy and Singh, 1979). Lemon (*Citrus limon* L.) is an arid & semi-arid to humid tropical fruit cultivated in many tropical and subtropical regions of the India. It is the third important commercial fruit crop grown in India (Jaiman *et al.*, 2022). *Tylenchulus semipenetrans* is known to infect all type of citrus plants and it is responsible for a substantial amount of damage in citrus orchards. The yield of mature trees got reduced by 10-30 per cent due to citrus nematode, *Tylenchulus semipenetrans* (Mashela and Nthangeni, 2002). This nematode is present in about 92 per cent of Southern California citrus orchard soils and is believed to be one of the important causal factors of the citrus replant problem (Cobb, 1914; Thomas, 1923; Baines and Clark, 1952). Maximum density of citrus nematode was observed at a distance of 2ft., 4ft. and 6ft. horizontally and 1 ft., 1.5 ft. and 2 ft. vertically in Lemon. Nematode population decreases in horizontal and vertical distribution may be due to lesser feeder roots in roots system (Jaiman *et al.*, 2023).

From India, the first report on the presence of *T.*

semipenetrans was made by Siddiqi (1961). It is now known to be widely distributed in the country including Punjab, Delhi, Rajasthan, Uttar Pradesh, Maharashtra, Assam, Orissa and Kerala (Siddiqi, 1961; Swarup *et al.*, 1964; Chona *et al.*, 1965). In almost all cases this species is found to be Predominant wherever die-back symptoms are present and is suggested that citrus nematode is at least one of the main factors responsible for slow decline of citrus trees in India.

Materials and Methods

Lemon plants infected with *T. semipenetrans* were used for collection of soil and roots samples from the different infected plant from the lemon orchard of Department of Horticulture, RCA, Udaipur and brought into laboratory. In Department of Horticulture, population or colony of citrus nematode has been already maintained on lemon. Therefore, citrus nematode isolated from lemon plants as well as infested soil also collected. Two hundred cubic soil was processed using Cobb's sieving and decanting technique (Cobb, 1918) followed by Baermann's funnel assembly (Christie and Perry, 1951). After 24 hours the suspension was drawn in a beaker from the funnel and kept for some time to allow the nematode to settle down. The excess water was gently poured out of the beaker without disturbing the nematodes already settled at bottom. The volume of suspension was made to 100 ml and then after thoroughly bubbling 10 ml of suspension was drawn with the help of a pipette and poured over a counting dish for counting. Population count was done under a stereoscopic binocular microscope and determine accordingly.

Root samples were collected from each pot, labelled properly and brought to the laboratory. Roots were gently washed in running tap water to remove and clean adhering soil particles. These roots stained by using acid fuchsin and lactophenol. Roots were completely observed under stereoscopic binocular microscope for counting of females, egg masses and eggs and larvae of nematode. Eggs and larvae could be separated from egg mass and squeezed gently and count eggs and larvae by using telecounter.

For estimate the population changes of *Tylenchulus semipenetrans* at different time intervals, we were selected ten plants from the lemon orchard. After selecting the plants, we were marked them for further observations. The observations were taken at 30 days interval for six months from July, 2022 to December, 2022. For sampling we were collected the root samples at 2 feet distance horizontally and 1.5 feet distance vertically. Total five samples were collected from each plant and take the average of nematode parameter in each month. All the methodology was similar in respect to

extraction of nematode from soil and plant roots. Effect of temperature and relative humidity on the extraction of second-stage juveniles of citrus nematode was also correlated. Temperature and relatively humidity affect the soil temperature and soil moisture. In this experiment observations *viz.*, number of females per 5 g roots, number of egg masses per 5 g roots, number of eggs & larvae per egg mass and nematode population in 200 cc soil were recorded. These observations analysed to correlate with temperature and relative humidity, for estimation of fluctuation in nematode in different time interval.

Results and Discussion

Estimation of population of citrus nematode, *Tylenchulus semipenetrans* during different time interval and different season periodically in the citrus field situated at RCA horticulture farm, MPUAT. This experiment was carried out to know the population dynamics of citrus nematode, *Tylenchulus semipenetrans*. Observations on nematode reproduction (number of egg masses per 5 g roots, number of females per 5 g roots, number of eggs & larvae per egg mass and nematode population per 200 cc soil) were recorded (first week of every month from July to December, 2022), analyzed & presented in Table-1 and illustrated through Figure 1 & 2.

a. Females per 5 g roots : At the time of sampling, females per 5 g of roots were recorded at the 1st week of the following months of July (126.50), August (135.00), September (120.20), October (101.60), November (88.00) and December (69.40). It was recorded maximum at the 1st week of the following months of July (136.00), August (148.00), September (128.00), October (114.00), November (102.00) and December (86.00). Temperature correlation analysis was performed on the given set of data for and the correlation factor was found to be 0.94. Moisture (R.H.) correlation analysis was performed on the given set of data for and the correlation factor was found to be 0.83.

b. Egg masses per 5 g roots : Egg masses per 5 g of roots was recorded at the 1st week of the following months of July, August, September, October, November and December from the plant sample as 101.10, 108.90, 105.60, 94.20, 79.00 and 45.90, respectively. It was recorded maximum at the 1st week of the following months of July (110.00), August (120.00), September (116.00), October (102.00), November (88.00) and December (52.00). Temperature correlation analysis was performed on the given set of data and the correlation factor was found to be 0.97. Moisture (R.H.) correlation analysis was performed on the given set of data for and the correlation factor was found to be 0.69.

Table-1 : Population dynamics of citrus nematode, *Tylenchulus semipenetrans* infecting lemon in Udaipur.

Month	No. of females / 5g roots	No. of egg masses / 5g roots	No. of eggs & larvae / egg mass	Nematode Population / 200 cc soil	Mean Temperature (°C)	Mean R.H. (%)
July	126.50 (112.00-136.00)	101.10 (90.00-110.00)	48.80 (44.00-51.00)	703.50 (420.00-900.00)	28.70 (22.30-35.00)	73.50 (64.00-83.00)
August	135.00 (120.00-148.00)	108.90 (98.00-120.00)	49.10 (47.00-52.00)	1035.50 (710.00-1280.00)	27.60 (22.60-32.50)	72.50 (65.00-80.00)
September	120.20 (100.00-128.00)	105.60 (95.00-116.00)	48.10 (45.00-51.00)	1159.50 (915.00-1385.00)	27.10 (21.20-33.00)	77.00 (72.00-82.00)
October	101.60 (79.00-114.00)	94.20 (80.00-102.00)	48.10 (46.00-50.00)	565.00 (290.00-800.00)	26.00 (17.00-35.00)	59.50 (45.00-74.00)
November	88.00 (68.00-102.00)	79.00 (68.00-88.00)	47.20 (44.00-51.00)	414.00 (245.00-610.00)	21.50 (11.50-31.50)	44.00 (22.00-66.00)
December	69.40 (42.00-86.00)	45.90 (35.00-52.00)	46.10 (42.00-49.00)	314.50 (175.00-470.00)	16.20 (5.60-26.80)	55.00 (24.00-86.00)
SEm±	3.077	1.983	0.616	48.633	-	-
CD at 5%	9.076	5.849	1.817	138.273	-	-

Data are the average of ten replications

Data in parentheses are the range of nematode population, temperature and R.H.

c. Eggs & Larvae per Egg mass : Number of eggs & larvae per egg mass was recorded at the 1st week of the following months of July, August, September, October, November and December from the plant sample as 48.80, 49.10, 48.10, 48.10, 47.20 and 46.10, respectively. Maximum eggs & larvae per egg mass was recorded at the 1st week of the following months of July (51.00), August (52.00), September (51.00), October (50.00), November (51.00) and December (49.00). Temperature correlation analysis was performed on the given set of data and the correlation factor was found to be 0.96. Moisture (R.H.) correlation analysis was performed on the given set of data for and the correlation factor was found to be 0.71.

d. Nematode Population per 200 cc soil : Nematode Population per 200 cc soil was recorded at the 1st week of the following months of July (703.50), August (1035.50), September (1159.50), October (565.00), November (414.00) and December (314.50). It were recorded Maximum at the 1st week of the following months of July, August, September, October, November and December from the plant sample as 900.00, 1280.00, 1385.00, 800.00, 610.00 and 470.00, respectively. Temperature correlation was analyzed on the given set of data and the correlation factor was found to be 0.75. Moisture (R.H.) correlation analysis was performed on the given set of data for and the correlation factor was found to be 0.85 (fig.2).

The experiment was carried out to know the population dynamics of citrus nematode, *T. semipenetrans* from July, 2022 to December, 2022 of citrus orchard (RCA farm). Results indicated that *T. semipenetrans* reached its peak in the months of August & September from where it started declining till December

as the temperature declined and change in relative humidity. Citrus nematode population was found to increase for the period of July, 2022 to September, 2022 due to optimum soil temperature and presence of optimal relative humidity & this prevailed during the rainy periods. The population reduction became more during winters months of November and December due to lower temperature & moisture loss resulting in asphyxia and reduced proliferation rates as well as enhance the time of life-cycle. As the winters set in it seemed the population decreased the rate of reproduction and entered a state of decline due to prevailing low temperature conditions. This was observed in the pattern of the population mean for females per 5 g roots of July (126.50), August (135.00), September (120.20), October (101.60), November (88.00) and December (69.40). Similar pattern was observed with respect to number of egg masses per 5 g roots. Nematode population per 200 cc soil observed in the months of July (703.50), August (1035.50), September (1159.50), October (565.00), November (414.00) and December (314.50). No significant change was observed for eggs and larvae per egg mass for various months July to December, 2022. This study showed that nematode population parameter, first increase and then decrease when temperature & relative humidity decreased. It means nematode population and abiotic factor are positively correlated to each other.

Similar results were observed by Prasad and Chawla (1965), they found that citrus nematode population was smallest in January and then gradually increases until it reaches its highest level in August. O' Bannon *et al.* (1966) observed that development and reproduction were slower at 20° than at 30° C during the winters.

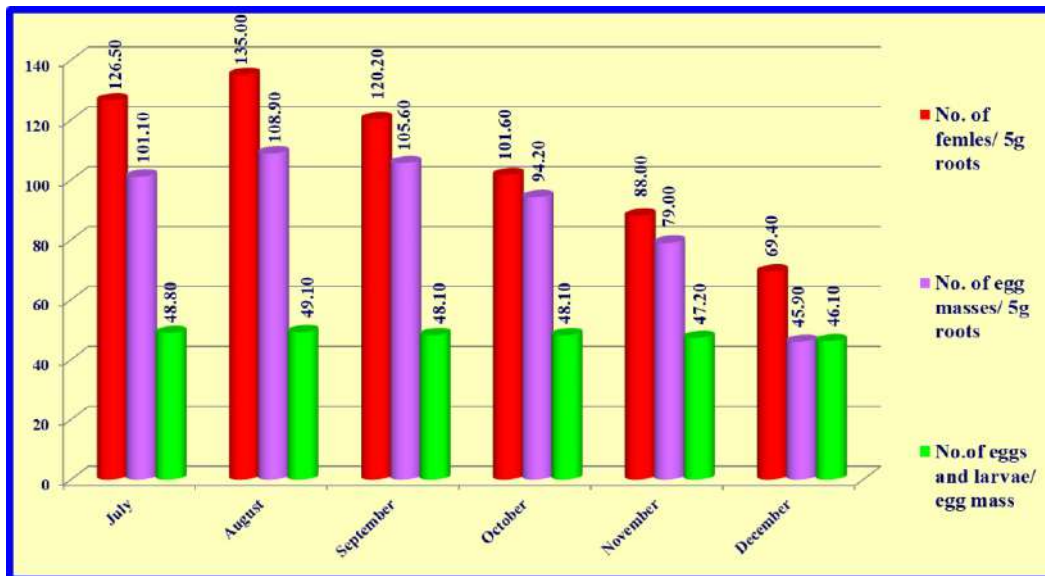


Fig-1 : Population dynamics of citrus nematode, *T. semipenetrans* on lemon at different time intervals (July to December, 2022).

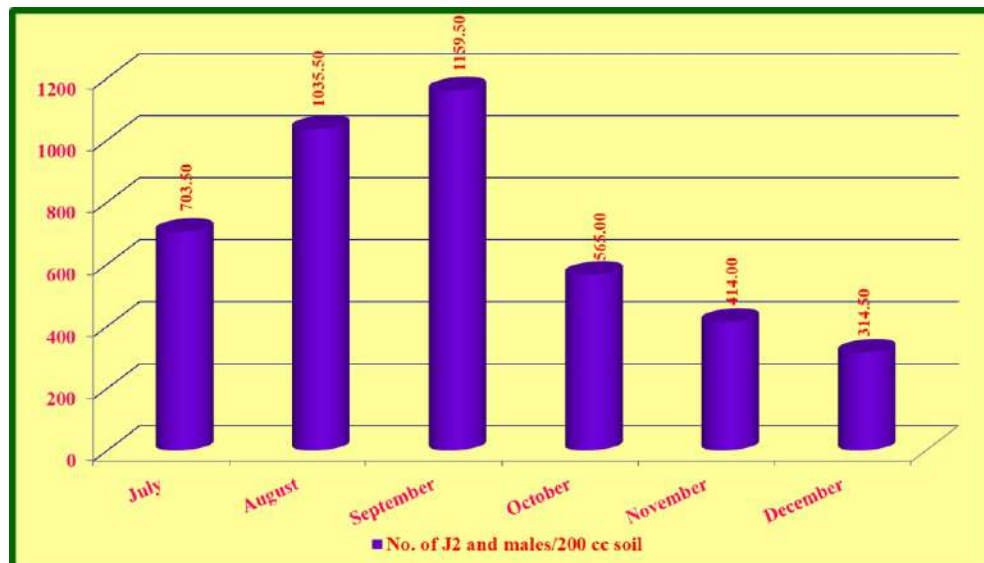


Fig-2 : Final soil population of citrus nematode, *T. semipenetrans* on lemon at different time intervals (July to December, 2022).

Maafi and Damadzadeh (2008) found that citrus nematode population densities peaked once a year during July-August and declined to lower levels during autumn and winter. Amin and Youssef (2014) recorded the highest nematode population in roots appeared in August in the same year.

Thus, from the recorded observations we can conclude that the nematode is significantly correlated to temperature and moisture conditions of the seasons. Mostly because these factors have a direct effect on soil moisture through the season and thus affect nematode reproductive and physiological behavior. Thus, we found that temperature directly affected on nematode reproduction & feeding. When Correlation analysis

performed then the nematode population showed correlation with both temperature and relative humidity. In case of temperature and relative humidity, temperature affected the nematode population more compared to relative humidity, as per the results of correlation.

However, in contrast Thapa and Mukhopadhyay (1994) found nematode (*T. semipenetrans* Cobb) population was high during March-April and low during November-December under Darjeeling condition.

These studies revealed that the population of citrus nematode greatly fluctuated and depends on ecological conditions *i.e.* temperature, soil moisture, relative humidity, pH, soil type, crop and it's variety, age of orchard etc.

Conclusion

Population dynamics studies showed that nematode population increased from July to September and obtained maximum numbers in September month. Thereafter nematode population declined due to sharp decrease in soil temperature and relative humidity till December. Minimum nematode population was recorded in the month of December, 2022.

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Potential Impact of Micro, Small and Medium Enterprises (MSMEs) on Agri Business

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Abstract

MSMEs are involved in the manufacturing, processing and production of goods and services. The MSME development act was launched in 2006 and MSMEs have become an important and integral part of Indian Economy. MSMEs in India produce over 6000 unique products, contributing to about 48 percent of the nation's exports and with a 45 percent share in the manufacturing sector and stands as a backbone of the economy. They provide a great deal to the employment generation. MSMEs provide great opportunities to entrepreneurs to create and build innovative and cost effective products that increase growth of business and intern the economy. This paper deals with statutory bodies of MSME ministry, Govt. policies, MSME registration, opportunities for MSMEs in India and role of MSMEs in agriculture. In the agriculture and food sector, these enterprises are, playing a key role in tackling food security, meeting consumer demand, reducing poverty through inclusive and sustainable development.

Key words : MSMEs, Agribusiness, Govt. policies, employment, sustainability.

Introduction

MSME means micro, small and medium enterprises. MSME enterprises are involved in the manufacturing, processing and production of goods and services. They are categorized into two classes: manufacturing and service enterprises. Manufacturing enterprises includes the production of goods whereas service enterprises are engaged in providing services.

The MSME Development Act (MSMED) was launched in 2006 and since then, MSMEs have become an important and integral part of the economy. MSMEs in India produce over 6,000 unique products. They contribute about 48 percent of the country's exports and have a 45 percent share in the manufacturing sector. India has the largest base of MSMEs in the world after China, contributing to 30 percent of the country's GDP. In short, MSMEs stands as a backbone of the economy.

They have become the accelerators of growth and it all started in the year 1961 when the Ministry of MSME merged with the Ministry of Agro and Rural Industries. MSMEs provide a great deal to the employment generation after the agricultural sector. They employ approximately 110 million people in the country and provide opportunities to the underprivileged and rural population. Over 50 percent of the MSMEs in India work in the rural sector.

MSMEs provide great opportunities to entrepreneurs to create and build innovative and breakthrough the

products that increase the growth of businesses and, in turn, the economy.

Classification of MSMEs

According to the Micro, Small, and Medium Enterprises Development Act, 2006. The latest classification by the government for both services and manufacturing MSMEs in India.

Manufacturing Enterprises :

Enterprise Type	Investment Amount (in INR)	Turnover (INR)	Investment in P&M/ Equipment
Micro enterprises	< 25 lakhs	< 5 crores	< 1 crore
Small enterprises	< 5 crores	<50 crores	< 10 crores
Medium enterprises	< 10 crores	<250 crores	< 50 crores

Service Enterprises :

Enterprise Type	Investment Amount (in INR)	Turnover (INR)	Investment in P&M/EQUIPMENT
Micro enterprises	< 10 lakhs	< 5 crores	< 1 crore
Small enterprises	< 2 crores	< 50 crores	< 10 crores
Medium enterprises	< 5 crores	<250 crores	< 50 crores

Manufacturing Enterprises :

It states that there are approximately 2.2 million micro-enterprises, 0.29 million small, and 10,981 medium enterprises in India. Uttar Pradesh has the largest share of MSMEs in the country, followed by West Bengal with 14.2 percent and 14 percent respectively. Maharashtra and Tamil Nadu each contribute to 8 percent of the total MSMEs.

There are four statutory bodies in the MSME ministry:

1. Khadi and Village Industries Commission (KVIC)
2. National Small Industries Corporation Limited (NSIC)
3. National Institute for Micro, Small and Medium Enterprises (NI-MSME)
4. Mahatma Gandhi Institute for Rural Industrialization (MGIRI)

The KVIC is accountable for strengthening and developing the rural economy by promoting khadi and other village industries. Generation of employment opportunities for the rural population is one of the important focus areas of this body. NSIC encourages, aids, and fastens the growth of micro and small enterprises. NI-MSME is more focused on growing entrepreneurs, formulation of policies, and promoting enterprises. Finally, MGIRI encourages rural and village economies and struggles to empower rural populations by introducing innovation and technology.

Role of MSMEs in Agriculture

MSMEs can support and encourage small-scale farming, ensure sourcing from local entities and small-scale producers for office purposes as much as possible and demonstrate transparency in the agricultural supply chain particularly when sourcing. In the agricultural food sector MSMEs are key to tackling food security, meeting growing consumer demand and reducing poverty through inclusive and sustainable development.

Government Policies For MSMEs : The Indian government confess the role of MSMEs in the economy and developed policies to encourage these businesses and help them grow.

Finance minister declared INR 3 lakh crore (\$41Bn) collateral-free loans for MSMEs as a COVID-19 relief.

It announced Guarantee Emergency Credit Line (GECL) of INR 10,000 crores for eligible MSMEs in the Union Budget 2021 to accelerate and boost the sector.

The government assigned INR 7,572 crores for MSMEs in FY20, whereas in FY21, it doubled the budget to approximately INR 15,700 crores.

MSME Registration : From July 1, 2020, it is compulsory to obtain “Udyam” registration for all the existing MSMEs in the country and new MSMEs. It is a simple process that can be done online by self. Aadhaar number is compulsory certification required to obtain the MSME Udyam registration online.

In the case of an ownership company, the Aadhaar number would be of the proprietor (individual). For a partnership organization, the managing partner's Aadhaar is required. In the case of a Limited Liability Partnership (LLP) or a trust or cooperative society, the authorized signatory's Aadhaar has to be provided.

Once you complete the online MSME registration process, the company (MSME Unit) provides an “Udyam Registration Certificate for which there is no expiry. Till the time the business follows ethical practices and is financially viable, the certificate is legal. There are many benefits of having an MSME registration online. Post-registration, the minimum alternate tax can be carried forward 15 years (initially it was 10 years). It is easier to get government tenders. The government has the authority to deregister the company in case of any violations, like, if the investment is more than the limit mentioned under the MSME act or manufactures any products requiring other license.

Benefits of Government Policies : The pandemic and the country-wide lockdown impacted economic growth. It has put severe financial stress on businesses, especially micro and small businesses. Considering this, the finance minister declared the Atmanirbhar Bharat Abhiyan program. Furthermore, an economic package with new initiatives and policies was introduced to help businesses navigate and channelize capital better. Government has announced various subsidy programs and schemes to make the market more competitive and help them grow.

The 45-day Cycle of Invoices

In micro and small businesses, the credit cycle and businesses usually run tight on capital and have low liquidity. This was directed under the MSMED Act of 2016. The buyers are responsible to pay the seller (clear their invoices) within 45 days from the invoice date. In case of delays, the buyer is liable to pay interest on invoice amount.

Mandated 25 percent Sale to Certain Departments

To promote MSMEs and enhance their businesses, the government mandated that certain departments and public sector companies purchase about 25 percent of their product requirements from MSMEs.

Emergency Credit

One of the critical concerns of MSMEs is, it has been the easy access to credit. To address this, government has launched an emergency credit line for MSMEs where up to INR 3 trillion can be sanctioned. In this scheme, banks and financial institutions will be able to provide funds without any additional guarantees.

Debt Schemes

Businesses are usually capital intensive. Raising

funds is as important as running the business itself. To finance via equity funding is difficult, and the COVID-19 pandemic has just made it worse. Majority of the promoters are facing difficulty in raising funds. To assist the businesses, the government launched the subordinate debt scheme. This helps the businesses by providing capital via debt.

Speedy clearance of payments

The government identifies the importance of liquidity in businesses, especially in the case of MSMEs. In confessing this, the government has mandated a 45-day limit for public sector units and government departments to clear their dues for purchases made from MSMEs.

Supporting growth

The government started a new portal (Champions Portal) for the MSMEs to help them with the entire supply chain from procurement of raw materials to sales. The portal encourages the MSMEs to take over new opportunities with the changing needs of the economy.

Funds of Fund scheme

Among all the different schemes, government launched for MSMEs, the funds of fund scheme is to provide funding and financial support to companies that showcase immense growth potential and economic and business viability. It was launched with an INR 10,000 crore.

Credit-linked Capital Subsidy

For any business that seeks to develop its technology or other assets to increase the productivity and efficiency of its business, this capital subsidy scheme comes in handy. A subsidy is given to these businesses by the banks under this scheme on the induction of well-established and upgraded technology.

Other benefits of Government policies for MSMEs :

Collateral-free loans

ISO certification charge-reimbursement

Delayed payments protection

MSMEs are eligible under the industrial promotion subsidy program

Discount on utility bills

Exemption of 1 percent on the overdraft interest rate

Subsidy of 50 percent on registering a patent

Although there are multiple benefits, schemes, policies in favour of these businesses, they still face a significant number of challenges that are the roadblocks affecting their growth, such as, lack of innovation and adoption of new technological tools, low capacity of production, inadequate facilities (infra, power, roads, water), inefficient supply chain processes, lack of visibility,

inadequate manpower (skilled and unskilled), limited financing options, high cost of credit, and limited access to global markets. The government and the start-up ecosystem are constantly evaluating these challenges and providing businesses with different incentives to overcome these challenges.

Opportunities for MSMEs in India : Government owns and runs an e-commerce website called Government e-Marketplace (GeM), where MSMEs can market and sell their products. The different ministries and the public sector companies source their goods from this platform. The government provides enormous opportunities for entrepreneurs who set up enterprises and contribute to the economy and employment of the country. MSMEs are broadly supported and promoted. The employment opportunities in MSME has the potential to increase rapidly by over 50 percent till the next decade. In numerous benefits and growth opportunities will attract huge participation and registration in the MSME sector.

As per India's population, the country should produce 10 to 15 million employment chances over the next decade. The current employment status in MSME stands at 28 percent.

India is proceeding towards a more industrialised economy with enough growth in various sectors. All the economic sectors need to perform well to reflect the stability in MSMEs' growth to achieve entire growth.

The manufacturing sector has observed a growth rate of 18 percent, and the services sector has shown a growth rate of 34 percent in employment.

The MSME has large growth potential in the khadi, coir, and village industry.

MSMEs in Telangana : It is estimated that Telangana is home to about 2.6 million MSMEs out of which 56 percent are in rural areas and 44 percent in urban areas. As many as 19,954 registered MSME units have commenced their operations since the formation of the state with an investment about Rs.31,023 crores.

There are 28 Industrial parks developed by TSIIC which are available for MSMEs across 2500 acres of land. 6 new parks have been proposed and 12 are under upgradation.

Green Industrial Park for MSMEs in Yadadri – Industries Minister inaugurated Dandumalkapur TSIIC-TIF-Micro Small and Medium Enterprises (MSMEs) Green Industrial Park in Nov 2019. MSME Park is expected to attract 1,553 crore investments, house more than 450 industries and generate about 35,000 jobs. This is the first model industrial park to be set up for the MSME sector after the formation of

Telangana. The government provided the infrastructure and basic amenities in the park and also laid a road from the park to the national highway.

Micro Industrial Park, Rairaoopeta, Bibinagar, Yadadri – A new Industrial Park development started during 2020-21, for Micro enterprises in 40 acres of land for 171 units. The park will attract investments of Rs. 420 Crores and provide direct employment to 4200 people.

TIHCL – Telangana industries health clinic :

Prevent the incipient sickness in micro and small manufacturing enterprises (MSEs).

Create service offerings for Revival, Restructuring and Rehabilitation of MSEs.

Promote investments in manufacturing MSEs in clusters across the State.

Prepare the MSEs to participate in the Equity markets to achieve next growth levels.

TS Global linker :

Global Linker : A unique digital networking platform with over 3,00,000 plus MSMEs where businesses like yours can find buyers & sellers globally, read about industry insights and avail MSME exclusive offers.

TS-Global Linker was launched on 27th March 2019 in collaboration with Government of Telangana to promote and support local MSMEs of the state. Since then, the portal has registered 7000 plus SMEs from the state. The portal provides knowledge & efficiency tools, digitizes stores and creates free e-marketplace for SMEs to buy, sell and connect with potential partners.

Global Linker and Confederation of all India Traders (CAIT) joined hands recently to launch “SMEs of Digital India” program aimed at digitizing the business of more than 7 crore traders in India. Global Linker team has been actively working with government and participating in Industry association events to spread awareness about the portal.

7000 plus MSMEs from Telangana and 3 lakh plus from south east Asia

Creating unique and customizable e-store free of cost, with integrated delivery and payment options
Opportunity to interact with other businesses & buyer-seller tie-ups

Regular seminars /interactions with experts; access to Govt. info.

Kiranalink.in launched during COVID-19 in May '20 to digitize local kirana stores in collaboration with CAIT (Confederation of All India Traders)

Profitable MSMEs for Agribusiness:

Cold storage for shrimp and agri. products

Production of jute gunny bags

Particle boards from wheat / rice straw

Groundnut oil production and refinery

Indian kitchen spices (masala powders)

Biodegradable plastic bags from corn & cassava starch granules

Peanut butter unit

Rice milling units

Flour and dhal mills

Tomato sauce manufacturing unit

Roasted rice flakes

Banana fibre extraction and weaving

Agri. implements and hand tools

Bakery products

Desiccated coconut powder

Papad manufacturing

Summary and Conclusion

MSME is the chief support of the Indian economy. It has proven the instrumental in the growth of the nation, leverage exports, creating huge employment opportunities for the unskilled, fresh graduates, and the underemployed. It also extended the opportunities to banks for giving more credit to enterprises to MSME Sector. The government should take the special care by addressing the significance of MSME in terms of providing more advantages by implementing better regulations and enable financial institutions to lend more credit at less interest rate for sustainability of this sector.

It creates large-scale employment : Enterprises that are inclusive in this sector need low capital to start up new business. Moreover, it creates a large opportunities for the unemployed people to avail. MSME is the blessing for the fresh talent in India.

Encourages Inclusive Growth : The comprehensive growth is at the top of the agenda of Ministry for Medium, and small and Medium-sized enterprises for several years. On the other hand, poverty and deprivation are discouragement to the development of India. It also includes marginalized sections of a society which is a key challenge lying before the Ministry of MSME.

Cheap Labour and minimum overhead : While in the large-scale organizations, one of the main challenge is to retain the human resource through an effective human resource management professional manager. But, when it

comes to MSME, the requirement of labour is less and it does not require a highly skilled labourer. Therefore, the indirect expenses sustained by the owner is also low.

Simple Management Structure for Enterprises : MSME can start with restricted resources within the control of the owner. On the contrary, a huge corporation needs a specialist for every departmental functioning as it has a complex organizational structure. Whereas a small enterprise does not require to hire an external specialist for its management. The owner can manage himself, hence, it could run single-handedly.

The main role in the mission of “Make in India”: The initiative by the Prime Minister of India “Make in India” has been made easy with MSME. It is taken as a support in making this dream a possibility. In addition to this, the government has directed the financial institution to lend more credit to enterprises in the MSME sector.

India's economy is steadily growing, and its growth has remained constant over the last few years. The government's different schemes have initiated MSMEs' growth, creating huge employment opportunities for the country. In spite of the many challenges that the sector faces, it has successfully evolved over the years. It is now gaining more popularity and support from the people and the government compared to earlier. The sector has also been recognised globally and is a major driver for poverty reduction and improved societal lifestyle.

The micro, small, and medium enterprises' extraordinary growth opportunities are the lead to the country's overall development. However, facilitation from the Government is required to reduce the transaction costs of technology upgradation, market penetration, modernisation of infrastructure etc. History shows that only with constant and effective Government support in these areas, the SMEs of countries like Japan, Korea etc. emerged as global players.

The Government of India is working with the World Bank to facilitate and facilitate the accessibility of credit to MSMEs. They collectively focus on different policies, fine tech platforms, initiatives, systems to channelize and

operationalize this. With its appropriate focus on MSMEs and domestic production, the economy will witness exponential growth with MSMEs driving as a core engine.

The role of MSMEs in the Indian economy is key and significant and will continue to be so. With the right initiatives, policies, and technology, this sector will demonstrate immense growth and contribute significantly to the country's economy.

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Varietal Assessment of Chilli LCA-625 and LCA-620 in Anakapalli District of Andhra Pradesh

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Abstract

An On-Farm Trial (OFT) for three consecutive years (2020-21, 2021-22 and 2022-23) was conducted by ICAR- ANGRAU, Krishi Vigyan Kendra, Kondempudi directly in farmers' fields of five selected villages viz., Kondempudi, Garnikam, Thotakurapalem, Jaithavaram and Pottidorapalem in Anakapalli district of Andhra Pradesh to assess the performance of two promising chilli varieties viz. LCA-625 and LCA-620 with regard to yield and economic analysis against the farmers' practice variety Potti mirapa. A total of twenty-five farmers actively participated in the OFT covering an area of 7.5 acres. With regard to yield, LCA-625 proved to be the best followed by LCA-620 and Potti mirapa with dry chilli yield of 49.62, 45.42 and 30.81 q/ha, respectively. During the years of the trial, the dry chilli yields of LCA-625 and LCA-620 increased from 36.84 to 39.56% and 31.36 to 35.34 %, respectively. Average cost-benefit ratios for the three years for LCA-625, LCA-620 and Potti mirapa varieties were 1:1.38, 1:2.02 and 1:1.77 respectively. The Extension gap was between 17.5 to 15.6 and 12.65 to 12.42 q/ha for LCA-625 and LCA-620, respectively. Results on Technology Index ranged between 29.62 to 27.92, 30.65 to 26.06 and 18.59 to 27.58% for LCA-625, LCA-620 and Potti mirapa (farmers' practice), respectively revealed that for both the chilli varieties, there is much scope for demonstrated technology in Anakapalli district and the surrounding areas of north coastal Andhra Pradesh.

Key words : *On-farm trials (OFT), extension gap, technology gap, technology index, demo plots and cost of cultivation.*

Introduction

Chilli (*Capsicum annum* L.), a member of the Solanaceae family, is a universal spice crop with immense economic significance. The crop is commercially cultivated as a spice, condiment, vegetable, culinary supplement, medicine and ornamental plant throughout the world (Dias, 2013). Chilli and its preparations are used as ingredients to add more to flavour and colour in many delicacies. Chilli, rich in vitamins A and C, calcium and iron, is used in preparations for treating asthma, coughs and sore throats. Chilli, consequent to its demand in local, national and international markets, is a profit-making commercial crop (Pandey *et al.*, 2008). In India, chilli is cultivated in an area of 774.9 thousand ha with production of 13.76 million ton per year contributing to 39.19 % of total global area and 36.57 % production (Geetha and Selvarani, 2017). However, yield in Anakapalli district and surrounding areas of north coastal Andhra Pradesh yields are very poor, despite favourable climate and soil due mainly to lack of knowledge and technology adoption regarding the selection of the right variety, seed treatment, nursery raising, Integrated Nutrient Management (INM), and plant protection measures. Keeping these gaps in interest, an on-farm trial (OFT) was undertaken right in farmers' fields by ICAR- ANGRAU, Krishi Vigyan Kendra, Kondempudi for demonstrating to the farmers for the cultivars better suited than theirs along with other agronomic practices. Twenty-five participant farmers

drawn from five villages viz. Kondempudi, Garnikam, Thotakurapalem, Jaithavaram and Pottidorapalem (7.5 acres field area with LCA-625 and LCA-620 varieties) participated in the OFT for three consecutive years viz. 2020-21, 2021-22 and 2022-23.

Materials and Methods

The list of the participant farmers was prepared very meticulously based on the response and interest evinced in group meetings and interaction sessions with scientists. The skill training in the demos focussed on the selection of quality of seeds, seed treatment, fertilizer schedule and nutrient management, irrigation schedule, plant protection measures, and fruit picking at right stage and right time. Prior to commencing the demos, Soil pH, electrical conductivity, and available potassium were determined by standard methods (Jackson, 1973). Available nitrogen and phosphorus were determined by alkaline permanganate method (Subbaiah and Asija, 1956) and colorimetric method (Bray and Kurtz, 1945), respectively. Seeds of LCA-625 and LCA-620 were selected for demos; those of potti mirapa variety were marked as the farmers' practice/reference check/local variety for assessing the yield and economic analysis. Due to small seed size and high cost, the seeds were sown in pro trays for ensuring better germination. The seedlings when 35 day old were transplanted to the main field. The spacing (90 cm x 60 cm) facilitated easy weeding operation with power

weeder. Seed treatment for preventing sucking insects was done with @ 8 g imidacloprid and metalaxyl @ 3g/kg seeds for insect pests and fungal diseases, respectively. The fields received well decomposed FYM @ 8 tonnes /acre at last ploughing. N, P and K @ 120, 24 and 48 kg/acre were applied through commercial fertilizers. P was applied as basal dose, while N and K were applied in four equal splits at 30, 60, 90, 120 days after transplantation. Foliar spray of zinc sulphate @ 1 g/litre and Planofix @ 1 ml/4 litre were practiced. Plant protection measures included installation of blue and yellow sticky traps @ 4 to 6 /acre for chilli trips and whiteflies. Sprayings of fipronil @ 2 ml/litre, copper oxychloride @ 3 g/litre and carbendazim @ 1 g/litre were done for controlling thrips, wilt and fruit rot diseases, respectively. Plants were irrigated by drip system. At maturity stage, picking was done at five days interval. Performance and yields of LCA-625 and LCA-620 were compared against Potti mirapa (farmers' practice). The extension parameters such as Extension Gap, Technology Gap, and Technology Index were calculated by formulae suggested by (Samui *et al.* 2000, Renbomo and Pijush Kanti 2016, and Kale *et al.*, 2020) to study the impact of Front-Line Demonstrations over traditional practices by farmers.

1. Technology gap = Potential yield – Demonstrated yield
2. Extension gap = Demonstrated yield – Yield under existing practice
3. Technology Index = $\frac{\text{Potential yield} - \text{Demonstrated yield}}{\text{Potential yield}} \times 100$
4. Technology Index = $\frac{\text{Potential yield} - \text{Demonstrated yield}}{\text{Potential yield}} \times 100$
5. Per cent increase over farmers practices = $\frac{\text{Improved practices} - \text{Farmers practices}}{\text{Farmers practices}} \times 100$
6. Per cent increase yield = $\frac{\text{Demonstration yield} - \text{Farmer practice yield}}{\text{Farmer practice yield}} \times 100$

Results and Discussion

Physicochemical properties of the soils viz. pH 6.62, electrical conductivity 0.06 dS m⁻¹, and available N, P and K at 179.82, 37.34 and 95.58 kg ha⁻¹ respectively, indicated the soils to be ideal for commercial cultivation of chilli. Dry chilli yield (q/ha) of the three treatments increased substantially from 2020-21 to 2021-22; thereafter the yield decreased in 2022-23 in all three treatments (Table 1 and Fig. 1). The increase and subsequent decrease in yield might be due to the incidence of *Scirtothrips dorsalis*. Elsewhere similar results have also been reported by Basavaraj *et al.* (2022), Hulagappa *et al.* (2022), Veeranna *et al.* (2022), Patel *et al.* (2022), and Subhasree *et al.* (2023). Some of these authors opined the decline in yield in similar pattern to be due to the invasion of Indonesian flower thrips (*Thrips*

parvispinus) causing poor fruit setting. The results of the study are in line with those of Janaki *et al.* (2015) and Venkanna and Bhaskar Rao, (2020) who reported higher dry chilli yield in 2021-22 in all the three treatments in comparison to that of 2022-23 (52.72, 48.15 and 33.05 q/ha as against 48.65, 45.67 and 29.40 q/ha for LCA-625 LCA-620, respectively). Yield wise performance of the varieties LCA-625 and LCA-620 superior to that of the farmers' practice could be due to genetic superiority of the former. Going deeper, Rekha *et al.* (2016) and Asati and Yadav (2004) suggested bearing habit to be responsible for similar results in yield. Obidiebube (2012) reported yield differences in chilli cultivars to be due to variations in number of fruits and dry weight.

Per cent increase in yield over farmers' practice were 36.84, 37.31 and 39.56 for LCA-625, and 29.66, 31.36 and 35.34 for LCA-620 during 2020-21, 2021-22 and 2022-23, respectively. The increase might be due to greater number of branches and number of fruits per plant as were also reported for LCA-625 by Rohini and Lekshman (2017) and Venkanna and Bhaskar Rao, (2020) and for LCA-620 by Kale *et al.* (2020). Nagaraju *et al.* (2018) reported fruit number per plant as the single most contributing character for genetic divergence for yield. Singh *et al.* (2011) also reported increase in yield of 28.22 per cent in tomato, 29.17 per cent in chilli and 21.43 per cent in brinjal in Rajasthan conditions through FLDs on improved production technology. Yield enhancement in crops in frontline demonstration are well documented by various authors (Haque, 2000; Sagar and Ganesh, 2003; Mishra *et al.*, 2009; Kumar *et al.*, 2010, Poonia and Pithia, 2011, and Singh and Sharma, 2004). The results the present studies convincingly establish the superiority LCA-625 and LCA-620 over the existing farmers' practice in this region of north coastal Andhra Pradesh.

The Extension gap with LCA-625 and LCA-620 ranged between 17.5 to 15.6 and 12.65 to 12.42 q/ha, respectively (Table 2 and Fig. 6). The results fit in line with those of finding of Hiremath and Nagaraju (2010) and Kale *et al.*, (2020). Increasing use of latest production technologies with high yielding varieties shall lower the extension gap. There is thus much need to educate the farmers for selecting a high yielding variety recommended for the area and adoption of modern technology to plug this wide extension gap through various extension methodologies viz. front-line demonstrations, cluster frontline demonstrations, kisan melas, field days and convergence meeting with line departments. These measures and campaigns shall certainly motivate the farmers in discontinuing their old practices and go for the adoption of new technology suggested by visiting scientists.

Table-1 : Yield, Technology Gap, Extension Gap and Technology Index of the cultivation of chilli.

Particulars	Dry chilli yield (q/ha)			Pooled dry chilli yield (q/ha)	Potential dry chilli yield (q/ha)	% Increase in yield over farmers' practice			Technology Gap(q/ha)			Extension Gap (q/ha)			Technology Index (%)		
	2020-21	2021-22	2022-23			2020-21	2021-22	2022-23	2020-21	2021-22	2022-23	2020-21	2021-22	2022-23	2020-21	2021-22	2022-23
T ₁ : Farmers' practice- (Pottimirapa)	30.00	33.05	29.40	30.81	40.6	—	—	—	10.6	7.55	11.2	—	—	—	26.10	18.59	27.58
T ₂ : LCA-625 (demo plot)	47.50	52.72	48.65	49.62	67.5	36.84 %	37.31 %	39.56 %	20.0	18.85	14.78	17.5	23.32	15.6	29.62	21.89	27.92
T ₃ : LCA-620 (demo plot)	42.65	48.15	45.47	45.42	61.5	29.66 %	31.36 %	35.34 %	18.85	16.03	13.35	12.65	18.75	12.42	30.65	21.70	26.06

Table-2 : Economic analysis of the cultivation of chilli.

Particulars	Cost of Cultivation (Rs/ha)			Gross Return (Rs/ha)			Net Return (Rs/ha)			Cost Benefit Ratio		
	2020-21	2021-22	2022-23	2020-21	2021-22	2022-23	2020-21	2021-22	2022-23	2020-21	2021-22	2022-23
T ₁ : Farmers' practice- (Pottimirapa)	164312	169735	171342	168463	375000	367500	385208	210687	196158	216745	1:1.28	1:1.43
T ₂ : LCA-625 (demo plot)	196725	206872	209964	204520	593750	608125	620291	397025	398161	415771	1:2.018	1:1.89
T ₃ : LCA-620 (demo plot)	196725	206872	209964	204520	533125	568375	567791	336400	358411	363271	1:1.71	1:1.70

Technology Gap consistently decreased in all the three chilli varieties during the three years of study. The Technology Gap with LCA-625 and LCA-620 ranged from 20.0 to 14.78 and 18.85 to 13.35 (q/ha) respectively. The gap may be attributed to the variations in inherent soil fertility and weather conditions (Mukherjee, 2003 and Renbomo and Pijush Kanti, 2016). Variety wise location specific trial and recommendation are required for minimizing the technology gap in yield in different situations. The technology gap results revealed that the OFT farmers after observing the high yields in the first year enthusiastically implemented the package of practices of the demo plots in the subsequent two years. Similar findings were also recorded by Kale *et al.*, (2020), Singh *et al.*, (2019) and Chapke (2012).

There was decrease in Technology Index parameter from 2020-21 to 2022-23 (Table 2 and Fig. 7). The Index for LCA-625 for 2020-21 and 2022-23 was 29.62 and 27.92, while the same for LCA-620 for the years was 30.65 and 26.06, respectively. Lower the value of Technology Index, more is the feasibility of introducing a technology to reach a desired target. There is thus much scope for demonstrated technology in growing chilli in this region for improving its yield. Similar results have earlier been reported in mustard by Jeengar *et al.* (2006), Renbomo and Pijush Kanti, (2016), Kale *et al.* (2020), Katore *et al.* (2011), Keshavareddy *et al.* (2018) and Dayanand (2012).

Results on economic analysis parameters such as the cost of cultivation, gross return, net return and benefit-cost (B:C) ratio are depicted in Table 2 and Fig. 5. There was a consistent rise in the cost of cultivation over the years which was higher for the demo plots due to increased costs of inputs and labour wages. Higher costs due to inputs and labour wages in the demo plots were again due to implementation of recommended practices, more vigorous growth attributes, and greater number of pickings. Cost of cultivation of LCA-625 ranged from Rs. 1,96,725 in 2020–21 to Rs. 2,09,964/ha in 2022–23, while for LCA-620, the same ranged from Rs 1,15,462 in 2020–21 to Rs 1,38,288/ha in 2022–23. The net return too increased steadily in the demo plots and ranged from Rs 3,97,025/ha during 2020-21 to Rs 4,52,128/ha during 2021-22 (LCA-625). However, the net returns decreased in all three treatments during 2022-23 which might be due to incidence of *Scirtothrips dorsalis*. Similar results have been reported by Basavaraj *et al.* (2022), Hulagappa *et al.* (2022), Veeranna *et al.* (2022), Patel *et al.* (2022) due to invasion of Indonesian flower thrips (*Thrips parvispinus*). Net returns were higher in the demo plots in all the three years of study (Fig. 4). The results corroborate those of Hiremath *et al.* (2009), Renbomo and Pijush Kanti (2016),

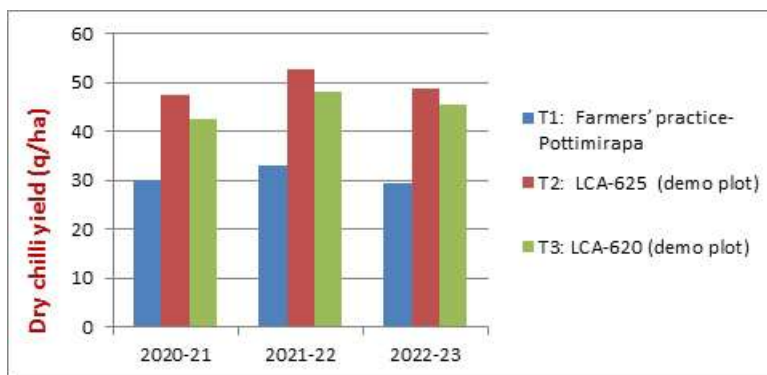


Fig.-1 : Yield of chilli in demo plots and farmers' practice.

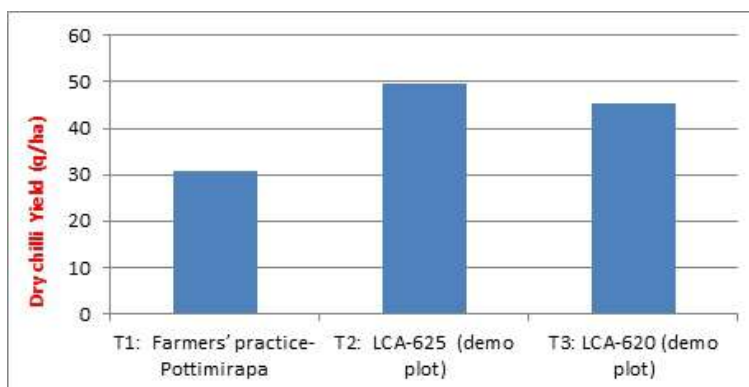


Fig.-2 : Pooled yield of chilli varieties.

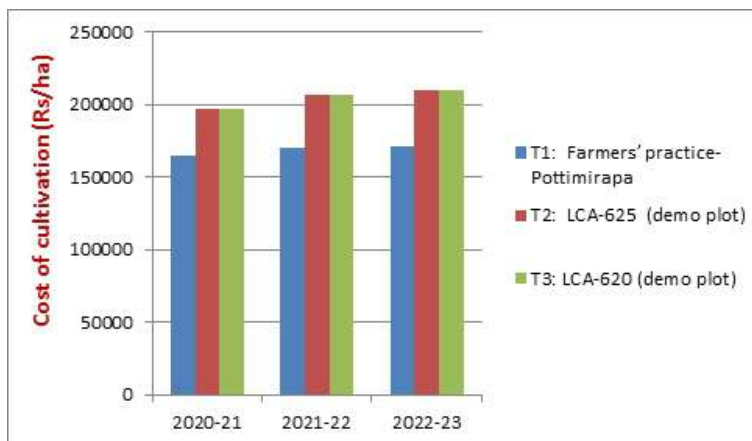


Fig.-3 : Cost of cultivation of chilli.

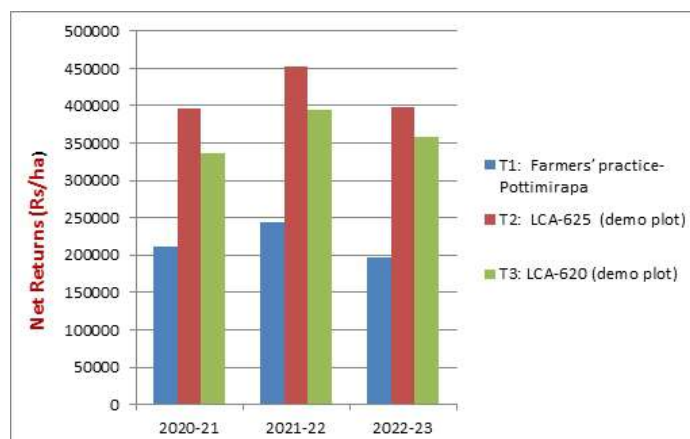


Fig.-4 : Net returns of the cultivation of chilli.

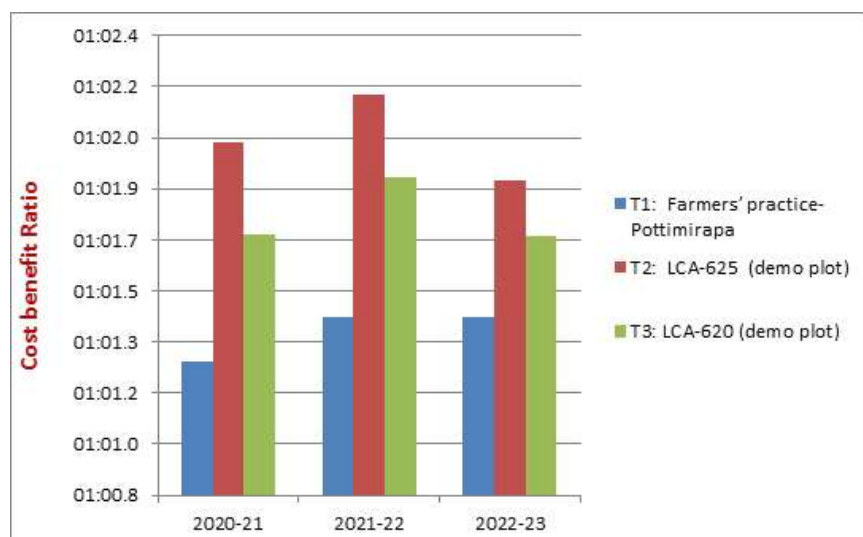


Fig-5 : Cost benefit ratio of the cultivation of chilli.

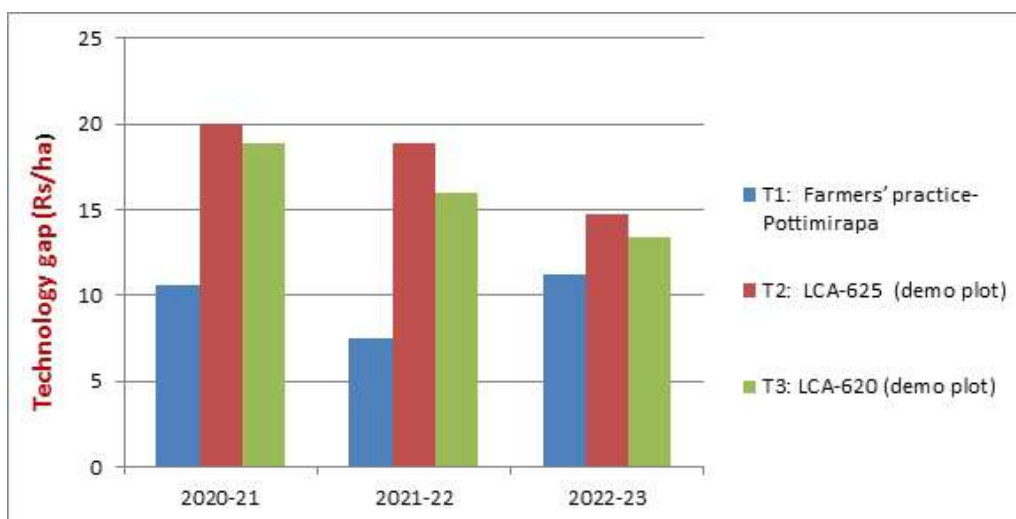


Fig-6 : Technology Gap in the cultivation of chilli.

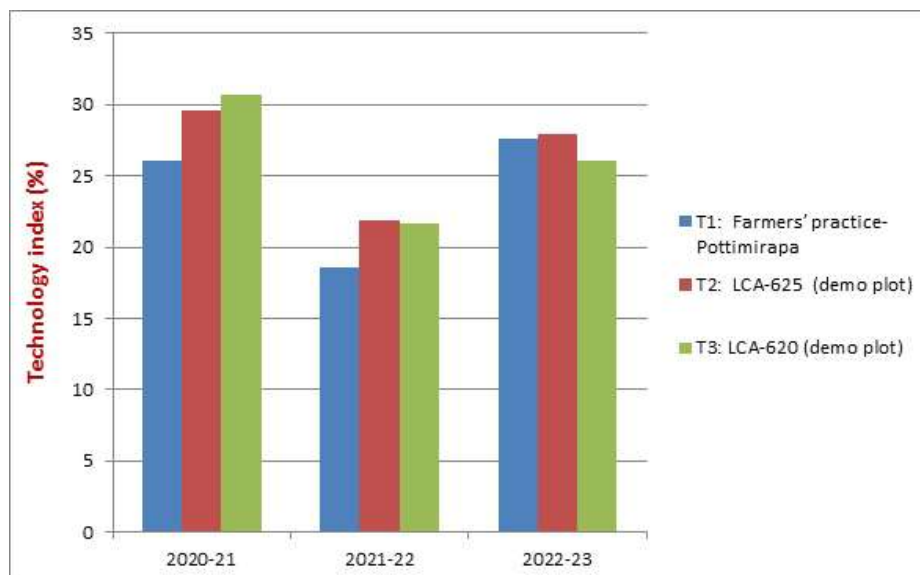


Fig-7 : Technology Index of the cultivation of chilli.



Kale *et al.*, (2020), Mokidue *et al.*, (2011) and Keshavareddy *et al.*, (2018). C:B ratio was higher in the demo plots in all the three years of study (Table 2 and Fig. 5). Srinivas *et al.* (2017) and Naganirmala and Mallikarjuna (2019) also reported similar results with LCA-625 in Southern Telangana.

The results point out that cultivation of chilli following recommended technology as done with the varieties LCA-620 and LCA-625 in the demo plots in this study shall bridge the Technology Gap, help the chilli growers of the region in achieving higher yields and improve their economic status and livelihood substantially. It is imperative to state that the Agricultural Extension agencies and Krishi Vigyan Kendras of the region have to take up this responsibility in right earnest and true spirit.

Conclusions

High yielding chilli varieties (LCA-625 and LCA-620) in the demo plots recorded substantially higher yields than farmers' practice (Potti mirapa). The net returns and benefit cost ratio in the demo plots were also higher in comparison with farmers' practice. On-farm trials run by the scientists in the farmers fields with active participation of the farmers demonstrated the role of new varieties, seed treatment, and adoption of recommended package of practices such as judicious scheduling and application of fertilizers, pesticides, plant growth regulators, irrigation, and right time pickings for realising the bountiful yield of chilli. Chilli is a crop that has a very high demand in trade and market. Chilli growers of the region are however, unaware of growing chilli scientifically and even hesitant

too in technology adoption. Through more of such OFTs, the farmers could themselves see right in their own fields, how technology can lead to a higher yield. And higher yield implies greater profit and better economic life of the farmers.

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Exploring the Interactional Effect of Pre-germination Treatment and Provenance Source on Germination of *Prosopis cineraria* in Nursery Conditions

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Abstract

This study investigated the interactional effect of pre-germination treatment and provenance source on the germination of *Prosopis cineraria* in nursery conditions. *Prosopis cineraria*, commonly known as the Khejri tree is a valuable tree species with numerous ecological and economic benefits. However, its germination process can be challenging, often requiring specific treatments to enhance seed viability and promote successful establishment. To assess the impact of pre-germination treatment, three different methods were employed: mechanical scarification with scarifier, Hot water and Chemical scarification with Sulphuric acid (H_2SO_4) and HCl. Additionally, seeds were collected from four different provenance sources: Haryana (Bhiwani and Hisar) and Rajasthan (Churu and Hanumangarh). The study was conducted in a nursery location, providing controlled conditions conducive to seed germination. The experimental design followed a completely randomized design, with three replicates for each treatment combination. Germination parameters such as germination speed, seedling establishment, total height and biomass were recorded and analyzed statistically. Results indicated a significant interactional effect between pre-germination treatment and provenance source on *Prosopis cineraria* germination. Scarification treatment resulted in the highest germination percentage and rate compared to the other treatments. Seeds sourced from the Hanumangarh exhibited higher germination performance compared to other sources.

Key words : *Prosopis cineraria*, interactional effect of pre-germination and provenance source, nursery

Introduction

Prosopis cineraria, commonly known as the Khejri tree, is a drought-tolerant and economically important tree species native to arid and semi-arid regions of South Asia and the Middle East (Kumar *et al.* 2019). It plays a crucial role in the ecosystem by providing shade, food, and fodder for humans and livestock, as well as contributing to soil conservation and restoration (Baibout *et al.*, 2022). However, the successful germination and establishment of *Prosopis cineraria* can be challenging, requiring specific pre-germination treatments and the selection of appropriate seed sources.

Germination is a critical stage in the life cycle of any plant species, and understanding the factors that influence germination success is essential for successful nursery production and subsequent transplantation of seedlings (Datta *et al.*, 2017). Various factors affect the germination process, including seed characteristics, environmental conditions, and pre-germination treatments (Ashraf *et al.*, 2005). Additionally, the provenance source, which refers to the geographic origin of the seed, can have a significant impact on germination performance. Pre-germination treatments are commonly employed to overcome seed dormancy, improve seed viability, and enhance germination rates (Gupta *et al.*, 2011). Scarification, which involves mechanically breaking or thinning the seed coat, has been widely used to

promote germination in hard-seeded species. Soaking seeds in hot water or other solutions like sulphuric acid (H_2SO_4) and hydrochloric acid (HCl) can also aid in softening the seed coat and promoting water absorption, thereby stimulating germination. However, the efficacy of these treatments may vary depending on the species and environmental conditions.

Furthermore, the provenance source of the seeds can influence their germination behavior. Seeds collected from different geographical regions may have adapted to specific environmental conditions, resulting in variations in germination requirements and performance (Finch-Savage *et al.*, 2016). Therefore, selecting the appropriate provenance source is crucial for maximizing germination success and ensuring the establishment of healthy seedlings. While several studies have investigated the germination requirements of *Prosopis cineraria*, there is limited research exploring the interactional effect of pre-germination treatment and provenance source on germination in nursery conditions. Understanding how these factors interact and influence germination outcomes can provide valuable insights for improving nursery production techniques and optimizing the establishment of *Prosopis cineraria* seedlings.

This study aims to fill this research gap by examining the interactional effect of pre-germination treatment and provenance source on the germination of *Prosopis cineraria* in a nursery setting. By evaluating different

Table-1 : Combined effect of mechanical scarification and provenances on establishment and growth parameters of seeds and seedlings of *Prosopis cineraria*.

Treatment combinations (T × P)	Speed of germination	Seedling establishment (%)	Total height (cm)	Collar diameter (mm)	No. of leaves/ seedling	Shoot dry weight (g)	Root dry weight (g)
T ₁ × P ₁	5.2	69.7	-	1.8	15.0	114.6	-
T ₁ × P ₂	5.7	73.4	-	1.9	15.9	117.2	-
T ₁ × P ₃	6.7	80.1	-	2.3	18.1	121.1	-
T ₁ × P ₄	5.7	72.9	-	2.1	16.9	118.6	-
T ₂ × P ₁	7.7	96.4	-	2.0	19.1	128.2	-
T ₂ × P ₂	8.5	96.9	-	2.2	21.1	133.3	-
T ₂ × P ₃	8.5	99.3	-	2.6	22.2	136.6	-
T ₂ × P ₄	8.5	99.3	-	2.4	20.1	135.1	-
T ₃ × P ₁	6.5	80.6	-	1.9	17.9	126.7	-
T ₃ × P ₂	6.5	80.2	-	2.0	19.4	127.0	-
T ₃ × P ₃	7.2	86.3	-	2.4	20.8	131.0	-
T ₃ × P ₄	7.0	80.4	-	2.1	18.3	129.5	-
T ₄ × P ₁	4.8	63.3	-	1.7	13.1	114.3	-
T ₄ × P ₂	5.7	63.3	-	1.8	14.2	114.9	-
T ₄ × P ₃	6.4	69.8	-	2.0	15.1	116.8	-
T ₄ × P ₄	5.8	66.5	-	1.7	14.4	117.8	-
T ₅ × P ₁	4.3	56.2	-	1.9	11.1	101.5	-
T ₅ × P ₂	4.3	63.4	-	1.7	11.0	104.5	-
T ₅ × P ₃	5.8	66.8	-	1.9	12.0	106.7	-
T ₅ × P ₄	4.6	63.5	-	1.8	12.3	106.0	-
T ₆ × P ₁	1.1	40.2	-	0.5	6.8	86.4	-
T ₆ × P ₂	1.2	43.4	-	0.7	7.0	88.3	-
T ₆ × P ₃	1.6	50.3	-	1.4	9.1	90.6	-
T ₆ × P ₄	1.4	46.2	-	1.0	7.0	89.6	-
LSD(p<0.05)	0.44	2.2	NS	0.18	0.88	1.81	NS

T= Mechanical Scarification-T (minutes): T₁:1.0; T₂:1.5; T₃:2.0; T₄:2.5; T₅:3.0 and T₆: Control P= Provenance: P₁: Hisar; P₂: Bhiwani; P₃: Churu and P₄: Hanumangarh

pre-germination treatments and comparing seeds from different provenance sources, we can gain a better understanding of the factors that contribute to successful germination. The findings of this study will have practical implications for nursery managers, land managers, and restoration practitioners seeking to enhance the germination and establishment of *Prosopis cineraria* seedlings in arid and semi-arid regions.

Materials and Methods

Four locations were identified, two each in Haryana (Bhiwani and Hisar) and Rajasthan (Churu and Hanumangarh). Within the selected population, trees were chosen that exhibited the best physical traits in terms of height and collar diameter. From these chosen trees, fully developed and undamaged pods were harvested. Using a calliper, the length and breadth of each harvested pod were measured. To get at the seeds, the pods were gently opened after collection. To get rid of any unwanted debris, the extracted seeds were cleansed. Seeds were subjected to pre-germination treatment t include: (1) Mechanical scarification using a scarifier was done for 1,

1.5, 2, 2.5, and 3 minutes. (2) Treatment with hot water for 20, 25, 30, 35, 40, and 45 minutes. (3) For 4, 10, 15, 20, 25, and 30 minutes, sulphuric acid (H₂SO₄) and HCl treatment.

For the purpose of determining the rate of germination and seedling establishment, the number of seeds that germinated each day was recorded. The Heydecker (1969) formula was used to calculate the rate of germination. By counting all of the seedlings once the emergence was complete, the seedling establishment was calculated. From 10 seedlings, the height was measured from the collar to the growing tip. The average height was calculated and given in centimeters. Using a digital caliper, the collar diameter was measured at the location where the root and shoot separated just above the ground level and was represented in millimeters. 10 seedlings were counted for each replication, and the average number of leaves per seedling was calculated. Destructive sampling assessed the root dry weight. Five seedlings from each treatment were selected for every observation. The plant was uprooted from the poly bag and the roots were separated and are washed thoroughly

Table-2 : Combined effect of chemical scarification (hot water) and provenances on establishment and growth parameters of seeds and seedlings of *Prosopis cineraria*.

Treatment combinations (T × P)	Speed of germination	Seedling establishment (%)	Total height (cm)	Collar diameter (mm)	No. of leaves/seedling	Shoot dry weight (g)	Root dry weight (g)
T ₁ × P ₁	4.2	63.5	65.17	1.0	11.2	-	-
T ₁ × P ₂	4.4	63.3	65.77	1.2	12.3	-	-
T ₁ × P ₃	4.7	65.5	66.60	1.6	13.5	-	-
T ₁ × P ₄	4.9	65.2	65.93	1.5	13.1	-	-
T ₂ × P ₁	5.2	62.5	66.07	1.4	12.6	-	-
T ₂ × P ₂	5.7	62.7	67.40	1.6	13.5	-	-
T ₂ × P ₃	5.8	69.3	71.90	1.8	15.3	-	-
T ₂ × P ₄	5.4	65.5	70.13	1.7	14.1	-	-
T ₃ × P ₁	5.2	74.1	68.57	1.5	14.0	-	-
T ₃ × P ₂	5.8	72.5	69.70	1.7	15.3	-	-
T ₃ × P ₃	6.4	80.3	73.80	2.1	16.1	-	-
T ₃ × P ₄	5.9	75.7	72.00	2.0	15.3	-	-
T ₄ × P ₁	4.0	56.7	67.07	1.2	12.1	-	-
T ₄ × P ₂	4.5	59.3	64.97	1.3	12.2	-	-
T ₄ × P ₃	5.5	63.3	67.37	1.5	12.5	-	-
T ₄ × P ₄	4.9	63.8	66.70	1.3	12.2	-	-
T ₅ × P ₁	3.5	40.4	57.93	0.9	8.3	-	-
T ₅ × P ₂	3.6	43.2	59.97	1.1	9.2	-	-
T ₅ × P ₃	4.3	51.4	63.07	1.2	11.1	-	-
T ₅ × P ₄	3.6	50.2	61.33	1.2	10.1	-	-
T ₆ × P ₁	2.4	26.1	51.00	0.5	5.1	-	-
T ₆ × P ₂	2.3	25.6	54.03	0.7	5.8	-	-
T ₆ × P ₃	2.7	32.6	59.33	1.0	7.1	-	-
T ₆ × P ₄	2.5	30.1	55.80	0.9	5.9	-	-
T ₇ × P ₁	1.1	40.5	55.37	0.5	7.0	-	-
T ₇ × P ₂	1.2	43.5	56.63	0.7	7.0	-	-
T ₇ × P ₃	1.6	50.3	62.90	1.4	8.5	-	-
T ₇ × P ₄	1.4	49.6	60.23	1.0	7.1	-	-
LSD (p<0.05)	0.39	2.5	1.66	0.20	0.86	NS	NS

T= Hot water treatment-T (minutes): T₁:20.0; T₂:25.0; T₃:30.0; T₄:35.0; T₅:40.0; T₆:45.0 and T₇: Control P= Provenance: P₁: Hisar; P₂: Bhiwani; P₃: Churu and P₄: Hanumangarh

in tap water. The samples were oven dried at 60-80 degree Celsius for 72 hours and dry weight was recorded and expressed as dry weight per seedling in milligrams.

Results and Discussion

The data presented in the table 1 shows that the interactional effect between the pre germination treatment with a scarifier and provenance source had a significant effect on the speed of germination, seedling establishment, collar diameter, number of leaves/seedling and shoot dry weight. Maximum interaction (8.5) and (99.3%) were observed for speed of germination and seedling establishment in combination (T₂×P₂, T₂×P₃ and T₂×P₄) and (T₂×P₃ and T₂×P₄) respectively, however minimum were recorded in T₆×P₁ (1.1and 40.2%). A non-significant interactional effect was exhibited by the seedlings for total height. Collar diameter exhibited the maximum interaction of 2.6mm in combination of T₂×P₃ which was at par with T₂×P₄ 92.4mm and minimum was

recorded in T₆×P₁ (0.5mm). Similarly for number of leaves/seedling and shoot dry weight, a highest interaction was observed in T₂×P₃ (22.2 and 136.6g) and lowest in T₆×P₁ (6.8 and 86.4g). Root dry weight interaction between the scarification treatment and provenance source was found to be non-significant. For all the parameters, it was observed that maximum interaction was observed when churu seeds were scarified for 1.5 minutes.

Interactional effect between the hot water treatment and provenance source was found to be significant for Speed of germination, seedling establishment, total height, collar diameter and number of leaves/seedling (table 2). The maximum interactional effect was recorded in combination of T₃×P₃ (6.4, 80.3%, 73.80cm, 2.1mm and 16.1) for Speed of germination, seedling establishment, total height, collar diameter and number of leaves/seedling. This showed that when churu seeds

Table-3 : Combined effect of chemical scarification (H_2SO_4 and HCl) and provenances on establishment and growth parameters of seeds and seedlings of *P. cineraria*.

Treatment combinations	Speed of germination		Seedling establishment (%)		Total height (cm)		Collar diameter (mm)		No. of leaves/seedling		Shoot dry weight (g)		Root dry weight (g)	
(T × P)	H_2SO_4	HCl	H_2SO_4	HCl	H_2SO_4	HCl	H_2SO_4	HCl	H_2SO_4	HCl	H_2SO_4	HCl	H_2SO_4	HCl
T ₁ × P ₁	4.2	3.3	59.9	43.5	64.87	60.30	-	-	13.2	-	-	-	-	-
T ₁ × P ₂	4.2	3.1	60.4	46.5	66.33	61.20	-	-	13.7	-	-	-	-	-
T ₁ × P ₃	4.8	3.6	66.5	50.6	69.90	64.37	-	-	15.2	-	-	-	-	-
T ₁ × P ₄	4.4	3.4	63.4	46.7	68.17	62.70	-	-	14.3	-	-	-	-	-
T ₂ × P ₁	5.1	4.3	73.7	56.4	71.07	64.60	-	-	14.3	-	-	-	-	-
T ₂ × P ₂	6.1	4.7	76.1	61.1	73.33	68.00	-	-	15.3	-	-	-	-	-
T ₂ × P ₃	6.6	5.2	82.6	63.6	75.23	68.40	-	-	16.3	-	-	-	-	-
T ₂ × P ₄	6.4	5.4	80.2	63.2	74.00	67.03	-	-	15.7	-	-	-	-	-
T ₃ × P ₁	6.0	5.2	80.2	66.5	72.13	65.07	-	-	15.6	-	—	-	-	-
T ₃ × P ₂	6.4	5.2	83.2	65.7	73.00	67.40	-	-	16.2	-	-	-	-	-
T ₃ × P ₃	7.9	6.3	86.0	73.6	78.13	70.27	-	-	18.4	-	-	-	-	-
T ₃ × P ₄	6.7	6.2	83.6	74.1	75.5	67.40	-	-	17.4	-	-	-	-	-
T ₄ × P ₁	4.3	3.6	53.5	45.7	66.17	59.47	-	-	11.2	-	-	-	-	-
T ₄ × P ₂	4.5	4.3	56.1	50.1	66.83	60.63	-	-	12.1	-	-	-	-	-
T ₄ × P ₃	5.4	4.8	70.3	57.2	72.07	66.20	-	-	13.6	-	-	-	-	-
T ₄ × P ₄	5.0	4.3	60.5	53.3	69.30	63.40	-	-	12.7	-	-	—	—	-
T ₅ × P ₁	3.3	3.3	43.2	36.7	57.07	56.27	-	-	9.2	-	-	-	-	-
T ₅ × P ₂	3.2	3.1	46.7	41.0	61.33	57.57	-	-	10.3	-	-	-	-	-
T ₅ × P ₃	3.7	3.3	56.5	43.5	65.03	63.80	-	-	11.3	-	-	-	-	-
T ₅ × P ₄	3.6	4.4	50.4	42.9	62.97	60.50	-	-	10.4	-	-	-	-	-
T ₆ × P ₁	1.2	2.2	26.7	26.0	52.53	52.00	-	-	6.3	-	-	-	-	-
T ₆ × P ₂	2.2	2.2	30.0	31.0	54.17	54.80	-	-	6.5	-	-	-	-	-
T ₆ × P ₃	2.6	2.8	36.8	33.8	58.23	58.10	-	-	8.4	-	-	-	-	-
T ₆ × P ₄	2.4	2.4	33.4	31.1	56.30	56.87	-	-	6.4	-	-	-	-	-
T ₇ × P ₁	1.1	1.1	39.8	40.3	55.73	55.73	-	-	7.2	-	-	-	-	-
T ₇ × P ₂	1.2	1.2	43.1	43.5	57.20	57.50	-	-	7.3	-	-	-	-	-
T ₇ × P ₃	1.6	1.6	50.2	50.6	63.43	63.50	-	-	9.2	-	-	-	-	-
T ₇ × P ₄	1.4	1.4	46.7	46.6	60.03	60.57	-	-	7.3	-	-	-	-	-
LSD (p<0.05)	0.37	0.42	1.94	1.58	1.56	1.84	NS	NS	0.44	NS	NS	NS	NS	NS

T= Acid Scarification-T (minutes): T₁:5.0; T₂:10; T₃:15; T₄: 20; T₅: 25; T₆: 30 and T₇: Control P= Provenance: P₁: Hisar; P₂: Bhiwani; P₃: Churu and P₄: Hanumangarh

were treated with hot water for 30 minutes gave the best results. Combination T₃xP₃ for collar diameter was found to be at par with T₃xP₄ (2.0mm) and for number of leaves at par with T₃xP₄, T₂xP₃, T₃xP₄ (5.4) respectively. The minimum interactional effect for speed of germination was found with combination of T₇xP₁ (1.1), for seedling establishment T₆xP₂ (25.6%), for total height, collar diameter and number of leaves/seedling T₆xP₁ (51cm), (0.5mm) and (5.1) respectively. A non-significant interaction was observed between the hot water treatment and provenance source for shoot and root dry weight.

The data presented in the table-3 shows the combined effect of chemical treatment (H_2SO_4 , HCl) and provenance source on Speed of germination, seedling establishment, total height, collar diameter, number of leaves/seedling and biomass parameters. A significant interactional effect was recorded for Speed of germination, seedling establishment, total height, and

number of leaves/seedling. The maximum interactional effect between (H_2SO_4 & HCl) and provenance source was recorded in combination T₃xP₃ for maximum speed of germination (7.9, 6.3), for seedling establishment (86.0%, 73.6%) and for total height (78.13 and 70.27 cm) respectively. For number of leaves in H_2SO_4 treatment, interaction was significant with combination T₃xP₃ (18.4) whereas a non significant interaction was recorded when seeds were treated with HCl. This maximum interaction in combinations showed that when churu seeds treated with H_2SO_4 , HCl for 15 minutes gave the best results. However the minimum interaction for speed of germination was observed with combination of T₇P₁ (1.1, 1.1), T₆P₁ for seedling establishment (26.6 and 26.0%) and T₆P₁ for total height (52.5 and 52.0 cm) when hisar seeds were treated with H_2SO_4 , HCl respectively. The interaction was found to be non significant between the seeds treated with acid (H_2SO_4 , HCl) and provenance source for collar diameter, shoot and root dry weight.

Conclusions

In conclusion, the combined effect of pre-germination treatment and provenance source has a significant impact on the establishment, growth, and biomass parameters of *Prosopis cineraria* seedlings. Pre-germination treatments such as mechanical scarification, hot water treatment, and acid scarification play a crucial role in enhancing seed germination and seedling establishment. These treatments break the seed dormancy, improve water absorption, and promote early root and shoot growth. They can also increase the overall seedling vigor and survival rate. Furthermore, the provenance source, which refers to the geographic origin of the seeds, affects the adaptability and performance of the seedlings. Different provenances may have varying genetic traits, environmental adaptations, and growth characteristics. Therefore, the choice of provenance can influence the growth and development of *Prosopis cineraria* seedlings. The combined effect of pre-germination treatment and provenance source on the growth parameters of *Prosopis cineraria* seedlings is significant. It can influence attributes such as total height, collar diameter, number of leaves/seedling, and biomass production. Certain pre-germination treatments may enhance these growth parameters, while specific provenances may exhibit superior growth performance. Moreover, the establishment of seedlings is closely linked to their ability to withstand biotic and abiotic stresses. Pre-germination treatments and provenance source can influence the seedling's resistance to pests, diseases, and adverse environmental conditions such as drought or salinity. Therefore, the combined effect of these factors is crucial in

determining the successful establishment of *Prosopis cineraria* seedlings in different environments. In conclusion, considering the combined effect of pre-germination treatment and provenance source is essential for optimizing the establishment, growth, and biomass parameters of *Prosopis cineraria* seedlings. Further research and experimentation are needed to identify the most effective pre-germination treatments and select suitable provenances for specific planting sites, leading to improved afforestation and reforestation efforts involving *Prosopis cineraria*.

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Effect of Pruning and Growth Regulators on Growth, Fruit Yield and Quality of Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl.]

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Abstract

The research experiment was carried out at the Research Farm of the Department of Vegetable Science, CCS, Haryana Agricultural University, Hisar during rainy season of 2022-23. The present investigation consists of three pruning levels (no pruning, pruning at 1.0 m and 1.5 m length of main vine) and three levels each of plant growth regulators (GA₃ @ 25, 50, 75 ppm and Ethrel @ 75, 100, 125 ppm) were sprayed at 2-4 leaves stage, flowering and fruiting stage along with control treatment. The results indicated that application of ethrel @ 125 ppm significantly increased the growth, fruit yield and its related attributes over control treatment. The spraying of GA₃ @ 50 ppm with pruning at 1.0 m vine length recorded maximum number of primary branches per vine (8.7). However, GA₃ @ 75 ppm with pruning at 1.0 m vine length significantly reduced the node to first male flower appearance (7.7) and days taken to first male flower opening (41.3), while the minimum node to first female flower appearance (12.3), days taken to first female flower opening (50.0) and days to first fruit harvest (60.3) were observed with ethrel @ 125 ppm along with pruning at 1.0 m vine length. The spraying of ethrel @ 125 ppm with pruning at 1.5 m vine length recorded maximum total soluble solids of the fresh fruit (3.51 %), whereas the ethrel @ 125 ppm with pruning at 1.5 m vine length significantly increased the leaf area (207.53 cm²), length of the fruit (61.64 cm), girth of the fruit (20.76 cm), number of fruits per vine (20.0) and fruit yield per vine (4.19 kg/vine). It may be concluded that bottle gourd when sprayed with ethrel @ 125 ppm with pruning at 1.5 m produced the maximum fruit yield (251.40q/ha).

Key words : Bottle gourd, pruning, growth regulators, growth parameters and fruit yield.

Introduction

The bottle gourd, scientifically referred to as *Lagenaria siceraria*, is a member of the Cucurbitaceae family. It is believed to have originated from South Africa (Chakravarty, 1982). In India, it is known by various names such as calabash gourd, white flower gourd, lauki, ghia, and dudhi (Sharma *et al.*, 2012). Bottle gourd is a highly nutritious vegetable, known for its abundance of carbohydrates, Vitamin A, Vitamin C, and minerals (Hilli *et al.*, 2008). The fruit of the bottle gourd has a composition that includes 96.3% moisture, 2.9% carbohydrates, 0.2% protein, 0.1% fat, 0.5% mineral matter, and 11 mg of vitamin C per 100 g of fresh weight (Thamburaj and Singh, 2005). In India, bottle gourd is cultivated across a vast area of 1.93 lakh hectares, with an annual production reaching 31.71 lakh tonnes. Specifically in Haryana, bottle gourd cultivation occupies an area of 18.47 thousand hectares, resulting

in an annual production of 261.47 thousand tonnes (Anonymous, 2021). The immature fruits of the bottle gourd are commonly consumed as a vegetable, while medium-ripe fruits are suitable for creating sweet and jelly dishes. Additionally, the fresh fruit juice is also beneficial for people suffering from biliousness, indigestion and convalescences.

Pruning is a technique that involves the removal of specific plant parts such as leaves, branches, flowers, or fruits. In the case of bottle gourd, a popular vegetable crop, pruning provides numerous advantages. One key benefit is its ability to enhance plant growth and yield by directing the plant's energy towards increased fruit production. Additionally, pruning promotes the formation of flowers and fruits by eliminating excess vegetative growth, allowing the plant to prioritize the maturation of its fruits, thereby resulting in a higher-quality harvest. Furthermore, pruning assists in controlling the shape and size of the plant, making it particularly valuable in smaller gardens or when utilizing trellises.

The flowering stage plays a crucial role in the growth of cucurbits, as it directly influences fruiting and subsequent production. The bottle gourd plants are monoecious and they have separate male (staminate) and female (pistillate) flowers on the same plant (Desai *et al.*, 2011). Plant growth regulators are extensively utilized in crop production to control various physiological processes. These regulators play a role in regulating flowering and fruiting, promoting fruit set, inducing parthenocarp (fruit development without fertilization), and facilitating post-harvest ripening, germination, assimilate partitioning, and growth inhibition (Weaver, 1975). Application of growth regulators at the two to four

leaf stage in bottle gourd can have an impact on the sex expression of the plant. Specifically, it can enhance the development of female flowers while suppressing the formation of male flowers, thereby favouring a shift towards femaleness in the plant's sex expression (Hossain, 2004). In order to investigate the effects of pruning and plant growth regulators on the growth, fruit yield and quality of bottle gourd, this research aims to find out the best pruning level and plant growth regulator with its optimal dosage for enhancing the fruit yield of bottle gourd.

Materials and Methods

During the rainy season of 2022-23, a field experiment was carried out at the Research Farm of the Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The trial involved the application of different treatments, including three levels of pruning (no pruning, pruning at 1.0 m vine length, and pruning at 1.5 m vine length) and seven levels of growth regulators (control, GA₃ @ 25, 50, and 75 ppm, and ethrel @ 75, 100, and 125 ppm). The experimental design employed a split plot design (two-factor analysis) with four replications. GA₃, available in powder form, was dissolved with a small quantity of solvent (alcohol) after weighing the required amounts on an electronic balance. Ethrel, on the other hand, is in liquid form and was directly dissolved with water. Separate solutions of varying concentrations for each growth regulator were prepared for the study. The bottle gourd cv. Pusa Summer Prolific Long seeds were sown in the first fortnight of June, with a crop spacing of 3.0 m × 0.6 m.

The pruning treatments were implemented based on the length of the vines. The first treatment involved no pruning, the second treatment involved pruning when the vine length reached 1.0 m, and the third treatment involved pruning when the vine length reached 1.5 m. Pruning was carried out meticulously, using gentle hand techniques such as thumb and forefinger. Once the plants reached the 2-4 true leaf stage, the prepared solutions were sprayed onto the plants according to their respective treatments. This process was repeated at the flowering and fruiting stages. Throughout the experiment, all recommended cultural practices and plant protection measures for growing a healthy crop in the specific conditions of Haryana were implemented to ensure successful crop cultivation.

The observations were recorded in one growth parameter namely *i.e.*, number of primary branches per vine, five flowering parameters namely *i.e.*, node to first male flower appearance, node to first female flower appearance, days taken to first male flower opening (days), days taken to first female flower opening (days),

days to first fruit harvest (days) and seven fruiting parameters namely *i.e.*, length of the fruit (cm), girth of the fruit (cm), leaf area (cm²), number of fruits per vine, total soluble solids of fresh fruit (%), fruit yield per vine (kg) and fruit yield per hectare (q/ha). The experimental data recorded from various observation were analysed in split plot design with four replications for analysis of variance in OPSTAT (<http://14.139.232.166/opstat/default.asp>) statistical software developed by Chaudhary Charan Singh, Haryana Agricultural University, Hisar, Haryana, India (Sheoran, 2010).

Results and Discussion

Growth parameters : The pruning and growth regulators significantly influenced the growth parameters of bottle gourd. Among the various levels of pruning, it was observed that pruning at 1.0 m vine length resulted in a significantly mean maximum number of primary branches per vine (7.6) compared to both, no pruning and pruning at 1.5 m vine length, based on all the recorded observations. This phenomenon can be attributed to the effect of pruning, which leads to a redirection of auxin concentrations from the plant's tips to the lower portion. As a result, the plants experience increased physiological activity, leading to a higher number of branches in the bottle gourd. The results are in concurrence with the findings of Patel *et al.* (2017) and Zafari *et al.* (2019) who also observed a significant impact of pruning on both the vegetative and reproductive growth of bottle gourd.

The application of plant growth regulators also had a significant impact on the number of primary branches per vine. Among the various levels of growth regulators recorded, the mean number of primary branches per vine (7.9) was found to be significantly maximum when GA₃ was applied at 50 ppm. This response could be attributed to the application of gibberellic acid stimulated cell division and elongation in the apical meristems, which was responsible for the formation of new shoots and branches. As a result, there was an increased initiation and development of lateral shoots that led to greater number of primary branches per vine. The research findings are consistent with that of Rapha (2022) in bottle gourd.

Flowering parameters : The pruning and growth regulators significantly influenced the flowering parameters of bottle gourd. Among the different pruning levels, the mean minimum node to first male flower appearance (9.0), node to first female flower appearance (14.3), days taken to first male flower opening (43.3 days), days taken to first female flower opening (51.4 days) and days to first fruit harvest (62.8) was recorded with pruning at 1.0 m vine length (Table-1). This can be explained by the effect of pruning on the translocation of stored

Table-1 : Effect of pruning and growth regulators on growth, flowering and quality parameters of bottle gourd.

Treatments	Number of primary branches per vine	Node to first male flower appearance	Node to first female flower appearance	Days to first male flower opening	Days to first female flower opening	Days to first fruit harvest	Total soluble solids of fresh fruit (%)
P ₁ : No Pruning	5.7	11.3	17.0	46.4	54.0	66.0	2.99
P ₂ : Pruning at 1.0 m vine length	7.6	9.0	14.3	44.3	51.4	62.8	3.05
P ₃ : Pruning at 1.5 m vine length	7.3	9.7	14.8	45.2	52.5	64.0	3.09
Mean P	6.9	10.0	15.4	45.3	52.6	64.3	3.04
C.D. at 5 %	0.3	0.2	0.3	1.1	1.1	1.4	0.08
G ₁ : Control	5.5	10.0	15.5	45.8	52.3	64.0	2.73
G ₂ : GA ₃ @ 25 ppm	7.2	9.6	16.1	43.7	53.0	65.0	2.77
G ₃ : GA ₃ @ 50 ppm	7.9	9.2	16.7	43.1	53.5	66.2	2.81
G ₄ : GA ₃ @ 75 ppm	7.5	8.8	17.1	42.7	54.0	67.7	2.89
G ₅ : Ethrel @ 75 ppm	6.4	10.2	14.7	46.2	52.6	63.2	3.26
G ₆ : Ethrel @ 100 ppm	6.5	10.8	14.1	47.2	51.8	62.1	3.40
G ₇ : Ethrel @ 125 ppm	6.9	11.5	13.2	48.2	51.2	61.5	3.45
Mean G	6.8	10.0	15.3	45.3	52.6	64.2	3.04
C.D at 5 %	0.2	0.3	0.4	0.8	1.0	1.5	0.07
Treatment combinations							
P ₁ G ₁	4.7	11.3	17.0	47.0	54.0	66.0	2.69
P ₁ G ₂	6.0	11.0	18.0	44.7	54.3	66.7	2.73
P ₁ G ₃	6.7	10.7	18.3	44.3	54.7	67.7	2.77
P ₁ G ₄	6.3	10.3	18.7	44.0	55.0	69.0	2.79
P ₁ G ₅	5.0	11.7	16.3	47.3	53.7	64.7	3.22
P ₁ G ₆	5.3	12.0	16.0	48.0	53.3	64.3	3.32
P ₁ G ₇	5.7	12.3	14.7	49.3	52.7	63.3	3.39
P ₂ G ₁	6.0	9.0	14.3	44.7	51.0	62.0	2.73
P ₂ G ₂	8.0	8.3	14.7	42.7	51.3	63.0	2.76
P ₂ G ₃	8.7	8.0	15.7	42.0	52.0	64.7	2.85
P ₂ G ₄	8.3	7.7	16.3	41.3	53.0	66.7	2.92
P ₂ G ₅	7.3	9.0	13.7	45.3	51.7	62.0	3.25
P ₂ G ₆	7.3	9.7	13.0	46.7	50.7	60.7	3.42
P ₂ G ₇	7.7	11.0	12.3	47.3	50.0	60.3	3.45
P ₃ G ₁	5.7	9.7	15.3	45.7	52.0	64.0	2.78
P ₃ G ₂	7.7	9.3	15.7	43.7	53.3	65.3	2.82
P ₃ G ₃	8.3	8.7	16.0	43.0	53.7	66.3	2.81
P ₃ G ₄	8.0	8.3	16.3	42.7	54.0	67.3	2.97
P ₃ G ₅	7.0	10.0	14.0	46.0	52.3	63.0	3.30
P ₃ G ₆	7.0	10.7	13.3	47.0	51.3	61.3	3.47
P ₃ G ₇	7.3	11.3	12.7	48.0	51.0	61.0	3.51
C.D. at 5% Factor (G) at same level of P	0.3	0.5	NS	NS	0.7	NS	NS
C.D. at 5% Factor (P) at same level of G	0.3	0.5	NS	NS	0.8	NS	NS

NS-Non significant, G-levels of growth regulators, P-Pruning levels.

photosynthates and the narrowing of the carbon-to-nitrogen (C:N) ratio, both of which stimulate metabolic activity and promote branch development. When a plant is pruned, it redistributes its resources, including energy and nutrients, among the remaining branches and fruits. By removing excess branches or foliage, pruning helps the plant prioritize fruit development. With fewer branches to support, the plant can allocate more resources to the developing fruit potentially leading to an earlier first

harvest. The conclusions of the current research agree with those of Ciba and Syamala (2017) and Naafe *et al.* (2022) in bottle gourd. The results are consistent with those of Rajalingam *et al.* (2017) with respect to days to first fruit harvest in cucumber.

Among the different treatments of growth regulators, the effect of the ethrel is observed beneficial. It reduces the node to first female flower appearance and days taken to first female flower opening, while increasing the node to

Table-2 : Effect of pruning and growth regulators on fruit and yield parameters of bottle gourd.

Treatments	Length of the fruit (cm)	Girth of the fruit (cm)	Leaf area (cm ²)	Number of fruits per vine	Fruit yield per vine (kg/vine)	Fruit yield (q/ha)
P ₁ : No Pruning	49.79	17.67	187.35	8.7	3.63	217.45
P ₂ : Pruning at 1.0 m vine length	52.48	18.32	192.17	9.5	3.77	225.94
P ₃ : Pruning at 1.5 m vine length	54.24	19	195.78	10.3	3.94	236.23
Mean P	52.17	18.33	191.77	9.50	3.78	226.54
C.D. at 5 %	1.05	0.39	2.00	0.2	0.10	6.16
G ₁ : Control	46.52	16.48	182.04	7.8	3.50	209.81
G ₂ : GA ₃ @ 25 ppm	48.33	17.47	186.27	8.3	3.57	214.20
G ₃ : GA ₃ @ 50 ppm	50.18	17.74	188.29	8.9	3.68	220.79
G ₄ : GA ₃ @ 75 ppm	51.82	18.22	191.15	9.4	3.77	226.21
G ₅ : Ethrel @ 75 ppm	53.62	18.98	192.45	10.1	3.90	233.79
G ₆ : Ethrel @ 100 ppm	55.89	19.44	198.45	10.6	3.96	237.40
G ₇ : Ethrel @ 125 ppm	58.84	20.00	203.72	11.3	4.06	243.59
Mean G	52.17	18.33	191.77	9.5	3.78	226.54
C.D. at 5 %	1.15	0.43	3.02	0.3	0.11	5.89
Treatment combinations						
P ₁ G ₁	45.30	16.01	180.67	7.3	3.41	204.60
P ₁ G ₂	47.41	17.15	182.55	7.7	3.45	207.00
P ₁ G ₃	48.41	17.08	183.97	8.0	3.50	209.97
P ₁ G ₄	49.49	17.52	186.03	8.3	3.52	211.23
P ₁ G ₅	51.29	18.15	188.35	9.3	3.77	226.20
P ₁ G ₆	52.40	18.56	192.20	9.7	3.81	228.57
P ₁ G ₇	54.26	19.22	197.65	10.3	3.91	234.60
P ₂ G ₁	46.68	16.55	182.10	7.7	3.47	208.20
P ₂ G ₂	48.31	17.46	185.39	8.3	3.55	213.00
P ₂ G ₃	50.59	17.90	188.90	8.7	3.65	219.00
P ₂ G ₄	51.77	17.96	191.82	9.3	3.78	226.80
P ₂ G ₅	53.16	18.81	192.54	10.0	3.86	231.60
P ₂ G ₆	56.25	19.56	198.46	10.7	3.97	238.23
P ₂ G ₇	60.62	20.03	205.97	11.7	4.08	244.77
P ₃ G ₁	47.59	16.86	183.37	8.3	3.61	216.63
P ₃ G ₂	49.27	17.80	190.86	9.0	3.71	222.60
P ₃ G ₃	51.52	18.24	191.98	10.0	3.89	233.40
P ₃ G ₄	54.19	19.19	195.59	10.7	4.01	240.60
P ₃ G ₅	56.41	19.97	196.48	11.0	4.06	243.57
P ₃ G ₆	59.02	20.19	204.68	11.3	4.09	245.40
P ₃ G ₇	61.64	20.76	207.53	12.0	4.19	251.40
C.D at 5% Factor (G) at same level of P	1.94	NS	NS	0.5	NS	NS
C.D at 5% Factor (P) at same level of G	1.97	NS	NS	0.4	NS	NS

NS-Non significant, G-levels of growth regulators, P-Pruning levels

first male flower appearance and delaying the opening of male flowers in bottle gourd crop. The mean minimum days taken to first female flower opening (51.2), node to first female flower appearance (13.2) and days to first fruit harvest (61.5 days) were recorded with ethrel @ 125 ppm which also recorded the mean maximum days taken to first male flower opening (48.2) and node to first male flower appearance (11.5). However, the mean minimum days taken to first male flower opening (42.7) and node to first male flower appearance (8.8) were recorded when

the crop plants sprayed with GA₃ @ 75 ppm which also reported mean maximum days taken to first female flower opening (54.0), node to first female flower appearance (17.1) (Table 1). This effect could be attributed to the impact of ethrel on reducing the levels of endogenous gibberellins, which are responsible for accelerating the early initiation of female flowers and this difference in response can be attributed to the role of gibberellins, as they accelerate the early production of male flowers. Ethrel application can promotes female flowering and

enhance fruit set, leading to an earlier first fruit harvest. The findings of the current experiment are consistent with those of Sabu *et al.* (2022) who reported that ethrel @ 200 ppm reduced the nodes to first female flowers appeared and number of days taken to first female flower opening in bottle gourd. Similar results were obtained by Duhan *et al.* (2022) that application of ethrel @ 200 ppm recorded minimum days to female flower appearance and early days to fruit harvesting in bottle gourd.

Fruiting parameters : Pruning and growth regulators significantly influenced the fruiting parameters of bottle gourd. Among the different levels of pruning, the mean maximum leaf area (195.78 cm^2), number of fruits per vine (10.3), length of the fruit (54.24 cm), girth of the fruit (19.00 cm), total soluble solids of the fresh fruit (3.09 %), fruit yield per vine (3.94 kg/vine) and fruit yield (236.23 q/ha) was recorded with pruning at 1.5 m vine length. However, the mean minimum leaf area (187.35 cm^2), number of fruits per vine (8.7), length of the fruit (49.79 cm), girth of the fruit (17.67 cm), total soluble solids of the fresh fruit (2.99 %), fruit yield per vine (3.63 kg/vine) and fruit yield (217.45 q/ha) was recorded with no pruning (Table 2). In case of leaf area, length and girth of the fruit, it can be attributed to fact that pruning can improve light exposure to the remaining branches and leaves. Increased light availability stimulates photosynthesis, leading to more robust leaf growth as well as expansion of leaf area, elongation of the fruits and girth of fruit. Earlier such findings were reported by Alia and Mehrajc (2016) in bottle that, removal of flower buds registered significantly high leaf area. The results are in concurrence with the works of Zafari *et al.* (2019) with respect to girth of bottle gourd. In case of number of fruits per vine, the promotion of lateral branches, which in turn leads to a higher occurrence of female flowers and a narrower sex ratio. Additionally, the pruned plants exhibited enhanced photosynthetic activity, resulting in a higher assimilation of food materials. Consequently, a higher number of fruits were produced per vine. The current study's findings are consistent with those of Arora and Malik (1989), who found that ridge gourd plants pruned to six major branches with a medium spacing level (45 cm) produced more fruits. Similar observations were recorded by Asghari and Khokhar (2013), Ndereyimana *et al.* (2021) in watermelon, Chapagain *et al.* (2022) in cucumber and Rehan *et al.* (2022) in bottle gourd. In case of total soluble solids of the fresh fruit, pruning involves the selective removal of shoots and leaves, redirecting the plant's energy towards fruit production. This redirection of resources likely contributes to the accumulation of metabolites in the fruit of bottle gourd, resulting in higher total soluble solids content. The results are consistent to the findings of Chang *et al.* (2010) in melon. In case of fruit

yield per vine and fruit yield (q/ha), pruning includes improved vegetative growth, a higher number of fruits and heavier individual fruits. All of these factors combined contribute to an overall increase in the fruit yield per vine. The increase in this pattern is quite consistent with findings of Naafe *et al.* (2022) in bottle gourd. The results are in concurrence with findings of Anand *et al.* (2014) in bottle gourd and Rehan *et al.* (2022) in bottle gourd.

Among the different levels of growth regulators, the increase in ethrel concentration significantly improved the fruiting parameters. The mean maximum leaf area (203.72 cm^2), number of fruits per vine (11.3), length of the fruit (58.84 cm), girth of the fruit (20.00 cm), total soluble solids of the fresh fruit (3.45 %), fruit yield per vine (4.06 kg/vine) and fruit yield (243.59 q/ha) was recorded when the bottle gourd crop plants were sprayed with ethrel @ 125 ppm. However, the mean minimum leaf area (182.04 cm^2), number of fruits per vine (7.8), length of the fruit (46.52 cm), girth of the fruit (16.48 cm), total soluble solids of the fresh fruit (2.73 %), fruit yield per vine (3.50 kg/vine) and fruit yield (209.81 q/ha) were recorded with control (Table 2). In case of leaf area, length and girth of the fruit, it may be due to the enlargement of cells. The elongation of cells contributes to a simultaneous increase in leaf area. Ethrel also enhance photosynthetic efficiency by influencing chlorophyll synthesis and stomatal behaviour. Ethrel can facilitate the breakdown of chlorophyll, potentially leading to increased chlorophyll content in leaves. This can enhance the plant's ability to capture light energy and carry out photosynthesis, resulting in greater leaf area, length and girth in bottle gourd. The results are similar to the research findings of Soni *et al.* (2015) and Kumari *et al.* (2019) in bottle gourd. The findings are consistent with those of Ghani *et al.* (2013) who found that ethrel at 500 ppm enhanced the fruit girth of bitter gourd. Sahay *et al.* (2022) and Duhan *et al.* (2022) also discovered similar results in bottle gourd. In case of number of fruits per vine, the exogenous application of ethrel can promote the development of female flowers in bottle gourd. Ethrel can influence hormone signaling pathways, favouring the differentiation and maturation of female flower buds. This increase in the number of female flowers directly contributes to a higher potential for fruit production. The findings are consistent with those of Barot *et al.* (2022) who discovered that the application of ethrel significantly augmented the number of fruits on bottle gourd. In case of total soluble solids of the fresh fruit, ethrel to stimulate the production of enzymes involved in sugar metabolism. This stimulation can lead to an increased accumulation of sugars in the fruit, resulting in higher total soluble solids content in bottle gourd. Prakashmahala *et al.* (2014) also reported that ethrel applied at 100 ppm was most effective in

improving fruit quality parameters in bottle gourd. In case of fruit yield per vine and fruit yield (q/ha), The increase of fruit yield was definitely carried on by the use of ethrel, which enhanced the number of female flowers and fruit characters (length, diameter, weight). Similar results were obtained by Wamiq *et al.* (2020) and Rahman *et al.* (2020) in bottle gourd. The findings are consistent with those of Sabu *et al.* (2022) and Sahay *et al.* (2022) with respect to fruit yield per vine and fruit yield (q/ha) in bottle gourd.

Conclusions

From the present study, it was concluded that different levels of pruning and growth regulators had significant effect on the growth and fruit yield of bottle gourd crop. Different levels of pruning and growth regulators had significant effect on the growth, yield and seed quality of bottle gourd crop. On the basis of one year study, it can be concluded that, among all the growth regulators, when ethrel @ 125 ppm was applied at 2-4 true leaves stage gives the maximum fruit yield (243.59 q/ha) and quality parameters in bottle gourd. Among the different levels of pruning, when the vine was pruned at 1.5 m vine length, it gives the maximum fruit yield (236.23 q/ha) and quality parameters in bottle gourd under semi-arid, subtropical condition of sandy loam soil in Haryana.

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Performance of Integrated Weed Management on Growth, Productivity, Profitability and Nutrient Uptake of Irrigated Indian Mustard Crop (*Brassica juncea* L.)

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Abstract

The trial was drawn with the aiming impact on growth, yield, nutrient uptake and economics of mustard crop in gird zone by using of integrated weed management practices in Rabi season during 2021-2022 at agronomy research farm, college of agriculture, Gwalior, RVSKVV in Randomized Plot Design with ten treatments replicate thrice on sandy clay loam soil. Studied traits included plant height, number of branches/plant, number of leaves /plant, no. of siliquae/plant, no. of seeds/plant, test weight, biological yield, seed yield, Nitrogen, Phosphorus and Potassium uptake kg/ha by mustard crop, Net income and B:C. It could be concluded that from one year experimental result the application of Pendimethalin 30 EC, 750 g a.i./ha PE + HW at 45 DAS was registered highest growth characteristics, yield contributing characteristics, yield of seed (2027 kg/ha) and stover (5502 kg/ha), nutrient (N,P&K 46.55,11.23 &12.15 kg/ha) uptake of crop and Net return (81935 Rs/ha) and B:C.(3.7). The treatment of Pendimethalin 30 EC, 750 g a.i./ha PE + HW at 45 DAS increased seed yield of mustard 119% and 11% to weedy check and Two hand weeding at 30 and 60 DAS, Respectively.

Key words : Mustard, weed management, growth , yield, nutrient uptake and economics.

Introduction

Indian mustard (*Brassica juncea* L.) is an important winter (*Rabi*) season oil seed crop. Rapeseed and mustard is the third important oilseed crop grown in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis* Jacq.) for edible oil. In India, it is the second most important edible oilseed after groundnut sharing 27.8% in the India's oilseed economy (Shekhawat *et al.* 2012). In India, rapeseed and mustard grown in 7.10 m/ha with production of 7.98 mtonnes average productivity of 1281 kg/ha (Anonymous 2019). In Madhya Pradesh, Rapeseed and mustard grown in 0.77 mha with production of 1.05mtonnes with average productivity of 1305 kg /ha (Anonymous 2019). Technological advancement in Rapeseed and mustard production has resulted in increased productivity. But many biotic stresses such as weeds cause severe yield losses up to 45% in Rapeseed and mustard (Singh *et al.* 2013). Weed competition in Indian mustard is more serious during early stage; because crop growth during winter (*Rabi*) season remains slow during the first 4-6 weeks after sowing (Chauhan *et al.* 2005). The critical period of crop - weed competition is early growth stages especially between 15–40 days after sowing (Shekhawat *et al.* 2012 and Singh *et al.* 2013). Therefore, to improve the yield of mustard, timely and proper control of weeds is indispensable. Weeds are one of the major constraints for the poor yield of mustard crop

as they compete with the crop plants for moisture, nutrients, light and space. Approximately, 20-30 % yield reduction caused by the weeds in rapeseed and mustard crop. Among the various methods of weeds control, the traditional methods of weed control like hand-weeding, hoeing, and intercultural operations have many limitations. These are very often back breaking, costly, time consuming and needs so much of human labour/resource.

Thus, use of herbicide may be the best option to control the complex weed flora in mustard. Hence, pre and post emergence herbicides application or herbicide along with hand weeding may be the best alternative for controlling the diverse weed flora in mustard crop. Keeping above in mind, the present experiment was planned to evaluate effect of herbicide integration alone or with hand weeding on growth, yield and nutrient uptake of existing region of mustard.

Materials and Methods

This field experiment was conducted at Agronomy Research Farm, College of Agriculture, RVSKVV, Gwalior during the *rabi* season of 2021-22. The region of the experimental site falls under the central zone of India and soil of the experimental field was sandy clay loam in texture, slightly alkaline (pH 7.4) in reaction, low in organic carbon (0.46 %), nitrogen (180 kg ha⁻¹) and medium in available phosphorus (12.5 kg ha⁻¹) but high in potassium

(200 kg ha⁻¹). The soil moisture content at field capacity was 21%, having bulk density and infiltration rate 1.4mgm⁻³ and 2.2 mm/hr, respectively. The experiment consisted of 10 treatments viz. Pendimethalin PE 750 g/ha alone; and with one hand weeding at 45 DAS ; with followed by Quizalofop ethyle POE 50g/ha; with followed by Clodinafop-p-ethyle POE 60g/ha, Oxyfluorfen PE 230g alone and with one hand weeding at 45 DAS, Quizalofop ethyle POE 50g/ha, Clodinafop-p-ethyle POE 60g/ha, Two hand weeding at 30 and 60 DAS and Weedy check which were laid out in Randomized Block Design (RBD) and replicated thrice. Mustard variety RVM-2 was sown on 15th November, 2021, using of seed 5 kg/ha at row and plant spacing of 40 cm x 10 cm apart. Two irrigations were given to mustard crop during the whole growing period. Recommended dose of nitrogen, phosphorous and potassium i.e., 80, 40 and 20kg ha⁻¹ were applied through urea, SSP and MOP respectively. The recommended agronomic practices and plant protection measure of mustard crop were followed. The herbicide were applied using knapsack sprayer fitted with flat fan nozzle with spray volume of 500 l/ha. The post emergence herbicides were applied at 2 to 3 leaf stage and weeding was done manually with help of hand tool 'khurpi', as required in treatment. The standard statistical procedure was adopted to analyse the recorded data as per procedure was advocated by Gomez and Gomez (1984). Five plants were selected randomly from each plot, tagged permanently and each tagged plant was measured at harvest stage and used for measurement of plant height (Height of from the base of the plant to the top of the main shoot by metre scale), number of branches per plant, number of leaves /plant and number of siliqua/plant and their average of five was computed as mean plant height, number of branches per plant, number of leaves /plant and number of siliquae/plant. From the individual plot, the crop of net plot area was harvested and dried. After air drying, the produce was threshed and seeds were cleaned. The final seed yield and stover yield was recorded in kg per plot and converted into kg/ha. Nitrogen content in crop was estimated by Modified Microjeldahl's Method, Phosphorus was determined by Vandomolybdo-phosphate yellow colour method and Potash was extracted by diacid digestion and then determined by Flame photometer method as outlined by Jackson (1967) and were expressed in percentage and dry weight were used to calculate the total uptake of nitrogen, phosphorus and potash by crop and expressed in kg/ha. Monetary returns for different treatments were calculated with the help of prevailing market rates of produce and different inputs used in the experiments.

Net monetary returns (Rs/ha) = Gross return (Rs/ha) – Cultivation cost (Rs/ha)

Benefit cost ratio = Gross return (Rs/ha) / Cost of cultivation (Rs/ha)

Results and Discussion

Effect on Growth : It is evident from the result that there was significant difference found between treatments of plant height, number of branches and number of leaves at harvest stage and all treatments was found significantly superior to weedy check. The application of Pendimethalin 30 EC, 750 ga.i./ha PE + HW at 45DAS was found the best treatment among all the treatments and it gave the maximum plant height, number of branches and number of leaves at harvest followed by two hand weeding at 30 and 60 DAS. Better plant height, branches and leaves recorded by different weed management practices may be due to less competition for moisture, nutrients, light and space caused by presence of weeds which ultimately resulted in higher number of branches and leaves per plant than that of weedy check. Findings are in agreement with those of Sharma *et al.* (2005), Tekale *et al.* (2005), Rathod *et al.* (2017), Singh (2017), Gupta *et al.* (2018), Nayak *et al.* (2020) and Singh and Kumar (2020).

Effect on yield attributing : On the basis of one year research data, the different treatment and its combinations of weed management practices significantly influenced the yield parameters in mustard plant. The maximum yield parameters (viz., number of siliqua per plant, number of seeds, test weight, seed yield per plant,) were recorded in treatment T₃ (Pendimethalin 30 EC, 750 g a.i./ha PE + HW at 45DAS) and it was found the best treatment among all the treatments followed by two hand weeding at 30 and 60 DAS. These results indicated that increase in yield attributes was more in these treatments which had low population and dry matter of weeds during early stages of the crop growth and remained consistently low throughout the crop growth period. Less inter plant competition in above treatments might be due to less crop-weed competition and more favourable environmental condition which enabled the crop plant to make maximum use of inputs for crop growth and thereby development of yield attributes which was reflected as bolder seeds as compared to other treatments. It may therefore, be expected that low weed competition during the early crop growth period produced beneficial effect on the number of siliqua per plant as well as seeds per siliqua and other yield attributes. These results are supported by the findings of Chouhan *et al.* (2005), Sharma *et al.* (2005), Singh *et al.* (2016), Yadav *et al.* (2017), Gupta *et al.* (2018), Nayak *et al.* (2020) and Singh *et al.* (2020).

Effect on yield of mustard : As the mean analysis of

Table-1 : Impact of integrated weed management practices on growth, yield contributing characters of mustard.

Treatment detail	Plant height (cm)	Number of branches per plant	Number of leaves/plant	Number of siliquae per plant	Number of seeds per siliqua	Test weight (g)	Seed yield per plant (g)
Pendimethalin 30 EC, 750 ga.i./ha PE	195.57	19.53	13.11	230.81	13.77	4.38	13.92
Oxyflurofen 23.5 EC 230 ga.i./ha PE	188.72	18.25	12.56	209.77	13.43	4.24	11.91
Pendimethalin 30 EC, 750 ga.i./ha PE + HW (45 DAS)	207.52	22.39	15.37	273.34	15.76	4.70	20.27
Oxyflurofen 23.5 EC 230 ga.i./ha PE + HW (45 DAS)	190.30	19.35	12.76	234.76	13.95	4.31	14.08
Quizalofop ethyl 5 EC 50 ga.i./ha POE at 2 to 3 leaf stage	187.51	17.70	12.30	206.68	13.15	4.23	11.50
Clodinafop-p-ethyl 15 WP 60g a.i./ha POE at 2 to 3 leaf stage	185.15	17.15	11.85	202.79	13.00	4.20	11.07
Pendimethalin 30 EC, 750 ga.i./ha PEfb Quizalofop ethyl 5 EC 50 ga.i./ha POE at 2 to 3 leaf stage	198.36	20.51	13.76	250.82	14.18	4.55	16.17
Pendimethalin 30 EC, 750 ga.i./ha PEfb Clodinafop-p-ethyl 15 WP 60g a.i./ha POE at 2 to 3 leaf stage	199.19	20.03	13.44	242.05	13.99	4.44	15.08
Two hand weeding at 30 and 60 DAS	205.66	21.46	14.82	260.59	14.95	4.64	18.10
Weedy check	178.44	15.40	11.03	186.78	12.14	4.08	9.25
SEm $\pm$	5.018	0.722	0.288	8.512	0.596	0.047	0.895
CD 5%	14.910	2.146	0.857	25.291	1.770	0.139	2.658

Table-2 : Impact of integrated weed management practices on yield, nutrient uptake and economics of mustard.

Treatment detail	Seed yield (kg/ha)	Stover yield (kg/ha)	Nitrogen uptake (kg/ha)	Phosphorus uptake (kg/ha)	Potassium uptake (kg/ha)	Net returns (Rs/ha)	B : C
Pendimethalin 30 EC, 750 ga.i./ha PE	1392.01	4837.45	30.04	6.78	7.20	53731	3.0
Oxyflurofen 23.5 EC 230 ga.i./ha PE	1190.81	4513.56	25.43	5.49	5.59	42511	2.5
Pendimethalin 30 EC, 750 ga.i./ha PE + HW (45DAS)	2026.65	5501.69	46.55	11.23	12.15	81935	3.7
Oxyflurofen 23.5 EC 230 ga.i./ha PE + HW (45DAS)	1407.61	4622.13	31.50	6.90	7.05	49014	2.5
Quizalofop ethyl 5 EC 50 ga.i./ha POE at 2 to 3 leaf stage	1149.70	4469.92	24.64	5.30	5.13	40860	2.5
Clodinafop-p-ethyl 15 WP 60g a.i./ha POE at 2 to 3 leaf stage	1107.43	4213.27	23.30	5.01	4.39	39292	2.5
Pendimethalin 30 EC, 750 ga.i./ha PEfb Quizalofop ethyl 5 EC 50 ga.i./ha POE at 2 to 3 leaf stage	1616.96	5016.60	34.27	8.20	8.79	62893	3.2
Pendimethalin 30 EC, 750 ga.i./ha PEfb Clodinafop-p-ethyl 15 WP 60g a.i./ha POE at 2 to 3 leaf stage	1508.24	4968.78	32.50	7.28	7.88	58315	3.1
Two hand weeding at 30 and 60 DAS	1810.37	5233.45	40.06	9.47	10.12	66869	2.9
Weedy check	924.87	4001.39	19.80	4.23	3.64	31246	2.2
SEm $\pm$	89.455	41.641	2.940	0.705	0.895	-	-
CD 5%	265.794	123.727	8.735	2.095	2.659	-	-

variance, the all treatment significantly influenced by weed management practices in respect to seed yield (kg/ha) and biological yield of mustard plant. The maximum seed yield (2027kg) and stover yield (5502 kg) were found in treatment Pendimethalin 30 EC, 750 ga.i./ha PE + HW at 45DAS and it was found the best treatment among all the treatments, while it was at par to treatment Two hand weeding at 30 and 60 DAS. However, the minimum seed yield (924.87 kg) was observed in treatment Weedy check. increase in yield attributing characters the overall yield was increased. These results are supported by the findings of Chouhan *et al.* (2005), Sharma *et al.* (2005), Singh *et al.* (2016), Yadav *et al.* (2017), Gupta *et al.* (2018), Nayak *et al.* (2020) and Singh *et al.* (2020).

Effect on nutrient uptake by crop : Among the different weed management practices the maximum nutrient

uptake (46.55 kg N, 11.23 kg P₂O₅ and 12.15 kg K₂O) by crop was registered in treatment Pendimethalin 30 EC, 750 g a.i./ha PE + HW at 45 DAS and it was found significantly superior treatment as compared to all other weed control treatments, whereas the minimum nutrient uptake (19.80 kg N, 4.23 kg P₂O₅ and 3.64 kg K₂O) by crop at harvest was recorded in treatment Weedy check. It might be due to less competition between crop plants and weeds and congenial environment as compared to others. The results are in confirmation with the results achieved by Chouhan *et al.* (2005), Singh (2017), Yadav *et al.* (2017), Jangir *et al.* (2018) and Nayak *et al.* (2020).

Economics of the treatments : On the basis of one year data the maximum net returns (Rs 81935 /ha) and B:C ratio (3.7) was observed in treatment Pendimethalin 30 EC, 750 ga.i./ha PE + HW at 45 DAS. Because that this treatment obtained maximum yield. However the

minimum net returns (Rs 31246 /ha) and B:C ratio (2.2) was recorded in treatment Weedy check. All the herbicides realized more net return and benefit: cost ratio as compared to weedy check. Similar results for most of the characters were also reported by Bazaya *et al.* (2004), Kumar *et al.* (2012), Singh *et al.* (2016), Singh (2017), Rathod *et al.* (2017), Gupta *et al.* (2018), Singh and Kumar (2020) and Singh *et al.* (2020).

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Forecasting of Water Table Fluctuation Using Artificial Neural Network and Sensitivity Analysis of Algorithm for Priyadarshani Watershed

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Abstract

Groundwater is a vital resource that supports various human activities, including agriculture, industry, and domestic use. It also plays a crucial role in maintaining healthy ecosystems and preserving biodiversity. ANNs are able to learn complex non-linear relationships between input and output variables from data, without requiring explicit knowledge of physical parameters or equations. To develop an artificial neural network (ANN) model, data sets are required for training, validation, and testing the ANN networks. In this study, various data sets such as observed rainfall data, infiltration data, water level, permeability data, temperature data, and solar data have been used to train and validate the ANN model. To optimize the ANN model, the Levenberg-Marquardt (LM) algorithm and the Neuro Solutions software were used. LM is widely used for groundwater fluctuations for short period of time. The observed data for LM showed maximum R value 0.9717 for well 2 (2-9-1) with rainfall and permeability as input parameters and minimum R value 0.717 for well 1 (2-9-1) with rainfall and permeability as input parameters and the average R value from all the well predicted from Levenberg- Marquardt is 0.834. Considering sensitivity analysis for all the nine wells of LM the correlation of predicted data and observed data had good correlation by using Levenberg-Marquardt algorithm.

Key words : Artificial neural network, groundwater, levenberg-marquardt, fluctuations.

Introduction

Groundwater is an essential natural resource that sustains life on earth. Interestingly, over 98% of the planets freshwater are located below its surface [1]. The majority (68%) of the nation's yearly ground water supply is made up of precipitation. The remaining 32% is derived from various sources, including as canal seepage, irrigation return flow, recharge from tanks, ponds, and water-saving devices. According to Suhag,[2], the annual national water availability per person fell from 1,816 cubic metres in 2001 to 1,544 cubic metres in 2011. According to the natural runoff (flow) in rivers, the country has an annual water availability or resource potential of 1,869 BCM. However, it has been calculated that the nation's available water resources are 1,123 BCM annually. Due to topographic limitations and an unequal distribution of the resource across different river basins, it is challenging to harvest the whole 1,869 BCM per year that is available.

Artificial neural networks (ANN) have been increasingly used as a powerful tool for modelling and predicting complex hydrological processes, including groundwater levels [3]. ANNs are able to learn complex non-linear relationships between input and output variables from data, without requiring explicit knowledge of physical parameters or equations. By training an ANN model on historical data of groundwater levels and associated meteorological, hydrological, and

anthropogenic variables, it is possible to predict future groundwater levels under different scenarios of these variables. ANNs can also be used to identify the most important variables affecting groundwater levels and to assess the sensitivity of the groundwater system to changes in these variables. Sensitivity analysis is a method for extracting cause and effect relationship between inputs and outputs of network [4]. In ANN modelling effects of each network inputs on the network output should be observed. This shows which input channels are the most significant, which helps to decide to the insignificant parameters and removing them, will reduce size of the datasets and network. This reduces complexity and training time.

Groundwater is one of the major sources of supply for domestic, industrial and agricultural purposes. To gain insight in the processes including the groundwater system, one needs knowledge about the essential variables and how they fluctuate over time. Forecasting the ground water level fluctuations is an important requirement for planning conjunctive use in any basin.

Materials and Method

Study Area : The research work has been conducted at the Priyadarshini watershed, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist.- Ratnagiri (M.S.). The Priyadarshini Watershed is located at 17.1° N latitude,

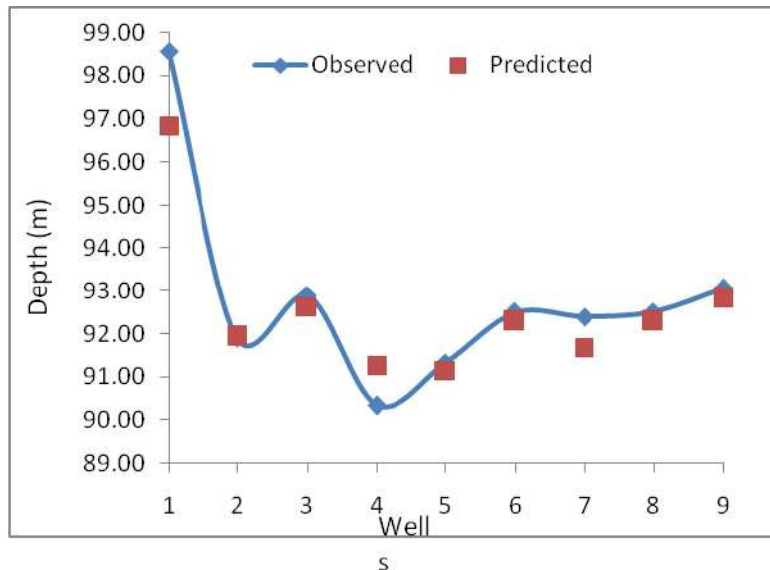


Fig.-1 : Observed and predicted average weekly water table depth of average value of LM.

73.26° E longitudes and 250 m above mean sea level. The region comes under heavy rainfall with average annual rainfall of 3500 mm. Priyadarshini watershed has 38.72 ha area. The ambient temperature of the region varies from 7.5 °C to 38.5 °C and relative humidity varies from 55 percent to 99 percent in different seasons. The climate of the region is hot and humid. The region has hilly topography with lateritic soils.

Data Description : The weekly data of 9 years (2005-2014) were collected for Rainfall, Temperature, Solar, from Department of Agronomy, COA, Dapoli and Well depth and Permeability data of Priyadarshini Watershed were collected from department of Soil and Water Conservation Engineering, CAET, Dapoli. Neuro Solutions is a software platform which is used in this study provides a user-friendly interface for building, training, and testing artificial neural networks. It allows users to select from a variety of neural network architectures and training algorithms, as well as to customize the input and output variables, the number of hidden layers and neurons, and other parameters. They can handle a large amount of data fast and efficiently.

ANN Architecture : The architecture of an artificial neural network typically consists of three layers: an input layer, a hidden layer (or multiple hidden layers), and an output layer. The input layer receives the input data, which is then processed by the hidden layer(s) and finally produces the output at the output layer. In feed-forward networks, data flow through network in one direction from input layer to output layer through hidden layer(s). In this study, four input parameters have been used as input, rainfall data, permeability data, solar data, temperature and one output parameter as well depth.

Input Nodes – The architecture of an artificial neural network typically consists of three layers: an input layer, a hidden layer (or multiple hidden layers), and an output layer. The input layer receives the input data, which is then processed by the hidden layer(s) and finally produces the output at the output layer. The input layer typically does not perform any computations on the input data, but simply passes it on to the next layer, which is usually a hidden layer [5].

Hidden Nodes-hidden layer receives the signals from all of the neurons in a layer above it, where most of the computation takes place, as the neurons in this layer apply weights to the input data and pass the results on to the next layer [5]. To calculate number of hidden layers to be used we use $(2n+1)$. Where n = no. of nodes.

Output Nodes – The output neurons may provide the outputs in the form of estimated values, classifications, or predictions, depending on the specific application Output nodes are collectively referred to as “Output Layer” and are responsible for computations and transferring information from the network to outside world [5].

Building of Neural Networks : To develop an artificial neural network (ANN) model, data sets are required for training, validation, and testing the ANN networks. In this study, various data sets such as observed rainfall data, infiltration data, water level, permeability data, temperature data, and solar data have been used to train and validate the ANN model. To optimize the ANN model, the Levenberg-Marquardt (LM) algorithm and the Neuro Solutions software were used. During the training stage, the number of nodes in the hidden layer will be increased step-by-step to accurately define the output. The software will also normalize the given data to ensure that the

Table-1 : Statistics of LM algorithms for developed ANN models.

Well no.	Model steps	R	RMSE	E	MAE
1	Training	0.684	0.146	-66.98	0.011
	Validation	0.369	0.303	-506.05	0.060
	Testing	0.905	0.058	0.896	0.011
2	Training	0.908	0.050	-5.660	0.004
	Validation	0.903	0.123	-45.007	0.024
	Testing	0.943	0.067	-24.252	0.012
3	Training	0.855	0.071	-7.542	0.006
	Validation	0.901	0.117	-1.598	0.023
	Testing	0.901	0.101	-4.390	0.019
4	Training	0.764	0.0991	-0.332	0.009
	Validation	0.868	0.263	-37.447	0.052
	Testing	0.893	0.133	0.361	0.025
5	Training	0.829	0.099	-14.548	0.009
	Validation	0.805	0.177	-7.663	0.0355
	Testing	0.865	0.118	-571.59	0.022
6	Training	0.854	0.080	-60.563	0.007
	Validation	0.889	0.108	0.194	0.216
	Testing	0.944	0.107	-3.157	0.020
7	Training	0.715	0.149	-51.661	0.013
	Validation	0.638	0.202	-45.523	0.040
	Testing	0.880	0.220	-8.186	0.042
8	Training	0.884	0.067	-166.52	0.006
	Validation	0.870	0.132	-21.706	0.026
	Testing	0.949	0.087	-0.368	0.016
9	Training	0.738	0.086	-61.015	0.007
	Validation	0.159	0.141	-1.176	0.028
	Testing	0.773	0.090	-3.211	0.017

network is able to learn effectively. In the ANN model, the neurons in the input layer have no transfer function, while the logistic sigmoid (logsig) transfer function will be used in the hidden and output layers. After successful training, the network will be tested with the test data, and statistical methods will be used to make comparisons between the predicted outputs and the actual outputs. Overall, the process of developing an ANN model involves several key steps, including data collection and preparation, network architecture design, training and validation using optimization algorithms, and testing and evaluation of the network's performance. Through careful planning and execution of these steps, it is possible to develop an effective and reliable ANN model that can be used for a wide range of applications.

Training with algorithm : The process of determining the best values of all the weights in an artificial neural network (ANN) is called training. In supervised learning mode, the actual output of the neural network is compared to the predicted output, and the weights are adjusted to minimize the variation between the predicted and actual output. During training, input and output data are presented to the network, and the network is allowed to run for a certain number of epochs. These data are known as training data.

For each input provided to the network, the corresponding predicted output is given, and the network is trained for a fixed number of epochs, typically ranging from a few hundred to several thousand. Training is considered complete when the artificial neural network reaches a desired performance level, usually in terms of statistical accuracy. At this level, the network can produce the required outputs for a given sequence of inputs, and the resulting weights are typically fixed for the application. Once the network has been trained, it is important to test it on a new set of data to ensure that it has learned the basic patterns involved in the application and has not simply memorized the training data. If the network performs poorly on the test set, then the training period should continue. Testing is an important step in evaluating the performance of an artificial neural network, as it allows us to assess how well the network generalizes to new data. By comparing the predicted outputs to the actual outputs, we can determine whether the network has learned to recognize the underlying patterns in the data or is simply memorizing the training set.

Levenberg-Marquardt (LM) : Levenberg-Marquardt (LM) is an optimization algorithm commonly used in the training of artificial neural networks (ANNs). It is a modification of

Table-2 : Sensitivity Analysis.

Wells	Parameter used	ANN Structure	R	RMSE	E	MAE
1	Rainfall and Permeability	2-9-1	0.717	0.2357	-3203	0.0102
2	Rainfall and Permeability	2-9-1	0.917	0.0465	-1.986	0.0035
3	Permeability	1-8-1	0.861	0.0692	-19.577	0.0052
4	Permeability	1-6-1	0.800	0.1197	-123.707	0.0091
5	Permeability and Solar	2-9-1	0.842	0.0828	1.306	0.0063
6	Permeability	1-9-1	0.886	0.0693	-26.470	0.0053
7	Permeability, Temperature and Solar	3-5-1	0.792	0.1329	-15.630	0.0101
8	Rainfall and Permeability	2-9-1	0.901	0.0665	0.921	0.0050
9	Rainfall and Permeability	2-9-1	0.810	0.0842	0.529	0.0064

Table-3 : Ranks for given Structures.

Wells	ANN Structure	R	MAE	Rank
1	2-9-1	0.717	0.0102	9
2	2-9-1	0.917	0.0035	1
3	1-8-1	0.861	0.0052	3
4	1-6-1	0.800	0.0091	7
5	2-9-1	0.842	0.0063	5
6	1-9-1	0.886	0.0053	4
7	3-5-1	0.792	0.0101	8
8	2-9-1	0.901	0.0050	2
9	2-9-1	0.810	0.0064	6

the Gauss-Newton algorithm, which is used to minimize the sum of squared errors between the predicted output of an ANN and the actual output. The LM algorithm combines the best features of both the Gauss-Newton and gradient descent algorithms. It adjusts the learning rate based on the curvature of the error surface, allowing it to converge faster than gradient descent and avoiding the slow convergence and oscillation problems associated with Gauss-Newton. The LM algorithm works by adjusting the weights of the neural network in small steps, guided by the gradient of the error function. It also includes a damping factor, which slows down the learning rate when necessary to prevent overshooting the minimum of the error surface. Overall, the LM algorithm is a popular choice for training ANNs because it is efficient, fast, and effective at minimizing the error between predicted and actual output.

Sensitivity analysis : Sensitivity analysis is a method for extracting cause and effect relationship between inputs and outputs of network [4], determine the relative importance of input variables in predicting the output of the network. This information can be useful in several ways, such as reducing the dimensionality of the input space, removing irrelevant or redundant features, and improving the overall accuracy and efficiency of the model. Identifying the critical regions of the input space where the network output is most sensitive to changes in the input values. This information can be used to improve the design and optimization of the input parameters in real-world applications. This method is the classical

stepwise method that consists of adding or rejecting step by step one input variable and noting the effect on the output result. Based on the changes in MAE, the input variables can be ranked according to their importance in several different ways depending on different arguments [6].

Results and Discussion

Statistical Analysis : Nash-Sutcliffe coefficient (E) (Nash and Sutcliffe, 1970), root mean square error (RMSE), mean absolute error (MAE), and Pearson coefficient (R) were used to assess the models response to that of observed value for different algorithms for developed ANN models during training, validation and testing period. It is observed that the maximum LM value of R for training and validation are 0.908 and 0.903 shown in well 2 (2-9-1) and testing is 0.949 shown in well 8 (2-9-1), whereas minimum value for training is 0.684 shown in well 1 (4-4-1) for validation and testing are 0.159 and 0.773 well 9 (3-5-1) (Table-1).

It is observed that the Pearson coefficient (R) indicates the strength and direction of linear relationship between two variable the correlation is +1 in case of perfect increasing linear relationship and -1 in case of decreasing linear relationship a correlation coefficient of 0 means there is no linear relationship between the variables minimum value is (0.159) during validation period of well 9 (2-9-1) for the LM algorithm and was maximum value is (0.949) during testing period of well 8 (2-9-1) for the LM algorithms (Table-1).

The variation of root mean square error (RMSE) statistics, a measure of residual variance which illustrates the results between the computed and observed water table depths, was minimum (0.050) during training period of well 2 (2-9-1) for LM algorithm and was maximum (0.303) during validation period of well 1 (2-9-1) for the LM algorithm (Table-1).

The mean absolute error (MAE) was found to be minimum (0.005) during validation period was maximum (0.216) of well 6 (4-4-1) (Table-1).

The coefficient of efficiency (E) was found to be varying from -506.05 (during validation period of well 1(2-9-1) for LM algorithm) to 0.896 (during testing period of well 1 (2-9-1) for LM algorithm (Table-1). It was observed that the predicted water table depths followed the observed water table pattern.

Similar studies suggested that feed forward network trained with training algorithm Levenberg-Marquardt showed best performance in predicting the ground water levels with data of relatively shorter period [7, 8]. Similarly, Al-Aboodi [9] reported that LM is best ANN algorithm for predicting ground water flow.

Sensitivity Analysis : In order to ensure the accurate output from the model, the sensitivity analysis was carried out. Stepwise method was introduced by Gevrey [6] that consists of adding or rejecting step by step one input variable and noting the effect on the output result. The effect of the output results is been taken based on R value which ranges between 0 to 1 where increasing R value can identify the best structure.

Table 2 to 3 shows the sensitivity analysis for all the nine wells for LM with selected network architectures. The observed data for LM showed maximum R value 0.9717 for well 2 (2-9-1) with rainfall and permeability as input parameters and minimum R value 0.717 for well 1(2-9-1) with rainfall and permeability as input parameters and the average R value from all the well predicted from Levenberg- Marquardt is 0.834. There are several prior studies that have broadly reviewed and classified the sensitivity analysis methods that exist [10, 11].

The observed maximum value of RMSE for LM is 0.235 shown in well 1 (2-9-1) with input parameters as rainfall and permeability and minimum value is 0.046 well 2 (2- 9-1) with input parameters as rainfall and permeability. Similarly, for E and MAE the maximum value is 0.921 shown for well 8 (2-9-1) with input parameters rainfall and permeability and 0.018 shown for well 1(2-9-1) with input parameters rainfall and permeability, respectively. Minimum value for E and MAE is -3203 shown in well 1 (2-9-1) with input parameters as rainfall and permeability and 0.003 shown in well 2 (2-9-1) with

input parameters as rainfall and permeability, respectively.

Considering sensitivity analysis for all the nine wells of LM the correlation of predicted data to the water depth of observed well 1 have moderately correlation to observed data with r greater than 0.717 but lesser than 0.8 [12] and for well 7, R is 0.792 which is also moderately correlated, shown in Fig 7 All other well have strongly correlated with observed value with maximum value for well 2, R is 0.917 for Levenberg-Marquardt algorithm. Shown in Fig-1.

The predicted water level trend followed the observed trend closely, showing the accuracy of the network. In present study, results were found and based on sensitivity analysis models selected and their statistical parameters for all the nine wells. It was observed that selected algorithms predicted the water table depths in a better way in terms of its statistical performance.

Conclusions

In this research, the ability of the ANNs model with various networks to simulate water levels fluctuations was analyzed. ANNs computing is considered as a successful technique to apply for monthly groundwater level simulation from the available groundwater data. The sensitivity analysis in the study was useful for confirming and even slightly refining the conceptual framework of the system, as well as providing insights for improving ANN prediction performance. Sensitivity analysis showed that permeability parameter affects the output most. Three wells have permeability as only one input, which gives better results. This study provides better insights of groundwater fluctuations and forecasting allows valuable contribution to groundwater management and decision-makers can better allocate water resources and make informed decisions about groundwater use, sustain groundwater for future use while using for irrigation and other priority based production relative to groundwater available.

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An Economic Analysis of Paddy Residue and it's Utilization in Raipur District of Chhattisgarh

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Abstract

Paddy residue is produced as a by-product of rice. It uses are not confined to only one purposes as it can be used for soil mulching, bio-gas generation, mushroom cultivation, and as source of domestic and industrial fuel etc. The present study pertained to the year 2021-2022. Primary data were collected from the farmers through pre tested questionnaire. The overall ratio of paddy grain to straw was 1:1.20. The overall input- output ratio obtained was 2.12 and Cost-Benefit ratio was 1.12. The Net return obtained overall was Rs 63771.88 per hectare. Cost of cultivation of straw was maximum for large farmers which was Rs. 4888.02 followed by medium, small and marginal farmers was Rs. 4544.95, Rs. 4038.03 and Rs. 3646.36 per hectare and on an average the overall cost of cultivation of grain and straw were Rs. 52924.75 and Rs. 4062.04 per hectare. Net return was higher in case of large farmers followed by medium, small and marginal farmers. Increased livestock population it will help not only paddy residue management but also it provides organic manure in addition to regular employment as well income to farmers for sustainable livelihood.

Key words : *Paddy, residue, benefit cost, profit, production, utilization.*

Introduction

Paddy residues can be used as animal feed, soil mulching, bio-gas generation, bio manure/compost, mushroom cultivation, ethanol production, and as source of domestic and industrial fuel etc. The residues of paddy and wheat are typically burnt on-farm across different states of the country. Burning of crop residues is economic loss in addition to cause's environmental pollution, is hazardous to human health, produces greenhouse gases causing global warming and results in loss of plant nutrients like N, P, K and S. Therefore, appropriate management of crop residues assumes a great significance. In Chhattisgarh donating the crop residues in thousands of Gauthans (cattle shed premises for conservation and augmenting livestock) where its used as fodder and in the process, the burning of stubble are checked from burning in the field across the state. Thus crop residues are of tremendous value to the farmers. However, a large portion of paddy the residues is burnt on-farm primarily to clear the field for sowing/planting of the succeeding paddy crop. The present study is an attempt to examine the cost of cultivation of paddy residue in Raipur district, Chhattisgarh.

Materials and Methods

Selection of Study area : Chhattisgarh state consist 33 districts, out of which Raipur district is selected purposively. Raipur district has four blocks namely Arang ,Tilda, Dharsiwa and Abhanpur Out of thes Arang block

have been selected because it covered the highest area of rice and geographical area under rice crop as compared to other blocks of Raipur district.

Arang block has 166 numbers of villages, Out of which 4 percent (6 villages) were selected purposively namely Chhatauna, Chhatud, Goindha, Godhi, Lingadi and Akolikala for study purpose as the villages were near to headquarter and respondent were ready to share information.

Out of 1605 farm families in selected villages a sample of 5 percent respondents will be selected by using probability proportional to size techniques subject to condition that at least 10 per cent of respondent should be included in sample from each categories of farms. Thus, 80 paddy growers in these four selected villages were selected to collect the required information on cost of cultivation, resedue utilization and other aspects of these crops. These 80 farmers are classified in to different categories based on their land holding. The growers were classified as Marginal (0-1.0 ha.), Small (1.0-2.0 ha.), Medium (2.0-4.0 ha.) and, Large farmers (above 4 ha.) categories. Finally, 35, 19, 16 and 10 paddy growers are considered as marginal, small, medium and large farmers respectively. The distributions of different categories of farmers in the selected six villages.

Collection of Data : The study will be based on both primary as well as secondary data of crop year 2020-21. Primary data will be collected by using separate specifically designed and pretested questionnaires and

having direct contact to the farmers. Secondary data will be collected from the office of district Deputy Director of Agriculture, Static book and Commission of Land Records 2020-21.

Techniques of data analysis : The cost concepts will be use for estimation of paddy chickpea and soybean cultivation, which adopted by the Commission for Agricultural Cost and Price, Ministry of Agriculture, GOI. Which include cost A1, A2, B1, B2, C1, C2 and cost C3.

Cost A1 : Consist of following items of costs :

1. Value of hired human labour (permanent & casual)
 2. Value of owned bullock labour.
 3. Value of hired bullock labour.
 4. Value of hired machinery.
 5. Value of owned machinery.
 6. Value of fertilizers.
 7. Value of manure (produced on farm and purchased).
 8. Value of seed (both farm-produced and purchased).
 9. Value of insecticides and fungicides.
 10. Irrigation charges (both of the owned & owned and hired tube wells, pumping sets.
 11. canal-water charges.
 12. Land revenue, cesses and other taxes.
 13. Depreciation on farm implements (both bullock drawn & worked with human labour).
 14. Depreciation on farm building, farm machinery.
 15. Interest on the working capital.
 16. Miscellaneous expenses (wages of artisans, and repairs to small farm implements)
- Cost A2= Cost A1+Rent paid for Leased in Land.
- Cost B1 = Cost A1+Interest on value of Owned Capital
- Cost B2 = Cost B1+ rental value of owned land and rent paid for leased-in land.
- Cost C1= Cost B1+ Imputed value of Family Labour.
- Cost C2 = Cost B2+Imputed value of Family labour.
- Cost C3 = Cost C2+ value of management input at 10% of cost C2.

Cost of Cultivation per hectare : Cost of cultivation per hectare at the different cost concepts has been worked out for the sample holdings. It is worked out by dividing the total cost by the area under the crops.

Net Income per hectare : Net income per hectare at the different cost concepts has been worked out by deducting the respective costs from the gross monetary returns per hectare.

Input-Output Ratio : Input-output ratio indicates the efficiency of input. It is computed as under :

$$\text{Input-Input output ratio} = \text{Gross return} / \text{Total input cost}$$

Cost-Benefit Ratio = Net return / Cost of cultivation

Gross income = Main product income + by product income

Net income = Gross income – Cost C2

Returns : Returns were noted in quintals and the monetary values were calculated at prevailing market prices.

Results and Discussion

Cost of cultivation of paddy crop : The overall per hectare cost-A1, Cost-A2, Cost-B1, Cost-B2, Cost C1, Cost- C2 and Cost-C3 were Rs. 28866.71, Rs. 28866.71, Rs. 31261.58, Rs. 54836.58, Rs. 33424.06, Rs. 56999.06, and Rs. 62698.96 per hectare respectively at the sampled farms. From the table it was observed that Cost-C2 was higher in case of large farmers (Rs. 62308.56) followed by medium (Rs. 59765.22), small (Rs. 56809.92) and lower in case of marginal farmers (Rs. 54320.19). It is presented in Table-3.

Yield, cost and returns : The overall input- output ratio obtained was 2.12 and Cost-Benefit ratio was 1.12. The Net return obtained from marginal (Rs. 61988.91), small (Rs. 64005.18), medium (Rs. 65170.98), large (Rs. 67330.44) and overall (63771.88) per hectare. Net return was higher in case of large farmers followed by medium, small, and marginal farmers. It is presented in table-4.

Economic analysis of paddy residue : According to table no. 5 and figure 4.14 the gross income for grain and straw yield overall was Rs 120770.93. It was Rs 116309.10, Rs 120815.10, Rs 124936.20, Rs 129639.00 for marginal, small, medium and large farmers. The overall contribution of grain was 92.87 per cent and straw was 7.13 per cent. The per hectare cost of cultivation of grain for marginal, small, medium, large and overall was calculated Rs. 50673.83, Rs. 52771.89, Rs. 55220.26, Rs. 57420.54, and Rs. 52924.75 per hectare, respectively. Cost of cultivation of straw was maximum for large farmers which was Rs. 4888.02 followed by medium, small and marginal farmers was Rs. 4544.95, Rs. 4038.03 and Rs. 3646.36 per hectare , respectively. On an average the overall cost of cultivation of grain and straw were Rs. 52924.75 and Rs. 4062.04 per hectare respectively.

Table-3 : Cost of cultivation of paddy crop.

S. No.	Different costs	Marginal	Small	Medium	Large	Overall
1.	Cost A1	26011.69	28544.83	31835.12	34721.43	28866.71
2.	Cost A2 (A1 + Rent paid for Leased in Land)	26011.69	28544.83	31835.12	34721.43	28866.71
3.	Cost B1(Cost A2 + interest on fixed capital	28401.77	30937.69	34234.62	37129.43	31261.58
4.	Cost B2 (Cost B1 + Rental value of owned land)	51976.77	54512.69	57809.62	60704.43	54836.58
5.	Cost C1 (Cost B1 + Family labourcost)	30745.19	33234.92	36190.22	38733.56	33424.06
6.	Cost C2 (Cost B2 + Family labour cost)	54320.19	56809.92	59765.22	62308.56	56999.06
7.	Cost C3 (Cost C2 + 10%of Cost C2)	59752.21	62490.91	65741.74	68539.42	62698.96

Table-4 : Yield, cost and returns, Input-Output ratio, cost of production per quintal of paddy in the study area (Rs./ha.)

S.No.	Particulars	Marginal	Small	Medium	Large	Overall
1.	Yield/ha	45.68	47.98	49.96	52.45	47.93
2.	Quantity sold in PACS	37.50	37.50	37.50	37.50	37.50
3.	Price of grain sold (Rs./qt.)	2540.00	2540.00	2540.00	2540.00	2540.00
4.	Value of grain yield in PACS (in Rs.)	95250.00	95250.00	95250.00	95250.00	95250.00
5.	Quantity sold in Mandi	8.18	10.48	12.46	14.95	10.43
6.	Price of grain sold in (Rs./qt.) in mandi	1620	1620	1620	1620	1620
7.	value of grain yield in Mandi (in Rs.)	13251.60	16977.60	20185.20	24219.00	16894.17
8.	Total value of grain yield (in Rs.)	108501.60	112227.60	115435.20	119469.00	112144.17
9.	Straw (in qt.)	52.05	57.25	63.34	67.80	57.51
10.	Price of straw sold (Rs./qt.)	150	150	150	150	150
11.	Value of straw yield (in Rs.)	7807.50	8587.50	9501.00	10170.00	8626.76
12.	Gross return (grain + straw)	116309.10	120815.10	124936.20	129639.00	120770.93
13.	Cost of cultivation(C2) (grain + straw)	54320.19	56809.92	59765.22	62308.56	56999.06
14.	Net return	61988.91	64005.18	65170.98	67330.44	63771.88
15.	Input-Output	2.14	2.13	2.09	2.08	2.12
16.	Cost-Benefit ratio	1.14	1.13	1.09	1.08	1.12

Table-5 : Contribution and economic analysis of paddy residue.

S. No.	Particulars	Marginal	Small	Medium	Large	Overall
1.	Value of grain yield (Rs)	108501.60 (93.29)	112227.60 (92.89)	115435.20 (92.40)	119469.00 (92.16)	112144.17 (92.87)
2.	Value of straw yield (Rs)	7807.50 (6.71)	8587.50 (7.11)	9501.00 (7.60)	10170.00 (7.84)	8626.76 (7.13)
3.	Gross income (Rs)	116309.10 (100)	120815.10 (100)	124936.20 (100)	129639.00 (100)	120770.93 (100)
4.	Contribution of grain (%)	93.29	92.89	92.40	92.16	92.87
5.	Contribution of straw (%)	6.71	7.11	7.60	7.84	7.13
6.	Cost of Cultivation of grain (Rs/ha)	50673.83 (93.29)	52771.89 (92.89)	55220.26 (92.40)	57420.54 (92.16)	52924.75 (92.87)
	Cost of cultivation of straw (Rs./ha.)	3646.36 (6.71)	4038.03 (7.11)	4544.95 (7.60)	4888.02 (7.84)	4062.04 (7.13)
7.	Cost of cultivation (C ₂)	54320.19 (100)	56809.92 (100)	59765.22 (100)	62308.56 (100)	56999.06 (100)
	BC ratio of straw	1.14	1.13	1.09	1.08	1.12

Utilization of paddy straw : Paddy straw use primarily depends on the harvesting techniques utilised; manually gathered straw is used for cow feeding, and mulching is also used. According to table 6, small and marginal farmers used biomass more frequently, and as farm size increased, biomass use decreased. Small and marginal farmers use more straw than other farmers for cow feeding and mulching since the majority of them harvest it

manually. For cattle feeding on an average overall 21.46 qt./farm. straw used which was maximum for large farmers which was 51.16 qt./farm. (16.86 percent) of straw followed by medium farmers 31.35 qt./farm. (21.06 percent), small farmers 19.98 qt./farm. (29.08 percent), and marginal farmers 9.25 qt./farm. (39.50 percent) from total straw production, which indicates increasing pattern. Mulching from marginal to large farms varies from 0.54 qt./farm. (2.31 percent) to 4.39 qt./farm. (1.45 percent).

Table-6 : Utilization of paddy straw of sampled household (qt./farm).

S. No.	Utilization	Marginal	Small	Medium	Large	Overall
1.	Cattle feeding	9.25 (39.50)	19.98 (29.08)	31.35 (21.06)	51.16 (16.84)	21.46 (30.51)
2.	Mulching and Thatching	0.54 (2.31)	1.22 (1.78)	3.03 (2.04)	4.39 (1.45)	1.68 (2.02)
3.	Left to decompose/incorporation of soil	12.33 (52.62)	42.94 (62.50)	90.95 (61.10)	189.90 (62.52)	57.52 (57.90)
4.	Burning of straw	0.00 (0.00)	0.00 (0.00)	8.06 (5.42)	17.92 (5.90)	3.85 (1.82)
5.	Donate to Gouthan	1.14 (4.88)	4.01 (5.83)	14.55 (9.77)	39.24 (12.92)	9.27 (7.09)
6.	Other purpose	0.16 (0.69)	0.55 (0.80)	0.92 (0.62)	1.12 (0.37)	0.53 (0.66)
	Total	23.42 (100)	68.70 (100)	148.85 (100)	303.73 (100)	94.30 (100)

Note : Figures in parentheses indicate percentages of the total straw yield.

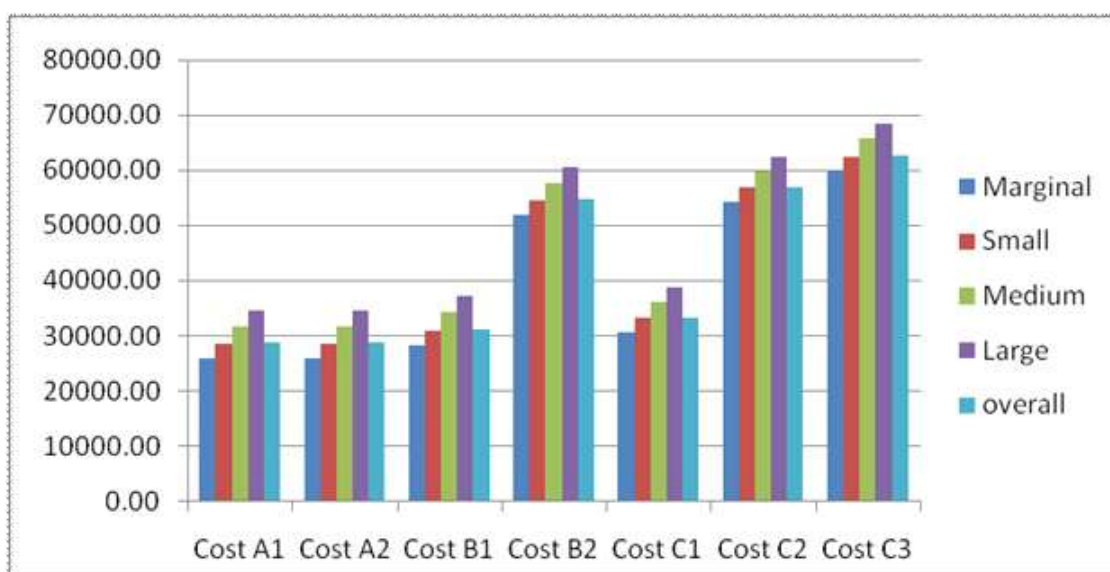


Fig-1 : Cost of cultivation of paddy of different size of farm households.

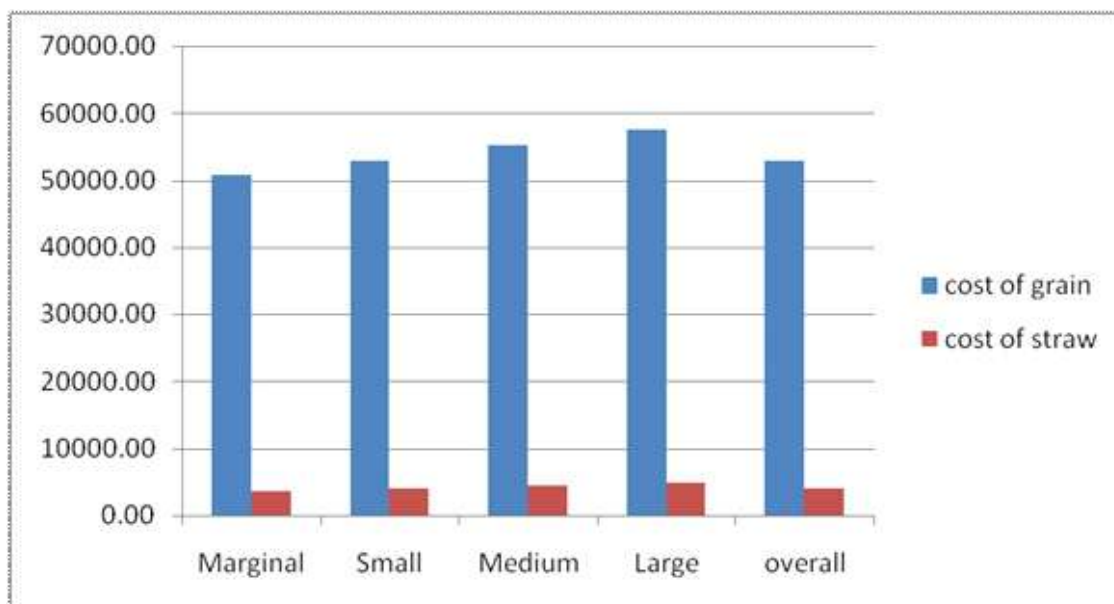


Fig-1 : Cost of cultivation of paddy of different size of farm households.

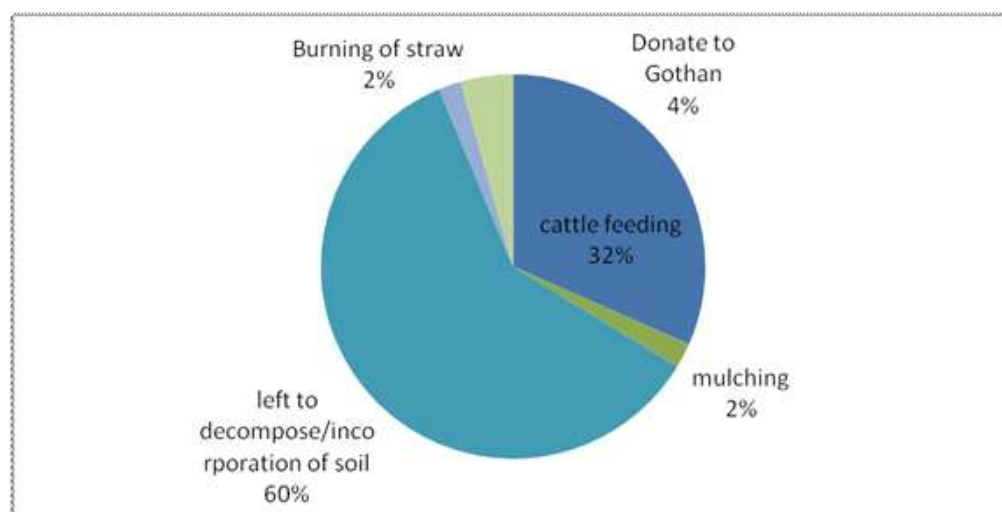


Fig.-3 : Paddy straw utilization.

Conclusions

Cost of cultivation of straw was maximum for large farmers which was Rs. 4888.02 followed by medium, small and marginal farmers was Rs. 4544.95, Rs. 4038.03 and Rs. 3646.36 per hectare. The overall ratio of paddy grain to straw was 1:1.20. The overall input- output ratio obtained was 2.12 and Cost-Benefit ratio was 1.12. The gross returns obtained from the main yield and the by produce (paddy straw) by farmers at overall level was Rs. 120770.93 per hectare. The Net return obtained at overall level was Rs 63771.88 per hectare. Net return was higher in case of large farmers followed by medium, small, and marginal farmers. From the study it was observed that cost for collection of residues was higher compared to burning, to overcome this Govt. should provide subsidize equipment/machines required for the making the paddy residue in to bales using reaper binder and transport it to fodder scarcity area in this connection, the Government could promote the reaper binder at subsidized price. It helps reduce the cost of residue left over after harvest and also reduce air pollution. For cattle feeding on an average overall 21.46 qt./farm. straw used which was maximum for large farmers which was 51.16 qt./farm. (16.86 percent) of straw followed by medium farmers 31.35 qt./farm. (21.06 percent), small farmers 19.98 qt./farm. (29.08 percent), and marginal farmers 9.25 qt./farm. (39.50 percent) from total straw production, which indicates increasing pattern. Mulching from marginal to large farms varies from 0.54 qt./farm. (2.31 percent) to 4.39 qt./farm. (1.45 percent).

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Role of Cluster Frontline Demonstration in Enhancement of Chickpea (*Cicer arietinum*) Production and Profitability in Dhamtari District of Chhattisgarh

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Abstract

Chhattisgarh agriculture, with each passing day is gaining a new momentum, which will help it to forward its steps towards an economically viable phase. Dhamtari district comes under plains region of Chhattisgarh and agriculturally it is very important district. In Dhamtari chickpea cultivation is very common but its productivity is very low. To establish the production potential of crop Cluster Front Line Demonstrations (CFLDs) is an appropriate tool. Cluster Front Line demonstrations (CFLDs) is a unique approach to provide an direct interface between researcher and farmers as the scientists are directly involved in planning, execution and monitoring of the demonstrations. The present study was conducted to assess the impact of cluster frontline demonstrations of chickpea crop in the Dhamtari district of Chhattisgarh state. To demonstrate production potential and economic benefits of improved technologies in the district, Krishi Vigyan Kendra, Sambalpur, Dhamtari (Chhattisgarh) conducted 75 demonstrations on chickpea under 30 ha area during 2020-21 to 2021-22 in 3 adopted villages. Study revealed that improved cultivation practices comprised under CFLDs viz., improved varieties, proper tillage, proper seed rate, line sowing using seed cum fertilizer drill, seed treatment with bio-fungicide *Trichoderma sp.*, dual inoculation of Rhizobium + PSB, RDF as per IGKV, water management at critical stages, weed management and application of IPM module for the management of insect (Specially on gram pod borer) resulted in increase in yield in gram crop over the check plots. The improved technologies gave higher yields and recorded a mean yield of 12.55 and 10.30 q/ha chickpea yield during 2020-21 to 2021-22, respectively which was 25.50 and 41.10 percent higher compared to prevailing farmers practice. The B:C ratios of chickpea cultivation under improved practices were 3.15 and 2.99 as compared to 2.74 and 2.27 under farmer practices for the two consecutive years.

Key words : Chickpea, bio-fertilizer, yield gap, economic.

Introduction

In India, pulses are playing an important role in regular diet by contributing a major share to the total intake of proteins. Apart from the supply of protein, pulses adds nitrogen to soil and improve physical structure of soil, fit in to mixed/inter cropping system/crop rotation, provide green pods used as vegetable and foliage as nutritious fodder for cattle. The results from household consumption surveys indicate decline in the consumption of pulses leading to increase in malnutrition and decline in protein intake (Shailendra *et al.*, 2013). Interestingly India is the largest producer, importer and consumer of Pulses in the world. Pulses occupy a prominent place in human nutrition particularly among the lower income groups of people in developing countries like India. The Indian Institute of Pulses Research, Kanpur, has projected the country's demand of pulses at 39 million tonnes by 2050, which will require pulses production to grow at an annual rate of 2.2% (IIPR, 2015). To fulfill the growing requirement, the country has to produce enough pulses as well as remain competitive to protect the domestic production. To achieve this, it is imperative to develop and adopt more efficient crop production technologies along with favorable

policies and market support to encourage farmers to bring more area under pulses. Total Pulses production during 2019-20 is estimated at 23.02 million tonnes which is higher by 2.76 million tonnes than the Five years' average production of 20.26 million tonnes (The Economics times 2020). India is the largest producer and consumer of pulses in the world accounting for about 29 per cent of the world area and 19 per cent of the world's production. Among the various pulses Chickpea (*Cicer arietinum* L.) is the most important pulse crop. Even though India ranks first in area and production of chickpea, it was importing from Australia (85.1%), Russia (4.7%) and other countries to meet its own consumption. One of the reasons for this was the low productivity (995 kg/ha) as against world's highest productivity of 3759 kg/ha (Anon, 2016).

The area, production and productivity of chickpea of Chhattisgarh and in district Dhamtari is also quite low as compared to other states, national acreage and production. The cause of low productivity of pulses is due to use of old varieties, higher seed rate and broadcasting method of sowing and biotic/abiotic stresses in the district. Thus, there is need to create awareness among the farming community to popularize the location specific improved varieties to increase the production and

productivity of pulse crops in the district. To increase production and productivity of legumes, various types of efforts have been made by the farmers and agricultural researchers from time to time. Thus, there is a great challenge for policy makers, farm scientists extension functionaries farming community to enhance pulse productivity diversify their cropping systems to meet out the national local pulse requirements. The cluster frontline demonstration programme (CFLDs) in pulses is a unique programme started by Ministry of Agriculture, Govt. of India, conducted under close supervision of farm scientists. Main objective of CFLDs' in pulses is to demonstrate popularize the improved agro technology on farmers' fields under varied farming situations for effective transfer of generated technology fill the gap between improved technology adopted/indigenous technology to enhance pulse productivity farm gains for sustaining the production systems especially under rainfed farming (Choudhary et al., 2009b). Keeping in view the above facts, an intensive intervention such as cluster front-line demonstrations was conducted to transfer the generated farm technology through FLDs' in chickpea in district Dhamtari with the objectives of enhancing productivity, profitability narrowing in the extension yield gaps. KVK Sambalpur, Dhamtari under the guidance of the Indira Gandhi Krishi Vishvavidyalaya, Raipur, C.G. and ATARI Jabalpur initiated to organize the cluster frontline demonstration at farmers field with the objective to demonstrate the improved chickpea production technology viz., deep summer ploughing once in 3 years, soil test based fertilizer application, seed treatment with Rhizobium, application of PSB and *Trichoderma viridi*, use of wilt tolerant varieties, installation of bird perches, nipping at 15-20 cm height, two irrigations first at branching and second at pod initiation stage, timely weed control and spray of NSKE 5% or Azadirachtin 0.03% (300 ppm) at pre-flowering stage in Dhamtari district and boost the pulse production. Technological extension yield gaps under chickpea in this comprehensive study are also presented in this paper for framing appropriate extension strategy for effective transfer of technology to target farmers in the district Dhamtari introduce and disseminate improved varieties of Chickpea to increase the crop yield during 2020-21 and 2021-22.

Materials and Methods

The present study was carried out by the Krishi Vigyan Kendra, Sambalpur, Dhamtari (Chhattisgarh) during rabi season from 2020-21 to 2021-22 (02 years) at the farmers' fields of different three villages of Dhamtari district of Chhattisgarh. The area of rice fallow under medium-black soils having considerable irrigation facilities was selected in the villages of Dhamtari district of Chhattisgarh State.

Pre-seasonal interaction was conducted during the initiation year, 2020-21 and collected information on existing practices, yields, profits and problems faced by the farmers. Based on the collected information, technological gaps were identified and a suitable demonstration package was prepared. As the seed was an important factor, a new chickpea variety, RVG-202 was selected against existing old variety (JAKI 9218 and JG14) and demonstrated as a whole package with a recommended package of practices by state agricultural university (Indira Gandhi Krishi Vishvavidyalaya, Raipur, C.G.) (Table 1). In total 75 frontline demonstrations in 30 ha area in different villages were conducted. Chickpea fields from adjacent area in the same village were considered as control (farmer's practice). Materials for the demonstrations with respect to CFLDs and farmers' practices were given in Table 1. In each year a preseasonal training and three trainings during the crop period were conducted to prepare the farmers on implementation of selected package of practices. The critical inputs were supplied to the farmers by procuring certified seed of RVG-202 from KVK, Kawardha district of Chhattisgarh, *Trichoderma viridi*, PSB and Rhizobium culture from Bio Control Laboratory, IGKV, Raipur and remaining were purchased from local market and nonmonetary inputs like timely sowing in lines and timely weeding were performed. The demonstration farmers were facilitated by KVK scientists in performing field operations like sowing, spraying, weeding, harvesting etc. during the course of training and visits. Data on cost of cultivation, yield and gross returns were collected from each selected farmer as well as from non-practicing farmer for the comparison. From the collected data, mean values for cost of cultivation, yield, gross returns, net profits and B:C ratio were worked out on the basis of prevailing market prices of inputs and Minimum Support prices of outputs.

The technology gap, extension gap and technology index were calculated using the following Formulae given by (Samui et al., 2000).

Technology gap = Potential yield - Demonstration yield

Extension gap = Demonstration yield - yield under existing practice

Technology index = {(Potential yield - Demonstration yield)/Potential yield} x 100

Results and Discussion

Yield and Economics : During the first year of assessment (2020-21) obtained higher yields in technology demonstration with a mean of 12.55 q/ha which was 25.50 percent higher than farmer's practice (10

Table-1 : Details of different components of assessed technology against the farmer's practice of chickpea.

Sr.No.	Component	Farmer's Practice	Assessed Technology	Gap
1.	Seed rate (kg/ha)	100 kg/ha	75 kg/ha	Partial gap
2.	Seed treatment	No	Seed treatment with <i>Trichoderma viridi</i> @ 10 g/kg	Full gap
3.	Method of sowing	Broadcasting	Line sowing	Full gap
4.	Bio-fertiliser	No	Rhizobium & PSB	Full gap
5.	Chemical fertilisers	DAP @ 125 kg/ha	Soil test based application	Partial gap
6.	Weed control	No	Spraying of Pendimethalin @ 2.5 l/ ha as Pre-emergence	Full gap
7.	Wilt management	No	<i>Tricoderma viridi</i> soil application @ 10 kg/ha	Full gap
8.	Number of irrigations	2	2	No gap
9.	Pest management	Chemical spray	<i>Azadirachtin</i> 0.03% @ 5 ml/l at pre-flowering stage and need based chemical spray	Partial gap

Table-2 : Yield performance of chickpea under CFLDs at farmer's field.

Year	Yield q/ha		% yield Increase over FP	Technology gap (q/ha)	Extension gap (q/ha)	Technology Index %
	Demonstration	Farmer's practice				
2020-21	12.55	10	25.50	5.45	2.55	30.27
2021-22	10.30	7.30	41.10	7.7	3	42.77
Average	11.43	8.65	33.30	6.57	2.78	36.52

Table-3 : Economical comparison between recommended practice and farmers practice.

Year	Gross cost (Rs./ha)		Gross return (Rs./ha)		Net return (Rs./ha)		B:C Ratio	
	Demonstration	Farmer's practice	Demonstration	Farmer's practice	Demonstration	Farmer's practice	Demonstration	Farmer's practice
2020-21	19106	17500	60240	48000	41134	30500	3.15	2.74
2021-22	17895	16195	54340	37787	36445	21592	2.99	2.27
Average	18501	16848	57290	42894	38790	26046	3.07	2.51

q/ha). With mean gross returns of Rs. 60240/ha realized higher net profits in demonstration (Rs. 41134/ha) compared to control (Rs. 30500/ha). However, cost of cultivation was higher in demonstration as incurred towards critical inputs particularly seed. Overall superior performance of demonstrated technology over farmer's practice was resulted an additional income of Rs. 12744/ha with high B:C ratio (3.07) compared to control (2.51). Despite of increased cost of cultivation for the second year (2021-22), it was reduced during subsequent years over control in the year 2021-22. For both the years, increased yields were obtained in demonstration with an increase of 25.50 and 41.10 per cent for the year 2020-21 and 2021-22, respectively. With combined effect of yield increase and cost saving, achieved higher net profits of Rs. 41134/ha and Rs. 36445/ha for the year 2020-21 and 2021-22, respectively as compared to control (Table-2). The results obtained in the present study were in line with the findings of Yasa *et al* (2020) who reported the higher net returns (Rs. 47,825/ha) and benefit cost ratio (1.91) for chickpea gained through the improved production technologies demonstrated under CFLD programme.

During the second year of demonstration (2021-22), increased yield (41.10 %) and cost saving were contributed to an additional income of Rs. 14853/ha by recording higher B:C ratio of 2.99 over control (2.27).

These results were in accordance with the earlier findings of Mauria *et al* (2017), Meena (2017), Purushottam *et al* (2012) and Narwale *et al* (2009) as reported higher yield of demonstration plots compared to the control plots. The cumulative data analysis over two years revealed that, the superiority of demonstrated technology by recording yield increase of 32.5 per cent with the average additional income of Rs. 14921/ha over control. Similarly the yield increase of chickpea was ranged from 7.10 to 47.28 per cent under demonstration over the farmer's practice as reported by Lakshmi *et al* (2017).

Benefit to Cost ratio : The overall cumulative mean for B:C ratio was recorded as 3.07 and 2.51 for demonstration and farmer's practice, respectively. Overall superior performance was proved for the demonstrated technology by exhibiting significant higher values for yield, net profit and B:C ratio (Table 3). Present results were in line with the earlier findings of Jayalakshmi *et al* (2018) who reported higher net profits in demonstration with an additional income of Rs 7743/ha and B:C ratio of 2.09 against control (1.59). Over two years of chickpea demonstration with improved package of practices including a new variety (RVG 202), identified 2.78 q/ha as extension yield gap which was filled through the assessed technology with an additional investment of Rs. 1653/ha. However, still there was a considerable technology yield



Fig-1 : Different technology demonstration activities at farmer's field.

gap (6.57 q/ha) to catch the potential yield of 18 q/ha as signified by the technology index of 36.52 per cent. Technology yield gap found in this study might be due to variations in the soil fertility status, time of sowing and seasonal weather conditions as similarly concluded by Tomar *et al* (2010) and this could be overcome by developing fine tuned location specific package. The overall findings of present study were in concurrence with the earlier findings of Kaur *et al* (2019) who reported 16.28 per cent increase in yield of chickpea demonstration plots over farmer's practice, and also similarly found technology gap of 125 kg/ha, extension gap of 264 kg/ha and technology index of 6.23 per cent.

Conclusion

Improved technology for cultivation of chickpea under rice-fallow was proved profitable in the present yield economics assessment. It could help the farmers to better utilize the vacant land of rice-fallow and it adds to the pulses production in the district.

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Effect of Sowing Dates, Fertilizer's Application and Genotypes on Growth and Yield Attributes in Irrigated Coriander under Malwa Plateau of Madhya Pradesh

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Abstract

Present investigation was carried out to find out the effect of different sowing dates on plant growth and seed yield and yield attributing traits of irrigated winter season coriander genotypes. Experiment was conducted at experimental farm of KVK, Mandsaur (M.P.) during Rabi season 2018-19 and 2019-20. The treatments comprised of three different sowing dates viz., October 20, 2018 & 2019 (D₁), October 31, 2018 & 2019 (D₂) and November 10, 2018-19 (D₃) two fertilizer levels viz., F₁ - 60:35:35:20 N:P:K:S ha⁻¹, F₂ - 80:55:50:35 N:P:K:S ha⁻¹ and three genotypes viz., Ajmer Coriander⁻¹ (V₁), Ajmer Coriander⁻² (V₂) and Pant Haritima as a check (V₃). The experiment was laid out in Randomized Block Design with factorial concept in three replications. Observations with respect to seed germination, plant height (cm), No. of primary and secondary branches, Days taken to 50% flowering were recorded for growth parameters whereas, No. of umbels, No. of umbellate, No. of Seeds Umbel⁻¹, Test Weight (g), Seed yield (kg ha⁻¹) for seed yield and yield attributes in each treatment were recorded. Results revealed that parameters like minimum days to germination initiation (8.17), minimum days to complete germination (10.86), plant height at harvest (127.93 cm) were recorded in the plants grown on 20th October date of sowing. Similarly, maximum number of primary branches (8.50), secondary branches (26.73), number of umbel plant⁻¹ (40.01), number of umbellate umbel⁻¹ (6.81), seed yield plant⁻¹ (12.22 g) and seed yield (1532 kg ha⁻¹) was also recorded with 31st October date of sowing. Irrespective of different sowing dates and genotypes, the fertilizer levels of NPKS 80:55:50:35 (F₂) recorded significantly more umbels (37.13) plant⁻¹, seeds (31.25) umbel⁻¹, seed yield (1544kg ha⁻¹) and 1000 seed weight (11.06g) as compared to F₁ fertilizer level. The maximum gross return and net return was recorded in the crop sown on 31st October (122533, 86373) followed by 20th October (115253, 79053). The trend was observed similar during both the years. The maximum B:C ratio was recorded in the crop sown on 31st October (3.39) followed by 20th October (3.22).

Key words : Coriander, sowing, umbel, yield (seed), attributes and economics.

Introduction

Coriander is Apiaceae family annual herb plant and seeds are important for taste, flavour in various food meals. ACr-1 is a leafy type variety suitable for dual purpose (leaves and seed production) while ACr⁻² and Pant Haritima is mainly grown for seed purpose. Seeds are small in size and good quality. Green leaf is having 0.071% essential oil with good aroma and flavour. It is precocious ingredient in the preparation of Unani and ayurvedic medicines and more use in rheumatism, gastrointestinal complaints etc. Coriander is generally sown in winter season for seed production. Time of sowing is high-priority for the crop for vegetative growth and primarily pronouncement of seed. More advanced and delayed sowing may hamper the vegetative growth, seed yield as well as quality of the crop produce. In case of coriander, early sowing leads to early flowering but may be vulnerable to damage in case of aphids and frost. Another

hand, late sowing affected the growth and seed yield in adverse condition. Meena et. al. (2014) reported that early sowing and selection of less susceptible variety proved a suitable component for the control of aphid in coriander. Ghobadi et al. (2012), Soleimani, et al. (2011), Sharangi, et al. (2011) also worked for standardization of agro techniques towards enhanced production of coriander. However, most of the detection on date of sowing is local in nature and very low findings are sufficient to be conclusive in general. The environment created by temperature, humidity, rainfall and other meteorological factors has profound influence on growth, biomass partitioning and ultimately the yield of coriander which may individually or collectively limit the plant growth and production. The phenological development of the crop along with efficient conversion of biomass into yield is precisely influenced by time of sowing Zolleh et al (2009). Better vegetative growth expressed by plant height in earlier date of sowing is perhaps due to more favourable

temperature and more sunshine reaching the crop during its growth period Pan *et al.* (2003). Since, AGCr⁻¹ is a new emerging variety of coriander especially for green leaf in off season and seed in winter season, the standardization of date of sowing is very much pertinent to boost the yield of quality produce. The present investigation on the different sowing dates was carried out for identifying the important sowing times towards the maximum seed production of coriander.

Materials and Methods

The experiment was conducted to study the effect of different sowing dates on plant growth and seed yield and yield attributes of winter season irrigated coriander genotypes Ajmer Coriander⁻¹ (ACr⁻¹), Ajmer Coriander⁻² (V₂) and Pant Haritima (V₃) was conducted on clay loam soil during 'Rabi season 2018-19 and 2019-20 at experimental farm of KVK, Mandsaur (M.P.) India. The field experiment consisted of three dates of sowing viz., 20 October, 2018 & 19 (D₁), 31 October, 2018 & 19 (D₂) and 10 November, 2018 & 19 (D₃), two fertilizer application levels viz., F₁ - 60:35:35:20 N:P:K:S ha⁻¹, F₂ - 80:55:50:20 N:P:K:S ha⁻¹ and three genotypes viz., Ajmer Coriander⁻¹ (ACr⁻¹), Ajmer Coriander-2 (V₂) and Pant Haritima (V₃). The experiment was laid out in Randomized Block Design with factorial concept in three replications. The experiment was laid out in RBD with three replications. The soil of the experimental field was clay loam having low organic matter (0.27 %), available nitrogen (188.26 kg ha⁻¹), phosphorus (11.2 kg ha⁻¹) and enough available potassium (336.43 kg ha⁻¹), slightly saline alkali with pH (8.0) and EC (0.072 dS m⁻¹). Different sowing dates viz., 20th October, 31st October, and 10th November were taken into consideration for sowing of seeds. The unit plot size was 2.0 m × 3.0 m. The seeds (fruits) were rubbed for separating the mericarp (seeds) and were also treated with Bavistin @ 2 g kg⁻¹ of seeds before sowing. The seeds were sown with the crop geometry of 25 cm × 7.5 cm using 15 kg ha⁻¹ according to the sowing dates. First weeding was done at 35 days after sowing (DAS). Plant thinning was also done with weeding to maintain the required plant population. The irrigation was done at 20 days interval after emergence according to the need of the field soil. Data were collected from the inner rows of each plot to avoid the border effect. In each unit plot 5 plants were selected randomly for recording data on plant growth parameters and yield attributes. Plot yield was converted to per hectare yield. The collected data were properly analyzed statistically through method suggested by Panse and Sukhatme (1985).

Results and Discussion

Growth parameters : The plant growth attributes of

coriander were highly influenced by sowing date (Table-1). The crop sown on 20th October (D₁) significantly registered minimum days to germination Initiation (8.17), Days to complete germination (10.86), Plant height (cm) at harvest (127.93), No. of Primary branches at harvest (8.50), No. of Secondary branches at harvest (26.73), while the Days taken to 50% flowering was registered in 31 Oct., (D₂). This increase was ultimately reflected in overall improvement in growth of coriander crop quantified in terms of biomass accumulation at successive growth stages and at harvest. Ghobadi *et al.* (2012) and Hornok L (1976) also observed that low temperature at the time of emergence caused slow germination of coriander. The present study is in conformity with the findings of Naghera *et al.* (2000) and Tiwari *et al.* (2002) in coriander at Junagarh and Pantnagar, respectively. It is clear that a delay in sowing from 20 October (D₁) decreased all growth parameters and fruit maturity decreased significantly. The significant decrease in morphological characters associates with the delay in sowing can be related to higher temperature at the time of harvesting that the plant at the late sowing dates experienced which limited their growing period. The plant did not have optimum opportunity for photosynthesis and turn their height and branch bearing capacity decreased. Better vegetative growth expressed by plant height in earlier date (appropriate) of sowing is perhaps due to more favourable temperature and more sunshine reaching the crop during its growth period Pan *et al.* (2003). Data *et al.* (2008) also found an increase in plant height as well as increasing trend in primary and secondary branches per plant in early sown plants in black cumin. Same trends are found by Singh *et al.* (2005), Carrubba *et al.* (2006), Moosavi (2012) in coriander.

Fertilizer application : Growth parameters at harvest were significantly influenced with application of varying levels of fertilizer application. Application of two fertilizer levels viz., F₁-60:35:35:20 N:P:K:S ha⁻¹, F₂- 80:55:50:35 N:P:K:S ha⁻¹. F₂ resulted higher plant height, number of branches plant⁻¹, number of secondary branches plant⁻¹, and number of umbels plant⁻¹ at harvest and days taken to 50 percent flowering over application of F₁-60:35:35:20.

Yield attributes : The 31st October sown crop exhibited significant improvement in yield attributes namely, highest number of umbels plant⁻¹ (40.1), No. of Umbellate umbels Plant⁻¹ (6.81), No. of Seeds Umbel⁻¹ (31.63), Test Weight (g) (11.23), Seed Yield per Plant (g) (12.22) and Seed Yield (Q/ha) (15.32). These results are in close agreement with findings of Moosavi *et al.* 2012 and Data *et al.* 2008. Number of umbels per plant of coriander were significantly affected by different sowing date and fertilizer application. Present findings are in accordance with Ibrahim *et al.* (2006), and El- Mekawey *et al.* (2010), . This may be due

Table-1 : Effect of sowing dates, fertilizer application and genotypes on growth parameters of Coriander.

Treatments	Days to germination initiation	Days to complete germination	Plant height (cm) at harvest	No. of branches at harvest		Days taken to 50% flowering
				Primary	Secondary	
Sowing dates						
D ₁ : 20 October	8.17	10.86	127.93	8.50	26.73	92.40
D ₂ : 31 October	8.85	13.04	112.64	8.01	20.50	92.30
D ₃ : 10 November	8.59	11.79	105.32	7.49	22.02	88.97
S. Em ±	0.21	0.26	3.53	0.19	0.38	0.93
CD (P=0.05)	NS	0.75	10.30	0.55	1.12	2.71
Fertilizer application						
N:P:K:S 60:35:35:20 (F ₁)	8.12	11.59	110.30	7.12	21.66	93.16
N:P:K:S 80:55:50:35 (F ₂)	8.96	12.21	120.34	8.86	24.55	89.23
S. Em ±	0.18	0.21	2.89	0.16	0.31	0.76
CD (P=0.05)	0.51	0.61	8.41	0.45	0.91	2.22
Genotypes						
V ₁ : Ajmer Coriander ACr ⁻¹	8.30	11.35	114.21	7.77	21.93	92.65
V ₁ : Ajmer Coriander ACr ⁻²	8.90	12.26	123.98	8.88	25.76	92.53
V ₁ : Pant Haritima	8.42	12.05	107.72	7.33	21.67	88.48
S. Em ±	0.21	0.26	3.53	0.19	0.38	0.93
CD (P=0.05)	NS	0.75	10.30	0.55	1.12	2.71

Table-2 : Effect of sowing dates, fertilizer application and genotypes on yield and yield attributes in Coriander.

Treatments	No. of Umbels Plant ⁻¹	No. of Umbellates Plant ⁻¹	No. of Seeds Umbel ⁻¹	Days taken to seed harvesting	Test Weight (g)	Seed yield per Plant (g)	Seed yield (q ha ⁻¹)
Sowing dates							
D ₁ : 20 October	38.64	6.64	30.63	130.07	10.87	10.97	13.77
D ₂ : 31 October	40.01	6.81	31.63	128.03	11.23	12.22	15.32
D ₃ : 10 November	26.78	5.75	26.40	126.73	9.65	11.70	14.41
S. Em $\pm$	0.79	0.19	0.36	0.90	0.22	0.26	0.33
CD (P=0.05)	2.29	0.55	1.06	2.61	0.63	0.76	0.96
Fertilizer application							
N:P:K:S 60:35:35:20 (F ₁)	33.15	5.75	27.90	129.40	10.12	10.98	13.55
N:P:K: S 80:55:50:35 (F ₂)	37.13	7.05	31.25	127.13	11.06	12.27	15.44
S. Em $\pm$	0.64	0.16	0.30	0.73	0.18	0.21	0.27
CD (P=0.05)	1.87	0.45	0.86	2.13	0.52	0.62	0.78
Genotypes							
V ₁ : Ajmer Coriander ACr ⁻¹	34.80	6.17	29.70	130.30	10.25	10.73	14.91
V ₁ : Ajmer Coriander ACr ⁻²	42.76	7.49	32.27	130.83	10.91	12.97	15.67
V ₁ : Pant Haritima	27.90	5.53	26.70	123.73	10.55	11.20	12.93
S. Em $\pm$	0.79	0.19	0.36	0.90	0.22	0.26	0.33
CD (P=0.05)	2.29	0.55	1.06	2.61	0.63	0.76	0.96

Table-3 : Economics analysis of different treatments in Coriander.

Treatments	Cost of cultivation (Rs. ha ⁻¹)	Gross returns (Rs. ha ⁻¹)	Net returns (Rs. ha ⁻¹)	Benefit : Cost Ratio
Sowing dates				
D ₁ : 20 October	36200	115253	79053	3.22
D ₂ : 31 October	36160	122533	86373	3.39
D ₃ : 10 November	34170	110160	75990	3.18
Fertilizer application				
N:P:K:S 60:35:35:20 (F ₁)	33500	108373	74873	3.24
N:P:K: S 80:55:50:35 (F ₂)	37520	123520	86000	3.29
Genotypes				
V ₁ : Ajmer Coriander ACr ⁻¹	35600	119280	83680	3.35
V ₁ : Ajmer Coriander ACr ⁻²	35730	125360	89630	3.51
V ₁ : Pant Haritima	35200	103467	68267	2.94

Note : Seed selling price @ D 8000 q-1 prevailing market rate.

to poultry manure is due to enriched nitrogen content as compared to farmyard manure and compost. Nitrogen, phosphorus and potash are the three major nutrient required for good production or yield of coriander. Increasing seed yield of coriander ultimately depends on good yield contributing characters, which results from proper dose of fertilizers. Number of umbels per plant were significantly influenced with regard to application of fertilizer levels and different sowing date.

Flowering attributes : The data in respect of days required to 50 per cent flowering in coriander as influenced by different varieties are presented in Table 1. The character, days to 50 per cent flowering for all the three varieties ranged between 88d to 92d with the average of (88d) for 50 per cent flowering. The variety Pant Haritima required minimum (88.97d) 50 per cent flowering and the variety Ajmer Coriander ACr⁻¹ (V₁) required maximum (92.40d) to 50 per cent flowering. The significant differences among varieties were observed for number of umbel per plant, No. of Umbellates Plant⁻¹, No. of Seeds Umbel⁻¹ Days to seed harvesting The maximum (42.76) numbers of umbel per plant, No. of Umbellates Plant⁻¹ (7.49) No. of Seeds Umbel⁻¹ (32.27), Days to seed harvesting (130.83) were observed in variety Ajmer Coriander ACr⁻² (V₂) and the minimum (27.90) number of umbel per plant, No. of Umbellates Plant⁻¹ (5.53) No. of Seeds Umbel⁻¹ (26.76), Days to seed harvesting (123.73) was observed in Pant Haritima (V₃).

The differences in maturity period can be attributed to genetic differences among the cultivars and ecological as well as climatic condition, as climate during growth and development of plant plays a dominant role in growth, yield and quality of coriander. Similar trend of result was also observed and supports the results of present findings by Kofidis et al (2008) in coriander, Meena et al (2014) in coriander.

The number of seed per umbel indicated significant differences among the different coriander varieties. The maximum number of seed per umbel were obtained in the variety Ajmer Coriander ACr⁻² (32.27). The less number of seed per umbel was obtained in the variety Pant Haritima (26.70). The variety Ajmer Coriander ACr⁻¹ recorded minimum (10.25) test weight. It might be due to the fact that, genetic cause or responses of the particular genotype to the soil and climatic conditions might be reflected in such characters. Similar results were reported by Singh and Singh (2013), Dyulgerov and Dyulgerova (2013) which supports the results of present findings.

The data in respect of seed yields per plant (g) were significantly influenced by the different varieties of coriander (Table 2). The variety Ajmer Coriander ACr⁻² recorded maximum yield per plant (12.22g) whereas

minimum was recorded by cultivars Ajmer Coriander ACr⁻¹ (10.97g), the similar variations in seed yield per plant among different varieties have reported by Moniruzzaman et al (2013) in variety CS011 of coriander, Meena et al (2014) in coriander, which supports the results of present findings.

The data with respect of seed yield (q/ha) in coriander influenced by different varieties of coriander (Table-2). The results indicated that, the seed yield per hectare was significantly influenced due to different varieties under study. The cultivar Ajmer Coriander ACr⁻² recorded maximum seed yield per ha (15.32q/ha). The cultivar Ajmer Coriander ACr⁻¹ produced minimum (13.77q/ha) seed yield per ha. It was observed that, the varieties which performed better in a unit area were likely to perform better on large scale as the yield per hectare was calculated by multiplying yield per plot with hectare factor. The yield is the result of interaction of the variety to a given agro climatic and management factors. The variations in yield among the coriander varieties were also reported by several workers i.e. Yadav (1999) in coriander Singh and Singh (2013) in coriander, Meena et al (2014) in coriander, Moniruzzaman et al (2013) in variety CS011 of coriander which supports the results of present findings.

Economics of treatments : The economics of all Eight treatments was calculated. The data presented (Table 3) revealed that the average cost of cultivation in all treatments is more or less similar; the maximum in 20th October sowing (36200) may be due to irrigation management practices. The maximum gross return and net return was recorded in crop sown on 31 October (122533, 92240) followed by 20 October (115253, 79053). The trend was observed similar during both the years. The maximum B:C ratio was recorded in crop sown on 31st October (3.39) followed by 10 November (3.22) and minimum in crop sown on 20 October (3.18). It might be due to fluctuation in the environmental condition like low and high temperature, humidity etc. The B:C ratio is one of most important aspects for selection of sowing time of crop by the farmers. It is suggested from the study that the farmers should start growing of coriander crop in suitable times (20th to 31st of October month) to fetch better return.

Conclusions

On the basis of experimentation over two consecutive years, it has been concluded that the coriander cultivar Ajmer Coriander ACr⁻² (V₂) is far superior not only in growth parameters, but also performed well in terms of yield attributes and ultimately raises the income of the farmers in the Malwa plateau of M.P. It may be recommended for *Rabi* season cultivation to obtain the maximum seed yield, net return and high B:C.

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Isolation, Identification and Pathogenicity of Wilt in Chilli (*Capsicum annuum* L.)

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Abstract

In recent years, chilli wilt diseases is severely infecting in many parts of India and causes major economic losses about 10-50 per cent yield loss in India. As chilli is most important vegetable as well as spice crop of India causal pathogen should be isolated, identify and their symptomatology should be studied. Therefore, we conducted a experiment on fungal isolation, identification, purification and pathogenicity from the infected plant parts of chilli wilt. Chilli wilt shows typical symptoms brown vascular discolouration followed by upward and inward rolling of the upper leaves and subsequently wilting of the plants. On reisolation of pathogen it was found that pathogen was identical to original isolates and identified as *Fusarium oxysporum* f. sp. *capsici* causal agent of chilli wilt. These study provide an elementary idea about chilli wilt disease as well as paved the path for seeking of proper recommendation of proper farming practices to combat against this disease.

Key words : Chilli, identification, pathogenicity, wilt, *Fusarium oxysporum* f. sp. *capsici*

Introduction

Chilli (*Capsicum annuum* L.,) 2n=24 is one of the most important vegetable as well as spice and a cash crop of India and belongs to the family *Solanaceae*. It is grown in tropical and subtropical regions of the world for its pungent fruits which are used both green and ripe. Chilli is the most widely used spice and condiment in the world and is greatly priced for its pungency and adding special flavor to many cuisines throughout the world. In India, 2020-2021 chilli grown on 0.74 million hectares area, with production of 1.91 million tons and productivity 2.57 metric tons per hectares (Anon., 2020a). In Gujarat, its area and production were 11299 hectares, 22051 MT, respectively (Anon., 2020b). Though India is the leading producer, the average yield of chilli is very low (1.11 t/ha dry chilli) as compared to developed countries like USA, China etc, where the average yield ranges from 3-4 t/ha (Bai *et al.*, 2018). But in the recent years, the production and productivity is constrained due to many biotic and abiotic stresses. Among them the most devastating are fungal diseases like wilt which lower the yield considerably annually and emerged as serious problem in past decade.

Chilli wilt caused by *Fusarium oxysporum* f. sp. *capsici*, has become a major problem in chilli cultivation throughout India and causes 10-50 per cent loss in India (Bai *et al.*, 2018). The wilt appears both in seedling and later stage but the highest mortality occurs at flowering and fruiting stage, as a result whole plant wilts leading to a complete loss.

Materials and Methods

Collection and isolation of wilt pathogen : The samples

were collected from chilli infected field of wilt and were brought to Department of Plant Pathology, CoA, JAU, Junagadh laboratory for isolation. Pathogens were isolated by standard tissue isolation technique (Tuite, 1969). The infected plant part were sliced into 5-6 mm size small pieces after being rinsed with tap water to remove all soil particles. After disinfecting the pieces, using 0.1 per cent mercuric chloride solution for one minute, they were washed three times in sterilised distilled water to eliminate excess mercuric chloride solution. In each Petri plate, three to four pieces were aseptically plated on sterilised potato dextrose agar with the help of forceps. The Petri plates were incubated at 28 ± 1 °C for 10 days.

The culture were purified by single hyphal tip technique (Rangaswami, 1972). The hyphal tip from margins of resulting colonies were cut with the help of sterilized 5 mm cork borer and transferred to petri plates containing PDA media and maintained by mass transfer on PDA slants and incubated at 25 ± 1 °C for further studies.

Maintenance of the culture : The fungus were subcultured on the PDA slants and allowed to grow at 25 ± 1 °C. The culture obtained was stored at 4 °C for further studies and was subcultured periodically.

Pathogenicity and symptomatology of wilt pathogen :

Pathogenicity of the isolate *Fusarium* spp. was proved under net house condition by soil infestation method. To establish the pathogenicity earthen pots of the size 15 cm width x 15 cm depth were used and sterilized by 4 per cent formaldehyde solution. Whereas soil was sterilized by autoclaving at 15 lbs psi (1.038 kg/cm²) at 121.6 °C for one hour for three consecutive days.



Fig.-1 : Pathogenecity and morphological characteristics of *Fusarium oxysporum* f. sp. capsici. (A) Pathogenecity, H=Healthy and I=Inoculated. (B) Pure culture on PDA plates, (C) Reverse side of Petri plate shows orange pigmentation of agar base, (D) Vascular discolouration of chilli plants, (E) Macroconidia, (F) Microconidia and (G) Chlamydospores.

The inoculum of *Fusarium* spp. was prepared on half boiled sorghum grain media. 250 grams of the medium (sterilized sorghum grain) will filled into plastic bags of two kg size and then sterilized at 15 lbs psi (1.038 kg/cm²) for a hour for two consecutive days. The flasks/polyethylene bags containing the sterilized media was inoculated with mycelial disc of *Fusarium* (five mm diameter) using cork borer and incubated at $28 \pm 1^{\circ}\text{C}$ for 10 days. This inoculum were used for soil inoculation at 40 g/kg soil in the upper 4 to 5 cm layer in each pot except control (Shirsole *et al.*, 2018). The pots without the inoculation of fungus served as control. After one week, five chilli seedlings per pot (30 days old) of local hybrid cultivar were transplanted and watering was done as and when required.

The plants were observed regularly for the appearance and development of the disease symptoms. The symptoms of chilli wilt were studied and expression of the characteristic symptoms and if any variation observed were recorded. The pathogenic nature of the organism was proved by following Koch's postulates.

Identification of wilt pathogens : Morphological characters of the fungus were studied with the help of a compound microscope. Slides of the fungus were prepared by staining an actively growing fungus with cotton blue. After calibrating the microscope shape, size and colour of hyphae, conidia, chlamydospores were taken with the help of ocular and stage micrometers. The causal fungus were identified on the basis of its morphological and cultural characters.

Results and Discussion

Isolation of wilt pathogens : The pathogen was isolated on Potato dextrose agar medium from surface sterilized roots of wilted chilli plants showing typical symptoms. The growth of fungus from infected tissue was distinctly visible after three to four days in Petri plates containing the Potato dextrose agar medium and put forth moderately rapid growth covering the Petriplate in 7-10 days.

Pathogenicity and symptomatology of wilt pathogen : Pathogenicity of *Fusarium* wilt was proved by applying soil infestation method in pot and transplanting seedlings of local hybrid cultivar of chilli. Control was maintained without inoculation of pathogens into pot.

The typical symptoms of fusarium wilt expressed in artificially inoculated (sick soil) chilli seedlings were leaf tip yellowing extended down the leaf and whole leaf gradually turned yellow to brown coloured. Symptoms are characterized initially by slight yellowing of the older leaves followed by younger leaves. Base of the stem turned brown and sunken and such plants gradually withered due to brown vascular discoloration of the collar portion of stem and roots. Thereafter, stem shrivels and entire plant wilts. Variable symptoms are observed which includes vein clearing, leaf epinasty, chlorosis, necrosis, abscission and wilting. The wilt pathogen were reisolated from the conducting tissues of the artificially diseased/wilted chilli plants, on PDA plates. Reisolated cultures of the wilt pathogen exhibited similar cultural characteristics to those of the isolates obtained/isolated from naturally wilted chilli plants. Similarly, Suryanto *et al.* (2010), Joshi *et al.* (2013), Moosa *et al.* (2016), Abada *et al.* (2018) and Basco *et al.* (2017) proved the pathogenicity of *F. oxysporum* by sick soil method.

Identification of wilt pathogens : *Fusarium* wilt pathogens grew profusely on potato dextrose agar medium with cottony white mycelia. The colour of colony was pinkish white turning felted, peach brown or orange colour at agar base. Fungus grew profusely at temperature range of 25-30°C and attained colony diameter of 90 mm within 6-7 days. The hyphae of fungus were branched, septate and hyaline. The fungus produced two types of spores viz. Macroconidia and microconidia. Macroconidia were hyaline and fusiform, pointed at both ends with 2-5 septa and measured 32-44 x 3.50-4.80 µm in size. Microconidia were hyaline and round to cylindrical, straight or curved in shape, 1-2 septate and measured 6.0-13.2 x 2.2-3.8 µm in size. Chlamydospores were spherical, smooth or rough walled, produced terminally, latterly or intercalary hyaline in colour of 5.50-9.60 µm in size. Based on symptomatology (naturally and artificially wilted plants), morpho-cultural characteristics,

microscopic observations and pathogenicity test, the test pathogen was identified as *Fusarium oxysporum* f. sp. *capsici* and further confirmed by comparing its characteristics described earlier by Naik.2006; Raghu *et al.* (2016); Usha and Ramya (2017); Bai *et al.* (2018) and Gowda *et al.* (2020).

Conclusions

In the present study, chilli fusarium wilt was isolated and identified from infected field. Further pathogenecity was proved by soil infestation method and Koch's postulates were proved and identified as *Fusarium oxysporum* f. sp. *capsici*. The results can be useful for other studies such as search of resistant variety against both pathogen, adopting the appropriate agronomic practices to control the diseases and integrated diseases management approach towards both diseases.

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Isolation, Identification and Pathogenecity of Collar Rot in Chilli (*Capsicum annuum* L.)

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Abstract

In recent years, collar rot diseases in chilli is severely infecting in many parts of India and causes major economic losses about 16-80 per cent yield loss in India. As chilli is most important vegetable as well as spice crop of India causal pathogen should be isolated, identify and their symptomatology should be studied. Therefore, we conducted a experiment on fungal isolation, identification, purification and pathogenecity from the infected plant parts of and collar rot. Typical symptoms of collar rot shows dark brown lesions on the stem and white mycelium crept down adjacent to the ground and creamy to white or brown colour spherical sclerotia on infected roots and stem. Followed by drooping and wilting of infected leaves due to loss of vigour and gradual wilting of the whole plant. On reisolation of pathogen it was found that pathogens was identical to original isolates and identified as and *Sclerotium rolfsii* causal agent of collar rot of chilli. These study provide an elementary idea about collar rot diseases as well as paved the path for seeking of proper recommendation of proper farming practices to combat against both the diseases.

Key words : Chilli, identification, pathogenecity, collar rot and *sclerotium rolfsii*

Introduction

Chilli (*Capsicum annuum* L.,) 2n=24 is one of the most important vegetable as well as spice and a cash crop of India and belongs to the family *Solanaceae*. It is grown in tropical and subtropical regions of the world for its pungent fruits which are used both green and ripe. Chilli is the most widely used spice and condiment in the world and is greatly priced for its pungency and adding special flavor to many cuisines throughout the world. In India, 2020-2021 chilli grown on 0.74 million hectares area, with production of 1.91 million tons and productivity 2.57 metric tons per hectares (Anon., 2020a). In Gujarat, its area and production were 11299 hectares, 22051 MT, respectively (Anon., 2020b). Though India is the leading producer, the average yield of chilli is very low (1.11 t/ha dry chilli) as compared to developed countries like USA, China etc, where the average yield ranges from 3-4 t/ha (Bai *et al.*, 2018). But in the recent years, the production and productivity is constrained due to many biotic and abiotic stresses. Among them the most devastating are fungal diseases like collar rot which lower the yield considerably annually and emerged as serious problem in past decade.

Sclerotium collar rot induced by *Sclerotium rolfsii* Sacc. is a major problem in chilli which may be contributed due to scanty rainfall and high temperature at the cropping time. The disease causes extensive losses under favourable conditions. It causes up to 16- 80 % reduction in yield (Singh and Dhancholia, 1991; Mathur and Gurjar, 2001).

Materials and Methods

Collection and isolation of collar rot pathogens : The samples were collected from chilli infected field of collar rot and were brought to Department of Plant Pathology, CoA, JAU, Junagadh laboratory for isolation. Pathogens were isolated by standard tissue isolation technique (Tuite, 1969). The infected plant part were sliced into 5-6 mm size small pieces after being rinsed with tap water to remove all soil particles. After disinfecting the pieces, using 0.1 per cent mercuric chloride solution for one minute, they were washed three times in sterilised distilled water to eliminate excess mercuric chloride solution. In each Petri plate, three to four pieces were aseptically plated on sterilised potato dextrose agar with the help of forceps. The Petri plates were incubated at 28 ± 1 °C for 10 days. The culture were purified by single hyphal tip technique (Rangaswami, 1972). The hyphal tip from margins of resulting colonies were cut with the help of sterilized 5 mm cork borer and transferred to petri plates containing PDA media and maintained by mass transfer on PDA slants and incubated at 25 ± 1 °C for further studies.

Maintenance of the culture : The fungus were subcultured on the PDA slants and allowed to grow at 25 ± 1 °C. The culture obtained was stored at 4 °C for further studies and was subcultured periodically.

Pathogenicity and symptomatology of collar rot pathogens : Pathogenicity of the isolate *S. rolfsii* was proved under net house condition by soil infestation method. To establish the pathogenicity earthen pots of the



Fig.-2 : Pathogenicity and morphological characteristics of *Sclerotium rolfsii*. (A) Pathogenicity, H=Healthy and I=Inoculated. (B) White mycelial growth and dark sunken lesion at crown region. (C) White fluffy growth of mycelium and white sclerotia. (D) Mature brown sclerotia. (E) Septate mycelium with clamp connection.

size 15 cm width x 15 cm depth were used and sterilized by 4 per cent formaldehyde solution. Whereas soil was sterilized by autoclaving at 15 lbs psi (1.038 kg/cm^2) at 121.6°C for one hour for three consecutive days.

The inoculum of *Sclerotium rolfsii* was prepared on half boiled sorghum grain media. 250 grams of the medium (sterilized sorghum grain) will filled into plastic bags of two kg size and then sterilized at 15 lbs psi (1.038 kg/cm^2) for a hour for two consecutive days. The flasks/polyethylene bags containing the sterilized media was inoculated with mycelial disc of *Fusarium* and *Sclerotium* (five mm diameter) using cork borer and incubated at $28 \pm 1^\circ \text{C}$ for 10 days. This inoculum were used for soil inoculation at 40 g/kg soil in the upper 4 to 5 cm layer in each pot except control (Shirsole *et al.*, 2018). The pots without the inoculation of fungus served as control. After one week, five chilli seedlings per pot (30 days old) of local hybrid cultivar were transplanted and watering was done as and when required.

The plants were observed regularly for the appearance and development of the disease symptoms. The symptoms of collar rot disease of chilli were studied and expression of the characteristic symptoms and if any variation observed were recorded. The pathogenic nature of the organism was proved by following Koch's postulates.

Identification of wilt and collar rot pathogens : Morphological characters of the fungus were studied with

the help of a compound microscope. Slides of the fungus were prepared by staining an actively growing fungus with cotton blue. After calibrating the microscope shape, size and colour of hyphae, conidia and sclerotia were taken with the help of ocular and stage micrometers. The causal fungus were identified on the basis of its morphological and cultural characters.

Results and Discussion

Isolation of collar rot pathogens : The pathogen were isolated on Potato dextrose agar medium from surface sterilized roots of wilted and collar rot chilli plants showing typical symptoms. The growth of fungus from infected tissue was distinctly visible after three to four days in Petri plates containing the Potato dextrose agar medium and put forth moderately rapid growth covering the Petriplate in 7-10 days.

Pathogenicity and symptomatology of collar rot pathogens : Pathogenicity of collar rot pathogens was proved by applying soil infestation method in pot and transplanting seedlings of local hybrid cultivar of chilli. Control was maintained without inoculation of pathogens into pot.

Collar rot disease showed typical symptoms after 6 to 8 days of inoculation at root and collar regions. Initially white cottony growth of mycelium crept at the base of stem or collar region of plant is observed. On such infected roots and stem black to brown sclerotia are found

at inoculated plants. Severely infected chilli plants showed characteristics yellowing of leaves followed by loss of vigour and death of the plants. The diseased plants can be easily pulled out easily from the soil. Reisolation of collar rot pathogens were performed by placing sclerotia and infected root on PDA plates. Reisolated cultures of the collar rot pathogen exhibited similar cultural characteristics to those of the isolates obtained/isolated from naturally collar rot infected chilli plants. Similarly, Ansari and Agnihotri (2000), Yaqub and Shahzad (2005), Shinde and Reddy (2009) and Hussain *et al.* (2010) proved the pathogenecity of *S. rolfsii* by soil infestation method.

Identification of collar rot pathogens : *Sclerotium rolfsii*
Sacc. colonies grew fast on PDA attained diameter of 90 mm within 5 days at room temperature with profuse mycelia growth after 6 to 7 days whitish sclerotial formation occurred. Initially the fungus produced white profuse mycelia growth, which gradually turned brown-black due to the formation of numerous small brown-black sclerotia which is initially whitish after 5 to 6 days when it mature it turned in to the dark brown to black color. The mycelium was aggregate, dense cottony and alight fluffy. After 4-day of incubation period on PDA at 25 °C, a typical clamp connection structure was observed in the hyphae. The sclerotia formed in culture were brown-black, round shaped, peripheral, scattered all over plate. Sclerotia were spherical to ellipsoidal in shape and measured 0.5 to 2.05 mm in diameter. The studies on the morphological characters of isolated *Sclerotium* sp. showed its closed identity with *Sclerotium rolfsii* Sacc. described by Cillierse *et al.* (2000), Pandey *et al.* (2005), Okereke and Wokocha (2007), Akram *et al.* (2008), Hussain *et al.* (2010), Rakholiya and Jadeja (2011) and Tortoe and Clerk (2012). Based on symptomatology (naturally and artificially wilted plants), morpho-cultural characteristics, microscopic observations and pathogenicity test, the test pathogen was identified as *Sclerotium rolfsii*.

Conclusions

In the present study, fungal diseases of chilli collar rot was isolated and identified from infected field. Further pathogenecity was proved by soil infestation method and Koch's postulates were proved and identified as *Sclerotium rolfsii*. The results can be useful for other studies such as search of resistant variety against both pathogens, adopting the appropriate agronomic practices to control the diseases and integrated diseases management approach towards both diseases.

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Effect of Zinc and Boron on Yield and Yield Attributes of Linseed (*Linum usitatissimum* L.)

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Abstract

Present field investigation was conducted during rabi season of 2022-23 at Agriculture Botany Farm, Shri Shivaji Agriculture College, Amravati. The linseed variety "PKV NL-260" taken for experimentation was sown on 25th November. The seed rate of 25 kg ha⁻¹ with recommended dose of fertilizers was 60:30:00 N:P:K kg ha⁻¹ respectively. The experiment was laid out in Randomized Block Design replicated thrice with nine treatments viz, RDF + Control (T1), RDF + Soil application of ZnSO₄ @ 25 kg/ha (T2), RDF + Foliar application of ZnSO₄ @ 0.5% at 45 DAS (T3), RDF + Soil application of ZnSO₄ @ 25 kg/ha + Foliar application of ZnSO₄ @ 0.5% at 45 DAS (T4), RDF + Soil application of Borax @ 1.5 kg/ha (T5), RDF + Foliar application of Borax @ 0.3% at 45 DAS (T6), RDF + Soil application of Borax @ 1.5 kg/ha + Foliar application of Boron @ 0.3% at 45 DAS (T7), RDF + Foliar application of ZnSO₄ @ 0.5% + Borax @ 0.3% at 45 DAS (T8) and RDF + Soil application of ZnSO₄ @ 25 kg/ha + Borax @ 1.5 kg/ha (T9). Application of RDF + foliar application of ZnSO₄ @ 0.5% + borax @ 0.3% at 45 DAS recorded significantly highest seed yield (1183.0 kg ha⁻¹) over RDF + Control (906.33 kg ha⁻¹) in linseed. Maximum harvest index (34.33%) was recorded with RDF + foliar application of ZnSO₄ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to RDF + Control (32.74%).

Introduction

Linseed (*Linum usitatissimum* L.) is a major rabi oilseed crop of the country, and it is next in importance to rapeseed and Mustard in area as well as production. India occupies fourth largest linseed growing country in the world (10.8%) after Kazakhstan, Canada and Russia. Linseed seed rich in protein (20%), oil (41%) and dietary fibre (28%). Linseed is basically an industrial oilseed crop and its every part is endowed with commercial and medicinal importance (Marchenkov *et al.*, 2003)^[1]. It is grown mainly for seeds which are used for extracting oil as well as fibre which is used for manufacturing of linen. The seed of linseed contains about 33-47 percent oil. It contains 35-70% linolenic acid (Omega-3 fatty acid), the factor which reduces blood cholesterol concentration. It is generally grown under rainfed condition with little use of micronutrients, such as zinc and boron, however, its cultivation is widely extended in irrigated areas because of higher yield potential. Linseed has many industrial, medicinal properties and used for value added product. One of the limiting factors for low yield is due to poor management of inputs. The average yield of flax is very low in India due to many constraints like poor soil fertility, inadequate application of macro and micronutrients, competition with other crop and traditional crop management practices. Due to constantly increasing demand of the crop, there is a direct need to increase seed yield potential of flax crop. Its production can be increased by growing high yielding cultivators and by the uses of macro and micronutrients in balance quantity.

Micronutrients especially zinc and boron play very important role in increasing yield, uptake, and quality of linseed. (Md. Parwaiz Alam *et al.*, 2020)^[2] The deficiency of these two micronutrients in soil adversely affects the growth and development of linseed. Zinc is one of the essential micronutrients require for optimum crop growth and deficiency of it causes various adverse effect on growth and yield of linseed. Boron plays a significant role in enzyme activation, protein synthesis, improves photosynthesis and is associated with calcium uptake and its utilization. Boron application imposed a positive trend in production of more dry matter, seed yield and oil content. The research was on zinc and boron application and its effect on growth and development of linseed is very meagre. Therefore, an experiment was conducted to find out the suitable dose of zinc and boron for linseed.

Materials and Methods

Present field investigation was conducted during *rabi* season of 2022-23 at Agriculture Botany Farm, Shri Shivaji Agriculture College, Amravati. The soil of the experimental site was medium black with 4.21 kg ha⁻¹ organic carbon, Bulk density 1.41 g cm² and initial status of soil was 188, 18, 326 Kg ha⁻¹ N:P:K respectively. The linseed variety "PKV NL-260" taken for experimentation was sown on 25th November. The seed rate of 25 kg ha⁻¹ with recommended dose of fertilizers was 60:30:00 N:P:K kg ha⁻¹ respectively. The experiment was laid out in Randomized Block Design replicated thrice with nine treatments viz, RDF + Control (T1), RDF + Soil application of ZnSO₄ @ 25 kg/ha (T2), RDF + Foliar application of

Table-1 : Effect of zinc and boran application.

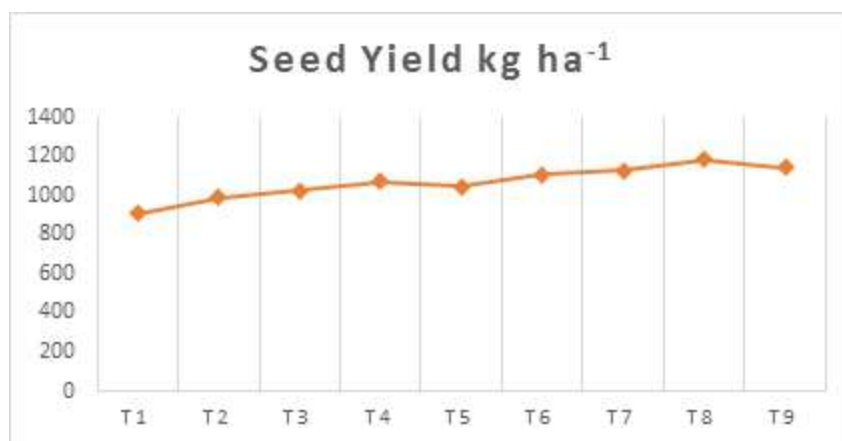
S.No.	Treatments	Capsules plant ⁻¹	Seeds capsules ⁻¹	Test weight (g)	seed yield kg ha ⁻¹	stover yield Kg ha ⁻¹	Harvest index %
T1	RDF + control	30.33	5.67	5.47	906.33	1845.67	31.70
T2	RDF + Soil application of ZnSO ₄ @ 25 kg ha ⁻¹	34.33	6.73	6.73	991.00	2022.67	33.32
T3	RDF + foliar application of ZnSO ₄ @ 0.5% at 45 DAS	31.67	7.07	6.23	1026.33	2081.33	32.37
T4	RDF + Soil application of ZnSO ₄ @ 25 kg ha ⁻¹ + foliar application of ZnSO ₄ @ 0.5% at 45 DAS	36.00	7.13	6.80	1072.67	2180.33	32.76
T5	RDF + Soil application of Borax @ 1.5 kg ha ⁻¹	31.33	6.97	6.77	1048.00	2139.33	33.06
T6	RDF + foliar application of Borax @ 0.3 % at 45 DAS	36.33	7.27	6.90	1109.33	2209.33	32.95
T7	RDF + Soil application of Borax @ 1.5 kg ha ⁻¹ + foliar application of Borax @ 0.3 % at 45 DAS	37.33	6.83	6.83	1128.33	2222.00	32.97
T8	RDF + foliar application of ZnSO ₄ @ 0.5% + foliar application of Borax @ 0.3 % at 45 DAS	43.00	7.33	7.10	1183.00	2252.67	34.37
T9	RDF + Soil application of ZnSO ₄ @ 25 kg ha ⁻¹ + Soil application of Borax @ 1.5 kg ha ⁻¹	41.67	6.67	6.67	1145.00	2239.33	33.35
	SE m±	1.012	0.270	0.273	25.627	41.771	0.385
	CD (P=0.05)	3.004	1.116	1.128	105.862	172.551	1.589

ZnSO₄ @ 0.5% at 45 DAS(T3), RDF + Soil application of ZnSO₄ @ 25 kg/ha + Foliar application of ZnSO₄ @ 0.5% at 45 DAS(T4), RDF + Soil application of Borax @ 1.5 kg/ha(T5), RDF + Foliar application of Borax @ 0.3% at 45 DAS(T6), RDF + Soil application of Borax @ 1.5 kg/ha + Foliar application of Boron @ 0.3% at 45 DAS(T7), RDF + Foliar application of ZnSO₄ @ 0.5% + Borax @ 0.3% at 45 DAS (T8) and RDF + Soil application of ZnSO₄ @ 25 kg/ha + Borax @ 1.5 kg/ha(T9). The observations were recorded as per the standard procedure by sampling from three places in each plot. All data recorded were analyzed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez 1984)^[3]

Results and Discussion

An appraisal of data (Table-1) revealed that significantly highest number of capsules plant⁻¹ (43.0) were registered with RDF + foliar application of ZnSO₄ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to control (30.33). This might be due to micronutrient application at vegetative stage, increased the nutrient uptake and chlorophyll content that resulted into production of greater number of branches plant⁻¹ and ultimately greater number of capsules. Similar results on linseed were also reported by Elayaraja (2015)^[4], Swati Kumari and Santosh Kumar (2021)^[5]. Number of seeds capsule⁻¹ was significantly influenced by micronutrient treatments. Availability of these micronutrients to the crop increases the number of seeds per capsule. Significantly highest numbers of seeds per capsule (7.33) were registered with RDF + foliar application of ZnSO₄ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to RDF + Control (5.67). Similar results on

linseed were also reported by Mousa *et al.* (2010)^[6]. Test weight was influenced by micronutrient treatments and got better nutrient availability of specially zinc and boron at branching stage for their growth and development there by increasing the weight of the seed. The significantly highest test weight (7.10) was registered with RDF + foliar application of ZnSO₄ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to RDF + Control (5.47). Singh *et al.*, (2020)^[7] also reported similar findings. Seed yield of linseed had shown positive response to different micronutrient treatments. Application of RDF + foliar application of ZnSO₄ @ 0.5% + borax @ 0.3% at 45 DAS recorded significantly highest seed yield (1183.0 kg ha⁻¹) over RDF + Control (906.33 kg ha⁻¹) in linseed which might have influenced the metabolism of carbohydrate positively leading to increased translocation and partitioning of photosynthates towards growth and yield attributing characters, thereby increasing seed yield of linseed. Mishra *et al.*, (2016)^[8] and Swati Kumari and Santosh Kumar (2021)^[5] in linseed had also reported similar results. Application of RDF + foliar application of ZnSO₄ @ 0.5% + borax @ 0.3% at 45 DAS recorded significantly highest straw yield (2252.67 kg ha⁻¹) over RDF + Control (1845.67 kg ha⁻¹) in linseed. These findings are in close conformity to those of Singh and Singh (2017)^[9] in linseed. The data on harvest index (HI) under the influence of different micronutrient treatments in linseed showed that there is significant impact of micronutrient treatments on harvest index. However, maximum HI (34.33%) was recorded with RDF + foliar application of ZnSO₄ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to RDF + Control (32.74%). Similar results have also been reported by Alam *et al.*, (2021)^[10].



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Costs and Returns Analysis of Jatropha Plantation and Other Major Crops Grown In Virudhunagar District of Tamil Nadu, India

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Abstract

The Government of India had launched the National Biofuel Mission in the year 2003 as an initiative to limit the country's dependence on crude oil imports. An integral part of this mission is the Biodiesel Blending program and Jatropha, a tree-borne biodiesel yielding crop, is the keystone of the program. This study has been specifically designed to carry out economic assessment of the upcoming jatropha-based biodiesel value chain in TamilNadu state. The study, based on primary data collected from major jatropha growing Virudhunagar district, TamilNadu has observed that jatropha cultivation was an extensively cultivation scheme in the long-run as indicated by favourable values of costs and return analysis were worked. The net returns per hectare remained positive with Rs.16329.84 for green gram, Rs.14350.70 for black gram, Rs.7789.50 for cumbu traditional (rainfed variety, CO1), Rs.14188.40 for the cumbu hybrid, Rs.11180 for cotton traditional, Rs.17400 for hybrid Bt cotton and Rs.7415.50 for sorghum. However, for jatropha, in the initial two years there were no returns, from third year onwards the plant started producing seeds. From the fifth year onwards, the yield is expected to stabilize. However, the existing biodiesel value chain in India lacks this integration and is characterized by under-developed seed markets, sub-optimal processing infrastructure and ill-defined biodiesel distribution channels. The involvement of corporate players to participate in processing and distribution activities has further delayed the program to take off. The study has cautioned that unless proactive orientation of all the stakeholders is ensured, the program may fail to meet its objectives, at least in the medium-term.

Key words : *Jatropha, bio-diesel, establishment cost, maintenance cost, tamilnadu, costs and returns.*

Introduction

With fast depletion of fossil fuels, increasing focus is being given to the development of bioenergy as a potential future source of energy and this has brought jatropha, a tree-borne oil seed crop, into limelight. The plant jatropha (*Jatropha curcas*) is widely known as a feedstock crop for biodiesel. World over, considerable investments are being made on the jatropha-based biodiesel development projects. A survey conducted by Global Exchange for Social Investment (GEXSI, 2008) has identified 242 jatropha projects in different parts of the world and a majority of them are located in Asia. India is currently the leading cultivator of jatropha with more than 0.4 M ha (million hectares) of area under this crop. In India, it is the Planning Commission report on development of biofuel that has officially endorsed the use of jatropha as a feedstock for biodiesel production (GOI, 2003). Even though various other oilseeds also qualify as feed stocks for biodiesel, jatropha has been specifically chosen because it is a non-edible oilseed crop which does not impinge on the food security of the nation even if promoted commercially. Also, jatropha is a drought-tolerant and hardy crop which can be grown in a relatively less fertile and marginal lands with minimal inputs and management. The scope of earning 'carbon credits' from jatropha cultivated lands is considered as an added advantage.

Several studies at the global level too favour the cultivation of jatropha in marginal or less productive lands (Tilman *et al.*, 2009; Fargione *et al.*, 2008).

The Government of India has introduced a numerous of programs and policies to encourage the upcoming of biofuel sector in the country. As a part of this, the National Biofuel Mission (NBM) was launched in the year 2003, of which Biodiesel Blending Program (BDBP) and Ethanol Blended Petrol Program (EBPP) are the integral components. The BDBP mandates blending of biodiesel in high speed diesel (HSD) with a target of effecting 5 per cent blending by the year 2012, 10 per cent by 2017, and 20 per cent after 2017. As substantial area is to be brought under biofuel plantations to meet the mandated blending target, the government policy is to utilize the wastelands available across the country to grow non-food biofuel crops. In its 2003 report, the Planning Commission has mentioned that an estimated area of around 13.4 M ha is suitable to plant jatropha. To ensure fair price to the farmers growing jatropha, various state governments have announced Minimum Support Price (MSP) for jatropha seeds. The Minimum Purchase Price (MPP) offered by the oil marketing companies acts as a guarantee to the biofuel (both bioethanol and biodiesel) manufacturers against price holders. Various subsidy programs and tax concessions/exemptions are also part

of the government's effort to speed up the partial transition from fossil fuels to biofuels. For instance, National Oilseeds and Vegetable Oils Development Board (NOVOD) under the Ministry of Agriculture, Government of India, is providing a back-ended subsidy of 30 per cent for the promotion of tree-borne oilseeds like jatropha and pongamia. Along with government, other non-state actors such as non-governmental organizations (NGOs), self-help groups (SHGs), co-operative societies, private entrepreneurs, and corporate bodies are also involved at various levels in the jatropha based biodiesel value chain.

Materials and Methods

Seven villages one each predominantly cultivating the selected crops were taken in Virudhunagar block in Virudhunagar district of TamilNadu have been identified and 10 farmers from each of the selected villages were chosen randomly (constituting a total sample size of 70). Major Jatropha cultivators among these farmers provided data on cost and returns for Jatropha. A detailed questionnaire was prepared, field tested and finalized. The data collected relate to the crop year 2018-19.

Tools of Analysis

Plantation of Jatropha and Associated Costs in TamilNadu : Cost of jatropha plantation varies depending upon its geographical location, agro-climatic condition, input-use, other operational practices, etc. The per hectare estimated cost, associated with different stages of jatropha plantation are discussed in brief below.

(a) Establishment Cost : The establishment cost of jatropha plantation includes the costs on seedlings, farm yard manure (FYM), labour on various activities, farm building, etc. However, seedling and labour costs were found as the only two components of establishment cost in TamilNadu.

(b) Operation and Maintenance Cost : Operation and maintenance cost of jatropha included the costs incurred on post plantation management operations. These operations include soil working and weeding, FYM and fertilizer application, pruning, application of insecticides and pesticides, etc. However, in TamilNadu, pruning, weeding, and replanting were the major post-plantation operations. The major component of cost in these operations was the cost on labour. However, these costs varied from state to state as scale of operation varies across states.

The fruiting in jatropha takes place at the top of its shoots. The pruning ensures increase in branching and thus availability of more fruits. Another aspect of pruning is that it keeps a plant in an appropriate size and shape.

Apart from pruning and weeding, replanting is another post plantation operation found in TamilNadu, India. It is done to fill the gaps in the plantation area where existing plants become dead. However, the mortality rate of jatropha plant in the state being low, the cost on replanting is also low. Other activities such as application of irrigation, FYM, fertilizer, etc. are not common in the state.

Results and Discussion

The cropping pattern in the sample farms reveals a diversified set of crops grown with maize (29.35 per cent), sorghum (25.68 per cent), cumbu (12.22 per cent), cotton (9.58 per cent), Flowers Jasmine (7.20 per cent), sun flower (3.98 per cent), pulses like black gram and green gram (6.67 per cent) together accounting for 94.62 per cent of the total cropped area. Jatropha occupied only 0.50 per cent of the total cropped area in the sample farms (Table-1).

The cost and returns of the possible major grown crops for Jatropha in rainfed conditions, namely; green gram, black gram, cumbu, cotton and sorghum, which occupied 54.15 per cent of the total cropped area in the sample farms, revealed that the net returns per hectare remained positive with Rs.16329.84 for green gram, Rs.14350.70 for black gram, Rs.7789.50 for cumbu traditional (rainfed variety, CO1), Rs.14188.40 for the cumbu hybrid, Rs.11180 for cotton traditional, Rs.17400 for hybrid Bt cotton and Rs.7415.50 for sorghum. The duration however are approximately 3 months, 3 months, 4 months 4.5 months and 4 months, respectively for green gram, black gram, cumbu, cotton and sorghum unlike Jatropha which is a perennial crop and annual yields are computed on yearly basis hence effectively 12 months. This also precludes the option in jatropha cultivation of changing crops after a season or the next year. Therefore, the net return per month considering the duration of the crops was also worked out for the competing crops and jatropha. The net return per hectare per month was Rs.5443.28 for green gram, Rs.4783.57 for black gram, Rs.1947.38 for cumbu traditional/local variety, Rs.3547.10 for cumbu hybrid, Rs.2484.44 for cotton traditional variety, Rs.3866.67 for hybrid Bt cotton and Rs.1853.88 for sorghum (Table 2-8).

However, for jatropha, in the initial two years there were no returns, from third year onwards the plant started producing seeds. From the fifth year onwards, the yield is expected to stabilize. Accordingly, for jatropha the net return per hectare per month worked out to Rs. -332.33 and Rs. -151.63 for the 3rd and 4th year, respectively and from the fifth year onwards, it was estimated to be Rs.29.08. The net return per hectare per month from

Table-1 : Cropping Pattern in the Sample Farms in Virudhunagar district of Tamil Nadu (Ha).

S. No.	Crops	Aruppukkottai Block							All
		Koppu Siththam Patti	Vadhuvaar Patti	Ramanaicken Patti	Ramanaicken Patti (West)	Amanaku Naththam	Periya Puliampatti	Gopala Puram	
1.	Sorghum	8.91 (8.62)	2.43 (10.66)	6.68 (21.57)	0.81 (4.57)	47.98 (49.85)	42.91 (32.51)	0 (0.00)	109.72 (25.68)
2.	Maize	21.86 (21.13)	0.81 (3.55)	3.24 (10.46)	5.67 (31.96)	33.91 (35.24)	53.85 (40.80)	6.07 (25.11)	125.41 (29.35)
3.	Cumbu	41.70 (40.31)	0 (0.00)	0 (0.00)	0 (0.00)	4.45 (4.62)	6.07 (4.60)	0 (0.00)	52.22 (12.22)
4.	Black gram	4.45 (4.30)	0 (0.00)	8.40 (27.12)	1.01 (6.68)	0.40 (0.42)	0 (0.00)	0.40 (1.66)	14.66 (3.43)
5.	Green gram	3.64 (3.52)	2.02 (8.86)	6.98 (22.54)	0 (0.00)	0.40 (0.42)	0 (0.00)	0.81 (3.35)	13.85 (3.24)
6.	Sunflower	0 (0.00)	0 (0.00)	0.40 (1.29)	0 (0.00)	0 (0.00)	16.60 (12.58)	0 (0.00)	17 (3.98)
7.	Jatropha	0 (0.00)	2.13 (9.35)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2.13 (0.50)
8.	Coconut	0 (0.00)	0 (0.00)	0 (0.00)	0.04 (0.22)	0.81 (0.84)	0 (0.00)	0 (0.00)	0.85 (0.20)
9.	Banana	0 (0.00)	0 (0.00)	0.61 (1.97)	3.24 (18.26)	0.40 (0.42)	0 (0.00)	0 (0.00)	4.25 (0.99)
10.	Cotton	6.68 (6.46)	8.30 (36.42)	2.23 (7.20)	2.13 (12.01)	7.29 (7.57)	0 (0.00)	14.07 (58.21)	40.70 (9.52)
11.	Flowers (Jasmine)	15.59 (15.07)	0 (0.00)	0.81 (2.62)	2.62 (14.77)	0 (0.00)	11.74 (8.90)	0 (0.00)	30.76 (7.20)
12.	Vegetables	0.61 (0.59)	0.61 (2.68)	1.62 (5.23)	1.41 (7.95)	0 (0.00)	0 (0.00)	2.42 (10.01)	6.67 (1.56)
18.	Others	0 (0.00)	6.49 (28.48)	0 (0.00)	0.81 (4.57)	0.60 (0.62)	0.81 (0.61)	0.40 (1.66)	9.11 (2.13)
	Total	103.44 (100.00)	22.79 (100.00)	30.97 (100.00)	17.74 (100.00)	96.24 (100.00)	131.98 (100.00)	427.33 (100.00)	

(Numbers in parentheses indicate percentage to total cropped area)

Table-2 : Cost and returns of Green gram (VBN3) Cultivation in Sample Farms in Virudhunagar district of Tamil Nadu (Year 2018-19).

S. No.	Particulars	Qty	Value (Rs.)
1	Human labour (Man days)	74.1	13091 (53.12)
2.	Machine labour (hrs)	6.17	3458 (14.03)
3.	Seeds (Kg)	7.41	333.45 (1.35)
4.	Manures (Tonnes)	2.47	2470 (10.02)
5.	Fertilizer nutrients (Kg)	-	-
	N	3.705	167.96 (0.68)
	P	-	-
	K	123.5	3211.00 (13.03)
	DAP		
6.	Plant Protection Chemicals (litre)	3.08750	1482 (6.01)
	(Rogar1.2350, Monocrotophos1.8525)	0.61750	432.25 (1.76)
	Aceta Powder 0.6175(Kg)		
7.	Total variable cost (Rs)		24645.66 (100.00)
8.	Yield (quintal)		9.26
9.	Price (Rs/quintal)		4425
10.	Gross return(Rs)		40975.50
11.	Net return (Rs)		16329.84
	(Numbers in parentheses indicate percentage to total cost.)		
S.No.	Particulars		Value (Rs)
1.	Net returns per month		Rs.5443.28

Table-3 : Cost and returns of Black gram (VBN3) Cultivation in Sample Farms in Virudhunagar district of TamilNadu (Year 2018-19).

S. No.	Particulars	Qty	Value (Rs)
1.	Human labour (Man days)	79.04	10176.40 (57.14)
2.	Machine labour (hrs)	8.65	3211 (18.03)
3.	Seeds (Kg)	14.82	592.80 (3.33)
4.	Manures (Tonnes)	2.47	2470 (13.87)
5.	Fertilizer Nutrients (Kg)	-	-
	N	-	-
	P	-	-
	K	-	-
	DAP	-	-
6.	Plant Protection Chemicals (litre)	1.115	1111.50(6.24)
	Monocrotophos 1.1115 (litre)	0.247	247(1.39)
	Aceta Powder 0.247 (Kg)		
	Total variable cost (Rs)		17808.70
	Yield (quintal)		7.41
	Price (Rs/quintal)		4340
	Gross Return (Rs)		32159.40
	Net Return (Rs)		14350.70

(Numbers in parenthesis indicates per centage to total cost)

S. No.	Particulars	Value (Rs)
1.	Net returns per month	Rs. 4783.57

Table-4 : Cost and returns of Cumbu (Co 1) Cultivation in Sample Farms in Aruppukkottai Block (Year 2018-19). (Rs/ha)

S. No.	Particulars	Qty	Value (Rs)
1.	Human labour (Man days)	29	4240(40.73)
2.	Machine labour (hrs)	6.65	2300(22.09)
3.	Seeds (Kg)	2.47	370.50(3.56)
4.	Manures (Tonnes)	2	1000(9.61)
5.	Fertilizer Nutrients (Kg)		-
	N	-	-
	P	-	-
	K	-	-
	DAP (75 Kg)	75	1800(17.29)
	Complex Mixture (17:17:20) (50 Kg)	50	400(3.84)
6.	Plant Protection Chemicals (Kg)		175(1.68)
	Neem Powder 1.247 (Kg)	1.247	125(1.20)
	+ Urea 25 (Kg)	25	
	Total variable cost(Rs)		Rs.10410.50(100.00)
	Yield (quintal)		14
	Price (Rs/quintal)		1300
	Gross Return (Rs)		18200
	Net Return (Rs)		7789.50

(Numbers in parenthesis indicates per centage to total cost)

S. No.	Particulars	Value (Rs)
1.	Net returns per month	1947.38

jatropha was negative in the 3rd and 4th year and very negligible from the 5th year onwards. Thus, the farmers have clear disadvantage in growing jatropha. Lack of marketing opportunities is a further discouragement for the jatropha growers (Table 9 & 10).

Talking The Limitations Obtained From The Jatropha Cultivated Farmers

The above conversation makes it clear that the development of a commercial biodiesel industry based on jatropha and other non-edible oilseeds is at a very nascent

stage in India at present. The farm surveys have suggested that the farmers are not happy with the current yield of the crop. To discourse this constraint, identification of superior germplasm with high-yield potential through systematic varietal improvement programs is a pre-requisite to large scale planting. A centrally coordinated breeding program that replaces the current piecemeal approach in research can pay high dividends. It is also extensively felt that jatropha is not a fully domesticated crop and cannot be grown successfully in all kinds of marginal lands. Unscrupulous planting

Table-5 : Cost and returns of Cumbu (Pioneer hybrid) Cultivation in Sample Farms in Aruppukkottai Block (Year 2018-19).
(Rs/ha)

S. No.	Particulars	Qty	Value (Rs)
1.	Human labour (Man days)	30	4350 (39.50)
2.	Machine labour (hrs)	7.42	2593.50 (23.55)
3.	Seeds (Kg)	2.47	568.10 (5.16)
4.	Manures (Tonnes)	2	1000 (9.08)
5.	Fertilizer Nutrients (Kg)		1800 (16.35)
	N		
	P		400 (3.63)
	K		
	DAP(75 Kg)	75	
	Complex Mixture (17:17:20) (50 Kg)	50	
6.	Plant Protection Chemicals (Kg)	1.247	175 (1.59)
	Neem Powder 1.247 (Kg)		
	+		
	Urea 25 (Kg)	25	125 (1.14)
	Total variable cost (Rs)		11011.60
	Yield (quintal)		18
	Price (Rs/quintal)		1400
	Gross Return (Rs)		25200
	Net Return (Rs)		14188.40

(Numbers in parenthesis indicates per centage to total cost)

S.No.	Particulars	Value (Rs)
1.	Net returns per month	Rs.3547.10

Table-6 : Cost and returns of Cotton (Traditional) Cultivation in Sample Farms in Aruppukkottai Block (Year 2018-19).
(Rs/ha)

S. No.	Particulars	Qty	Value (Rs)
1.	Human labour (Man days)	68	7000 (42.89)
2.	Machine labour (hrs)	3	1800 (11.03)
3.	Seeds (Kg)	5.5	1100 (6.74)
4.	Manures (Tonnes)	2	3400 (20.83)
5.	Fertilizer Nutrients (Kg)		2400 (14.71)
	N		
	P		
	K	100	
	DAP (50 Kg)		
6.	Plant Protection Chemicals (Kg, Litre)		300 (1.84)
	Carbofuran (0.750) (Kg)	0.750	320 (1.96)
	+	0.5	
	Neemicide 0.5 (litre)		
	Total variable cost (Rs)		16320
			(100.00)
	Yield (quintal)		10
	Price (Rs/quintal)		2750
	Gross Return (Rs)		27500
	Net Return (Rs)		11180

(Numbers in parenthesis indicates per centage to total cost)

S. No.	Particulars	Value (Rs)
1.	Net returns per month	Rs. 2484.44

irrespective of the geographical and climatic contours can only disrupt the program. Most of the jatropha growing farmers being marginal, small or resource-poor, initial support in the form of subsidized seedlings and other inputs, technical assistance, buyback assurance, minimum support price (MSP), etc. is of extreme importance for the success of biodiesel production. Early withdrawal of support facilities may jeopardise the

program. Cost and returns analysis of jatropha plantations is critical in retentive the interest of the farmers. Higher prices of seeds are being realized presently because of their demand for seedlings of new plantings. However, once this phase is over, there is every chance of prices going down unless a jatropha seed market with both backward and forward integration is changed.

Table-7 : Cost and returns of Cotton (Bt hybrid) Cultivation in Sample Farms in of Virudhunagar district of TamilNadu (Year 2018-19). (Rs/ha)

S. No.	Particulars	Qty	Value (Rs)
1.	Human labour (Man days)	70	7350 (40.83)
2.	Machine labour (hrs)	3	1850 (10.28)
3.	Seeds (Kg)	1.5	2400 (13.33)
4.	Manures (Tonnes)	2	3600 (20.00)
5.	Fertilizer nutrients (Kg) N P K DAP (50Kg)	- - - 100	- - - 2450 (13.61)
6.	Plant Protection Chemicals (Kg, litre) Carbofuran (0.750 Kg) + Neemicide 0.5 (litre)	- 0.5	- (0.00) 350 (1.95)
7.	Total variable cost (Rs)		18000 (100.00)
8.	Yield (quintal)		12
9.	Price (Rs/quintal)		2950
10.	Gross return (Rs)		35400
11.	Net return (Rs)		17400

(Numbers in parentheses indicate percentage to total cost.)

S. No.	Particulars	Value (Rs)
1.	Net returns per month	Rs. 3866.67

Table-8 : Cost and returns of Sorghum (Traditional) Cultivation in Sample Farmers in of Virudhunagar district of TamilNadu (Year 2018-19). (Rs/ha)

S. No.	Particulars	Qty	Value (Rs)
1.	Human labour (Man days)	24	4840 (38.46)
2.	Machine labour (hrs)	14	4130 (32.82)
3.	Seeds (Kg)	7.41	864.50 (6.87)
4.	Manures (Tonnes)	1	1500 (11.92)
5.	Fertilizer Nutrients (Kg) N P K DAP (50 Kg)	- - - 50	0 (0.00) 0 (0.00) 0 (0.00) 1250 (9.93)
6.	Plant Protection Chemicals (Kg, litre) Carbofuran (0.750 Kg) + Neemicide 0.5 (litre)	0 0	0(0.00) 0(0.00)
7.	Total variable cost (Rs)		12584.50 (100.00)
8.	Yield (quintal)		20
9.	Price (Rs/quintal)		1000
10.	Gross return (Rs)		20000
11.	Net return (Rs)		7415.50

(Numbers in parentheses indicate percentage to total cost.)

S. No.	Particulars	Value (Rs)
1.	Net returns per month	Rs. 1853.88

Conclusions

It is too early to judge the success of India's biofuel program though it was launched twenty years ago. There are too many beginners at this stage particularly about the jatropha based biodiesel program. Still, farm studies propose that jatropha is a profitable crop in the long-run,

provided, government support in the form of input subsidies and technical and marketing assistance is made available during the initial few years. The farmers consider jatropha as additional crop which can augment their income and employment to a certain extent but are also concerned about the uncertainty regarding its yield potential, long-term economic viability essentially linked

Table-9 : Establishment Cost of Jatropha Plantations by Sample Farmers in of Virudhunagar district of Tamil Nadu (Year 2018-19). (First Year) (Rs/ha)

Sl. No	Particulars	Month of Operation	Quantity/ha	Unit Cost	Rs/ha (1 Year)
I	Preparatory cultivation	April / May			
a.	Land preparation		2 Ploughing	Rs. 700/ Ploughing	1400 (7.13)
b.	Digging pits (1x1x1 foot)		1820	Rs. 1 per pit	1820 (9.27)
II	Planting	June / July			
a.	Cost of Seedling (including Transport)		1820 plants / Ha	Rs. 2.00 per plant	3640 (18.55)
b.	Planting labour		1820	Rs. 1.00 per pit	1820 (9.27)
c.	Basin formation		1820	Rs. 1.00 per pit	1820 (9.27)
III	Weeding (2 weeding)	Oct / Nov			
a.	Labour cost		8 women / weeding	Rs.85 / woman / day	1360 (6.93)
IV	Manure & Fertilizers application	June / July/August			
a.	Farm yard manure(FYM)		3.0 tonnes	Rs. 800 / tonne	2400 (12.23)
b.	Cost of application		4 men	Rs. 115/man/day	460 (2.34)
c.	Fertilizers 1. Urea 2. DAP 3. Potash		70Kg 80Kg 75Kg	Rs.4.5/Kg Rs.17.5/Kg Rs.6.00/Kg	315 (1.60) 1400 (7.13) 450 (2.29)
d.	Cost of application		3 women	Rs. 85 / woman / day	255 (1.30)
V	Plant protection				
a.	Cost of pesticides	(one-time insecticide and fungicide spray)			1600(8.15)
b.	Cost of application		1 women, 1 men	Rs.85/woman/day, Rs.115/men/day (Rs.20/tank @totally10tanks)	430 (2.19)
VI	Irrigation				
a.	Labour cost				
VII	Pruning	Dec / Jan			
a.	Labour cost		4 men/Ha	Rs. 115 / man / day	460(2.34)
	Applic of Application of Gibberillic acid				0
VIII	Harvest				0
a.	Labour cost				
	Total Cost				19630 (100.00)
	YIELD	Tonnes / Ha			NIL
	Gross returns	Rs. / Ha			NIL
	Average No. of Plants per ha, Net returns		1820		-19630
	Cost per Plant				10.79

(Numbers in parentheses indicate percentage to total cost.)

with a sustained demand for seeds, undesirable externalities like loss of common grazing land, etc. On the seed processing front, biodiesel can compete with petro-diesel if the processing plants are operated at sufficient economies of scale. This can be realized by safeguarding a stable supply of feedstock and consistent market demand of biodiesel and its by-products. Proper backward and forward integration at each level of the supply chain is therefore crucial in making the biodiesel industry operate at economically viable scale. So far, the participation of corporate sector in developing the processing infrastructure and distribution channels has been thin. Necessary steps have to be taken to bond this

gap. A centrally co-coordinated mechanism to supervise research, extension, development of processing and market infrastructure and various other assistance programs should replace the existing disorganized approach. Permissible provisions to check a possible change of jatropha area towards food crops is also worth considering. To conclude, practical orientation of all the stakeholders is critically important in satisfying the thrust of the program and to contribute towards the efforts to find answers for the perennial concerns of energy security, environmental sustainability and poverty reduction in the state and too country.

Table-10 : Maintenance Cost of Jatropha Plantations by Sample Farmers in of Virudhunagar district of TamilNadu (Year 2018-19). (From 2nd year on wards). (Rs/ha)

S. No.	Operations	2 nd year	3 rd year	4 th year	5 th year onwards
1.	Weeding (2weeding) a.Labour cost	1190 (10.10)	1190 (12.97)	1190 (12.40)	1190 (11.87)
2.	Fertilizer Nutrients Application (Kg) a. Cost of fertilizer 1. Urea (2 bag/100 Kg) 2. DAP (2 bag/100 Kg) 3. Potash (2 bag/100 Kg) b. Cost of application (3 mandays)	460 (3.90) 1780 (15.10) 580 (4.92) 345 (2.93)	460 (5.02) 1780 (19.40) 580 (6.32) 345 (3.76)	460 (4.79) 1780 (18.54) 580 (6.04) 345 (3.59)	460 (4.59) 1780 (17.76) 580 (5.79) 345 (3.44)
3.	Plant Protection a. Cost of Pesticide b. Cost of application (1men,1womenRs.20/tank @totally10tanks)	1700 (14.43) 420 (3.56)	1800 (19.62) 430 (4.69)	1860 (19.38) 450 (4.69)	1900 (18.95) 490 (4.89)
4.	Ear thing up	3640 (30.89)	0 (0.00)	0 (0.00)	0 (0.00)
5.	Irrigation a. Labour cost	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
6.	Pruning(two prunings at flowering) a. Labour cost	920 (7.81)	460 (5.01)	575 (5.99)	690 (6.88)
7.	Application of Gibberillic acid	750 (6.36)	750 (8.17)	750 (7.81)	750 (7.48)
8.	Harvest a. Labour cost	0 (0.00)	1380 (15.04)	1610 (16.77)	1840 (18.35)
	Total Cost	11785 (100.00)	9175 (100.00)	9600 (100.00)	10025 (100.00)
	YIELD (tons / Ha)	0	0.494	0.741	0.988
	Cost per plant (Rs)	6.48	5.04	5.27	5.51
	Gross returns (Rs./ Ha @ Rs.10.50 / Kg of seed)	0	5187	7780.5	10374
	Net returns (Rs)	-11785	-3988	-1819.5	349

(Numbers in parentheses indicate percentage to total cost.)

S. No.	Particulars	Value (Rs)			
1.	Net returns per month	2 nd year	3 rd year	4 th year	5 th year onwards
		-	-332.22	-151.63	29.08

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Comparative Economics of Cultivation of Jatropha and the Competing Crops in Tamil Nadu : A Discounted Net Returns Analysis

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Abstract

The Kyoto Protocol has initiated Clean Development Mechanism projects in developing countries as one means to offset carbon emitted in developed nations. Biofuels may be a viable solution, but we argue here that it may also compete with local smallholder farming systems, competing crops and labour resources. This study assesses the integration of tree bio-diesel crop *Jatropha curcas* into smallholder agriculture in Tamil Nadu, India using data collected from 110 farms through surveys and interviews. *Jatropha* cultivation carries significant risks for the smallholders. *Jatropha* competes for space and harvest labour with other market and subsistence crops and does not produce any economic returns until three years after planting. If the *jatropha* harvests or market price fail or fluctuate, smallholders could default on their loans. This risk could lead to significant changes in the land-holding class structure. Climate change policies, non-governmental organizations, and national and regional governments should support landholders to sustainably integrate a new crop like *jatropha* into current holdings, otherwise the current alternative energy revolution could create more problems than it solves. Smallholders are particularly vulnerable to economic risk and crop failure exposure even with well-planned biofuel policies. The results reveal that maize is the most profitable crop under the three scenarios of discounting (i.e., at 7%, 10% and 12% discount rates.). Maize is a competing crop to *Jatropha*.

Key words : Bio-fuels, *Jatropha curcas*, comparative economics, discount net return, Tamil Nadu.

Introduction

India's biofuel policy regime is influenced broadly by: (a) energy security concerns – ever increasing energy demand necessitates search for renewable energy alternatives given India's limited fossil fuel reserves; (b) environmental concerns – growing local pollution and climate change concerns make it imperative to search for environmentally friendly alternatives; (c) wasteland utilization – biofuel feedstock cultivation could bring wastelands and other unproductive lands for effective utilization; and (d) enhance rural livelihood options. The National Policy on Biofuels adopted in 2009 envisaged strengthening India's energy security by encouraging use of renewable energy resources to supplement transport 5 fuels. The policy aimed at achieving 20 percent blending of transport fuels (petrol and diesel) with bioethanol and bio-diesel by 2017.

The feasibility analysis of meeting blending targets outlined in the National Biofuel Policy raises important issues regarding land availability in case of biodiesel production, and the need for identifying alternative feedstock in case of bioethanol production. Based on the Integrated Energy Policy projections, India's high speed diesel (HSD) requirement would reach 190 million tons by 2031-32. Twenty percent blending target outlined in the National Biofuel Policy 2009 translates to 6 biodiesel

demand of about 38 million tons by 2031-32. With a yield of around 3.75 tons per ha, cultivating *jatropha* in 33.2 million hectares of land would meet the biodiesel demand. Singhal and Sengupta (2012) show that about 37.38 million hectares of wasteland suitable for *jatropha* cultivation is available in India. However, as discussed further in the fourth section below, the wasteland is not strictly wasteland with significant rural population dependent on miscellaneous tree growth supported by such lands. Also, the overall area under food grains has remained static in India over past decade or so. In such context use of wasteland for fuel purposes remains debatable. This acquires further importance in the context of South Asian Enigma of stagnant per-capita food consumption (compared to North Africa and West Asia) despite impressive growth registered in terms of per-capita income.

For example, the molasses prices in the last decade have fluctuated between Rs 1000 and Rs 5000 per ton (Shinoj *et. al.*, 2011). Additionally, ethanol produced has many other alternative uses such as potable alcohol, and input in the chemical and pharmaceutical industry. During the constrained ethanol supply periods, the utilization tends to be more towards potable and industrial uses due to inability of the Oil Marketing Companies to procure the required amount of fuel ethanol 7 bending at prevailing market prices (Shinoj *et. al.*, 2011). Import of ethanol for

fuel usage is currently restricted through policy and even if made free, would cost the exchequer very dearly, as the international markets for ethanol are already very tight due to demand from other biofuel-consuming countries. Under the scenario of 10 percent blending requirement, the growing demand for alcohol from the potable and chemical sector (growing at 3-4 percent per annum) and the highest available alcohol from molasses pegged at 2.3 billion litres, there will still be a shortage of alcohol for blending (Basavaraj *et. al.*, 2012).

Materials and Methods

Seven villages one each predominantly cultivating the selected crops were taken in Aruppukkottai block in Virudhunagar district of TamilNadu have been identified and 10 farmers from each of the selected villages were chosen randomly (constituting a total sample size of 70). Major Jatropha cultivators among these farmers provided data on cost and returns for Jatropha and too Four villages one each predominantly cultivating the selected crops were taken in Periyanaicken Palayam block in Coimbatore district of TamilNadu have been identified and 10 farmers from each of the selected villages were chosen randomly (constituting a total sample size of 40). Hence, totally 110 sample size of farmers were taken in TamilNadu. Jatropha cultivators among these farmers provided data on discounted net return analysis for Jatropha was worked out. A detailed questionnaire was prepared, field tested and finalized. The data collected relate to the crop year 2018-19.

Results and Discussion

The results of the analysis of data collected from the sample farmers are presented in Table-1 to 6. The major results and inferences are given below :

Periyanaicken Palayam Block in Coimbatore district of TamilNadu : The comparative economics of Jatropha and the competing crops in irrigated conditions in the P.N.Palayam Block are given in Tables 1-3. The results reveal that maize is the most profitable crop under the three scenarios of discounting (i.e., at 7%, 10% and 12% discount rates.). Maize is a competing crop to Jatropha. However, when compared to the discounted returns of other competing crops namely, Bengal gram (chick pea), cow pea and sorghum, Jatropha performs better if the duration of the crops is ignored. But, the issue is twofold; (i) Jatropha market is characterized by oligopsony wherein only few buyers are available (the oil marketing companies), more so, the enforcement of bio-fuel mixing is not strictly enforced, whereas the competing crops operate in a near perfect competitive market and there is flexibility altering area depending on market on year to year basis; (ii) Even while, the competing crops yield

positive net returns in all the years, Jatropha starts yielding only in the third year, more over, to recover the initial investment of two years coupled with the maintenance expenditure from the third year onwards, it takes four years. These are the discouraging factors in cultivation of jatropha. However, out of 40 farmers who previously had jatropha, fifteen of them up rooted the crop in the absence of market especially in Periyanaicken palayam block sample farms (Tables 1-3).

Aruppukkottai Block in Virudhunagar District of TamilNadu : The comparative economics of Jatropha and the other competing crops in rainfed conditions are given in Tables 4-6. The results revealed that Bt cotton, green gram are the most profitable crops under the three scenarios of discounting (i.e., at 7%, 10% and 12% discount rates.). Discounted returns of other competing crops namely, black gram, cumbu (Traditional Co-1 variety) and (Pioneer hybrid), cotton (traditional variety) and sorghum also indicate these are profitable, whereas Jatropha in Aruppukkottai block under rainfed condition resulted in heavy loss, when discounted over a period of 15 years. Besides, as in the case of Periyanaicken Palayam Block, the issue is again twofold: (i) Jatropha market is characterized by oligopsony wherein only few buyers are available (the oil marketing companies), more so, the enforcement of bio-fuel mixing is not strictly enforced, where as the competing crops operate in a near perfect competitive market and there is flexibility of altering area depending on market on year to year basis. Similarly it was also observed that farmers have uprooted the Jatropha plantations in most case, out of 70 farmers who previously had jatropha, forty of them up rooted the crop in the absence of market as a result of marketing problems especially in Aruppukkottai block sample farms (Tables 4-6).

Conclusions

The field study indicated that barring a few isolated cases, the jatropha cultivation has significantly declined in the recent years. The main reasons for declined interest in jatropha cultivation include: (a) significantly lower realized yields on the fields compared to what have been achieved in the research plots; (b) substantially high irrigation requirements for achieving good yields – which again differed from what has been shown on research plots. High initial investment requirements favoured larger land holders compared to small and marginal land holders. This in turn undermined the very objective of the Biofuel Policy.

The survey and analysis of the economics of jatropha and competing crops cultivation revealed that the returns per hectare per month was invariably higher for competing crops in both the environments with the

Table-1 : Comparative Economics of cultivation of Jatropha and the competing crops: Discounted net returns for 15 years at 7% Discount rate in Periyanaicken Palayam block in Coimbatore district of Tamil Nadu. (Indian rupee)

Sl. No.	Name of crop	Discounted cost	Discounted Return	Net Discounted returns
1.	Jatropha	108730.90	258495.50	149764.60
2.	Competing crops			
	i. Maize	499423.40	694143.30	194719.90
	ii. Bengal gram	481307.70	609393.70	128086
	iii. Cowpea	230814.60	337448.20	106633.60
	iv. Sorghum	218891.40	263826	449934.62

Table-2 : Comparative Economics of cultivation of Jatropha and the competing crops : Discounted net returns for 15 years at 10% Discount rate in Periyanaicken Palayam block in Coimbatore district of Tamil Nadu. (Indian rupee)

Sl. No.	Name of crop	Discounted cost	Discounted Return	Net Discounted returns
1.	Jatropha	92176.41	206537.8	114361.4
2.	Competing crops			
	i. Maize	417071.8	579683.7	162611.9
	ii. Bengal gram	401943.3	508908.70	106965.4
	iii. Cowpea	192754.8	281805.2	89050.46
	iv. Sorghum	182797.7	220322.9	37525.20

Table-3 : Comparative Economics of cultivation of Jatropha and the competing crops : Discounted net returns for 15 years at 12% Discount rate in PeriyanaickenPalayam block in Coimbatore district of TamilNadu. (Indian rupee)

Sl. No.	Name of crop	Discounted cost	Discounted Return	Net Discounted returns
1.	Jatropha	83384.17	179365.92	95981.75
2.	Competing crops			
	i. Maize	373466.90	519077.80	145610.80
	ii. Bengal gram	359920.10	455702.30	95782.21
	iii. Cowpea	172602.30	252342.50	79740.24
	iv. Sorghum	163686.20	197288.10	33601.94

Table-4 : Comparative Economics of cultivation of Jatropha and the competing crops: Discounted net returns for 15 years at 7% Discount rate in Aruppukkottai block in Virudhunagar district of Tamil Nadu. (Indian rupee)

Sl. No.	Name of crop	Discounted cost	Discounted Return	Net Discounted returns
1.	Jatropha	100802.65	69516.40	-31286.23
2.	Competing crops			
	i. Green gram	224470.55	373201.35	148730.78
	ii. Black gram	162200.11	292905.05	130704.95
	iii. Cumbu	94817.95	165764.05	70946.10
	a. Traditional Co1variety	100292.72	259519.43	129226.73
	b. Pioneer hybrid	148641.17	250467.64	101826.48
	iv. Cotton	163942.45	322420.16	158477.70
	a. Traditional variety	114618.54	182158.28	67539.74
	b. Bt hybrid			
	v. Sorghum			

Table-5 : Comparative Economics of cultivation of Jatropha and the competing crops: Discounted net returns for 15 years at 10% Discount rate in Aruppukkottai block in Virudhunagar district of Tamil Nadu. (Indian rupee)

Sl. No.	Name of crop	Discounted cost	Discounted Return	Net Discounted returns
1.	Jatropha	85508.41	55232.54	-30275.90
2.	Competing crops			
	i. Green gram	187456.80	311662.90	124206.10
	ii. Black gram	135454.40	244607	109152.60
	iii. Cumbu	79183.09	138430.60	59247.56
	a. Traditional Co-1variety	83755.11	191673.20	107918.10
	b. Pioneer hybrid	124131.20	209167.20	85035.97
	iv. Cotton	136909.40	269255.20	132345.80
	a. Traditional variety	95718.71	152121.60	56402.88
	b. Bt hybrid			
	v. Sorghum			

Table-6 : Comparative Economics of cultivation of Jatropha and the competing crops: Discounted net returns for 15 years at 12% Discount rate in Aruppukkottai block in Virudhunagar district of Tamil Nadu. (Indian rupee)

Sl. No.	Name of crop	Discounted cost	Discounted Return	Net Discounted returns
1.	Jatropha	77382.76	47783.10	-29599.70
2.	Competing crops	167858.30	279078.60	111220.30
	i. Green gram	121292.60	219033.30	97740.67
	ii. Black gram	70904.5	12395.70	53053.23
	iii. Cumbu	74998.52	171633.80	96635.27
	a. Traditional Co1 variety	111153.30	187298.80	76145.46
	b. Pioneer hybrid			
	iv. Cotton			118509
	a. Traditional variety	122595.60	241104.60	50505.97
	b. Bt hybrid	85711.32	136217.30	
	v. Sorghum			

exception of only sorghum at Periyanaicken Palayam. The discounted net returns over a 15 years period also revealed that the advantage is for competing crops in Aruppukkottai block.

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Analysis on Impact of Regular Physical Fitness and Yoga Classes on Selected Physical Fitness and Physiological Parameters of Male Collegiate Students of UAS Raichur

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Abstract

The present study aims to find out the impact of regular physical fitness and yoga classes on selected physical fitness and physiological parameters of male collegiate students of University of Agricultural Sciences, Raichur campus. To achieve the purpose of the study pre-test data on selected physical fitness and physiological parameters of collegiate students were taken 3 months prior to the regular physical fitness and yoga classes and post-test data were taken in vice-versa. Total 84 participants completed testing at two (pre and post) stages, the results have shown significant changes between two stages of tests were found for abdominal strength, shoulder strength, explosive strength, flexibility and agility performances. Further, significance changes in the resting pulse rate and body mass index composition measures were observed.

Key words : physical fitness, yoga, abdominal strength, shoulder strength, explosive strength, flexibility, agility, training, resting pulse rate, body mass index.

Introduction

Physical fitness is a general state of health and well-being or specifically the ability to perform aspects of sports or occupations. Physical fitness is generally achieved through correct nutrition, exercise, hygiene and rest. It is a set of attributes or characteristics that people have or achieve that relates to the ability to perform physical activity.

Regular physical activity promotes growth and development and has multiple benefits for physical, mental, and psychosocial health that undoubtedly contribute to learning. Physical activity can improve mental health by decreasing and preventing conditions such as anxiety and depression, as well as improving mood and other aspects of well-being.

Physical activity programming specifically designed to do so can improve psychosocial outcomes such as self-concept, social behaviors, goal orientation, and most notably self-efficacy. These attributes in turn are important determinants of current and future participation in physical activity.

Exercise, a subset of physical activity, is “planned, structured and repetitive” (Carpersen et al., 1985, p. 128) and designed to target a particular outcome, for example, cardiorespiratory capacity or another component of fitness. Physical education provides opportunities for developmentally appropriate physical activity, usually structured to promote motor skill development, fitness, and health.

Yoga asana are ways of moving and/or holding the body in different position. Yoga asana has several exercises or postures that work wonders on fitness and health. Varying widely in application and style, these exercises (postures) gently stretch and explore all parts of body. Yoga asana boost physical strength, stamina and flexibility, improve blood circulation, enhance posture and muscle tone and bestow greater powers of concentration and self-control. Through the practice of yoga, we become aware of the connection between our emotional, mental and physical levels.

The ultimate goal of yoga is to make it possible for individual to be able to fuse together the gross material (annamaya), physical (pranamaya), mental (manomaya), intellectual (vijñanamaya) and spiritual (anandamaya) levels within your being. In a yogic point of view, proper breathing is to bring more oxygen to the blood and to the brain, and to the control prana or the vital life energy.

Statement of the Problem : Analysis on impact of regular physical fitness and yoga classes on selected physical fitness and physiological parameters of male collegiate students of UAS Raichur.

Objectives of the study :

1. To find out the impact of regular physical fitness and yoga classes on selected physical fitness parameters of male collegiate students in pre and post-test conditions.
2. To assess the impact of regular yoga classes on selected physiological parameters of male collegiate students in pre and post-test conditions.

Materials and Methods

Subjects : Total 84 students were selected from both College of Agriculture and Agriculture Engineering on random basis. Their age ranged between 17-19 years.

Selection of Variables :

Physical Fitness measures :

Abdominal strength
Explosive strength
Shoulder strength
Flexibility
Agility

Physiological measures :

Body Mass Index
Resting Heart Rate

Tests : Following tests were utilized for the present study:

Tests used for Physical Fitness Measures :

Bent knee sit-ups: Abdominal strength
Standing board jump: Explosive strength
Push-ups: Shoulder strength
Sit & Reach test: Flexibility
Shuttle Run Test: Agility

Tests used for Physiological Measures :

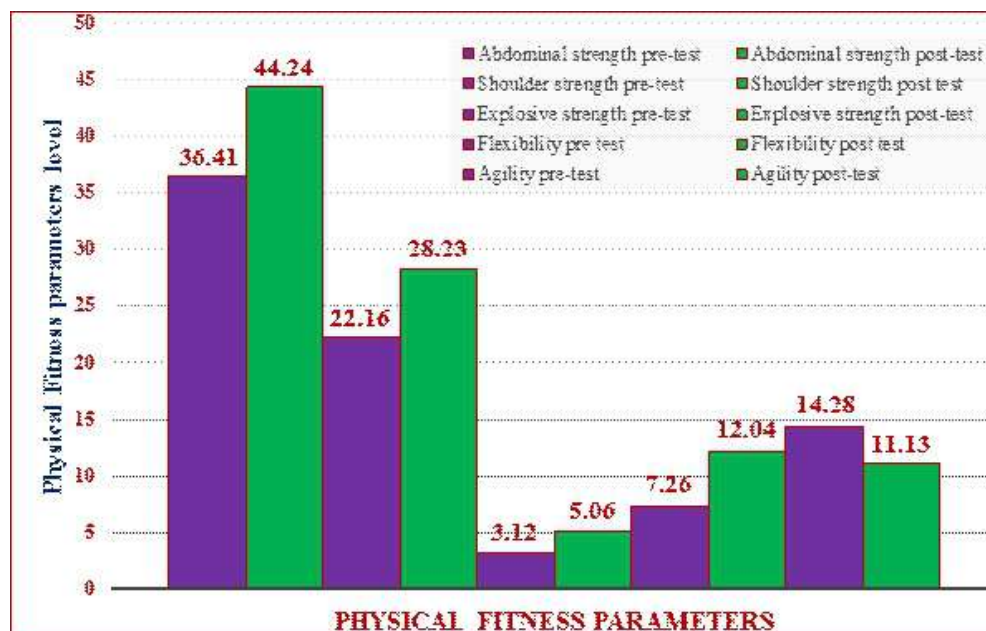
Resting Pulse Rate: Carotid & Ulna Pulse test
Body Mass Index: Height and Weight

Data Collection : The researcher him-self-administered the regular physical fitness and yoga classes. The subjects were participated in regular physical fitness and yoga classes for three months, twice in a week. Necessary instruction was given by the researcher, to the subjects before the administration of selected physical fitness and physiological parameters tests. All pre-test data were collected on selected physical fitness and physiological parameters of collegiate students were taken prior to the

Table-1 : Comparison of means of selected physical fitness parameters of pre-test & post-test scores.

Components	Group	Mean	SD	t-value
Abdominal strength (in No's)	Pre-test	36.41	2.59	7.14*
	Post-test	44.24	4.28	
Shoulder strength (in No's)	Pre-test	22.16	3.54	8.14*
	Post-test	28.23	4.06	
Explosive strength (in feet)	Pre-test	3.12	0.64	2.91*
	Post-test	5.06	0.86	
Flexibility (in centimeters)	Pre-test	7.26	0.71	6.04*
	Post-test	12.04	0.92	
Agility (in secs)	Pre-test	14.28	2.26	4.12*
	Post-test	11.13	1.92	

Significant at 0.05 level.

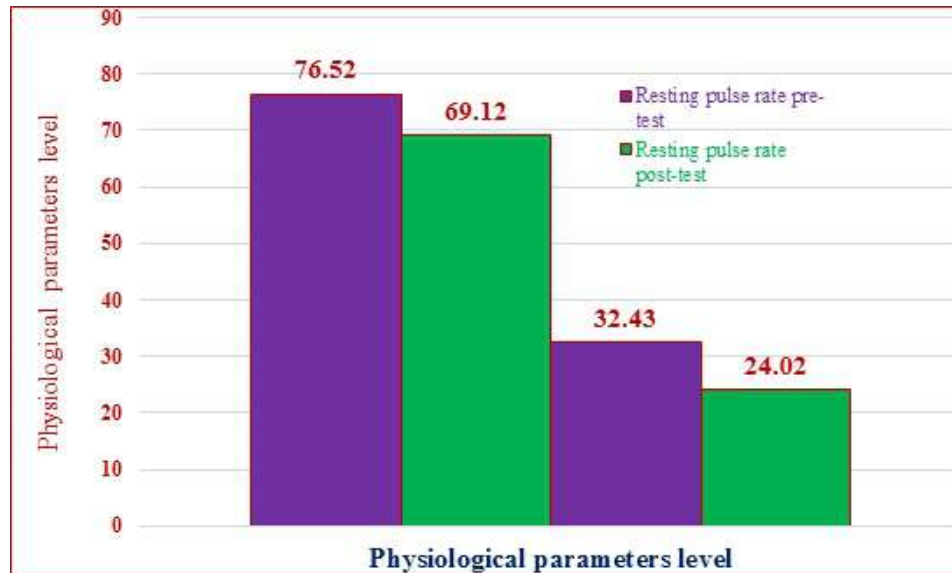


Graph-1 : Comparison of means of selected physical fitness parameters of pre-test & post-test scores.

Table-2 : Comparison of means of selected physiological parameters of pre-test & post-test scores.

Components	Group	Mean	SD	t-value
Resting pulse rate	Pre-test	76.52	4.18	12.42*
	Post-test	69.12	2.91	
Body mass index	Pre-test	32.43	3.41	14.71*
	Post-test	24.02	2.26	

Significant at 0.05 level.

**Graph-2 : Comparison of means of selected physiological parameters of pre-test & post-test scores.**

regular physical fitness and yoga classes (3 months before) and post-test data were taken in vice-versa.

Statistical Procedure : For analysis of the data collected from the students, Mean and SD was computed. To find out the effect of regular physical fitness and yoga classes on selected physical & physiological parameters of students, t-test was applied and level of significance was set at .05 levels.

Results and Discussion

Table-1 shows the means, standard deviation and t-value of selected physical fitness parameters of pre-test and post-test scores. It is observed from the table that in abdominal strength (sit-up test) mean value of pre- test is 36.41 and post- test is 44.24. In shoulder strength test (push-ups) mean value of pre- test is 22.16 and post- test is 28.23. In explosive strength (standing broad jump) mean value of pre- test is 3.12 and post- test is 5.06. In agility test (shuttle-run) mean value of pre- test is 14.28 and post- test is 11.13. In flexibility test (sit & reach test) mean value of pre- test is 14.28 and post- test is 11.13. In agility test mean value of pre- test is 14.28 and post- test is 11.13.

The results show that there is a significant difference found between the means of selected physical fitness parameters (abdominal strength, explosive strength,

endurance, flexibility and agility) of students, as t-values (7.14, 2.91, 14.56, 6.04 and 4.12) were significant at 0.05 level.

Similar, findings were found by Raub (2002), reported after his study that Yoga can improve strength and flexibility. Ray et al. (2001), also reported that shoulders, hip, trunk and neck flexibility improved due to yogic exercises. Cowen & Adams (2005) also reported significant improvements in upper body and trunk between the means of selected physical variables (Muscular strength(dynamic) & muscular endurance of arm & shoulders; Speed and agility; Explosive strength of leg; Speed of lower extremities & explosive strength; Cardio-vascular endurance) of physical education students, as t-value were significant.

Table-2 shows the means, standard deviation and t-value of selected physiological parameters of pre-test and post-test scores. It is observed from the table that in resting pulse rate (carotid & ulna test) mean value of pre-test is 76.52 and post- test is 69.12. In body mass index mean value of pre- test is 32.43 and post- test is 24.02. The results show that there is a significant difference found between the means of selected physiological parameters (resting pulse rate and body mass index) of students, as t-values (12.42 and 14.71) were significant at 0.05 level.

Similar, findings were found by Raub, (2002) reported to that yoga may help control such physiological variables as blood pressure, respiration and heart rate, metabolic rate to improve overall exercise capacity. Harinath, (2004) also reported that yogic practices for 3 months resulted in an improvement in cardio-respiratory performance. Joshi (1992) also reported that six weeks courses in “pranayama” improve ventilatory function in the form of lowered respiratory rate, and increases in the forced vital capacity, forced expiratory volume, maximum voluntary ventilation, peak expiratory flow rate, and prolongation of breath holding time.

Conclusions

Regular physical fitness and yoga classes is beneficial for improvement in muscular strength, endurance, flexibility and agility of the students. Further, results of the study shown significant improvement in the body mass index and resting pulse rate of the students.

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Effect of Foliar Application of Micronutrients (Fe, B and Mg) on Guava Crop : A Review

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Abstract

Micronutrients provide special lubricants required for variety of energy transfer mechanism within the plants. Application of micronutrients such as boron, zinc, iron, and manganese can significantly enhance guava growth, yield, and fruit quality. For instance, boron application can improve flower bud formation, fruit set, and quality. Iron application can increase fruit yield and enhance fruit quality by improving the sugar and acid content. Magnesium application can also increase fruit yield and enhance fruit quality by improving the antioxidant content. Micronutrients happen to improve quality, size, colour, taste and earliness of fruits thereby enhancing their market appeal, improve input use efficiency of NPK fertilizers and water. Integrated supply of micronutrients with macronutrients in adequate amount and suitable proportions is one of the most important factors that control the plant growth in fruit crops. Micronutrients are involved in all metabolic and cellular functions. Plants differ in their need for micronutrients.

Introduction

Guava (*Psidium guajava* L.) is one of the most popular fruit grown in tropical and sub-tropical regions of India, which belongs to the family Myrtaceae. It is the fifth most important fruit in respect of area after mango, banana, citrus and apple and in production after banana, mango, citrus and papaya. It is cultivated in India since early 17th century. Due to its wider adaptability in diverse soils and agro-climatic regions, low cost of cultivation, prolific bearing and being highly remunerative with nutritive values, it has gained more popularity among the fruit growers (Das *et al.*, 1995). This fruit is a native of tropical America and extensively grown in South Asian countries. The leading guava growing states are Uttar Pradesh, Bihar, Madhya Pradesh and Maharashtra. In terms of area and production, guava is the fifth most important fruit crop of India after mango, banana, citrus and papaya (Saxena and Rao, 2017). In India, area under guava is 2.87 lakh ha with a production of 43.07 lakh MT (anonymous, 2020). Guava is often recognized for its food and nutritional values and rich in ascorbic acid content (upto 300 mg/100 g) and good source of pectin which ranges from 0.5-1.8 per cent. Guava is a fair source of vitamin A (about 250 IU/100 g), calcium, phosphorous, pantothenic acid, riboflavin, thiamin and niacin (Kamath *et al.*, 2008). Due to its high calorific value, quality characteristics, high consumer preference and relatively lower cost, it has achieved the fame as “Super fruit” in India. Guava is grown successfully in tropical and sub-tropical regions up to an altitude of 1500 m with assorted types of soil ranging from heavy clay to light sandy soils having a pH range of 4.5-8.2. The majority of nutrients are absorbed by the

roots of the tree confining up to the top 25 cm of soil depth and therefore, surface (0-15 cm) and sub surface (15-30 cm) soil should be fertile enough to supply essential nutrients for promoting new growth (Chadha *et al.*, 2001). Growth and productivity of the guava tree is influenced by a large number of factors. One of the important factor is inadequate supply of plant nutrients, that may be macro nutrients like nitrogen, phosphorus and potassium which plays a vital role in promoting the plant growth, vigour and productivity, or the micronutrients like zinc, iron, copper, manganese and boron having specific functions in growth, development, quality produce and uptake of nutrients (Zagade *et al.*, 2017). Recently, foliar feeding (i.e. refers to application of essential plant nutrients to above-ground plant parts) has been widely practiced and accepted as an essential part of crop production, especially in horticultural crops (Pace, 1982). The ability of plant leaves to absorb water and nutrients was recognized approximately three centuries ago. Plant nutrients can be taken up by both; roots and upper plant parts mainly through leaves. Foliar fertilization has been widely adopted in modern crop management where it is used to ensure optimal crop performance when nutrient supply from the soil is inadequate or uncertain. The nutritional status of a plant has a significant effect on response to foliar fertilizer applications. Foliar fertilizers offer specific advantages over soil fertilizers when plant demand for nutrients exceeds the capacity for root nutrient uptake; when elemental mobility within the plant limits delivery to tissues; and when environmental conditions limit the effectiveness or hinders the application of nutrients to the soil. In many production systems, foliar fertilizers are marketed as ‘insurance’ to minimize the potential impacts

of unpredictable nutrient deficiencies. Foliar fertilization emerging appears to an efficient tool for the sustainable and productive management of fruit crops in order to obtain higher fruit yield. Therefore, in this review, we focus on effect of foliar application of boron, magnesium and iron on yield and quality of guava crop.

Effect of micronutrients on growth parameters : Boron is much required for cell division and development in the growth regions of the plant near the tips of shoots and roots. It also affects the sugar translocation and appears to be associated with functions of calcium. In addition, Boron affects pollination and the development of viable seeds which in turn affect the normal development of fruit (Suman *et al.*, 2016). Photosynthetic efficiency and the structure and function of the photosynthetic apparatus are heavily Fe-dependent, directly or indirectly via the porphyrin biosynthesis pathway leading to heme and chlorophyll synthesis from their common protoporphyrin IX precursor (Layer *et al.*, 2010). The best known physiological roles for magnesium are in harvesting solar energy by occupying the central position in the chlorophyll structure, as a cofactor and allosteric modulator for more than 300 enzymes (including carboxylases, phosphatases, kinases, RNA polymerases, and ATPases), and in chelation to nucleotidyl phosphate forms (Cowan, 2002; Hawkesford *et al.*, 2012). Vikas and Verma (2020) conducted a research trial on effect of micronutrients on growth, yield and leaf nutrient status in guava (*Psidium guajava* L.) cultivar Allahabad Safeda at Dhaulakuan, Sirmour (H.P.) and found the maximum increase in annual shoot growth, plant height, spread, stem girth in T₁₅ (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%). Kumawat *et al.* (2012) conducted research on Guava cv. Sardar and reported that double spray of Zn (0.5%) + B (0.2%) + Mn (0.1%) in the month of August and October also significantly increased diameter of one-year-old shoot (9.13 mm), canopy volume (321.15 m³), relative growth of the shoot at 105th and 135th days (28% and 10.8%), respectively. Kumar *et al.* (2015) conducted an experiment on guava plant comprising foliar sprays of boron, zinc, calcium and potassium at two stages, viz., at fruit set and two weeks after fruit set and reported that the foliar fertilization on 'Pant Prabhat' guava showed an increasing trend towards plant height (12.17%) with 0.03 per cent zinc application two weeks after fruit set. Goswami *et al.* (2015) observed that foliar application of Zn (0.5%) + B (0.2%) + Mn (1%) significantly increased plant height, plant spread and trunk diameter as compared to control in guava cv. Pant Prabhat. Balakrishnan (2000) studied the effect of micronutrient foliar applications alone and their combinations of Zn as ZnSO₄, Fe as FeSO₄, Mg as MgSO₄ and borax on

6-year-old guava cv. Lucknow-49 in Periyakulam, Tamil Nadu and found that the combination of all the micronutrients, Zn at 0.25% + Fe at 0.25% + Mg at 0.25% + borax at 0.1%, resulted in the highest number of shoots per twig (5.97), length of shoot (16.60 cm) and number of leaves (13.15). Sau *et al.* (2016) conducted a field experiment on guava cv. Allahabad Safeda and results revealed that the foliar treatment of 0.2 per cent H₃BO₃ + 0.5 per cent ZnSO₄ + 0.5 per cent CuSO₄ produced the highest number of shoots/meter branch (14.95), new leaves per shoot (14.54) and leaf area (53.51 cm²) over other treatments. Waskela *et al.* (2013) observed the effect of foliar application of ZnSO₄ @ 0.75 per cent and MgSO₄ @ 0.75 per cent showed significant increase in the shoot length (13.4 cm), leaves per shoot (11.6), shoot diameter (0.52 cm) and leaf area (71.6 cm²) in guava. Bagali *et al.* (1993) reported the highest shoot length (8.36 cm), number of leaves per shoot (9.18) and number of flower buds/shoot (1.38) in guava with the foliar application of ZnSO₄ + Boric acid (0.3 % each). Hada *et al.* (2014) studied the effect of different levels of boron and zinc on flowering, fruiting and growth parameter of winter season guava cv. Sardar and reported that the maximum shoot length (38.12 cm), number of leaves (26.23) and leaf area (62.82 cm²) was found in ZnSO₄ (0.8%) + borax (0.4%).

Effect of micronutrients on fruiting and yield parameters : Balakrishnan (2000) studied the effect of micronutrient foliar applications alone and their combinations of Zn as ZnSO₄, Fe as FeSO₄, Mg as MgSO₄ and borax on 6-year-old guava cv. Lucknow in Periyakulam, Tamil Nadu and found that the combination of all the micronutrients, Zn at 0.25% + Fe at 0.25% + Mg at 0.25% + borax at 0.1%, resulted in the higher fruit set (83.11%) and fruit yield (70.15 kg/tree). Vikas and Verma (2020) conducted a research trial to study the effect of micronutrients on growth, yield and leaf nutrient status of guava (*Psidium guajava* L.) cultivar Allahabad Safeda at Dhaulakuan, Sirmour (H.P.) and found the maximum fruit retention, fruit length, fruit breadth, fruit weight and fruit yield in T₁₅ (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%). An experiment was conducted by Suman *et al.* (2016) with guava cv. L-49 which was sprayed with MgSO₄ @ 0.7 per cent along with iron, boron, manganese and zinc; and results revealed that maximum number of fruits per plant along with higher yield and quality of guava was obtained. A study was conducted by Goswami *et al.* (2014) on the effect of micronutrients calcium nitrate (1, 1.5 and 2 %), boric acid (0.2, 0.4, and 0.6%) and zinc sulphate (0.2, 0.4, and 0.6%) on guava cv. Sardar. They reported the maximum fruit length (6.18 cm), diameter (5.46 cm) and volume (120.28 cc) with zinc sulphate 0.4

per cent and maximum weight (120.87 g) @ 0.4 per cent boric acid. Kumawat *et al.* (2012) conducted research on Guava cv. Sardar and reported that double foliar spray of micronutrients in combination gave the maximum fruit yield (12.63 kg/plant) over control. Yadav *et al.* (2011) conducted experiment on effect of foliar application of micronutrients on guava cv. L-49 at Faizabad (U.P.) and reported maximum fruit retention (57.27%) fruit length (6.07 cm), fruit width (5.92 cm), fruit weight (98.48 kg), fruit yield (48.63 kg/tree) were recorded with foliar application of Borax 0.4 per cent followed by the application of zinc sulphate 0.8%. Haggag *et al.* (1987) reported that the application of magnesium sulphate either to the soil or as a foliar spray caused a pronounced increase in the fruit yield, average weight of fruits and juice volume in guava. Bagali *et al.* (1993) reported that two sprays of zinc sulphate, magnesium sulphate and boron in combinations at 0.3 per cent concentration in June and July resulted in maximum number fruit set per shoot and fruit retention per shoot in winter season guava cv. Sardar. Zagade *et al.* (2017) studied the effect of foliar application of micronutrients on yield and quality of guava cv. Sardar and the maximum number of fruits per tree (170), yield per tree (35.6 kg) and yield per hectare (14.2 t) was recorded in treatment (T₇) Zinc sulphate @ 1%. The maximum values of weight of fruit (193 g) and weight of pulp (153.6 g) were observed with the application of CuSO₄ @ 1%+ FeSO₄ @ 1% + ZnSO₄ @ 1% + Borax @ 0.5% (T₁₁). Rajkumar *et al.* (2014) conducted an experiment with foliar application of zinc and boron (1% each) on guava cv. Pant Prabhat during 2006-07 reported significant effect on fruit set and fruit retention (72.55%) and also showed least fruit drop (27.45%) with the same dose during both the years. Bhoyar and Ramdevputra (2016) evaluated the response to foliar application of micronutrients on guava cv. Sardar and reported that combination of 0.5 per cent zinc sulphate 0.5 per cent ferrous sulphate + 0.3 per cent borax gave maximum fruit length (9.4 cm), fruit width (8.5 cm), fruit weight (219.7 g), fruit volume (274 ml). An experiment was conducted by Shreekanth and kumar (2017) revealed that the maximum fruit set (68.80%), fruit retention (65.80%) was recorded with the foliar application of borax @ 1 per cent in winter season guava cv. Sardar. Suman *et al.* (2016) observed that when guava cv. L-49 was sprayed with iron along with boron, magnesium, manganese and zinc, maximum number of fruits per plant and B:C was observed under boric acid @ 0.3% + ferrous sulphate @ 0.4% + magnesium sulphate @ 0.7% + manganese sulphate @ 0.5% + zinc sulphate @ 0.5% while highest yield/tree and yield/ha were recorded under boric acid @ 0.3% + ferrous sulphate @ 0.4% + magnesium sulphate @ 0.7% + manganese sulphate @ 0.5% + zinc sulphate @ 0.5% + copper sulphate @ 0.4%. Ahamad *et al.* (1998)

studied the effect of foliar application of ferrous sulphate on the yield and quality of guava cv. Allahabad Safeda and observed the maximum yield (37.2 kg/plant) with the foliar application of 0.5 per cent ferrous sulphate. Gaur *et al.* (2014) reported the highest fruit retention (57.27%), fruit yield (48.63 kg/tree) and minimum fruit drop (42.33%) with foliar application of 0.4 per cent borax on winter season guava cv. Sardar. Baranwal *et al.* (2017) conducted an experiment on 12 years old guava plants and the results revealed that among nutrient treatments, ZnSO₄ @ 0.75 per cent and borax @ 0.4 per cent spray increased fruit set percentage significantly over 0.5 per cent of ZnSO₄ and 0.2 per cent of borax spray, respectively but fruit retention percentage was recorded significantly highest with 1 per cent ZnSO₄ and 0.6 per cent borax solution spray. Kharwade *et al.* (2018) studied the effect of foliar application of different chemicals on guava cv. Sardar and revealed that maximum number of fruits per tree (288), yield per tree (55.69 kg) and yield (15.50 t/ha) were recorded with the treatment of 19:19:19 @ 1 per cent + ZnSO₄ @ 0.5 per cent + FeSO₄ @ 0.5 per cent + boric acid @ 0.3 per cent. Bagali *et al.* (1993) reported that foliar application of ZnSO₄ + MgSO₄ + boric acid (0.3 % each) resulted in maximum fruit weight (110.55 g), length (5.6 cm), diameter (5.94 cm) and diameter of seed cavity (4.58 cm) whereas foliar application of ZnSO₄ + boric acid (0.3% each) resulted in highest pulp thickness (0.79 cm). Gaur *et al.* (2014) reported that maximum fruit length (6.07cm), fruit width (5.92cm), and fruit weight (98.48 g) was observed with the foliar application of 0.4 per cent borax on winter season guava cv. Sardar. An experiment was conducted by Suman *et al.* (2016) to study the effect of foliar application of micronutrients on fruit quality of 'Sardar' guava and revealed that the maximum fruit weight, fruit volume, diameter of fruit, diameter of seed cavity, pulp thickness were recorded with the treatment receiving boric acid @ 0.3% + ferrous sulphate @ 0.4% + magnesium sulphate @ 0.7% + manganese sulphate @ 0.5% + zinc sulphate @ 0.4% + copper sulphate @ 0.4%. Bhoyar and Ramdevputra (2016) reported that combination of 0.5 per cent zinc sulphate + 0.5 per cent ferrous sulphate + 0.3 per cent borax significantly influenced one sensory characters like aroma (7.7), taste (8.1), flavour (8.2), texture (7.5) and also overall acceptability (7.9) in guava cv. Sardar. Yadav *et al.* (2017) revealed that the fruit set, fruit retention, fruit size (length and width), weight, volume, specific gravity and yield were more with foliar spray with 1 per cent zinc sulphate and 1 per cent borax. Khayyat *et al.* (2007) observed that the spray of H₃BO₃ (1500 ppm) resulted in highest yield as well as higher pulp weight, pulp/seed ratio, fruit length and diameter of date palm cv. Shahany compared to control. Bhadke *et al.* (2018) reported that the yield and yield

attributing characters of guava were observed to improve with the spray of 0.8% ZnSO_4 whereas combined application of ZnSO_4 and FeSO_4 was found to be the best treatment for maximum yield with quality of guava fruits. Gaur *et al.* (2014) found the minimum acidity (0.3%), maximum fruit length (6.1 cm), fruit width (5.92 cm), and fruit weight (98.48 g) with foliar application of 0.4% borax on winter season guava cv. L-49. Kumar *et al.* (2019) conducted a research to study the effect of foliar applications of calcium, magnesium and iron on yield and quality of guava cv. Sardar at Pantnagar and reported that the maximum seed index (0.88 g), number of seeds (399.67) were recorded with T_{21} [FeSO_4 (0.6%) + CaCl_2 (0.6%) + MgSO_4 (0.6%)] whereas seed hardness and fruit specific gravity were observed to be non significant with respect to the application of calcium, magnesium and iron. Bhoyar and Ramdevputra (2016) evaluated the response to foliar application of micronutrients on guava cv. Sardar and found that combination of 0.5 per cent zinc sulphate along with 0.5 per cent ferrous sulphate + 0.3 per cent borax had minimum weight (0.017 g) and minimum number of seeds (204.7) per fruit.

Effect of micronutrients on Physio-chemical attributes : Balakrishnan (2000) studied the effect of micronutrient foliar applications alone and with combinations of Zn as ZnSO_4 , Fe as FeSO_4 , Mg as MgSO_4 and borax on 6-year-old guava cv. Lucknow in Periyakulam, Tamil Nadu and found that the combination of all the micronutrients, Zn at 0.25% + Fe at 0.25% + Mg at 0.25% + borax at 0.1%, resulted in the highest total soluble solids (14.15°brix), total sugars (10.28%) and vitamin C [ascorbic acid] content (160.08 mg/100 g) compared to the control while control treatment had the highest acidity percentage (0.75%). Vikas and Verma (2020) conducted research on effect of micronutrients on growth, yield and leaf nutrient status of guava (*Psidium guajava* L.) cultivar Allahabad Safeda at Dhaulakuan, Sirmour (H.P.) and found that the maximum TSS, total sugars, reducing sugar, non reducing sugar, ascorbic acid content, and minimum acidity were observed in T_{15} (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%). Kumawat *et al.*, (2012) conducted research on Guava cv. Sardar and reported that double spray of micronutrients in combination gave maximum (TSS 13.20%, total sugars 6.98% and vitamin C content 239 mg/100 g pulp) over single spray and control. Bhoyar and Ramdevputra (2016) reported that the combination of 0.5 per cent zinc sulphate + 0.5 per cent ferrous sulphate + 0.3 per cent borax gave maximum TSS (13.60 °Brix), total sugars (7.9%), ascorbic acid content (225.0 mg/100g pulp), pectin content (0.65%) and minimum acidity (0.38%) in guava cv. Sardar. Yadav *et al.*, (2011) found that, the foliar application of 0.4% borax

recorded the maximum TSS (11.70%), total sugar (7.51%), ascorbic acid (172.00 mg/100 g fruit pulp) and minimum acidity (0.30%) in guava fruits. Gaur *et al.*, (2014) recorded maximum TSS (11.7 °Brix), total sugar (7.51%), ascorbic acid (172 mg/100g) with foliar application of 0.4% borax on winter season guava cv. L-49. Chaitanya *et al.* (1997) found that foliar application of ZnSO_4 and borax both at 0.3 per cent improved the quality of guava fruits cv. Sardar. Yadav *et al.*, (2011) conducted experiment on effect of foliar application of micronutrients on guava fruit cv. L-49 Faizabad (U.P.) and reported that maximum total soluble solids (11.70°Brix), ascorbic acid (172.00 mg/100 g), reducing sugar (3.98%), non-reducing (3.53%). Total sugars (7.51%) and minimum fruit drop (42.23%), acidity (0.30%) were recorded with foliar application of Borax 0.4 per cent followed by zinc sulphate 0.8%. Foliar application of zinc sulphate @ 0.6 per cent and boric acid @ 0.5 per cent (in combination) before and after fruit set resulted in higher fruit TSS (15.40%), acidity (0.55%), ascorbic acid content (221.51 mg/100 g fruit pulp), total sugars (8.66%), non-reducing sugars (3.76%) and sugar-acid ratio (15.76) in guava (Trivedi *et al.*, 2012). A study was conducted by Jat and Kacha (2014) to study the effect of foliar application of urea and zinc on fruit quality of 'Bhavnagar Red' guava and revealed that maximum TSS (11.85%), ascorbic acid (220.79 mg/100 g), pectin content (0.67%), reducing sugars (2.37%), non-reducing sugars (4.66%), total sugars (7.03%) and minimum acidity (0.48%) was recorded with foliar application of 1.5 per cent urea whereas foliar application 0.6 per cent zinc sulphate recorded 11.85 per cent TSS, 0.47 per cent acidity, 219.21 mg/100 g ascorbic acid, 0.67 per cent pectin content, 2.34 per cent reducing sugars, 4.61 per cent non-reducing sugars and 6.95 per cent total sugars. Zagade *et al.*, (2017) conducted research on effect of foliar application of micronutrients on yield and quality of guava cv. Sardar and found the maximum TSS (11.80 °brix), reducing sugar (4.52%) and total sugar (7.40%) with application of Zinc sulphate 1% (T_7) whereas minimum acidity (0.35%) was observed with application of Ferrous sulphate 1% (T_5). Waskela *et al.*, (2013) reported that the application of magnesium sulphate @ 0.75 per cent showed significantly higher TSS (11.04%), ascorbic acid (158.24 mg/100 g), TSS: acid ratio (16.73), pectin content (0.84%), reducing sugars (3.45%) and non reducing sugars (3.45%) content in guava fruits. Lambe *et al.*, (2017) reported that when guava plants were sprayed with magnesium along with calcium, zinc and boron at 50% flowering and one month after first spray, MgSO_4 (0.1%) spray recorded significantly superior quality attributes like TSS (11.72 °Brix), Total sugars (7.81%) and Non-reducing sugars (3.96%,). Suman *et al.*, (2016) observed the maximum

TSS, ascorbic acid, reducing sugars, total sugars, sugar acid ratio and minimum acidity under treatment of boric acid 0.3% + ferrous sulphate 0.4% + magnesium sulphate 0.7% + manganese sulphate 0.5% + zinc sulphate 0.4% + copper sulphate 0.4% in guava cv. Sardar. Ahamad *et al.*, (1998) studied the effect of foliar application of ferrous sulphate (0.25-1.25%) on the quality of guava cv. Allahabad Safeda. Application of 0.5% ferrous sulphate gave the best results in terms of TSS (11.95%), ascorbic acid (189.9 mg/100 g pulp) and pectin content (0.78%) and the lowest acidity (0.36%).

Effect of micronutrients on leaf analysis : Balakrishnan (2000) studied the effect of micronutrient foliar applications alone and their combinations of Zn as ZnSO₄, Fe as FeSO₄, Mg as MgSO₄ and borax on 6-year-old guava cv. Lucknow-49 in Periyakulam, Tamil Nadu and found that the combination of all the micronutrients, Zn at 0.25% + Fe at 0.25% + Mg at 0.25% + borax at 0.1%, resulted in the highest chlorophyll content (3.03 mg/g). Prakash *et al.*, (2006) conducted experiment on effect of foliar application of zinc and boron on guava cv. Pant Prabhat and found that the maximum boron content (107.32 ppm) was observed in ZnSO₄ (1.0%) + H₃BO₃ (1.0%) in treated plants. These findings indicated that ZnSO₄ (1.0%) + H₃BO₃ (1.0%) significantly influenced the N, Zn and B concentrations in the leaves of guava cv. Pant Prabhat. Vikas and Verma (2020) conducted research on effect of micronutrients on growth, yield and leaf nutrient status in guava (*Psidium guajava* L.) cultivar Allahabad Safeda at Dhaulakuan, Sirmour (H.P.) and found that the leaf nutrient contents of Fe, Mg and B were also significantly affected by foliar application of combined micronutrients *i.e.* zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%. Reay *et al.*, (1998) reported the effect of magnesium on guava plant that Magnesium treatment in the tree canopy of apple increased the chlorophyll and carotenoid concentration on the back side of the fruit (not facing the sun).

Conclusion

Foliar application of boron, magnesium and iron alone and in combination was found to be an instant and effective method of nutrient application. The foliar application of micronutrients is an effective strategy for enhancing guava crop productivity and fruit quality. By implementing appropriate nutrient management practices, farmers can optimize guava crop yields and improve the nutritional value of the fruit.

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Protein Profiling by SDS-PAGE Gel Electrophoresis of Wheat (*Triticum aestivum* L.) Crop under Salinity Condition

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Abstract

The study often different varieties of wheat crop under salinity condition protein profiling By SDS-PAGE. The variability of leaves proteins was analyzed by sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE). The result According to dendrogram analysis there is minimum similarity between varieties like NW-1076, NW-4018 and NW-1067. There is maximum similarity between varieties like RAJ-3777, Kharchia-65, K-9006 and DBW-129. SDS-PAGE system is discontinuous buffer system. Different pH (and ionic strength) in stacking gel and separating gel can help protein samples concentrate/stack in stacking gel before running in a separating gel.

Key words : Wheat, *Triticum aestivum*, Sodium dodecyl sulfate polyacrylamide gel electrophoresis, salinity

Introduction

Wheat is second important crop being next only to rice and contributes about 33 percent of the total food grain production of this country. Two species i.e., *Triticum aestivum* L. and *Triticum durum* are mainly under cultivation. Former is the most important species occupying more than 65 percent of the total area under wheat owing to its high productivity and high responsiveness to fertilizer and irrigation it is this (*Triticum aestivum* L.) species of wheat that is found more suitable for chapati making. In addition to this wheat also consumed in various other preparations such as dalia, halwa, sweet meals etc.

Wheat (*Triticum aestivum* L.) has been utilized as staple food and forage in several ways in the history of mankind. Wheat, the second most important crop of India, however, faces salinization problem which decreases average yield of the crop by more than 50 %. About 20 % of the arable land is affected by different degrees of salinity and large chunks of the irrigated land is developing salinity (Bartels and Sunkar 2005; Silva and Gero's 2009) In India, more than 8.6 mha of lands are salt affected and pose a problem to productivity of crops worldwide (Kumar *et al.* 2008).

SDS-PAGE is quite a useful tool for distinguishing and determining genetic similarities among varieties/cultivars. It was first introduced for the separation of wheat proteins by Bietz and Wall (1972). Since then, SDS-PAGE has been widely used for separating cereal proteins from all cereals. SDS-PAGE

provides a relatively low cost, high throughput method for analyzing cereal proteins. Seed proteins being stable are not affected by environmental factors hence electrophoresis analysis of seed proteins can be used for varietal identification. Diversity among cultivars can be identified and characterized by analyses of seed storage proteins and phylogenetic relationship among the accessions can be understood. (Banta *et al.*, 2021)

Materials and Methods

Protein profiling done by method given by Laemmli (1970). SDS-PAGE is an electrophoresis method that allows protein separation by mass. The medium (also referred to as 'matrix') is a polyacrylamide-based discontinuous gel. The polyacrylamide-gel is typically sandwiched between two glass plates in a slab gel.

Preparation of Gels for SDS-PAGE

a. Composition of separating gel buffer 12% (30 ml total volume)

1. Stock acrylamide -10 ml
2. Tris buffer 1.875M, pH 8.8 - 6.0 ml
3. Distilled water -13.4 ml
4. Ammonium per sulphate -150µl
5. TEMED - 50µl

Above solution was taken in flask and shaken well and contains transferred quickly into the Chamber between the glass plates. The gel was left alone for polymerization (20-30 minutes).

b. Composition of stacking Gel (Upper gel) 4 % total

volume 10ml : Stacking gel (upper gel) was prepared by mixing of the following solution.

1. Stock acrylamide -1.3 ml
2. Tris buffer 0.6M pH 6.8 - 2.5 ml
3. Distilled water -6.0 ml
4. Ammonium per sulphate -100 µl
5. TEMED - 50 µl

Above solution was taken in flask and shaken well the solution was poured in the chamber containing polymerized running gel.

The comb was placed in between the plate and after complete polymerization of stacking gel in plate the comb was removed without distorting the shape of the well

The glass plate with gel was assembled in electrophoresis unit containing electrode buffer in lower and upper tank of unit.

Preparation of sample :

2g of tissue (sample) grind in 2ml of 0.1M Tris buffer pH 6.7 with the help of mortar and pestle.

Ground sample was transferred into centrifuge tube of 15ml capacity

Centrifuged at 5000 rpm for 10 minutes at 4°C

After centrifugation, the supernatant (upper layer) was transfer into another centrifuge tube

To this 0.2ml, 12% SDS and 20µl mercapto-ethanol were added

Boil the sample on water bath for 2 minutes (ensure complete interaction between protein and SDS)

After allowing to cool, 0.1 ml of bromophenol blue dye and glycerol 1 ml was added and mix it

This sample was used for electrophoresis

Loading of sample into Well :

40-60 µl of sample (containing about 75-200 µl protein) was loaded into wells with the help of micropipettes

Formation of bubbles was avoided during loading of sample

After proper loading the electrophoresis unit was connected with power supply

The current was turned on allowing 30 mA and 220 volt for initial 10 minutes until the sample travels through the stacking gel.

Result and Discussion

SDS-PAGE electrophoresis of Protein : The analysis of SDS-PAGE for only ten selected varieties namely-Kharchia-65, NW-4018, HI-1619, RAJ-3777, K-9006, HD-2851, NW-1067, NW-1012, NW-1076 and DBW-129 are follows.

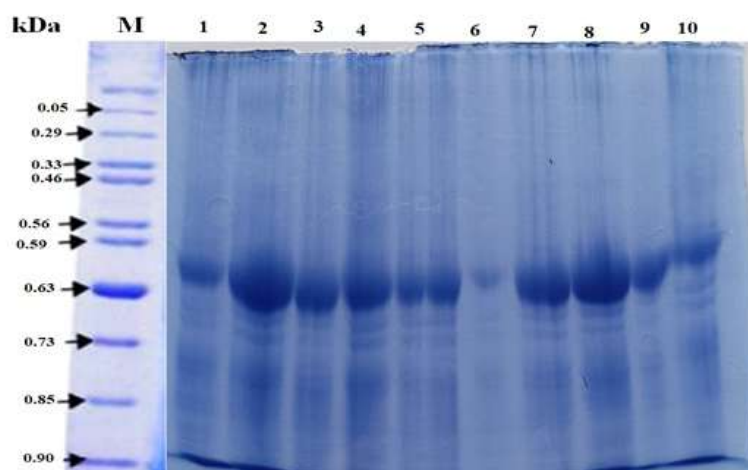


Figure-1 : Appearance of bands in wheat leaves of SDS-PAGE (12 %)

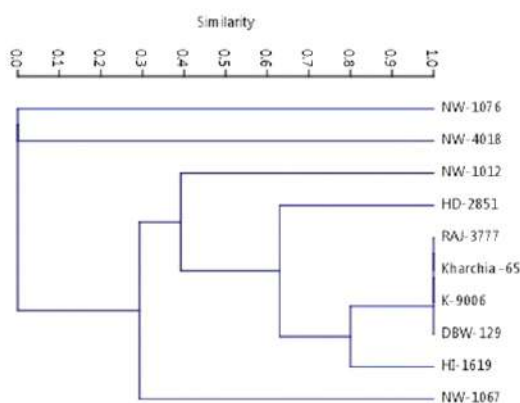


Figure-2 : Dendrogram of ten wheat varieties under salinity condition.

Table-1 : Relative mobility of (12 %) SDS-PAGE in wheat leaves.

S. No.	RM value	Varieties									
		Kharchia-65	NW-4018	HI-1619	RAJ-3777	K-9006	HD-2851	NW-1067	NW-1012	NW-1076	DBW-129
1.	0.29	+	-	+	+	+	-	-	+	-	+
2.	0.53	+	-	+	+	+	-	-	+	-	+
3.	0.63	+	-	-	+	+	-	+	-	-	+
4.	0.75	+	-	+	+	+	+	+	-	-	+
5.	0.85	+	-	+	+	+	+	-	+	-	+

Table-2 : Dendrogram of ten wheat varieties under salinity condition.

Groups	Sub-group	Varieties
A		NW-1076
B		NW-4018
C	C ₁	NW-1067
	C ₂	HI 1619, DBW-129, H-9006, Kharchia-65, Raj-3777, HD-2851 and NW-1012.

SDS-PAGE analysis of wheat variety : The RM values of different wheat varieties are given in (Table 4.4). The leaf protein of Indian wheat showed variability in banding pattern of polypeptide at 12% acrylamide gel during SDS-PAGE. Relative Mobility value of different genotypes of wheat was observed by Protein profiling through SDS-PAGE which is given here.

The dendrogram was divided into three groups A, B and C having similarity (0.0) again group A and B have one variety each NW-1076, NW-4018 and Group C is further divided into two sub groups C₁ and C₂, similarity between these is (0.25). Group C₁ has single variety NW-1067 and C₂ has 7 varieties HI 1619, DBW-129, K-9006, Kharchia-65, Raj-3777, HD-2851 and NW-1012. DBW-129, H-9006, Kharchia-65, Raj-3777 are similar. Similarity between DBW-129, K-9006, Kharchia-65, Raj-3777 and HI 1619 is (0.75). Similarity between HD-2851 and DBW-129, K-9006, Kharchia-65, Raj-3777, HI 1619 is (0.62). Similarity between NW-1012 and HD-2851, DBW-129, K-9006, Kharchia-65, Raj-3777, HI 1619 is (0.38).

Conclusions

According to dendrogram analysis there is minimum

similarity between varieties like NW-1076, NW-4018 and NW-1067. There is maximum similarity between varieties like RAJ-3777, Kharchia-65, K-9006 and DBW-129.

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Effect of Supplementation of Ashwagandha (*Withania Somnifera*) on Economics of Supplementation and Nutrient Utilization in Broiler Chicks

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Abstract

The study was conducted to evaluate the effect of dietary supplementation of ashwagandha (*Withania somnifera*) on nutrient utilization and economics in broiler chicks. One hundred sixty straight run coloured broiler chicks (day-old) were used in a completely randomized design in 4 treatments with 4 replicates, each consisting of 10 chicks. The treatment comprised of T1 (basal diet), T2 (basal diet with 0.5% ashwagandha root powder), T3 (basal diet with 1% ashwagandha root powder) and T4 (basal diet with 1.5% ashwagandha root powder). The effect of supplementation was studied on utilization of nutrients and economics of rearing of broiler chicks. A metabolism trial was conducted at 8th weeks of age and digestibility of all the nutrients were estimated. The intakes of DM, CP, EE, CF, NFE and GE were significantly ($P<0.01$) higher in control, however, digestible nutrients as well as digestibility coefficients did not differ among different treatment groups. The data revealed that the supplementation has improved utilization of the nutrients in broiler chicks. The feed cost as well as total cost was significantly ($P<0.01$) higher in T2 and T3 as compared to T4 and control. The supplementation of ashwagandha powder at 0.5% has significantly ($P<0.01$) increased gross return, net return and benefit cost ratio in broiler chicks. It may be concluded that the supplementation of broiler diets with ashwagandha powder leads to better utilization of nutrients and higher returns.

Key words : Ashwagandha, broiler, nutrient utilization, digestibility, economics.

Introduction

Poultry farming is the fastest and immediate growing sector of livestock in terms of economy. Amongst the various animal husbandry enterprises, poultry production has secured number one position and attained industrial status in India. Poultry farming is very laborious and it requires minimum capital for rearing birds with quick returns. It has been recognised as a crucial sector for the generation of employment and highly nutritious food for ever-growing human population.

Feed additives are commonly described as non-nutrient substances that improve growth, efficiency of feed utilization, beneficial for health and metabolism of the birds. Medicinal plants as natural feed additives are recently used in poultry diets to enhance the performance of birds. There has been increased interest in the herbal feed additives for growth promoter and health maintenance of birds in recent decades. These herbal additives are economical and improve the digestibility and palatability of the feed and hence improve both nutrient intake as well as nutrient digestibility in the body of birds.

Withania somnifera L. commonly called as 'ashwagandha' and 'winter cherry', roots of ashwagandha are stout fleshy, whitish brown and are the main portions of the plant used therapeutically. The roots have strong pungent smell and bitter in taste and contain several alkaloids (0.13 to 4.30%), which offer medicinal usages.

Ashwagandha plant constitutes alkaloids and steroidal lactones, but the withanone, the main alkaloids found in its roots and leaves is thought to be responsible for its biological activity. The herb ashwagandha reportedly has antioxidant, antistress, anticoccidial, immuno-modulatory and antilipidemic effect besides playing a vital role in lowering blood sugar, serum cholesterol and stress induced gastric indigestion and ulcers (Mushtaq *et al.* 2012). Ashwagandha contains many active principles such as withanolides, somnitalglucose, inorganic salt and withanone. Feeding of *Withania somnifera* (ashwagandha) root powder improves growth rate, feed consumption, feed conversion efficiency, economics and lower mortality rate in poultry birds. The supplementation of ashwagandha root powder as herbal feed additive improves the DM metabolizability, nitrogen metabolizability and GE metabolizability (Jyotsana *et al.* 2018). Therefore, the present study was carried out by effect of dietary supplementation of ashwagandha (*Withania somnifera*) on nutrient utilization and comparative economics of broiler.

Materials and Methods

Experimental birds and diets : One hundred sixty straight run coloured broiler chicks were randomly divided into 4 treatment groups with 4 replicates of 10 chicks each. The chicks were fed basal ration comprising maize, soybean deoiled cake, deoiled rice bran and vitamin premix in control group and supplemented with

ashwagandha root powder at 0.5, 1.0 and 1.5 % of the basal ration T2, T3 and T4 groups respectively. the chicks were fed experimental feed for 8 weeks and at the end of the experiment i.e. after 8 weeks, a metabolism trial was conducted. Two birds from each replicate in a treatment were randomly selected and shifted to metabolic cage. Thus, a total of 8 birds from each treatment were used for metabolism trial. The birds were individually fed with experimental diet. The birds were given adaptation period followed by collection of excreta for three consecutive days. During the collection period quantity of feed offered, feed left over and excreta voided were recorded and taken for nutrient analysis. Representative feed sample were collected for proximate analysis. Similarly aliquot of faecal sample were also processed for nutrient analysis as per A.O.A.C. (2005).

For the digestibility percentage of nutrient analysis was carried out using a standard method and the results were calculated by using following formula :

$$\text{Metabolizability} = \frac{\text{Nutrient in feed} - \text{Nutrient in faces}}{\text{Nutrient in feed}} \times 100$$

The gross energy (GE) of the dried and ground sample of feed ingredients and excreta were determined using adiabatic bomb calorimeter. The classical ME values of assay diets were determined by total collection method (Sibbald *et al.*, 1960)

Economics of production : The chicks were fed starter ration from 0-3 weeks and the fed with finisher ration from 4th week till end of the experiment. The chicks were fed with mixture of maize, soya deoiled cake, Deoiled rice bran and vitamin premix with inclusion of ashwagandha root powder at different levels. The feed costs for chick ration were Rs. 26.33, Rs. 27.76, Rs. 29.26 and Rs. 30.69 per kg in T1, T2, T3 and T4 respectively whereas, the grower ration costs were Rs. 26.45, Rs. 27.88, Rs. 29.30 and Rs. 30.73 per kg in T1, T2, T3 and T4 respectively.

The total cost for the entire experimental period (0-8 weeks of age) was calculated by taking into consideration the sum of costs such as feed cost with supplementation and other miscellaneous cost. The return was calculated by multiplying final body weight with prevailing sale price of chicken. The benefit cost ratio was calculated as under following formula.

$$\text{B.C ratio} = \frac{\text{Total return}}{\text{Total cost}}$$

Statistical analysis : The experimental design was conducted in completely randomized design (CRD) and the data were analysed as per Snedecor and Cochran, (1994).

Results and Discussion

Nutrient utilization : The mean dry matter intake

(g/bird/day) was significantly higher ($P<0.01$) in T1 as compared to T4, while the mean dry matter intake in T2 and T3 was at par with T1 and T4. The difference in mean digestible dry matter intake amongst different groups was found to be statistically non-significant. The mean digestibility coefficient of dry matter was also found to be non-significant. The mean crude protein intake (g/bird/day) was significantly higher ($P<0.01$) in T1 and T3 as compared to T4, while the CP intake in T2 did not differ significantly with other treatment groups. The mean digestible crude protein intakes and digestibility coefficients of CP was found to be non-significant amongst different dietary groups. Mean CF intakes significantly higher ($P<0.05$) in T3 as compared to T1 and T2, while the values observed in T4 did not differ with other treatment groups. The mean digestible CF intakes and digestibility coefficients followed the similar trend as observed for CP. The mean EE intake was significantly higher ($P<0.01$) in T1 as compared to T4, whereas the difference in T2 and T3 did not differ with T1 and T4. The perusal of data revealed that mean NFE intake was significantly higher ($P<0.01$) in T1 as compared to T4 whereas, the mean NFE intake in T2 and T3 did not differ with other treatment groups (Table-1).

The gross energy intake was significantly higher ($P<0.01$) in T1 as compared to T4, while the difference in GE intake in T2 and T3 were found to be statistically non-significant with T1 and T4. The energy balances were 254.64 ± 3.05 , 261.33 ± 5.94 , 253.15 ± 11.92 and 253.57 ± 4.13 Kcal per bird per day. The difference in GE balance amongst different groups was found to be statistically non-significant. The nitrogen intake was significantly ($P<0.01$) higher in T1 and T3 as compared to T4, while the value in T2 did not differ significantly with any treatment groups (Table-1).

Jyotsana *et al.* (2018) studied the dietary inclusion of ashwagandha root powder (*Withania somnifera*) on growth performance and metabolizability in broiler and reported the dietary supplementation at the rate of 0.75% and 1% ashwagandha powder results in significantly higher dry matter metabolizability, nitrogen metabolizability and gross energy metabolizability as compare to control group. Saini *et al.* (2017) observed that dry matter digestibility of broiler ration increased with increase in level of *Withania somnifera* upto 1.0% and thereafter decreased. Further, he also suggested that inclusion of *Withania somnifera* as feed additives at the rate of 1.0% in broiler ration, exerted maximum nitrogen retention and thereafter at 0.5% level of inclusion. These results are in similar with the findings of Attia *et al.* (2017) revealed that apparent digestibility coefficient of dry matter, crude protein and ether extract increases with increasing inclusion. Similarly, Raghavan *et al.* (2011)

Table-1 : Effect of supplementation of ashwagandha root powder on nutrient intake and digestibility in broiler chicks.

Particulars	T1	T2	T3	T4	SEm	CD
DM Intake(g/bird/d)	98.32 ^a ±0.90	96.21 ^{ab} ±1.31	96.84 ^{ab} ±0.88	94.33 ^b ±0.58	0.59	2.56**
Digestible DMI (g/bird/d)	67.97±1.81	71.79±2.07	67.96±5.03	69.24±1.45	2.05	NS
CP intake (g/bird/d)	19.82 ^a ±0.18	19.35 ^{ab} ±0.23	19.44 ^a ±0.18	18.90 ^b ±0.12	0.12	0.51**
Digestible CP intake (g/bird/d)	14.05±0.25	14.71±0.45	13.96±0.68	14.14±0.20	0.44	NS
CF intake (g/bird/d)	5.22 ^b ±0.06	5.17 ^b ±0.07	5.33 ^a ±0.07	5.25 ^{ab} ±0.04	0.03	0.10*
Digestible CF intake (g/bird/d)	3.47±0.11	3.75±0.27	3.89±0.25	3.81±0.08	0.12	NS
EE intake (g/bird/d)	2.76 ^a ±0.03	2.69 ^{ab} ±0.03	2.69 ^{ab} ±0.02	2.62 ^b ±0.02	0.02	0.07**
Digestible EE intake (g/bird/d)	2.02±0.03	2.09±0.06	1.98±0.09	2.01±0.03	0.05	NS
NFE Intake (g/bird/d)	61.46 ^a ±0.70	60.17 ^{ab} ±0.76	60.47 ^{ab} ±0.75	58.94 ^b ±0.50	0.37	1.60**
Digestible NFE intake (g/bird/d)	46.69±0.73	48.29±1.17	46.43±2.49	45.02±0.86	1.06	NS
GE intake (Kcal/bird/d)	324.45 ^a ±3.69	317.49 ^{ab} ±4.00	319.56 ^{ab} ±3.97	311.30 ^b ±2.65	1.96	8.45**
GE balance (Kcal/bird/d)	254.64±3.05	261.33±5.94	253.15±11.92	253.57±4.13	5.11	NS
Nitrogen intake (g/bird/d)	3.17 ^a ±0.03	3.10 ^{ab} ±0.04	3.11 ^a ±0.03	3.02 ^b ±0.02	0.02	0.08**
Nitrogen balance (g/bird/d)	2.25±0.04	2.35±0.07	2.23±0.11	2.26±0.03	0.07	NS
Digestibility Coefficient (%)						
DM	69.17±2.64	74.57±1.25	70.17±5.05	73.38±0.92	1.85	NS
CP	70.94±1.76	75.97±1.45	71.78±3.38	74.76±0.62	2.06	NS
CF	66.56±2.86	72.60±4.82	73.10±4.55	72.48±0.96	2.06	NS
EE	73.01±2.31	77.66±1.11	73.61±4.47	76.45±0.82	1.63	NS
NFE	76.01±2.05	80.22±0.97	76.76±3.93	76.38±0.82	1.45	NS

Table-2 : Effect of feeding ashwagandha root powder on economics of broiler chicks.

Particulars	T1	T2	T3	T4	SEm	CD
Body weight (g)	1595.00 ^c ±99.05	1980.00 ^a ±7.26	1800.00 ^{ab} ±91.71	1695.00 ^{bc} ±33.33	47.38	204.68**
Feed intake (kg/bird)	2.88±0.13	3.34±0.15	3.18±0.31	2.83±0.31	0.24	NS
Feed cost (Rs/Bird)	76.17 ^c ±0.21	92.99 ^a ±0.30	93.19 ^a ±0.22	86.86 ^b ±0.15	0.23	0.70**
Chick Cost (Rs/Bird)	40	40	40	40	0	0
Miscellaneous cost (Rs/Bird)	15	15	15	15	0	0
Total cost (Rs/Bird)	131.17 ^c ±0.43	147.99 ^a ±0.40	148.19 ^a ±0.24	141.88 ^b ±0.20	0.33	1.03**
Gross Return (Rs/Bird)	199.38 ^d ±5.34	247.45 ^a ±4.03	225.00 ^b ±0.58	211.88 ^c ±3.84	3.87	12.05**
Net Return (Rs/Bird)	68.21 ^c ±1.05	99.51 ^a ±1.11	76.81 ^b ±2.03	70.00 ^c ±1.27	1.42	4.43**
B:C ratio	1.52 ^b ±0.04	1.67 ^a ±0.03	1.52 ^b ±0.01	1.49 ^c ±0.02	0.03	0.09**

**P<0.01

Means bearing different superscripts in a row differ significantly.

also observed significant effect on nitrogen balance due to supplementation of herbs. However, in the present study the digestibility coefficient % of nutrients did not differ significantly.

Economics : The data with respect to effect of feeding ashwagandha root powder to broiler chicks on feed cost, gross returns, net returns and benefit cost ratio is presented in Table 2. The day-old straight run chicks of coloured broiler were procured from hatchery unit at Rs 40/- per chick. They were fed basal ration and graded levels of ashwagandha root powder in different dietary treatments. The feed cost was calculated from composition of different feed ingredients in the respective

ration and prevailing market rates of individual feed ingredients. Total feed cost was calculated by multiplying quality of starter or finisher ration consumed with cost of ration in each treatment. The final body weight at the time of slaughter was considered for gross return which was calculated by body weight and sale price per kg live weight, the sale price / kg live weight was Rs.125 at the time of experiment. The cost incurred in labour, medicines etc. were also considered as miscellaneous cost to work out total cost of rearing of chicks. The miscellaneous cost of was considered at Rs 15 for the entire experimental period. The net returns were calculated by subtracting total cost from gross returns and benefit cost ratio was calculated as ratio of gross return and total cost.

It was found that the feed cost was significantly higher ($P<0.01$) in T2 and T3 followed by T4 and T1, while the feed cost in T2 and T3 did not differ significantly. The total cost including chick, feed and miscellaneous costs were found to be 131.17 ± 0.43 , 147.99 ± 0.40 , 148.19 ± 0.24 and 141.88 ± 0.20 rupees in T1, T2, T3 and T4 groups respectively. The total cost was significantly higher ($P<0.01$) in T2 and T3 and lowest in T1, however, the total cost in T2 and T3 was found to be statistically non-significant. The gross returns (Rs/bird) were significantly highest ($P<0.01$) in T2 followed by T3, T4 and lowest in T1. The net returns (Rs/bird) were significantly highest ($P<0.01$) in T2 (Rs 99.51) followed by T3 (Rs 76.81), T4 (Rs 70.00) and lowest in T1 (Rs 68.21) whereas, the difference between T4 and T1 did not differ significantly. The benefit cost ratio was significantly higher ($P<0.01$) in T2 as compared to rest of the treatment groups whereas, the difference among T3 and T1 were found to be statistically non-significant (Table-2).

Mane *et al.* (2012) observed that supplementation of ashwagandha (*Withania somnifera*) and shatavari (*Asparagus racemosus*) in broilers diet has positive effect in terms of net profit. Pedulwar (2004) and Shisodiya *et al.* (2008) found higher net profit per bird in broiler supplemented with ashwagandha. In contrast, Sanjyal and Sapkota (2011) and Kale *et al.* (2015) observed less income per bird in ashwagandha fed broilers than control group which could be due to smaller number of birds having higher cost of maintenance.

The net return per bird at Rs. 99.51 was higher in 0.5% ashwagandha supplemented group over control to a magnitude of 46% and supplemented @ 1% increased net return by 13% over control. The net return observed in the present study, higher than reported by Ansari *et al.* (2008), Shisodiya *et al.* (2008) and Pandey *et al.* (2013) on supplementation of ashwagandha powder at 0.4, 0.5 or 1% in the diet. On the contrary, Joshi *et al.* (2015) evaluated the effects of dietary addition of ashwagandha (*Withania somnifera*) root powder and guduchi (*Tinospora cordifolia*) stem powder and reported no effect of supplementation with ashwagandha alone or in combination with guduchi stem powder.

Conclusions

It may be concluded from the present study that feeding of ashwagandha root powder at 0.5% of total feed is beneficial in terms of utilization of nutrients and economics of rearing of coloured broiler chicks.

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Effect of Sulphur and Biofertilizers on Nutrient Content and Uptake in Blackgram (*Vigna mungo* L.)

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Abstract

A field experiment was conducted at instructional farm, Rajasthan college of Agriculture, MPUAT, Udaipur (Rajasthan) during the *kharif* season 2022 to study the effect of sulphur and bio-fertilizers on nutrient content and uptake in blackgram (*Vigna mungo* L.). Application of 60 kg sulphur ha⁻¹ was found at par with application of 40 kg sulphur ha⁻¹ and both these levels significantly increased N, K and S content in seed and haulm thereby uptake of N, P, K and S by seed, haulm and total over application of 20 kg sulphur ha⁻¹ and control. Seed inoculation with *Rhizobium* + PSB + KMB at par with *Rhizobium* + PSB both significantly increased N, P, K and S content and uptake by seed and haulm thus total over inoculation with *Rhizobium* alone.

Key words : Bio-fertilizers, blackgram, nutrient content, nutrient uptake, sulphur.

Introduction

Pulses a vital of the Indian agriculture sector after cereals and oilseed crops because it is the second important constituent of diet after cereals. Pulses are essential with regards to its contribution to human nutrition and also in respect of their contribution to farmers income. They also contribute significantly through enriching the soil with nitrogen fixation. India is the largest grower and consumer of pulses in the world. Sulphur is the fourth most important mineral nutrient after nitrogen, phosphorus and potassium and its deficiency has been especially visible in Rajasthan soils. Sulphur deficiency has been reported as a hidden hunger in several crops, particularly oilseed and pulses, despite the continuous use of high analysis fertilizers like urea and DAP and high yielding variety.

In the recent years, continuous and imbalance application of chemical fertilizers is leading to poor nutrient use efficiency, low yield of crop. At the same time increasing cost of production due to more and more use of costly nutrient sources is becoming unaffordable to the most of farmers. Hence, it has become imperative to search for other complementary and alternative sources of nutrients among which use of bio-fertilizers of biological origin for integrated nutrient management in blackgram is an important avenue. In this approach, microbial fertilization with *Rhizobium* as well as PSB and KMB has been found promising to improve soil health and crop production.

Materials and Methods

The experiment was laid out at the Instructional Farm,

Rajasthan College of Agriculture, Udaipur. It falls under agro climatic zone IVa "Sub-Humid Southern Plain and Aravali Hills" of Rajasthan. The soil of experimental field was clay loam in texture, slightly alkaline in reaction (pH 8.1), medium in available nitrogen (284.42 kg ha⁻¹) and phosphorus (18.14 kg ha⁻¹) while high in available potassium status (316.45 kg ha⁻¹). The treatment consisted of four levels of sulphur (0, 20, 40, 60 kg ha⁻¹) and three combinations of bio-fertilizers (*Rhizobium*, *Rhizobium* + PSB, *Rhizobium* + PSB + KMB) thereby making 12 treatments combinations replicated thrice in FRBD. Blackgram crop variety MU-2 was used as test crop. A uniform dose of 20 kg N+ 40 kg P₂O₅ ha⁻¹ was applied at the time of sowing through Urea and DAP. The crop was raised as per recommended package and practices of the region.

Effect of sulphur on nutrient uptake by crop : A significant increase N, P, K and S uptake in seed, haulm as well as total by crop were recorded with successive increase in sulphur levels up to 40 kg ha⁻¹ which was significantly higher over application of 20 kg sulphur ha⁻¹ and control (Table 1 and 2). The magnitude of increase in total uptake of N, P, K and S were to the extent of 16.7, 10.1, 13.2, 9.2 per cent over application of 20 kg sulphur ha⁻¹ and 34.6, 24.7, 40.3, 25.3 per cent, over control, respectively. This was closely followed by the application of 60 kg sulphur ha⁻¹ which increased total uptake of N, P, K and S by 22.3, 15.0, 18.7, 17.5 and 44.1, 29.1, 46.7, 34.9 per cent, respectively over application of 20 kg sulphur and control.

Improvement in nutritional environment of plants in

Table-1 : Effect of sulphur levels and bio-fertilizers on nutrient content in blackgram.

Treatments	Nutrient content (%)							
	Nitrogen		Phosphorus		Potassium		Sulphur	
	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm
Sulphur Levels (kg ha ⁻¹)								
0	3.128	1.251	0.326	0.207	1.200	2.045	0.231	0.110
20	3.229	1.302	0.328	0.208	1.295	2.292	0.238	0.113
40	3.486	1.394	0.334	0.211	1.356	2.386	0.240	0.114
60	3.504	1.411	0.335	0.212	1.368	2.412	0.249	0.117
S.Em.±	0.013	0.008	0.003	0.002	0.005	0.010	0.002	0.001
C.D. (P=0.05)	0.037	0.024	NS	NS	0.014	0.029	0.005	0.003
Bio-fertilizers								
<i>Rhizobium</i>	3.304	1.302	0.326	0.206	1.282	2.262	0.237	0.111
<i>Rhizobium</i> + PSB	3.349	1.356	0.332	0.209	1.315	2.294	0.240	0.114
<i>Rhizobium</i> + PSB + KMB	3.357	1.360	0.335	0.212	1.318	2.296	0.243	0.115
S.Em.±	0.011	0.007	0.003	0.001	0.004	0.008	0.001	0.001
C.D.(P=0.05)	0.0318	0.021	0.007	0.004	0.012	0.025	0.004	0.003

Table-2 : Effect of sulphur levels and biofertilizers on nutrient uptake by blackgram.

Treatments	Nutrient uptake (kg ha ⁻¹)											
	Nitrogen			Phosphorus			Potassium			Sulphur		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Sulphur Levels (kg ha⁻¹)												
0	27.80	12.12	39.92	2.89	2.00	4.90	10.67	19.81	30.48	2.05	1.07	3.12
20	31.95	14.12	46.07	3.25	2.25	5.50	12.82	24.85	37.66	2.35	1.22	3.58
40	37.31	16.45	53.77	3.58	2.48	6.06	14.52	28.12	42.64	2.57	1.34	3.91
60	39.12	17.23	56.36	3.75	2.59	6.33	15.28	29.44	44.72	2.79	1.43	4.21
S.Em.±	0.88	0.44	1.05	0.10	0.06	0.12	0.34	0.73	0.84	0.06	0.03	0.08
C.D.(P=0.05)	2.58	1.30	3.09	0.28	0.18	0.35	0.99	2.15	2.47	0.18	0.10	0.22
Bio-fertilizers												
<i>Rhizobium</i>	30.88	13.55	44.43	3.03	2.14	5.18	11.99	23.56	35.55	2.21	1.16	3.37
<i>Rhizobium</i> + PSB	34.84	15.34	50.18	3.44	2.36	5.80	13.68	25.97	39.64	2.49	1.28	3.77
<i>Rhizobium</i> + PSB+ KMB	36.42	16.05	52.48	3.63	2.49	6.12	14.30	27.13	41.44	2.63	1.35	3.98
S.Em. ±	0.76	0.38	0.91	0.08	0.05	0.10	0.29	0.63	0.73	0.05	0.03	0.07

general seems to be due to greater availability of nutrient from the soil and later on their higher extraction by roots and translocation to plant parts. It is generally believed that in the plant system extracted nutrients are used for maintain their critical concentration which can be used for growth of developing structures. Thus higher concentration of nutrients under sulphur fertilization suggests adequate supply of nutrients. The trend of nutrient uptake is seemed to similar that of grain, haulm and total yield. Which is due to the fact that nutrient uptake, is the function of yield and nutrient content. The result so obtained corroborate with the finding of Singh and Singh (2013) and Mir *et al.* (2013).

Effect of bio-fertilizers : Data show that inoculation with bio-fertilizers alone or in combination significantly increased nitrogen, phosphorus, potassium and sulphur uptake. Inoculation of seed with *Rhizobium* + PSB + KMB

accumulated highest quantum of N, P, K and S in seed, haulm thereby total which was found at par with dual inoculation of *Rhizobium* + PSB. The magnitude of increases in total N, P, K and S uptake by the crop due to *Rhizobium* + PSB + KMB were 18.1, 18.1, 16.5, 18.1 per cent, respectively over single inoculation of *Rhizobium*. While corresponding increase in total N, P, K and S uptake due to *Rhizobium* + PSB inoculation were to the tune of 12.9, 12.9, 11.5, 11.8 per cent, respectively.

Significant improvement in nutrient contents and uptake by the crop under the influence of microbial inoculation appears to be on accounts of improvement in nutrients by various plant parts. Besides this, higher nodulation might have resulted in improving N, p, k and S status of the plant thus overall improvement in crop growth and nutrient status of plants ultimately led to accumulation of higher nutrient under the influence of

Rhizobium + PSB + KMB. Significant increase in nutrient content and uptake the influence of *Rhizobium* + PSB + KMB was also reported by Iswarya et al. (2019) and Kumar et al. (2021).

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GG-40 : A High Yielding and High Oleic Spanish Bunch Groundnut Variety

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Abstract

A Spanish bunch groundnut genotype GG-40 (ICGV 16668) was developed through MABC at ICRISAT, Patancheru, Telangana in collaboration with MORS, JAU, Junagadh. This entry was under testing from 2018 to 2021 during *kharif* season. It has recorded the highest pod yield of 3321 kg/ha as compared to the checks viz., TG-37A (2486 kg/ha), GPBD-4 (2562 kg/ha) and GJG-32 (3560 kg/ha). The genotype was also tested in HOVTSB trials of AICRP during *kharif*-2018, *kharif*-19 and *kharif*-21 and performed better than the checks TG-37A (33.57%) and GPBD-4 (29.59%). Average kernel yield of GG-40 was 2103 kg/ha as against the checks viz., TG-37A (1723 kg/ha) and GPBD-4 (1791 kg/ha). It contains >80% oleic acid, average 100 kernel weight of 37.00 g, average shelling out-turn of 63.00% and average oil content 51.00%. The reaction against stem rot, collar rot, ELS and PBNB diseases were comparable and infestation due to thrips, leaf hopper, spodoptera and leaf minor in proposed variety was comparable to the zonal checks; TG37A, GPBD 4, ICGV 03043, K 1812, JL 1085 and DH 256. Based on the superior performance, and higher oleic acid content (>80%) GG-40 has been recommended for cultivation in Rajasthan, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu and Telangana during *kharif* season.

Key words : GG-40, groundnut, spanish bunch, high yield, oleic acid

Introduction

Groundnut (*Arachis hypogaea* L.) is the world's fourth most important sources of edible oil and third most important source of vegetable protein. Gujarat is the leading groundnut growing state. The area under groundnut in Gujarat during 2021-22 was 19.06 lakh ha having 43.28 lakh tones production along with productivity of 2307 kg/ha (Anonymous, 2021). Presently Spanish bunch GJG 9 was released in 2010 at state level for *kharif* cultivation, while GJG 32 was released in 2017 in Zone V as well as Gujarat state during 2018 with high yield. The demand of groundnut oil with high oleic acid content is increasing day by day looking to the health benefits; hence, with an objective to replace the Spanish bunch groundnut varieties with high oleic variety, an attempt was made to develop a new variety with desired agronomic features.

Materials and Methods

Spanish bunch groundnut variety with high yield and high oleic acid contented GG40 (ICGV 16668) was developed by Marker Assisted Back cross in collaboration with ICRISAT. It is a derivative of [ICGV 06110 x (ICGV 06110 x Sun Oleic 95-R)]. The segregating material was advanced and from the segregating populations, a Spanish bunch type was isolated and evaluated for its yield performance. The genotype was nominated for evaluation under AICRP-G trials during *kharif*, 2017, 2018 and 2021. It was screened for reaction to pests (thrips and jassids) and diseases (tikka, rust, stem rot and collar rot)

under field and sick plot conditions. Reaction to tikka and rust diseases was recorded under natural and artificial conditions as suggested by Subrahmanyam *et al.* (1995). All the recommended package of practices was followed for a good and healthy groundnut crop. The yield data was analyzed by randomized block design as suggested by Panse and Sukhatme (1985).

Results and Discussion

On the basis of mean oleic acid data from the AICRP-G trials, GG-40 had proven its superiority by giving higher oleic acid by 66.54%, 3.12%, 86.59%, 86.51%, 81.68% and 90.47% over the zonal check varieties viz., TG-37A, GPBD-4, ICGV-03043, K-1812, JL-1085 and DH-256, respectively (Table-1). Mean pod yield of GG-40 was 3321 kg/ha, which was 33.59% and 29.63% higher over the zonal check varieties viz., TG-37A (2486 kg/ha) and GPBD-4 (2562kg/ha), respectively over the locations and years in rainfed *kharif* seasons (Table-1). Average kernel yield of GG-40 was 2103 kg/ha, which was 22.05% and 17.42% higher over the zonal check varieties viz., TG-37A (1723 kg/ha) and GPBD-4 (1791 kg/ha), respectively over the locations and years in rainfed *kharif* seasons (Table -)

Ancillary observations of economic attributes of GG-40 along with the checks are presented in Table-3. It has medium kernel size having an average 100-kernel weight of 37g. The genotype also expressed higher oil content (51%) as compared to zonal check varieties viz., TG-37A (47%), GPBD-4 (50%), ICGV-03043 (50%), K-1812 (49%), JL-1085 (48%) and DH-256 (49%).

Table-1 : Mean pod yield (kg/ha) performance of groundnut variety GG-40 in the AICRP trials.

Particular		Year of testing and stage	No. of trials	Proposed variety GG 40	Check varieties	
					TG 37A (ZC)	GPBD 4 (ZC)
Mean yield (kg/ha)		HOVT(SB)-I 2018	5	2859	2200	2207
		HOVT(SB)-II 2019	5	3892	2517	2918
		AVT(SB) 2021	6	3229	2698	-
		Weighted Mean (16)	3321	2486	2562	
Per cent increase/decrease over checks		HOVT(SB)-I 2018	5	-	29.94	29.52
		HOVT(SB)-II 2019	5	-	54.60	33.40
		AVT(SB) 2021	6	-	19.69	-
		Weighted Mean (16)	-	33.57	29.59	

Table-2 : Mean kernel yield (kg/ha) performance of groundnut variety GG-40 in the AICRP trials.

Particular		Year of testing and stage	No. of trials	Proposed variety GG 40	Check varieties	
					TG 37A (ZC)	GPBD 4 (ZC)
Mean yield (kg/ha)		HOVT(SB)-I 2018	5	1800	1521	1541
		HOVT(SB)-II 2019	5	2496	1735	2042
		AVT(SB) 2021	6	2028	1883	-
		Weighted Mean (16)	2103	1723	1791	
Per cent increase/decrease over checks		HOVT(SB)-I 2018	5	-	18.35	16.86
		HOVT(SB)-II 2019	5	-	43.92	22.25
		AVT(SB) 2021	6	-	7.72	-
		Weighted Mean (16)	-	22.04	17.41	

Table-3 : Mean data of oleic and linoleic acid of groundnut variety GG-40 along with checks.

Name of Trials			Year of Testing	Zonal Check Varieties					
				Proposed variety GG-40	TG 37A (ZC)	GPBD 4 (ZC)	ICGV 03043 (ZC)	K 1812 (ZC)	JL 1085 (ZC)
1	2	3	4	5	6	7	8	9	10
HOVTSB-I	2018	O	79.91	38.47	49.81	38.25	-	-	-
		L	2.81	39.07	28.12	39.21	-	-	-
HOVTSB-II	2019	O	79.71	64.10	72.84	53.94	-	-	-
		L	3.13	15.54	8.64	25.75	-	-	-
AHOVTSB	2021	O	81.90	48.98	-	42.08	43.28	44.43	42.38
		L	4.40	32.73	-	38.38	36.92	35.20	37.47
	Mean	O	80.72	48.47	58.44	43.26	43.28	44.43	42.38
		L	3.56	31.31	20.81	35.97	36.92	35.20	37.47
% increased/ decreased	O	-	66.54	38.12	86.59	86.51	81.68		
		L	-	-88.63	-82.89	-90.10	-90.36	-89.89	
O/L Ratio		22.67	1.55	2.81	1.20	1.17	1.26		

The variety GG-40 was screened for major pests and diseases in field conditions. It showed comparable reaction against major pests as compared to all the check varieties. GG-40 showed comparable reactions against major diseases as compared to zonal checks during the three years of testing under field conditions (Table-5 and 6).

Based on its consistent superior performance of oleic acid and high yield in Spanish bunch group it has

been proposed for release for general cultivation in the groundnut growing areas of Rajasthan, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu and Telangana during *kharif* season. It has been notified (Notification No. S.O. 1056 (E) dated:6-3-2023 by Central Variety Release Committee for Crop Standards, Notification and Release of Varieties for Agricultural Crops, F-212, Shastri Bhavan, Ministry of Agriculture, Govt. of India, New Delhi-110001" New Delhi (Anonymous, 2023).

Table-4 : Ancillary observations of economic attributes of groundnut GG-40 along with checks.

Sr. No.	Character	Variety GG-40	Zonal Check Varieties					
			TG 37A	GPBD 4	ICGV 03043	K 1812	JL 1085	DH 256
1.	Pod yield (kg/ha)	3321	2486	2562	3560	3800	3333	3441
2.	Kernel yield (kg/ha)	2103	1723	1791	2434	2671	2303	2432
3.	Oil yield (kg/ha)	1073	810	896	1217	1309	1105	1192
4.	Shelling (%)	63	69	68	68	70	69	70
5.	Oil content (%)	51	47	50	50	49	48	49
6.	Protein content (%)	26	26	26	27	27	30	28
7.	100-kernel wt. (g)	37	39	32	36	37	35	38
8.	SMK (%)	89	91	86	88	89	92	90
9.	Maturity days	113	110	112	113	111	112	113

Table-5 : Reaction of groundnut variety GG-40 along with checks against diseases.

Diseases	Variety GG-40	Zonal Check Varieties				
		TG 37A (ZC)	ICGV 03043 (ZC)	K 1812 (ZC)	JL 1085 (ZC)	DH 256 (ZC)
Rust (1-9 scale)	1-4	1-6	1-4	2-4	1-5	1-5
ELS (1-9 scale)	1s-3	1-4	1-3	1-4	1-3	1-3
LLS (1-9 scale)	1-8	1-9	1-5	1-7	1-6	1-6
ALB (1-9 Scale)	0-4	0-3	0-3	0-2	0-2	0-1
Stem rot (% incidence)	5.0-28.4	3.5-30.8	0.0-20.8	4.7-25.6	6.0-26.5	4.5-17.6
Collar rot (% incidence)	0.0-11.0	0.0-10.1	0.0-7.4	0.0-7.0	0.0-6.4	0.0-6.3
PBND (% incidence)	0.0-0.0	0.0-0.0	0.0-0.0	0.0-5.5	0.0-0.0	0.0-5.0
PSND (% incidence)	0.0-4.2	0.0-2.4	0.0-9.0	0.0-3.3	0.0-1.0	0.0-1.4
Dry root rot (% incidence)	0.0-18.3	1.5-17.2	0.0-17.5	1.0-13.4	0.0-15.6	0.0-15.2

Table-6 : Reaction of groundnut variety GG-40 along with checks against insect-pests

Insect-Pests	Variety GG-40	Zonal Check Varieties				
		TG 37A (ZC)	ICGV 03043 (ZC)	K 1812 (ZC)	JL 1085 (ZC)	DH 256 (ZC)
Thrips (1-9 Scale)	2-3	2-3	2-4	2-3	1-4	2-3
Leaf hopper (1-9 Scale)	2-4	2-4	2-3	2-3	2-3	1-3
<i>Spodopteralitura</i> (1-9 Scale)	2-5	2-5	2-5	2-5	2-5	2-4
Leaf miner (1-9 Scale)	0-4	0-4	0-4	0-4	0-3	0-4

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Effect of Dietary Inclusion of Ashwagandha (*Withania somnifera*) Root Powder on Performance Index, Protein Efficiency and Energy Efficiency of Kuroiler Chicks

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Abstract

An experiment was conducted to find the effect of dietary supplementation of Ashwagandha (*Withania somnifera*) root powder on performance of Kuroiler chicks. A total of one hundred and twenty, day old Kuroiler chicks were used on a completely randomized design in four treatments and further divided into three replicates, each consisting of 10 chicks. The treatments involved the control group (T₁) fed with chick starter feed and other group were fed on basal diet mixed with Ashwagandha root powder @ 0.5%, 1.0% and 1.5% in T₂, T₃, T₄ respectively. The chicks were reared in brooder house under standard management practices as per recommendation throughout the investigational period of 8 weeks. For further analysis the feed intake and body weight of chicks was recorded at weekly intervals. Statistically analyzed data shown that the average performance index, protein efficiency ratio, energy efficiency ratio were significantly higher in T₃ group than all other treatments. Thus, it can be concluded that, the supplementation of Ashwagandha at 1.0% level was found beneficial in improving performance index, protein efficiency and energy efficiency. It can also be concluded that 1% Ashwagandha can be used as efficient, effective and economical alternative to chemical growth promoters in poultry industry.

Key words : Ashwagandha, energy efficiency, kuroiler chicks, performance index, protein efficiency.

Introduction

In India, scientific poultry keeping was first initiated and advocated by Christian missionaries. Poultry is one of the fastest growing segments of agriculture in India today. It required less space, less capital investment, also in poultry farming there is quick return and well distributed turn over throughout the year which makes it remunerative in rural as well as urban areas. Meat production from poultry is 4.78 million tonnes contributing about 51.44% of total meat production i.e. 9.29 million tonnes with 8th rank in the world's meat production (Anonymous, 2022). Kuroiler is a dual purpose hybrid breed of chicken developed by the Kegg farms group in Gurgaon, Haryana. Due to high nutritional value, no religious taboo, universal taste appeal and comparatively economical the poultry meat and egg are gaining popularity. Poultry meat is easy to digest and contains high quality protein for optimum human nutrition. Feed plays a major role because maximum expenditure accounted by feed in poultry production. In the past, antibiotics were used as major growth promoters have been helpful in improvement of growth performance and feed conversion ratio in poultry (Izat *et al.*, 1990; Dibner and Buttin, 2002 and Miles *et al.*, 2006). Due to the adverse effect of the synthetic feed additives many of the herbal growth promoters are being used as an alternative feed additive in the poultry ration. The dietary use of herbal growth promoter increases the performance of broiler by increasing live weight gain and

reduces FCR (Prasad and Sen, 1993 and Samarth *et al.*, 2002). One of these herbal plants is Ashwagandha (*Withania somnifera*) also called as winter cherry, Indian ginseng and poison gooseberry. It belongs to solanaceae family. It has broadly disseminated in dry places of tropical and subtropical areas and has good medical properties (Mirjalili *et al.*, 2009). Ashwagandha contain biologically active compounds like withanolides alkaloids, polyphenols and flavonoids (Mishra *et al.*, 2000). Withanine the main alkaloid present in its roots and leaves. The herb Ashwagandha reportedly have antistress, antioxidative, anticoccidial, immunomodulatory and antilipidemic effect besides playing vital role in lowering serum cholesterol, blood sugar, stress induced gastric indigestion and ulcers (Mushtaq *et al.*, 2012), beside anti-fungal and antibacterial properties (Punetha *et al.*, 2010). The objectives of this study were to evaluate the possible improvement in overall performance and to find safe, cheap and efficient natural growth promoter for kuroiler chicks.

Materials and Methods

The experiment was conducted at Poultry farm, S.K.N. College of Agriculture, Jobner, Jaipur, (Rajasthan, India). The area falls in agro-climatic zone III-A (Semi-arid eastern plain zone of Rajasthan). Geographically Jobner is located at 26° 05' North latitude, 75° 28' East longitude. The investigation was conducted to study the effect of Ashwagandha feeding on performance of

Kuroiler chicks from day old to 8 weeks of age. Total 120, day old Kuroiler chicks were randomly distributed into four treatment groups each having 30 chicks with three replicates consisting 10 chicks in each. Ashwagandha root were dried in sunshine and crushed to make fine powder were mixed at appropriate concentration in feed as specified for different treatments.

Table 1: Treatments detail :

Groups	Treatment
T ₁	Control (StandardchickRation)—as per BIS (2007) Specifications
T ₂	T ₁ + Ashwagandha root powder in feed @ 0.5%
T ₃	T ₁ + Ashwagandha root powder in feed @ 1.0%
T ₄	T ₁ + Ashwagandha root powder in feed @ 1.5%

Experimental brooder rooms, equipment's and utensils were cleaned and disinfected thoroughly with 2.5% phenol and subsequently fumigated with formaldehyde gas (40ml of commercial formalin and 20g potassium permanganate per hundred cubic feet volume). The corners of brooder rooms were rounded by using the cardboard to avoid any piling up of chicks. The chicks (day old) were weighed at the beginning of the experiment and divided into groups randomly. Initially Saw dust of 2 inches thickness was used as litter material which was subsequently increased by 0.5 inch on 15th and 30th day of the experiment. All Standard management practices such as vaccination, brooding, proper lighting, raking of litter, cleaning of feeders, waterers, etc. were followed. The chicks were offered all crumbled chick starter feed ad libitum, according to BIS (2007) specifications. Initially the feed was offered by putting the newspapers on ground and after 3 days horizontal feeder was used to feed the chicks upto the age of two weeks. After two weeks the chick feeder was used and continued during whole experimental period. The feeders were kept at shoulder height of birds and were filled only two third to minimum the feed wastage. The birds were offered clean and fresh drinking water ad libitum using chick waterers during the whole experimental period.

Statistical analysis : Data obtained were subjected to statistical analysis as per Snedecor and Cochran (1994) using Completely Randomized Design (CRD). All the data were subjected to ANOVA using the General Linear Models procedure. The mean difference among different treatments were separated by Duncan's multiple range tests. Consequently, a level of ($P < 0.05$) was used as the criterion for statistical significance (Duncan, 1955).

Results and Discussion

Performance index : The weekly Performance Index (P.I.) of chicks fed diets supplemented with Ashwagandha

is presented in Table 2. The mean P.I. values of chicks at 8 week remained significantly ($P = 0.05$) different in all the treatment groups. The mean P.I value of T₃ (ARP @ 1.0 %) was significantly higher ($P = 0.05$) as compared to control group (T₁) and all the treatment groups at 8th week of age. The mean P.I. value of chicks recorded during 8th week of experiment ranged from 52.67 (T₁) to 66.00 (T₃). Patel *et al.* (2014) recorded similar effects on performance index on the supplementation of garlic alone and in combination with fenugreek in the intensive production of cob-400 broiler chicks. Meena (2015) also found an improvement in growth performance of broilers on supplementation of rosemary and fenugreek. Similar results were also found by Anurag *et al.* (2018), Kayath *et al.* (2022) on performance index on the supplementation of herbal feed additives of pratapdhan and kuroiler chicks.

Protein efficiency ratio (P.E.R) : The treatment means of protein efficiency ratio (PER) showing significance of Ashwagandha supplementation have been shown in Table-3. The mean P.E.R. values of chicks at 8th week of age remained significantly better ($P = 0.05$) in T₃ (ARP @ 1.0%) as compared to all treatment groups. The data recorded were 1.34, 1.39, 1.53 and 1.33 for T₁, T₂, T₃ and T₄ respectively at 8th week of experiment. This was favorably compared with earlier report of Singh *et al.* (2015), Anurag *et al.* (2018), Kayath *et al.* (2022) who revealed that, all the herbal growth promoting additive treatments had better protein efficiency ratio (PER) than control. Elbushra (2012) also reported significant ($P = 0.05$) improvements in protein efficiency values for the groups fed diets with 0.5 and 1.5% fenugreek during the experiment period.

Energy efficiency ratio (E.E.R.) : The means of energy efficiency ratio (EER) showing the effect of Ashwagandha supplementation are given shown in Table 4. The mean values ranged between 9.47 (T₄) to 10.90 (T₃) at 8th week of age. The mean E.E.R. values of chicks at 8 week period remained significantly better ($P = 0.05$) in T₃ (ARP @ 1.0%) as compared to control and all other treatment groups. This improvement was in agreement with Safaeikatouli *et al.* (2012), Anurag *et al.* (2018), Kayath *et al.* (2022) who revealed that, all the growth promoting additive treatments had better energy efficiency ratio (EER) than control.

Conclusions

Thus, it concluded that the supplementation of ashwagandha root powder @ 10g/kg feed level was found advantageous in improving performance index, protein efficiency and energy efficiency. It can also be concluded that 1% Ashwagandha can be used as efficient, effective and economical alternative to chemical growth promoters in poultry industry.

Table-2 : Effect of Ashwagandha on Mean Performance Index of Kuroiler Chicks

Week	Treatments			
	T ₁	T ₂	T ₃	T ₄
1	18.85 ^b ± 0.514	28.26 ^a ± 0.924	29.05 ^a ± 1.367	16.21 ^b ± 0.905
2	26.54 ^c ± 0.892	35.33 ^{ab} ± 0.919	37.99 ^a ± 1.73	32.05 ^b ± 1.315
3	39.16 ^a ± 2.633	40.81 ^a ± 1.007	43.35 ^a ± 3.986	40.97 ^a ± 1.144
4	57.26 ^a ± 3.057	56.41 ^a ± 0.247	57.35 ^a ± 2.549	51.31 ^a ± 0.517
5	68.65 ^b ± 4.791	81.36 ^a ± 2.311	76.88 ^{ab} ± 4.595	65.97 ^b ± 1.173
6	64.67 ^{ab} ± 4.621	69.81 ^{ab} ± 3.222	76.25 ^a ± 4.167	63.38 ^b ± 1.127
7	58.13 ^c ± 1.109	62.09 ^b ± 0.713	80.45 ^a ± 0.491	63.65 ^b ± 0.695
8	52.67 ^b ± 0.585	55.22 ^b ± 0.364	66.00 ^a ± 0.546	53.78 ^b ± 1.31

Each value is a mean of three replicates.

Means bearing different superscripts, differ significantly (P=0.05) row wise.

Table-3 : Effect of Ashwagandha on Mean Protein Efficiency Ratio of Kuroiler Chicks.

Week	Treatments			
	T ₁	T ₂	T ₃	T ₄
1	2.89 ^b ± 0.047	3.54 ^a ± 0.052	3.59 ^a ± 0.096	2.85 ^b ± 0.093
2	2.43 ^b ± 0.048	2.90 ^a ± 0.055	3.10 ^a ± 0.087	2.66 ^b ± 0.079
3	2.31 ^b ± 0.09	2.51 ^{ab} ± 0.04	2.63 ^a ± 0.133	2.28 ^b ± 0.044
4	2.11 ^{ab} ± 0.06	2.19 ^a ± 0.012	2.23 ^a ± 0.046	2.01 ^b ± 0.019
5	1.84 ^b ± 0.074	2.05 ^a ± 0.038	2.01 ^a ± 0.061	1.83 ^b ± 0.015
6	1.63 ^b ± 0.06	1.73 ^{ab} ± 0.038	1.82 ^a ± 0.053	1.61 ^b ± 0.012
7	1.45 ^b ± 0.009	1.51 ^b ± 0.009	1.74 ^a ± 0.000	1.51 ^b ± 0.015
8	1.34 ^c ± 0.012	1.39 ^b ± 0.006	1.53 ^a ± 0.009	1.33 ^c ± 0.012

Each value is a mean of three replicates.

Means bearing different superscripts, differ significantly (P=0.05) row wise.

Table-4 : Effect of Ashwagandha on Mean Energy Efficiency Ratio of Kuroiler Chicks.

Week	Treatments			
	T ₁	T ₂	T ₃	T ₄
1	20.63 ^b ± 0.33	25.28 ^a ± 0.384	25.61 ^a ± 0.694	20.39 ^b ± 0.68
2	17.37 ^b ± 0.345	20.68 ^a ± 0.41	22.13 ^a ± 0.637	18.98 ^b ± 0.568
3	16.53 ^b ± 0.621	17.95 ^{ab} ± 0.287	18.81 ^a ± 0.95	16.26 ^b ± 0.311
4	15.05 ^{ab} ± 0.447	15.62 ^a ± 0.072	15.92 ^a ± 0.337	14.39 ^b ± 0.128
5	13.16 ^b ± 0.518	14.64 ^a ± 0.276	14.33 ^{ab} ± 0.451	13.08 ^b ± 0.107
6	11.62 ^b ± 0.431	12.36 ^{ab} ± 0.285	13.00 ^a ± 0.371	11.51 ^b ± 0.078
7	10.39 ^c ± 0.061	10.79 ^b ± 0.058	12.41 ^a ± 0.015	10.75 ^b ± 0.084
8	9.56 ^c ± 0.075	9.93 ^b ± 0.039	10.90 ^a ± 0.058	9.47 ^c ± 0.097

Each value is a mean of three replicates.

Means bearing different superscripts, differ significantly (P=0.05) row wise.



Fig-1 : Effect of Ashwagandha on Mean Performance Index of Kuroiler Chicks.

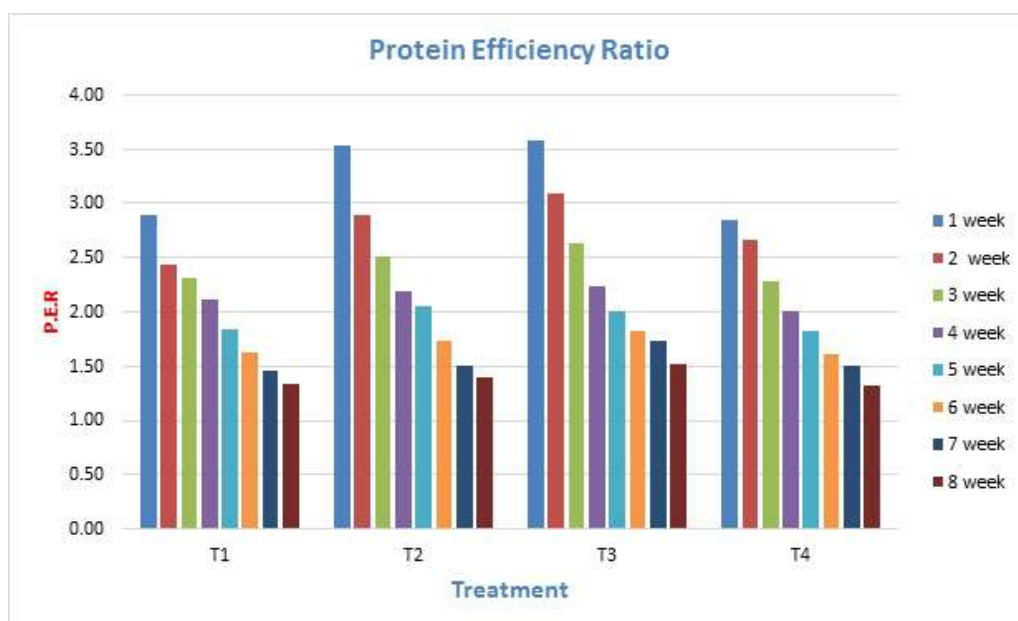


Fig-2 : Effect of Ashwagandha on Mean Protein Efficiency Ratio of Kuroiler Chicks.

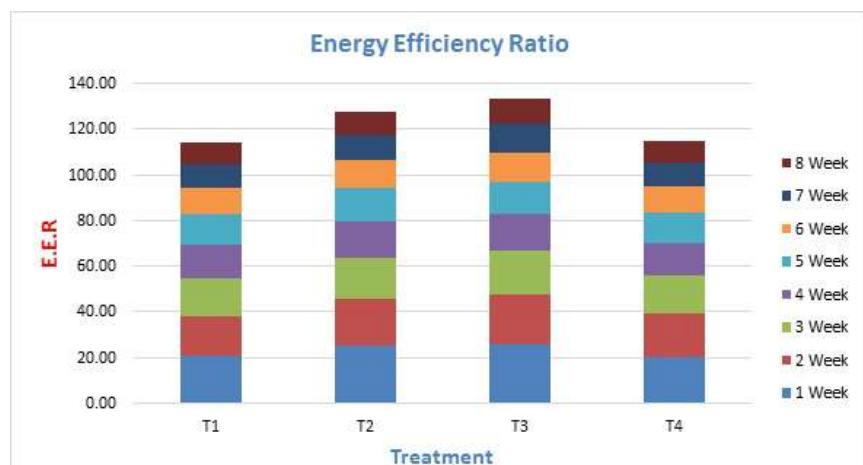


Fig-3 : Effect of Ashwagandha on Mean Energy Efficiency Ratio of Kuroiler Chicks.

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Genetic Architecture and Association Analysis of Yield and Related Attributes in *Linum usitatissimum* (L.)

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Abstract

Oilseed crops are important part of the agricultural economy in India. Among the various oilseeds, linseed is one of the prime oilseed and fiber producing crop. The narrow genetic base and lack of hybrid production system in the linseed led to slow path of genetic improvement. Hence, this current study was carried out to determine the genetical component of the variability and association of various traits in linseed [*Linum usitatissimum* (L.)] during Rabi 2021-22 in randomised block design in three replications at Sardarkrushinagar Dantiwada Agricultural University, Gujarat. The mean square for genotypes for genotypes found significant for all the ten traits studied showed sufficient genetic variability among the studied genotypes. The SHA-2, TL-99, Sharda, HIMALINI and Kota barani als-4 were reported high seed yield per plant based on *per se* performance. High GCV and PCV were revealed by seed yield per plant and number of capsules per plant, indicating a high level of variability among the genotypes. High heritability associated with high genetic advance as a per cent of mean was found for days to flowering, number of primary branches per plant, number of capsules per plant, 1000-seed weight and seed yield per plant suggesting heritable fixed genes governing this traits. The seed yield per plant showed positive and significant association with number of primary branches per plant exhibited the highest and positive direct effect for seed yield per plant followed by number of capsules per plant, oil content, days to maturity, 1000-seed weight, number of seeds per capsule and days to flowering which indicated more importance should be given while forming selection of high yielding linseed genotypes.

Key words : Association analysis, genetic advance, genotypic and phenotypic coefficient of variation, heritability, linseed, path analysis.

Introduction

Oil seeds have prominent position in Indian economy. In India, Linseed [*Linum usitatissimum* (L.)] is the second leading crop after rapeseed-mustard in terms of area and production. (1) The Southeast Asian originated linseed [2n=30] comes under *Malpighiales* order having *Linaceae* and *Lineae* tribe having a haploid genome size is 373 mb. (2) Total 230 spp. belongs to the *Linum* genus but cultivated linseed/ flax are major growing since ancient times for fibre and oil. *Alasi*, *Pesi*, *Phesi* or *Tisi* in odia are popular local name of linseed. This crop requires 25 to 30° C (approx..) during germination and vegetative phase while during seed formation 15 to 20 ° C are required. (3)

An erect annual herbaceous plant with slender glabrous, grayish green stem which matures in 120 to 140 days depending upon cultivar. Linseed and Flax varieties are cultivated with the main purpose of extracting of oil from the seeds and fibre from the stem, respectively. A relatively taller (80-12- cm) in height with consecutive culms and a smaller number of secondary branches towards the top of the stem are comes under flax type category. Flax types usually produce fewer capsules and smaller seeds. Whereas, linseed type having tap root

system with fibrous branches which tends to 60-80 cm in height, profusely branched and bushy shoot is the main character. Generally, these plants produce more number of capsule with larger seeds. Seeds are small, flat, oval, brown or yellow or deep brown coloured and composition of seed differs with size of seeds, varieties, maturity time and environmental conditions. 36-48 % oil is extracted from then seed which contains higher amount of unsaturated fatty acid specifically linolenic acid and 6 % of mucilage which is found under seed coat. (3) It is predominantly a self pollinated crop having < 2 per cent cross pollinated by insect. Being heavy and sticky pollen pollinated by wind is rare.

After Canada and China, India ranks third in area under the cultivation of linseed which accounted 0.18 million hectares produced 0.12 M tonnes with productivity of 671 kg per ha during 2019-20 in India. (3,4) Eastern uttar Pradesh, Madhya Pradesh, Chahhatisgrah, Maharashtra, Odisha Bihar are major linseed growing states in india.

Since ancient times, The oil of linseed has been used as a drying oil. Stem derived fibers are two to three time more robust than cotton derived fibre in terms of length and strength. Due to it's numerous industrial uses,

linseed plays a significant role in Indian economy. Due to presence of high health promoting omega-3 fatty acids (alpha linolenic acid) lowers cholesterol level, imparts cardio vascular benefits and providing raw materials for medicine, food, textiles since 8000 years for human welfare. Hence, it is considered as "Founder crops". (3) In present times, the average productivity is quite lower due to biotic and abiotic stress. Therefore, there is crucial demand to increase the yield aperture and build out varieties with high yield. For the improvement of the seed yield, the high genetic variability, high heritability with high genetic advance are the main considerations. (5) IN addition to that, in india there is a limited aspects for linseed. So, there is urgent need to create information on genotypic and phenotypic variance with heritability and trait association for yield and it's related attributes in linseed genotypes. Likewise, the association of naturally occurring diversity in linseed population helps to selection of diverse genotypes groups for efficient hybridization program. (6) The current research was carried out to study genetic architecture and association analysis of yield and related attributes in linseed.

Research Methodology

The current study accommodated with thirty diverse genotypes of linseed to obtain information on genetic variability, association, direct and indirect effects, genetic diversity of different traits on seed yield at Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. This experiment was set up in a complete randomised block design with three replication in *Rabi* 2021-22. Each genotype was represented by single row of two meter of length in each replication. The inter and intra row distance were 30 cm and 10 cm, respectively. The observation were recorded on five competing plants chosen at random in each replicates and their averages were calculated for plant height, number of primary branch per plant, number of capsule per plant, capsule size, number of seed per capsule, 1000 seed weight and seed yield per plant. Whereas, days to flowering and days to maturity observation were studied on plot basis. The seed oil content was determined by solvent extraction method using Soxhlet apparatus as per standard method using petroleum ether 60-80 % as solvent. As per Burton (7) suggestions genotypic and phenotypic coefficient of variation are calculated. Broad sense heritability and genetic advance at 5 per cent selection intensity using the constant 'k' as 2.06. were calculated as per the formulas by the method suggested by Johnson *et al.* (9) Association analysis expressed the correlation between two variables by estimating the covariance components. For analysis of covariance for all possible of ten characters was carried

out using the method of Panse and Sukhatame (10). The genotypic correlation among the different characters combinations was utilized to construct the path coefficient analysis suggested by Wright (11) and used by Dewey and Lu (12) in plants. According to Rao (13), the diversity analysis was performed and multivariate divergence analysis as per Mahalanobis's D^2 statics.

Results and Discussion

Analysis of variance : The analysis of variance for different traits under study is presented in Table 1. The result revealed the mean sum of square due to genotypes were high significant for all the characters, indicated the existence of sufficient amount of variability in the material under study. Similar kind of results were also reported in linseed by (10) and (11).

Per se performance : The mean performance of thirty diverse linseed genotypes that the genotype Shival depicted earliness in flowering and earliness in maturity. The genotypes namely JLS-66, Kota Barani, Alsi-3 and SHA-3 were dwarf while, 1000-seed weight was recorded highest by SHA-2 followed by TL-99 and Sharda. The highest oil content was found in genotype SLS-73 followed by Gaurav and SHA-8. Whereas, the genotype SHA-2 was the high seed yielding linseed genotype among the thirty diverse genotypes.

Genotypic and Phenotypic coefficient of variation (GCV and PCV) : The highest genotypic and phenotypic coefficient of variation were observed for number of capsule per plant and seed yield per plant indicated the presence of high amount of variability among the genotype for these traits (Table 1). The similar results were also recorded by Dabalo *et al.* (6), Kumar *et al.* (14), Leelavathi and Mongali (16), Paul *et al.* (17) and Naik and Setapathy (18). The moderate level of GCV and PCV were recorded in days to flowering and 1000-seed weight which is similar to the findings of Leelavathi and Mogali (16) and Vardhan and Rao (19). For plant height low genotypic coefficient of variation and moderate phenotypic coefficient of variation were observed which were supported by the result obtained by Dabalo *et al.* (14), Kumar *et al.* (14) and Bhushan *et al.* (20).

Heritability and Genetic Advance as per cent of mean : Days to flowering, number of primary branch per plant, number of capsule per plant, 1000-seed weight and seed yield per plant were observed high heritability with high genetic mean as per cent of mean amongst all observed traits which suggested that presence of heritable fixable variation for these traits. This results were also accordance with Leelavathi and Mogali (16), Kumar *et al.* (14), Rajanna *et al.* (21) and Naik and Setapathy (18) findings. High heritability with moderate genetic advance

Table-1 : Analaysi of variance for various characters in linseed.

Characters	Mean sum of squares		
	Replication	Genotype	Error
Degree of Freedom	2	29	58
Days to flowering	17.01	145.86*	5.59
Days to maturity	4.81	18.55**	2.93
Plant height	2.62	118.71**	4.39
Number of primary branches per plant	0.24	1.02**	0.18
Number of capsule per plant	226.35	2042.18**	79.46
Capsule size	0.07	0.37**	0.073
Number of seed per capsule	0.33	0.94**	0.20
1000-seed weight	0.15	1.32**	0.11
Oil content	11.45	19.08**	4.16
Seed yield per plant	0.96	7.06**	0.33

*, **Significant at 0.05 and 0.01 levels of significance, repectively.

Table-2 : Various genetic parameters of variation for seed yield and its contributing characters in linseed.

Sr. No.	Characters	Coefficient of variation			$h^2_{(b.s.)}$	GA	GAM (%)
		GCV (%)	PCV (%)	ECV (%)			
1.	Days to flowering	10.52	11.13	3.64	89.33	13.31	20.49
2.	Days to maturity	1.97	2.46	1.47	64.03	3.76	3.24
3.	Plant height	9.98	10.54	3.39	89.68	12.04	19.48
4.	Number of primary branches per plant	17.73	22.72	14.21	60.87	0.85	28.49
5.	Number of capsule per plant	24.51	25.96	8.54	89.17	49.76	47.69
6.	Capsule size	4.42	5.82	3.78	57.75	0.50	6.92
7.	Number of seed per capsule	5.88	7.92	5.30	55.23	0.76	9.01
8.	1000-seed weight	11.52	13.04	6.10	78.09	1.16	20.97
9.	Oil content	7.32	9.92	6.70	54.47	3.39	11.13
10.	Seed yield per plant	25.23	27.00	9.60	87.37	2.89	48.59

as per cent of mean was observed in plant height and moderate amount of heritability with moderate genetic advance as per cent of mean observed in oil content which indicated that the equal importance of both heritable fixable and heritable and non-fixable genetic variation. This result are similar with the findings of Dabalo *et al.* (6), Paul *et al.* (17), Chaudhary *et al.* (22), Rajanna *et al.* (21), Bibi *et al.* (23) and Vardhan and Rao (19).

Trait Association Analysis : Association analysis is used to find out the correlation between two or more characters. It measures the type and amount of association between a pair of characters. This correlation provides the information about the economic characters like yield and yield contributing attributes which can utilize for the selection and improvement of yield which is beneficial for the plant breeder to select a desirable genotype from the diverse plant genotypes. The phenotypic and genotypic correlation coefficients were analyzed for all ten characters for thirty linseed genotypes to determine the degree and direction of association of seed yield with other traits which is presented in Table-3.

In current experiment, seed yield per plant showed

positive and significant correlation with capsule size ($rg = 0.9935^{**}$ and $rp=0.7216^{**}$), number of capsule per plant ($rg=0.9812^{**}$ and $rp=0.9747^{**}$), number of seed per capsule ($rg = 9721^{**}$ and $rp = 0.7978^{**}$) and 1000-seed weight ($rg = 0.7692^{**}$ and $rp = 0.7546^{**}$) at both genotypic and phenotypic levels which indicated that these characters as yield attributing traits and improvement in any of these traits will leads to the improvement in seed yield. However, negative and significant association of seed yield was found with oil content ($rg = -0.5156^{*}$ and $rp= -0.3034^{**}$) at both genotypic and phenotypic levels which indicates oil content is inversely proportionate and yield also suggesting need of different programmes for the quality improvement and yield improvement in linseed. Similar result of seed yield per plant with various traits was also reported by Ataii *et al.* (24), Kasana *et al.* (15), Patial *et al.* (25), Chaudhary *et al.* (26), Sharma *et al.* (27) and Rahimi *et al.* (28).

Path Coefficient analysis : Any two characters may be demonstrated linked as they are associated with third common character. For selection and understanding those yield components affecting yield improvement, the

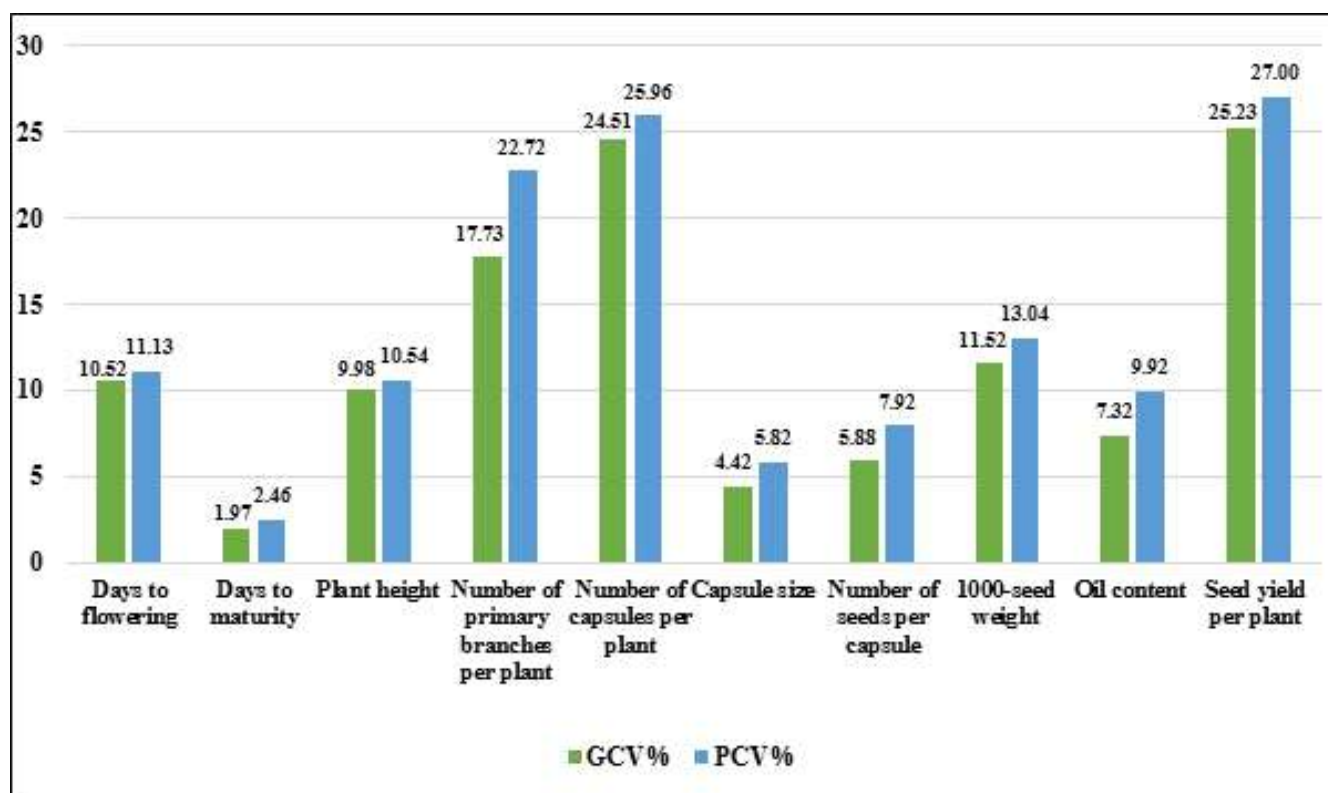


Fig-1 : Graphical representation of genotypic and phenotypic coefficient of variation for ten characters of linseed.

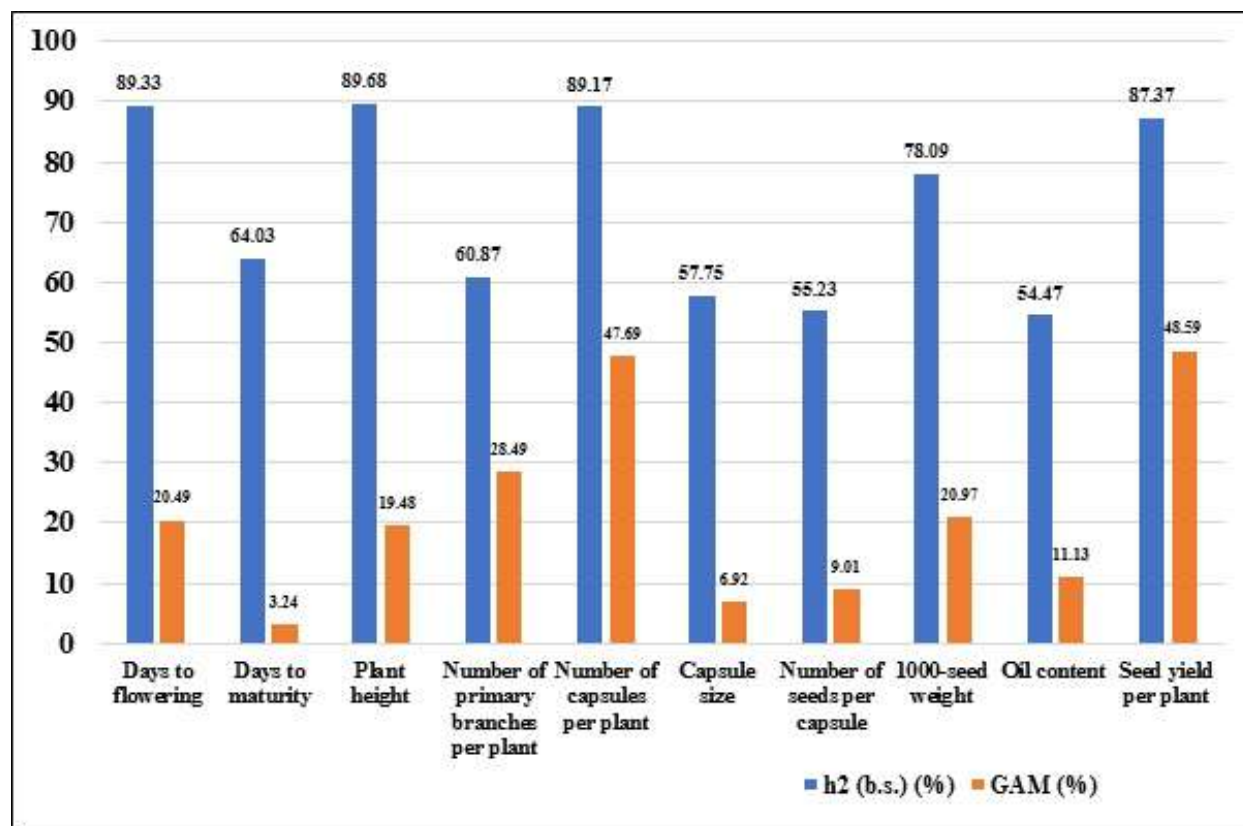


Fig-2 : Graphical representation of heritability and genetic advance as per cent of mean for ten characters in linseed.

Table-3 : Genotypic and Phenotypic correlation coefficient for different characters in linseed.

Sr. No.	Characters	DF	DM	PH	NPBP	NCPP	CS	NSPC	SW	OC	SYPP
1.	DF	r_g	1.0000	0.5272 **	0.3346	0.3265	0.2618	0.1296	0.1394	-0.4424*	0.2808
2.	DM	r_p	1.0000	0.4808 **	0.2565 *	0.2746 **	0.2012	0.0992	0.0934	-0.2960**	0.2367*
3.	PH	r_g	1.0000	-0.3607	-0.5758 **	-0.2928	-0.4985**	-0.4353*	-0.4303*	0.3777*	-0.3142
4.	NPBP	r_p	1.0000	-0.2824 **	-0.3756 **	-0.2527 *	-0.2047	-0.3486**	-0.3275**	0.2318*	-0.2708**
5.	NCPP	r_g	1.0000	1.0000	0.5198 **	0.3499	0.2800	0.1546	0.1783	-0.3631*	0.2786
6.	CS	r_p	1.0000	1.0000	0.3764 **	0.3294 **	0.1591	0.1325	0.1770	-0.2392*	0.2651 *
7.	NSPC	r_g	1.0000		1.0000	0.9303 **	0.9473**	0.9527**	0.8065**	-0.6727**	0.9317**
8.	SW	r_p	1.0000		1.0000	0.6550 **	0.5416**	0.5598**	0.5537**	-0.3187**	0.6570**
9.	OC	r_g	1.0000			1.0000	0.9567**	0.9028**	0.7386**	-0.5181**	0.9812**
10.	SYPP	r_p	1.0000			1.0000	0.7005**	0.7595**	0.7230**	-0.3391**	0.9747**
		r_g				1.0000	1.0000	0.8420**	0.9734**	-0.5393**	0.9935**
		r_p				1.0000	1.0000	0.6448**	0.6802**	-0.3541**	0.7216**
		r_g					1.0000	1.0000	0.9045**	-0.5133**	0.9721**
		r_p					1.0000	1.0000	0.7586**	-0.2863**	0.7978**
		r_g					1.0000	1.0000	1.0000	-0.6046**	0.7692**
		r_p					1.0000	1.0000	1.0000	-0.4119**	0.7546**
		r_g						1.0000	1.0000	1.0000	-0.5156**
		r_p						1.0000	1.0000	1.0000	-0.3034**
		r_g								1.0000	1.0000
		r_p									1.0000

study of their and indirect effect through association and path coefficient analysis are required. (18) The direct and indirect effects of all the characters on seed yield per plant presented in Table 4 and the graphical representation of path diagram given in Fig.-3.

The study of path coefficient analysis revealed that the number of primary branches per plant exhibited the highest and positive direct effect (1.1651) toward the seed yield per plant. Similar result reported by Sharma *et al.* (27), Ibrar *et al.* (29), Chaudhary *et al.* (26), Rahimi *et al.* (28) and Naik and Setapathy (18). Number of capsule per plant (0.3231) recorded high and positive direct effect towards the seed yield per plant which is in accordance with the result of Leelavathi and Mogali (16), Kasana *et al.* (15), Ibrar *et al.* (29), Tariq *et al.* (30), Rajanna *et al.* (21), Rahimi *et al.* (28) and Naik and Setapathy (18). Whereas, oil content (0.2274) recorded moderate and positive while, days to maturity (0.1595) and 1000-seed weight (0.1252) recorded low and positive direct effect toward the seed yield per plant. The result of 1000-seed weight and oil content in present study are in accordance with the results of Ibrar *et al.* (29) and Akbar *et al.* (31). Number of seeds per capsule (0.0977) and days to flowering (0.0774) recorded negligible and positive direct effect towards the seed yield per plant. Similar results were reported by Patial *et al.* (25). Whereas, Capsule size exhibited highest and negative direct effect (-0.3899) to the seed yield per plant followed by plant height (-0.2689). Similar result of plant height towards the seed yield per plant was also reported by Kasana *et al.* (15), Ibrar *et al.* (20), Chaudhary *et al.* (26), Tadesse *et al.* (32), Naik and Setapathy (18) and Akbar *et al.* (31). Among all traits number of seed per capsule recorded the highest and positive indirect effect (1.1037) towards the seed yield per plant via number of primary branch per plant. Whereas, capsule size (1.1037) and number of capsule per plant (1.0839) also recorded the very high and positive direct effect towards the seed yield via number of primary branch per plant. The result of very high and positive indirect effect of number of capsule per plant on seed yield per plant via number of primary branch per plant is in accordance with the findings of Reddy *et al.* (33). Such type of finding indicated that, increased in number of primary branch per plant leads to improve the number of capsule per plant, number of seed per capsule and capsule size which ultimately contributed towards the seed yield.

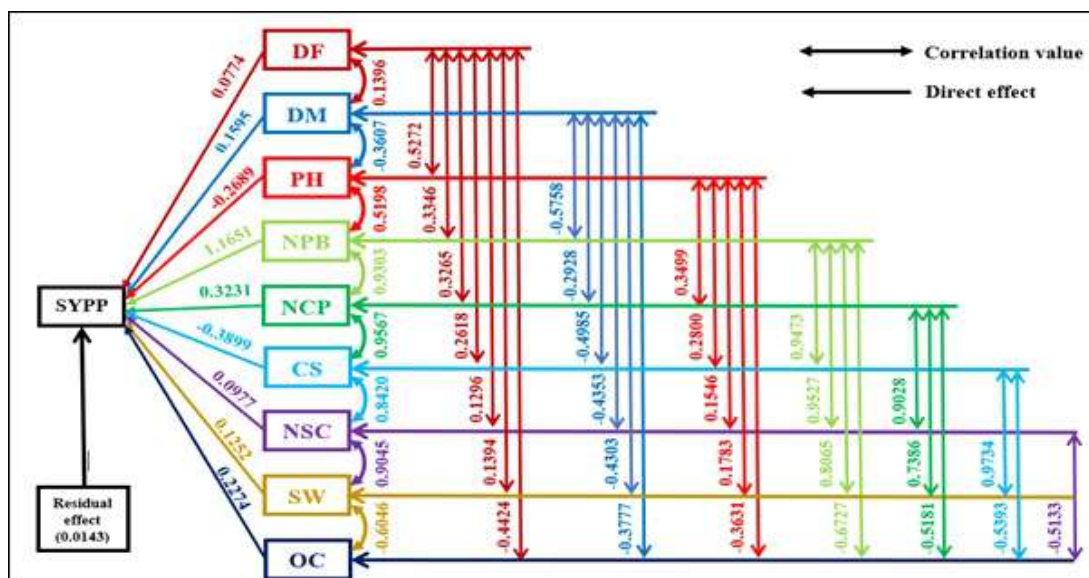
The residual effect (0.0143) reported in the present investigation indicating presence of those independent traits which are associated with seed yield of linseed genotype and were not include in the study but provided

Table-4 : Path coefficient analysis showing direct and indirect effects of various traits on seed yield per plant in linseed.

S. N.	Characters	DF	DM	PH	NPBPP	NCPP	CS	NSPC	SW	OC	Genetic correlation with seed yield per plant
1.	DF	0.0774	0.0223	-0.1418	0.3898	0.1055	-0.1021	0.0127	0.0175	-0.1005	0.2808
2.	DM	0.0108	0.1595	0.0970	-0.6708	-0.0946	0.1944	-0.0425	-0.0539	0.0859	-0.3142
3.	PH	0.0408	-0.0575	-0.2689	0.6056	0.1130	-0.1092	0.0151	0.0223	-0.0826	0.2786
4.	NPBPP	0.0259	-0.0918	-0.1398	1.1651	0.3006	-0.3694	0.0931	0.1009	-0.1529	0.9317**
5.	NCPP	0.0253	-0.0467	-0.0941	1.0839	0.3231	-0.3731	0.0882	0.0924	-0.1178	0.9812**
6.	CS	0.0203	-0.0795	-0.0753	1.1037	0.3091	-0.3899	0.1059	0.1218	-0.1226	0.9935**
7.	NSPC	0.0100	-0.0694	-0.0416	1.1100	0.2917	-0.4228	0.0977	0.1132	-0.1167	0.9721**
8.	SW	0.0108	-0.0686	-0.0479	0.9397	0.2387	-0.3796	0.0884	0.1252	-0.1375	0.7692**
9.	OC	-0.0343	0.0602	0.0977	-0.7837	-0.1674	0.2103	-0.0501	-0.0757	0.2274	-0.5156**

Residual effect = 0.0143 , Note: Bold diagonal value indicate direct effect.

Where, DF=days to flowering, DM=days to maturity, PH=plant height (cm), NPBPP=number of primary branch per plant, NCPP=number of capsule per plant, CS=capsule size (mm), NSPC=number of seed per capsule, SW=1000-seed weight, OC=oil content (%), SYPP=seed yield per plant (g)

**Fig-3 : Diagrammatic representation of genotypic path analysis in linseed.**

a good scope for improvement in seed yield in linseed genotypes. Low estimate of residual effect in present study was indicating most of the traits showing variability had been included.

Genetic divergence : In this present study, thirty diverse genotypes of linseed were sorted out into thirteen cluster by D2 Statistics by (34) and tocher's method which described by (13) in table 5 and the amounts of contribution towards the genetic divergence showed in the table 6 and fig 4.

In Table-6, number of capsule per plant recorded as highest contributor for the divergence followed by days to flowering, plant height, 1000-seed weight, seed yield per plant, Oil content and days to maturity. The result

revealed that cluster – I contains highest number of genotypes (6 genotypes) followed by cluster-V (5 genotypes), cluster-III (4 genotypes), clusters-IV and VI (genotypes). While, the each from cluster VIII to XIII have one genotype.

Geographic regions showed no impact on genetic diversity since genotypes from the same set were grouped into various clusters and genotypes from other locations were grouped together. As a result, a plant breeders must evaluate their material for genetic diversity instead of solely geographical diversity.

The maximum intra cluster distance was recorded between VII and III ($D^2 = 283.75$) and lowest recorded between I and II ($D^2 = 32.89$). Whereas, Inter cluster

Table-5 : Distribution of cluster according to D² statistics of thirty genotypes of linseed.

Sr. No.	Cluster No.	Number of genotypes in cluster	Name of Genotypes in cluster
1.	I	6	Varsha Alsí, Meera, JLS-95, Baner, SHA-1, RL-914
2.	II	2	SHA-1, Parvati
3.	III	4	SHA-2, HIMALINI, Sharda, Pratap Alsí-1
4.	IV	3	SHA-8, Gaurav, Hira
5.	V	5	SHA-73, SHA-4, SHA-5, Kota Barani Alsí-3, Kota Barani-4
6.	VI	3	T-7, Azad Alsí-1, Mukta
7.	VII	1	JLS-66
8.	VIII	1	SHA-3
9.	IX	1	Shival
10.	X	1	SHA-9
11.	XI	1	TL-99
12.	XII	1	SHA-6
13.	XIII	1	GPI-24

Table-6 : Contribution of traits towards the genetic divergence.

Sr. No.	Characters	Time ranked	Per cent contribution towards genetic divergence
1.	Days to flowering	104	23.91
2.	Days to maturity	15	3.45
3.	Plant height	102	23.45
4.	Number of primary branches per plant	1	0.23
5.	Number of capsule per plant	117	26.90
6.	Capsule size	4	0.92
7.	Number of seed per capsule	0	0.000
8.	1000 seed weight	48	11.04
9.	Oil content	15	3.45
10.	Seed yield per plant	29	6.67

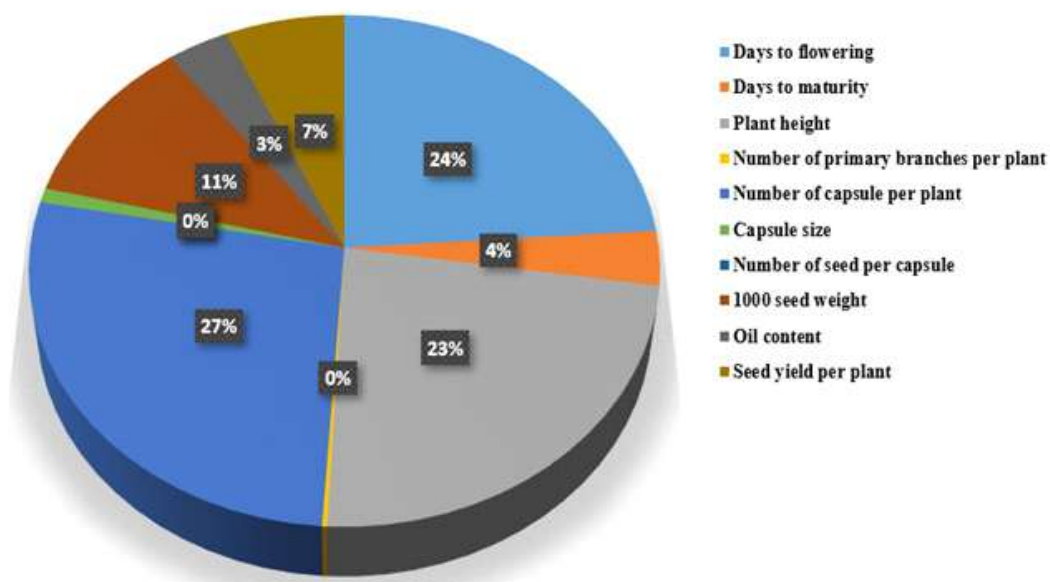


Table-7 : D² values depicting average inter and intra cluster distance between clusters of linseed genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I	25.99	32.89	116.56	54.62	44.42	52.64	102.80	44.97	93.34	68.49	95.24	65.03	93.30
II		11.28	74.04	86.97	67.41	106.40	123.85	40.78	166.31	73.34	80.33	60.26	121.45
III			28.55	216.16	174.69	228.44	283.85	127.99	281.65	199.19	65.62	84.78	241.75
IV				17.36	54.04	42.37	109.29	52.22	97.76	57.65	163.79	143.00	53.12
V					29.99	55.25	43.96	105.83	75.29	77.29	89.11	104.66	120.29
VI						27.98	100.90	82.46	62.20	71.01	172.08	149.20	114.50
VII							0.00	192.16	140.15	95.48	143.17	203.74	188.29
VIII								0.00	158.93	55.05	168.16	107.93	94.98
IX									0.00	176.01	190.46	129.05	131.82
X										0.00	171.09	208.66	167.61
XI											0.00	82.78	190.05
XII												0.00	109.07
XIII													0.00

distance recorded highest in cluster V ($D^2 = 29.99$) and lowest in cluster VII, VIII, IX, X, XI, XII and XIII ($D^2 = 0.00$) because of single genotype in each cluster.

Conclusions

High heritability values associated with high genetic advance were recorded for most of observed characters viz. days to flowering, plant height, number of capsule per plant, 1000 seed weight and seed yield indicating that these traits are governed by additive gene effects and direct selection will be more benefited in genetic improvement. Yield is positively associated with capsule size, number of capsule per plant, number seed per capsule, number of primary branches per plant and 1000 seed weight. So, the selection for these traits can directly affect in yield improvement in linseed. The genotypes from the cluster III, VII, IX, XIII and VI can be used for intercrossing due to high genetic for creation of wide spectrum genetic diversity and obtain transgressive segregants for seed yield improvement in linseed.

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Incidence of Urolithiasis, among Patients Visiting Urology Department at Government Hospital

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Abstract

Urolithiasis is the most common painful disorder of urinary tract. Hence the increased threat is attributable to genetic and environmental factors such as variations in geographical conditions in terms of regional stones belt, hot climate and sunlight exposure. Because of high temperature and excessive exposure to sunshine, the prevalence of urolithiasis was much higher in south asia and southeast asia, such as in India and Malaysia. Department of urology, Prince Bijoy Singh Memorial (PBM), associated group of Hospitals, S. P. Medical College Bikaner was visited by the investigator after obtaining a formal permission from the authorities of hospital administration. As per available hospital records, information was simultaneously assembled regarding overall number of patients visited department of urology and treated for various diseases of urinary system and year wise numbers of registered OPD and IPD patients of urinary stones profile were noted and incidence of urolithiasis was estimated from the period of 2010 to 2018. Every year out of all registered patients, 4,149 to 5,371 were treated for various diseases of urinary system. Incidence of urolithiasis ranged between 517 and 889 in number (12.46-19.96%) per year, indicating increment in prevalence for all IPD patients each with the succeeding year.

Key words : Urolithiasis, OPD, IPD, Incidence and prevalence.

Introduction

Normal composition and volume of body fluid is maintained by the urinary system. This is accomplished by glomerular filtration, tubular reabsorption, and tubular secretion of soluble and filterable plasma components. By such means, urine contains water, electrolytes, minerals, hydrogen ions, end products of protein metabolism such as urea, uric acid, and creatinine (Jayaraman and Gurusamy, 2018). Normal urine is slightly acidic and volume up to 2000ml per day, depending upon fluid intake, diet, environmental temperature, loss of fluid from the body by evaporation of sweat, mental state and physical conditions.

Urinary stone formation is the basic output in any kind of urinary disorder. Urinary stone incidents are expanding particularly in urban and rural areas of India. Large part of total population of country is suffering with urinary stone which caused due to deposition of phosphate, calcium and oxalates. This stone formation occurs due to continuous accumulation of chemical over a nucleus. If these stones may stick for longer period of time it leads to secondary complications which cause serious consequences. Kidney excretes uric acid, phosphate and oxalate along with minerals like sodium, calcium and magnesium from metabolism of digested food. Stones are formed if above mentioned crystals precipitated. These stones can be of different shapes & sizes which may be stuck between kidney and urethra inside the urinary tract.

Effective diet modifications would be safer and less costly than medication, and more suitable for lifelong continuation (Abrams et al., 2002). More severe cases may require surgical intervention. Thus, urolithiasis imposes substantial economic consequences and a great public health importance. Along with that the epidemiology of urolithiasis fluctuate according to geographical area in term of prevalence and incidence, age and sex distribution, stone composition and stone location. Such differences have been explained in terms of race, diet and climate factors. Furthermore, varying socio-economic conditions also causes changes in the prevalence, incidence and distribution for age, sex and type of lithiasis in terms of both the site and the chemical-physical composition of the calculi (Tricheiri, 2008).

This disease affects all age groups from less than 1-year-old to more than 70 years old, with a male to female ratio of 2 to 1 and the prevalence of calculi may be ranges from 4 to 20 per cent (Abbagani et al., 2010). There is a known geographic variation in stone disease that has been attributed to regional differences in temperature, so the incidence of kidney stone disease is particularly high in areas with dry, hot climate. A combination of factors comes into view to be responsible for stone formation in which the main factors responsible for formation of stones are low urinary volume and high urinary concentration due to low intake of water. Urinary calculi develop more frequently in individuals with a family

history of urinary calculi than with no family history. Hence the increased threat is attributable to genetic and environmental factors such as variations in geographical conditions in terms of regional stones belt, hot climate and sunlight exposure. Therefore, this higher risk population should be made aware of the importance of maintaining good hydration, especially during the warmer months. Countries in tropical and subtropical areas have also reported a high incidence of urolithiasis (Rizvi et al., 2002). Approximate 2 million people in India are affected with urolithiasis every year and some parts of country have name denoted as a stone belt that is, Gujarat, Maharashtra, Punjab, Rajasthan, Delhi, Haryana and part of states on North East side (Sohgaura and Bigoniya, 2017). The prevalence of urolithiasis is rising due to various changes in the socio-demographic and other etiological factors due to the stone belt zone in the north-western states of India in general; Rajasthan in particular and there is a lack of proper scientific studies on its incidence rate, socioeconomic status, clinical factors and nutritional factors which may be accountable for the development of urinary stones. Dietetic consideration of urinary stone patients' needs particular awareness and consideration from geographical, economical, medicinal and dietetic point of view to prevail over this health dilemma by appropriate supervision and management in this province of the nation, hence, keeping these points in mind; the present research was initiated to find out the incidence of urolithiasis among patients who were visiting department of urology at a district government hospital.

Research Methodology

The study was conducted in the Department of Food and Nutrition, College of Home Science, SKRAU, Bikaner. The research procedure has been distinctly described under the following heads:

- 1 Locale of the study
- 2 Incidence of urolithiasis
- 3 Ethical approval to conduct the study

Locale of the study : The study was conducted in the department of Food and Nutrition, College of Home Science, SKRAU, Bikaner, Rajasthan with the help of Prince Bijoy Singh Memorial (PBM), associated group of Hospitals, S. P. Medical College Bikaner which was selected purposely for data collection of the study.

Prince Bijoy Singh Memorial (PBM) hospital is a Government hospital situated in a huge area of Bikaner city. PBM hospital is considered as one of the biggest hospitals of Rajasthan. Department of Urology is a significant wing of the hospital, where patients suffering from infection of urinary tract, prostates, bladder pain

syndrome, urethritis, epididymitis, male sexual dysfunction, female sexual dysfunction, testicular tumours, tumours of penis and urethra, urolithiasis; infection, inflammation and urolithiasis of the paediatric genitourinary tract, visit daily in the yearn for their treatment. These patients belong not only to division of Bikaner (Bikaner, Sriganganagar, Hanumangarh, Churu) but also to nearby and surrounding districts like Nagaur, Jaisalmer, Jodhpur, Sikar and Jhunjhunu. As per available hospital records approximately, per OPD 140-150 patients visit the Urology department twice in a week where 30 per cent of them were suffering from Urolithiasis. Therefore, Department of Urology of the PBM hospital was identified for the present study in view of the possibilities of getting required sample size of the subjects.

Incidence of Urolithiasis : To find out incidence of urolithiasis, among patients who were visiting the Urology department, a formal permission was taken from the Head of the Urology department, PBM hospital, Bikaner (Rajasthan). After obtaining permission from the hospital administration, Urology department was visited by the investigator to study the incidence of urolithiasis.

Patients suffering from urolithiasis were identified purposively for the present study on the basis of registered OPD and IPD patients of urinary stones profile at Department of Urology, PBM hospital, Bikaner during June to December, 2016. On the basis of hospital records, year wise numbers of patients were noted and incidence of urolithiasis was estimated from the period of 2010 to 2018.

Ethical approval to conduct the study : There is a statutory obligation to obtain the prior approval of ethics committee. The ethics committee granted permission to conduct the study after examining and discussing documents.

Results and Discussion

Table-1(i) represents the incidence and number of outdoor and indoor patients registered at urology department all through the years in between 2010 to 2018. During this study period, 13,038 to 17,998 numbers of total patients registered at the urology department indicating increment in number each with the succeeding year. Every year out of all registered patients, 4,149 to 5,371 were treated for various ailments of urinary system. Incidence of urolithiasis ranged between 517 and 889 in number (12.46-19.96%) per year. Further, year wise constant increase in the cases of urolithiasis has been observed during the present study [Table 1 (i)]. Rest of the subjects suffered from hypospadias (3.33-5.94%), hydronephrosis (6.92-7.00%), neurogenic bladder

Table-1(i) : Number of patients visiting urology department and incidence of various urinary diseases.

Year of Assessment	Number of patients registered in Urology department (indoor + outdoor patients)	No. of outdoor patients	No of indoor Patients	Number of indoor patients treated for various diseases of Urinary system							
				Urolithiasis	Hypo-speldiasis	Hydro-nephrosis	Neurogenic Bladder	Hematuria	Stricture Urethra	Urinary Tract Infection	Benign Prostatic Hyperplasia
2010	13,038	8,889	4,149	517 (12.46)	138 (3.33)	287 (6.92)	177 (4.27)	276 (6.65)	523 (12.61)	1243 (29.96)	988 (23.81)
2011	13,562	10,069	4,637	618 (13.33)	204 (4.39)	278 (5.99)	186 (4.01)	365 (7.87)	511 (11.02)	1332 (28.72)	1143 (24.64)
2012	14,225	10,081	4,144	556 (13.42)	174 (4.19)	224 (5.40)	144 (3.47)	290 (6.99)	312 (7.52)	1134 (27.36)	876 (21.13)
2013	14,739	9,368	5,371	757 (14.09)	288 (5.36)	311 (5.79)	165 (3.07)	357 (6.64)	518 (9.64)	1543 (28.72)	1432 (26.66)
2014	15,145	10,707	4,438	669 (15.07)	214 (4.82)	256 (5.77)	136 (3.06)	255 (5.74)	416 (9.37)	1114 (25.10)	1378 (31.05)
2015	15,476	10,747	4,729	733 (15.50)	255 (5.39)	287 (6.06)	134 (2.83)	286 (6.04)	541 (11.44)	1287 (27.21)	1206 (25.50)
2016	15,562	12,069	3,493	548 (15.69)	152 (4.35)	221 (6.32)	103 (2.94)	214 (6.12)	292 (8.35)	1041 (29.80)	922 (26.39)
2017	17,462	12,136	5,326	881 (16.54)	145 (2.7)	275 (5.16)	152 (2.85)	392 (7.3)	541 (10.15)	1521 (28.55)	1419 (26.64)
2018	17,998	13,543	4,455	889 (19.96)	265 (5.94)	312 (7.00)	133 (2.98)	304 (6.82)	231 (5.18)	1102 (24.73)	1219 (27.36)

Note : Percentage values given in parenthesis.

Table-1(ii) : Incidence of urolithiasis according to anatomical site of the stones.

Year of Assessment	No of indoor Patients	Total subjects of urolithiasis	Number of patients according to their anatomical location of stones						
			Kidney stone	Ureteral stone	Bladder (vesicle) stone	Stone in Pelvic-Ureter-Junction	Stone in Vesiculo-Ureter-Junction	Urethral stone	Stone at Multiple site
2010	4,149	517(12.46)	257(49.71)	106(20.50)	61(11.80)	17(3.29)	19(3.68)	9(1.74)	48(9.28)
2011	4,637	618(13.33)	297(48.06)	145(23.46)	71(11.49)	20(3.24)	21(3.40)	12(1.94)	52(8.41)
2012	4,144	556(13.42)	246(44.24)	126(22.66)	63(11.33)	14(2.52)	18(3.24)	11(1.98)	78(14.03)
2013	5,371	757(14.09)	342(45.18)	203(26.82)	76(10.04)	24(3.17)	30(3.96)	14(1.85)	68(8.98)
2014	4,438	669(15.07)	311(46.49)	131(19.58)	79(11.81)	31(4.63)	44(6.58)	11(1.64)	62(9.27)
2015	4,729	733(15.50)	325(44.34)	208(28.38)	61(8.32)	21(2.86)	29(3.96)	13(1.77)	76(10.37)
2016	3,493	548(15.69)	249(45.44)	123(22.45)	69(12.59)	18(3.28)	18(3.28)	10(1.82)	61(11.13)
2017	5,326	881(16.54)	398(45.18)	211(23.95)	88(9.99)	43(4.88)	51(5.79)	16(1.82)	74(8.40)
2018	4,455	889(19.96)	451(50.73)	226(25.42)	82(9.22)	18(2.02)	24(2.70)	9(1.01)	79(8.89)

Note : Percentage values given in parenthesis.

(4.27-2.98%), hematuria (6.65-6.82), stricture urethra (12.61-5.18%), urinary tract infection (29.96-24.73%) and benign prostatic hyperplasia /BPH (23.81-27.36%) and were treated.

The present findings are supported with the results of various researchers like Rajput & Arif, (2006) and Sohgauna & Bigoniya (2017) that the prevalence and incidence of urolithiasis is to be increasing across the world. The major causes for urinary stone problems are environmental and metabolic. In India, Rajasthan belongs to stone-belt zone; about 10-14% of the population is expected to have urinary stones in sub-tropical arid (desert) climatic region which includes western parts of Bikaner, Jaisalmer, Barmer, Jodhpur and southern parts

of Ganganagar district. Geographical factors like climate and increasing rates of hypertension, diabetes, obesity, gender, dietary habits raises the risk of urolithiasis. Yoshida *et al.*(1999), Hesse *et al.*(2003) as well as Rohrborn & Mcconnel, (2007), Raheem *et al.*(2017) have also affirmed that the incidence of urolithiasis is steadily increasing, represents a potential environmental cause as add on to genetic predisposition.

Data in Table 1 (i) & (ii) disclose the per cent prevalence of urolithiasis during present study ranged between 12.46 to 19.96 per cent. According to Sathish *et al.* (2008) and Khan *et al.* (2019) urinary stone formation affects up to 15 per cent of population. Sunitha *et al.* (2018) have also stated 12 per cent pervasiveness of

urinary stone in tropical and semi-arid region of Tamilnadu. These findings of earlier scientists are also in close proximity with present findings.

Table-1(ii) represents, incidence of urolithiasis according to anatomical location, during the year 2010 to 2018. The subjects suffering from urolithiasis were classified according to site of stone in the urinary system. During the study period, occurrence of kidney stone varied from 44.24 to 50.73 per cent, ureteral stone from 19.58 to 28.38 per cent, bladder (vesicle) stone 8.32 to 12.59 per cent, vesiculo ureteral junction stone (VUJ) 2.70 to 6.58 per cent, pelvic ureteral junction (PUJ) 2.02 to 4.88 per cent, urethral stone 1.01 to 1.98 per cent and stone at multiple site as 8.40 to 14.03 per cent.

Table also markedly discloses that the incidence of kidney stones were highest as compared to stone formation at other sites of urinary system. Similar findings about larger incidence of stones in kidney also reported by Jan *et al.*(2008) and Sunitha *et al.*(2018), while studying various aspects of urinary stones.

Summary and Conclusions

This exploratory study was carried out at Department of Food and Nutrition, College of Home Science, Swami Keshwanand Rajasthan Agricultural University, Bikaner (Raj.), during 2016-19 to find out the incidence of urolithiasis, nutritional status of subjects, underlying causes of urolithiasis & its association with different factors and to provide guidelines for prevention and management of urolithiasis. Data collection was carried out at Prince Bijoy Singh Memorial (PBM) hospital, Bikaner, which was selected purposely for the study. This is a Government organization and has separate Urology Department.

To find out incidence of urolithiasis, among patients who were visiting the Urology department, a formal permission was taken from the Head of the Urology department, PBM hospital, Bikaner (Rajasthan). After obtaining permission from the hospital administration, Urology department was visited by the investigator to study the incidence of urolithiasis.

On the basis of hospital records, year wise numbers of registered OPD and IPD patients of urinary stones profile were noted and incidence of urolithiasis was estimated from the period of 2010 to 2018. Every year out of all registered patients, 4,149 to 5,371 were treated for various diseases of urinary system. Incidence of urolithiasis ranged between 517 and 889 in number (12.46-19.96%) per year, indicating increment in prevalence for all IPD patients each with the succeeding year. During the study period prevalence of kidney stone varied from 44.24 to 50.73 per cent, ureteral stone from

19.58 to 28.38 per cent, bladder (vesicle) stone 8.32 to 12.59 per cent, vesiculo-ureteric junction stones 2.70 to 6.58 per cent, pelvic-ureteric junction 2.02 to 4.88 per cent, urethral stone 1.01 to 1.98 per cent and stone of multiple site 8.40 to 14.03 per cent.

Patients suffering from urolithiasis were identified purposively for the detailed study on the basis of registered IPD patients of urinary stone profile at Department of Urology, PBM hospital, Bikaner.

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Effect of Pruning and Growth Regulators on Seed Yield and Seed Quality of Sponge Gourd [*Luffa cylindrica* (L.) Roem.]

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Abstract

A field experiment was conducted during the rainy season of 2022-23 at Research Farm, Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar with the objective to study the effect of pruning and growth regulators on seed yield and seed quality of sponge gourd. The experiment comprised of three pruning levels (no pruning, pruning at 0.75 m and 1.25 m length of main vine) and seven levels of growth regulators (control, GA₃ @ 25, 50, 75 ppm and ethrel @ 75, 100, 125 ppm). The results clearly indicated that ethrel @ 125 ppm with pruning at 1.25 m vine length recorded maximum seed yield per vine (0.052 kg/vine) and seed yield (202.58 kg/ha). The maximum value of standard germination (86.83 %), seedling length (38.08 cm), seedling weight (83.44 mg), vigour index-I (3,304.87) and vigour index-II (7,242.59) were observed with GA₃ @ 75 ppm with pruning at 1.25 m vine length.

Key words : Pruning, growth regulators, seed yield, seed quality.

Introduction

Sponge gourd is a warm-season vegetable which has chromosome number of 26. According to botany, it is a cross-pollinated annual climbing vine with peculiar tendrils and leaves. Fruits are cylindrical pepo. In the tropical and subtropical regions of the world, it is commonly cultivated. According to Oboh and Aluyor (2009), the main countries for commercial production are China, Japan, India, and Central America. Punjab, Karnataka, Gujarat, Maharashtra, Tamil Nadu, Assam, West Bengal, and Andhra Pradesh are among the Indian states where it is cultivated. Since sponge gourd crop is cultivated in mixed cropping in river beds and as monocrop in the garden lands, hence, exact area and production are unknown. However, the productivity of this crop is 10.52 tonnes per hectare (Anonymous, 2022). The sponge gourd has been reported to have excellent nutritional and medicinal properties. It is easily digested, has been shown to be beneficial for malaria patients and boost appetite. Mature dry fruit is composed of a hard-shell enclosing seed within the stiff and dense network of fibres made up of 60% cellulose, 30% hemicellulose, and other materials.

Pruning is the removal of excess or undesirable plant part judiciously to maintain the plant stature as well as its reproductive phase. Pruning is majorly done to regulate flowering and fruiting. Additionally, it is accomplished to divert the energy towards fruits to get a good quality harvest. The Cucurbits have quick vegetative development therefore, pruning helps save space, improve aeration and sunlight absorption. In general, vine pruning is done for a variety of reasons (Humphries and

Vermillion, 1994), but it mostly helps promote plant branching, achieve the optimal vegetative growth, fruit production and quality.

Although cucurbits have a broad spectrum of sex forms, they are mostly monoecious. Production of staminate flowers is greater than that of pistillate flowers. Since the appearance of pistillate flowers increases the fruits and seeds, it is crucial to examine at the options for enacting a shift in this direction. An important part of the physiology and morphology of plants is played by growth regulators. Growth regulators affects the crop growth and development which varies depending on plant species, variety, development stage, chemical concentration, application technique, and frequency. Ethrel slows down cell division and cell elongation in the meristematic tissue of the shoot, affecting crop development, while gibberlic acid (GA₃) helps break seed dormancy and enhances seed quality. It may modify sex ratio, growth, and attributes that increase seed yield and seed quality.

Materials and Methods

In the rainy season of 2022-23, a field trial was conducted on the Research Farm of the Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The treatment included three levels of pruning *i.e.*, no pruning, pruning at 0.75 m vine length and pruning at 1.25 m vine length and seven levels of growth regulators (control, GA₃ @ 25, 50, 75 ppm and ethrel @ 75, 100, 125 ppm) applied at 2-4 true leaves, flowering and fruiting stage. The treatments were applied in a split plot design (two factor analysis) with four replications. GA₃ is available in powder form therefore, after weighing the

required amounts of GA₃ on the electronic balance, it was first dissolved with a little quantity of solvent (alcohol) and then final solution was prepared. Ethrel is present in liquid form, which is directly dissolved with water. For this study, solutions of different concentrations of each growth regulator were prepared separately. The seed of sponge gourd cv. Pusa Chikni were sown at a crop spacing of 2.0 m × 0.6 m in first fortnight of June. The pruning treatments were applied according to the vine length. First treatment of no pruning, second treatment of pruning at 0.75 m vine length and third at 1.25 m vine length, was performed when the suitable vine length was achieved respectively. Pruning was performed very carefully by gentle hand using thumb and forefinger.

When the plants reached at 2-4 true leaf stages, the first spray of the above prepared solutions were sprayed treatment wise and the same process was repeated at flowering as well as fruiting stage. All the recommended cultural packages of practices and plant protection measures adopted for raising a healthy crop in Haryana condition are followed to grow a successful crop. The observations were recorded in seven parameters namely *i.e.*, seed yield per vine (kg), seed yield (kg/ha), standard germination (%), seedling length (cm), seedling dry weight (mg), vigour index-I and vigour index-II (Abdul-Baki and Anderson, 1973). The experimental data recorded from various observation were analysed in split plot design with four replications for analysis of variance in OPSTAT (<http://14.139.232.166/opstat/default.asp>) statistical software developed by Chaudhary Charan Singh, Haryana Agricultural University, Hisar, Haryana, India (Sheoran, 2010).

Results and Discussion

Seed yield parameters : Pruning and growth regulators significantly affected the fruiting parameters of sponge gourd. Among the different levels of pruning, when the vine was pruned at 1.25 m vine length, it recorded the mean maximum seed yield per vine (0.048 kg) and seed yield (181.34 kg/ha). However, the minimum seed yield per vine (0.042 kg) and seed yield (161.31 kg/ha) was recorded with no pruning (table 1). This might be due to the fact that pruning is known to increase the proportion of female flowers and reduce the number of male flowers. Female flowers are the ones that develop into fruit, so increasing their proportion can potentially increase the seed yield parameters. Pruning is also known to increase seed yield in cucurbits by improving the fruit size and weight. More fruits with better characteristics will have more quality seeds.

Among different levels of growth regulators, ethrel @ 125 ppm recorded the mean maximum seed yield per vine

(0.050 kg) and seed yield (189.23 kg/ha), whereas the minimum seed yield per vine (0.042 kg) and seed yield (158.63 kg/ha) was recorded with control (table 1). The reason for this is that ethrel stimulates the production of abscisic acid (ABA), a plant hormone that plays a role in the development and maturation of seeds. When ethrel is applied to cucurbits, it triggers the plant to produce more ABA, which can lead to an increase in seed yield. Additionally, ethrel can also promote the development of more flowers and fruit, which can also contribute to a higher seed yield. Similar findings were revealed by Jyoti *et al.* (2016) in ridge gourd and Kumar *et al.* (2020) in bottle gourd.

Seed quality parameters : Pruning and growth regulators significantly affected the standard germination of sponge gourd. Similarly, among the different pruning levels, pruning at 1.25 m vine length recorded the mean maximum standard germination (81.21 %), seedling length (35.34 cm), seedling dry weight (78.74 mg), vigour index-I (2,875.60) and vigour index-II (6,404.62). However, the minimum standard germination (78.06 %), seedling length (31.96 cm), seedling dry weight (74.84 mg), vigour index-I (2498.32) and vigour index-II (5,850.31) was recorded with no pruning (table 2). The reason may be that pruning leads to healthier plants and better-quality bold seeds with optimum amount of reserve food materials. Additionally, pruning can help the plant to direct more resources towards fruit development, resulting in larger and more uniform fruits that are more likely to contain more viable seeds with better seed quality characters.

Among different levels of growth regulators, GA₃ @ 75 ppm recorded the mean maximum standard germination (85.06 %) seedling length (36.59 cm), seedling dry weight (81.19 mg), vigour index-I (3,114.32) and vigour index-II (6,907.55), whereas the minimum standard germination (75.83 %), seedling length (31.75 cm), seedling dry weight (69.58 mg), vigour index-I (2,408.22) and vigour index-II (5,279.44) was observed with control (table 2). In case of standard germination, seed germination is typically inhibited by the presence of hard seed coats that prevent water and oxygen from entering the seed. GA₃ helps to break seed dormancy by stimulating the production of enzymes that soften the seed coat and promote water uptake. This leads to better germination of good quality seeds. The observations are similar to those of Kumar *et al.* (2019) in bottle gourd. In the case of seedling length, the application of GA₃ may have led to increased seedling length by stimulating cell division and elongation in the embryonic axis of the seed. This could have resulted in longer and more vigorous seedlings. The observations are similar to those of

Table-1 : Effect of pruning and growth regulators on seed yield parameters of sponge gourd.

Treatments	Seed yield per vine (kg/vine)	Seed yield (kg/ha)
P ₁ : No pruning	0.042	161.31
P ₂ : Pruning at 0.75 m vine length	0.046	173.66
P ₃ : Pruning at 1.25 m vine length	0.048	181.34
Mean P	0.045	172.10
C.D at 5 %	0.002	3.91
G ₁ : Control	0.042	158.63
G ₂ : GA ₃ @ 25 ppm	0.043	164.12
G ₃ : GA ₃ @ 50 ppm	0.044	167.68
G ₄ : GA ₃ @ 75 ppm	0.045	171.73
G ₅ : Ethrel @ 75 ppm	0.046	174.55
G ₆ : Ethrel @ 100 ppm	0.047	178.80
G ₇ : Ethrel @ 125 ppm	0.050	189.23
Mean G	0.042	172.11
C.D at 5%	0.003	4.04
Treatment combinations		
P ₁ G ₁	0.040	150.80
P ₁ G ₂	0.041	154.18
P ₁ G ₃	0.042	156.67
P ₁ G ₄	0.043	163.70
P ₁ G ₅	0.043	164.34
P ₁ G ₆	0.043	166.03
P ₁ G ₇	0.045	173.44
P ₂ G ₁	0.042	160.82
P ₂ G ₂	0.044	166.30
P ₂ G ₃	0.044	168.52
P ₂ G ₄	0.045	173.47
P ₂ G ₅	0.046	175.85
P ₂ G ₆	0.047	179.02
P ₂ G ₇	0.050	191.67
P ₃ G ₁	0.043	164.26
P ₃ G ₂	0.045	171.88
P ₃ G ₃	0.047	177.83
P ₃ G ₄	0.047	178.02
P ₃ G ₅	0.048	183.44
P ₃ G ₆	0.051	191.35
P ₃ G ₇	0.053	202.58
C.D at 5% Factor (G) at same level of P	NS	NS
C.D at 5% Factor (P) at same level of G	NS	NS

NS-Non significant, G-levels of growth regulators, P-Pruning levels.

Hirpara *et al.* (2015) in bitter gourd. In case of seedling dry weight and vigour indices, GA₃ helps in process of germination, resulting in faster and more uniform germination rates. This leads to the production of stronger and more vigorous seedlings, which can have greater dry weight. Additionally, GA₃ can also enhance the uptake of nutrients and water by the seedlings, leading to increased growth and dry weight. The observations are similar to

those of Sandra *et al.* (2015) in bitter gourd and Kumar *et al.* (2019) in bottle gourd.

Conclusions

From the present investigation, it was concluded that different levels of pruning and growth regulators had significant effect on the seed yield and seed quality parameters of sponge gourd crop. Among all the

Table-2 : Effect of pruning and growth regulators on seed quality parameters of sponge gourd.

Treatments	Standard germination (%)	Seedling length (cm)	Seedling dry wt. (mg)	Vigour Index-I	Vigour Index-II
P ₁ : No pruning	78.06	31.96	74.84	2498.32	5850.31
P ₂ : Pruning at 0.75 m vine length	79.43	33.81	77.19	2690.59	6142.02
P ₃ : Pruning at 1.25 m vine length	81.21	35.34	78.74	2875.60	6404.62
Mean P	79.57	33.70	76.92	2688.17	6132.32
C.D at 1 %	2.19	0.80	1.64	79.50	163.16
G ₁ : Control	75.83	31.75	69.58	2408.22	5279.44
G ₂ : GA ₃ @ 25 ppm	80.82	34.07	78.91	2756.28	6377.76
G ₃ : GA ₃ @ 50 ppm	82.17	34.61	80.21	2846.27	6592.28
G ₄ : GA ₃ @ 75 ppm	85.06	36.59	81.19	3114.32	6907.55
G ₅ : Ethrel @ 75 ppm	76.22	32.34	74.43	2465.66	5674.51
G ₆ : Ethrel @ 100 ppm	77.20	32.97	75.69	2547.62	5843.65
G ₇ : Ethrel @ 125 ppm	79.68	33.56	78.44	2678.83	6251.03
Mean G	79.57	33.70	76.92	2688.17	6132.32
C.D at 1 %	2.25	0.90	1.89	105.86	217.41
Treatment combinations					
P ₁ G ₁	75.17	30.47	67.62	2289.24	5086.78
P ₁ G ₂	78.95	32.12	76.46	2533.95	6034.84
P ₁ G ₃	81.17	32.44	77.55	2633.28	6294.10
P ₁ G ₄	84.00	34.74	77.91	2918.56	6545.34
P ₁ G ₅	75.33	30.82	72.13	2321.75	5434.10
P ₁ G ₆	75.72	31.45	74.36	2381.94	5631.01
P ₁ G ₇	76.11	31.66	77.81	2409.54	5925.99
P ₂ G ₁	75.28	31.48	69.58	2369.72	5238.49
P ₂ G ₂	80.89	33.92	79.38	2749.69	6419.05
P ₂ G ₃	82.11	34.18	80.65	2807.06	6622.28
P ₂ G ₄	84.33	36.96	82.22	3119.53	6934.70
P ₂ G ₅	75.61	32.74	75.08	2473.93	5675.19
P ₂ G ₆	77.22	33.22	75.38	2567.91	5819.39
P ₂ G ₇	80.55	34.08	78.02	2746.29	6285.02
P ₃ G ₁	77.05	33.30	71.54	2565.69	5513.05
P ₃ G ₂	82.61	36.17	80.89	2985.19	6679.38
P ₃ G ₃	83.22	37.22	82.42	3098.48	6860.46
P ₃ G ₄	86.83	38.08	83.44	3304.87	7242.59
P ₃ G ₅	77.72	33.45	76.08	2601.30	5914.23
P ₃ G ₆	78.67	34.24	77.33	2693.03	6080.56
P ₃ G ₇	82.39	34.94	79.50	2880.64	6542.07
C.D at 1% Factor (G) at same level of P	NS	1.08	NS	NS	NS
C.D at 1% Factor (P) at same level of G	NS	1.02	NS	NS	NS

NS-Non significant, G-levels of growth regulators, P-Pruning levels.

treatments of growth regulators, when ethrel @ 125 ppm was applied at 2-4 true leaves stage, it recorded the maximum seed yield (189.23 q/ha) in sponge gourd. Among the different levels of pruning, when the vine was pruned at 1.25 m vine length, it recorded the maximum seed yield (181.34 q/ha) in sponge gourd. Among all the treatments of growth regulators, when GA₃ @ 75 ppm was

applied at 2-4 true leaves stage, it recorded the maximum values for seed quality parameters in sponge gourd. However, among the different levels of pruning, when the vine was pruned at 1.25 m vine length, it recorded the maximum values for seed quality parameters in sponge gourd under semi-arid, subtropical condition of sandy loam soil in Haryana.

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Assessment of Pruning and Growth Regulators on Growth, Fruit Yield and Quality of Sponge Gourd [*Luffa cylindrica* (L.) Roem.]

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Abstract

A field experiment was conducted during the rainy season of 2022-23 at Research Farm, Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar to study the effect of pruning and growth regulators on growth, fruit yield and quality of sponge gourd. The experiment comprised of three levels of pruning (no pruning, pruning at 0.75 m and 1.25 m length of main vine) and seven treatments of growth regulators (control, GA₃ @ 25, 50, 75 ppm and ethrel @ 75, 100, 125 ppm). It has been observed that GA₃ @ 50 ppm with pruning at 0.75 m vine length recorded maximum number of primary branches per vine (9.3). The minimum node to first male flower appearance (7.3) and days taken to first male flower opening (44.0) were observed with GA₃ @ 75 ppm with pruning at 0.75 m vine length while the minimum node to first female flower appearance (12.0), days taken to first female flower opening (51.3) and days to first fruit harvest (61.7) were observed with ethrel @ 125 ppm along with pruning at 0.75 m vine length. GA₃ @ 75 ppm with pruning at 1.25 m vine length recorded maximum total soluble solids of the fresh fruit (5.59 %). The maximum leaf area (127.49 cm²), length of the fruit (27.15 cm), diameter of the fruit (3.81 cm), number of fruits per vine (16.3), fruit yield per vine (2.34 kg/vine) and fruit yield (140.33 q/ha) was recorded with ethrel @ 125 ppm with pruning at 1.25 m vine length.

Key words : pruning, growth regulators, growth parameters, fruit yield.

Introduction

Sponge gourd is a warm season vegetable of cucurbitaceae family with chromosomal number 26. As a cross-pollinated crop, it is cultivated as an annual climbing vine with peculiar leaves and tendrils for support. Botanically, fruits are berry called cylindrical pepo. It is widely cultivated in the tropical and subtropical areas of the world. China, Japan, India and Central America are the primary nations for commercial production (Oboh and Aluyor, 2009). It is cultivated in a number of Indian states, including Punjab, Karnataka, Gujarat, Maharashtra, Tamil Nadu, Assam, West Bengal, and Andhra Pradesh. Since sponge gourd crop is grown in mixed cropping in river beds and as monocrop in the garden lands, hence, exact area and production are unknown. However, the productivity of this crop is 10.52 tonnes per hectare (Anonymous, 2022). It has been reported that sponge gourd possesses robust nutritional and therapeutic qualities. It is readily digestible, has been proven to be helpful for malaria patients, and has been observed to boost appetite. Mature dry fruit is composed of a hard shell enclosing a stiff and dense network of fibres made up of 60% cellulose, 30% hemicellulose, and other materials.

Pruning is the planned removal of excessive or undesired plant parts in order to maintain the crop growth and reproductive stage. The main purposes of pruning are to manage flowering and fruiting. It also

helps to acquire a good quality harvest, by directing the energy and photosynthates into fruits. It also plays a vital role to conserve space, enhance aeration, and increase sunlight absorption. According to Humphries and Vermillion (1994), vine pruning is generally done for a number of reasons, but it primarily serves to encourage plant branching, accomplish the best possible vegetative growth and increase fruit yield and quality.

Cucurbits exhibit a wide range of sex forms but mostly they are monoecious. When compared to pistillate flower production, staminate flower production is higher. It is important to investigate the possibilities of bringing about a shift in favour of pistillate flowers since the emergence of these flowers improves the crop yield. Growth regulators have a significant role in the physiology and morphology of plants. Effects of growth regulators vary depending on plant species, development stage, chemical concentration, application technique, and frequency. Ethrel affects plant growth by slowing down cell division and cell elongation in meristematic tissue of the shoot while gibberellic acid (GA₃) helps in breaking dormancy as well as improves fruit set, leaf elongation, cambial activity, growth and cell elongation. It can alter a plant's growth, sex ratio and yield-enhancing traits.

Materials and Methods

In the rainy season of 2022-23, a field trial was conducted on the Research Farm of the Department of Vegetable

Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The treatment includes three levels of pruning *i.e.*, no pruning, pruning at 0.75 m vine length and pruning at 1.25 m vine length and seven levels of growth regulators (control, GA₃ @ 25, 50, 75 ppm and ethrel @ 75, 100, 125 ppm) applied at 2-4 true leaves, flowering and fruiting stage. The treatments were applied in a split plot design (two factor analysis) with four replications. GA₃ is available in powder form therefore, after weighing the required amounts of GA₃ on the electronic balance, it was first dissolved with a little quantity of solvent (alcohol) and then final solution was prepared. Ethrel is present in liquid form, which is directly dissolved with water. For this study, solutions of different concentrations of each growth regulator were prepared separately. The seed of sponge gourd cv. Pusa Chikni were sown at a crop spacing of 2.0 m × 0.6 m in first fortnight of June. The pruning treatments were applied according to the vine length. First treatment of no pruning, second treatment of pruning at 0.75 m vine length and third at 1.25 m vine length, was performed when the suitable vine length was achieved respectively. Pruning was performed very carefully by gentle hand using thumb and forefinger.

When the plants reached at 2-4 true leaf stages, the first spray of the above prepared solutions were sprayed treatment wise and the same process was repeated at flowering as well as fruiting stage. All the recommended cultural packages of practices and plant protection measures adopted for raising a healthy crop in Haryana condition are followed to grow a successful crop.

The observations were recorded in thirteen parameters namely *i.e.*, number of primary branches per vine, node to first male flower appearance, node to first female flower appearance, days taken to first male flower opening (days), days taken to first female flower opening (days), days taken to first fruit harvest (days), length of the fruit (cm), diameter of the fruit (cm), leaf area (cm²), number of fruits per vine, total soluble solids of fresh fruit (%), fruit yield per vine (kg) and fruit yield per hectare (q/ha). The experimental data recorded from various observation were analysed in split plot design with four replications for analysis of variance in OPSTAT (<http://14.139.232.166/opstat/default.asp>) statistical software developed by Chaudhary Charan Singh, Haryana Agricultural University, Hisar, Haryana, India (Sheoran, 2010).

Results and Discussion

Growth parameters : The pruning and growth regulators significantly affect the growth parameters of sponge gourd crops. In this experiment, it was also noted that among the different pruning levels, the mean maximum number of primary branches per vine was recorded with pruning at

0.75 m vine length (8.4). However, the minimum number of primary branches per vine (6.5) was observed with no pruning (Table 1). This may be due to pruning, which led to diversion of auxins from the tips to the lower part of the plant. The plants become more active physiologically and thus results in the increase of number of branches in sponge gourd. The results are in confirmation with the findings of Arora and Malik (1989) in ridge gourd.

The number of primary branches per vine was significantly affected with the application of growth regulators as well. Among different levels of growth regulators, mean maximum number of primary branches per vine (8.5) was observed significantly maximum with the application of GA₃ @ 50 ppm, whereas the mean minimum number of primary branches per vine (7.0) was recorded with control (Table 1). The reason behind this response lies in the physiological effects of gibberellic acid on plant growth. When GA₃ is applied to cucurbits, it stimulates cell division and elongation in the apical meristems, which are responsible for the formation of new shoots and branches. This results in the increased initiation and development of lateral shoots, leading to more primary branches per vine. The research findings are consistent with that of Hilli *et al.* (2010) in ridge gourd.

Flowering parameters : The pruning and growth regulators significantly affected the flowering parameters of sponge gourd. Among the different pruning levels, the mean minimum node to first male flower appearance (8.7), node to first female flower appearance (13.9), days taken to first male flower opening (45.8 days), days taken to first female flower opening (52.7 days) and days to first fruit harvest (64.1) was noted with pruning at 0.75 m vine length, whereas, the mean maximum node to first male flower appearance (11.5), node to first female flower appearance (17.1), days taken to first male flower opening (47.1 days), days taken to first female flower opening (55.3 days) and days to first fruit harvest (67.3 days) was observed with no pruning (Table 1). This may be explained by effect of pruning in the translocation of stored photosynthates and the narrowing of the C:N ratio, both of which enhanced metabolic activity and increased synthesis of certain bioreagents which led to early male as well as female flowering and fruiting at lower nodes. The results are consistent with those of Arora and Malik (1989), who found that pruning of ridge gourd plants to six primary branches along with a medium spacing level (45 cm) caused pistillate flowers to emerge earlier than usual. Similar observations were also reported by Aurin and Rasco (1988) with respect to days to first fruit harvest in sponge gourd.

Among the different treatments of growth regulators, the effect of the ethrel is observed beneficial. It reduces

Table-1 : Effect of pruning and growth regulators on growth, flowering and quality parameters of sponge gourd.

Treatments	Number of primary branches per vine	Node to first male flower appearance	Node to first female flower appearance	Days to first male flower opening	Days to first female flower opening	Days to first fruit harvest	Total soluble solids of fresh fruit (%)
P ₁ : No Pruning	6.5	11.5	17.1	47.1	55.3	67.3	4.83
P ₂ : Pruning at 0.75 m vine length	8.4	8.7	13.9	45.8	52.7	64.1	4.89
P ₃ : Pruning at 1.25 m vine length	7.7	9.4	15.2	46.2	53.9	65.4	4.98
Mean P	7.5	9.9	15.4	46.4	54.0	65.6	4.90
C.D at 5 %	0.3	0.3	0.5	0.7	1.7	2.1	0.07
G ₁ : Control	7.0	9.9	15.7	46.5	54.0	65.3	4.40
G ₂ : GA ₃ @ 25 ppm	7.7	9.2	16.1	45.3	54.4	66.3	5.23
G ₃ : GA ₃ @ 50 ppm	8.5	8.8	16.7	45.0	54.8	67.5	5.46
G ₄ : GA ₃ @ 75 ppm	8.1	8.4	17.1	44.4	55.3	69.0	5.52
G ₅ : Ethrel @ 75 ppm	6.8	10.3	15.0	47.0	53.5	64.4	4.45
G ₆ : Ethrel @ 100 ppm	7.2	10.6	13.9	47.5	53.1	63.5	4.52
G ₇ : Ethrel @ 125 ppm	7.6	11.7	13.5	48.8	52.5	62.9	4.70
Mean G	7.6	9.8	15.4	46.4	53.9	65.6	4.90
C.D at 5 %	0.5	0.4	0.4	0.8	0.9	1.4	0.12
Treatment combinations							
P ₁ G ₁	5.7	11.7	17.3	47.3	55.3	67.3	4.33
P ₁ G ₂	6.7	10.7	17.7	46.0	55.7	68.0	5.17
P ₁ G ₃	7.3	10.3	18.0	45.7	56.0	69.0	5.33
P ₁ G ₄	7.0	10.0	18.3	45.0	56.3	70.3	5.45
P ₁ G ₅	6.0	12.0	16.7	48.0	55.0	66.0	4.39
P ₁ G ₆	6.3	12.3	16.3	48.3	54.7	65.7	4.45
P ₁ G ₇	6.7	13.3	15.7	49.3	54.0	64.7	4.66
P ₂ G ₁	8.0	8.7	14.0	45.7	53.0	63.3	4.39
P ₂ G ₂	8.7	8.0	14.3	44.7	52.7	64.3	5.22
P ₂ G ₃	9.3	7.7	15.3	44.3	53.3	66.0	5.48
P ₂ G ₄	9.0	7.3	16.0	44.0	54.3	68.0	5.51
P ₂ G ₅	7.3	9.0	13.7	46.3	52.3	63.0	4.44
P ₂ G ₆	8.0	9.3	12.3	47.1	52.0	62.0	4.52
P ₂ G ₇	8.3	10.7	12.0	48.3	51.3	61.7	4.67
P ₃ G ₁	7.3	9.3	15.7	46.3	53.7	65.3	4.47
P ₃ G ₂	7.7	9.0	16.3	45.3	54.7	66.7	5.31
P ₃ G ₃	8.7	8.3	16.7	45.0	55.0	67.6	5.57
P ₃ G ₄	8.3	8.0	17.0	44.3	55.3	68.7	5.59
P ₃ G ₅	7.0	9.7	14.7	46.7	53.3	64.3	4.53
P ₃ G ₆	7.3	10.3	13.0	47.3	52.7	62.7	4.59
P ₃ G ₇	7.7	11	12.7	48.7	52.3	62.3	4.77
C.D at 5% Factor (G) at same level of P	0.4	0.3	0.5	NS	NS	NS	NS
C.D at 5% Factor (P) at same level of G	0.4	0.3	0.6	NS	NS	NS	NS

NS-Non significant, G-levels of growth regulators, P-Pruning levels.

the node to first female flower appearance and days taken to first female flower opening, while increasing the node to first male flower appearance and delaying the opening of male flowers in sponge gourd crop. The mean minimum days taken to first female flower opening (52.5), node to first female flower appearance (13.5) and days to first fruit harvest (69.0 days) were recorded with ethrel @ 125 ppm which also recorded the mean maximum days taken to

first male flower opening (48.8) and node to first female flower appearance (11.7). However, the mean minimum days taken to first male flower opening (44.4) and node to first male flower appearance (8.4) were recorded when the crop plants sprayed with GA₃ @ 75 ppm which also reported mean maximum days taken to first female flower opening (55.3), node to first female flower appearance (17.1) (Table-1). This may also be due to the

Table-2 : Effect of pruning and growth regulators on fruit and yield parameters of sponge gourd.

Treatments	Length of the fruit (cm)	Diameter of the fruit (cm)	Leaf area (cm ²)	Number of fruits per vine	Fruit yield per vine (kg/vine)	Fruit yield (q/ha)
P ₁ : No Pruning	24.11	2.97	113.35	11.0	1.84	110.75
P ₂ : Pruning at 0.75 m vine length	24.81	3.13	115.61	13.2	2.04	122.68
P ₃ : Pruning at 1.25 m vine length	25.55	3.36	118.01	14.9	2.16	129.30
Mean P	24.82	3.15	115.66	13.0	2.01	120.91
C.D at 5 %	0.65	0.13	2.57	0.4	0.03	3.72
G ₁ : Control	22.34	2.65	107.40	11.8	1.85	110.83
G ₂ : GA ₃ @ 25 ppm	23.97	2.75	111.42	12.1	1.88	113.08
G ₃ : GA ₃ @ 50 ppm	24.19	2.95	113.17	12.7	1.95	116.87
G ₄ : GA ₃ @ 75 ppm	24.97	3.16	116.23	13.0	2.03	121.67
G ₅ : Ethrel @ 75 ppm	25.51	3.32	114.46	13.6	2.07	124.38
G ₆ : Ethrel @ 100 ppm	26.12	3.58	121.68	13.9	2.12	127.42
G ₇ : Ethrel @ 125 ppm	26.65	3.64	125.22	14.3	2.20	132.12
Mean G	24.82	3.15	115.65	13.1	2.01	120.91
C.D. at 5 %	0.55	0.14	2.43	0.5	0.05	3.24
Treatment combinations						
P ₁ G ₁	21.69	2.54	106.37	10.0	1.72	103.40
P ₁ G ₂	23.39	2.57	108.67	10.3	1.76	105.63
P ₁ G ₃	23.12	2.71	109.69	10.7	1.78	106.57
P ₁ G ₄	23.83	2.93	114.42	11.0	1.81	108.83
P ₁ G ₅	24.71	3.07	112.86	11.3	1.89	113.67
P ₁ G ₆	25.91	3.44	118.77	11.7	1.95	116.83
P ₁ G ₇	26.12	3.49	122.63	12.3	2.00	120.30
P ₂ G ₁	22.05	2.63	107.57	12.0	1.84	110.67
P ₂ G ₂	24.14	2.74	110.13	12.3	1.86	111.37
P ₂ G ₃	24.39	2.97	113.51	12.7	2.01	120.93
P ₂ G ₄	24.65	3.15	116.00	13.0	2.08	125.10
P ₂ G ₅	25.48	3.23	113.83	13.7	2.11	126.67
P ₂ G ₆	26.23	3.56	122.68	14.0	2.14	128.30
P ₂ G ₇	26.69	3.61	125.53	14.3	2.26	135.73
P ₃ G ₁	23.27	2.77	108.26	13.3	1.97	118.43
P ₃ G ₂	24.37	2.95	115.48	13.7	2.04	122.23
P ₃ G ₃	25.07	3.18	116.31	14.7	2.05	123.10
P ₃ G ₄	26.44	3.39	118.26	15.0	2.18	131.07
P ₃ G ₅	26.34	3.67	116.70	15.7	2.21	132.80
P ₃ G ₆	26.22	3.75	123.57	16.0	2.29	137.13
P ₃ G ₇	27.15	3.81	127.49	16.3	2.34	140.33
C.D at 5% Factor (G) at same level of P	NS	NS	NS	NS	NS	NS
C.D at 5% Factor (P) at same level of G	NS	NS	NS	NS	NS	NS

NS-Non significant, G-levels of growth regulators, P-Pruning levels.

accumulation of photosynthates in plants those received from various foliar applications of ethrel, which resulted in early flowering. The results of present study are in close conformity with the findings of Mahida *et al.* (2015) who reported that ethrel @ 250 ppm reduced the number of days taken to first female flowers appeared in sponge gourd. Whereas, Aishwarya *et al.* (2019) observed that application of ethrel @ 200 ppm recorded early pistillate flower appearance and delayed male flower appearance in bitter gourd.

Fruiting parameters : Pruning and growth regulators significantly affected the fruiting parameters of sponge gourd. Among the different levels of pruning, the mean maximum leaf area (118.01 cm²), number of fruits per vine (14.9), length of the fruit (25.55 cm), diameter of the fruit (3.36 cm), total soluble solids of the fresh fruit (4.98 %), fruit yield per vine (2.16 kg/vine) and fruit yield (129.30 q/ha) was recorded with pruning at 1.25 m vine length. However, the mean minimum leaf area (113.35 cm²),

number of fruits per vine (11.0), length of the fruit (24.11 cm), diameter of the fruit (2.97 cm), total soluble solids of the fresh fruit (4.83 %), fruit yield per vine (1.84 kg/vine) and fruit yield (110.75 q/ha) was recorded with pruning (Table 2). In case of leaf area, length and diameter of the fruit, it could occur due to the exposure of pruned plant to light conditions, enhanced higher photosynthetic activities which ultimately increased the leaf area, length and diameter of the fruit of sponge gourd. The observations are similar to those of Davis (1994) in sponge gourd and Shivaraj *et al.* (2018) in cucumber. In case of number of fruits per vine, pruning induces more lateral branches which encourage more female flowers and fruits. Higher assimilation of food material due to enhanced photosynthetic activity in pruned plants results in high number of fruits per vine. The findings of current study are consistent with those of Arora and Malik (1989), who found that ridge gourd plants pruned to six major branches with a medium spacing level (45 cm) produced maximum number of fruits per vine. In case of total soluble solids of the fresh fruit, Pruning helps in energy redirection towards fruit production leading to increase in metabolites accumulation which might be the reason behind the increase in the concentration of soluble solids in the fruit of sponge gourd. Similar observations were recorded by Devi and Varma (2014) in Muskmelon. In case of fruit yield per vine and fruit yield (q/ha), pruning leads to better vegetative growth and heavier fruits which contribute to an increase in fruit yield. The increase in this pattern is quite consistent with findings of Buwalda and Freeman (1986) that, vine pruning enhanced the production of marketable yield in melon. Similar findings were reported by Rajalingam *et al.* (2017) in cucumber and Ndereyimana *et al.* (2021) in watermelon.

Among the different levels of growth regulators, the increase in ethrel concentration significantly improved the fruiting parameters. The mean maximum leaf area (125.22 cm²), number of fruits per vine (14.3), length of the fruit (26.65 cm), diameter of the fruit (3.64 cm), fruit yield per vine (2.20 kg/vine) and fruit yield (132.11 q/ha) was recorded when the sponge gourd crop plants were sprayed with ethrel @ 125 ppm, while the mean maximum total soluble solids of the fresh fruit (5.52 %) were recorded with GA₃ @ 75 ppm. However, the mean minimum leaf area (107.40 cm²), number of fruits per vine (11.8), length of the fruit (22.34 cm), diameter of the fruit (2.65 cm), total soluble solids of the fresh fruit (4.40 %), fruit yield per vine (1.85 kg/vine) and fruit yield (110.83 q/ha) were recorded with control (Table 2). In case of leaf area, length and diameter of the fruit, it may be due to the enlargement of cells. The elongation of cells leads to the simultaneous increase in leaf area as well as length and diameter of the fruit. The findings are consistent with

those of Vyas *et al.* (2015) in ridge gourd. In case of number of fruits per vine, it may be explained by the fact that exogenous ethrel treatment raised endogenous auxin levels, increasing the quantity of fruits per vine. The findings are consistent with those of Muhammad *et al.* (2013) who discovered that the application of ethrel significantly augmented the number of fruits on bitter gourd. Similar results were obtained by Mahida *et al.* (2015) in sponge gourd and Hidayatullah *et al.* (2012) in ridge gourd. In case of total soluble solids of the fresh fruit, GA₃ can stimulate the production of enzymes involved in sugar metabolism, which can lead to an accumulation of sugars in the fruit, which ultimately increase the total soluble solids of fresh fruit in sponge gourd. The findings are in close consonance with the recordings of Prasad *et al.* (2022) in bottle gourd. In case of fruit yield per vine and fruit yield (q/ha), The increase of fruit yield was definitely carried on by the use of ethrel, which enhanced the number of female flowers and fruit characters (length, diameter, weight). Similar results were obtained by Shailendrakumar *et al.* (2017), Barsoom and Attala (2020) in sponge gourd.

Conclusions

From the present investigation, it was concluded that different levels of pruning and growth regulators had significant effect on the growth and fruit yield of sponge gourd crop. Among all the treatments of growth regulators, when ethrel @ 125 ppm was applied at 2-4 true leaves stage, it recorded the maximum fruit yield (132.12 q/ha) and fruit quality parameters in sponge gourd. Among the different levels of pruning, when the vine was pruned at 1.25 m vine length, it recorded the maximum fruit yield (129.30 q/ha) and fruit quality parameters in sponge gourd under semi-arid, subtropical condition of sandy loam soil in Haryana.

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Pre-Harvest Treatment of Chitosan and Potassium Schoenite on Yield, Quality, Biochemical Changes and Shelf Life in Manjri Shyama Grapes (*Vitis vinifera* L.)

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Abstract

An investigation was carried out to know the effect of foliar application of Chitosan and Potassium Schoenite with different concentration on Manjri Shyama grape (*Vitis. Vinifera. L.*) at ICAR-NRCG Pune, during 2021-2022. The experiment was carried out in Randomized Block Design with five treatments and four replications. The application of Potassium Schoenite @ 2.5g/l, 5 g/l and Chitosan @ 0.2% and 0.4 % along with control vines was carried out at veraison stage. The effect of Potassium Schoenite and Chitosan were studied on bunch, berry characters, yield and quality parameters. The results revealed that the vines treated with chitosan 0.2 % recorded higher bunch weight (493.5 g) and yield/vine (38.42 kg). In terms of quality parameters i.e. TSS (21.98° Brix), Acidity (0.60%) were recorded in vine treated with Chitosan @ 0.2%. The Potassium Schoenite @ 5 g/l recorded higher phenol, tannin and flavonoids content. Among these treatment anthocyanin content was increased due to application of Potassium Schoenite, which is important for colour development of berry. From this investigation the foliar application of 0.2% of Chitosan and 5g/l of Potassium Schoenite reported higher yield, quality and improve shelf life of grapes.

Key words : Chitosan, potassium schoenite, yield, quality, physiological loss in weight.

Introduction

Grape (*Vitis vinifera* L.) is the most important commercial crop grown in India, especially in Maharashtra. The fruit of grapes is like by consumers worldwide for its taste and is blessed with a bundle of nutritional property. Sugar, minerals, enzymes, vitamin and acids are nutritive for our human health that contain in table grapes. Grapes production contributes about 16 per cent of the total fruit production. Archeological evidence suggest human began to growing grapes as early as 6500 BC during the Neolithic era B.C (1). China rank 1st country in world in grapes production, while India is ranked 7th in world. Major grapes growing state in India is Maharashtra, Tamil Nadu, Karnataka, Andrapradesh. Maharashtra state reported 62.7% production from out of total production of grapes in India. The popular cultivars of grapes grown are Thompson Seedless and its mutant like Tas-A-Ganesh, Sonaka, Manik Chaman, Kismish Charni and Flame Seedless, Clone-2. (2).

Manjari Shyama grapes formed by cross between Black Champa and Thompson Seedless. It is table grapes variety. Which is black in color, bold and seedless. Its average yield of 12 to 14 tones/ acre and no berry cracking recorded till now. After pruning it matures between 125 to 135 days. It give better economic return due to high yield potential and uniform berry color. Now this variety evaluated at many locations of India i.e. Tamil Nadu, Karnataka and Madhya Pradesh. This variety

reported yield 16-18 kg/vine, average bunch weight 350-450 g, TSS 18-20° brix and 4.5-5.5 g/l acidity. It is moderately resistance to downy mildew disease. Adequate supply of nutrient required for proper reproductive growth and vegetative growth of grapevine. Mineral nutrition and balance between macro and micro nutrients in different parts of vine leads to good quality and yield of grapes. (3).

Nitrogen, Phosphorus, Potassium, Sulphur, Calcium and Magnesium are most important macro nutrient among them Potassium are used to increase the shelf life and yield. Uptake of Potassium is related to vegetative growth and it accumulates subsequently in fruit cell. It plays significant role in physiological and biochemical activity of plant like photosynthesis, PH stabilization, stomata function, activation of protein, maintain salt balance, transport of metabolite and extensibility that leads to increase in fruit size (4). High supply of Potassium increases total soluble solid and reduction in acidity. In biotic and abiotic stress condition it involve in plant adaptation. Which is necessary to translocate sugar to berry. Adequate amount of Potassium is required at harvesting time for to provide attractive look and long shelf life of grapes (2). Foliar application of Potassium fertilizer accelerate anthocyanin accumulation by altering the transcript levels of PAL, CYP73A, 4CL, CHS, F3H and UFGT of flavonoids biosynthesis. Potassium Schoenite is good source of Potassium, Magnesium and Sulphur. It influence fruit size, appearance, colour, total soluble solid,

acidity, vitamin, taste as well as shelf-life (5). High supply of Potassium increasing total soluble solid and reduction in acidity of berry.

Potassium Schoenite is useful in acidic and alluvial soil. It protect soil from leaching (3). It is useful in promoting healthy roots system, increase plant vigour and resistance to disease and act as enzyme activator. It has low salt index and it is chloride free so it is ideal for crop who are sensitive to chloride and salt. It does not change the PH of soil (Titan biotech Ltd. Group) it is an alternate form of Potassium fertilizer for enhancing growth, yield and quality of many crops. Not only for better productivity but also good quality of fruit, farmer have started to use biopolymer like Chitosan for plant defence mechanism.

Chitosan is polysaccharide resulting from the De-acetylation of chitin. This natural polymer is convenient and largely available as waste from shell of shrimps and crabs processed by the seafood industry. It is nontoxic, biocompatible, biodegradable, antimicrobial and antioxidant properties, due to presence of free amine group and hydroxyl groups to scavenge free radicles to form stable micro molecular radicle (6). The positive effect of Chitosan on metabolism and increased photosynthesis which enhanced the plant growth (7), (8). Plant growth may be attributed to an increase in the key enzyme activities of nitrogen). Chitosan nanoparticle used as carrier system for plant growth hormones. Therefore the aim of Present study is to determine the effect of pre harvest application of Potassium Schoenite and Chitosan on yield, quality, biochemical changes and shelf life of Manjari Shyama grapes (*Vitis Vinifera L.*).

Materials and Methods

The experiment was conducted at ICAR-National Research Center for Grapes during the fruiting season of 2021-2022. Geographically Pune is located at latitude 18.32 °N and longitude 73.51°E. The experiment carried out in randomized block design with five treatments and four replications. All the treatments application was made with a high-volume pneumatic knapsack sprayer fitted with a hollow cone nozzle using spray fluid @ 500 liters/ha.

Table-1 : Treatment details :

Treatment	Details	Time
T1	P. Schoenite @ 2.5 g/Lit	The vine received the treatment at veraison, (15-20% berries coloration)
T2	P. Schoenite @ 5 g/Lit	
T3	Chitosan @ 0.2% (20g/10L)	
T4	Chitosan @ 0.4 % (40g/10 L)	
T5	Control	

Observations recorded

Yield per vine (Kg) : The observations recorded on average bunch weight, 10 berry weight were taken by using an electronic balance and Pedicel thickness, Berry diameter and Berry length were measured by using digital vernier caliper 0- 300 mm.). Average berry weight bunch weight and yield per vine were recorded. Hundred berry samples were randomly selected from each replicate, processed in a blender and strained through two layers of muslin cloth. Total soluble solids concentration was determined from the juice using a digital refractometer (model ERMA of Japan). The titratable acidity was calculated by using the titration method. The 5 ml of fruit juice from each replications was titrated with sodium hydroxide solution of known normality (NaOH N =0.1N) using phenolphthalein indicator as an suggested by (A.O.A.C) (9). The results of these titrations were converted to percent of titratable acidity using the following equation;

$$\text{Percent of titratable acidity} = \frac{(N.NaOH \times \text{ml.NaOH} \times 0.075 \times 100)}{\text{Juice in ml}}$$

*0.075 = Equivalent weight of tartaric acid.

Biochemicals study : The total phenol, tannin contents of the fruit extract was determined using the Folin-Ciocalteu method (Singleton and Rossi 1965(10) using gallic acid as the standard. Total anthocyanins were estimated as suggested by (11) and total flavonoids by (12). All bio chemicals were estimated by using UV spectrometer. The standard reference chemicals were obtained from the O.K chemicals Ltd., Mumbai (India). All other buffers and chemicals were of AR grade and obtained from Merck Pvt. Ltd., Mumbai.

Physiological loss in weight (PLW) : The PLW was calculated on an initial weight basis. The physiological loss in weight of grape bunches was recorded based on the initial fresh weight of the fruit and subsequent loss in weight which occurred during post-harvest storage and was expressed as a percentage value.

$$\text{PLW (\%)} = \frac{\text{Initial weight of fruit} - \text{Final weight of fruit}}{\text{Initial weight}} \times 100$$

Statistical analysis : The various data collected were subjected to analysis of variance in randomized block design (RBD) using SAS software version 9.2 (13) with a generalized linear model (GLM) procedure. Means were separated using least significant differences (LSD) test at 5% level of significance.

Results and Discussion

Yield and quality Parameters : The significant differences were recorded on yield and yield attributing

Table-2 : Effect of Chitosan and Potassium Schoenite on yield and quality parameters in Manjri Shyama Grapes.

Treatments	Bunch weight(g)	Yield kg/vine	50 Berry weight (g)	Berry length (cm)	Berry diameter (mm)	TSS (°Brix)	Acidity (%)	TSS/ Acidity ratio
T1	387.50	30.23	162.43	22.50	16.00	18.68	0.67	27.90
T2	428.25	33.40	174.53	21.00	16.50	18.70	0.65	29.04
T3	492.50	38.42	183.38	23.30	17.30	21.98	0.60	36.94
T4	429.00	33.46	173.65	21.30	16.30	18.20	0.71	25.73
T5	336.00	26.21	150.98	19.30	15.30	17.13	0.75	22.74
SEm(±)	12.65	0.99	1.52	0.08	0.08	0.3	0.01	0.77
C.D. @ 5%	39.42	3.08	4.73	0.25	NS	0.92	0.04	2.4

Table-3 : Effect of Chitosan and Potassium Schoenite on Skin Thickness, Pedicel Thickness and PLW (%) in Manjri Shyama Grapes.

Treatments	Skin Thickness (mm)	Pedicel Thickness (mm)	PLW (%)
T1	32.25	1.28	8.25
T2	25.50	1.28	8.13
T3	35.25	1.33	7.74
T4	31.75	1.28	9.75
T5	27.25	1.13	8.35
SEm(±)	1.97	0.04	0.82
C.D. @ 5%	6.14	0.12	NS

Table-4 : Effect of Chitosan and Potassium Schoenite on Biochemical parameter in Manjri Shyama Grapes.

Treatments	Phenol (mg/g)	Tannin (mg/g)	Reducing sugar (mg/g)	Anthocyanin (mg/L)	Flavonoids (mg/g)
T1	1.58	1.82	321.66	25.16	33.00
T2	2.86	3.53	302.56	54.96	60.57
T3	2.15	2.58	323.87	41.32	48.40
T4	1.4	1.55	314.26	41.01	33.69
T5	1.32	1.44	258.37	22.46	29.22
SEm(±)	0.05	0.05	11.5	2.94	1.69
C.D. @ 5%	0.15	0.17	38.07	9.15	5.24

characters in Manjri Shyama and depicted in Table No. 2. Present data illustrate that foliar application of Chitosan at 0.2% and 0.4% at veraison stage leads to increase in yield as compared to treatment treated with Potassium Schoenite. The highest yield/vine (38.42 Kg), bunch weight (493.5 g), 50 berry weight (183.38 g) were recorded in Chitosan @ 0.2%, followed by Potassium Schoenite at 2.5 g/lit. While the minimum yield /vine (26.21 kg) and bunch weight (336 g) were recorded in untreated control. (14) while working on strawberry (*var. winter dawn*), they reported that Chitosan significantly increase in vegetative growth parameter due to availability and uptake of water and essential nutrients through adjusting cell osmotic pressure and reducing the accumulation of harmful free radicals by increasing antioxidants and enzyme activities. The result of present investigation is similar with study of (15), (3), they reported that the Lower doses of Chitosan could have an effective for increment in crop growth and yield and higher doses decreases crop growth and yield. The Maximum berry diameter (17.30 mm) and Berry length (23.30 mm) were reported in Chitosan at 0.2%, followed by Potassium Schoenite (8),

they found that okra fruit size increased on application of Chitosan as compared with other treatment.

Chitosan is the N-deactivated derivate of chitin. Chitosan is commercial interest because of it high percent of nitrogen. In this study maximum TSS (21.98° brix) reported in treatment treated with 0.2% of Chitosan, followed by Potassium Schoenite @ 5g/lit (18.700 brix) as compared to untreated control (17.130 brix). Acidity (0.60%) reported lowest in Chitosan @ 0.2% and higher (0.75%) in untreated control. This study is correlate with (16) and (17), According to (17) they found that Chitosan increases the total soluble solids (TSS) and decreases titratable acidity during storage. The TSS/Acidity ratio was recorded higher (36.94) in Chitosan @ 0.2% followed by treatment treated with 5g/lit of Potassium Schoenite (29.04).

Skin Thickness, Pedicel Thickness and PLW (%) :

Data recorded on Skin Thickness, Pedicel Thickness and PLW (%) were recorded and depicted in Table-3. Skin Thickness (35.25 mm) and Pedicel Thickness (1.33 mm) were recorded higher in Chitosan @ 0.2%, followed by

Table-5 : Correlation between different parameters in relation to yield in Manjri Shyama Grapes.

	50 berry weight (g)	Berry length (mm)	Berry diameter (mm)	Pedicle Thickness (mm)	Skin Thickness (mm)	TSS (°Brix)	Acidity (%)	TSS/ Acidity ratio	Yield kg/ vine	Bunch weight (g)	Phenol (mg/g)	Tannin (mg/g)	Reducing sugar ((mg/g)	Anthocyanin (mg/L)	Flavonoids (mg/g)
50 berry weight (g)	1.00														
Berry length (mm)	0.72	1.00													
Berry diameter(mm)	0.97	0.81	1.00												
Pedicle Thickness (mm)	0.77	0.69	0.67	1.00											
Skin Thickness (mm)	0.47	0.81	0.56	0.45	1.00										
TSS (°Brix)	0.81	0.85	0.92	0.43	0.70	1.00									
Acidity (%)	-0.83	-0.85	-0.92	-0.54	-0.48	-0.92	1.00								
TSS/Acidity ratio	0.82	0.85	0.94	0.45	0.61	0.99	-0.96	1.00							
Yield (kg)/vine	0.99	0.78	0.99	0.71	0.58	0.89	-0.86	0.89	1.00						
Bunch weight (g)	0.99	0.78	0.99	0.71	0.58	0.89	-0.86	0.89	1.00	1.00					
Phenol (mg/g)	0.59	0.26	0.59	0.30	-0.29	0.43	-0.69	0.55	0.53	0.53	1.00				
Tannin (mg/g)	0.59	0.27	0.60	0.30	-0.28	0.44	-0.70	0.56	0.54	0.54	1.00	1.00			
Reducing sugar (mg/g)	0.77	0.93	0.76	0.90	0.69	0.67	-0.75	0.68	0.77	0.77	0.28	0.29	1.00		
Anthocya Nine (mg/L)	0.78	0.22	0.67	0.59	-0.18	0.36	-0.55	0.45	0.68	0.68	0.83	0.83	0.39	1.00	
Flavonoids (mg/g)	0.68	0.28	0.66	0.35	-0.23	0.49	-0.71	0.59	0.62	0.62	0.99	0.99	0.31	0.88	1.00

similar to (18), they reported that the pre-harvest spray of Chitosan on orange increases in fruit peel thickness. This data revealed that there is significant interaction between storage intervals and treatment for the percentage PLW. The physiological loss in weight was recorded in 8th days of storage. The minimum weight loss (7.74%) is recorded in grapes bunch treated with Chitosan @ 0.2%, followed Potassium Schoenite @ 5g/lit (8.13%). According to (19), reported that the chitosan decreases weight loss due to covering of Chitosan protect berry against bacterial contamination and also moisture transfer to extend shelf life.

Biochemical parameter : The data recorded on biochemical changes of Manjri Shyama and presented in Table-4. The significant differences were recorded in phenol, Tannin, Anthocyanin and Flavonoid, content. Treatment treated with Potassium Schoenite @ 5 g/lit were recorded maximum phenol (2.86 mg/g) and Flavonoid (60.57 mg/g) contents, followed by chitosan @ 0.2% as compared with untreated control (29.22 mg/g). The higher concentration of Anthocyanin (54.96) were recorded in Potassium Schoenite @5g/lit, followed by chitosan @0.2% (41.32 mg/g). While control treatment reported very low concentration of anthocyanin (22.46 mg/g). Magnesium is present in Potassium Schoenite, According to (20), they reported that the higher level of magnesium increases anthocyanin accumulation. Tannins and anthocyanin are most concentrated natural antioxidant in grapes. Maximum concentration of tannin (3.53 mg/g) found in treatment treated with Potassium Schoenite @5g/lit, followed by treatment treated with chitosan @ 0.2% (2.58 mg/g). Similar result found by (21), they reported that higher concentration of Potassium source increase tannins in Date Palm. Reducing sugar content is higher (323.87 mg/g) in treatment treated with Chitosan 0.2%, followed by Potassium Schoenite @5g/lit (321.66 mg/g). This study is correlate with (22), they found that application of Chitosan increase osmo protectants compound such as sugar, free amino acid and soluble phenols. According to (16) reported that the lower concentration of chitosan (50% mineral + 250 ppm Nano K) improved the berry quality of 'Flame seedless' grapevines. Lower doses of chitosan could have an effective for increase in crop growth and yield, whereas higher doses decrease this benefit.

Correlation between different parameters : The correlation between different parameter are studied and present in Table No. 5. The positive and negative correlation between different morphological parameter showed due to use of different concentration of Chitosan and Potassium Schoenite. Among all parameter 50 berry weight high positive relationship with yield bunch weight. TSS show negative relationship with Acidity. Phenol show positive relationship with tannin and reducing sugar.

Conclusion

From this study it is revealed that the application of chitosan, Potassium Schoenite increases the bunch weight, berry weight and yield /vine, reduces PLW % in this study. However it increases the Phenol, Tannin, Anthocyanin by application of Potassium Schoenite @5 g/l. The application of Chitosan @ 0.2% were reported higher Pedicel thickness and reducing sugar. The Potassium Schoenite and chitosan were beneficial for increasing berry quality, yield and biochemical changes and recorded good shelf life in Manjari Shyama grapes.

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Understanding Consumer Perceptions on Quality Attributes of Potato Varieties Towards Prediction of Varietal Preference

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Abstract

Consumer preferences are the main driving force behind developing appropriate varieties and technologies. Still, the consumer perceptions are rarely explored in depth with scientific methods and considered seriously in agriculture. While making a purchasing decision, consumers' perception of different quality attributes plays a significant role. This study analyses the perception pattern for fresh potatoes in West Bengal, India, by collecting data from Hooghly District through a survey of 100 consumer households belonging to different social strata following a holistic and multidimensional approach. Consumer perception was assessed through an analysis of the direction and intensity of their attitudes towards the selected three varieties (i.e. Chandramukhi, Jyoti and Super-6) with respect to fifteen different quality attributes. Semantic differential scale, Principal Component Analysis and Expectancy Value Model were applied. The findings from this study revealed that the majority of the consumer desire attributes like good boiling quality, sandy texture and good taste to be present in their preferred potato varieties, and they mostly associate these attributes with the variety, Chandramukhi. Six factors were identified from the quality attributes: Storage qualities, texture related characteristics, price related factors, physical appearance, cooking qualities and peeling qualities. The present study findings have wider connotations for breeders, extension personnel, traders, policymakers, producers, and other stakeholders.

Key words : *Consumer perception, quality attributes, semantic differential scale, expectancy value model.*

Introduction

Market-led approach is considered one of the sensible approaches in commercial crop production almost everywhere in the world [1], [2], [3], [4], [5]. In this approach, consumers are the most important stakeholders in the value chain. Therefore, an in-depth understanding of consumer preferences is a precursor for the development of agro-food industries across the globe. Potato is an essential vegetable in terms of domestic consumption and production in India. It is also a popular crop in West Bengal due to its high production and productivity [6], [7]. Therefore, before a potato variety is introduced in an area, a study regarding consumers' perception towards the variety is recommendable as it influences consumers' purchasing preference. Producers should know which quality cues and attributes are pertinent to consumers. From consumers' perspectives, qualities need to be visible and understandable to scale back uncertainty about the products. So, perception study is effective in meeting consumers' expectations. Past studies have shown that perception of hedonic variables is important for identifying their varietal preference in fresh market. Those findings help breeders and marketers make a precise decision while selecting appropriate varieties [8].

While making a purchasing decision, consumers

evaluate both intrinsic and extrinsic properties of a product and eventually decide on the quality attributes demanded in the food they consume [9]. Their decision is influenced by factors like nutritional knowledge, lifestyle, taste preferences, opinions or beliefs etc. Thus, an in-depth understanding of consumers' attitudes towards quality attributes is considered indispensable for advancing agro-food industries across the globe. Quality attributes are informative impulses available to the buyer before purchasing [10], defining the extent of a product's superiority or its practicality for precise use [11]. Quality cue is a construct containing multiple properties and can be classified further into intrinsic and extrinsic cues [11], [12], [13]. Intrinsic cues represent the physical details of the product that are consumed while consuming the product. Examples are composition, flavour, design, colour, marbling, fat content etc. [14]. Extrinsic cues are associated attributes that are not part of the physical product, like brand, price, country of origin etc. [14]. Consumers have more details and greater confidence in dealing with extrinsic cues [15] because extrinsic cues highlight technical and objective aspects, whereas intrinsic cues are challenging to determine as these are the outcome of subjective-internal processes of people [16], [17]. So, these cues form a valid basis for their purchasing decisions [18], [19] and have to be optimized to create a flourishing product in the marketplace.

In the case of fruits and vegetables, many extrinsic and intrinsic attributes influence the purchasing decision process. Among external elements, appearance influences on any purchase decision [20], particularly when purchasing fresh vegetables [20], [21], [22]. In addition, physical characteristics of the product, i.e. size, colour, shape *etc.*; organoleptic qualities like taste, aroma, and flavour [23], [24], [25]; environmentally-safe product [26], [27], [28]; packaging and branding [29] play a vital role in purchasing decisions. The country of origin is also among the extrinsic aspects in purchasing decisions [30]. Thus, consumers' perception of those attributes can raise and lower consumer approval of a product [31], [32]. An examination regarding perceptions of the necessary quality traits, particularly of fresh fruits and vegetables, has shown that attributes such as the absence of defects, absence of blemishes, ripeness, freshness, lack of pesticides and preservatives, nutritional value, and cleanliness are unfailingly rated as the most important [33]. Hence, the present study is conducted to assess consumers' perception regarding three potato varieties (Chandramukhi, Jyoti and Super-6) popular in Tarakeswar, West Bengal, India, through an analysis of the direction and intensity of their attitudes towards the varieties in respect to fifteen different quality attributes. This study can be helpful for the potato growers and other stakeholders such as seed producing companies, breeders and other related persons in the value chain.

Materials and Methods

This study was conducted in Tarakeswar municipality of Hooghly district in West Bengal. Hooghly district was purposively selected for the study as it is the hub of potato production in the state, contributing a major portion of the total potato cultivation. This district is also known for its high-quality Chandramukhi variety. The study sample comprised 100 consumer households selected through a random sampling technique. For data collection, a questionnaire was developed after reviewing the related literature [33], [34], [35]. The questionnaire was pretested and improved accordingly before proceeding with survey. Data was collected through personal interviews by maintaining proper social distancing measures from January to June 2021. Three potato varieties, *i.e.* Chandramukhi, Jyoti and Super-6 and fifteen quality attributes naming shape, boiling quality, keeping quality, uniformity in size, absence of blemishes, absence of bruises, cleanliness, texture, smoothness of skin, skin colour, flesh colour, price, taste, ease of peeling and number of eyes were selected for the present study. These attributes were drawn from the relevant literature [16], [33], [34], [35], [36], [37] and finalized in consultation with relevant experts and few non-sample consumers.

At first, consumer perception on those attributes' importance was measured using a four-point scale of agreement. Then a semantic differential scale was developed using a standardized protocol [38], [39], [40], [41] to compare consumer attitude towards the three varieties graphically. Those fifteen attributes were further classified into factors using principal component analysis (PCA) with oblimin rotation and Kaiser Normalization [42]. Factor analysis of attributes of fresh fruits and vegetables has been considered to be very useful in identifying major characteristics or factors perceived as useful by the consumers. The respondents were asked to rate fifteen possible attributes of fresh potatoes on a four-point agreement scale. Principal component analysis [43] was applied to extract the factors from the responses to the attributes. After that, the multi-attribute model of Fishbein [44] was followed to describe consumers' attitudes toward alternative varieties by combining their beliefs and evaluative aspect of that particular belief [45]. Consumers build attitudes toward alternative brands by combining their evaluation criteria with their beliefs to make a buying decision [46], [47], [48]. The outcome of this process is ranking alternative brands in terms of their relative preference position, and selecting the most preferred brand for most occasions. The 'Expectancy value Model' elaborately states that the consumer gives weight to every brand belief and its attribute importance in arriving at a global attitude toward each brand [49], [50], [51]. The applicability of this model was tested in the present case of consumers' evaluation and purchase of three potato varieties.

Results and Discussion

Consumer Perception of Different Quality Attributes of Potato : For the majority of respondents, the shape is slightly important (32%) or slightly unimportant (31%). Only 12% of respondents find shape as an extremely important attribute. Boiling quality is considered extremely important by 53% consumers, whereas 46% find it slightly important. Only 1% of them find it unimportant. Only 5% of respondents mark uniformity in size as an extremely important attribute whereas 25% of them find it extremely unimportant. Keeping quality is also an extremely important attribute considered by 43% and slightly important by 37% of respondents. The number of eyes in potato is marked as an extremely highly unimportant attribute by 63% of consumers, and only 7% consider them a slightly important attribute. Price is observed as an extremely important attribute by 77% of respondents, and only 5% find it slightly unimportant. The absence of blemishes is considered extremely unimportant by 41% and slightly unimportant by 33%, whereas 21% find it as extremely important. The texture is a significant attribute,

Table-1 : Consumer Perception of Different Quality Attributes of Potato.

Sl. No.	Attributes	Extremely unimportant	Slightly unimportant	Slightly important	Extremely important
		1	2	3	4
1.	Shape	25	31	32	12
2.	Boiling Quality	1	0	46	53
3	Uniformity in size	25	37	33	5
4.	Keeping Quality	5	15	37	43
5.	No of eyes	63	30	7	0
6.	Price	0	5	18	77
7.	Absence of blemishes	41	33	5	21
8.	Texture	0	1	61	38
9.	Skin colour	1	14	54	31
10.	Absence of bruises/cuts	12	37	23	28
11.	Smoothness of skin	69	29	2	0
12.	Flesh colour	1	22	54	23
13.	Ease of peeling	14	34	44	8
14.	Cleanliness	14	31	26	29
15.	Taste	0	0	9	91

Table-2 : Strategic Conglomeration of Variables into Factor.

Statement		Rotated Component Matrix						Communalities
		Component						
		1	2	3	4	5	6	
X2	Flesh colour	-0.603						0.611
X4	Keeping Quality	0.514						0.560
X10	Absence of Bruises	0.701						0.623
X7	Absence of blemishes	0.800						0.696
X11	Smoothness of skin		-0.644					0.583
X8	Texture		0.819					0.752
X14	Cleanliness			0.505				0.726
X6	Price			0.732				0.574
X9	Skin Colour				-0.636			0.541
X1	Shape				-0.352			0.380
X3	Uniformity in Size				0.796			0.668
X2	Boiling Quality					0.472		0.628
X15	Taste					0.896		0.799
X5	No. of eyes						0.851	0.730
X13	Ease of Peeling						0.570	0.619
Eigen Values		2.597	1.778	1.495	1.349	1.25	1.021	
Percentage of Variance		17.31	11.854	9.970	8.996	8.333	6.804	
Percentage of Cumulative		17.31	29.164	39.134	48.13	56.464	63.267	

Table-3 : Brand Expectation and Brand Choice Matrix of Three Potato Varieties.

Brand Expectation	Brand Choice			Row Totals	X ₂ value	Contingency co-efficient (C)	Highest limit of C	Percentage of E _i A _i
	A ₁	A ₂	A ₃					
E ₁	E ₁ A ₁	E ₁ A ₂	E ₁ A ₃	100	190.299**	0.623	0.816	70.33
	72	21	7					
E ₂	E ₂ A ₁	E ₂ A ₂	E ₂ A ₃	100				
	15	69	16					
E ₃	E ₃ A ₁	E ₃ A ₂	E ₃ A ₃	100				
	11	19	70					

**Significant at 0.01 level

E_i=Expectancy/Preference for variety, A_i=Actual choice of product i; i₁ - Chandramukhi, i₂ - Jyoti, i₃ - Super-6

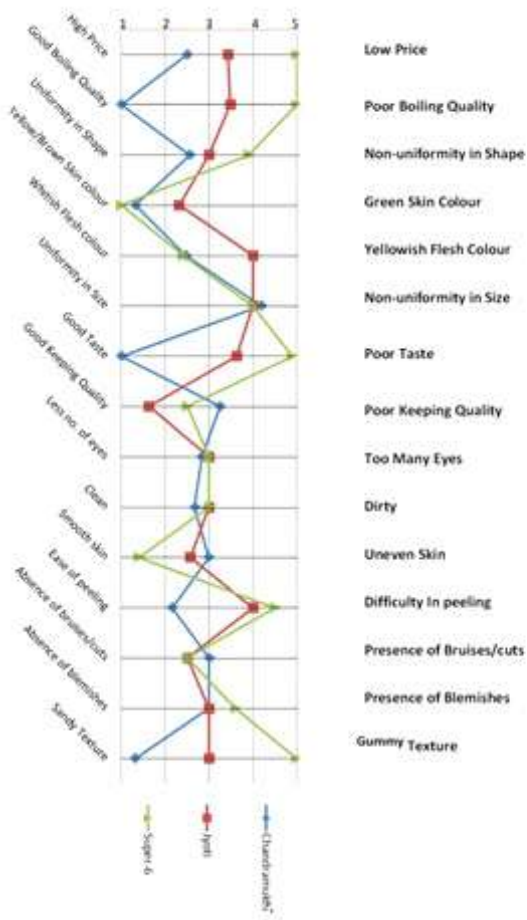


Fig-1 : Semantic Differential Scale to elicit the Consumer Perception of Three Potato Varieties.

considered extremely important by 38% and slightly important by 61%. Skin colour is considered extremely important by 31% and slightly important by 54% of respondents whereas 1% of them find it extremely unimportant. For some respondents absence of bruises/cuts is extremely important (28%), and for some, it is extremely unimportant (12%). The smoothness of skin is an unimportant attribute. Flesh colour is slightly important for a majority of them (54%). Ease of peeling is also considered as a slightly important attribute by 44% of respondents. The importance of cleanliness varies between consumers [12]. Taste is an extremely important quality attribute for a majority of the respondents (91%). Basu *et al.* [38] observed partly similar results in their study where the price was the most important attribute for consumers, followed by smooth skin and boiling quality. Tumer *et al.* [26] also found that consumers paid more attention to the taste while purchasing potatoes. Chikkamath *et al.* [25] also observed similar results in their study on vegetables.

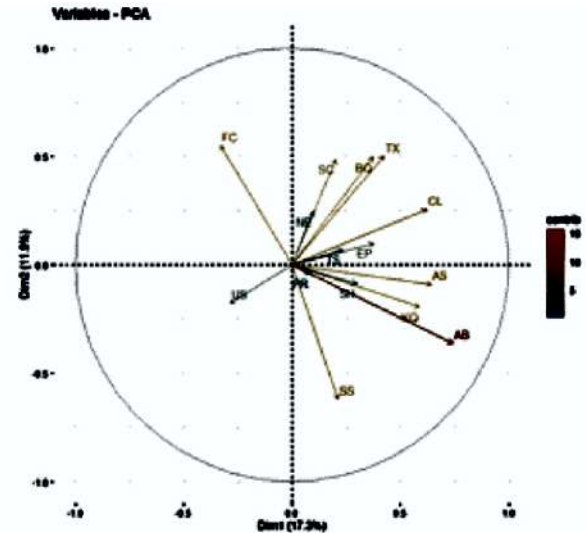


Fig-2 : Representation of the variables and the components. The red colour variables are the most explanatory; those in blue are the least explanatory variables, thus defining the gradients.

Perception of consumers regarding three potato varieties :

The perception of consumers regarding three potato varieties has been studied through an analysis of the direction and intensity of their attitudes towards the varieties. The measuring device administered is the semantic differential on fifteen quality attributes. Fig 1 shows the consumers' attitude for the three varieties of potato. Consumers mainly associate higher prices with Chandramukhi variety and lower prices with Super-6. Their perception of boiling quality significantly differs variety wise. Chandramukhi is generally associated with good boiling quality, while Super-6 is associated with the poorest boiling quality. Skin colour, uniformity in shape and size- for these three attributes, consumer perception is more or less the same for three varieties. Whitish flesh colour is mainly associated with Chandramukhi and Super-6 whereas Jyoti is associated with yellowish flesh colour. According to consumers, Chandramukhi has excellent taste and Super-6 is associated with poor taste. Consumers perceive that the Jyoti variety has the best keeping quality of the three varieties, followed by Super-6 and Chandramukhi. Consumer perception of number of eyes, cleanliness, absence of bruises/cuts and blemishes, and smoothness of skin do not significantly differ for the varieties. Ease of peeling is generally associated with Chandramukhi, whereas both Jyoti and Super-6 are associated with difficulty in peeling. Their perception of texture significantly varies for the varieties. Sandy texture is related to the Chandramukhi variety while Gummy texture is with Super-6, and Jyoti lies in between them in the scale.

Classifying those attributes into a set of factors by using Principal Component Analysis :

Those fifteen attributes were categorised into six factors and renamed as follows (Table 2): Factor 1: Storage Qualities: Factor 1 accounted for 17.310% of the total variance. Keeping quality (0.514), absence of Blemishes (0.800), absence of Bruises (0.701) and flesh colour (-0.603) represent this factor. Eigenvalue of this factor is 2.597, and it has 17.310% cumulative weightage. Factor 2: Texture Related Factors: Factor 2 accounted for 11.854% of the total variance. Texture (0.819) and smoothness of skin (-0.644) represent this factor. Eigenvalue of this factor is 1.778, and it has 29.164% cumulative. Factor 3: Price Related Factors: Factor 3 accounted for 9.970% of the total variance. Price (0.732) and cleanliness (0.505) represent this factor. Eigen value of this factor is 1.495, and it has 39.134% cumulative. Factor 4: Physical Appearance: Factor 4 accounted for 8.996% of the total variance. Uniformity in size (0.796), shape (-0.352) and skin colour (-0.636) represent this factor. Eigenvalue of this factor is 1.349, and it has 48.130% cumulative. Factor 5: Cooking Qualities: This factor, consisting of Taste (0.896) and Boiling Quality (0.472), accounted for 8.333% of the total variance. Eigenvalue is 1.250, and it has 56.464% cumulative. Factor 6: Peeling Qualities: This factor accounted for 6.804% of total variance. Number of eyes (0.851) and ease of peeling (0.570) represent this factor. Eigenvalue is 1.021, and it has 63.267% cumulative.

Multi-Attribute Model (i.e. Expectancy Value Model) :

The expectation (E) and choice (A) of hundred consumers on three varieties, Chandramukhi, Jyoti and Super-6 are presented in a matrix (Table 3). The combination of expectancy and choice (EA) depicts the nature of preference and choice made. Out of nine possible combinations, the E_1A_1 , E_2A_2 , and E_3A_3 situations describe the same preference and actual choice of a variety. Chi-squared (X^2) test was done against the hypothesis (H_0) that there was no association between brand expectancy and brand choice. X^2 value was found significant at 0.01 level, which supported an association between them. Further contingency co-efficient (C) were calculated from the X^2 value to determine the degree of association between expectancy and choice. It is close to the highest limit (0.816), i.e., a high degree of association (Table 4). So statistically, it is proved that the expectancy value model closely approximates (70.33 per cent) the evaluation procedures of the consumers in selecting potato varieties.

The findings from this study suggest that most consumers desire attributes like good boiling quality, sandy texture and good taste to be present in their preferred potato varieties [2], [11]. Consumers mostly

associate these attributes with the variety, Chandramukhi. They also connect significance to price and keeping quality of potatoes while purchasing, although Chandramukhi variety has the poorest keeping quality among the three varieties with a relatively higher price. Information about 'behaviour and preference in this domain seems very important to potato growers and to other stakeholders such as seed producing companies, breeders and persons in the value chain in general. This study provides feedback to the production sector, which must consider their downstream buyers' preference pattern to increase their profits. The application of brand prediction model has proved its efficiency in predicting varietal choice empirically. This study has opened up a new methodological horizon for the growers and other stakeholders such as researchers, extension officials, policymakers, seed-producing companies, breeders and traders in general and the potato production ecosystem in particular. Therefore, this type of research should be repeated in different technology domains (material or methods) before research and extension agenda setting to save precious resources in terms of money, workforce and time for producing and promoting appropriate technologies with precision.

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Sire Influence on Productive Traits in FG Halfbred and Inter-SE Crossbred Cattle

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Abstract

The study investigated the impact of sire on various milk production traits in different genetic groups. The data on production traits of FG halfbred and *inter-se*(825) maintained at MPKV, Rahuri, Maharashtra from 1972 to 2012 (41 years) were used to investigate the effect of sire on production traits. The results indicated that sire had a significant effect on total lactational milk yield (TLMY), 300 days or less milk yield (300DMY), wet average and 300 days or less wet average (300DWA) in the FG, and IFG group. In the FG group, progenies of sire no. 35 had the highest TLMY and 300DMY, while progenies of sire no. 59 had the lowest TLMY and 300DMY. Similar patterns were observed in the other genetic group, with different sires influencing milk yield differently. The highest lactation length was observed in progenies of sire no. 15 in the FG group and progenies of sire no. 5 in the IFG group. Progenies of sire no. 38 had the highest wet average in the FG group and progenies of sire no. 21 had the highest wet average in the IFG group. Overall, the study demonstrated that the choice of sire significantly influenced various milk production traits, including total lactational milk yield, 300 days or less milk yield, lactation length, wet average, and 300 days or less wet average, in different genetic groups. These findings highlight the importance of sire selection for improving milk production in dairy cattle breeding programs.

Key words : Sire, TLMY, 300 DMY, LL, WA, 300 DWA

Introduction

The importance of sire in cow breeding programs cannot be overstated. Sire selection is a critical aspect of improving the genetic potential and performance of a dairy herd. Sires contribute 50% of the genetic material to their offspring. By carefully selecting sires with desirable traits, such as high milk production, longevity, disease resistance, and conformation, breeders can make significant genetic progress in their herds. This leads to improved performance and overall quality of the offspring. Sires with high milk production genetics can pass on superior milk production traits to their progeny. By selecting sires with a proven track record of high milk yields, breeders can increase the productivity and profitability of their herds. This is particularly crucial in dairy farming, where milk production is the primary source of income. In Maharashtra, one of the project was started at MPKV, Rahuri. The ICAR terminated this programme in 1986. Later on the AICRP on Cattle is designated as RCDP on Cattle. This project evolved halfbred (FG) and three breed cross (FJG) also, they had been bred *inter-se* followed by rigorous selection and their performances were tested. Therefore, an attempt was made to investigate the effect of sire on production performance of FG halfbred.

Materials and Methods

The data on reproduction and production traits of 825 FG halfbred and *inter-se* cows spread over a period of 41 years (1972-2012), maintained at Research cum Development Project on Cattle, Mahatma Phule Krishi Vidyapeeth, Rahuri were analysed to study the comparative productive performance. Data of production traits were standardized and normalized.

Least-squares analysis : The data were analysed by (SAS version 9.3, 2011) least squares model to overcome the problem of non-orthogonality of data results due to unequal number of observations and disproportionate subclass frequencies.

Model-I : Fixed model was used to estimate the influence of sire on production traits as follows :

$$Y_{ij} = \mu + S_i + e_{ij}$$

Where,

Y_{ij} = The value of jth animal under the ith sire

μ = Overall mean

S_i = Effect of i^{th} sire ($i = 1, 2, \dots, n$)

e_{ij} = Random error associated with NID ($0, \sigma^2$)

The sires having 5 or more progenies were only considered for the statistical analysis.

Table-1 : ANOVA of TLMY, 300 DMY, LL, WA and 300 DWA in FG halfbred and inter-seaaffected by sire.

Traits Source of variation	TLMY				300 DMY			
	Genetic group				Genetic group			
	FG		IFG		FG		IFG	
	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.
Sire	14	4798204.62**	18	2204260.13**	14	4363224.71**	18	1796826.46**
Error	486	826631.93	832	711978.20	486	721184.44	832	553505.91

Traits Source of variation	LL				WA			
	Genetic group				Genetic group			
	FG		IFG		FG		IFG	
	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.
Sire	14	4759.35*	18	12972.73**	14	31.60**	18	22.08**
Error	486	2271.29	832	3971.60	486	7.10	832	5.42

Source of variation	300 DWA			
	Genetic Group			
	FG		IFG	
	d.f.	M.S.S.	d.f.	M.S.S.
Sire	14	41.54**	18	23.69**
Error	486	7.56	832	5.82

* : P < 0.05

** : P < 0.01

Table-2 : Least-squares means for TLMY (kg) in FG and IFG as affected by sire.

Genetic group									
Sire No.	FG				Sire No.	IFG			
	N	Mean	SE	RANK		N	Mean	SE	RANK
μ	501	3757.67	43.26		μ	851	2826.73	29.55	
SIRE 35	28	4550.95	149.57	15	SIRE 2	16	2538.54	167.70	6
SIRE 36	81	4026.53	82.91	13	SIRE 3	54	2931.52	141.94	14
SIRE 38	33	4488.88	149.52	14	SIRE 5	123	2812.11	78.60	11
SIRE 40	23	3596.99	208.40	6	SIRE 6	49	2527.35	102.58	4
SIRE 46	21	3948.66	223.73	12	SIRE 13	48	2455.96	100.44	3
SIRE 47	33	3611.61	158.71	7	SIRE 15	78	2985.37	100.26	15
SIRE 48	42	3531.00	109.92	5	SIRE 16	15	2801.81	132.12	10
SIRE 49	17	3309.84	190.04	2	SIRE 19	49	2715.99	133.54	8
SIRE 50	28	3482.33	194.66	4	SIRE 21	39	3115.12	166.71	19
SIRE 51	20	3622.30	257.74	9	SIRE 24	9	2256.78	199.21	1
SIRE 53	38	3652.60	170.73	10	SIRE 31	56	2647.54	107.68	7
SIRE 54	50	3616.37	158.51	8	SIRE 65	38	3074.72	129.58	16
SIRE 55	33	3810.38	178.39	11	SIRE 66	37	2888.98	143.79	12
SIRE 57	35	3371.33	120.55	3	SIRE 67	19	3095.40	185.71	18
SIRE 59	19	3061.74	163.30	1	SIRE 73	45	2733.20	119.82	9
					SIRE 74	30	2538.05	134.19	5
					SIRE 76	37	2926.17	144.54	13
					SIRE 78	102	3088.84	79.99	17
					SIRE 79	7	2281.54	171.33	2

Duncan's multiple range test (DMRT) : Duncan's multiple range test (DMRT) as modified by Kramer (1957) was used to make pairwise comparison between the least squares means with the used of inverse elements and root mean square error.

Results and Discussion

The results pertaining to the analysis of variance, least square means for TLMY, 300 Days or less milk yield,

Lactation length, Wet average and 300 Days or less wet average in FG halfbred and *inter-sea* presented in Table 1, 2, 3, 4, 5 and 6 respectively.

Total Lactational Milk Yield : The variation due to sire was found to be significant ($P < 0.01$) on total lactational milk yield in FG and IFG group (Table 1). The overall mean of total lactational milk yield as affected by sire were estimated as 3757.67 ± 43.26 and 2826.73 ± 29.55 kg in FG and IFG group, respectively. Similar significant

Table-3 : Least-squares means for 300 DMV (kg) in FG and IFG as affected by sire.

Genetic group									
Sire No.	FG				Sire No.	IFG			
	N	Mean	SE	RANK		N	Mean	SE	RANK
μ	501	3605.54	40.53		μ	851	2654.64	26.10	
SIRE 35	28	4350.05	141.79	15	SIRE 2	16	2372.14	157.07	4
SIRE 36	81	3878.99	79.90	13	SIRE 3	54	2671.99	124.82	13
SIRE 38	33	4297.30	151.16	14	SIRE 5	123	2574.62	69.92	9
SIRE 40	23	3513.48	202.05	9	SIRE 6	49	2427.51	95.48	5
SIRE 46	21	3692.05	197.92	11	SIRE 13	48	2328.93	93.07	3
SIRE 47	33	3487.58	149.06	8	SIRE 15	78	2796.14	87.86	15
SIRE 48	42	3275.65	95.39	5	SIRE 16	15	2638.97	121.93	11
SIRE 49	17	3224.05	169.60	2	SIRE 19	49	2638.84	130.42	10
SIRE 50	28	3435.36	183.44	6	SIRE 21	39	3018.09	153.98	19
SIRE 51	20	3252.70	191.14	3	SIRE 24	9	2228.62	198.64	2
SIRE 53	38	3542.81	167.37	10	SIRE 31	56	2562.70	95.46	8
SIRE 54	50	3466.67	149.67	7	SIRE 65	38	2802.99	90.91	16
SIRE 55	33	3707.99	169.51	12	SIRE 66	37	2676.03	126.58	14
SIRE 57	35	3262.40	106.69	4	SIRE 67	19	2969.45	188.54	18
SIRE 59	19	2999.52	155.36	1	SIRE 73	45	2533.76	87.91	7
					SIRE 74	30	2429.57	121.66	6
					SIRE 76	37	2654.34	110.77	12
					SIRE 78	102	2927.16	69.40	17
					SIRE 79	7	2220.86	143.71	1

Table-4 : Least-squares means for LL (days) in FG and IFG as affected by sire.

Genetic group									
Sire No.	FG				Sire No.	IFG			
	N	Mean	SE	RANK		N	Mean	SE	RANK
μ	501	323.07	2.16		μ	851	326.17	2.21	
SIRE 35	28	341.04	8.38	14	SIRE 2	16	339.63	15.39	16
SIRE 36	81	327.42	4.76	10	SIRE 3	54	344.52	10.93	17
SIRE 38	33	336.12	8.64	12	SIRE 5	123	349.48	7.20	19
SIRE 40	23	310.43	8.74	4	SIRE 6	49	308.43	7.51	5
SIRE 46	21	333.52	12.34	11	SIRE 13	48	325.75	7.13	10
SIRE 47	33	320.33	7.70	8	SIRE 15	78	321.60	6.27	9
SIRE 48	42	338.00	9.28	13	SIRE 16	15	329.20	13.95	11
SIRE 49	17	316.12	9.61	6	SIRE 19	49	298.33	7.66	2
SIRE 50	28	308.14	7.75	2	SIRE 21	39	311.26	7.79	6
SIRE 51	20	341.80	6.12	15	SIRE 24	9	287.44	19.79	1
SIRE 53	38	320.61	8.16	9	SIRE 31	56	301.02	6.76	3
SIRE 54	50	308.76	5.06	3	SIRE 65	38	336.58	10.08	15
SIRE 55	33	318.70	6.01	7	SIRE 66	37	345.97	9.56	18
SIRE 57	35	316.00	8.48	5	SIRE 67	19	331.53	10.07	12
SIRE 59	19	302.63	5.50	1	SIRE 73	45	332.87	10.95	13
					SIRE 74	30	318.40	9.18	7
					SIRE 76	37	335.22	11.92	14
					SIRE 78	102	319.60	6.27	8
					SIRE 79	7	307.71	9.36	4

Table-5 : Least-squares means for WA (kg) in FG and IFG as affected by sire.

Genetic group									
Sire No.	FG				Sire No.	IFG			
	N	Mean	SE	RANK		N	Mean	SE	RANK
μ	501	11.68	0.12		μ	851	8.73	0.08	
SIRE 35	28	13.48	0.49	14	SIRE 2	16	7.60	0.54	3
SIRE 36	81	12.39	0.26	13	SIRE 3	54	8.58	0.38	10
SIRE 38	33	13.51	0.49	15	SIRE 5	123	8.24	0.23	6
SIRE 40	23	11.53	0.52	9	SIRE 6	49	8.26	0.31	7
SIRE 46	21	12.04	0.76	12	SIRE 13	48	7.58	0.30	2
SIRE 47	33	11.24	0.43	6	SIRE 15	78	9.26	0.26	16
ISIRE 48	42	10.55	0.30	3	SIRE 16	15	8.58	0.39	11
SIRE 49	17	10.41	0.43	2	SIRE 19	49	9.06	0.39	14
SIRE 50	28	11.37	0.60	7	SIRE 21	39	10.00	0.47	19
SIRE 51	20	10.60	0.57	4	SIRE 24	9	7.88	0.51	4
SIRE 53	38	11.48	0.53	8	SIRE 31	56	8.76	0.29	13
SIRE 54	50	11.77	0.43	10	SIRE 65	38	9.12	0.27	15
SIRE 55	33	11.94	0.51	11	SIRE 66	37	8.40	0.40	9
SIRE 57	35	10.70	0.38	5	SIRE 67	19	9.44	0.59	17
SIRE 59	19	10.14	0.48	1	SIRE 73	45	8.27	0.28	8
					SIRE 74	30	7.96	0.36	5
					SIRE 76	37	8.68	0.30	12
					SIRE 78	102	9.79	0.23	18
					SIRE 79	7	7.38	0.41	11

Table-6 : Least-squares means for 300 DWA (kg) in FG and IFG as affected by sire.

Genetic group									
Sire No.	FG				Sire No.	IFG			
	N	Mean	SE	RANK		N	Mean	SE	RANK
μ	501	12.25	0.13		μ	851	9.17	0.08	
SIRE 35	28	14.51	0.47	15	SIRE 2	16	8.03	0.53	3
SIRE 36	81	13.03	0.27	13	SIRE 3	54	9.16	0.41	13
SIRE 38	33	14.42	0.51	14	SIRE 5	123	8.76	0.24	7
SIRE 40	23	12.13	0.59	9	SIRE 6	49	8.57	0.31	6
SIRE 46	21	12.34	0.67	11	SIRE 13	48	7.96	0.30	2
SIRE 47	33	11.83	0.45	7	SIRE 15	78	9.62	0.27	15
SIRE 48	42	11.06	0.30	3	SIRE 16	15	8.91	0.39	9
SIRE 49	17	11.01	0.52	2	SIRE 19	49	9.31	0.40	14
SIRE 50	28	11.80	0.61	6	SIRE 21	39	10.46	0.49	19
SIRE 51	20	11.20	0.58	5	SIRE 24	9	8.07	0.46	4
SIRE 53	38	12.04	0.57	8	SIRE 31	56	9.05	0.30	11
SIRE 54	50	12.15	0.45	10	SIRE 65	38	9.63	0.28	16
SIRE 55	33	12.48	0.55	12	SIRE 66	37	9.01	0.41	10
SIRE 57	35	11.10	0.39	4	SIRE 67	19	10.11	0.63	17
SIRE 59	19	10.42	0.50	1	SIRE 73	45	8.77	0.28	8
					SIRE 74	30	8.31	0.38	5
					SIRE 76	37	9.10	0.33	12
					SIRE 78	102	10.30	0.24	18
					SIRE 79	7	7.53	0.46	1

influence of sire on TLMY was obtained by Patond (2013) in Gir triple cross cows. However, Kharat *et al.* (2008) observed non-significant effect of sire on first lactation milk yield in HF cows.

In FG, the TLMY was highest in progenies of sire no. 35 (4550.95 ± 149.57 kg) and lowest in progenies of sire no. 59 (3061.74 ± 163.30 kg). In IFG group, the TLMY was highest in progenies of sire no. 21 (3115.12 ± 166.71 kg) and lowest in progenies of sire no. 24 (2256.78 ± 199.21 kg) (Table-2).

300Days or less Milk Yield : The effect of sire was found to be significant ($P < 0.01$) on 300 DMY in FG and IFG group (Table-1). The overall mean 300 days or less milk yield as affected by sire was estimated as 3605.54 ± 40.53 and 2654.64 ± 26.10 kg in FG and IFG group, respectively (Table 3). Similar result was noticed by Patond (2013) in Gir triple cross cow. However, Gaikwad (2010) reported non-significant effect of sire on 300DMY in Phule Triveni cattle. The 300DMY of FG group was highest in daughters of sire no. 35 (4350.05 ± 141.79 kg) and lowest in daughters of sire no. 59 (2999.52 ± 155.36 kg). The 300DMY was highest in daughters of sire no. 21 (3018.09 ± 153.98 kg) and lowest in daughters of sire no. 79 (2220.86 ± 143.71 kg) in IFG group.

Lactation Length : The effect of sire was found to be significant ($P < 0.01$) on lactation length in IFG and ($P < 0.05$) in FG halfbred (Table 1). The overall mean lactation length as affected by sire was 323.07 ± 2.16 and 326.17 ± 2.21 days in FG and IFG group, respectively (Table 4). The present results did not agree with Patond (2013) noticed in Gir triple cross cows. In FG group, the lactation length was highest in progenies of sire no. 15 (341.80 ± 6.12 days) and lowest in progenies of sire no. 59 (302.63 ± 5.50 days). In IFG, the lactation length was highest in progenies of sire no. 5 (349.48 ± 7.20 days) and lowest in progenies of sire no. 24 (287.44 ± 19.79 days).

Wet Average : The analysis of variance showed that sire had significant ($P < 0.01$) effect on wet average in FG and IFG group (Table 1). The overall mean wet average as affected by sire was 11.68 ± 0.12 and 8.73 ± 0.08 kg in FG and IFG, respectively (Table 5). In FG group, the highest wet average was noticed in daughters of sire no. 38 (13.51 ± 0.49 kg) and lowest in daughters of sire no. 59 (10.14 ± 0.48 kg). In IFG group, highest wet average was observed in daughters of sire no. 21 (10.10 ± 0.47 kg) and lowest in

daughters of sire no. 79 (7.38 ± 0.41 kg). There was no literature review present on sire effect on wet average.

300 Days Wet Average : The result showed that sire had significant ($P < 0.01$) effect on 300 DWA in FG and IFG group (Table 1). The overall mean 300 days or less wet average as affected by sire was 12.25 ± 0.13 and 9.17 ± 0.08 kg in FG and IFG group, respectively (Table 6). The 300 DWA was highest in progenies of sire no. 35 (14.51 ± 0.47 kg) and lowest in progenies of sire no. 59 (10.42 ± 0.50 kg) in FG group. The highest 300 DWA was recorded in daughters of sire no. 21 (10.46 ± 0.49 kg) and lowest in daughters of sire no. 79 (7.53 ± 0.46 kg) in IFG group. There was no literature review present on sire effect on 300 days wet average.

Conclusion

By choosing the right sire, farmers and breeders can improve the overall milk production in their herds. This is crucial for dairy farmers who rely on milk production as a source of income. Sire selection that favours longer lactation lengths can help optimize milk production and herd management. Wet average refers to the average milk yield per day, and it is a key indicator of cow productivity. Overall, the study emphasizes that sire selection plays a crucial role in determining the production performance of cows. Choosing sires with desirable genetic traits for milk production can lead to improved productivity, profitability, and sustainability in dairy farming. It enables farmers to optimize their herd's potential, meet market demands for milk, and enhance overall herd management strategies.

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Studies on Moisture Conservation Practices in Linseed (*Linum usitatissimum* L.)

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Abstract

A field experiment was conducted during *rabi* season of 2020-2021 at Experimental Farm, Agronomy Section, College of Agriculture, Latur to determine the Studies on the moisture conservation practices in linseed. The soil of experimental plot was clayey in texture, neutral in reaction having pH (7.02) with chemical composition such as available nitrogen (231 kg ha⁻¹), very low in available phosphorous (8.57 kg ha⁻¹) and very high in available potassium (580 kg ha⁻¹). It was well drained and favorable for optimum crop growth. The gross monetary return was significantly influenced due to different treatments. Significantly highest gross monetary return of ₹ 85,888 ha⁻¹ was obtained with the application of soybean straw mulching at 5 t ha⁻¹. The experiment was laid out in Randomized Block Design with Eight treatments. The treatments were T1 : No mulching, T2 : Soybean straw mulching at 5 t ha⁻¹, T3 : Spreading of FYM at 5 t ha⁻¹ as a mulch, T4 : Incorporation of FYM in soil at 5 t ha⁻¹, T5 : Dust mulching at 30 DAS & Hand weeding, T6 : Dust mulching at 30 DAS, Hand weeding & Hoeing at 45 DAS, T7 : Dust mulching at 30 DAS & Hoeing, T8 : Dust mulching at 30 DAS & Hoeing at 45 DAS. The result showed that application of Soybean straw mulching at 5 t ha⁻¹ (T2) was found most effective for increasing growth and productivity of linseed. Among the different treatments, application of Soybean straw mulching at 5 t ha⁻¹ was found beneficial in increasing growth, yield attributing characters and seed yield of linseed than No mulching alone or combination with Spreading of FYM at 5 t ha⁻¹ as mulch respectively. Application of Soybean straw mulching at 5 t ha⁻¹ (T2) was superior in respect of gross and net monetary returns and followed by T3 & T4. Similarly higher B:C ratio (2.29) was recorded with the application of Soybean straw mulching (T2).

Key words : Linseed, mulching, moisture conservation.

Introduction

Linseed (*Linum usitatissimum* L.) is an important *rabi* oilseed crop belonging to the family Linaceae. It is originated from Mediterranean region and Southwest Africa. The name *Linum* originated from *lin* or thread and the species name *usitatissimum* is a Latin word meaning most useful. It has been grown from ancient time for getting fiber (flex) and for its seed which is rich in oil. It is known as Agasi (Kannada), Jawas or Alashi in (Marathi), Alsi in (Hindi) and Ousahalu in (Telugu). The Genus *Linum* has over 200 species of *Linum usitatissimum* L. It is widely cultivated for economically important species. It has somatic chromosome number 2n=30 and varies from 18 to 86 in other species. There is two morphologically different cultivated species of linseed are recognized, mainly for flax and seed. The flax type of linseed is commercially grown for extraction of fibre, whereas the linseed is mainly used for extraction of oil from there seed.

The divers agro-ecological condition in India is favorable for growing oilseeds. Oil and fat occupy an important role in human life. They form essential and integral part of our daily diet, oilseed have also medicinal and therapeutic values. The oilseeds are good source of energy for human body.

It is the third largest natural fibre producing crop and one of the fifth major oilseed crop in the world. It is grown under rainfed and irrigated situation. It contains 35 to 47 per cent oil and 11 to 32 per cent protein. The oil extracted from linseed is mainly used in paint industries as a medium for oil paint, pad ink and printing ink etc. In India the paint and allied industries are the major consumer of linseed oil accounting to 70 per cent of the total consumption.

In a germination of seed, primary tap-root develops from seed in which grow towards down producing numerous small lateral roots. Stem is either erect or procumbent, depending on the fiber of linseed varieties. the plant height normally varies between 40 to 70 cm. Leaves are linear to lanceolate, smooth, tapering to a blunt apex and green to blueish green. Inflorescences are corymbose, with a single flower born terminally on the pedicel in a multiple flower panicle. Tolerance to biotic and abiotic stress is a most important characteristics of linseed crop. Due to this property of linseed survival and cultivation of linseed is prevailing in wide range of tropical, sub-tropical and temperate regions.

Linseed contains 35-70% linolenic acid, (omega-3 fatty acid) this factor is reducing blood cholesterol

concentration of cardiovascular tissue and benefited by affecting prostaglandins and leukotriene related to blood clotting and inflammatory disorder in blood like rheumatoid arthritis. Linseed has a natural source of lignin which is anticarcinogenic properties and also provide protection against certain form of cancer due to estrogenic and antiestrogenic activities happen inside the body (Srivastava, 2010)^[1].

Among the oilseed crops linseed is an important crop in the world cultivated over an area of 22.70 lakh hectare with a high production of 22.39 lakh tons and productivity is 985 kg ha⁻¹. In India, linseed is mainly grown in central part of the country, like Madhya Pradesh, Eastern Maharashtra, Bihar and Uttar Pradesh. It also grown in a small extent in Karnataka, Odisha, Rajasthan, West Bengal and Andhra Pradesh. Total cultivated area of linseed in India is about 0.017 million ha over a total production of 0.09 MT and productivity is 575 kg ha⁻¹ (Anonymous, 2019)^[2]. In Maharashtra total area under linseed cultivation is about 7000 ha⁻¹ with an annual production of 2.7 thousand tons. The average productivity of linseed in Maharashtra is about 380 kg ha⁻¹, It is below world and national average. The area under linseed in Latur district is about 1.75 hundred ha⁻¹, with total production is 0.7 hundred tones in per hectare productivity of 387.5 kg ha⁻¹ (Anonymous, 2018)^[3]

The national average productivity of linseed is very low as compared to the world. Low productivity of linseed among the many reasons, that is an inadequate and imbalanced fertilization are the major factor. The major implementation of the lower national average productivity have been the area of production under major linseed producing states of India in that basically lies under irrigated input starved and poor crop management conditions. The cultivation of low yielding linseed cultivar under input starved conditions are the major obstacles in low productivity of national level. To increase the productivity of linseed, use of balanced fertilization by the application of chemical fertilizer along with organic manure is a great importance. Integration of inorganic fertilizer with organic manure will not only help to sustain the crop productivity but also effective for keeping good soil health and improving the nutrient use efficiency (Verma, et al. 2005)^[4].

To enhance the productivity of linseed use of mulch can increase the yield, water use efficiency, profitability and simultaneously decreasing weed problems (Goswami and Shaha, 2006)^[5] reported that Beneficial effect of rice straw mulch is a protective layer of organic material that is spread on the top of soil to check moisture loss from the soil by preventing evaporation from soil and decreasing water loss from plant, Prevent weed growth, Improve the

soil condition, Provide home for earthworm and natural enemies found in the soil, Mulch helps to regulate soil temperature by shading in summer thus keeping it cool and help insulate it in the winter from chilling wind. Mulching improves nutrients and water retention in soil, encourages favorable soil microbial activity and worms, and suppresses weed growth.

Therefore, in view of the above facts the present field experiment entitled studies on moisture conservation practices in linseed (*Linum usitatissimum* L.) was undertaken to find out the effect of moisture conservation practices in linseed at experimental farm, Department of Agronomy, College of Agriculture, Latur during rabi season 2021 with the following :

Objectives :

To find out suitable moisture conservation practices in linseed grown under rainfed situation.

To study the effect of moisture conservation practices on growth and yield of linseed.

To study the economics of moisture conservation practices in linseed.

Materials and Methods

The experiment was conducted during rabi season of 2020-2021 at Experimental Farm of Agronomy section, College of Agriculture, Latur. To study "Studies on moisture conservation practices in Linseed (*Linum usitatissimum* L.)" was laid out in Randomized Block Design with three replications. The experiment consisted of eight treatments. T1: No mulching, T2: Soybean straw mulching at 5t ha⁻¹, T3: Spreading of FYM at 5t ha⁻¹, as a mulch, T4: Incorporation of FYM in soil at 5t ha⁻¹, T5: Dust mulching at 30 DAS and Hand weeding, T6: Dust mulching at 30 DAS, Hand weeding and hoeing at 45 DAS, T7: Dust mulching at 30 DAS & Hoeing, T8: Dust mulching at 30 DAS & Hoeing at 45 DAS.

The experimental unit was gross plot size of each 5.40 x 4.50 m² and net plot- 4.50 x 3.60 m² respectively. The Linseed cultivar LS-93 Sowing was done on 09 November 2021 by dibbling method with seed rate of 20 kg ha⁻¹. The recommended dose of fertilizer for linseed crop was 40:20:20: kg NPK ha⁻¹. Half dose of nitrogen along with full dose of phosphorous and potash was applied as basal dose and reaming dose of nitrogen was applied at 30 DAS.

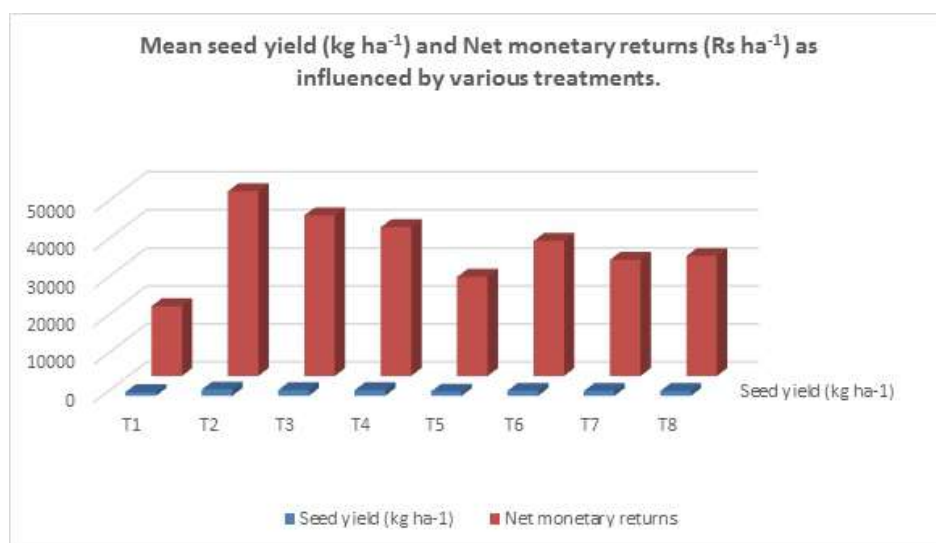
Harvest index indicates the efficiency of plant material to convert the photosynthate into the economic yield and it is worked out as.

Harvest Index (%)

$$= \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield of respective plot (kg ha}^{-1}\text{)}} \times 100$$

Table-1 : Mean seed yield (kg ha⁻¹), Gross monetary returns (Rs. ha⁻¹), Cost of cultivation (Rs. ha⁻¹), Net monetary returns (Rs. ha⁻¹) and benefit: cost ratio (B : C) as influenced by various treatments.

Treatments	Seed yield (kg ha ⁻¹)	Gross monetary returns (Rs ha ⁻¹)	Cost of cultivation (Rs ha ⁻¹)	Net monetary returns	B : C Ratio
T1-No mulching	974	50660	32354	18306	1.56
T2-Soybean straw mulching at 5 t ha ⁻¹	1651	85888	37354	48534	2.29
T3-Spreading of FYM at 5 t ha ⁻¹ as a mulch	1530	79560	37354	42206	2.12
T4-Incorporation of FYM in soil at 5 t ha ⁻¹	1470	76440	37354	39086	2.04
T5-Dust mulching at 30 DAS & hand weeding	1123	58396	32354	26042	1.80
T6-Dust mulching at 30 DAS, Hand weeding and hoeing at 45 DAS	1343	69836	34354	35482	2.01
T7-Dust mulching 30 DAS & Hoeing	1248	64896	34354	30542	1.88
T8-Dust mulching at 30 DAS & hoeing at 45 DAS	1267	65884	34354	31530	1.91
SE±	61.23	3183.96	-	3183.96	-
CD at 5%	185.73	9657.96	-	9657.96	-
General mean	1325.9	68945	-	33966	1.95



The benefit cost ratio was calculated on the basis of formula given below :

$$B : C \text{ ratio} = \frac{\text{Gross monetary returns (ha}^{-1}\text{)}}{\text{Cost of cultivation (ha}^{-1}\text{)}}$$

Results and Discussion

Economics of linseed cultivation

Seed Yield : From one year data, it reveals that, amongst the different moisture conservation practices recorded in Soybean straw mulching at 5 t ha⁻¹ (T2) was significantly highest seed yield 1651 kg ha⁻¹. Significantly lowest seed yield was observed in No mulching practice (T1) (974 kg ha⁻¹).

Gross monetary return (₹ ha⁻¹) : Data pertaining to the gross monetary return (GMR) as influenced by different treatments are presented in Table-1. The mean gross monetary return of linseed was recorded ₹ 68945 ha⁻¹. The gross monetary return was significantly influenced due to different treatments. Significantly the highest gross

monetary return of ₹ 85888 ha⁻¹ was obtained with the application of soybean straw mulching at 5 t ha⁻¹ (T2) This treatment was found significantly superior over rest of the treatments except all which were at par with Spreading of FYM in soil at 5 t ha⁻¹ (T3) while treatment T1 (Control) gave the significantly lowest gross monetary return ₹ 50660.

Net Monetary Return (₹ ha⁻¹) : Data pertaining to net monetary return (₹ ha⁻¹) as influenced by various treatments are presented in Table-1. The mean net monetary return of ₹ 33966 ha⁻¹ was obtained. The net monetary return (₹ ha⁻¹) of linseed was differed significantly due to different treatments. Application of soybean straw mulching at 5 t ha⁻¹ (T2) recorded higher net return ₹ 48534 ha⁻¹. It was found significantly superior over rest of the treatments except all which were at par with T3. The control (T1) recorded only ₹ 18306 ha⁻¹ net return which was the lowest among all treatments.

Benefit: Cost ratio : Data in respect of B: C ratios as influenced by various treatments are presented in Table

4.14. The mean benefit ratio was observed as 1.95. The higher B: C ratio (2.29) was observed with the application of soybean straw mulching at 5 t ha⁻¹ (T2) whereas control gave lowest B : C ratio (1.56).

Conclusions

The application of Soybean straw mulching at 5 t ha⁻¹ in linseed gives more seed yield and monetary net returns. It also found that higher the B:C ratio with this treatment.

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Season-wise Temporal Shift in Cropping Pattern the Nagpur District

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Abstract

Cropped Area always seen shifted from traditional crops to demand oriented crops over the period of time, particularly in different seasons. Such temporal shift in area is also seen in Nagpur district through various articles and discussions. The present paper is done with an intention to find Season-wise temporal shift in cropping pattern in Nagpur district in past 20 years. The data on area is collected from Department of Agriculture, Government of Maharashtra. The simple temporal shifts are estimated from 2001-02 to 2022-23. The variation and compounded growth rates are also estimated to support the shift in acreage. From the results it is found that the share of the area under Oilseeds in Total Cropped Area is reduced from 50.23 percent to 27.04 percent over the period of 20 years and which share is compensated by Foodgrains (increased from 49.47 to 72.96 percent). The Foodgrains production varied and unstable due to variation in area and productivity in both period and overall period. The Foodgrains area is increased significantly (2.55 percent per annum) and accordingly the production is also increased (6.36 percent per annum), which is compensated by declined in area (3.23 percent per annum) and production(3.49 percent per annum) of oilseeds.

Key words : Temporal shift in area, Nagpur.

Introduction

Cropping Pattern is important parameter to estimate and forecast the production of the country. It also reveals the per head average nutrition composition. It also acts as guideline for deciding Minimum Support Price. It also gives idea about quantity of input demands in agriculture. Different past studies in the India and State reveals that the area under different crops shifted over the time from one crop to another. Shifting in area can be a result of change in demand in agricultural produce.

Nagpur is located at central part of the India. The major crops of the Districts are now Rice, Tur, Soyabean, Cotton, Wheat and Gram. It is hypothesized that the Area under crops is shifted in the period of 20 years. The shift in area of different crops in a Kharif season is different that the Rabi season. The study of identifying the shift in crop acreage can provide the clear view and information about proportional / percentage change in area over the time, crops in demands etc.

Looking to the needs of the time, it is necessary to find the Season-wise temporal shift in crop acreage in Nagpur district, the present study is selected.

Objectives : The objectives of paper are as follows :

To find season-wise temporal shifts in Cropping pattern in Nagpur district;

To evaluate the variation in Area, Productivity and Production of major crops in Nagpur district; &

To estimate the growth rates in Area, Productivity and Production of Major crops in Nagpur district;

Research Methodology

This methodology will throw light on the source of data, period of the data, crop included, methods considered to achieve the objectives.

(A) Date source : Cropping area data of major Crops in Nagpur district is collected from the office of the Department of Agriculture, Maharashtra

(B) Estimation of Temporal Changes in Cropping pattern : The Percentage share of crops in total area is estimated for with interval of 5 years and their percentage shares are compared over the time. The triennial averages are estimated to calculate temporal shift.

(C) Estimation of Instability : The instability of cropped area is estimated by the Coefficient of Variation and Cuddy Della Index is used. The formula is as given follows

(a) Coefficient of Variation(CV) : Standard Deviation / Mean the following Cuddy Della Index (Ix) is used in comparison with CV to avoid over estimation.

(b) Cuddy Della Index (Ix) is as follows :

$$I_x = CV \sqrt{(1 - \bar{R}^2)}$$

Where, CV = Coefficient of Variation ($\bar{X}$)

$\bar{R}^2$ = Adjusted coefficient of multiple determination

The variation is estimated for two decades and overall, the period first period is specified from 2000-01 to 2010-11 and the period second period is specified from 2011-12 to 2022-23.

(D) Estimation of growth in Cropped area in Nagpur district : In the present research paper, the Compound Growth Rates in cropped area of major crops in Nagpur district are estimated as per the following formula

The exponential function of the following type was used.

$$Y = abt$$

Where

Y = Crop Area

t = time period in the years

b = trend value (coefficient)

a = intercept.

Compound Growth Rate = (Antilog b-1) 100.

(Chand and et al. 2012)

The significance of the growth in the selected crop groups is tested with the help of 't' test. For getting normal base year, the triennial averages are taken as base year.

Results and Discussion

This section will focus on the extracts of the data analysis and discussion of the results of the analysis of the temporal shift in cropping pattern, variation in area and growth in area over the time in Nagpur district. Results are presented and discussed in this section on the line of objectives mentioned.

Temporal shifts in Cropping pattern in Nagpur district: The table number 1 reveals the temporal shift in cropping pattern in major crops in Nagpur district with the interval of five years.

The result shows that the share of each in total area in Nagpur district is changed over the time. The share of Kharif Rice is suddenly increased in year 2011-12 (9.26%), year 2016-17 (15.02 %) and 2021-22 (20.12 %) which came from the reduction in the area of Kharif Jowar. The share of the area under Cotton is also increased from 16.96 % to 37.42 % over the period of the 20 years and this area share came from the reduction in the area of Kharif Groundnut and Kharif Soybean.

The temporal shift in Rabi season crops is shown in table number 2. The share of area in Rabi Jowar is declined from 5.85 percent in total area in year 2001-02 to 0.01 percent in year 2021-22. Linseed area share also declined from 3.57 percent in total area in year 2001-02 to 0.01 percent in year 2021-22. Whereas the temporal shift

was not seen in Wheat and Gram and their share was almost constant over the period of time.

The temporal shift in cropped area of Summer crops in Nagpur district is presented in table number 3. It is seen from result that the share of the Summer Rice in cropping pattern was 25.49 percent in year 2001-02 which slowly declined to 3.66 percent in year 2021-22. The share in Summer Sunflower was declined from 3.92 percent to negligible. This declined in share was compensated by the increased by increase in area of Summer Groundnut, whose share increased from 33.33 percent to 45.95 percent.

Overall, it is seen from the temporal shift in cropping pattern in Nagpur District (table number 4), the share of the area under Oilseeds in Total Area is reduced from 50.23 percent to 27.04 percent over the period of 20 years and which is compensated by Foodgrains (increased from 49.47 to 72.96 percent).

Variation of the Area, Productivity and Production of Major crops in Nagpur district : The table 5 depicts the Variation in Cropping area in Nagpur district for area, productivity and production for two decades and overall.

The variation is seen more in the Kharif Jowar area consequently production was also unstable (44.65 percent CDI unstable.) in overall period but it was less unstable in period first as compared to second period. Kharif Rice production was more unstable in both period and overall due to instability in area and productivity. Same results are found in Tur, Mung, Udid Gram, Soybean, Kharif Groundnut and Cotton. While variation in production of Summer Groundnut. Overall, whole foodgrains production varied and unstable due to variation in area and productivity in both period and overall period.

Growth rates of the Area, Productivity and Production of Major crops in Nagpur district : The table 6 shows the Growth rates in Area, Productivity and Production in all major crops in Nagpur district.

In Kharif cropped area, it is found that the area under Kharif Jowar(17.53 percent per annum), Mung(5.79 percent per annum), Udid(6.01 percent per annum) and Kharif Groundnut (9.81 percent per annum) is declined significantly and consequently their production is also declined. While it is shifted to Kharif Rice(4.93 percent per annum), Cotton(5.08 percent per annum) and Tur (1.55 percent per annum)significantly. The impact of change in area shows significant change in production respectively. Soyabean area found increased in first period and declined drastically in second period, consequently production also changed.

In Rabi cropped area, Wheat (7.11 percent per

Table-1 : Temporal Shift in Kharif Cropping Pattern from year 2001-02 to 2021-22.

Crop	Year									
	2001-02	% share	2006-07	% share	2011-12	% share	2016-17	% share	2021-22	% share
Kh Rice	408.67	9.26	468.67	9.89	719.67	15.02	911.57	18.96	970.38	20.12
Kharif Jowar	473.00	10.71	306.67	6.47	90.00	1.88	28.35	0.59	14.52	0.30
Kh maize	4.33	0.10	4.33	0.09	3.00	0.06	0.30	0.01	11.62	0.24
Other kh.Cereals	0.67	0.02	2.00	0.04	1.00	0.02	0.44	0.01	0.89	0.02
Tur	497.67	11.27	534.00	11.27	576.67	12.03	664.74	13.83	677.16	14.04
Mung	27.67	0.63	16.33	0.34	15.00	0.31	10.01	0.21	10.03	0.21
Udid	25.00	0.57	16.00	0.34	15.33	0.32	9.10	0.19	7.48	0.16
Other kh Pulses	49.00	1.11	25.00	0.53	23.00	0.48	4.29	0.09	1.42	0.03
Kh. Groundnut	90.67	2.05	62.33	1.32	31.00	0.65	27.01	0.56	10.24	0.21
Kharif Sesamum	3.33	0.08	1.33	0.03	1.00	0.02	0.51	0.01	0.25	0.01
Kh Sunflower	0.67	0.02	0.00	0.00	0.00	0.00	0.80	0.02	0.00	0.00
Soybean	2073.33	46.96	2619.33	55.27	2402.33	50.13	1743.89	36.28	1280.97	26.56
Other Kharif Oilseeds	2.00	0.05	1.67	0.04	2.67	0.06	2.02	0.04	0.50	0.01
Total Kh Cereals	886.67	20.08	781.67	16.49	813.67	16.98	940.52	19.57	997.40	20.68
Total Kh pulses	599.33	13.57	591.33	12.48	630.00	13.15	688.14	14.32	696.09	14.43
Total Kh Foodgrains	1486.00	33.66	1373.00	28.97	1443.67	30.12	1628.07	33.87	1693.49	35.11
Total Kharif oilseeds	2170.00	49.15	2684.67	56.65	2437.00	50.85	1774.23	36.91	1291.97	26.78
Cotton	748.67	16.96	679.67	14.34	907.67	18.94	1360.23	28.30	1804.78	37.42
Sugarcane	10.33	0.23	1.67	0.04	4.33	0.09	44.22	0.92	33.32	0.69
Total Kharif Area	4415.00	100.00	4739.00	100.00	4792.67	100.00	4806.75	100.00	4823.56	100.00

Table-2 : Temporal Changes in Rabi Cropping Pattern from year 2001-02 to 2021-22.

Crop	Year									
	2001-02	% share	2006-07	% share	2011-12	% share	2016-17	% share	2021-22	% share
Wheat	313.33	21.39	604.33	22.02	781.33	24.26	1212.34	32.15	1060.83	28.77
Rabi Jowar	85.67	5.85	47.00	1.71	25.67	0.80	4.84	0.13	0.26	0.01
Rabi maize	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.01	2.98	0.08
Othr Rabi Cereals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.02
Gram	296.33	20.23	641.00	23.35	752.67	23.37	650.81	17.26	768.05	20.83
Other Rabi Pulses	6.00	0.41	40.33	1.47	38.00	1.18	10.56	0.28	4.73	0.13
Rabi Sesamum	1.00	0.07	0.33	0.01	0.67	0.02	0.00	0.00	0.00	0.00
Rabi Sunflower	4.33	0.30	46.67	1.70	7.33	0.23	2.70	0.07	0.00	0.00
Safflower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.01
Linseed	52.33	3.57	22.33	0.81	11.00	0.34	0.56	0.01	0.45	0.01
Castorseed	2.00	0.14	1.67	0.06	2.67	0.08	2.00	0.05	0.00	0.00
Rape & Mustard	2.33	0.16	8.33	0.30	3.00	0.09	4.50	0.12	0.00	0.00
Other Rabi Oilseeds	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.11	11.16	0.30
Total Rabi cereals	399.00	27.24	651.33	23.73	807.00	25.06	1217.43	32.28	1064.67	28.88
Total Rabi Pulses	302.33	20.64	681.33	24.82	790.67	24.55	661.37	17.54	772.78	20.96
Total Rabi foodgrains	701.33	47.88	1332.67	48.55	1597.67	49.62	1878.80	49.82	1837.45	49.84
Total Rabi Oilseeds	62.00	4.23	79.33	2.89	24.67	0.77	13.76	0.36	12.02	0.33
Total Rabi Area	1464.67	100.00	2744.66	100.00	3220.00	100.00	3771.36	100.00	3686.92	100.00

annum) and Gram (4.37 percent per annum)is increased significantly in both period and subsequently the production also increase.

Summer Groundnut area was declined in first period but increased in second period and overall. Productivity has shown significant contribution and share in growth of Gram and Wheat.

Overall, the Foodgrains area is increased significantly (2.55 percent per annum) and accordingly the

production is also increased (6.36 percent per annum), which is compensated by declined in area (3.23 percent per annum) and production(3.49 percent per annum) of oilseeds.

Conclusions

From the results it is found that the share of the area under Oilseeds in Total Cropped Area is reduced from 50.23 percent to 27.04 percent over the period of 20 years and

which share is compensated by Foodgrains (increased from 49.47 to 72.96 percent). The Foodgrains production varied and unstable due to variation in area and productivity in both period and overall period. The Foodgrains area is increased significantly (2.55 percent per annum) and accordingly the production is also increased (6.36 percent per annum), which is compensated by declined in area (3.23 percent per annum) and production (3.49 percent per annum) of oilseeds.

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Major Fruit Tree Based Agrihorti Systems of Coastal Ecosystem

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Abstract

Performance of four short duration legume inter crops (Arhar, Groundnut, Blackgram and Cowpea) was studied in agrihorticultural system involving three major fruit tree species (Mango, Jackfruit and Cashew). The crops were grown in the alleies of tree row in the first fortnight of July. The experiment was conducted from June 2019 to September 2022. The experiment was laid out in Factorial randomized block design (FRBD) including 12 numbers of treatments. The Jackfruit recorded the highest plant height (7.85 m) followed by Cashew (5.68 m) and Mango (4.41 m) in general and all the fruit trees recorded highest tree height with Cowpea followed by Black gram as an intercrops at 66 months after planting. Among the intercrops Arhar produced the highest net return of Rs 53,380 Rs 43,660 and Rs 32,720 /ha/yr with Benefit Cost Ratio 3.13 2.75 and 2.31 with three fruit trees i.e. Mango, Jackfruit and Cashew respectively. Partial shade had absolutely no effect on the growth and economic yield of these intercrops as the tree canopy during the period was very less. Analysis of soil after one month after harvest of inter crops viz. Arhar, Clusterbean, Blackgram and Cowpea grown with the fruit tree species in agrihorti system indicated highest values of available N (266.8 kg ha⁻¹) and K₂O (158.7 kg ha⁻¹) with cowpea and higher values of available P₂O₅ (36.5 kg ha⁻¹) with Arhar irrespective of fruit trees. Organic carbon percentage in this system varied from 0.61 in Mango & Jackfruit with Cowpea intercrop to 0.51 in Mango & Cashew with Cluster bean. The maximum carbon sequestration (6,218 kg ha⁻¹) was observed in Jackfruit with Cowpea followed by Cashew + Cowpea (4,958 kg ha⁻¹).

Key words : Agrihorti system, fruit trees, legume intercrops, biometrics, soil fertility carbon sequestration, yield and economics

Introduction

Farmers generally prefer the intercropping system because it produces higher total crop yield per unit area, provides insurance against total crop failure, and also reduces incidences of pests and diseases (Lyocks *et al.*, 2013). Intercropping has been associated with several advantages such as higher yield stability, the variability of food supplies, increased return per unit area, a spread of labour and income and reduced dependency on one crop or diversified production (Hauggard-Nielsen *et al.*, 2003). The choice of component crops, on the other hand, depends on the agro-ecological zones, preference of the grower and ability to complete growth cycle. In agri-horti system, trees and agricultural crops are combined together and they compete with each other for growth resources such as light, water and nutrients. The resource sharing in component crops may result in complementary or competitive effect depending upon nature of species involved in the system. The fruit based intercropping system can be defined as a planting system comprising combinations of plants with various morpho-phenological features to maximize the natural resource use efficiency and enhanced total factor productivity. The system comprises of a combination of perennial and annual plant species as different components in the same piece of land arranged in a geometry that facilitates maximum utilization

of space in four dimensions (length, width, height and depth) leading to maximum economic productivity of the system. Fruit trees in intercropping system prove remunerative to the farmers and that impart stability to the income. Similar interest was shown for the fast growing timber trees for high return. Mango is the most predominant species followed by cashewnut. In the past few years jackfruit which was not considered as an economically important fruit crop is gaining popularity, for its use in culinary purpose rather than table purpose. Mango being a promising and income generating fruit tree, its inclusion in the trial with timber trees and field crops may provide useful information to develop a remunerative intercropping system for the rainfed uplands. The tree based land-use intercropping system is an ideal scientific approach in restoring soil fertility and improving its quality by several ways. The presence of tree component in intercropping systems influence the physio-chemical properties of soil as physical (Bulk density, water holding capacity, texture, structure, temperature) and chemical (pH, exchangeable bases, available N, P, K, soil organic carbon). The yield and productivity of the intercropping systems depend on the compatibility of the crops introduced as well as nutrient availability and management. The success of intercropping system under orchard crops depends very much on the selection of compatible crop combination and

the geometry of the planting in which each crop exploits a distinct and different zone of atmosphere and soil, so the competition for moisture, nutrients, space and solar radiation will be the minimum. Keeping this all above facts in view, a research was conducted on “Major Fruit Tree Based Agrihorti Systems of Coast Ecosystem”.

Materials and Methods

The experimental site is situated inside the Horticultural Research Station of OUAT, 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 area comes under tropical hot and humid climate, with rainfall of 1472 mm, average maximum temperature of 32.7 °C and minimum temperature of 25.2 °C. The texture of the soil is sandy loam. Iron and aluminium oxides abound, but basic cations and soluble salts are low. To enrich the soil, well rotten FYM was applied after harrowing and well-mixed with the soil by planking and leveled. Soil is sandy loam texture. It is rich in oxides of iron and aluminum, 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 the possible precautions prescribed for soil sampling. This experiment was started in 2018 kharif season and this is the fifth year of agrihorticultural system. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications. The experiment was consisted of 16 treatment combinations involving three fruit crops along with open control and four legume intercrops. Three fruit tree species such as *Magnifera indica* (Mango), *Anacardium occidentale* (Cashewnut), *Artocarpous heterophyllus* (Jackfruit) and four intercrops are *Cajanus cajan* L. (Arhar), *Arachis hypogea* (Groundnut), *Vigna mungo* (Blackgram), *Vigna unguiculata* (Cowpea) were grown in kharif season from 2019-22. The fruit trees such as jack fruit, mango, and cashewnut were raised in 2018 by transplanting of seedlings at spacing of 8 m × 7.5 m with recommended package of practices. During the crop growth season, need based insecticides and fungicides were applied to fruit crops and intercrops. The tree heights of mango, jackfruit, and cashewnut were measured by the Hypsometer from convenient distance vertically from ground level to the tip of the leading crown. On using a measuring tape and calliper, the collar girth of individual trees was measured at 15 cm above the soil surface. Crown spread was recorded by the taking the mean of crown width in east - west direction as well as north – south direction. For physico-chemical analysis, soil samples were collected from 0-15 cm depth of each plot before planting and after harvesting of annual crops before sowing and after harvest of each season crop for analysis of soil fertility status. The parameters such as Soil

organic carbon (SOC), bulk density (BD) and available N, P and K were estimated by following standard chemical analysis methods. Soil carbon sequestration was estimated by using the following formula. (Singh *et al.* 2008). The yields of fruit trees and intercrops were recorded from time to time from each plot and the total yield was calculated at the end of each season and converted to yield per hectare. Economics was worked out to compare the profitability of different treatments. The experimental data obtained were subjected to statistical analysis adopting Fisher's method of analysis of variance as out lined by (Gomez and Gomez, 1976).

Result and Discussion

The tree growth parameters and the effect of trees (66 months old) on growth of intercrops were assessed in relation to their sole crop yields. The highest plant height was recorded with the intercrop cowpea with jackfruit followed by mango and cashew (7.85 m, 5.68 m and 4.41m) respectively. Similarly the basal girth (72.24 cm, 58.32 cm and 65.38 cm) and crown spread (7.63 m, 6.72 m and 6.36 m) recorded highest with the intercrop cowpea with the fruit crops followed by black gram. Irrespective the intercrops, jackfruit recorded the maximum total height followed by Cashewnut and mango. This is because of jackfruit has more growth in sapling stage as comprised to mango and cashewnut. Irrespective of woody species, the total height in trees in association with cowpea and black gram was observed higher over cashewnut and arhar. It is shows that less competition gives by cowpea and black gram for moisture, nutrient etc. to fruit trees. The height of fruit trees with arhar was observed less, that might be because arhar gives more competition to fruit trees for different resources as arhar is a exhaustive crop with regards to water utilization, nutrient uptake, etc. and it's also have long growing duration as compared to other intercrops grown. Jackfruits have hereditary more growth rate as compare to cashewnut and mango as well as positive effect of cowpea and black gram as intercrop. Similar trend also found by Rathore *et al.* 2013 and Swain 2014. In compared to other intercrops, arhar had the least positive influence on collar girth. The positive effect of black gram and cowpea as intercrop has also been reported by Raut and Jain 2013, Mishra and Swain 2002. The variation in crown spread was due to the genetic makeup among fruit trees with regard to expansion of crown. Cashewnut plants have more crown expansion ability in comparison to jackfruit and mango.

Analysis of soil after harvesting of inter crops viz. arhar, groundnut, black gram and cowpea grown with the fruit tree species in fruit based agroforestry systems indicated in Table 2. It was observed that pH in all the

Table-1 : Growth of fruit trees in agrihortisilvicultural system (Three years Pooled data, 2019-22).

Fruit Tree species	Intercrops	Plant height (in meter)	Basal girth (In cm)	Crown spread (in meter)
Mango	Arhar	4.16	55.25	5.61
	Groundnut	4.44	56.35	5.87
	Blackgram	4.72	57.93	6.02
	Cowpea	5.68	58.32	6.36
Jackfruit	Arhar	7.13	61.65	6.01
	Groundnut	7.28	67.43	6.12
	Blackgram	7.46	68.58	6.34
	Cowpea	7.85	72.24	6.72
Cashew	Arhar	3.86	58.43	7.05
	Groundnut	4.02	60.77	7.24
	Blackgram	4.27	63.16	7.45
	Cowpea	4.41	65.38	7.63
CD (0.05)		0.37	2.25	0.34

Table-2 : Soil fertility status as influenced by trees and crops in agrihortisilvi system (Three years Pooled data, 2019-22).

Fruit Tree species	Intercrops	pH	EC	Organic carbon (%)	Available N(kg/ha)	Available P ₂ O ₅ (kg/ha)	Available K ₂ O(kg/ha)
Mango	Arhar	5.56	0.22	0.56	243.4	36.5	147.3
	Groundnut	5.62	0.13	0.53	238.8	31.7	153.5
	Blackgram	5.05	0.19	0.63	252.1	30.3	155.6
	Cowpea	5.75	0.18	0.66	266.8	33.6	158.7
Jackfruit	Arhar	5.53	0.21	0.58	235.5	34.5	143.6
	Groundnut	5.58	0.13	0.56	237.6	29.7	151.8
	Blackgram	5.69	0.20	0.59	245.8	30.1	152.2
	Cowpea	5.71	0.18	0.64	254.2	32.4	157.1
Cashew	Arhar	5.52	0.17	0.54	222.1	35.3	146.2
	Groundnut	5.53	0.12	0.56	221.3	30.1	142.9
	Blackgram	5.60	0.19	0.58	244.7	29.4	150.9
	Cowpea	5.62	0.15	0.60	241.4	31.2	151.7
Initial soil status (2015)		5.47	0.11	0.49	208.6	38.2	146.4

Table-3 : Yield and Economics of agrihortisilvicultural systems (Three years Pooled data, 2019-22).

Fruit Tree species	Intercrops	Intercrop grain / green yield (kg ha ⁻¹)	Fruit yield (kg ha ⁻¹)	Harvest index of intercrop	Arhar Equv. Yield (kg ha ⁻¹)	Net return (Rs. ha ⁻¹)	B : C ratio	Carbon sequestration (kg ha ⁻¹)
Mango	Arhar	580	711	0.19	858	43,660	2.75	3,636
	Groundnut	1076	742	0.15	670	28,610	2.14	3,963
	Blackgram	280	693	0.25	529	17,350	1.70	4,708
	Cowpea	1368	845	0.17	659	27,710	2.11	4,865
Jackfruit	Arhar	552	452	0.21	721	32,720	2.31	4,758
	Groundnut	914	496	0.13	528	17,300	1.70	3,485
	Blackgram	271	423	0.25	430	9,370	1.37	3,938
	Cowpea	1170	526	0.16	490	14,180	1.58	6,218
Cashew	Arhar	386	475	0.18	980	53,380	3.13	4,704
	Groundnut	792	442	0.14	850	42,960	2.72	4,080
	Blackgram	254	418	0.26	778	37,120	2.49	3,734
	Cowpea	1232	532	0.19	973	52,840	3.11	4,958

intercropping systems were higher compared to their initial values (5.47). The pH values of fruit based agroforestry systems ranged from 5.05 to 5.71. The value was higher under Jackfruit with cowpea (5.71) and by jackfruit + black gram (5.69). E.C. ranges from 0.22 to

0.12 dS m⁻¹. The higher value seen under mango + arhar system (0.22 dS m⁻¹) followed by jackfruit + arhar (0.21 dS m⁻¹) and cashewnut + arhar (0.17). The maximum organic carbon percentage of 0.66 was found under mango + cowpea followed by jackfruit + cowpea (0.64%).

Lowest organic carbon content was found in mango + groundnut (0.53%). The available nitrogen content from fruit based agroforestry systems was increased over initial status (208.6 kg ha⁻¹). The value ranged from 221.3 kg ha⁻¹ to 266.8 kg ha⁻¹ in different systems. The maximum available nitrogen content of 266.8 kg ha⁻¹ was found under mango + Cowpea followed by Jackfruit + cowpea (254.2 kg ha⁻¹) and the lowest was found in cashewnut + groundnut system (221.3 kg ha⁻¹). The maximum available phosphorous content of 36.5 kg ha⁻¹ was found under mango + arhar system followed by cashew + arhar system (35.3 kg ha⁻¹) and the lowest available phosphorous content was recorded in cashewnut + black gram system (29.4 kg ha⁻¹). The maximum available potassium content of 158.7 kg ha⁻¹ was found under mango + cowpea system followed by jackfruit + cowpea system (157.1 kg ha⁻¹) and the lowest available potassium content was found in cashewnut + arhar system (142.9 kg ha⁻¹). Verma *et al.* (2018) E.C. was reported that the intercropping system increases the soil organic carbon and influences the soil biological properties. Maximum nitrogen concentration in intercropping treatment of cowpea was observed by. (Bedse *et al.*, 2015). The increase in availability of phosphorous content in the soil was because of legume intercrop root exudates solubilized the exchangeable phosphorus as well as increase the total microorganisms in rhizosphere particularly PSB (phosphorous solubilising bacteria) (Cardoso, 2002).

The maximum fruit yield was recorded in mango + cowpea system i.e. 845 kg ha⁻¹ followed by mango + groundnut (742 kg ha⁻¹). Similarly among all the intercrops the highest yield was recorded by mango + cowpea (1368 kg ha⁻¹) followed by cashew + cowpea (1232 kg ha⁻¹) and jackfruit + cowpea (1170 kg ha⁻¹). Cashew + blackgram recorded the highest harvest index of intercrop (0.26) followed by mango + black gram and jackfruit + blackgram (0.25). The lowest harvest index of intercrop was recorded with groundnut irrespective of fruit tree species. The highest arhar equivalent yield was recorded in cashew + arhar (980 kg ha⁻¹) followed by cashew + cowpea (973 kg ha⁻¹). The lowest arhar equivalent yield was recorded with jackfruit + blackgram (430 kg ha⁻¹). The net return from intercrops significantly differs in the fruit based agroforestry system. Arhar produced the highest net return of Rs 53,380 Rs 43,660 and Rs 32,720 /ha/yr with BCR 3.13 2.75 and 2.31 with three fruit trees i.e. cashew, mango and jackfruit respectively. Cluster bean was the next best inter crop with fruit trees which recorded net returns of Rs. 42960, 28610 and 17300 /ha/yr with BC ratio 2.72, 2.14 and 1.70 in the system when intercropped with cashew, mango and jackfruit respectively. It was observed that highest carbon

sequestration in maximum carbon sequestration (6,218 kg ha⁻¹) was observed in Jackfruit with cowpea followed by cashew + cowpea (4,958 kg ha⁻¹). The lowest carbon sequestration potential was recorded with mango + arhar (3,636 kg ha⁻¹). The carbon sequestration potential of Agroforestry systems in India is estimated between 0.25 – 19.14 and 0.01 to 0.60 Mg C/ha/yr for tree and crop component, respectively (Dhyani *et al.* 2016).

During the gestation period intercrops not only provide some seasonal return but also helps in improvement of soil physic-chemical properties. However, the variation in benefit-cost ratio was seen under agricultural component in various combinations due to difference in returns and cost. Shade had absolutely no effect on the growth and economic yield of these intercrops as the tree canopy during the period was very less. Arya *et al.* (2010) reported that yield was superior in multicropping system rather than sole cropping. Raut and Jain (2013) reported that maximum number of mango fruits was observed with intercrop blackgram whereas, maximum average fruit weight was found in pigeonpea.

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Influence of Potassium Application on Yield of Chickpea in Potassium Deficient Soils

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Abstract

Chickpea (*Cicer arietinum* L.) is an important winter season pulse crop. The productivity of chickpea is low because it is grown on receding soil moisture during rabi season and farmers do not apply fertilizers being a legume crop. The yield gap of chickpea may be attributed to ignorance of the farmers regarding improved cultivation practices for growing chickpea. On farm trial technology is one of the most powerful tools for assessment and transfer of technology. Keeping in view the present study was carried out to find out the production enhancement and economics through on farm trial technology of chickpea on farmers field in district Pathankot. There were three treatments T1: 87.5 kg DAP ha⁻¹ (Farmers Practice), T2: Application of 32.5 kg urea ha⁻¹ + 125 kg SSP ha⁻¹ (RP), T3: Application of 32.5 kg urea ha⁻¹ + 125 kg SSP ha⁻¹ + 50 kg MOP ha⁻¹ (IP). All the treatments were applied as basal dose. The pooled yield data of the OFT conducted revealed that a maximum yield was observed in T3 treatment where potassium was applied along with recommended dose of nitrogen (urea) and phosphorus (single superphosphate) as compared to other two treatments. The pooled yield data of 3 years reveals that there was a considerable increase of 32 and 11.8 % in yield of chickpea with treatment T3 with potassium application over T1 and T2. Economic analysis of treating chickpea with potash revealed that application of 50 kg MOP ha⁻¹ along with recommended dose of urea and single superphosphate gave the maximum net benefit during all the three years of trial. The average benefit-cost ratio was higher under chickpea demonstration where potassium fertilizer along with recommended dose of urea and single superphosphate was applied in T3 treatment as compared to other two treatments T1 and T2 where only diammonium phosphate (T1) and urea and single superphosphate (T2) were applied during the three years of the study. The mean value of benefit-cost ratio of chickpea cultivation under treatment T3 treatment where potassium was applied during the years was 3.8 which was highest over the treatments T1 (2.7) and T2 (3.4).

Key words : Potassium application, chickpea, pulses

Introduction

Pulses occupy a remarkable position in the Indian diet because of the constituting cheapest source of vegetable protein for the vegetarian population of India (1). Legumes possess high nutritive value and a balanced ratio of proteins (13-15%) and carbohydrates (4-23%), which suggests that they are potential protein base food for the vegetarian population all over the world. Moreover, the highly nutritive proteins in legumes are considered as 'poor people's meat' (8). Pulse cultivation does not require intensive irrigation and can be carried out in rainfed areas. Pulses can fix atmospheric nitrogen and improve soil fertility, which in turn reduces the dependence of farmers on expensive fertilizers (22). To satisfy the demand of pulses requirement of ever increasing population, the production of pulses has to be increased either by increasing the area or yield/unit area/day.

Chickpea (*Cicer arietinum* L.) also called Bengal gram, is the premier pulse crop in India and is the third most important legume in the world covering about 8.25 million hectares which is 40 per cent of the total pulses area with annual production of 7.05 million tones contributing 50 per cent of the total pulses production in

the country (6). More importantly, the 20 per cent demand of pulses in India is met by imports only (21). Nutritionally, it is an important source of protein (16-20%) in vegetarian diet and has become more important to mitigate the problem of protein energy malnutrition (13). It holds an important role in the vegetarian diets due to its high protein content (16- 20%), carbohydrates (51%), fat (25.8%), total dietary fibre, vitamins and minerals (7). Gram is mostly consumed in the form of processed whole seed and dal but also used for preparing a variety of snacks, sweets and condiments, which are very useful for stomach ailments and blood purification.

The productivity of chickpea is low because it is grown on receding soil moisture during rabi season and farmers do not apply fertilizers being a legume crop (6). Farmers have a wrong notion that chickpea being a legume crop, does not need any nutrition and usually grow it on the marginal lands, without applying any fertilizer.

The yield gap of chickpea may be attributed to improper agro-technology used by the farmers. Among production inputs fertilizer plays a key role in enhancing productivity levels. Pulse crop fix atmospheric N, the prominent mechanism to meet their N requirement,

however, recommendation on phosphorous is made in all states. Potassium application has been neglected in many countries, including India, which has resulted in soil K depletion in agricultural ecosystems and a decline in crop yields (15). Plant needs large quantities of potassium which not only improves the crop yield, but crop quality also.

Potassium has been described as the “quality element” for crop production. Adequate supply of potassium during growth period, improves the water relations of plant and photosynthesis, maintains turgor pressure of cell which is necessary for cell expansion, helps in osmotic-regulation of plant cell, assists in opening and closing of stomata, increases tolerance to water stress and enhances water use efficiency. It has utmost importance for imparting drought and disease resistance and has synergistic effect with nitrogen and phosphorus, (4). It is not a constituent of organic structures, but regulates enzymatic activities (over 60 enzymes require K for activation) translocation of photosynthates, (10) and considerably improves seed yield of chickpea if applied as a fertilizer (17, 20). Keeping in view the importance of potash for plants this study was carried out to investigate the yield response of chickpea to potash.

The main aim of Krishi Vigyan Kendra is transfer of technology through on and off campus training programs for farmers and extension functionaries, front line demonstrations, on farm trials and other extension activities. Conducting OFT on farmer field helps to identify potential technology compared to farmer practices and powerful tool to find out the suitable particular technology for a region (19) it helps in improving the economic and social status of the farmers.

Materials and Methods

On farm trial was conducted at farmer's field during rabi 2018-19, 2019-20 and 2020-21 with an objective to assess the influence of potassium application on the yield of chickpea in potassium deficient soils. The soil of the farmers field were sandy-loam in texture, neutral in reaction (pH: 7.1) and medium in available P (16.2 kg ha⁻¹), medium in organic carbon (0.43%) and low in available potassium (93 kg ha⁻¹). Crop management practices were followed as per the Punjab Agricultural University package and practices for the cultivation of chickpea. The detail of treatment is given in table-1. All the treatments were applied as basal dose. The yield data were collected from all the three treatments farmers practice, recommended practice and intervention and there feasibility and economic viability were accessed.

Results and Discussion

The yield performance of the on farm trial were analyzed and presented in Table-2. The pooled yield data of the OFT conducted during these years revealed that a maximum yield was observed in T3 treatment where potassium was applied along with recommended dose of nitrogen (urea) and phosphorus (single superphosphate) as compared to other two treatments (Table-2). The pooled yield data of 3 years reveals that there was a significant increase of 32 and 11.8 % in yield of chickpea in treatment T3 with potassium application over treatment T1 and T2 where only diammonium phosphate and recommended dose of urea and single superphosphate was applied (Table-2). Application of K increased the availability of nitrogen and phosphorus (16) which resulted in better plant growth and more number of branches per plant and higher seed yield. Application of K might have enhanced the photosynthetic activity which resulted in more number of seeds per pod. Similar results have been reported by (17) who examined significantly higher number of seeds per pod with the application of potash as compared to control. The K is third major nutrient element after N and P and play an important role for crop development (9; 18). Similarly, experiment conducted on various K rates application on chickpea recorded higher yield with potassium application (2). Significantly higher yield of chickpea with the application of 40 kg K₂O ha⁻¹ closely followed by 30 kg K₂O ha⁻¹ with continuous three years study was reported by (6). Similar results were reported by (11; 3; 12; 5), where various K levels between (25 to 60 K₂O kg ha⁻¹) were effective in enhancing growth and grain yield of different chickpea. The use of NPK could help to support plant in a better way for enhancing plant growth parameters which may lead to support in higher crop production (14).

Economic analysis : Economic analysis of treating chickpea with potash (Table 3) revealed that application of 50 kg MOP ha⁻¹ along with recommended dose of urea and single superphosphate gave the maximum net benefit. The average benefit-cost ratio was higher under chickpea demonstration where potassium fertilizer along with recommended dose of urea and single superphosphate was applied in T3 treatment as compared to other two treatments T1 and T2 where only diammonium phosphate (T1) and urea and single superphosphate (T2) were applied during the three years of the study (Table 3). The pooled mean value of benefit-cost ratio of chickpea cultivation under treatment T3 where potassium was applied during the 3 years was 3.8 which was highest over the treatments T1 (2.7) and T2 (3.4). The high net returns and B: C ratio in chickpea fields where potassium fertilizer was applied was due to the high

Table-1 : Treatment details

S. No.	Treatments
T1	Application of 87.5 Kg DAP ha ⁻¹ (FP)
T2	Application of 32.5 Kg urea ha ⁻¹ + 125 kg SSP ha ⁻¹ (RP)
T3	Application of 32.5 Kg urea ha ⁻¹ + 125 kg SSP ha ⁻¹ (RP + 50 Kg MOP ha ⁻¹ (IP))

Table-2 : Effect of potassium application on yield of chickpea (pooled mean of 3 years).

S. No.	Treatments	Yield (qha ⁻¹)
T1	Application of 87.5 Kg DAP ha ⁻¹ (FP)	12.1
T2	Application of 32.5 Kg urea ha ⁻¹ + 125 kg SSP ha ⁻¹ (RP)	14.3
T3	Application of 32.5 Kg urea ha ⁻¹ + 125 kg SSP ha ⁻¹ (RP + 50 Kg MOP ha ⁻¹ (IP))	16.0
	CD (5%)	1.3

Table-3 : Economics of potassium application on chickpea yield (Pooled mean of 3 years).

S. No.	Treatments	B : C ratio	Net return (Rs/ha)
T1	Application of 87.5 Kg DAP ha ⁻¹ (FP)	2.7	39809
T2	Application of 32.5 Kg urea ha ⁻¹ + 125 kg SSP ha ⁻¹ (RP)	3.4	53684
T3	T2 + Application of 50 Kg MOP ha ⁻¹ (IP)	3.8	61767

grain yield and fetching of the better selling price of the chickpea in the market. These results are consistent with the findings reported by (20 and 17). Hence, it clearly shows that the field plots of chickpea with the application of potassium were better than the farmer's practices. Thus, economic analysis data suggests that the successful transfer of new and improved technology and its adoption in pulses may increase the profitability substantially on farmer's field.

Conclusions

In this study, it was concluded that application of K with other major nutrients (N and P) influenced the growth and yield enhancement of chickpea. Similarly, it can be concluded application of K might have enhanced the photosynthetic activity which resulted in more number of seeds per pod. The above results clearly showed that consistent response of chickpea to basal application of potassium.

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In-Vitro Evaluation of Fungicides against *S. rolfsii* Sacc. Causing Pod Rot of French Bean

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Abstract

Legumes play vital role in agriculture as they provide not only a dietary protein but also help in fixing nitrogen from the air. Thousands of legume species exist in the world such as French bean (*Phaseolus vulgaris* L.), lablab bean (*Lablab purpureus* L.), lima bean (*Phaseolus lunatus* L.), etc. Among them, French bean is consumed as a vegetable more than any other species. It is consumed as matured grain, immature seed as well as a vegetable. It suffers heavily from pod rot disease which is incited by *Sclerotium rolfsii* Sacc. Among four different fungicides were evaluated against *S. rolfsii* Sacc, it was revealed that propiconazole at 0.05, 0.1 and 0.15 concentrations exhibited 100% inhibition of growth of pathogen. Cent per cent inhibition of growth were observed in mancozeb at 0.1, 0.15 and 0.2% concentrations. While hexaconazole at 0.15% concentration exhibited 81.85%. Copper oxychloride at 0.2% concentration exhibited 58.51% inhibition of growth of pathogen.

Introduction

French bean is an important vegetable food and also an export crop in India. French beans are grown throughout the world and contribute nearly 30% of the total production of food legumes (Vasishtha and Srivastava, 2012). Majority of population in India are vegetarian and increased consumption of French bean as a pulse and vegetable can appropriately supplement their nutritional requirement (Singh *et al.*, 2009). French bean is a rich source of nutrient and minerals. The French bean seeds (Rajma) contains 17.8-28.7% protein, green pods contain 1.4-2.5% protein, 11.7% fat, 70% carbohydrates and 340-450 Kcal energy (Sardana *et al.*, 2000). French bean is an important cool season legume crop grown for its tender pods, shelled green bean and dry beans. The ideal temperature range for French bean crop is 10-27°C. French bean crop prone to many diseases such as anthracnose, pod rot, bean rust, white mold and fusarium rot. Among these, pod rot incited by *S. rolfsii* Sacc. causes 40-50% yield loss in India (Dasgupta *et al.*, 2005).

The fungus *S. rolfsii* Sacc. was first observed in United States (Rolf in 1892). *S. rolfsii* Sacc. incites pod rot diseases on many crops. It favours high temperature (25-35°C) and Relative humidity (85%). Under heavy soil moisture sometimes more than 60-70% crops have been damaged due to this disease.

Symptoms are typified by the development of white fungal thread over the affected pods. The white profuse mycelial growth of fungus covers the entire pod. The pathogen attacks the germinated seedlings and causes wilt. The pathogen produces initially white colour

sclerotia, later turned to dark brown and the small round bodies about the size of mustard seed like sclerotia.

S. rolfsii Sacc. is a soil borne pathogen which infects more than 500 plant species including brinjal, bean, cucumber, groundnut, maize, soybean, tomato and watermelon, etc. It causes different types of diseases such as pod rot, collar rot, sclerotium wilt, stem rot, charcoal rot, seedling blight, damping-off, foot rot, stem blight and root-rot in many economically valuable crops. Anahosar (2001) studied bioagents viz., *Trichoderma harzianum*, *Penicillium* sp, *Bacillus subtilis*, *Pseudomonas fluorescens* and Mycorrhiza; which inhibit *Sclerotium rolfsii* Sacc. causing rot, wilts and damping-off diseases. *Bacillus subtilis* secretes antifungal substance which is highly antagonistic against *S. rolfsii* Sacc. which inhibits 92% under green house condition in peanut (Allah., 2001).

The use of fungicides as a plant protection measures against plant diseases have been most common and proved most effective as compared to other measures besides the fact that it causes harmful effect to the environment and human being. Country like India where more than 80% of the population is engaged in agriculture. The application of chemical fertilizers, pesticides, fungicides etc, are extensively used.

Sharma and Verma (1985) reported sclerotial inhibition at all the concentration of PCNB (quintozene) tested while Bavistin was least effective. Shahid *et al.* (1990) found that *in-vitro* tests with 10 fungicides, captan and metalaxyl were the most effective in inhibiting mycelial growth and sclerotia production of *S. rolfsii*. Germination of sclerotia was checked most effectively by

benomyl and metalaxyl. Metalaxyl and benomyl at 500 ppm, applied as seed treatment and soil drench respectively, gave 100% control of collar rot on lentil seedlings. Bhat and Srivastava (2003) evaluated *in vitro* efficacy of captan, thiophanate methyl and propiconazole at 250, 500 and 1000 ppm concentrations against *S. rolfsii*. They found that propiconazole was effective even at 250 ppm concentration against *S. rolfsii*.

Materials and Methods

In-vitro evaluation of fungicides against *S. rolfsii*

Sacc. : Four fungicides namely, hexaconazole and propiconazole each 0.05, 0.1 and 0.15 and copper oxychloride & mancozeb each 0.1, 0.15 and 0.2 were evaluated against *S. rolfsii* on the PDA medium by poisoned food technique described by Nene and Thapliyal (2002) under *in-vitro* conditions.

Required quantity of fungicides were added separately into 100ml sterile molten and warm PDA media taken in 250 ml conical flasks and thoroughly mix to dissolve the chemical and get appropriate concentrations of each fungicide. 15 ml of poisoned medium from each specific concentration were poured into each sterilized Petri plate separately. Petri plates only PDA served as control. Mycelial discs of 5mm size from three-day old culture of the pathogen was picked up and inoculated at the centre of each Petri plate facing the fungal mycelium on medium. Three replications were maintained for each treatment. The plates were incubated at $28 \pm 1^\circ\text{C}$. Mean colony diameter for each treatment was recorded after the fungus in control plates attained full growth. The per cent

inhibition of mycelial growth was calculated by using the formula given by Vincent (1927) as

$$\text{Inhibition (\%)} = \frac{C - T}{C} \times 100$$

Where,

“C” is the maximum growth of the fungal mycelia under control

“T” is fungal mycelia growth in dual culture.

Results and Discussion

In-vitro evaluation of fungicides against *S. rolfsii*

Sacc. : Four different fungicides were evaluated against *S. rolfsii* Sacc. by poisoned food technique. Results revealed that propiconazole at 0.05, 0.1 and 0.15 concentrations exhibited 100% inhibition of growth of pathogen. Cent per cent inhibition of growth were observed at 0.1, 0.15 and 0.2% concentrations. While hexaconazole at 0.15% concentration exhibited 81.85%. Copper oxychloride at 0.2% concentration exhibited 58.51% inhibition of growth of pathogen.

Conclusions

From the present investigation, it was observed that pod rot of French bean incited by *S. rolfsii* Sacc. was found predominantly well distributed in different localities of Meghalaya. Results of present study revealed that propiconazole at 0.05, 0.1 and 0.15 concentrations exhibited 100% inhibition of growth of pathogen. Cent per cent inhibition of growth were observed in mancozeb at 0.1, 0.15 and 0.2% concentrations. Thus these fungicides

Table-1 : Efficacy of various fungicides against growth of *S. rolfsii* under in-vitro conditions.

Treatments	Conc. (%)	Growth (cm)	Inhibition (%)
Copper oxychloride (Blitox 50% WP)	0.1	4.24 ± 0.26	51.88 ± 2.12 (40.89) ^b
	0.15	3.70 ± 0.05	58.88 ± 1.68 (46.01) ^b
	0.2	3.31 ± 0.30	63.22 ± 0.37 (49.88) ^b
Mancozeb (Indofil M-45 75% WP)	0.1	0.00 ± 0.00	100 ± 0.00 (89.97) ^a
	0.15	0.00 ± 0.00	100 ± 0.00 (89.97) ^a
	0.2	0.00 ± 0.00	100 ± 0.00 (89.97) ^a
Hexaconazole (Contaf 5% EC)	0.05	3.33 ± 0.44	63.70 ± 2.27 (52.96) ^b
	0.1	2.41 ± 0.41	73.33 ± 3.39 (58.95) ^c
	0.15	1.63 ± 0.40	81.85 ± 3.40 (64.87) ^d
Propiconazole (Tilt 25% EC)	0.05	0.00 ± 0.00	100 ± 0.00 (89.97) ^a
	0.1	0.00 ± 0.00	100 ± 0.00 (89.97) ^a
	0.15	0.00 ± 0.00	100 ± 0.00 (89.97) ^a
Control		9.0 ± 0.00	0.00 ± 0.00 (0.95) ^g
SEm (±)		2.13	4.12
CD (0.05)		0.62	8.17

It Data in parentheses are arc sine transformed values.

Data followed by different small letters after mean values within each column indicate significant difference among treatments using ANOVA at p=0.05.

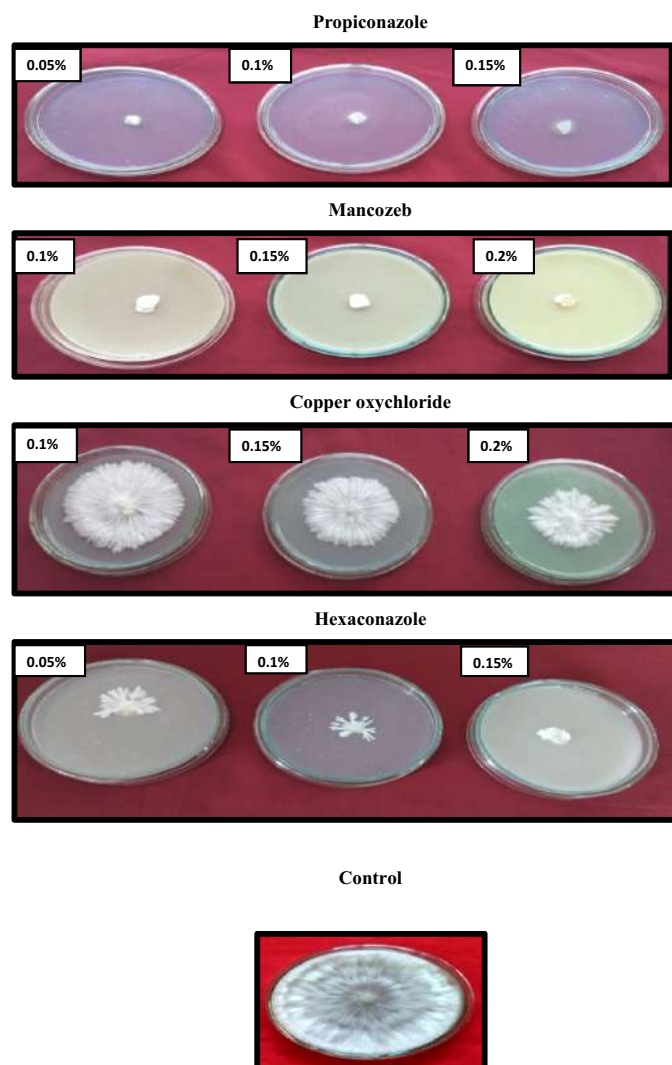


Plate-1 : In-vitro evaluation of fungicides against growth of *S. rolfsii* Sacc.

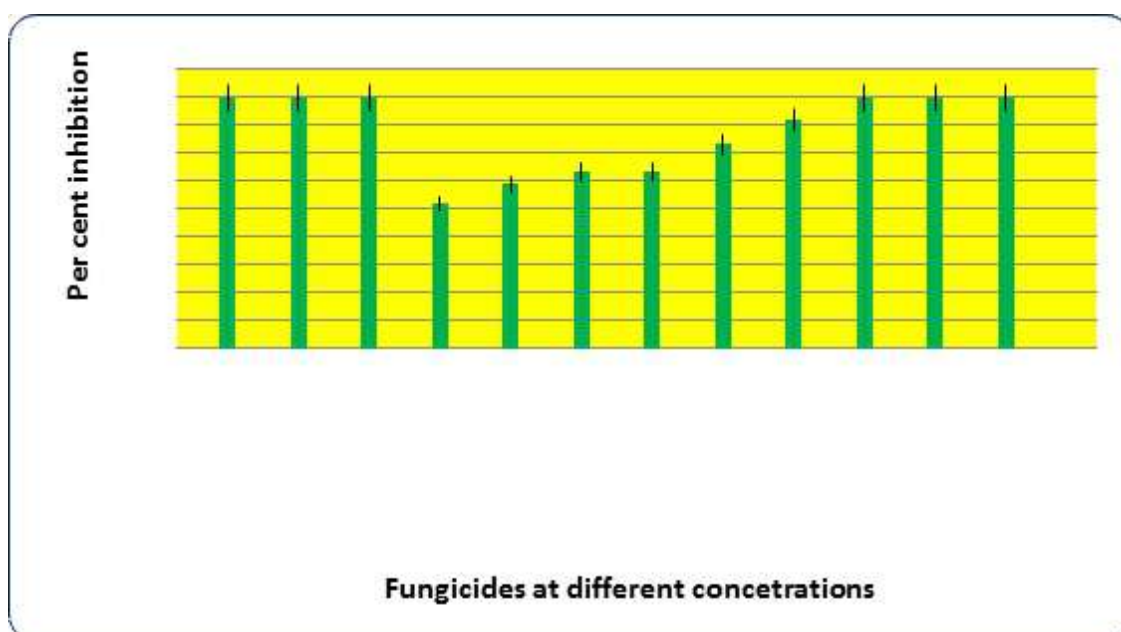


Fig.-1 : Per cent inhibition of fungicides against *S. rolfsii* Sacc.

can be recommended French bean farmers to control the pod rot disease.

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Biochemical and Morphological Traits Associated with Resistance to *Helicoverpa armigera* (Hubner) and *Maruca vitrata* (Geyer) in Pigeonpea

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Abstract

An experiment was conducted to study the morphological and biochemical factors of pigeonpea [*Cajanus cajan* (L.) Millsp.] associated with resistance to *Helicoverpa armigera*, *Melanagromyza obtusa* and *Maruca vitrata* during Rabi 2018-19 and Rabi 2019-20 at Krishi vigyan Kendra, Dhasmtari Chhattisgarh, India. Among the morphological factors, trichome density on flower calyx and trichome length on flower calyx showed significant correlation with correlation coefficient (r) being = -0.851 and -0.71, respectively with pod damage due to *H. armigera* and correlation coefficient (r) being -0.93 and -0.56 with pod damage due to *M. vitrata*, respectively. Thus, the genotypes having higher density of trichomes on flower calyx and pods suffered less pod damage due to pod borers. Among the biochemical factors, sugars and proteins present in flowers showed significant correlation with correlation coefficient (r) being -0.77 and 0.80, respectively with pod damage due to *H. armigera*. Further, there exists a strong correlation between proteins and phenols with flowers with correlation coefficient (r) being 0.72 and -0.72, respectively against pod damage due to *M. vitrata*. Thus, proteins present in pod walls showed positive correlation and phenols and tannins showed negative correlation against pod damage due to pod borers in pigeonpea, respectively.

Key words : *Helicoverpa armigera*, *Maruca vitrata*, *Melanagromyza obtusa*, phenols, pigeonpea, pod borers, protein, sugar, richomes

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important food legume crop in semi-arid tropical and sub-tropical farming systems (Khanapara and Kapadia, 2011). In India pigeonpea was grown in 3.96 million ha with a production of 2.56 million tonnes and productivity of 646 kg / ha, whereas, in Chhattisgarh, the area, production, productivity of pigeonpea was 63.25 thousand ha, 25.75 thousand metric tonnes and 407kg/ha, respectively during 2017 (CG Agriculture statistics, 2017). Nearly 300 species of insect pests are known to infest pigeonpea at its various growth stages in India. Among these insect pests, gram pod borer, *Helicoverpa armigera* (Hubner) and spotted pod borer, *Maruca vitrata* (Geyer) cause significant economic loss, especially cause damage to economical parts such as flowers, buds and pods. Under favorable conditions, this pod borer causes 60 to 90 per cent loss in grain yield. In all crops put together it was estimated to cause loss of US \$400 million annually (ICRISAT, 2007).

Materials and Methods

During Rabi 2017-18 and Rabi 2018-19, the screening was conducted taking 30 pigeonpea genotypes at the Krishi vigyan kendra's Sehradabari farm Dhamtari for two years in a row to evaluate the resistance/tolerance levels against *H. armigera* and *M. vitrata* in field under

unprotected conditions in a Randomized Block Design (RBD) with 2 replications.

Morphological traits : The present study was carried out to know the relationship of pod borer complex with different plant characters plant height, growth habit, pod length, pod breadth and days to maturity of pigeonpea cultivars were also recorded for pest preference under field conditions.

Trichome length (mm) : The length of trichomes on pods and on flowers calyx was measured by pressing gently a sticky transparent tape on the leaf, pod and flower surface and trichomes adhered to sticky tape surface were then fixed to a glass slide and measured under a microscope using ocular micrometer method (Jackai and Ogihakhe, 1989).

Trichome density : The leaves and pods of test genotypes were cut into pieces of 9 mm diameter and the flowers especially sepals were cut into pieces of 4mm diameter, number of trichomes per unit area on the epidermal layer of the leaves, pods and flowers was counted under a binocular microscope

Biochemical Factors

Estimation of Sugars : Estimation of sugars in the flower and pod wall of pigeonpea genotypes was done as per the method developed by Hedge and Hofreiter (1962).

Estimation of phenols : Total phenol content was estimated by the method of Mahendaran and Sridhar (1986).

Estimation of proteins : Nitrogen content was determined by Micro-kjeldahl distillation method. The nitrogen per cent was calculated by using the following formula :

$$\text{Nitrogen (\%)} = \frac{\text{Titer value} \times 0.02 \times 1401}{\text{Weight of the sample}}$$

Protein content was calculated by multiplying nitrogen content of the material taken with factor (Sadasivam and Manickam, 1996).

Protein content (%) = Nitrogen content (%) × 6.25 (Factor)

Pod damage (%) : To assess the degree of infestation caused by *H. armigera* and *M. vitrata* were estimated by the formula given by Sreekanth *et al.*, 2017.

$$\text{Pod damage (\%)} = \frac{\text{Number of pods damage}}{\text{Total no. of pods}}$$

Results and Discussion

Morphological factors

Trichome length (mm) : The length of the trichomes on flower calyx (two year mean) indicated that mean flower calyx glandular trichomes length showed significantly difference among the tested genotype which varied from 1.3 mm to 2.5 mm. The results revealed highest flower calyx glandular trichomes length on RPS 2008-5 (2.5 mm). Lowest flower calyx glandular trichome length was recorded on Pragati (ICPL 87). Length of calyx glandular trichomes was observed to play an important role for offering resistance as the correlation of calyx glandular trichomes length with pod borer complex *viz.* *M. vitrata*, *H. armigera* infestation was found to be highly significant negatively with a correlation value (r) of -0.63. Thus, it is clear from the studies that as the calyx glandular trichome length decreases the level of infestation due to pod borer complex.

Trichome density : The glandular trichomes density of calyx (two year mean) showed non significant differences among the tested genotypes which varied from 1.1 to 2.7 trichomes per sq millimeter. The maximum density was recorded in resistance genotype RPS 2008-5 (2.7 per sq mm) and lowest was observed in susceptible TAT 10 (1.1 per sq mm). The correlation studies exhibited highly significant negative correlation between calyx glandular trichomes density and per cent pod damage by pod borer complex with a correlation value (r) of -0.85. The findings revealed that the increasing in the calyx glandular trichome density is not favorable for pod borers for

damage and the pod infestation decreased with increase in the calyx glandular trichomes density.

The present findings were in agreement with the observations of Oghiakhe *et al.* (1992), Sahoo and Senapati (2002), Sunitha *et al.* (2008) who reported that there exists a significant negative correlation between trichome density on leaves and pods with per cent pod damage due to pod borers.

Biochemical Factors : The bio chemical factors such phenols, proteins and sugars present in flowers and pod walls were estimated and presented.

Proteins (%) : Protein content in different genotypes varied from 14.97 to 22.98 %. Least protein content was recorded on the least susceptible genotype RPS 2008-5 i.e. 14.97%. The second lowest protein content was noticed on genotype RPS 2008-4 i.e. 15.45%. The overall observations indicated that the protein content was comparatively less in least susceptible genotype as compared to moderately susceptible and susceptible ones. The correlation studies clearly indicated a highly significant positive relation (r = 0.58) between protein content and infestation due to pod borer complex depicting the protein content increases so is the infestation of pod borer complex in an increasing manner.

Phenols (mg/g) : Total phenol content in different genotypes varied from 2.22 to 7.7 percent. Significantly highest (7.7%) phenol content was recorded in resistant genotype lines *viz.* RPS 2008-4 which was statistically at par with content of least susceptible lines i.e. RPS 2008-5. Moderate level of susceptible genotype AKT 501 had comparatively lower phenol content i.e. 2.22 percent which was statistically at par with content of moderate susceptible genotype lines i.e. PUSA 992, GT 100, TAT 10, PUSA 85, PUSA 84 and JKM-189. Phenol content seems to play a critical role for expressing the resistance in field conditions. The correlation between the total phenol content of genotypes with pod borer infestation showed highly significant negative value (r = -0.56**) indicating that as the phenol content increases infestation by the pod borer complex decreases (These findings were in accordance with Sunitha Devi *et al.* 2014).

Sugars (%) : Total sugar content in different genotype of pigeonpea crop ranged from 5.32 to 11.87 percent. Among the genotype RPS 2008-5 had recorded the maximum sugar content i.e. 11.87 percent. Second highest content was observed on genotype line RPS 2008-4 i.e. 10.19 percent, which was statistically at par with content of resistant genotype lines i.e. RPS 2007-109, RPS 2007-106, RPS 2007-105 and RPS 2015-25. Among the tested genotypes, moderately susceptible genotype PUSA 992 had lowest sugar content

Table-1 : Correlation coefficient between morphological characters of pigeonpea genotypes and percent pod damage by pod borer complex.

S.N.	Morphological characters	% pod damage by	
		<i>Maruca vitrata</i>	<i>Helicoverpa armigera</i>
1.	Trichomes length of flower calyx	-0.56**	-0.71**
2.	Trichomes length of pod	-0.92**	-0.76**
3.	Trichome density of flower calyx	-0.93**	-0.85**
4.	Trichome density of pod	-0.84**	-0.85**

Table-2 : Correlation coefficient between biochemical characters of pigeonpea genotypes and percent pod damage by pod borer complex viz. *Helicoverpa armigera* and *Maruca vitrata*.

S.N.	Biochemical characters	% pod damage by	
		<i>Maruca vitrata</i>	<i>Helicoverpa armigera</i>
1.	Protein (%)	0.72**	0.80**
2.	Total sugar (%)	- 0.72**	- 0.77**
3.	Total phenol (%)	- 0.68**	- 0.68**

Table-3 : Estimation of different biochemical characters in pigeonpea genotypes.

S.N.	Genotypes	Protein (%)	Total Sugar (%)	Total Phenol (%)
1.	RPS2007-10 (CG Arhar-1)	18.86	7.86	4.50
2.	Rajeevlochan (Check)	18.42	7.82	4.45
3.	JKM-189	20.54	6.98	3.71
4.	BDN 2	21.26	6.25	3.75
5.	TJT 501	20.25	7.90	3.88
6.	UPAS 120	20.17	7.80	3.89
7.	Laxmi (ICPL 85063)	19.31	8.11	4.50
8.	VLA 1 (ICPL 88039)	18.22	7.70	4.20
9.	Asha (ICPL 87119)	17.65	8.65	4.64
10.	RPS 2008-5	14.97	11.87	7.70
11.	RPS 2008-4	15.45	10.19	7.64
12.	RPS 2007-109	15.76	10.12	7.15
13.	RPS 2007-106	15.98	9.45	6.88
14.	RPS 2007-105	15.88	9.39	6.81
15.	RPS 2015-25	15.76	9.21	6.84
16.	RPS 2015-22	16.10	9.21	6.76
17.	RPS 2015-13	16.45	9.11	6.41
18.	RPS 2015-28	16.6	9.10	6.35
19.	RPS 2015-29	16.71	8.97	6.34
20.	Rajeshwari (PT 0012)	17.23	8.60	6.22
21.	PUSA 33	19.45	8.20	6.45
22.	Pragati (ICPL 87)	19.43	8.23	6.21
23.	AL 15	22.11	5.59	6.10
24.	PUSA 84	18.55	7.69	3.90
25.	PUSA 85	21.71	5.87	3.40
26.	GT 100	21.76	5.84	2.98
27.	AKT 501	22.10	5.67	2.22
28.	PUSA 992	22.98	5.32	2.65
29.	TAT 10	21.21	6.56	3.10
30.	GT 101	19.32	8.10	4.20
	CD	2.17	1.13	1.34

i.e. 5.32 percent, which was statistically at par with content of moderately susceptible (AKT 501, GT 100, PUSA 85 and TAT 10. The correlation studies indicated a highly significant negative relation ($r = -0.70^{**}$) between the total sugar content and pod borer complex infestation.

The present results were in agreement with the findings of Sahoo and Patnaik (2002) and Jagtap *et al.* (2012) who reported that low protein and sugar content and high phenol content in pod coats and seeds were responsible for the resistance of pigeonpea varieties against pod borers.

Conclusions

The present findings reveal that trichomes density showed strong negative correlation, whereas, protein present in flower calyx and pod walls were positively correlated whereas, phenols and total sugars were negatively correlated with pod damage due to pod borers in pigeonpea. Thus, from the present findings it was concluded that pigeonpea genotypes with more trichomes density on pod and flower calyx and high phenol, sugar content in flower and pod wall play an important role in imparting resistance against pod borers.

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Lifetime Productive Performance of Selected Dairy Breeds in Ayodhya Mandal of Uttar Pradesh

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Abstract

In terms of national milk production, indigenous dairy breeds play a significant role. The proportion of milk from indigenous breeds in the total production is about 41%. By analyzing milk production over the whole productive life of an animal, we can capture their additional productivity, physical, and management advantages. This study examines the lifetime productivity of three dairy breeds in Uttar Pradesh's Ayodhya mandal, namely Sahiwal, Murrah, and Crossbred (with jersey). Using a pre-tested structured schedule, 180 dairy breeds in their different lactation groups were collected for primary data collection. This study utilized Snowball sampling to select animals with different lactation stages. The tabular analysis was carried out to determine the productive performance. The key findings were that Murrah having longer total lactation length (2814.93), productive life (3616.18) and herd life (5495.46) where as Crossbred having shorter dry period (661.75) among the selected dairy breeds. Cross bred having 4501.84 L and 5502.41 L higher lifetime milk yield than murrah and sahiwal respectively. Average milk yield per day first increases then decreases in overall lactation stages. Cross bred having longest mean lactation length (292.92 ± 10.91 days) in her life followed by murrah (282.58 ± 12.21 days) and sahiwal (271.81 ± 9.72 days).

Key words : Dry period, indigenous breed, herd life, lactation, productive life.

Introduction

The total milk production in India has increased more than 12 folds from 17 million tons in 1951-52 to 210 million tons in 2020-21 (GoI, 2021-22). Consequently, the livestock sector is contributing 4.11 per cent to the GDP of the country and 25.6 per cent to the agricultural GDP at constant price (GoI, 2021-22). About 90 per cent of this milk production is coming from milch bovine population of 303 million comprising cattle (63.78%) and buffaloes (36.22%). Among bovine population, India has a large population of Indigenous descriptive breeds which have survived over a long time and fit well into the agro-ecological environment of their habitat. There are about 50 recognized indigenous breeds of cattle and 19 buffalo in India (ICAR-NBAGR, 2022). The major indigenous cattle breeds of India are Gir, Red Sindhi, Sahiwal, Amrit Mahal, Umbalacheri, Deoni, Haryana, Ongole, Rath, Vechur, etc. The major indigenous breeds of buffalo are mainly Bhadawari, Jafarabadi, Mehsana, Murrah, Surti, etc. National milk production is dominated by these indigenous breeds. In 2020-21, indigenous breeds contributed about 41 percent to total milk production, with indigenous cattle contributing 8.82 percent and buffalo contributing 32.13 percent each (GoI, 2021-22). The conventional economics of milk production which are based on single lactation studies do not capture the

additional productive, physical, and management advantages of these breeds. Many studies have been carried out to find the productive performance from milk production but for a single lactation (Kumawat, 2016; Keerthi S and Paramasivam P. 2019; Kumari et al. 2020; Lalrinsangpui et al. 2016; Singh et al. 2019, and Mohapatra et al. 2020). In order to capture the lifetime productive performance, the present paper attempted to analyze productive performance breed-wise and lactation-wise in different lactations. Different breeds are having different reproductive and physical characteristics and milk producing capacity. While making plans for the sustainability of these breeds and their increased role in National development, the usual economics based on one production cycle, say a year, may not serve as genuine basis. So, need is being felt to examine their contribution considering their entire life span. Lifetime traits of cattle and buffalo are important indicators economic point of view. The research hypothesis are productive and reproductive parameters of the indigenous breeds rarely differ much from crossbred considering their life-time values. The research gap is lifetime production and productivity has been estimated from Animal genetics and breeding point of view but it's economic angle have not been explored.

Materials and Methods

Study area and sampling plan : The ultimate sample units, the dairy animals in their different age group of a breed were selected to collect data on relevant variables. Indigenous cattle (Sahiwal), cross bred cattle (Jersey cross bred) and buffalo (Murrah) in Ayodhya mandal in Uttar Pradesh have been selected on the basis of concentration of the particular breed/ spp. in this region. Then block and clusters of villages were selected on the basis of their concentration using Snowball sampling design. From Ayodhya mandal, data will be collected from village/ village cluster where the maximum concentration of most prevalent breed is found. Help of department of animal husbandry and secondary data will be taken to identify the villages/area. To identify the initial respondents, help of the key informants (KIs) will be taken. Ayodhya Mandal has almost 5.1% of total buffalo in Uttar Pradesh. Among all, Murrah breed is almost 3.7% and this is the most common one. Among cows, Sahiwal population constitute 12% and Haryana about 5.6% to state cattle population. Ayodhya Mandal has 5.2% of total cross bred whereas HF is 6.4% and Jersey is 4.5% of total cattle population of UP.

Collection of Data : For studying the lifetime performance of a breed, a sample size of 180 animals were selected from different age groups in order to cover their whole life span. The age groups identified to complete the life cycle of a breed; are : 1. calf (<1 year age), 2. Heifer (1 year to age at first calving), 3. 1-3 lactation number, 4. 4-6 lactation number and 5. = 7 lactations. In making these age groups, it was assumed that economic parameters do not vary much within one lactation group. In this process, 12 animals in each lactation group were selected making a total sample size of 60 animals for each breed. The snowball sampling technique was followed to identify animals of different lactation groups with the farmers. Primary data was collected from the respondents during January- March, 2021 by using pre-tested survey schedule.

Analytical framework : Tabular analysis was used to analyse the productive performance characteristics and draw meaningful inferences in each group of selected breeds. The productive performance of animals falling in each groups were aggregated and average was calculated per animal. Some of the indicators for lifetime production and productivity were analyzed are :

Herd life length of different breeds/spp.

Length of the productive life

Total number of lactations, number of wet days and number of dry days in whole life.

Total lifetime milk yield.

Total quantity of dung and urine produced.

Each lactation period characteristics was calculated separately and then will be added to get the productive life characteristics.

Lifetime milk yield (LTMY) = $\sum_{i=1}^n$ (Average daily milk $\times$ Lactation length)

Life length = {Age at first calving (AFC) + (Lactation length $\times$ number of lactation + Total dry days till disposed off}

Productive life = {Life length – AFC – dry days after last lactation}

Milk yield per day of life = $\frac{\text{Lifetime milk yielded (L)}}{\text{Life length (days)}}$

Milk yield per day of productive life

= $\frac{\text{Lifetime milk yielded (L)}}{\text{Length of productive life (days)}}$

Milk yield per day of lactation

= $\frac{\text{Lifetime milk yielded (L)}}{\text{Lifetime lactation length (days)}}$

Results and Discussion

Lactation length : A perusal of the Table 1 reveals that, The average lactation lengths (LL) of crossbred cow in all lactation groups (1st to 3rd lactation, 4th to 6th lactation and = 7th lactation) were higher than Sahiwal and Murrah. The average LL of crossbred cow was 297.92 $\pm$ 6.56 days during 1st to 3rd lactation, 299.58 $\pm$ 4.98 days during 4th to 6th lactation and 281.25 $\pm$ 9.32 days during =7th lactation. The average LL of Murrah was found even higher than Sahiwal in all lactation groups. In case of Murrah, the average LL was 286.25 $\pm$ 8.56 days during 1st to 3rd lactation, 289.83 $\pm$ 8.91 days during 4th to 6th lactation and 271.67 $\pm$ 10.94 days during =7th lactation. The average LL of Sahiwal cow was 275.42 $\pm$ 5.82 days during 1st to 3rd lactation, 278.33 $\pm$ 5.18 days during 4th to 6th lactation and 261.67 $\pm$ 8.07 days during =7th lactation.

Dry period : As evident from Table-1, the average dry period (DP) of crossbred cow in all lactation groups (1st to 3rd lactation, 4th to 6th lactation and = 7th lactation) was shorter than Sahiwal and Murrah. The average DP of crossbred was 65.42 $\pm$ 4.98 days during 1st to 3rd lactation, 66.25 $\pm$ 3.77 days during 4th to 6th lactation and 88.92 $\pm$ 12.41 days during =7th lactation. The average DP of Sahiwal was even shorter than Murrah in all lactation stages. In case of Sahiwal, the average DP was 116.25 $\pm$ 4.62 days during 1st to 3rd lactation, 118.75 $\pm$ 7.72 days during 4th - 6th lactation and 134.17 $\pm$ 6.74 days during =7th lactation. The average DP of Murrah was 132.92 $\pm$ 9.16 days during 1st to 3rd lactation, 134.17 $\pm$ 7.33 days during 4th to 6th lactation and 142.08 $\pm$ 6.20 days during =7th lactation.

Table-1 : Average productive performance characteristics of selected breeds at field level.

Av. Productive Charact.	Sahiwal (n=12)			Cross bred (n=12)			Murrah (n=12)		
	Av±sd	Max	Min	Av±sd	Max	Min	Av±sd	Max	Min
Lac. Length (days) (1-3 rd)	275.42±5.82	285.00	265.00	297.92±6.56	310.00	290.00	286.25±8.56	305.00	275.00
Dry period (days)	116.25±4.62	125	110	65.42±4.98	75.00	60.00	132.92±9.16	150.00	120.00
Av. MY (L/day)	4.71±0.76	5.90	3.00	6.74±0.64	7.90	5.64	4.78±0.73	6.20	3.80
Lac. Length (days) (4-6 th)	278.33±5.18	285.00	270.00	299.58±4.98	305.00	290.00	289.83±8.91	305.00	275.00
Dry period (days)	118.75±7.72	130.00	105.00	66.25±3.77	70.00	60.00	134.17±7.33	145.00	125.00
Av. MY (L/day)	6.14±0.73	7.10	4.60	8.67±0.73	10.10	7.40	6.19±0.81	7.60	5.20
Lac. Length (days) (=7)	261.67±8.07	275	250	281.25±9.32	300.00	270.00	271.67±10.94	290.00	260.00
Dry period (days)	134.17±6.74	145.00	125.00	88.92±12.41	112	70.00	142.08±6.20	150.00	135.00
Av. MY (L/day)	3.78±0.54	4.80	3.10	5.53±0.70	6.30	3.50	4.13±1.01	5.95	2.70

Table-2 : Average lifetime productive characteristics of selected dairy animals at field level.

Lifetime Characteristics	Sahiwal cow (n=36)	Cross bred cow (n=36)	Murrah buffalo (n=36)
Max No.Lac	10	9	10
Total Lac Length (days)	2707.91	2636.25	2814.93
Total dry period (days)	1241.67	661.75	1369.57
Productive Life (days)	3412.91	3031.25	3616.18
Herd Life (days)	5029.97	4106.27	5495.46
Lifetime Milk Y (L)	12976.41	18478.81	13976.98
MY per day of Life (L/day)	2.58	4.50	2.54
MY per day of productive Life (L/day)	3.80	6.10	3.87
MY per day of Lac (L/day)	4.79	7.01	4.97

Average milk yield : Average milk yield (AMY) yield per day was estimated that AMY of Crossbred was the highest in all lactation groups (1st to 3rd lactation, 4th to 6th lactation and = 7th lactation) than Sahiwal and Murrah. AMY of crossbred was 6.74±0.64 litre/day during 1st to 3rd lactation, 8.67±0.73 litre/day during 4th to 6th lactation and 5.53±0.70 litre/day during = 7th lactation. The AMY of Sahiwal was recorded 4.71±0.76 litre/day during 1st to 3rd lactation, 6.14±0.73 litre/day, during 4th to 6th lactation and 3.78±0.54 litre/day during =7th lactation. In case of Murrah, the AMY was 4.78±0.73 litre/day during 1st to 3rd lactation, 6.19±0.81 litre/day during 4th to 6th lactation and 4.13±1.01 litre/day during =7th lactation.

Total lactation length : The average lactation length of Sahiwal, crossbred and Murrah was found to be 2707.91, 2636.25 and 2814.93 days respectively.

Total Dry period : The dry period of crossbred was shorter (661.75days) as compare to Murrah (1369.57days) and Sahiwal (1241.67days). The shorter dry period ensures more lifetime milk yield.

Productive life : Productive life of Sahiwal, crossbred and Murrah was 3412.91, 3031.25 and 3616.18 days, respectively.

Herd Life : Herd life of Sahiwal, crossbred and Murrah was 5029.97, 4106.27 and 5495.46 days, respectively.

Lifetime milk yield : The lifetime milk yield (LMY) of Sahiwal, crossbred and Murrah was 12976.41, 18478.81 and 13976.98 litres, respectively. The highest lifetime milk yield in case of crossbred stands for their advantage.

Conclusions

Average values of these productive parameters for three breeds of dairy animals in the different lactation group of selected breeds at field level. In all breeds average milk yield per day increases initially and then decreases. Among all, cross bred is having longer lactation length and higher milk yield on an average and shorter dry period. Murrah is having longer lifetime lactation length, productive life and herd life among the selected dairy breeds and Cross bred having shorter dry period and higher lifetime milk yield and milk yield per day of different aspects is higher i.e. milk yield per day of life and milk yield per day of productive life. The research infences that productive and reproductive parameters of the indigenous breeds not rarely differ much from crossbred considering their life-time values. So, the hypothesis is rejected.

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The Morphological and Cultural Variability among *Rhizoctonia solani* Isolates Causing Banded Leaf and Sheath Blight in Little Millet

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Abstract

The present study was undertaken to study morpho-cultural variability of *Rhizoctonia solani* causing banded leaf and sheath blight disease in little millet collected from different states of India. *In vitro* studies were conducted to find the variability among the isolates where significant variation was observed in their colony growth, colour, hyphal width, sclerotial arrangement pattern, time for initiation of sclerotia. In all these isolates of Andhra Pradesh (VZM-1 & VZM-2) were found superior in all aspects compared to the other.

Key words : Little millet, banded leaf and sheath blight, variability, morpho-cultural characters.

Introduction

Small millets, which have been the traditional staple food for millions of people living in arid and semiarid regions of Asian and African countries, have been confined to certain traditional growing areas. However, with changes in lifestyle leading to increased health problems, there is a growing trend among people to reconsider their food habits and proactively adopt nutritious crops like small millets (Anuradha *et al.*, 2022). In this little millet is suited to both the tropical and temperate climates. Currently, the crop is almost limited to some hilly areas in India. It is an important catch crop and cultivated by Indian tribals (Kalaisekar *et al.*, 2017). At Indus valley civilization sites of Farmana and Harappa, millet assemblage was dominated by little millet (Pokharia *et al.*, 2014). At Harappa, little millet cultivation was grown around 2600 BC. In India all the small millets together are cultivated over an area of 4,44,000 ha with annual production and productivity of about 3,47,000 lakh tonnes and 7,81,00 kg ha⁻¹ (www.Indianstat.com 2021). In India little millet is grown over an area of 2.34 lakh ha with total annual production of 1.27 lakh tones with productivity of 544 kg ha⁻¹ (Prabhakar *et al.*, 2017). Banded leaf and sheath blight disease caused by *Rhizoctonia solani* has a wide host range which can grow well in cloudy days, having high temperature and relative humidity (Ou, 1985). The disease symptom is characterized by a series of copper or brown colour bands across the leaves giving a very characteristic banded appearance (Patro *et al.*, 2018) these lesions enlarge

rapidly and coalesce to cover larger portions of the sheath and leaf lamina (Patro and Madhuri, 2014; Nagaraja *et al.*, 2007). Banded blight has become a severe and fatal crop disease, significantly impeding the overall yield. Furthermore, when exposed to waterlogged conditions, the crop has been found to be infected with sheath blight disease, which is caused by the soil-borne necrotrophic fungus *Rhizoctonia solani* Kuhn. The disease is appropriately named banded blight due to the characteristic banded appearance it creates, as symptoms manifest on every part of the plant (Patro *et al.* 2020). The evaluation of the disease's variety is one of the requirements for designing disease management programmes to control sheath blight (Desvani *et al.* 2018). There have been numerous attempts to group *R. solani* isolates based on their morphology (Lal and Kandhari 2009; Susheela and Reddy 2013; Mishra *et al.* 2014; Debbarma and Dutta 2015; Rajput and Harlapur 2016; Gopireddy *et al.* 2017; Singh *et al.* 2018). The morphological and cultural variations in *R. solani* causing BLSB in different geographic regions need to be clearly established so as to know their variations. Screening for resistant varieties is the best option to manage the disease, especially since resource-poor farmers, who predominantly grow the crop, cannot afford chemical control (Das *et al.*, 2021).

Material and Methods

Different isolates of *R. solani* from little millet infected with BLSB were collected from different states of India. Sodium

hypo chlorite (NaOCl) 1% was used for surface sterilization of plant material, rinsed with sterilised distilled water and dried on filter paper. Three small cut pieces were cultured on Potato dextrose agar (PDA) and were incubated at $27 \pm 1^\circ\text{C}$ in three replications. Then after pure cultures were maintained for further study. From three-day old culture 5 mm disc was transferred into centre of PDA in triplicate and incubated for 4 days. Morphological and cultural characteristics were studied for each of the isolate. Mean value of every character is recorded. Morphological characters like colour of sclerotia categorized into three as light brown, brown and dark brown, time for initiation of sclerotia which is recorded for every 24 h and they categorized as fast (< 4 days), moderately fast (4-5 days) and slow (>5 days), distribution as aerial and surface, pattern of arrangement categorized into five categories as central, sub-central, both central and sub-central, peripheral ring and scattered. Sclerotial weight and size

from every isolate were done by taking 25 observations and sclerotial texture categorized into two as rough and smooth type while number of sclerotia were also counted for each isolate. Cultural characteristics (Fig.2) like hyphal width, colony diameter which is measured for every 24h, growth rate was computed for five DAI, colony texture and colony colour were evaluated accordingly for each of the isolate to observe their cultural characteristics.

Results and Discussion

Variation was observed in morpho-cultural characters among the 10 isolates which were discussed below. These were grouped into three categories sclerotia of KAN-1 and ORA-1 isolates had brown colour, while KAN-2, VZM-2, TNA-1 and CHT-2 are dark brown in colour and those of VZM-1, ORA-2, TNA-2 and CHT-1 isolates sclerotia are light brown in colour. Budiarti *et al.* (2020) where they classified sclerotia as light brown.

Table-1 : List of *Rhizoctonia solani* isolates collected from different millet growing regions of India.

S. No.	The Isolate	Place of Collection	Latitude	Longitude	State
1.	KAN-1	Bangalore	13.0801°N	77.5785°E	Karnataka
2.	KAN-2	Mandya	12.5218°N	76.8951°E	Karnataka
3.	VZM-1	Vizianagaram	18.1067°N	83.3956°E	Andhra Pradesh
4.	VZM-2	Hiramandalam	18.6718°N	83.9506°E	Andhra Pradesh
5.	ORA-1	Semiliguda	18.7112°N	82.8508°E	Odisha
6.	ORA-2	Brahmapur	19.3150°N	84.7941°E	Odisha
7.	TNA-1	Coimbatore	11.0168°N	76.9558°E	Tamil Nadu
8.	TNA-2	Athiyandal	12.2358°N	79.0264°E	Tamil Nadu
9.	CHT-1	Jagdalpur	19.0861°N	82.0188°E	Chhattisgarh
10.	CHT-2	Raipur	21.2514°N	81.6296°E	Chhattisgarh

Table-2 : Variation in morphological characters among the isolates.

[illegible]

Table-3 : Variation of cultural characters among the isolates.

S.No.	Isolate	Colony diameter (cm)			Growth rate (mm h ⁻¹)			Hyphal width (µm)	Mycelial growth characters	Colony colour
		2 DAI	3 DAI	5 DAI	2 DAI	3 DAI	5 DAI			
1.	KAN-1	3.70 (1.92 ^{bc})	7.08 (2.61 ^{ab})	9.00 (3 ^a)	0.77	0.98	0.75	7.19 ^b	Abundantly growing cottony fluffy aerial and surface mycelium	Whitish (8/1 7.5YR)
2.	KAN-2	3.10 (1.76 ^{de})	6.25 (2.5 ^{cd})	8.91 (2.98 ^a)	0.65	0.87	0.74	5.22 ^d	Cottony fluffy mycelium without concentric rings	Whitish (8/1 7.5YR)
3.	VZM-1	4.24 (2.05 ^a)	7.55 (2.74 ^a)	9.00 (3 ^a)	0.88	1.05	0.75	8.28 ^a	Cottony aerial mycelium with concentric rings	Whitish (8/1 10YR)
4.	VZM-2	3.85 (1.96 ^{ab})	7.19 (2.68 ^{ab})	9.00 (3 ^a)	0.80	1.00	0.75	6.33 ^c	Profusely growing cottony fluffy aerial mycelium with concentric rings	Whitish (8/1 2.5YR)
5.	ORA-1	3.26 (1.80 ^{cd})	6.55 (2.55 ^c)	9.00 (3 ^a)	0.68	0.91	0.75	6.24 ^c	Abundantly growing cottony fluffy surface mycelium	Yellowish brown (8/3 10YR)
6.	ORA-2	3.11 (1.76 ^{de})	6.44 (2.53 ^{cd})	9.00 (3 ^a)	0.65	0.89	0.75	6.18 ^c	Abundantly growing cottony aerial and surface mycelium	Light yellowish brown (6/4 10YR)
7.	TNA-1	3.59 (1.89 ^{bc})	6.73 (2.59 ^{bc})	9.00 (3 ^a)	0.75	0.94	0.75	6.81 ^b	Abundantly growing cottony aerial and surface mycelium	White (8/1 2.5YR)
8.	TNA-2	2.80 (1.67 ^e)	5.85 (2.41 ^{ef})	8.63 (2.94 ^a)	0.58	0.81	0.72	8.31 ^a	Profusely growing sparse fluffy mycelium	Light yellowish brown (6/4 10YR)
9.	CHT-1	3.00 (1.73 ^{de})	6.01 (2.45 ^{def})	9.00 (3 ^a)	0.63	0.84	0.75	7.34 ^b	Cottony fluffy mycelium without concentric rings	Yellowish brown (8/3 10YR)
10.	CHT-2	2.65 (1.63 ^a)	5.64 (2.37 ^f)	8.90 (2.98 ^a)	0.55	0.78	0.74	8.05 ^a	Profusely growing sparse fluffy mycelium	Whitish (8/1 7.5YR)
CD (P = 0.05)		0.015	0.005	0.004				0.637		
SEm±		0.005	0.002	0.001				0.215		
CV %		0.535	0.146	0.110				5.312		

brown and dark brown. Except for a few, majority of the isolates produced sclerotia within five days. Sclerotia began to form four days after inoculation in the isolates KAN-2, VZM-1 and VZM-2 but took five days in KAN-1, ORA-2, TNA-1 and CHT-1 isolates and they were categorized as moderately fast. Sclerotia production took more than five days in ORA-1, TNA-2 and CHT-2 isolates, so they were categorized as slow (Goswami *et al.*, 2019). Based on sclerotial distribution *i.e.*, surface then both surface and aerial Thera *et al.* (2022), they were categorized into two types VZM-2, ORA-1, TNA-2 produced sclerotia both on aerial and surface while remaining produced surface sclerotia. Sclerotia arrangement pattern was divided into five types *viz.*, KAN-2, CHT-2, and TNA-1 had central sclerotia arrangements, whilst KAN-1 and ORA-2 had sub-central arrangements, but VZM-1 had both central and sub-central arrangements. In VZM-2 and CHT-1, a peripheral ring was found. TNA-2 had a scattered pattern of sclerotia arrangement while ORA-1 had irregularly arranged sclerotia (Budiarti *et al.*, 2020) and (Yaduman *et al.*, 2019). 60% of the isolates had smooth texture (KAN-1, ORA-1, ORA-2, TNA-1, TNA-2 and CHT-2) while the other had rough (KAN-2, VZM-1, VZM-2 and CHT-1). CHT-2 (11) isolate produced the fewest number of sclerotia per plate, while VZM-2 (41) isolate produced the highest. Mishra *et al.* (2014) as poor (no sclerotia), fair (1–10), moderate (11–20), good (21–40), very good (41–60) and

excellent (>60) and accordingly VZM-2 (41) is very good, while 50% of the isolates KAN-1 (22), ORA-1 (30), VZM-1 (35), TNA-2 (26) and CHT-1 (28) produced good number of sclerotia. The moderate group includes 40% of the isolates CHT-2 (11), KAN-2 (14), TNA-1 (17) and ORA-2 (18) (Table-2).

Cultural characters like hyphal width ranging from 8.31 µm (TNA-2) to 5.22 µm (KAN-2) were observed. There was no significant difference among the isolates CHT-2 (8.05 µm), VZM-1 (8.28 µm) and TNA-2 (8.31 µm). Similarly, the isolates VZM-2 (6.33 µm), ORA-1 (6.24 µm), ORA-2 (6.18 µm) and TNA-1 (6.81 µm) found to be on par with each other (Fig. 1). Singh *et al.* (2014) found that the hyphal width of maize isolates ranged from 5.418 to 10.764 µm. Maximum radial growth was observed in VZM-1 isolate with 4.24 cm with growth rate of 0.88 mm h⁻¹ within 2 days after inoculation (DAI) compared to that of other isolates and minimum radial growth rate was observed in CHT-2 isolate with 2.65 cm with growth rate of 0.55 mm h⁻¹. Mishra *et al.*, 2014, who classified growth into three types: fast, medium and slow. Based on these all the isolates were classified under slow category as they required >96 h to fill entire plate. Colony colour of the ten isolates initially showed whitish growth but later they turned to yellowish brown *viz.*, ORA-1 and CHT-1, light yellowish brown *viz.*, ORA-2 and TNA-1 but remaining isolates *viz.*, KAN-1, KAN-2, VZM-1, VZM-2, TNA-2, CHT-2 remain whitish colour. Gopireddy *et al.* (2017)

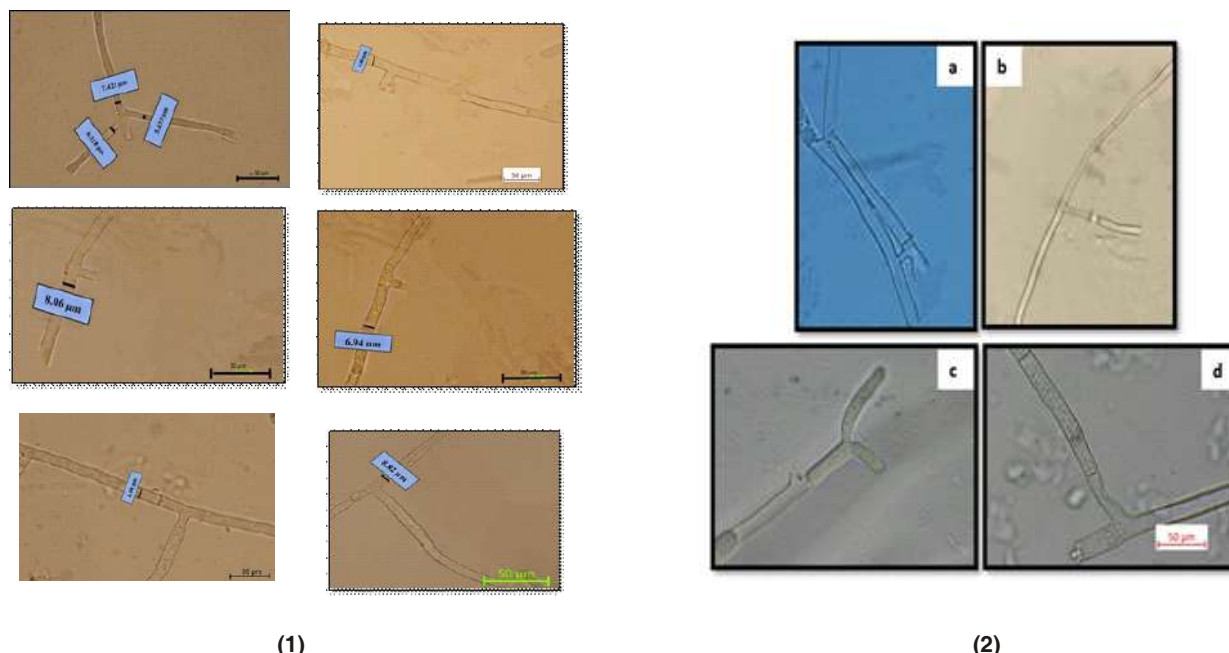


Fig-1. (1) Variation in hyphal widths of different isolates from different states of India. (2) a-Hyphal fusion b-Right angle c-Monoloid cells d-Constriction at the point of origin.

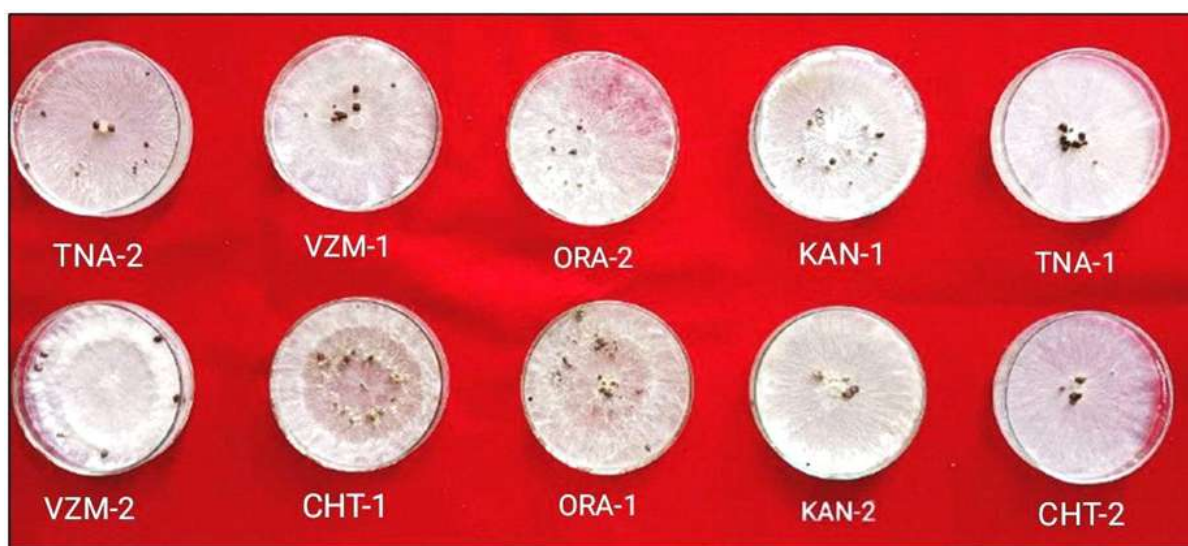


Fig.-2 : Cultural variability of different *R. solani* isolates on PDA.

determined colony colours and they ranged from brown, pale brown, dark brown and white to yellowish white. ORA-2 and TNA-1 had abundantly grown cottony aerial and surface mycelium, TNA-2 and CHT-2 had abundantly grown sparse fluffy mycelium, while KAN-2 and CHT-1 had cottony fluffy mycelium but no concentric rings. Cottony aerial mycelium with concentric rings was found in VZM-2 and VZM-1 isolates. Only the KAN-1 isolate has an abundance of cottony fluffy aerial and surface mycelium, while the ORA-1 isolate has an abundance of cottony fluffy surface mycelium. Budiarti *et al.* (2020), who observed that the pattern of *R. solani* mycelial growth ranged from cottony fluffy to cottony and sparse fluffy and

the colony colour ranged from light yellowish brown to yellow (Table-3).

Conclusions

In this present investigation has generated set of information where we could observe great diversity among the same plant which were collected from different states of India in morphological and cultural characteristics, but these variations are not due to geographical regions. Still there is a need to investigate if any genotypic variability existed among these ten isolates in order to confirm *R. solani* with respective hosts.

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Effect of Biocontrol Agents, Panchagavya and Fungicidal Application on Growth of *Rhizoctonia solani* Incitant Banded Leaf and Sheath Blight in Little Millet under In Vitro Conditions

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Abstract

In an *in vitro* experiment aimed at assessing the efficacy of various biocontrol agents (*Trichoderma asperellum*, *Bacillus subtilis*, *Pseudomonas fluorescens*) and Panchagavya at different concentrations (1%, 3%, 5%, 7%, 9%) and five different fungicides (Mancozeb 75 % WP, Chlorothalonil 75 % WP, Carbendazim 50 WP, Propiconazole 25 EC, Tebuconazole + Trifloxystrobin 75 WG) against banded leaf and sheath blight in little millet caused by *Rhizoctonia solani*, it was observed that *T. asperellum* exhibited the highest inhibition percentage over the control (76.93%). Notably, Panchagavya @5% demonstrated the most promising results among the different concentrations. Furthermore, Propiconazole 25 EC and Tebuconazole + Trifloxystrobin 75 WG were identified as the most effective fungicides when compared to the others.

Key words : Little millet, biocontrol agents, panchagavya, fungicides, *rhizoctonia solani*

Introduction

Small millets, the traditional staple food in arid regions, were confined to specific growing areas, but changing lifestyles drive a growing trend to adopt nutritious crops like them (Anuradha *et al.*, 2022). In this little millet (*Panicum sumatrense* Kuhn) which belongs sub-family Panicoideae and the tribe Paniceae (Rachie, 1975) is an important catch crop and was cultivated by Indian tribals (Kalaisekar *et al.*, 2017). It contains zein - like proteins which can be potentially used for production of transgenic plants with enhanced essential amino acid and protein contents (Sivakumar *et al.*, 2006). The 100g of grains consist of protein (8.7 g), mineral matter (1.7 g), fat (5.3 g) and carbohydrates (75.7 g). It is a rich source of iron (9.3 mg/100 g) and zinc (3.7 mg/100 g) (Rawat *et al.*, 2021). Because of its low glycaemic index, it helps to manage constipation, diabetes, blood pressure and also decreases cholesterol level in humans. It contains high amount of iron (9.3–18.6 mg/100 g) (Dwivedi *et al.* 2012; Kam *et al.* 2016). In India, the crop is cultivated in a vast area of 291 thousand hectares, but its annual production of 102 thousand tonnes and productivity of 349 kg ha⁻¹ are relatively low compared to other cereal crops (Patro *et al.* 2019). Banded blight has been emerged as a deadly disease in this crop which hinders the yield. Under water

logging conditions, found infected with sheath blight disease caused by a soil borne necrotrophic fungi *Rhizoctonia solani* Kuhn (Patro *et al.* 2020). *R. solani* (teleomorph: *Thanatephorus cucumeris*), a potentially devastating disease of cereal crops, including little millet, is one of the many biotic stresses that cause significant yield loss (Jain & Gupta, 2010; Chouhan, 2014) reducing grain yield and quality. The disease symptom is characterized by a series of copper or brown colour bands across the leaves giving a very characteristic banded appearance (Patro *et al.*, 2018). The central portion of the lesions subsequently turns white to straw with narrow reddish-brown border. Symptoms produced on every part of the plant thus gives a characteristic banded appearance, due to which the disease has been named as banded blight (Patro *et al.* 2017). *R. solani* exhibits a broad host range and belongs to a species complex comprising several anastomosis groups (AGs) and these AGs are formed through the hyphal fusion of numerous isolates, each displaying diverse genotypic and phenotypic characteristics Patro *et al.* (2021). In differentially inoculated plots with various treatments, disease incidence in little millet ranged from 1.8 to 8.2 grade, with 40.23 to 64.07 per cent yield loss, where yield loss increasing with increase in disease severity (Palanna *et al.*, 2021). In order to reduce yield loss and economical

loss due to banded leaf and sheath blight pathogen, use of resistant varieties, potential biocontrol agents (Patro *et al.*, 2018), use of botanical panchagavya, chemical methods of management like fungicides and other eco-friendly methods are being assessed for successful management of the pathogen. Screening for resistant varieties is the best option to manage the disease, especially since resource-poor farmers, who predominantly grow the crop, cannot afford chemical control (Das *et al.*, 2021).

Materials and Methods

Three biocontrol agents (*Trichoderma asperellum*, *Pseudomonas fluorescens* and *Bacillus subtilis*) were assessed using the dual culture method (Mortan and Stroube, 1955). The centre of the Petri plate containing potato dextrose agar was inoculated with an agar block (5 mm in diameter) of three-day-old culture of *R. solani* and one-day-old cultures of the bacterial test antagonists (*P. fluorescens* and *B. subtilis*) were streaked with two cm apart on either side of the block. Each dish containing one test pathogen mycelial disc opposite to fungal antagonist. *T. asperellum* mycelial disc and they were kept at least 6 cm apart. Five fungicides viz., mancozeb 75 % WP, chlorothalonil 75 % WP, carbendazim 50 WP, propiconazole 25 EC, tebuconazole + trifloxystrobin 75 WG were taken at recommended field concentrations against *R. solani* on potato dextrose agar (PDA) to ascertain the inhibitory effect of fungicides by using poison food technique (Nene and Thapliyal, 1993). Fungicide

amended PDA medium was then poured aseptically in Petri plates and allowed to solidify at room temperature. After solidification of the medium, all the plates were inoculated aseptically with 5 mm culture disc of the test fungus obtained from a three-day old actively growing pure culture of *R. solani*. Prepared panchagavya extracts were evaluated using poison food technique (Grover and Moore, 1962) and it was evaluated at 5 different concentrations viz., 1 %, 3 %, 5 %, 7 %, 9 %. The requisite quantity of panchagavya was added to lukewarm PDA medium in conical flasks under aseptic conditions before transferring into Petri plates and they were allowed to solidify. 5mm mycelial disc was taken by using sterilized cork borer and placed at the centre of Petri plate containing poisoned medium with the help of sterilized needle. The inoculated Petri plate without any of above treatment served as control. Per cent mycelial growth inhibition of the test fungus over untreated control was calculated by applying the formula given by Vincent (1927).

$$\text{PGI (\%)} = ((C - T)/C) \times 100$$

C - Radial growth in control

T - Radial growth in treatment

Results and Discussion

Evaluating these biocontrol agents viz., *T. asperellum*, *P. fluorescens*, *B. subtilis* against the pathogen *R. solani* using a dual culture technique. The results showed that *T.*

Table-1 : In vitro evaluation of bioagents against *R. solani*.

S. No.	Biocontrol agent	Radial growth of <i>R. solani</i> 5 DAI (mm)*	Per cent inhibition over control
1.	<i>T. asperellum</i>	20.76	76.93
2.	<i>P. fluorescens</i>	32.72	63.64
3.	<i>B. subtilis</i>	30.78	65.8
4.	Control	90.00	-
	SEm±		0.94
	CD (P=0.05)		4.47
	CV%		3.970

*Mean of four replications
DAI : Days after inoculation.

Table-2 : Bioefficacy of Panchagavya at different concentrations against *R. solani*.

S. No.	Concentration	Radial growth (cm)*			Per cent inhibition over control		
		2 DAI	4 DAI	5 DAI	2 DAI	4 DAI	5 DAI
1.	Panchagavya @ 1%	2.24 (1.496) ^b	2.41 (1.552) ^b	3.01 (1.734) ^b	27.74	69.57	66.55
2.	Panchagavya @ 3%	1.15 (1.072) ^c	1.33 (1.153) ^c	1.43 (1.196) ^c	62.9	83.2	84.11
3.	Panchagavya @ 5%	0.00 (0.03) ^d	0.00 (0.03) ^d	0.00 (0.03) ^d	100	100	100
4.	Panchagavya @ 7%	0.00 (0.00) ^d	0.00 (0.00) ^d	0.00 (0.00) ^d	100	100	100
5.	Panchagavya @ 9%	0.00 (0.00) ^d	0.00 (0.00) ^d	0.00 (0.00) ^d	100	100	100
6.	Control	3.1 (1.749) ^a	7.92 (2.815) ^a	9.00 (3.00) ^a			
	SEm ±	0.008	0.008	0.008			
	CD (P = 0.05)	0.025	0.024	0.023			
	CV (%)	1.073	0.993	0.957			

Table-3 : In vitro evaluation of fungicides against *R. solani*.

S. No.	Fungicides	Radial growth (cm)			Per cent inhibition over control		
		2 DAI	4 DAI	5 DAI	2 DAI	4 DAI	5 DAI
1.	Mancozeb @0.3%	1 (1)	1.33 (1.15)	1.36 (1.18)	68.05	78.55	84.44
2.	Chlorothalonil @0.25%	1.43 (1.20)	1.7 (1.3)	2.1 (1.46)	54.31	72.58	76.66
3.	Carbendazim @0.2%	1.2 (1.10)	1.56 (1.25)	1.8 (1.39)	61.66	74.83	78.89
4.	Propiconazole @0.1%	0 (0)	0 (0)	0.06 (0.21)	100	100	99.33
5.	Nativo @0.05%	0 (0)	0(0)	0(0.00)	100	100	100
6.	Control	3.13 (1.77)	6.2 (2.48)	9 (3)			
CD (P= 0.05)		0.03	0.04	0.07			
SEm±		0.01	0.01	0.02			
CV%		1.22	1.74	2.72			

Fig.-1 : Efficacy of biocontrol agents against radial growth of *R. solani* under *in vitro* conditions.

Fig.-2 : Bioefficacy of different fungicides at recommended concentrations.

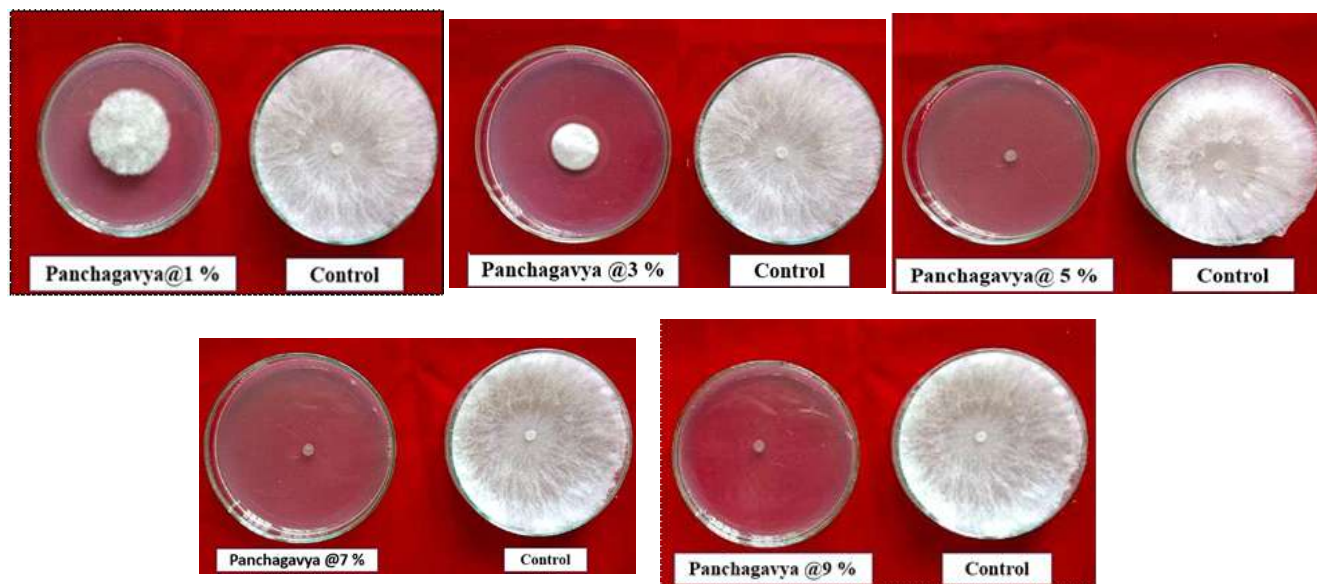


Fig-3 : Concentration of Panchagavya @ 1%, 3%, 5%, 7%, 9%.

asperellum (20.76 mm) was more effective than the other two in inhibiting *R. solani* with a maximum percentage of inhibition over control (76.93). The least amount of *R. solani* mycelial growth was observed in *P. fluorescens* (32.72 mm), with the lowest percentage of inhibition over control (63.64). *T. asperellum* is followed by *B. subtilis* with 65.8 per cent inhibition over control, and *R. solani* has mean radial growth of 30.78 mm (Table 1) (Fig.1). Similar results on the *in vitro* effectiveness of biological agents on Maize BLSB caused by *R. solani* were reported by Radhajeyalakshmi *et al.* (2020) where *T. asperellum* is the most effective in preventing *R. solani* mycelial development. Among Different concentrations of panchagavya which were tested 5% concentration was viewed as compelling one contrasted with the other, as it totally restrained the growth of *R. solani* (100%). The same holds true for the concentrations of 7% and 9%. However, the lowest percentage of inhibition over control were observed in 1% concentration on 2 DAI (27.74), 4 DAI (69.57) and 5 DAI (66.55), followed by panchagavya @ 3% concentration showed the percentage inhibition over control as 2 DAI (62.9), 4 DAI (83.2) and 5 DAI (84.11) (Fig.3) (Table 2). Karthika *et al.* (2017), claim that panchagavya completely inhibited *R. solani* mycelial development at a concentration of 5%. The required quantity of respective fungicides viz., mancozeb 75% WP @0.3%, chlorothalonil 75% WP @0.25%, carbendazim 50 WP @0.2%, propiconazole 25 EC @0.1%, (Nativo) tebuconazole + trifloxystrobin 75 WG @0.05% were evaluated *in vitro*. All of these results revealed that the pathogen is only slightly growing in response to mancozeb (1.36 cm), chlorothalonil (2.1 cm), and carbendazim (1.8

cm) at 5DAI, while it is minimally growing in response to propiconazole and no growth was observed in response to Nativo. As every fungicide were tested at their respective recommended concentrations maximum inhibition of the pathogen were observed. Madhavi *et al.* (2018) in their investigation reported that fungicides against *R. solani* isolates, the systemic fungicides i.e., carbendazim, propiconazole, hexaconazole, tebuconazole completely inhibited at recommended concentrations and were highly effective resulting in significantly increase in the grain yield (Table-3) (Fig.-2). Kaur and Singh (2016) tested the efficacy of different fungicides in which tebuconazole + trifloxystrobin 75 WG was found to be the most effective fungicide in showing 100% growth inhibition. In a study by Patro and Madhuri (2014), seed treatment with Propiconazole at 1ml kg⁻¹ significantly reduced disease incidence and increased yield. Treated crops showed only 12.57% disease severity and yielded 1435.87 kg ha⁻¹, while the untreated check had 42.2% disease severity and yielded 1324 kg ha⁻¹ when exposed to *R. solani* in Finger millet.

Conclusions

As a result, the current study demonstrated the potential for using biocontrol agents, panchagavya, and fungicides to inhibit *R. solani* and reduce the impact of banded leaf and sheath blight. Among the biocontrol agents *T. asperellum* found to be the most effective compared to the other two, while 5% panchagavya was found to be the most effective and trifloxystrobin +tebuconazole 75 WG@0.05% followed by propiconazole 25 EC@0.1% were effective to inhibit the pathogen growth.

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Assessment of Different Guava (*Psidium guajava* L.) Varieties for Growth Habit and Leaf Characters under Semi-Arid Region of Haryana

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Abstract

A field experiment was conducted at Guava Demonstration Centre, Bhuna (Fatehabad) and Dept. of Horticulture CCS Haryana Agricultural University, Hisar during rainy and winter season 2020-21. Fifteen varieties (Allahbad Safeda, L-49, Arka Kiran, Punjab Pink, Banarsi Surkha, Braf Khana, Aishwariya, Hisar Safeda, Arka Mridula, Hisar Surkha, Lalit, KG Guava, Pant Parbhat, Pant Red, Shweta) having a wide range of variability in growth were studied. Results showed that the significant variation was found in case of tree growth habit and leaf morphological parameters among different varieties. Most of the varieties had spreading type of growth habit, decussate type of phyllotaxy, oblong type leaf shape and dark green colour of leaf. Maximum values for foliage density, fruit length was found in KG Guava.

Introduction

Guava (*Psidium guajava* L.) is one of the important fruit crops of tropical and subtropical regions of India. It is member of family *Myrtaceae* and popularly known as “Apple of Tropics” (Pandey and Misra, 1984) and claims to be the fourth most important fruit in respect of area and production after mango, banana and citrus (Radha and Mathew, 2007). It is occupying fifth place in terms of area (2.87 lakh ha) and production, (43.07 lakh MT) respectively, in India (Anonymous, 2020). The leading guava producing states are Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar, Andhra Pradesh, West Bengal, Punjab and Gujarat. It is a major fruit crop of Haryana also. Haryana has a production of 2.61 lakh MT of Guava fruit from 0.15 lakh ha area (Anonymous, 2021). Guava is often recognized for its food and nutritional values throughout the world. It is rich in tannins, saponins, phenols, triterpenes, essential oils, fiber, carotenoids, flavonoids, lectins, vitamins and fatty acids. Guava fruit is one natural source of vitamin C and also contains substantial amounts of vitamin A as well. Guava fruits also contained considerable amount of pectin. The guava leaves are rich in flavonoids, in particular, quercetin (Joseph *et al.*, 2011). A mature fruit of guava contains Calories (77-86g), Protein (0.1-0.5), Fat (0.43-0.7), Ash (9.5-10), Carbohydrate (9.1-17mg), Calcium (17.8-30mg), Phosphorous (0.30-0.70mg), Iron (200-400 I.U.), Vitamin A (0.046mg), Vitamin B3 (35 I.U.), Riboflavin (0.6-1.068mg), Niacin (40 I.U.), Thiamin (0.03-0.04mg) (Kamath *et al.*, 2008). Guava is grown successfully in tropical and sub-tropical regions up to an altitude of 1500 m. It can be cultivated in assorted types of soil ranging from heavy clay to very light sandy soil. It performs

magnificently well in soil pH range of 4.5-8.2. The majority of nutrients taken up by the roots of the guava tree are from the top 25 cm of soil depth. Thus, the soil present near surface should be fertile enough to supply essential nutrients for promoting new growth (Chadha, 2001). Guava bears fruits almost throughout the year. However, two distinct seasons of flowering- one during April to May, the fruits of which are harvested in rainy season (late July to mid Oct) and the other in July to August, whose fruits are harvested during winter (late October to mid-February) (Mitra *et al.*, 2008). Winter season crop proved to be more money making than rainy season crop, as it is less infested by diseases and insects pests. Moreover, fruits of winter season crop exhibits better storage life and can be transported to a longer distance without spoilage (Singh, 2013). Guava is grown successfully in tropical and sub-tropical regions up to an altitude of 1500 m. It can be cultivated in assorted types of soil ranging from heavy clay to very light sandy soil. It performs magnificently well in soil pH range of 4.5-8.2. The majority of nutrients taken up by the roots of the guava tree are from the top 25 cm of soil depth. Thus, the soil present near surface should be fertile enough to supply essential nutrients for promoting new growth (Chadha, 2001). Guava bears fruits almost throughout the year. However, two distinct seasons of flowering- one during April to May, the fruits of which are harvested in rainy season (late July to mid Oct) and the other in July to August, whose fruits are harvested during winter (late October to mid-February) (Mitra *et al.*, 2008). Winter season crop proved to be more money making than rainy season crop, as it is less infested by diseases and insects pests. Moreover, fruits of winter season crop exhibits better storage life and can be transported to a longer distance without spoilage (Singh, 2013). It is the

initial stage in the characterization of any crop's germplasm morphological characteristics like growth habit, leaf traits etc. are characterized systematically and they could be valuable. Because they are not affected by the environment and are based on DNA fingerprinting, molecular markers are great instruments for analyzing genetic diversity and relationships. Keeping this in view this research was carried out.

Materials and Methods

This study was conducted at Guava Demonstration Centre, Bhuna (Fatehabad) and Dept. of Horticulture CCS Haryana Agricultural University, Hisar during rainy and winter season 2020-21. The plants were selected for the experiment in April, 2020. Bhuna has desert climate which is mainly dry with very hot summer and cold winter except during monsoon season. The hot weather season starts from mid March to last week of the June followed by the south-west monsoon which lasts till September. The transition period from September to October forms the post-monsoon season. The winter season start late in November and remains up to first week of March. The mean maximum and mean minimum temperature is 41.7 °C (May, June) and 5.6 °C (January), respectively. There is distinct temperature in summer and winter months. The annual rainfall is about 390 mm. Mostly rainfall is received from South-West monsoon during July to September. The soil is mainly sandy loam to loamy sand in texture. The soils of the study area are neutral to alkaline in reaction (7 to 8 pH). The field experiment was conducted on 9 years old guava varieties viz Aishwariya, Arka Kiran, Allahabad Safeda, Arka Mridula, Banarsi Surkha, Baraf Khan, Shweta, Hisar Safeda, Hisar Surkha, Lalit, L-49, Pant Parbhat, Punjab Pink, KG Guava and Pant Red with spacing 6m×3m. The experiment was conducted with three replications in a Randomized Block Design and Forty five uniformly grown plants were selected randomly. All the agronomic practices were carried out as per recommended package of practices. All cultivars were maintained under uniform condition of orchard management during the study period. Plant growth habit was recorded as Erect, Drooping and Spreading as given in the guidelines for DUS testing of PPV and FRA (Anonymous, 2016). Five branches from each plant were selected randomly and foliage density was observed in running per 30 cm branch length from the tip of branch and average value was workout. Phyllotaxy was explained on the basis of visual observation i.e. opposite in which leaves arise at same node in opposite direction and decussate in which leaves makes a cross as given in the guidelines for DUS testing of PPV and FRA (Anonymous, 2016). Shape of leaves was observed visually and interpreted as oblong, ovate, elliptical, trullate and round,

leaves with twisting as per leaf shape given in the guidelines for DUS testing of PPV and FRA (Anonymous, 2016). The colour of mature leaf was observed visually and recorded as green, light green, dark green as per leaf colour given in the guidelines for DUS testing of PPV and FRA (Anonymous, 2016).

Results and Discussion

The data presented in table-1 indicated that tree habit of different varieties varied as spreading, drooping and erect type. Guava varieties Hisar Surkha, L-49, Shweta, Lalit, Arka Kiran, Arka Mridula, and Banarsi Surkha had spreading type growth habit and drooping type growth habit was found in hisar safeda, pant parbhat, aishwariya, KG Guava and Punjab pink. While erect type growth habit was found in barf khan, Allahabad safeda and pant red under semi-arid condition of Haryana. The observation with respect to upright growth habit of Allahabad Safeda is in confirmation with that reported by Singh *et al.* (1976) and Sharma *et al.* (2010). The tree habit might be the varietal/germplasm characteristic because the variation in tree shape under different agro-climatic conditions remained the same (Singh, 2018). The variation in plant habit of was also observed in different cultivars under different agro-climatic conditions (Sharma *et al.*, 2010). The tree habit might be the varietal/germplasm characteristic because the variation in tree shape under different agro-climatic conditions remained the same (Singh, 2018). Foliage density of guava varieties during rainy season. The maximum foliage density (26.5 leaves per running 30 cm) was observed in KG Guava while, minimum foliage density was observed in L-49 (19.6 leaves per running 30 cm) variety of guava. Similarly, during winter season, maximum foliage density (24.8 leaves per running 30 cm) was observed in KG Guava, whereas, minimum dense foliage density was observed in L-49 (18.1 leaves per running 30 cm), which was statistically at par with Banarsi Surkha (18.2 leaves per running 30 cm). This type of variation is also found by Rani *et al.*, (2017), Sharma *et al.*, (2010) and Singh *et al.*, (2016). The difference in foliage density among the genotypes might be due to a genetic feature of particular varieties or might due to that of same varieties in a different area had different adaptability and performance with the prevailing local climatic conditions. However, more number of leaves can harvest more sunlight, hence increases the photosynthesis and finally can enhance the productivity. Majority of guava varieties i.e. Allahabad Safeda, Banarsi Surkha, Barf Khana, Hisar Surkha, Lalit, L-49, Pant Parbhat, Pant Red, Punjab Pink had a decussate type of phyllotaxy, while Aishwariya, Arka Kiran, Arka Mridula, Hisar Safeda, KG Guava and Shweta had an opposite type of phyllotaxy. Similar finding were

Table-1 : Growth habit and leaf characteristics of different guava varieties.

Varieties	Growth habit	Foliage density		Phyllotaxy	Leaf shape	Mature leaf colour
		Rainy	Winter			
Hisar Surkha	Spreading	24.1	22.5	Decussate	Oblong	Green
Hisar Safeda	Dropping	22.6	21.0	Opposite	Trullate	Light green
Barf Khan	Erect	23.2	21.3	Decussate	Oblong	Dark green
L-49	Spreading	19.6	18.1	Decussate	Oblong	Dark green
Allahabad Safeda	Erect	23.5	22.0	Decussate	Trullate	Green
Shweta	Spreading	25.7	24.2	Opposite	Trullate	Dark Green
Lalit	Spreading	21.8	20.4	Decussate	Oblong	Dark green
Pant Parbhat	Dropping	24.5	23.0	Decussate	Oblong	Green
Aishwarya	Dropping	22.4	21.0	Opposite	Elliptical	Green
Arka Kiran	Spreading	25.1	23.5	Opposite	Oblong	Light Green
Arka Mridula	Spreading	20.5	18.7	Opposite	Oblong	Dark green
Banarsi Surkha	Spreading	19.9	18.2	Decussate	Oblong	Light green
Pant Red	Erect	23.3	21.7	Decussate	Ovate	Dark Green
Punjab Pink	Dropping	23.2	21.5	Decussate	Ovate	Light green
KG Guava	Spreading	26.5	24.8	Opposite	Round	Light green
C.D. at 5%	—	0.2	0.5	—	—	—
Ranges	—	19.6-26.5	18.1-24.8	—	—	—

reported by Rani *et al.*, (2017) and Sharma *et al.*, (2010). The observed differences in the phyllotaxy of different varieties under different agro-climatic conditions might be due to their genetic makeup, prevailing climatic condition and/or the interaction effect of genotype with the environment.

Most of guava varieties *i.e.* Hisar surkha, Barf Khan, L-49, Lalit, Pant Parbhat, Arka Kiran, Arka Mridula, Banarsi Surkha had Oblong type leaf shape while, Hisar Safeda, Allahabad Safeda, Shweta had Trullate type. Pant Red, Punjab Pink had Ovate type leaf shape wherese, Aishwarya had Elliptical type and KG Guava had Round type of leaf shape. This type of variations also has been reported by Rani *et al.*, (2017), Sharma *et al.*, (2010) and Singh *et al.*, (2016). The leaf shape of particular variety is due to its genetic makeup and variation in leaf shape under different agro-climatic conditions remained the same (Singh, 2018). Among the total varieties, most of the varieties had Dark Green colour *i.e.* Barf Khan, L-49, Shweta, Lalit, Arka Mridula and Pant Red, while five varieties were noticed with light green colour *i.e.* Hisar Safeda, Arka Kiran, Banarsi Surkha, Punjab Pink and KG Guava and rest varieties had Green leaf colour *i.e.* Hisar surkha, Allahabad Safeda, Pant Parbhat and Aishwarya. Rani *et al.*, (2017) and Sharma *et al.*, (2010) found variations in mature leaf color in guava. The variations in mature leaf color among the different varieties under different agro-climatic conditions might be due to their genetic makeup, prevailing climatic condition

and/or the interaction effect of genotype with the environment. The selection of cultivar must be based on the performance of varieties under particular condition because the same variety behaves differently with a change in agro-climatic conditions.

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Edible Coating for Shelf Life Extension of Fig Fruits Using Banana Leaf Powder

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Abstract

The present investigation was undertaken to evaluate the effect of banana leaf powder on the post-harvest quality characteristics of fig fruits. Banana leaf produces important secondary metabolites like terpenoids, flavonoids, polyphenols, chlorophylls, betalains etc. Polyphenols which is present in banana leaf powder especially polyphenol oxidase, which is used for the treatment of Parkinson's disorder, weight loss supplement, it also maintains the blood sugar levels and controls blood pressure. Coating is a method of increasing the storage life in fig fruit. The effects of dried banana leaf powder (0, 0.3, 0.6, 0.9, 1.2 and 1.5% concentrations) on shelf life of fig fruit was carried out. The effect of coating of banana leaf powder on the fig fruit with respect to moisture, ash, carbohydrates, crude fibre, TSS, pH, weight loss, TPC, colour (L^* , a^* , b^*) and firmness were studied. The results showed that coating of banana leaf powder on fig fruit with 1.2 concentration showed the best results with reduced total plate count, increase in TSS, and increase in pH, decrease in crude fibre, and decrease in weight loss with the increase in storage period compared with the control which was on par with the 1.5% concentration.

Key words : *Banana leaf, fig fruit, weight loss supplement, anti-microbial, edible coating.*

Introduction

The fig (*Ficus carica*) is a member of the Moraceae botanical family, usually found in Asia and its fruit is one of the most important agricultural products. Figs are grown commercially in most Mediterranean countries, as well as in California. Fig fruit is an excellent source of nutrients, bioactive compounds and Carbohydrates, mostly sugars, fibre, vitamins, minerals, and antioxidants are all abundant in figs [1]. That contribute to a balanced diet when properly absorbed into human nutrition [2].

Fresh figs have a short shelf life due to microbial decomposition; a cold environment can extend postharvest storage life, although better procedures are recommended. The fruit is usually eaten within three to four days. Furthermore, edible coatings are environmentally friendly because they are made from renewable resources [3]. Due to the diminishing moisture of fresh fruits induced by evaporation and respiration processes, the edible coating helps for weight loss management [4]. In tropical and subtropical nations, the banana is one of the most frequently distributed and consumed fruits [5]. With high levels of minerals, vitamins, carbs, flavonoids, and phenolic compounds, it is one of the world's most nutritious food crops [6].

Banana leaf produces important secondary metabolites like terpenoids, flavonoids, polyphenols,

chlorophylls, betalains etc. Among these, phenolic compounds are considered to be the chief plant constituent because of its capacity to exhibit antioxidant, anti-cancerous, antimicrobial and anti-inflammatory properties. Polyphenols which is present in banana leaf powder especially polyphenol oxidase, which is used for the treatment of Parkinson's disorder, weight loss supplement, it also maintains blood sugar levels and controls blood pressure

The features of the raw materials as well as the processing affect the composition and physico-chemical properties of banana leaf powder [7]. In the chemical and food processing industries, dehydration is a crucial unit activity. The dehydration process involves a number of heat and mass transport events [8]. The primary goal of drying is to lower water activity, prevent microbe development, reduce spoiling reactions, extend shelf life, reduce packing needs, and reduce transportation weights.

Materials and Methods

Plant material : Fig fruits used in this study were harvested at commercial maturity stage from the market of Raichur, Karnataka, India. All fruits were carefully hand harvested leaving stems attached to the fruit and avoiding touching the surface, then stored at 20 °C until use.

Preparation of edible coating solutions : Banana leaf powder is cut into small pieces and dried using

dehumidified air dryer with 40 °C and 15 % RH and ground to powder using Liquid nitrogen grinding. Citric acid is added (4.5-4.6 g/L) to maintain the pH at 4. The different concentration of banana leaf (0, 0.3, 0.6, 0.9, 1.2 and 1.5g) is dissolved in the 100 mL ethanol solution in room temperature 25 °C.

Application of the edible coating solutions : Fig fruits were held at 20 °C and 50% RH for 24 h to equilibrate with the temperature. Without touching the surface, the fruits were thoroughly washed with running water (deionized water) to eliminate any visible contaminants and then allowed to dry at room temperature. Coating application was done by dipping in the banana leaf solution with different concentrations. The fruits were dipped into a solution for 30 to 60 s for complete equilibrium. This method involved holding the figs by the stems using clips and then withdrawn quickly and allowed to drain over the glass vessel.

Physico chemical analysis of coated fruits : The following physical and chemical analysis was carried out for the fruits to assess the effect of edible coating on the fruit quality

Physiological loss in weight (PLW) (%) : Fig fruits were weighed at zero time of the storage beginning and 1-day intervals during the storage period. Weight loss was determined as a percentage referring to index weight at zero time according to [9].

Moisture content (%) : The moisture content of edible coated fig fruit were determined by following (10) method.

pH, Titrable acidity and TSS : The pH of edible coated fig fruit was measured by using digital pH meter (Make: M/s Systronics, Model: 361 Uvsar India Ltd). All the readings were taken in triplicate [11].

Colour : Hunter's lab colorimeter was used for the measurement of color of edible coated fig fruit. The color was measured by using CIELAB scale at 10° observer at D65 illuminant. It provides reading in terms of L^* , a^* and b^* . The color L^* , a^* and b^* values is measured [12].

Firmness : Fruit firmness (by g cm) was determined by measuring the compression force (at 0.05 mm s) of the samples using a texture analyzer [13]

Microbiological Analysis : Ten grams of fig samples were added to 90 mL of sterile Ringer solution in sterile bags (Oxoid, Basingstoke, UK) and homogenized using a Stomacher 400 (Lab Blender, Seward Medical,

London, UK). Of the resulting mixture, 1 mL was taken and tenfold serial dilutions were prepared in sterile Ringer's solution [14].

Sensory analysis for evaluating fruit quality : Sensory analysis was carried out by ten selected panelists. The fruits were randomly selected from each batch and served on white plates. The sensory quality of each batch of fruits was evaluated visually in terms of color of the peel, fruit firmness, appearance and marketability. Sensory evaluation was carried out after every four days. The various quality parameters assessed and the scoring used is given below :

Colour

- 5- Bright green
- 4-Slight browning of the skin
- 3- Moderate browning of the skin.
- 2 - Severe browning of the skin
- 1-Blackening of the skin

Firmness

- 5 - Very firm
- 4 - Firm
- 3 - Moderately firm
- 2 - Soft
- 1 - Very soft

Appearance

- 4 - Smooth skin
- 3 - Slight Shriveling
- 2 - Moderate shriveling
- 1 - Severe shriveling

Marketability for fig fruits :

- 4-Highly marketable
- 3-Marketable with slight defects
- 2-Fair and moderate defects
- 1-Marketability limited

Eating quality : Eating quality was judged periodically using fruits from each treatment by tasting the peeled /skinned fruits. The fruits were rated using a 5 point hedonic scale (5-sweet to 1-bland).

Degree and rate of fruit spoilage : The differently coated fruits were visually observed for fungal spoilage and fruit rots. The number of fruits affected or spoiled were recorded periodically to assess the effect of the different coating on fruit spoilage and reported in percentage as total fruit decay [10].

Results and Discussion

Weight Loss (%) : Weight loss percentage increased significantly with the prolong of the storage period for all treatments (Fig 1). Normally, the weight loss occurs during the fruit storage due to its respiratory process, the transference of humidity and some process of oxidation [15]. Similar results were reported by [16] lower water vapor permeability for tragacanth gum compared to the other hydrocolloids such as Persian gum might be due to its low water diffusivity and having a high affinity to water. However, all the treatments for 0, 2, 4, 6, 8 days there is decrease in the weight loss of fig during the storage compared to the control were the lowest value is 3.12 for T₅ treatment for 2nd day and highest value is 38.41 for control on 8th day. Banana leaf

edible coating are selective barriers to O_2 and CO_2 . The interaction between the treatments and storage period were significant.

Moisture Content (%) : The Moisture content is decreased significantly with the prolong of storage period for all treatments (Fig.-2). Normally, the decrease in moisture content is due to storage loss of water content. However, all the treatments for 0, 2, 4, 6, 8 days there is loss of moisture content of fig during the storage compared to the treatments were there is gradual increase in the moisture content from T_0 to T_5 . The highest value of moisture content is for 75.71 for initial for T_5 treatment and the lowest value is 69.13 for T_0 treatment for 8th day.

pH : The pH is increased significantly with the prolong of storage period for all treatments (Fig 3). Normally, the increase in pH is due to H^+ and OH^- ions were it is leading to less acidic in nature with respect to both storage days and treatments reported that the increase in the pH of strawberry juices during the storage period can be attributed to the decrease in acidity of the fruit. [17] Stated that chitosan coating with oleic acid had no effect on the pH changes of strawberries during 16 days of study. However, all the treatments for 0, 2, 4, 6, 8 days there is increase in pH for treatments T_0 - T_5 . The highest value of pH is 7.2 for T_5 treatment and 8th day and lowest value is 4.9 for T_0 treatment for initial day.

Colour : The colour was measured recording lightness L^* value, Redness a^* value and darkness b^* value, there was significant decrease in L^* value and b^* value and increase in a^* value with increasing storage for all the treatments, showing the darker fruit colour during storage as in Fig 4(a), 4(b) and 4(c). Fig fruits treated with banana leaf concentration best results for T_5 on 6th day. The uncoated (control) fruit had darker colour on the other hand fruit coated with different treatments T_1 - T_5 gave fruits with higher chroma. The results were in agreement with [18], they found that strawberry fruits treated with edible coating delayed fruits senescence in which the external and internal color was lighter than that of uncoated fruits. Thus, the senescence delay, evidenced by the decrease in color changes, demonstrates the effectiveness of coating.

Firmness : Fruit firmness decreased with extending the storage period in all the treatments fig soften considerably due to ripening which mainly occurs because of degradation of the middle lamella of the cell wall of cortical parenchyma cells. Senescence, cellular breakdown, and pectin hydrolyzation or

depolymerization caused the fruit softening [19]. All tested treatments significantly maintained firmness compared with control (Fig 5). The highest value for T_5 is 7.54 N for initial day and lowest firmness for treatment T_0 for 8th day is 3.83 N. The results are in agreement with Tanada-Palmu and Grosso they stated the edible coating showed a good results with respect to the retention of fruit firmness probably because this coating slowed down metabolism and prolonged the storage life.

Microbial load : Microorganism's growth was increased significantly as the storage period was prolonged particularly in control treatment (Fig. 6). The highest microbial load was found is 29.25 T_0 for 8th day and lowest for 1.79 T_5 for initial day. All types of coatings had lower level of microbial load in comparison to control treatment. However, these results were in agreement with those types of microorganisms. Meanwhile, $CaCl_2$ treatment was obtained by Han [9]. Moreover, [20] clearly show that essential oil related inhibition in mycelia growth was observed to be associated with significantly decreased levels of aflatoxin production. Which provides a protective antimicrobial barrier against food borne pathogens in product. Also, microflora is usually restricted to fungal and lactic acid bacteria when pH was low [21].

Sensory analysis for evaluating fruit quality :

Sensorial characterization is important in the case of accepting or rejecting the food product [22]. Sensorial properties of the fig evaluated on day 8 for control and treatment T_5 (1.5%) of shelf-life study and the results are shown in Fig. 6 and 7. As can be seen, fig coated with banana leaf coating with 1.5 % (T_5) showed the highest sensorial score during the shelf-life assay. Fig kept in control obtained the lowest appearance and color values which can be attributed to the fungal development on the surface of fruit on 8th day. Total acceptance for all treatments showed a reduction during the time. Fig coated with banana leaf i.e., 1.5 % (T_5) had the highest acceptance at day 8 and the lowest was for the control treatment. The changes in sensorial properties might be due to weight loss and mold contamination on the fruit that affect the nutritional properties.

Conclusions

The same physical principles applied to dip-plate coatings can be applied to fruit coating systems. During dip coating of a fruit of a given size, liquid film thickness is defined by coating solution. When the liquid film

Table-1 : Banana leaf powder in 100 mL ethanol solution.

Sl. No.	Concentration (%)	Treatment
1	0.3	T ₁
2	0.6	T ₂
3	0.9	T ₃
4	1.2	T ₄
5	1.5	T ₅
6	Control	T ₀

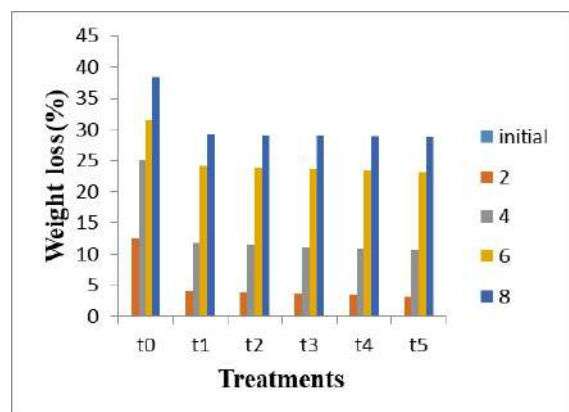


Fig-1 : Effect of Weight loss of banana leaf edible coating on fig fruits.

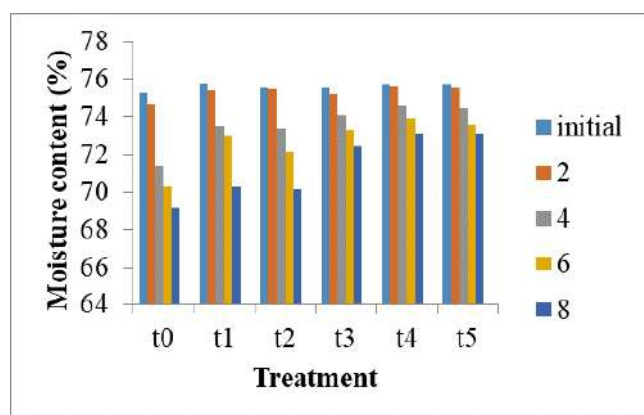


Fig-2 : Effect of Moisture content of banana leaf edible coating on fig fruits.

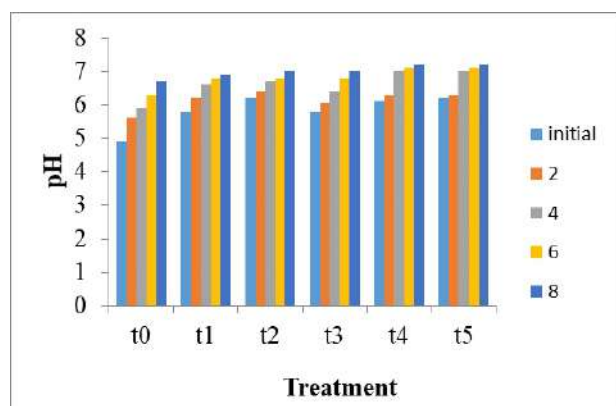
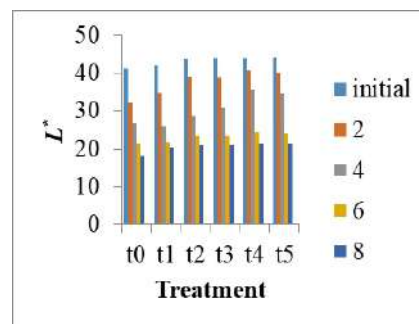
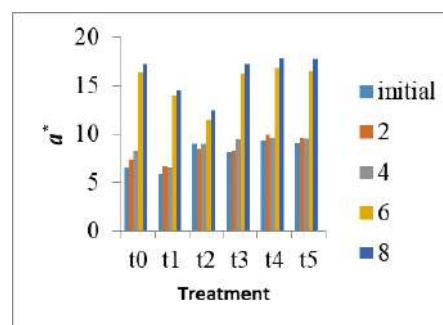


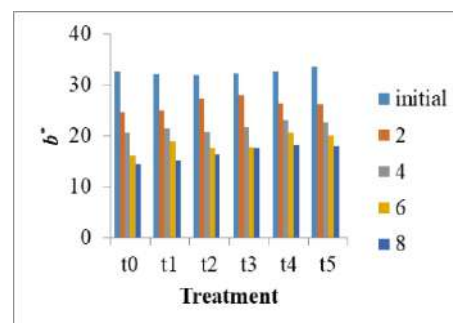
Fig-3 : Effect of pH for banana leaf edible coating on fig fruits.



(a)



(b)



(c)

Fig-4(a) L* value (b) a* value and (c) b* value effect of banana coated fig fruits.

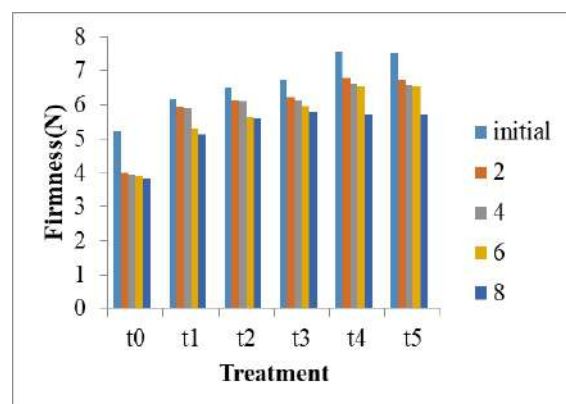


Fig-5 : Effect of Firmness for banana leaf edible coating on fig fruits.

dries, the dry film thickness is defined by the same solution properties and by the solid concentration of the original solution. Coating is a method of increasing the storage life in fig fruit. In this study, the effects of dried

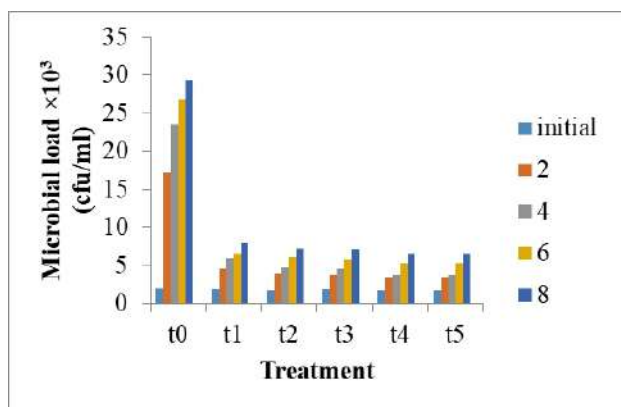


Fig. 6. Effect of Firmness for banana leaf edible coating on fig fruits.

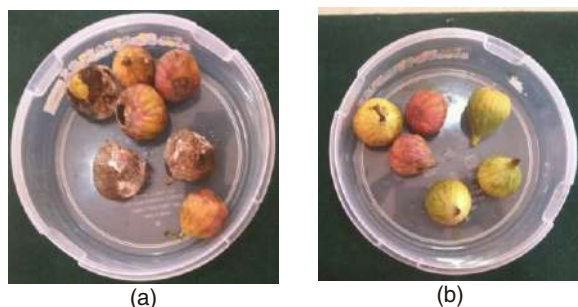


Fig-6. (a) Control Fig. fruits after 8 days; (b) T₅ coated with banana leaf concentration after 8 days.

banana leaf powder (0, 0.3, 0.6, 0.9, 1.2 and 1.5% concentrations) on shelf life of fig fruit was carried out. Fig-6 shows the control Fig. fruits after 8 days and Fig-7 shows the T₅ treatment coated with banana leaf concentration. It helps to enhance the shelf-life and postharvest quality of fig fruit. The effect of coating of banana leaf powder on the fig fruit with respect to moisture, ash, carbohydrates, crude fibre, TSS, pH, weight loss, TPC, colour (L^* , a^* , b^*) and firmness were studied. The results showed that coating of banana leaf powder on fig fruit with 1.2 concentration showed the best results with reduced total plate count, increase in TSS, increase in pH, decrease in crude fibre, decrease in weight loss with the increase in storage period compared with the control which was on par with the T₅ (1.5%) concentration.

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Seaweed Extract Application in Indian Agriculture : A Review

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Abstract

Seaweed extracts can play a beneficial role in agriculture by improving the growth, development, and health of crops. Seaweeds are rich in various growth-promoting substances, including amino acids, cytokinins, auxins, gibberellins, betaines, macro and micro nutrient. These substances can stimulate plant growth and improve the plant's ability to resist biotic and abiotic stresses. When applied to crops, seaweed extracts can enhance the absorption of nutrients, increase the root mass, and promote the development of secondary roots, leading to an increase in overall plant growth and yield. Seaweed extracts can also improve the quality of fruits and vegetables by enhancing their nutritional value, flavor, and shelf life. Moreover, seaweed extracts can also act as natural bio-stimulants and help crops to cope with environmental stresses such as drought, salinity, and extreme temperatures. Seaweed extracts can also improve the plant's resistance to pests and diseases, thus reducing the need for synthetic pesticides and herbicides. Application of seaweed extracts in agriculture can provide a natural and sustainable approach to crop management, leading to improved crop yields, quality, and resilience to environmental stresses.

Key words : Seaweed, Agriculture

Introduction

Seaweed is the name given to the many species of marine algae and plants that grow in water bodies such as rivers, seas and oceans. They range in colours from red, green, brown and black and also vary in size, from microscopic to large underwater forests. Seaweed is found on the shores across the world, but are more commonly a staple in Asian countries. Seaweeds are a power pack of nutrients like iron, zinc, magnesium, riboflavin, thiamin, vitamin A, B, C & K etc, are used as food for human, fodder for cattle, agricultural use. Seaweed contain multiple growth regulators such as cytokinins (Durand *et al.* 2003), auxins (Sahoo, 2000), gibberellins (Strik and Staden, 1997) and various macro and micronutrients necessary for plant growth and development. For centuries, agricultural areas close to these coastal zones have utilized seaweeds as a valuable source of organic matter for various soil types and for many different fruit and vegetable crops. Today, seaweed meals and soil amendments are available in ready-to-apply form for use in crop soils and home gardens. Moreover, high quality liquid and powder seaweed extract products can be found in pure form. Unlike, chemical fertilizers, extracts derived from seaweeds are biodegradable, non-toxic, non-polluting and non-hazardous to humans, animals and birds (Dhargalkar and Pereira, 2005). The use of seaweed as fertilizer or fertilizer additives is expected to be an alternative solution to environmental problems because it is safe for soil microbes and plants and also increases the economic value of seaweed. (Yusuf, 2016., Achmadi, 2019).

Use of sea weeds extract in agriculture : The use of seaweed extract in agriculture has been shown to have numerous benefits for seed germination, plant growth, and stress tolerance. As such, seaweed extract is an important tool for farmers and growers looking to improve the productivity and sustainability of their crops. Seaweed is an inexpensive and extensive resource along coastal agricultural areas, and it also has a great potential for commercial exploitation. Seaweed extracts isolated from seaweed, which contain a wide range of macronutrient and microelement nutrients and organic components such as growth hormones, amino acids, vitamins, betaines, cytokinins, and sterols, (Sivasankari, et al. 2006) have played an important role in the development of the environment-friendly crops planting system (Calvo *et al.*, 2014 and Craigie, 2011). Several authors mention that seaweed has been used since antiquity as amendments to the soil to increase crop productivity (Chapman and Chapman, 1980, Craigie, 2011). Craigie (2011) describes the first mention of the use of seaweed in agriculture.

Seaweed extracts are currently used in agricultural practices and have already been commercialised. Seaweed is available in a number of types, including LSF (Liquid Seaweed Fertilizer), granular, and powder. The whole or finely chopped driven algal manure has been used, and all of them have been shown to support cereals, pulses, and a number of flowering plants. Seaweed manure has the advantage of being free of weed seeds and other pathogenic fungi. The foliar spray of liquid extract from seaweed causes cereals,

vegetables, fruit plants, and horticultural crops to grow faster and produce more (Elansary *et al.*, 2016). In many commercial crops, foliar spraying with seaweed extract is a popular practice to increase yield (Khan *et al.*, 2009). The aim of recent research is to implement new methods for preparing various seaweeds, such as mixed consortiums, for use in agricultural fields and to increase yield. Brown algae liquid extracts are sold under different brand names as bio-stimulants or biofertilizers.

Helps in Germination : Seaweed extract has been found to be beneficial for improving the germination and growth of agricultural crops. Seaweed extracts contain various bioactive compounds such as cytokinins, auxins, and gibberellins, which have been shown to promote seed germination and early seedling growth. Studies have shown that treating seeds with seaweed extract can improve seed germination rates, increase seedling vigor, and enhance root growth. Khan *et al.* (2009) found that lettuce seedlings treated with seaweed extract had significantly higher germination rates and longer root lengths compared to untreated seedlings. Seaweed extracts have also been found to enhance plant growth and development by improving nutrient uptake and increasing stress tolerance. Higher germination percentage, shoot and root length, and seedling vigor index was observed when rice seeds were soaked in lower concentrations of seaweed extracts (Layek *et al.*, 2018). In the case of maize, a similar result was also published. Seeds soaked in lower concentrations (5%) of both seaweed saps (Kappaphycus and Gracilaria species) displayed a higher rate of germination, while seeds soaked in higher concentrations (15%) of extracts inhibited germination (Layek *et al.*, 2016). Higher germination percentage and seedling vigour was also reported in case of green gram (*Vigna radiata*) (Venkataraman and Mohan, 1997) and cowpea (*Vigna sinensis*) (Sivasankari *et al.*, 2006). The increase in germination and seedling vigour at low concentrations of seaweed extracts may be due to the presence of growth promoting substances like auxins, gibberellins, phenyl acetic acid (Sivasankari *et al.* 2006) and other micro-nutrients (Layek *et al.* 2014).

Plant growth promotion : Seaweed extracts contain a range of plant growth-promoting substances, including auxins, cytokinins, gibberellins, and betaines. These compounds can stimulate cell division and elongation, improve nutrient uptake and assimilation, and enhance resistance to biotic and abiotic stresses. Several studies have demonstrated the positive effects of seaweed extracts on plant growth and yield in various crops, including wheat, rice, tomato, and cucumber, Brinjal (Khan *et al.*, 2009; Rouphael *et al.*, 2017; Yusuf *et al.*, 2021., Hussain *et al.*, 2021). Seaweed extracts have also

been found to increase the concentration of antioxidants, such as ascorbic acid and phenolic compounds, in plants, which can enhance their nutritional quality and shelf life (Kumar *et al.*, 2018).

Effect on Yield : There is several studies suggest that seaweed extracts can increase the yield of agricultural and horticultural crops. Yildirim, 2016, found that foliar application of seaweed extracts improved the growth, yield, and quality of lettuce plants. The study concluded that the use of seaweed extracts as a foliar spray could be a useful tool for enhancing the yield and quality of lettuce crops. The application of seaweed extract significantly increased the yield of tomato plants, as well as improving their quality and resistance to disease (Aremu, 2017 and Yusuf *et al.*, 2021). It was confirmed that applying 0.6% concentrations of *Gracilaria dendroides*, and *Ulva lactuca* to sunflower resulted in higher oil content of 34.05 and 30.55%, respectively (Hannan *et al.*, 2011 and Salem *et al.*, 2011). To increase potato growth and yield, supplementing the prescribed fertiliser dose with extracts of either *Kappaphycus alvarezii* (K sap) or *Gracilaria aedulis* (G sap) at a 10% concentration could be used (Prajapati *et al.*, 2016). Spraying seaweed extract on potato tubers 30 and 60 days after planting resulted in higher tuber yield, increased nitrogen, total soluble solids, and protein content (Haider *et al.*, 2012). In the case of rice, a 15% *Kappaphycus* (K) or *Gracilaria* (G) sap application resulted in an 18.0% increase in rice grain yield as compared to control (Layek *et al.*, 2018). Cucumber plants showed that the application of seaweed extract increased yield by 48% compared to untreated plants (Peng *et al.* 2011). Similarly, a study on wheat plants showed that the application of seaweed extract increased yield by 31% compared to untreated plants (Khan *et al.*, 2009). In addition to improving crop yield, seaweed extracts have also been shown to improve the quality of crops. For example, a study on lettuce plants showed that the application of seaweed extract increased the content of phenolic compounds and antioxidants, which are important for human health. (Arancon, *et al.*, 2006). Craigie, 2020, analyzed the results of 82 studies on the use of seaweed extracts in agriculture. The review found that seaweed extracts can improve plant growth, yield, and quality by enhancing nutrient uptake, stimulating root growth, and improving plant resistance to biotic and abiotic stresses.

Stress tolerance : Seaweeds are adapted to survive in harsh marine environments and are therefore rich sources of compounds that can help plants tolerate various stresses, such as salinity, drought, and extreme temperatures. Seaweed extracts contain osmoprotectants, such as glycine betaine and proline, which can help plants maintain their water balance and

protect their membranes from damage under stress (Ertani *et al.*, 2017). Seaweed extracts have also been found to induce the expression of stress-responsive genes in plants, which can enhance their adaptive capacity (Khan *et al.*, 2019). Several studies have demonstrated the positive effects of seaweed extracts on plant growth and yield under stress conditions, such as drought and salinity (Akladios and Mohamed, 2014; Han *et al.*, 2019).

Disease and pest control : Seaweed extracts contain various compounds that can inhibit the growth and development of plant pathogens and pests. For example, phlorotannins, which are abundant in brown seaweeds, have been found to have antifungal and antibacterial activity (He *et al.*, 2017). Seaweed extracts have also been found to induce systemic resistance in plants, which can enhance their resistance to various pathogens (Jaulneau *et al.*, 2010). Several studies have demonstrated the efficacy of seaweed extracts in controlling plant diseases and pests, such as powdery mildew and spider mites (Du *et al.*, 2013; Kumar *et al.*, 2016).

Soil improvement and conditioning : Seaweed extracts can also improve soil quality by enhancing its physical, chemical, and biological properties. Seaweed extracts contain organic matter, a range of compounds such as alginate, carrageenan, and agar, which can improve soil structure, water holding capacity (Schiavon *et al.*, 2010 and Craigie, 2011). Seaweed extracts can also increase soil microbial activity, which can improve nutrient cycling and availability (Colla *et al.*, 2014). Several studies have demonstrated the positive effects of seaweed extracts on soil quality and plant growth in various cropping systems, such as organic and conventional farming (Battacharyya *et al.*, 2015; Ruzzi *et al.*, 2016; Khan *et al.*, 2009).

Improving Nutrient Uptake : Seaweed extracts contain a wide range of essential minerals and trace elements that help in improving nutrient uptake in plants. They also contain organic compounds that help in chelating soil nutrients, making them more available for plant uptake. Seaweed extracts can be used as a foliar spray or applied to the soil to enhance the uptake of essential nutrients like nitrogen, phosphorus, and potassium.

Khan *et al.*, 2009 found that seaweed extracts improved the uptake of nitrogen, phosphorus, and potassium in tomato plants. The researchers attributed this effect to the presence of plant growth regulators such as cytokinins and auxins in the seaweed extracts. Iqbal *et al.*, 2018 also observed that a seaweed extract application improved the uptake of nitrogen and phosphorus in wheat plants, resulting in increased biomass and grain yield. In soybean, *Kappaphycus alvarezii* derived seaweed extract

is effective in increasing the growth parameters, yield and enhancing nutrient uptake by the plant (Rathore *et al.*, 2009).

Sustainable Agriculture : Seaweed extracts are an eco-friendly input for agriculture. They are derived from a renewable resource and do not have any adverse effects on the environment. Seaweed extracts help in reducing the use of synthetic fertilizers and pesticides, promoting sustainable agriculture practices.

Conclusion

Seaweed extract is a versatile natural product that can provide numerous benefits to agricultural and horticultural crops. It can stimulate plant growth, enhance plant health, increase yield, and improve the quality of fruits and vegetables. With its many benefits, seaweed extract is becoming an increasingly popular choice for farmers and growers looking to improve the productivity and sustainability of their crops.

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Correlation of Physico-Chemical Parameters, Irrigation Ground Water Quality and Heavy Metals of Semi-Arid Region of Eastern Jaipur Rajasthan

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Abstract

The present investigation was carried out at Jaipur district of Rajasthan, India. In this study, a total 27 soil samples were collected at three different depths (0-15, 15-30, 30-40 cm) and analysed. Different results were analysed and according to the report correlation has been taken for the physio-chemical properties, irrigation ground water quality and heavy metals. The results showed that improvement has to be one for improving soil fertility and quality by analysing the correlation of physio-chemical properties, irrigation ground water quality and heavy metals.

Introduction

Soil is the soul of infinite life, medium for growth of land plants, and is generally refer to the loose material composed of weathered rock and other material including partly decayed organic matter. It is reservoir of nutrients and play pivotal role in supporting the growth of crops and other vegetation maintaining the earth's environment clean. It also acts as source and sinks for atmosphere gases. To improve productivity and economic condition of soil, we need to utilize it scientifically. Also, soil provides fodder, food, and fuel for living organisms. Healthy soil provides pure water and air for living organisms including plants, humans and animals. It is a reservoir of nutrients and balancing the gaseous exchanges by maintaining earth surface clean [1-3].

Micronutrients are also essential for crop growth but are not regularly applied in the soil along with the common fertilizers used by the farmers. Their removal from the soil had been for centuries without any systematic replenishment (Sharma *et al.*, 2008).

Micronutrient deficiencies were first reported at the end of the 19th century and today it is well known that the extensive areas of our soils are capable of supplying plants with sufficient amounts of micronutrients. The application of fertilizer in the soil having only major nutrients, the loss of micronutrients thought plant uptake and leaching, the decreasing proportion of farm yard manure and other organic manures in comparison with fertilizers, and several other factors collectively contribute towards the deficiency of micronutrients in soils (Rattan *et al.*, 2009).

Agricultural irrigation helps guarantee human food production; however, its application consumes large

amounts of fresh water. More than 70% of the world's total water intake is for irrigation, 90% of which represents consumptive water use. In recent years, the annual amount of water used for agriculture has been about 350 billion m³ in China, and the average amount of irrigation water applied per acre of irrigated farmland has reached 350 m³. Long-term, large-scale irrigation from rivers, reservoirs, and aquifers disturbs the runoff of more than half of the world's rivers and can also significantly alter the surface water cycle. In particular, large amounts of groundwater are extracted for farmland irrigation in arid and semi-arid areas, making the recharge rate of groundwater less than the extraction rate and leading to such adverse consequences as surface subsidence, collapse, and seawater intrusion.

Irrigation water use is a key parameter for quantifying farmland irrigation and also serves as the basis for studying human irrigation activities and their impacts on earth systems. For example, in hydrological and land surface numerical models, the water resources management process must reflect two interacting aspects: water amount along with water supply and distribution. The amount of available water resources is limited by the water supply and drives the allocation of water resources, which is reflected in the simulation as the process and total amount of water drawn from the water source. Irrigation represents a major source of water consumption. The precision of irrigation water use determines whether numerical models examining such topics as hydrology and land surface processes can accurately simulate human irrigation activities. In addition, irrigation water use is also the key to studying the impact of human irrigation activities on the ecological environment.

Material and Methods

Geographically, Jaipur district lies at Longitude 26°9'1.24" N and latitude 75°7'8.73" E. Total geographical area of the district is 11,06,148 ha. or 11061.48 sq km. The total Gross Cropped Area of the city is 8,48,313 ha with Net Sown Area being 6,63,167 ha out of which only 3,02,428 ha is Net Irrigated Area.

Analysis of soil : The physico-chemical properties and their methods are to be analyzed by the following standard protocols in Table-2.

The implementing design for the experiment was CRD (Completely Randomized Design) which is the most flexible and simplest design. It is used when the experimental units are homogenous as it involves two basic principles of the design of the experiment namely Replication and Randomization.

Results and Discussion

Calculation of Soil Moisture Similarity

Construction of the Samples of Soil Water Characteristics : Precipitation data are easier to obtain

Table-1 : Soil Samples collection site.

S. No.	Blocks	Village	Latitude ($^{\circ}$ N)	Longitude ($^{\circ}$ E)
1.	Chomu (B ₁)	Keshav Nagar (V ₁)	26.9039 ⁰	75.7844 ⁰
		Morija (V ₂)	27.2068 ⁰	75.7582 ⁰
		Nindola (V ₃)	27.3185 ⁰	75.7081 ⁰
2.	Sanganer (B ₂)	Goner (V ₄)	26.8865 ⁰	75.8341 ⁰
		Shrikishanpura (V ₅)	26.7998 ⁰	75.8582 ⁰
		Durgapura (V ₆)	26.8518 ⁰	75.7862 ⁰
3.	Shahpura (B ₃)	Shivpuri (V ₇)	26.9426 ⁰	75.7526 ⁰
		Manoharpur (V ₈)	26.2994 ⁰	75.9571 ⁰
		Nwalpura (V ₉)	26.8103 ⁰	75.8365 ⁰

Table-2 : Protocols were followed to analyses for physio-chemical parameters :

S.No.	Parameters	Method	Scientist
1.	Soil pH	Digital pH meter	Jackson, 1958
2.	Electrical conductivity (dSm ⁻¹)	Digital EC meter	Wilcox, 1950
3.	Organic Carbon (%)	Rapid Titration	Walkley and Black, 1947
4.	Available Nitrogen (kg ha ⁻¹)	Alkaline potassium permanganate	Subbiah and Asija, 1956
5.	Available Phosphorous (kg ha ⁻¹)	Colori meter	Olsen et al., 1954
6.	Available Potassium (kg ha ⁻¹)	Flame photometer	Toth and Prince, 1949
7.	Micro nutrients (Fe, Cu, Mn, Zn)	DTPA extractable method by AAS	Lindsay and Norvell, 1978

Table-3 : Correlation of physico-chemical parameters, irrigation ground water quality and heavy metals.

	EC (dS/m)	pH	Ca ²⁺ Mg ²⁺ (me/L)	Na ⁺ (me/L)	CO ₃ ²⁻ (me/L)	HCO ₃ ⁻ (me/L)	Cl ⁻ (me/L)	SO ₄ ⁴⁻ (me/L)	RSC (me/L)	SAR
EC (dS/m)	1									
pH	-0.98895	1								
Ca ²⁺ Mg ²⁺ (me/L)	0.56358	-0.50184	1							
Na ⁺ (me/L)	0.994913	-0.99098	0.477534	1						
CO ₃ ²⁻ (me/L)	0.743818	-0.78167	0.323569	0.751651	1					
HCO ₃ ⁻ (me/L)	0.713627	-0.67072	0.371573	0.712885	0.519439	1				
Cl ⁻ (me/L)	0.657261	-0.66855	0.104369	0.685489	0.797086	0.738327	1			
SO ₄ (me/L)	0.980717	-0.96875	0.604611	0.969653	0.653554	0.60176	0.505272	1		
RSC (me/L)	0.34507	-0.38658	-0.35202	0.409514	0.588587	0.584292	0.842587	0.182793	1	
SAR	0.875009	-0.90388	0.09932	0.9187	0.706514	0.66301	0.740778	0.824628	0.638804	1

Note : (*) represents significant at 0.05 level.

and more accurate than irrigation data. Therefore, precipitation data were selected to represent surface input water in this study, and the corresponding soil moisture change characteristics after the occurrence of precipitation events were obtained. The combination of precipitation data and soil moisture change characteristics was used to construct a soil moisture feature sample set. From the recorded precipitation events, those with a precipitation duration of <2 days and precipitation amount >5 mm were selected for the study's precipitation data. Due to surface interception and evapotranspiration, a small amount of precipitation lasting a short time is unlikely to reach the soil; therefore, it cannot increase the water content in the soil. In addition, soil water values before and after precipitation events were used to identify soil water characteristics. Ramamoorthy and Bajaj.

Based on the above principles, precipitation data meeting the established constraints and soil water data corresponding to describing the characteristics of soil water changes were selected from each station. The data were recorded from 2015 to 2020. Next, 80% of the filtered data were used to build the sample set; the other 20% were used to validate the model. The similarity between the characteristics of soil water changes at point k to be predicted and the characteristics of soil water changes in the sample set ($m_1, m_2, m_3, \dots$) was then calculated.

Correlation of physico-chemical parameters, irrigation ground water quality and heavy metals : The EC of the soil is negatively non-significantly correlated with pH (-0.98895) and positively correlated with Ca^{2+} Mg^{2+} (me/L) (0.56358), Na^+ (me/L) (0.994913), CO_3^{2-} (me/L) (-0.50184), HCO_3 (me/L) (0.713627), Cl^- (me/L) (0.657261), SO_4 (me/L) (0.980717), RSC(me/L) (0.34507), SAR (0.875009), pH of the soil is negatively non-significantly correlated with Ca^{2+} Mg^{2+} (me/L) (-0.56358), Na^+ (me/L) (-0.99098), CO_3^{2-} (me/L) (-0.78167), HCO_3 (me/L) (-0.67072), Cl^- (me/L) (-0.66855), SO_4 (me/L) (-0.96875), RSC(me/L) (-0.38658), SAR (-0.90388), pH (-0.98895) and Ca^{2+} Mg^{2+} positively correlated with Na^+ (me/L) (0.477534), CO_3^{2-} (me/L) (0.323569), HCO_3 (me/L) (0.371573), Cl^- (me/L) (0.104369), SO_4 (me/L) (0.604611), SAR (0.09932) and negatively with RSC(me/L) (-0.35202). The Na^+ (me/L) of the soil is positively correlated with CO_3^{2-} (me/L) 0.751651), HCO_3 (me/L) (0.712885), Cl^- (me/L) (0.685489), SO_4 (me/L) (0.969653), RSC(me/L) (0.409514), SAR (-0.9187). The CO_3^{2-} (me/L) of the soil is positively correlated with HCO_3 (me/L) (0.519439), Cl^- (me/L) (0.797086), SO_4 (me/L) (0.653554), RSC(me/L) (0.588587), SAR (0.706514). The HCO_3 (me/L) of the soil is positively correlated with Cl^- (me/L) (0.738327),

SO_4 (me/L) (0.60176), RSC(me/L) (0.584292), SAR (0.66301). The Cl^- (me/L) of the soil is positively correlated with SO_4 (me/L) (0.505272), RSC(me/L) (0.842587), SAR (0.740778). The SO_4 (me/L) of the soil is positively correlated with RSC(me/L) (0.182793), SAR (0.824628). The RSC(me/L) of the soil is positively correlated with SAR (0.638804).

Conclusions

The variable concentrations of various parameters and irregular distributions of micronutrients may be attributed due to the added fertilizers during crop production. It is concluded for that there is a need of proper nutrition and management approaches to attain optimum economic yield and maintain soil fertility. The major reason for lack of macronutrients is leaching due to higher amount of precipitation in the area and nutrient uptake by plants and inappropriate management practices. It suggests that still improvement can be done by improving cropping pattern, decomposition of organic waste, mulching, tillage practices and proper irrigation by management practices with knowledge and experience gained through studies and lead farmers to achieve quality produce and high yield through soil conservation.

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Tree Species Diversity in VSS Managed Northern Tropical Moist Deciduous Forests in Coastal Plain of Odisha

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Abstract

The present research was conducted in VSS managed patia reserve forest in Khurda district of Odisha to study the tree species diversity, distribution pattern and biodiversity indices. The density of tree, sapling, seedling was 435, 570, 10640 ind. ha⁻¹. Basal area of tree and sapling was 14.6 and 1.6 m²ha⁻¹ respectively. Species diversity of tree, sapling, seedling was 1.9, 2.1 and 2.3 respectively. The maximum IVI value was 132.43 reported for *Tectona grandis* and minimum 4.01 for *Anogeissus acuminata* in tree category. In saplings, The maximum IVI was 103.69 reported for *Diospyrus sylvatica* and minimum 3.11 for *Bridelia retusa*. The maximum provenance value of 38.2 was found in *Diospyrus sylvatica* and minimum of 1.8 was observed in *Bridelia pubescens*, *Antidesma ghaesemill* and *Cassia siamea* in seedlings. 56% tree species showed random distribution and 44% showed contagious distribution pattern.

Key Words : Species diversity , tropical forest, distribution pattern, IVI

Introduction

Forests have an important role towards sustainable development as they were regulating climate change, source of floristic diversity and forest products. Forest produce various ecosystem services such as checking of soil erosion and siltation, water conservation, protection of habitats and mitigation of climate change through carbon sequestration. The extent of stability and heterogeneity of a forest is regulated by the species diversity, abundance, richness and density of associated species. A thorough knowledge of species composition and structure of forest is an essential tool for assessment of the productivity, species conservation, and management of forest ecosystems. The tropical forests are considered to be one of the most diverse ecosystems. They play a major role by providing a range of forest produce to the forest dependent households. Trees are the functional unit of forest ecosystem act as an indicator of changes and stressors that occur at landscape level. The assessment of quantitative parameters of forest is very imperative to get the actual potential of the forest which also forms a basis for comparative study of other vegetation.

The diversity of tropical forests gives an idea about economical condition which may be important parameters for the future development as the forests enriched with economically important plant species. Due to these plants are mostly exploited by human being for their needs as well as agriculture and infrastructure. Forests are among the most exploited and endangered ecosystems of the biosphere (Gentry, 1992). Plant species diversity is a

fundamental component of ecosystem because they guide the structure and functional aspects of the ecosystem and also provide resources and habitats for other forest organisms. In tropical forests, the diversity of tree species varies by geography, habitat parameters and levels of disturbances (Whitmore, 1998). The spatial heterogeneity of diversity may be the result of some underlying pattern or process such as environmental heterogeneity, biotic control, and abiotic/biotic coupling process (Pringle, 1990). Understanding species diversity and distribution patterns is important for helping managers to evaluate the complexity and resources of forests.

The species level and species diversity is one of the most important indices for measurement of biodiversity which are used for the evaluation of ecosystem at different scales (Ardakani, 2004). The diversity can be studied with various indices, such as number of species per unit area (species richness) or the species diversity as Shannon-Weiner index, amongst other. These are used as indicators of the degree of complexity of the under story community and provide information on the homeostatic capacity of the system to unforeseen environmental change (Magurran, 1988). According to Singh, (2002), biodiversity is essential for human survival and for the ecosystem function and stability at the global scale, biodiversity is a balance between speciation and extension and at the ecosystem level, it is a balance between the rates of invasion and local extinction. Samant (2010) reported rapid loss of biodiversity was due to degradation of the habitat and over exploitation of the

habitats, species and communities for conservation and management programme for which the vegetation parameters are pre-requisites. Recruitment, growth, and survival are influenced by a range of microclimatic and edaphic factors, which vary among different tropical forest formations as observed by Augspurger (1984). Earlier studies of tropical tree regeneration have focused mainly on seedlings, which are usually more abundant than other life stages reported by Scholl and Taylor (2006); Parameters of seedling stands are crucial components of tree population dynamics reported by Clark (1986). As floristic and structural composition changes from one community to another there are concomitant changes in the competitive abilities of seedlings that depend on shifting opportunities for regeneration observed by (Barker and Kirckpatrick, 1994).

The purpose of research study is to explore the information those are mentioned in the research objectives. Present study aimed to carry out the various aspects of vegetation diversity and its distribution in Khurda forest division of Khurda district in Odisha.

Materials and Methods

The present research study was conducted in Khurda district of Odisha. The district is surrounded by Nayagarh on the north, Ganjam in south and Bay of Bengal in the east. Khurda Forest Division lies between $19^{\circ} 27'$ and $20^{\circ} 26'$ north latitude and between $84^{\circ} 59'$ and $85^{\circ} 56'$ east longitude. The total forest area of Khurda district is 457 sq. km. of the total geographical area of 2813 sq. km. which constitutes about 16.25 % the total geographical area. The study area is broadly in the coastal region of the State. 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. The three main seasons i.e, winter season (November to February), summer season (March to June) and rainy season (July to October). This division normally receives 80 to 85% rains by south-west monsoon between second week of June and last week of September. Days become hot during the period from last part of February to 15th of June of the year. Terrible heat of the sun is experienced in the month of May. This has been observed during the last decade that the mercury level sometimes touches 46° to 48° centigrade. The following forests are found in Khurda forest i.e. Northern tropical semi-evergreen forests (sub-group-2B), North Indian tropical moist deciduous forests (sub-group-3C) and Northern tropical dry deciduous forests (sub-group 5B) (Champion and Seth, 1968). The present study was carried out in Patia reserve forest with Lat- $19^{\circ} 57'49''$, Long- $85^{\circ} 19'16''$ at an altitude of 120.9m msl with Northern tropical moist deciduous forest.

The various parameters of forests such as density,

frequency, abundance, dominance, basal area, important value index, species richness, species diversity and concentration of dominance in each selected forest site was assessed using the quadrat method (Misra, 1968; Saxena and Singh, 1982). Each forest was analyzed for tree, sapling and seedling by placing randomly the adequate number of quadrats of 10x10m size for each category of tree and their species that formed the tree layer. The circumference/diameter of tree species was measured at breast height i.e. 1.37m with the help of meter tape/tree callipers. Tree saplings ($>3.3\text{cm}$ to 10cm dbh) and seedlings ($<3.3\text{cm}$ dbh and height $>15\text{cm}$) was assessed in each forest using quadrat of size 5x5m and 2.5x2.5m, respectively. The under canopy species in each forest such as shrubs and herbs was determined using quadrat of size 2x2m and 1x1m respectively. Plants were identified with the help of Flora of Orissa (Saxena and Brahman, 1996). The spatial location (latitude, longitude and altitude) of each quadrant was collected using a Global Positioning System (GPS).

Results and Discussion

Perusal of the data showed that the Patia reserve forest was dominated by *Tectona grandis* which was associated with *Cassia siamea*, *Strychnos nuxvomica*, *Diospyrus sylvatica*, *Acacia auriculiformis*, *Xantolis tomentosa*, *Lagerstroemia parviflora* and *Adina codifolia* etc. The details of the finding are presented as follows:

Tree Layer : A total of 16 tree species were found in the forest. The tree density was 435 ind. ha^{-1} , out of which the density of *Tectona grandis* was 220 ind. ha^{-1} . The minimum density was 5 ind. ha^{-1} reported for *Alstonia scholaris* and *Anogeissus acuminata* respectively. The highest frequency was recorded for *Tectona grandis* (80%) and lowest (10%) for *Acacia auriculiformis*, *Xantolis tomentosa*, *Alstonia scholaris*, *Cassia siamea*, *Lagerstroemia parviflora* and *Anogeissus acuminata*. The total basal area of trees was $14.63 \text{ m}^2 \text{ ha}^{-1}$, out of which $9.12 \text{ m}^2 \text{ ha}^{-1}$ was reported for *Tectona grandis* and minimum $0.06 \text{ m}^2 \text{ ha}^{-1}$ for *Anogeissus acuminata*. The maximum IVI value was 132.43 reported for *Tectona grandis* and minimum 4.01 for *Anogeissus acuminata* (Table-1).

Saplings : A total of 18 sapling species were found in the forest. The total density was 570 ind. ha^{-1} , out of which *Diospyrus sylvatica* density was 230 ind. ha^{-1} . The minimum density was 5 ind. ha^{-1} reported for *Xantolis tomentosa*, *Ficus arnotiana*, *Bridelia retusa* and *Cassia siamea*. The highest frequency was reported for *Diospyrus sylvatica* (70%) and lowest for *Xantolis tomentosa*, *Ficus arnotiana*, *Bridelia retusa* and *Cassia siamea* (10%). The total basal area of saplings was $1.64 \text{ m}^2 \text{ ha}^{-1}$, out of which maximum basal area was $0.82 \text{ m}^2 \text{ ha}^{-1}$ was reported for *Diospyrus sylvatica* and minimum 0.01

Table-1 : Density, Basal Area, IVI and Species Diversity of trees in studied forest (Patia Reserve Forest).

S. No.	Botanical Name	D (Ind.ha ⁻¹)	F (%)	A	A/F	BA (m ² ha ⁻¹)	RD	RF	RDo	IVI	H'	Cd
1.	<i>Tectona grandis</i>	220	80	5.5	0.07 ^C	9.12	50.58	19.51	62.35	132.43	0.345	0.256
2.	<i>Strychnos nux-vomica</i>	45	60	1.5	0.03 ^R	0.39	10.35	14.63	2.65	27.63	0.235	0.011
3.	<i>Adina cordifolia</i>	15	30	1	0.03 ^R	2.18	3.45	7.32	14.88	25.65	0.116	0.001
4.	<i>Schleichera oleosa</i>	25	50	1	0.02 ^R	0.22	5.75	12.20	1.47	19.41	0.164	0.003
5.	<i>Syzygium cumini</i>	15	30	1	0.03 ^R	0.33	3.45	7.32	2.25	13.02	0.116	0.001
6.	<i>Ficus racemosa</i>	10	20	1	0.05 ^R	0.66	2.30	4.88	4.51	11.69	0.087	0.001
7.	<i>Cassia siamea</i>	20	10	4	0.40 ^C	0.56	4.60	2.44	3.84	10.87	0.142	0.002
8.	<i>Dillenia pentagyna</i>	10	20	1	0.05 ^R	0.13	2.30	4.88	0.91	8.08	0.087	0.001
9.	<i>Canthium dicoccum</i>	10	20	1	0.05 ^R	0.12	2.30	4.88	0.80	7.98	0.087	0.001
10.	<i>Zizyphus rugosa</i>	10	20	1	0.05 ^R	0.11	2.30	4.88	0.77	7.95	0.087	0.001
11.	<i>Diospyrus sylvatica</i>	10	20	1	0.05 ^R	0.10	2.30	4.88	0.69	7.87	0.087	0.001
12.	<i>Acacia auriculiformis</i>	15	10	3	0.30 ^C	0.23	3.45	2.44	1.56	7.44	0.116	0.001
13.	<i>Lagerstroemia parviflora</i>	10	10	2	0.20 ^C	0.18	2.30	2.44	1.24	5.97	0.087	0.001
14.	<i>Xantolis tomentosa</i>	10	10	2	0.20 ^C	0.09	2.30	2.44	0.60	5.34	0.087	0.001
15.	<i>Alstonia scholaris</i>	5	10	1	0.10 ^C	0.16	1.15	2.44	1.07	4.66	0.051	0
16.	<i>Anogeissus acuminata</i>	5	10	1	0.10 ^C	0.06	1.15	2.44	0.43	4.01	0.051	0
	Total	435	410	28	1.73	14.63	100	100	100	300	1.940	0.28

Note-D-Density, F-Frequency, A- Abundance, A/F- Abundance to frequency ratio, BA- Basal area, RD- Relative density, RF- Relative frequency, R.Do-Relative Dominance, IVI-Importance value index, H'- Shannon-Wiener diversity index and Cd- Concentration of dominance.

Table-2 : Density, Basal Area, IVI and Species Diversity of sapling in studied forest (Patia Reserve Forest).

S. No.	Botanical Name	D (Ind/ ha ⁻¹)	F (%)	A	A/F	BA (m ² ha ⁻¹)	RD	RF	RDo	IVI	H'	Cd
1.	<i>Diospyrus sylvatica</i>	230	70	13.73	0.094 ^C	0.82	40.35	13.73	49.61	103.69	0.366	0.1628
2.	<i>Bambusa arundinaceae</i>	90	20	3.92	0.450 ^C	0.08	15.79	3.92	4.99	24.70	0.291	0.0249
3.	<i>Schleichera oleosa</i>	25	50	9.8	0.020 ^{Re}	0.13	4.39	9.8	7.99	22.18	0.137	0.0019
4.	<i>Pterospermum xylocarpum</i>	45	30	5.88	0.100 ^C	0.09	7.89	5.88	5.41	19.19	0.200	0.0062
5.	<i>Suregada multiflora</i>	25	40	7.84	0.031 ^R	0.07	4.39	7.84	4.39	16.62	0.137	0.0019
6.	<i>Strychnos nux-vomica</i>	25	40	7.84	0.031 ^R	0.06	4.39	7.84	3.6	15.83	0.137	0.0019
7.	<i>Acacia auriculiformis</i>	20	40	7.84	0.025 ^R	0.06	3.51	7.84	3.86	15.21	0.118	0.0012
8.	<i>Terminalia bellirica</i>	15	30	5.88	0.033 ^R	0.06	2.63	5.88	3.72	12.23	0.096	0.0007
9.	<i>Syzygium cumini</i>	15	30	5.88	0.033 ^R	0.05	2.63	5.88	3	11.51	0.096	0.0007
10.	<i>Diospyrus melanoxydon</i>	15	30	5.88	0.033 ^R	0.03	2.63	5.88	1.94	10.45	0.096	0.0007
11.	<i>Bridelia pubescence</i>	15	30	5.88	0.033 ^R	0.03	2.63	5.88	1.65	10.17	0.096	0.0007
12.	<i>Lepisanthes tetraphylla</i>	10	20	3.92	0.050 ^R	0.06	1.75	3.92	3.87	9.55	0.071	0.0003
13.	<i>Streblus asper</i>	10	20	3.92	0.050 ^R	0.03	1.75	3.92	1.99	7.66	0.071	0.0003
14.	<i>Adina cordifolia</i>	10	20	3.92	0.050 ^R	0.02	1.75	3.92	1.19	6.87	0.071	0.0003
15.	<i>Cassia siamea</i>	5	10	1.96	0.100 ^C	0.02	0.88	1.96	1.04	3.88	0.042	0.0001
16.	<i>Xantolis tomentosa</i>	5	10	1.96	0.100 ^C	0.02	0.88	1.96	0.98	3.82	0.042	0.0001
17.	<i>Ficus arnotiana</i>	5	10	1.96	0.100 ^C	0.01	0.88	1.96	0.51	3.34	0.042	0.0001
18.	<i>Bridelia retusa</i>	5	10	1.96	0.100 ^C	0.01	0.88	1.96	0.28	3.11	0.042	0.0001
	Total	570	510	100	1.435	1.64	100	100	100	300	2.149	0.205

Note-D-Density, F- Frequency, A- Abundance, A/F- Abundance to frequency ratio, BA- Basal area, RD- Relative density, RF- Relative frequency, R.Do- Relative Dominance, IVI-Importance value index, H'- Shannon-Wiener diversity index and Cd-Concentration of dominance.

m² ha⁻¹ for *Bridelia retusa* and *Ficus arnotiana*. The maximum IVI was 103.69 reported for *Diospyrus sylvatica* and minimum 3.11 for *Bridelia retusa* (Table-2).

Seedlings : A total of 20 seedling species were found in the forest. The total density was 10640 ind. ha⁻¹ out of

which *Diospyrus sylvatica* density was 2880 inds ha⁻¹. The minimum density of 40 ind. ha⁻¹ was calculated for *Bridelia pubescence*, *Antidesma ghaesembilla* and *Cassia siamea*. Frequency was recorded highest for *Suregada multiflora* (100%) and was minimum for majority of the species *Bridelia pubescence*, *Xantolis tomentosa*,

Table-3 : Density, A/F Ratio, PV and Species Diversity of seedling in studied forest (Patia Reserve Forest).

S. No.	Botanical Name	D (ind/ha ⁻¹)	F (%)	A	A/F	RD	RF	PV	H'	Cd
1.	<i>Diospyrus sylvatica</i>	2880	80	9	0.11 ^C	27.07	11.11	38.2	0.35	0.07327
2.	<i>Pterospermum xylocarpum</i>	1800	90	5	0.06 ^C	0.38	1.39	29.4	0.30	0.02862
3.	<i>Suregada multiflora</i>	1440	100	4	0.04 ^R	16.92	12.50	27.4	0.27	0.01832
4.	<i>Dalbergia paniculata</i>	960	30	8	0.27 ^C	13.53	13.89	13.2	0.22	0.00814
5.	<i>Mallotus philippensis</i>	280	70	1	0.01 ^{Re}	2.26	4.17	12.4	0.10	0.00069
6.	<i>Acacia catechu</i>	600	30	5	0.17 ^C	5.64	4.17	9.8	0.16	0.00318
7.	<i>Schleichera oleosa</i>	600	30	5	0.17 ^C	2.63	1.39	9.8	0.16	0.00318
8.	<i>Ixora pavetta</i>	200	40	1	0.03 ^R	2.26	4.17	7.4	0.08	0.00035
9.	<i>Ehretia laevis</i>	160	40	1	0.03 ^R	2.26	4.17	7.1	0.06	0.00023
10.	<i>Acacia auriculiformis</i>	240	30	2	0.07 ^C	1.50	5.56	6.4	0.09	0.00051
11.	<i>Streblus asper</i>	240	30	2	0.07 ^C	2.63	9.72	6.4	0.09	0.00051
12.	<i>Syzygium cumini</i>	240	30	2	0.07 ^C	1.13	1.39	6.4	0.09	0.00051
13.	<i>Zizyphus rugosa</i>	240	30	2	0.07 ^C	1.13	1.39	6.4	0.09	0.00051
14.	<i>Semicarpus anacardium</i>	120	30	1	0.03 ^R	1.88	5.56	5.3	0.05	0.00013
15.	<i>Xantolis tomentosa</i>	280	10	7	0.70 ^C	0.38	1.39	4.0	0.10	0.00069
16.	<i>Azadirachta indica</i>	120	10	3	0.30 ^C	5.64	4.17	2.5	0.05	0.00013
17.	<i>Bambusa aurindinacea</i>	120	10	3	0.30 ^C	2.26	4.17	2.5	0.05	0.00013
18.	<i>Bridelia pubescens</i>	40	10	1	0.10 ^C	9.02	4.17	1.8	0.02	0.00001
19.	<i>Antidesma ghaesembilla</i>	40	10	1	0.10 ^C	1.13	4.17	1.8	0.02	0.00001
20.	<i>Cassia siamea</i>	40	10	1	0.10 ^C	0.38	1.39	1.8	0.02	0.00001
	Total	10640	720	64	2.78	100	100	200	2.33	0.14

Note-D-Density, F- Frequency, A- Abundance, A/F- Abundance to frequency ratio, RD- Relative density, RF- Relative frequency, PV- Provenance value, H'- Shannon-Wiener diversity index and Cd-Concentration of dominance.

Azadirachta indica, *Antidesma ghaesembilla* and *Cassia siamea* (10%) (Table-3).

Biodiversity indices : The species diversity of trees, saplings and seedlings was 1.94, 2.15 and 2.33 respectively. The concentration of dominance value of 0.28, 0.21, and 0.14 was recorded for trees, saplings and seedlings respectively.

Distribution pattern : Out of 16 tree species, 7 species showed contagious distribution and 9 species showed random distribution. In saplings out of 18 species, 7 species showed contagious distribution and 10 species showed random and one species showed regular distribution. Out of 20 seedling species, 15 species showed contagious distribution, 4 species showed random distribution and 1 species showed regular distribution.

In tree layer, tree density was found to be 435 ind. ha⁻¹, *Tectona grandis* reported to have maximum density, frequency, basal area and IVI and minimum value was recorded for *Anogeissus acuminata*. Panda *et al.* (2013) found stand density varied from 268 stems ha⁻¹ in Nayagarh to as high as 655 stems ha⁻¹ in Rayagada district of Odisha which is consistent with the present finding. The

basal area of the tree layer was 14.63 m² ha⁻¹ which was in parallel with the findings of other scientists who reported 17.9 to 180.1 m² ha⁻¹ in the temperate forests of Himalaya Sharma and Baduni (2000).

In sapling layer, the maximum density, frequency, basal area and IVI was recorded in *Dispyrus sylvatica* and the minimum value was recorded for *Bridelia retusa*. The sapling density was found to be 570 ind ha⁻¹. The present finding was consistent with the findings of Panda *et al.* (2013) who reported sapling density of 530 inds ha⁻¹ of 20 species of the forest of Eastern Ghats of India.

The seedling density and PV was found highest in *Diospyrus sylvatica* and the lowest value was recorded in *Bridelia pubescence*, *Antidesma ghaesembilla* and *Cassia siamea*. The seedling density was found to be 10640 ind ha⁻¹. The finding of the present study was consistent with the findings of Panda *et al.* (2013) who reported the seedling and sapling density for ten different districts of odisha varied from 6301 to 9273 ind ha⁻¹.

The species diversity of trees, saplings and seedlings was 1.94, 2.15 and 2.33 respectively which were within the reported range of 0.83 to 4.1 for the forests of Indian sub-continent (Jha and Singh, 1990)

The concentration of dominance value of 0.28, 0.21, and 0.14 was recorded for trees, saplings and seedlings respectively which was less than 0.42-0.86, 0.58-1.0, 0.32- 0.58 for trees, saplings, and seedlings respectively in Lohaghat forest of Kumaun Himalaya (Lodhiyal *et al.*, 2015) but consistent with the findings of Sharma *et al.* (2009) reported concentration of dominance ranged from 0.135 to 0.321 in temperate mixed forest.

At the study site, 56% tree species showed random distribution and 44% showed contagious distribution pattern. Saha *et al.* (2016) found in a study at Garhwal Himalaya at lower altitude the tree species showed variable distribution pattern of contagious, regular and mostly contagious. Saplings showed contagious/random distribution but mostly contagious and seedlings should Random and contagious distribution and mostly random.

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Effect of Priming Treatments on Germination and Vegetative Performance of Seedlings in Red Sander (*Pterocarpus santalinus* Linn. f.)

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Abstract

The present investigation was undertaken to study the "Effect of priming treatments on germination and vegetative performance of seedlings in Red Sandalwood (*Pterocarpus santalinus* Linn. f.)" was carried out in the nursery of College of Forestry, Odisha University of Agriculture and Technology, Bhubaneswar 2021- 23. The experiment was laid out in Completely Randomized Design (CRD) which consists of 13 treatment combinations and three replications. The results of experiment showed that seeds treated with GA₃ @ 750 mg/l (T-6) gave the highest germination percentage (64.33%) including other germination parameters. Maximum seedling length (12.80 cm), collar diameter (0.32 cm) and root length (26.87 cm) were highest in T-6. In the biomass study, above ground dry weight (3.80g), below ground dry weight (2.46g) and total dry weight (6.26g) were maximum with the treatment of GA₃ @ 750 mg/l (T-6). The seeds soaked with T-6 (GA₃ @ 750 mg/l for 24 hours) minimized days required for initiation of germination as well as enhance germination percentage and growth of seedling. The same treatment also recorded maximum seed vigour index of 820.27 and highest Dickson quality index 0.598 of seedlings.

Introduction

Pterocarpus santalinus is most commonly known as red sandalwood in English and Rakta Chandana in Hindi belongs to the family Fabaceae. The name "Pterocarpus" comes from the Greek words "pteron" (wing), Karpos (fruit), which refers to the winged pod, and santalinus (meaning similar to), which refers to a plant with traits resembling those of Indian sandalwood, *Santalum album* L. It is an endemic species and due to overexploitation for its timber in South India, the IUCN categorised it as an endangered species. Red sander is a strong light demander and cannot withstand water-logged conditions. It thrives in extremely shallow to shallow brown, sandy loam, or bouldery soils on slopes and hills. Pterocarpus is prized for its dense, darkly figured heartwood, wavy grains, and santalin, a red- coloured dye. Bioactive substances found in the heartwood of this tree have been shown to have a wide range of biological activities, suggesting the potential of *P. santalinus* for the treatment of various diseases viz., pitta, leprosy, ulcers, fistula, and haemorrhages, diabetes, headache, skin diseases, and jaundice (Rastogi *et al.* 1960 and Arokiyaraj *et al.* 2008). This species is highly adulterated with *Santalum album*. Outside of India, Japan has been noted as the primary market for this species' wood. The leaves are trifoliate and alternating, measuring 3–9 cm long. The leaves fall starts from Jan to mid-March. The flowers are yellow, densely arranged in simple or sparingly branched racemes. Flowering occurs from February to April, soon after new leaves come in April and continue till mid-May. The fruits are 6–9-centimetre-long pods that formed

rapidly but get ripened in next February–March. After eleven months of flowering, the matured reddish brown winged pods are formed with one or two seeds in it (Dayanand, 1988). Pods have an irregular orbicular shape, are 3–4 cm in diameter (including the wing). Kalimuthu and Lakshmanan reported the poor seed germination in 1995. Seed germination has been advocated as one of the most viable tools for the ex-situ conservation of threatened germplasm (Rao *et al.*, 2004). Given the high demand for wood, constrained distribution, slow regeneration, illicit collection, trade, habitat degradation, and other factors, Red Sanders are difficult to propagate naturally because to their protracted dormancy, poor germinability, and low viability of seeds. Low germination speed results in prolonged germination that can last up to 60 days after sowing. (Kalimuthu and Lakshmanan, 1995). This species cannot be reproduced on a large scale using traditional vegetative propagation methods like grafting and air-layering, and cuttings from these plants have poor roots. (Reddy & Sri Vasuki, 1990). Tissue culture can be a promising technique for conservation and large-scale multiplication of several woody species but the Fabaceae family has difficulty with in vitro culturing. Air layers, when compared to stem cuttings, have robust and vigorous roots but the rate of manipulation is low and insufficient to transplant from nursery to main field (Rao & Raju, 2002). Because of the above-mentioned factors, seeds play a significant role in the multiplication of this species. (Dayanand & Lohidas, 1988). Given the value of *Pterocarpus santalinus* for commerce, the challenges of seed multiplication, the scientific understanding of seed characteristics causing poor germination, and methods to

address these challenges is important but deficit. Hence, this study was carried with the aim to achieve synchronised germination through seed priming techniques.

Materials and Methods

The study was conducted, in the nursery of College of Forestry, Odisha University of Agriculture and Technology, Bhubaneswar, during 2021-23. The present experiment was carried out to study the effect of different chemicals on seed germination and seedling growth of Red sander. The experimental design was CRD and there were 13 treatments which were replicated thrice. The treatment details are :

Treatment	Details of treatment
T ₁	Pods soaked in lukewarm water for 24 hours
T ₂	Pods soaked in lukewarm water for 48 hours. Water was changed once in 24 hours for leaching out of the chemicals present in the pods
T ₃	Pods soaked in lukewarm water for 72 hours. Water was changed once in 24 hours for leaching out of the chemicals present in the pods
T ₄	GA ₃ @ 500ppm for 24 hours
T ₅	GA ₃ @ 600ppm for 24 hours
T ₆	GA ₃ @ 750ppm for 24 hours
T ₇	KNO ₃ (1.5%) for 20 minutes and soaking in water (24 hrs)
T ₈	KNO ₃ (2.5%) for 20 minutes and soaking in water (24 hrs)
T ₉	KNO ₃ (5%) for 20 minutes and soaking in water (24 hrs)
T ₁₀	PEG 6000 @ 1% concentration for 12 hours
T ₁₁	PEG 6000 @ 2.5 % concentration for 12 hours
T ₁₂	PEG 6000 @ 5 % concentration for 12 hours
T ₁₃	No pre-treatments

The seeds were removed from respective solutions, air dried in room temperature on tissue paper for 15 minutes and then immediately used for sowing. The seeds were sown in polythene bags of 7?x9? size containing media mixture of red soil + FYM + vermicompost (1:1:1) at the depth of about 2 to 3 cm, covered by a shallow layer of media and watered immediately using rose can. The observations were recorded for days required for initiation of germination, germination percentage, number of leaves per seedling, collar diameter, seedling height, leaf area per plant, fresh weight of shoot, fresh weight of root, dry weight of shoot, dry weight of root, vigour index and seedling quality index.

Results and Discussion

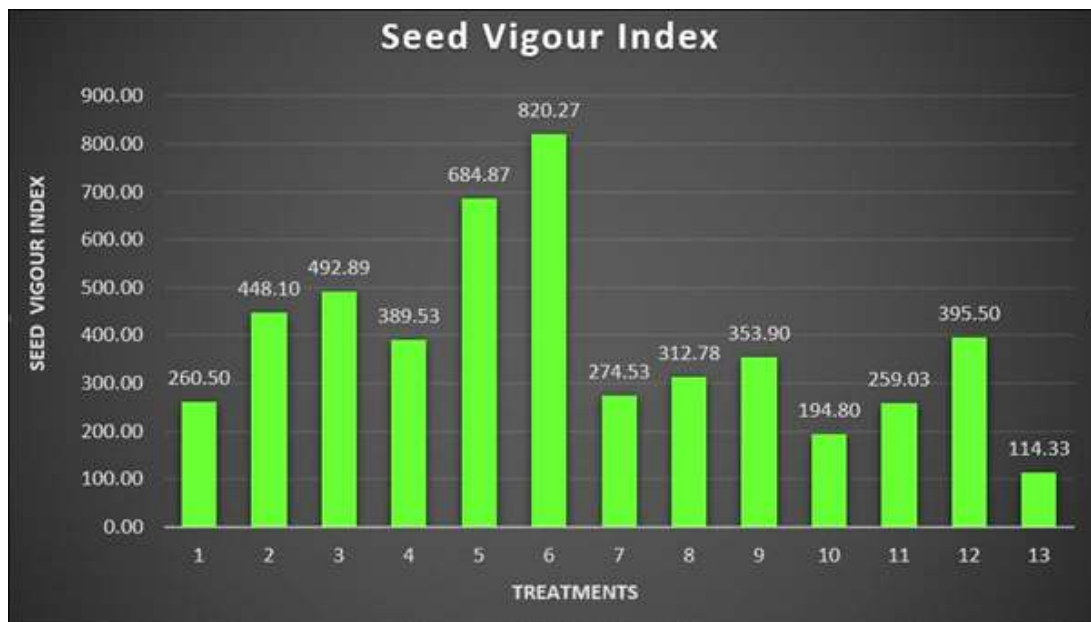
The treatment with GA₃ was effective in inducing highest germination percentage (66.33%) in T-6. the lowest germination percentage was observed in case of

untreated seeds. The germination energy and germination value were also highest for T-6 i.e., 45% and 22.93% respectively. Similar findings were observed by Patel *et al.*, (2018) where the *Red Sander* seeds when treated with GA₃ 500 ppm resulted in 66.67% germination and Thanuja *et al.*, (2019) in *Pterocarpus marsupium*. The increased germination percentage in GA₃ treated seeds might be attributed to fact that the GA₃ helps in breaking the seed dormancy which resulted in early and enhanced seed germination due to the diffusion of endogenous auxin and gibberellins like substances (Gurung *et al.*, 2014; Singh *et al.*, 2016). GA₃ enhanced seed germination, because it might have antagonized the effect of inhibitors present in aonla seeds reported by Kumari *et al.*, (2007). The increase in germination percentage with GA₃ might be due to involvement of GA₃ in the activation of cytological enzymes along with increase in cell wall plasticity and better water absorption (Padma *et al.*, 2013). All GA₃ treatments were effective for increasing seed germination when compared with the control. GA₃ stimulates germination power, relative growth rate and earlier beginning production with germination time. The seedling vigour index was highest in T-6 (820.27) and lowest in T-13(114.33).

The data pertaining to seedling growth after 110 days in nursery is shown in Table-2. Seeds primed with different priming agents showed significantly different seedling height. The significantly maximum height (12.80 cm) was found in T-6. While T-13 (control) was recorded with minimum height (5.50 cm). The maximum collar diameter of 0.31 cm and highest root length (46.27cm) was observed in T-6. Whereas the minimum collar diameter of 0.03 cm and the lowest root length (19.83cm) recorded for T-13. The present finding was consistent with the findings of Suteesh *et al.*, (2017) in *Santalum album*. This may be due to germination characters were directly correlated with the seedling growth and vigour. Seedlings of different treatments showed significantly different leaf area and number of leaves. The maximum leaf area (20.63cm²) and no. of leaves (9.01) was found in T-6. The present finding is in line with the observations made by Lalitha *et al.*, (2020) in *Emblica officinalis*. Seeds primed differently showed significantly different above ground biomass (fresh weight) and above ground biomass (dry weight). The maximum above ground biomass fresh and dry weight of 2.13g and 1.63g respectively was recorded in T-6. The significantly highest below ground biomass (fresh weight) of 1.34g was observed in T-6. However, the lowest below ground biomass (fresh weight) of 0.62g was recorded in T-13. Similarly, in case of dry weight of below ground biomass highest (1.21g) was recorded in T-6 and The highest total biomass dry

Table-1 : Germination parameters of *Pterocarpus santalinus*.

Treatments	Germ. %	G.E %	MGT	MDG	P.V.	G.V %
T ₁	34.67	23.33	11.06	1.64	2.9	4.73
T ₂	51.00	31.67	15.47	2.43	5.3	12.86
T ₃	52.67	28.00	14.44	2.50	5.9	14.73
T ₄	54.67	35.33	16.60	2.60	5.3	13.78
T ₅	60.33	37.33	17.39	2.87	6.2	17.77
T ₆	64.33	45.00	17.66	3.06	7.5	22.93
T ₇	32.67	23.33	6.95	1.55	4.8	7.50
T ₈	35.67	31.00	9.68	1.69	4.3	7.27
T ₉	38.67	24.67	9.88	1.84	4.9	9.00
T ₁₀	23.33	16.33	5.34	1.43	3.3	4.71
T ₁₁	28.33	20.67	5.87	1.35	4.2	5.66
T ₁₂	41.67	24.00	12.36	1.98	3.6	7.26
T ₁₃	20.67	17.33	6.88	0.98	2.1	2.02
SE	3.67	2.78	1.87	0.21	0.22	1.05
C.D. (5%)	7.53	5.72	3.84	0.43	0.46	2.15
C.V. (%)	10.83	12.38	19.87	12.75	5.92	12.79

Figure-1 : Seed vigour index of *Pterocarpus santalinus* different treatments.

weight of 2.84g was found in T-6. The reason for increased fresh and dry weight of the plant may be related to the seedling's overall growth and increased rate of photosynthesis, which caused the photosynthates to be assimilated and distributed throughout the entire plant. As a result of more dry matter accumulation, there is more growth. Patel *et al.*, (2018) reported similar findings in the recent study of *Pterocarpus santalinus*. Seedling quality index or Dickson's quality index quantifies the morphological quality of seedlings. Highest SQI was observed in T-6

(0.598) and lowest SQI was observed in case of T-13 (0.074).

Conclusions

On the basis of results obtained, it was concluded GA₃ was found to be a superior priming agent in the study. The seeds soaked with GA₃ @ 750 mg/l for 24 hours minimized days required for initiation of germination as well as enhance germination percentage and growth of seedling. The same treatment also recorded maximum seed vigour index of 820.27 and highest Dickson quality index of 0.598 for seedlings.

Table-2 : *Pterocarpus santalinus* seedling characters at 110 DAS in nursery.

Treatments	Plant height (cm)	Collar diameter (cm)	No. of leaves/plant	Leaf area (sq. cm)	Root length (cm)
T ₁	7.50	0.16	5.66	10.80	14.60
T ₂	8.80	0.18	6.33	15.40	15.55
T ₃	9.40	0.25	8.33	18.80	19.26
T ₄	7.10	0.27	6.66	12.60	16.32
T ₅	11.40	0.29	7.66	15.77	24.00
T ₆	12.80	0.32	9.01	20.63	26.87
T ₇	8.50	0.17	5.33	12.55	15.20
T ₈	8.75	0.20	5.39	16.23	17.27
T ₉	9.17	0.24	5.65	20.25	22.20
T ₁₀	8.30	0.22	7.00	9.00	16.43
T ₁₁	9.13	0.23	7.67	10.60	20.20
T ₁₂	9.50	0.24	8.00	14.00	28.47
T ₁₃	5.50	0.10	5.33	5.70	13.83
SEM	0.62	0.03	0.79	1.38	1.85
CD 5%	1.28	0.07	1.62	2.83	3.80
CV %	8.53	17.85	14.25	12.04	11.77

Table-3 : Seedling biomass of *Pterocarpus santalinus* at 110 DAS in nursery.

Treatment	Above ground biomass (fresh weight in grams)	Above ground biomass (dry weight in grams)	Below ground biomass (fresh weight in grams)	Below ground biomass (dry weight in grams)	Total biomass (dry weight in grams)
T ₁	1.16	0.90	0.71	0.58	1.48
T ₂	1.59	1.00	0.92	0.66	1.66
T ₃	2.07	1.23	1.20	0.89	2.12
T ₄	1.36	0.83	0.75	0.61	1.44
T ₅	1.49	1.38	1.29	1.12	2.50
T ₆	2.13	1.63	1.34	1.21	2.84
T ₇	0.81	0.72	0.65	0.62	1.34
T ₈	1.34	1.13	0.81	0.74	1.87
T ₉	1.59	1.25	1.12	1.01	2.26
T ₁₀	0.94	0.74	0.83	0.79	1.53
T ₁₁	1.24	1.01	0.94	0.90	1.91
T ₁₂	1.78	1.45	1.16	1.09	2.54
T ₁₃	1.07	0.71	0.62	0.59	1.30
SEM	0.17	0.17	0.14	0.13	0.22
CD 5%	0.35	0.35	0.30	0.27	0.45
CV %	14.45	19.18	18.61	19.26	14.05

Figure-2 : Seedling Quality Index of *Pterocarpus santalinus* in different priming treatments.

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Effect of Foliar Application of Micronutrients on Growth, Yield Attributes and Yield of Wheat (*Triticum aestivum* L.)

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Abstract

Wheat (*Triticum aestivum* L.) is the most significant crop for food production, a key cereal crop and a substantial source of staple foods. The trial in the field was completed in the *rabi* period 2022-23 to research the impact of foliar treatment of micronutrients on growth, yield attributes and yield of wheat (*Triticum aestivum* L.). The experiment was set up using a randomised block design (RBD) with three replications and nine treatments. The treatments include: T_1 (control), T_2 (water spray), T_3 (zinc 0.5%), T_4 (boron 0.5%), T_5 (manganese 0.5%), T_6 (zinc 0.5% + boron 0.5%), T_7 (boron 0.5% + manganese 0.5%), T_8 (manganese 0.5% + zinc 0.5%) and T_9 (boron 0.5% + manganese 0.5% + zinc 0.5%). The findings showed that foliar micronutrient application significantly enhanced plant height, total tiller count, spikelets per head, effective tiller count, grains per head, spike length, grain yield, test weight, biological yield, straw yield and harvest index of wheat over control and water spray. Among all the treatments, T_9 gave the best results which might be due to synergistic interaction of micronutrients.

Key words : Wheat, micronutrients, foliar application, growth, yield attributes and yield.

Introduction

Wheat (*Triticum aestivum* L.) is the most crucial crop for food production, a key cereal crop and a substantial source of staple foods. Wheat is the most important source of protein and is the major dietary component throughout the world as a food grain. Wheat has more nutritive value than most other cereals (Zohary and Hopf 2000). Globally, area under wheat (*Triticum spp.*) is about 222.15 million hectares with annual production and yield around 779.33 million tonnes and 3.51 tonnes per hectare respectively (USDA 2022).

Micronutrients are crucial for plant's metabolic and physiological processes and their lack can disrupt plant's developmental cycle and have a negative impact on productivity (Tripathi *et al* 2015). Wheat responded better to organic fertilisers when micronutrients were used in addition to NPK (Badaruddin *et al* 1999). All micronutrients applied topically have a considerable impact on yield characteristics and content of proteins. Although they are only required in small quantities, a sufficient supply increases availability of nutrients and has a favourable impact on the physiology of cells, which also affects productivity (Toaima *et al* 2000). Due to growing economic and environmental issues, micronutrient utilisation is crucial (Soleimani 2006). Micronutrients are believed to be crucial to the increase in yield (Rehm & Sims 2006). Due to the use of micronutrients, crop productivity has significantly increased (Liew 1988). According to Khan *et al* (2006), mineral fertilizer

application enhanced the copper, iron, manganese and zinc concentrations of wheat grain.

Foliar micronutrient application is more advantageous than other application techniques like seed priming, soil treatment and fortification. The percentage of seed protein and other yield-related factors rise as a result of foliar spray (Boorboori *et al* 2012). The combined foliar spray of macronutrients and micronutrients results in a significant boost in wheat output (Arif *et al* 2006). According to Mekkei and Eman (2014), the combined foliar spray of iron, copper, manganese and zinc produced higher values of plant height, tiller count per meter square, spike count per meter square, length of spike, spikelet count per head, grain count per head, test weight, biological yield, straw yield, grain yield and harvest index, correspondingly, in both seasons. This was followed by the values obtained from the foliar spray of zinc, manganese, iron and copper respectively. Response of wheat to exogenous micronutrient application has been estimated by many reports in the past but there is not too much work done on the combined treatment of micronutrients boron (B), zinc (Zn) and manganese (Mn) on growth and yield of wheat. Therefore, the objective of this experiment was to research the impact of foliar micronutrient application on growth, yield attributes and yield of wheat.

Materials and Methods

The research entitled "Effect of foliar application of micronutrients on growth, yield attributes and yield of

wheat (*Triticum aestivum* L.)” was completed in the *rabi* period 2022-23 at the Agricultural Experimental Farm of Regional Institute of Management and Technology located in Punjab, India. The current trial consisting of nine treatments was put up using a randomised complete block design. The treatments were allocated randomly in three replications. The plot's overall dimensions were 3.5 m by 1.4 m. The seeds of wheat variety “PBW 824” were sown at the rate of hundred kilogrammes per hectare with a gap of 20 cm between each row. The consistent amount of DAP was applied as a baseline dosage which provided full recommended dose of phosphorous and 20% of suggested dosage of nitrogen. Urea was used to administer the remaining quantity of nitrogen in two evenly split doses. The micronutrients were foliar sprayed twice, once at the boot stage and once at the anthesis stage. Treatments include:

T_1 : Control, T_2 : Water spray, T_3 : Zinc 0.5%, T_4 : Boron 0.5%, T_5 : Manganese 0.5% T_6 : Zinc 0.5% + Boron 0.5%, T_7 : Boron 0.5% + Manganese 0.5%, T_8 : Manganese 0.5% + Zinc 0.5%, T_9 : Boron 0.5% + Manganese 0.5% + Zinc 0.5%

The plant height was measured by selecting and tagging five random plants from each plot. The total tiller count and productive tiller count per metre row length were tallied at three separate locations in all plots and the mean was then calculated. The length of all the ears of the 5 tagged plants from all plots was estimated from the lower spikelet's base to the upper spikelet's tip. All the ears of the 5 labelled plants from each plot were cropped and the spikelets and grains in each spike were counted. For biological and grain yields ($q\ ha^{-1}$), whole plot was harvested and tied to bundles. Data was taken from net plot size. By deducting grain yield from biological yield, the straw yield ($q\ ha^{-1}$) was computed. The harvest index (%) was determined by dividing grain yield by biological yield and multiplying the result by hundred. A composite sample of grains was collected at the time of threshing from all the plots and 1000 grains were counted and weighted to obtain test weight. The data were analysed using the statistical tool OPSTAT (Sheoran *et al* 1998). The significance of the data as a whole was assessed using ANOVA and the treatment means were contrasted by applying a critical difference (CD) test with a probability threshold of 5%.

Results and Discussion

Growth parameters

Plant height : The plant height recorded at 60, 90, 120 DAS and at maturity is listed in Table-1. At 60 DAS, the difference in the plant heights caused by the various treatments was found to be non- significant. This may be

due to the reason that treatments were applied at booting and anthesis stages. Plant height recorded at 90, 120 DAS and at maturity was significantly affected by foliar micronutrient application. At 90 DAS, the plant height obtained from all the micronutrient treatments was significantly higher than the plant height obtained from treatments T_1 (control) and T_2 (water spray). The maximum plant height (103.5 cm) was noted for T_9 treatment which was at par with plant height (102.9 cm) recorded for T_7 treatment and significantly higher than all other treatments. Among T_4 , T_5 and T_3 treatments, higher plant height (98.1 cm) was noted for T_4 . The minimum plant height (94.9 cm) was attained from T_1 (control) which was equivalent to plant height (95.2 cm) obtained from T_2 (water spray). An analogous pattern was seen at 120 DAS and at maturity. These findings are in accordance with Magid *et al* (2000).

Total tiller count per metre length of row : The total tiller count was recorded at 60, 90, 120 DAS and at maturity (Table-2). At 60 DAS, the total tiller count owing to various treatments did not differ significantly. This may be due to the reason that the treatments were used at booting and anthesis stages. The total tiller count at 90, 120 DAS and at maturity was significantly impacted by foliar treatment of micronutrients. At 90 DAS, total tiller count obtained from all the micronutrient treatments was significantly higher than the total tiller count obtained from treatments T_1 (control) and T_2 (water spray). The highest total tiller count (83.3) was obtained from T_9 treatment which was equivalent to the total tiller count (82.7) obtained from T_7 treatment and significantly higher than all other treatments. Among T_4 , T_5 and T_3 treatments, maximum total tiller count (79.3) was due to T_4 . The lowest total tiller count (75.8) was obtained from T_1 treatment (control) which was equivalent to the total tiller count (76.3) obtained from T_2 treatment (water spray). Similar trend was observed at 120 DAS and maturity. These conclusions are in accordance with Khan *et al* (2010).

Yield attributes and yield

Productive tiller count per metre length of row : The productive tiller count recorded at 90, 120 DAS and at maturity was significantly impacted by foliar application of micronutrients (Table 2). At 90 DAS, productive tiller count obtained from all the micronutrient treatments was significantly higher than the productive tiller count obtained from treatments T_1 (control) and T_2 (water spray). The maximum productive tiller count (73.7) was obtained from T_9 treatment which was equivalent to the productive tiller count (72.7) obtained from T_7 treatment and significantly higher than all other treatments. Among T_4 , T_5 and T_3 treatments, maximum productive tiller count (69.3) was due T_4 . The minimum productive tiller count (65.8)

Table-1 : Effect of foliar micronutrient application on plant height.

Treatments	Plant height (cm)			
	60 DAS	90	120	Maturity
T ₁ : Control	65.8	94.9	97.6	98.9
T ₂ : Water spray	66.4	95.2	97.9	99.3
T ₃ : Zinc 0.5%	66.1	96.6	99.4	100.7
T ₄ : Boron 0.5%	66.6	98.1	100.3	101.9
T ₅ : Manganese 0.5%	66.3	97.8	100.2	101.2
T ₆ : Zn 0.5% + Boron 0.5%	66.6	100.5	103.5	104.8
T ₇ : Boron 0.5% + Mn 0.5%	66.1	102.9	105.7	107.2
T ₈ : Mn 0.5% + Zinc 0.5%	66.8	100.4	102.9	104.1
T ₉ : Boron 0.5% + Mn 0.5% + Zinc 0.5%	66.5	103.5	106.4	107.9
CD (0.05)	NS	0.8	0.9	0.85

Table-2 : Impact of foliar micronutrient application on total tiller count and productive tiller count of wheat.

Treatments	Total tiller count per metre length of row				Productive tiller count per metre length of row		
	60 DAS	90	120	Maturity	90 DAS	120	Maturity
T ₁ : Control	75.2	75.8	71.8	69.8	65.8	68.8	67.8
T ₂ : Water spray	75.7	76.3	72.3	70.3	66.3	69.3	68.3
T ₃ : Zinc 0.5%	75.2	77.7	73.7	71.7	67.7	70.7	69.7
T ₄ : Boron 0.5%	75.2	79.3	75.3	73.3	69.3	72.3	71.0
T ₅ : Manganese 0.5%	74.7	79.0	75.0	73.0	69.0	72.0	71.0
T ₆ : Zinc 0.5% + Boron 0.5%	75.0	81.5	77.5	75.5	72.2	75.2	74.2
T ₇ : Boron 0.5% + Manganese 0.5%	75.0	82.7	78.7	76.7	72.7	75.7	74.7
T ₈ : Manganese 0.5% + Zinc 0.5%	75.2	81.2	77.2	75.2	71.2	74.2	73.2
T ₉ : Boron 0.5% + Mn 0.5% + Zinc 0.5%	75.5	83.3	79.3	77.3	73.7	76.7	75.7
CD (0.05)	NS	1.0	1.0	1.0	1.2	1.2	1.3

was attained from T₁ treatment (control) which was equivalent to the productive tiller count (66.3) due to T₂ treatment (water spray). Similar trend was observed at 120 DAS and at maturity. These findings are consistent with those of Magid *et al* (2000) and Khan *et al* (2010).

Spike length (cm) : The spike length observed at maturity was significantly impacted by foliar treatment of micronutrients (Table 3). The spike length attained from all the micronutrient treatments was significantly higher than the spike length obtained from the treatments T₁ (control) and T₂ (water spray). The maximum spike length (10.3 cm) was obtained from T₉ treatment which was at par with the spike length obtained from T₇ (10.2 cm), T₆ (10 cm) and T₈ (9.9 cm) treatments. Among T₄, T₅ and T₃ treatments, higher value was obtained due to T₄ (8.89 cm). The minimum spike length (7.83 cm) was obtained from T₁ treatment (control) which was at par with the spike length (7.86 cm) obtained from T₂ treatment (water spray). These conclusions are consistent with those of Zain *et al* (2015).

Spikelets per head: The spikelets per head observed at maturity were significantly affected by foliar treatment of micronutrients (Table 3). The spikelets per spike obtained from all the micronutrient treatments were significantly higher than the spikelets obtained from the treatments T₁ (control) and T₂ (water spray). The maximum spikelets per

spike (19.0) were recorded for T₉ treatment which was at par with the spikelets (18.9) recorded for T₇ treatment and significantly higher than all other treatments. Among T₄, T₅ and T₃ treatments, maximum spikelets per spike (16.9) were recorded for T₄. The minimum spikelets per spike (14.3) were obtained from T₂ treatment (water spray) which was at par with the spikelets (14.4) obtained from T₁ treatment (control). These conclusions are consistent with those of Arif *et al* (2006).

Grains per head : The grain count per head observed at maturity was significantly impacted by foliar treatment of micronutrients (Table 3). The grain count per spike attained from all the micronutrient treatments was significantly higher than the grain count per spike attained from the treatments T₁ (control) and T₂ (water spray). The maximum grains per head (65) was obtained from T₉ treatment which was at par with grains per spike (64.5) obtained from T₇ treatment and significantly higher than all other treatments. Among T₄, T₅ and T₃ treatments, maximum grains per spike (55.2) were recorded for T₄. The minimum grains per spike (47.2) were obtained from T₁ treatment (control) which was at par with the grains per spike (47.7) obtained from T₂ treatment (water spray). These findings are in accordance with Khan *et al* (2010), Nadim *et al* (2011) and Amjad *et al* (2013).

Table-3 : Effect of foliar treatment of micronutrients on spike length, spikelets per head, grains per head and test weight.

Treatments	Spike length (cm)	Spikelets per head	Grains per head	Test weight (g)
T ₁ : Control	7.83	14.4	47.2	38.7
T ₂ : Water spray	7.86	14.3	47.7	38.9
T ₃ : Zinc 0.5%	8.78	15.5	51.3	40.4
T ₄ : Boron 0.5%	8.89	16.9	55.2	42.0
T ₅ : Manganese 0.5%	8.82	16.7	54.9	42.0
T ₆ : Zn 0.5% + Boron 0.5%	10.0	18.2	59.4	44.5
T ₇ : Boron 0.5% + Mn 0.5%	10.2	18.9	64.5	46.6
T ₈ : Mn 0.5% + Zinc 0.5%	9.90	18.1	58.7	44.3
T ₉ : B 0.5% + Mn 0.5% + Zn 0.5%	10.3	19.0	65	47.0
CD (0.05)	0.7	0.4	0.85	0.8

Table-4 : Impact of foliar treatment of micronutrients on grain yield, straw yield, biological yield and harvest index.

Treatments	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Biological yield (q ha ⁻¹)	Harvest index (%)
T ₁ : Control	52.2	77.3	129.5	40.3
T ₂ : Water spray	52.3	77.4	129.7	40.3
T ₃ : Zinc 0.5%	53.5	78.5	132.0	40.5
T ₄ : Boron 0.5%	55.0	79.5	134.5	40.9
T ₅ : Manganese 0.5%	54.9	79.3	134.2	40.9
T ₆ : Zn 0.5% + Boron 0.5%	57.1	80.7	137.8	41.4
T ₇ : Boron 0.5% + Mn 0.5%	59.0	81.5	140.5	42.0
T ₈ : Mn 0.5% + Zinc 0.5%	56.9	80.6	137.5	41.4
T ₉ : Boron 0.5% + Mn 0.5% + Zinc 0.5%	59.5	81.8	141.3	42.1
CD (0.05)	0.3	0.5	0.6	0.2

Test weight (g) : The test weight observed after harvesting was significantly impacted by foliar treatment of micronutrients (Table 3). The test weight obtained from all the micronutrient treatments was significantly higher than the test weight attained from the treatments T₁ (control) and T₂ (water spray). The maximum test weight (47 g) was obtained from T₉ treatment which was at par with the test weight (46.6 g) attained from T₇ treatment and significantly higher than all other treatments. Among T₄, T₅ and T₃ treatments, maximum test weight (42 g) was noted for T₄. The minimum test weight (38.7 g) was attained from T₁ treatment (control) which was at par with the test weight (38.9 g) obtained from T₂ treatment (water spray). These conclusions are in line with those of Khan *et al* (2010) and Amjad *et al* (2013).

Grain yield (q ha⁻¹) : The grain yield observed after harvesting was significantly impacted by foliar micronutrient application (Table 4). The grain yield attained from all the micronutrient treatments was significantly higher than the grain yield obtained from the treatments T₁ (control) and T₂ (water spray). The maximum grain yield (59.5 q ha⁻¹) was attained from T₉ treatment which was significantly higher than all other treatments. The grain yield attained from T₉ treatment was

followed by the grain yield (59.0 q ha⁻¹) attained from T₇, the grain yield (57.1 q ha⁻¹) attained from T₆ and the grain yield (56.9 q ha⁻¹) attained from T₈. Among T₄, T₅ and T₃ treatments, maximum grain yield (55.0 q ha⁻¹) was due to T₄. The minimum grain yield (52.2 q ha⁻¹) was attained from T₁ treatment (control) which was equivalent to the grain yield (52.3 q ha⁻¹) obtained from T₂ treatment (water spray). These conclusions are consistent with those of Amjad *et al* (2013) and Asad and Rafique (2002).

Straw yield (q ha⁻¹) : The straw yield was significantly impacted by foliar treatment of micronutrients (Table 4). The straw yield attained from all the micronutrient treatments was significantly higher than the straw yield obtained from the treatments T₁ (control) and T₂ (water spray). The maximum straw yield (81.8 q ha⁻¹) was attained from T₉ which was equivalent to the straw yield (81.5 q ha⁻¹) attained from T₇ and significantly higher than all other treatments. The minimum straw yield (77.3 q ha⁻¹) was attained from T₁ treatment (control) which was equivalent to the straw yield (77.4 q ha⁻¹) attained from T₂ treatment (water spray). These results are in accordance with Asad and Rafique (2002).

Biological yield (q ha⁻¹) : The biological yield was significantly impacted by foliar micronutrient application

(Table 4). The biological yield obtained from all the micronutrient treatments was significantly higher than the biological yield obtained from the treatments T_1 (control) and T_2 (water spray). The maximum biological yield (141.3 q ha^{-1}) was attained from T_9 treatment which was significantly higher than all other treatments. Among T_4 , T_5 and T_3 treatments, higher biological yield (134.5 q ha^{-1}) was due to T_4 . The minimum biological yield (129.5 q ha^{-1}) was attained from T_1 treatment (control) which was equivalent to the biological yield (129.7 q ha^{-1}) attained from T_2 treatment (water spray). These conclusions are consistent with those of Khan *et al* (2010).

Harvest index (%) : The harvest index was significantly impacted by foliar treatment of micronutrients (Table 4). The harvest index obtained from all the micronutrient treatments was significantly higher than the harvest index obtained from the treatments T_1 (control) and T_2 (water spray). The maximum harvest index (42.1%) was attained from T_9 treatment which was at par with harvest index (42.0%) due to T_7 treatment and significantly higher than all other treatments. Among T_4 , T_5 and T_3 treatments, higher harvest index (40.9%) was obtained from T_4 . The minimum harvest index (40.3%) was obtained from T_1 treatment (control) which was equivalent to the harvest index (40.3%) obtained from T_2 treatment (water spray). These conclusions are consistent with those of Zain *et al* (2015).

Conclusions

From the research, it may be concluded that foliar treatment of micronutrients significantly enhanced plant height, total tiller count, length of head, productive tiller count, spikelets per head, grains per head, grain yield, test weight, biological yield, straw yield and harvest index of wheat over control and water spray. Among all the treatments, T_9 (B 0.5% + Zn 0.5% + Mn 0.5%) gave the best results which might be due to synergistic interaction of micronutrients.

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Effect of Post-Emergence Herbicides on Growth, Yield and Economics of Soybean (*Glycine max* L. Merrill.)

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Abstract

A study was conducted at Instructional Farm, KVK, Khargone (M.P.) during *kharif* seasons of 2020 and 2021. The soil of the experimental field was classified as medium black cotton soils containing 50% silt and clay together. Sixteen weed management treatments administered in soybean replicated three times in randomized block design. The 20 kg N, 60 kg P₂O₅ and 20 kg K₂O per hectare were optimum dose for NPK. The Complete Dose of N, P and K were applied by DAP and muriate of potash at the time of sowing. Soybean variety 'JS 95-60' was sown at row spacing of 45 cm with seed rate of 80 kg ha⁻¹. All recommended practices were followed during crop growing season. The growth parameters viz.; plant height and number of Branches per plant were significantly higher in Weeds free check - T₁₅ than all the herbicidal treatments, while lowest value was noted under Weedy check - T₁₆. The significantly higher value of seed yield and harvest index were registered under Weeds free check - T₁₅ (2060 kg ha⁻¹ and 35.17%; respectively) over all the treatments, while lower value was noted under Weedy check - T₁₆ (931 kg ha⁻¹ and 24.31%; respectively). Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ were showed significantly effective and at par values over rest of the treatments. The next effective results showed under Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ were most effective over rest of the treatments. The net return were recorded significantly higher under Weeds free check - T₁₅ (69796 ? ha⁻¹) over all the treatments, while lower value was noted under Weedy check - T₁₆ (23639 ? ha⁻¹). Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ (65345 ? ha⁻¹) and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ (64172 ? ha⁻¹) were showed significantly effective and at par values over rest of the treatments. The next effective results showed under Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ (58124 ? ha⁻¹) and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ (58074 ? ha⁻¹) over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ (49671 ? ha⁻¹) and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ (49460 ? ha⁻¹) were most effective over rest of the treatments.

Key words : Growth parameters, harvest index, net return, soybean, weed management practices, yield.

Introduction

Soybean (*Glycine max* L. Merrill) being a "Miracle crop" has multiple uses. It contains 35-40% protein, 19% oil, 35% carbohydrate, 5% minerals and several other components like vitamins. In India, it is cultivated on an average area of 10.47 million hectares with the production of 10.98 million tonnes and productivity of 1049 kg ha⁻¹. Madhya Pradesh accounts for 47.9% of the total cultivated area and 48.5% of the total production of soybean in the country (Anonymous, 2022). In India soybean is extensively grown during rainy season (*kharif*) from June-September during which the environment is more congenial for excessive weed invasion. The excessive occurrence of weeds limits the full expression of yield potential of this crop.

The various grassy and broad leaf weeds compete for essential nutrients, moisture, sunlight and space especially during the first 40 days after sowing and cause substantial losses in the yield to the range of 31 to 84%

depending upon the weed flora and intensity (Kachroo *et al.*, 2003). Hand weeding is a traditional method of controlling weeds, but continuous rains and unavailability of labour during peak period are main limitations of this method. Under such circumstances, the only alternative that needs to be explored is the use of herbicides, but use of only single herbicide again and again may lead to development of resistance in different weed species. Besides, a use of any single weed control measure is also not feasible due highly diverse life cycles and survival strategies of different weed species. Therefore, sequential application of herbicidal mixture or integrated weed management may broaden the window of weed control by broad-spectrum herbicides. Some studies conducted in the northern part of the country indicated that application of herbicides alone or with mechanical weeding may provide consistent control of weeds rather than use of single method of weed control (Malik *et al.*, 2006) and give higher seed yield (Patel *et al.*, 2016).

Materials and Methods

A study was conducted at Instructional Farm, KVK, Khargone (M.P.) during *kharif* seasons of 2020 and 2021. The soil of the experimental field was classified as medium black cotton soils containing 50% silt and clay together. The experiment consisted of Sixteen weed management treatments comprising (Propaquizafop (10%) 100 g ha⁻¹ PoE + HW at 30 DAS, Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE, Haloxifop-r-methyl (10.5%) 135 g ha⁻¹ PoE + HW at 30 DAS, Quizalofop-ethyl (5%) 60 g ha⁻¹ PoE + HW at 30 DAS, Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE, Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS, Imazethapyr (35%) + Imazamox (35%) 70 g ha⁻¹ PoE, Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS, Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS, Sodium-acifluorfen (16.5%) + Clodinafop-propargyl (8%) 245 g ha⁻¹ PoE, Fenoxaprop-p-ethyl (10%) + Chlorimuron-ethyl (25%) 100+9.37 g ha⁻¹ PoE, Quizalofop-ethyl (5%) 50 g ha⁻¹ PoE + HW 30 DAS, Quizalofop-ethyl (5%) + Chlorimuron-ethyl (25%) 50+9.37 g ha⁻¹ PoE, Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS, Weeds free check and Weedy check) with three replications. The 20 kg N, 60 kg P₂O₅ and 20 kg K₂O per hectare were optimum dose for NPK. The Complete Dose of N, P and K were applied by DAP and muriate of potash at the time of sowing. Soybean variety 'JS 95-60' was sown at row spacing of 45 cm with seed rate of 80 kg ha⁻¹. All recommended practices were followed during crop growing season. The difference between treatment means were compared with the critical differences (CD) at 5% level of probability (P=0.05).

Results and Discussion

The growth parameters *viz.*; plant height and number of Branches per plant were significantly higher in Weeds free check - T₁₅ than all the herbicidal treatments, while lowest value was noted under Weedy check - T₁₆ at all growth stages except at harvest. Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ were showed significantly effective and at par values over rest of the treatments. The next effective results showed under Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ were most effective over rest of the treatments (Table 1 & 2).

The significantly higher value of seed yield and harvest index were registered under Weeds free check -

T₁₅ (2060 kg ha⁻¹ and 35.17%; respectively) over all the treatments, while lower value was noted under Weedy check - T₁₆ (931 kg ha⁻¹ and 24.31%; respectively). Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ (1937 kg ha⁻¹ and 34.60%; respectively) and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ (1904 kg ha⁻¹ and 34.37%; respectively) were showed significantly effective and at par values over rest of the treatments. The next effective results showed under Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ (1783 kg ha⁻¹ and 33.26%; respectively) and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ (1761 kg ha⁻¹ and 33.22%; respectively) over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ (1561 kg ha⁻¹ and 31.89%; respectively) and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ (1546 kg ha⁻¹ and 31.71%; respectively) were most effective over rest of the treatments (Table 3).

The net return were recorded significantly higher under Weeds free check - T₁₅ (69796 ? ha⁻¹) over all the treatments, while lower value was noted under Weedy check - T₁₆ (23639 ? ha⁻¹). Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ (65345 ? ha⁻¹) and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ (64172 ? ha⁻¹) were showed significantly effective and at par values over rest of the treatments. The next effective results showed under Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ (58124 ? ha⁻¹) and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ (58074 ? ha⁻¹) over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ (49671 ₹ ha⁻¹) and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ (49460 ? ha⁻¹) were most effective over rest of the treatments (Table 3).

Due to favourable conditions created by weed management practices; which resulted higher accumulation of crop dry matter and optimum translocation of food materials to the pod as well as effective uptake of nutrients and moisture. These results are in line with the work of Virk *et al.* (2018), Patel *et al.* (2019) and Koturwar *et al.* (2022).

Conclusions

For Nimar Valley Agro-climatic zone; effective value of growth parameters and yield as well as economics were recorded significantly under Weeds free check - T₁₅ over all the treatments, while lower value was noted under Weedy check - T₁₆. Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ were showed significantly effective and at par values over rest

Table-1 : Effect of herbicides on plant height of soybean (Pooled).

Symbol	Treatment	Plant height (cm)			
		At 20 DAS	At 40 DAS	At 60 DAS	At Harvest
T ₁	Propaquizafop (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	23.12	35.20	40.77	42.86
T ₂	Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha ⁻¹ PoE	22.84	33.48	39.99	42.04
T ₃	Haloxypop-r-methyl (10.5%) 135 g ha ⁻¹ PoE + HW at 30 DAS	23.06	35.03	40.57	42.64
T ₄	Quizalofop-ethyl (5%) 60 g ha ⁻¹ PoE + HW at 30 DAS	23.00	34.86	40.37	42.45
T ₅	Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha ⁻¹ PoE	22.77	33.13	39.79	41.78
T ₆	Imazethapyr (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	23.45	35.89	41.16	43.28
T ₇	Imazethapyr (35%) + Imazamox (35%) 70 g ha ⁻¹ PoE	22.70	32.78	39.40	41.67
T ₈	Imazethapyr (70%) 70 g ha ⁻¹ PE + HW at 30 DAS	24.25	36.24	41.55	43.49
T ₉	Chlorimuron-ethyl (25%) 9.37 g ha ⁻¹ PoE + HW 30 DAS	23.19	35.55	40.96	43.08
T ₁₀	Sodium-acifluorfen (16.5%) + Clodinafop-propargyl (8%) 245 g ha ⁻¹ PoE	22.64	32.51	39.21	41.45
T ₁₁	Fenoxaprop-p-ethyl (10%) + Chlorimuron-ethyl (25%) 100+9.37 g ha ⁻¹ PoE	22.61	32.26	39.01	41.23
T ₁₂	Quizalofop-ethyl (5%) 50 g ha ⁻¹ PoE + HW 30 DAS	22.93	34.51	40.18	42.26
T ₁₃	Quizalofop-ethyl (5%) + Chlorimuron-ethyl (25%) 50+9.37 g ha ⁻¹ PoE	22.54	32.09	38.81	40.90
T ₁₄	Diclosulam (84%) 26 g ha ⁻¹ PE + HW 30 DAS	24.39	36.76	41.94	43.68
T ₁₅	Weeds free check	24.70	37.45	43.11	45.51
T ₁₆	Weedy check	22.48	32.21	38.62	40.24
SEM±		0.62	0.90	1.17	1.13
CD @5%		1.75	2.54	3.30	NS

SE(m), Standard error of treatment mean; CD, Critical difference; PoE, Post-emergence; PE, Pre-emergence.

Table-2 : Effect of herbicides on branches plant⁻¹ of soybean (Pooled).

Symbol	Treatment	Branches plant ⁻¹			
		At 20 DAS	At 40 DAS	At 60 DAS	At Harvest
T ₁	Propaquizafop (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	0.53	1.87	2.23	2.30
T ₂	Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha ⁻¹ PoE	0.47	1.73	2.10	2.17
T ₃	Haloxypop-r-methyl (10.5%) 135 g ha ⁻¹ PoE + HW at 30 DAS	0.50	1.83	2.20	2.27
T ₄	Quizalofop-ethyl (5%) 60 g ha ⁻¹ PoE + HW at 30 DAS	0.50	1.80	2.17	2.23
T ₅	Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha ⁻¹ PoE	0.43	1.70	2.07	2.13
T ₆	Imazethapyr (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	0.53	1.93	2.30	2.37
T ₇	Imazethapyr (35%) + Imazamox (35%) 70 g ha ⁻¹ PoE	0.43	1.67	2.03	2.10
T ₈	Imazethapyr (70%) 70 g ha ⁻¹ PE + HW at 30 DAS	0.57	1.97	2.33	2.43
T ₉	Chlorimuron-ethyl (25%) 9.37 g ha ⁻¹ PoE + HW 30 DAS	0.53	1.90	2.27	2.33
T ₁₀	Sodium-acifluorfen (16.5%) + Clodinafop-propargyl (8%) 245 g ha ⁻¹ PoE	0.40	1.63	2.00	2.07
T ₁₁	Fenoxaprop-p-ethyl (10%) + Chlorimuron-ethyl (25%) 100+9.37 g ha ⁻¹ PoE	0.37	1.60	1.97	2.03
T ₁₂	Quizalofop-ethyl (5%) 50 g ha ⁻¹ PoE + HW 30 DAS	0.47	1.77	2.13	2.20
T ₁₃	Quizalofop-ethyl (5%) + Chlorimuron-ethyl (25%) 50+9.37 g ha ⁻¹ PoE	0.33	1.57	1.93	2.00
T ₁₄	Diclosulam (84%) 26 g ha ⁻¹ PE + HW 30 DAS	0.60	2.00	2.37	2.50
T ₁₅	Weeds free check	0.67	2.17	2.60	2.73
T ₁₆	Weedy check	0.17	1.00	1.20	1.37
SEM±		0.01	0.05	0.05	0.06
CD @5%		0.04	0.14	0.15	0.17

Table-3 : Effect of Post-emergence herbicides on yield and economics of soybean (Pooled).

Symbol	Treatment	Seed yield (kg ha ⁻¹)	HI (%)	Net return (₹ ha ⁻¹)
T ₁	Propaquizafop (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	1746	33.19	55523
T ₂	Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha ⁻¹ PoE	1561	31.89	49671
T ₃	Haloxifop-r-methyl (10.5%) 135 g ha ⁻¹ PoE + HW at 30 DAS	1724	32.89	56095
T ₄	Quizalofop-ethyl (5%) 60 g ha ⁻¹ PoE + HW at 30 DAS	1704	32.87	54024
T ₅	Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha ⁻¹ PoE	1546	31.71	49460
T ₆	Imazethapyr (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	1783	33.26	58124
T ₇	Imazethapyr (35%) + Imazamox (35%) 70 g ha ⁻¹ PoE	1527	31.59	48369
T ₈	Imazethapyr (70%) 70 g ha ⁻¹ PE + HW at 30 DAS	1904	34.37	64172
T ₉	Chlorimuron-ethyl (25%) 9.37 g ha ⁻¹ PoE + HW 30 DAS	1761	33.22	58074
T ₁₀	Sodium-acifluorfen (16.5%) + Clodinafop-propargyl (8%) 245 g ha ⁻¹ PoE	1500	31.49	46796
T ₁₁	Fenoxaprop-p-ethyl (10%) + Chlorimuron-ethyl (25%) 100+9.37 g ha ⁻¹ PoE	1483	31.45	45445
T ₁₂	Quizalofop-ethyl (5%) 50 g ha ⁻¹ PoE + HW 30 DAS	1686	32.72	53165
T ₁₃	Quizalofop-ethyl (5%) + Chlorimuron-ethyl (25%) 50+9.37 g ha ⁻¹ PoE	1471	31.41	45285
T ₁₄	Diclosulam (84%) 26 g ha ⁻¹ PE + HW 30 DAS	1937	34.60	65345
T ₁₅	Weeds free check	2060	35.17	69796
T ₁₆	Weedy check	931	24.31	23639
SEm±		41	0.81	1831
CD @5%		115	2.28	5180

of the treatments. The next effective results showed under Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ were most effective over rest of the treatments.

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Bio-Efficacy of Post-Emergence Herbicides against Weeds and Yield of Soybean (*Glycine max* L. Merrill.)

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Abstract

A study was conducted at Instructional Farm, KVK, Khargone (M.P.) during *kharif* seasons of 2020 and 2021. The soil of the experimental field was classified as medium black cotton soils containing 50% silt and clay together. Sixteen weed management treatments administered in soybean replicated three times in randomized block design. Soybean variety 'JS 95-60' was sown at row spacing of 45 cm with seed rate of 80 kg ha⁻¹. All recommended practices were followed during crop growing season. The weed floras were observed in the experimental field included *Cyperus rotundus* (L.), *Cynodon dactylon* (L.) Pers., *Commelina communis* (L.), *Parthenium hysterophorus* (L.), *Digera arvensis* (L.) Forsk. and *Alternanthera sessilis* (L.) R. Br. during both the years of study. The species-wise and total weeds density and dry weight were registered significantly higher in Weedy check - T₁₆ over all the treatments including Weeds free check - T₁₅. Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ were noted significantly effective and at par values over rest of the treatments. The next effective results registered by Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ under reducing the density and dry weight of weeds over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ were most effective in reducing the density and dry weight of weeds over rest of the treatments. The significantly higher value of seed yield, stover yield and harvest index were registered under Weeds free check - T₁₅ (2060 kg ha⁻¹, 3851 kg ha⁻¹ and 35.17%; respectively) over all the treatments, while lower value was noted under Weedy check - T₁₆ (931 kg ha⁻¹, 2987 kg ha⁻¹ and 24.31%; respectively).

Key words : Harvest index, Soybean, Weed management practices, Yield

Introduction

Soybean (*Glycine max* L. Merrill) being a "Miracle crop" has multiple uses. It contains 35-40% protein, 19% oil, 35% carbohydrate, 5% minerals and several other components like vitamins. In India, it is cultivated on an average area of 10.47 million hectares with the production of 10.98 million tonnes and productivity of 1049 kg ha⁻¹. Madhya Pradesh accounts for 47.9% of the total cultivated area and 48.5% of the total production of soybean in the country (Anonymous, 2022). In India soybean is extensively grown during rainy season (*kharif*) from June-September during which the environment is more congenial for excessive weed invasion. The excessive occurrence of weeds limits the full expression of yield potential of this crop.

The various grassy and broad leaf weeds compete for essential nutrients, moisture, sunlight and space especially during the first 40 days after sowing and cause substantial losses in the yield to the range of 31 to 84% depending upon the weed flora and intensity (Kachroo *et al.*, 2003). Hand weeding is a traditional method of controlling weeds, but continuous rains and unavailability of labour during peak period are main limitations of this method. Under such circumstances, the only alternative that needs to be explored is the use of herbicides, but use

of only single herbicide again and again may lead to development of resistance in different weed species. Besides, a use of any single weed control measure is also not feasible due highly diverse life cycles and survival strategies of different weed species. Therefore, sequential application of herbicidal mixture or integrated weed management may broaden the window of weed control by broad-spectrum herbicides.

Some studies conducted in the northern part of the country indicated that application of herbicides alone or with mechanical weeding may provide consistent control of weeds rather than use of single method of weed control (Bineet *et al.*, 2001) and give higher seed yield (Singh *et al.*, 2016).

Materials and Methods

A study was conducted at Instructional Farm, KVK, Khargone (M.P.) during *kharif* seasons of 2020 and 2021. The soil of the experimental field was classified as medium black cotton soils containing 50% silt and clay together. The experiment consisted of Sixteen weed management treatments comprising (Propaquizafop (10%) 100 g ha⁻¹ PoE + HW at 30 DAS, Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE, Haloxifop-r-methyl (10.5%) 135 g ha⁻¹ PoE + HW at 30 DAS, Quizalofop-ethyl (5%) 60 g ha⁻¹ PoE + HW at 30

DAS, Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE, Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS, Imazethapyr (35%) + Imazamox (35%) 70 g ha⁻¹ PoE, Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS, Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS, Sodium-acifluorfen (16.5%) + Clodinafop-propargyl (8%) 245 g ha⁻¹ PoE, Fenoxaprop-p-ethyl (10%) + Chlorimuron-ethyl (25%) 100+9.37 g ha⁻¹ PoE, Quizalofop-ethyl (5%) 50 g ha⁻¹ PoE + HW 30 DAS, Quizalofop-ethyl (5%) + Chlorimuron-ethyl (25%) 50+9.37 g ha⁻¹ PoE, Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS, Weeds free check and Weedy check) with three replications. The 20 kg N, 60 kg P₂O₅ and 20 kg K₂O per hectare were optimum dose for NPK. The Complete Dose of N, P and K were applied by DAP and muriate of potash at the time of sowing. Soybean variety 'JS 95-60' was sown at row spacing of 45 cm with seed rate of 80 kg ha⁻¹. All recommended practices were followed during crop growing season. The difference between treatment means were compared with the critical differences (CD) at 5% level of probability (P=0.05).

Results and Discussion

Effect on Weeds : The weed floras were observed in the experimental field included *Cyperus rotundus* (L.), *Cynodon dactylon* (L.) Pers., *Commelina communis* (L.), *Parthenium hysterophorus* (L.), *Digera arvensis* (L.) Forsk. and *Alternanthera sessilis* (L.) R. Br. during both the years of study.

The density and dry weight of *Digera arvensis*, *Commelina communis*, *Cynodon dactylon*, *Parthenium hysterophorus*, *Cyperus rotundus*, *Alternanthera sessilis* and Total weeds were significantly higher in Weedy check - T₁₆ over all the treatments including Weeds free check - T₁₅ at all growth stages except at 20 DAS (Table 1 & 2).

At 20 DAS; all treatments including Weedy check - T₁₆ recorded at par density and dry weight of all weeds except Weeds free check - T₁₅, Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈; which registered complete control of all weeds. At rest of the stages; Weeds free check - T₁₅ showed complete control of all weeds. Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ were noted significantly effective and at par values over rest of the treatments. The next effective results registered by Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ under reducing the density and dry weight of all weeds over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ and Fluazifop-p-butyl (11.1%)

+ Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ were most effective in reducing the density and dry weight of all weeds over rest of the treatments.

The weed control efficiency of treatments based on total weeds dry weight fluctuated to a significant extent under the influence of weed management practices at all crop growth stages (Table 3). At 20 DAS; Weeds free check - T₁₅, Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ recorded complete control of Total weeds, hence it registered significantly higher weed control efficiency over rest of the treatments including Weedy check - T₁₆. At rest of the stages; Weeds free check - T₁₅ recorded complete control of Total weeds. Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ were showed significantly effective and at par values over rest of the treatments. The next effective results showed Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ were most effective over rest of the treatments.

The superiority of Weeds free check - T₁₅ was due to complete control of weed flora under whole duration of crop. Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ showed effective results over rest of the treatments was due to weeds manage within critical period of crop-weed competition by the combination of herbicidal and mechanical methods of weed management. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ noted superiority over rest of the treatments due to their broad-spectrum effect by combination of two molecules, which enhance weed controlling ability. The other explanations of the lower weed dry weight under various treatments was mainly due to effective weed control efficiency; which resulted lower density of narrow-leaf and broad-leaf weeds. The results are in conformity with the findings of Meena *et al.* (2018), Emmiganur and Hosmath (2020) and Singh *et al.* (2020).

Effect on Yield : Yield is the economic part of the crop, which is based on availability of all favourable growth conditions which play very crucial role in enhancement of yield attributes.

The significantly higher value of seed yield, stover yield and harvest index were registered under Weeds free check - T₁₅ (2060 kg ha⁻¹, 3851 kg ha⁻¹ and 35.17%; respectively) over all the treatments, while lower value

Table-1 : Effect of herbicides on density of Total weeds in soybean (Pooled).

Symbol	Treatment	Density of Total weeds per m ²			
		At 20 DAS	At 40 DAS	At 60 DAS	At Harvest
T ₁	Propaquizafop (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	1.94 (86.99)	0.00 (0.00)	0.70 (4.11)	0.68 (3.89)
T ₂	Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha ⁻¹ PoE	1.94 (86.77)	0.55 (2.67)	0.88 (6.61)	0.87 (6.51)
T ₃	Haloxifop-r-methyl (10.5%) 135 g ha ⁻¹ PoE + HW at 30 DAS	1.95 (89.07)	0.00 (0.00)	0.74 (4.64)	0.74 (4.59)
T ₄	Quizalofop-ethyl (5%) 60 g ha ⁻¹ PoE + HW at 30 DAS	1.94 (87.20)	0.00 (0.00)	0.80 (5.39)	0.78 (5.12)
T ₅	Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha ⁻¹ PoE	1.92 (82.77)	0.61 (3.15)	0.91 (7.31)	0.90 (7.09)
T ₆	Imazethapyr (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	1.89 (77.39)	0.00 (0.00)	0.55 (2.67)	0.55 (2.67)
T ₇	Imazethapyr (35%) + Imazamox (35%) 70 g ha ⁻¹ PoE	1.95 (88.75)	0.68 (3.95)	0.94 (7.79)	0.94 (7.73)
T ₈	Imazethapyr (70%) 70 g ha ⁻¹ PE + HW at 30 DAS	0.00 (0.00)	0.00 (0.00)	0.43 (1.81)	0.44 (1.81)
T ₉	Chlorimuron-ethyl (25%) 9.37 g ha ⁻¹ PoE + HW 30 DAS	1.91 (80.59)	0.00 (0.00)	0.63 (3.36)	0.62 (3.25)
T ₁₀	Sodium-acifluorfen (16.5%) + Clodinafop-propargyl (8%) 245 g ha ⁻¹ PoE	1.89 (76.53)	0.70 (4.11)	0.98 (8.59)	0.97 (8.32)
T ₁₁	Fenoxaprop-p-ethyl (10%) + Chlorimuron-ethyl (25%) 100+9.37 g ha ⁻¹ PoE	1.92 (82.88)	0.78 (5.12)	1.00 (9.12)	1.00 (9.07)
T ₁₂	Quizalofop-ethyl (5%) 50 g ha ⁻¹ PoE + HW 30 DAS	1.90 (79.31)	0.00 (0.00)	0.84 (6.03)	0.83 (5.81)
T ₁₃	Quizalofop-ethyl (5%) + Chlorimuron-ethyl (25%) 50+9.37 g ha ⁻¹ PoE	1.94 (86.29)	0.81 (5.65)	1.03 (9.81)	1.02 (9.60)
T ₁₄	Diclosulam (84%) 26 g ha ⁻¹ PE + HW 30 DAS	0.00 (0.00)	0.00 (0.00)	0.38 (1.49)	0.38 (1.49)
T ₁₅	Weeds free check	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T ₁₆	Weedy check	1.95 (87.84)	1.99 (97.73)	2.02 (104.48)	2.03 (106.51)
SEm±		0.01	0.01	0.01	0.01
CD @5%		0.02	0.02	0.04	0.03
Trans.		Log(x+1)	Log(x+1)	Log(x+1)	Log(x+1)

*Data in parenthesis are actual data, SE(m), Standard error of treatment mean; CD, Critical difference; PoE, Post-emergence; PE, Pre-emergence.

Table-2 : Effect of herbicides on dry weight of Total weeds in soybean (Pooled).

Symbol	Treatment	Dry weight of Total weeds (g m ⁻²)			
		At 20 DAS	At 40 DAS	At 60 DAS	At Harvest
T ₁	Propaquizafop (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	67.96	0.00	4.35	5.11
T ₂	Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha ⁻¹ PoE	66.19	1.90	7.02	8.60
T ₃	Haloxifop-r-methyl (10.5%) 135 g ha ⁻¹ PoE + HW at 30 DAS	70.71	0.00	4.91	6.05
T ₄	Quizalofop-ethyl (5%) 60 g ha ⁻¹ PoE + HW at 30 DAS	66.31	0.00	5.71	6.75
T ₅	Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha ⁻¹ PoE	62.08	2.27	7.72	9.44
T ₆	Imazethapyr (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	57.37	0.00	2.82	3.46
T ₇	Imazethapyr (35%) + Imazamox (35%) 70 g ha ⁻¹ PoE	66.43	2.81	8.23	10.24
T ₈	Imazethapyr (70%) 70 g ha ⁻¹ PE + HW at 30 DAS	0.00	0.00	1.89	2.28
T ₉	Chlorimuron-ethyl (25%) 9.37 g ha ⁻¹ PoE + HW 30 DAS	62.14	0.00	3.55	4.22
T ₁₀	Sodium-acifluorfen (16.5%) + Clodinafop-propargyl (8%) 245 g ha ⁻¹ PoE	58.04	2.91	9.07	11.07
T ₁₁	Fenoxaprop-p-ethyl (10%) + Chlorimuron-ethyl (25%) 100+9.37 g ha ⁻¹ PoE	62.19	3.68	9.66	12.06
T ₁₂	Quizalofop-ethyl (5%) 50 g ha ⁻¹ PoE + HW 30 DAS	63.26	0.00	6.38	7.69
T ₁₃	Quizalofop-ethyl (5%) + Chlorimuron-ethyl (25%) 50+9.37 g ha ⁻¹ PoE	65.50	4.02	10.39	12.79
T ₁₄	Diclosulam (84%) 26 g ha ⁻¹ PE + HW 30 DAS	0.00	0.00	1.56	1.89
T ₁₅	Weeds free check	0.00	0.00	0.00	0.00
T ₁₆	Weedy check	66.29	109.34	152.74	200.40
SEm±		0.72	0.06	0.21	0.26
CD @5%		2.03	0.17	0.60	0.73

was noted under Weedy check - T₁₆ (931 kg ha⁻¹, 2987 kg ha⁻¹ and 24.31%; respectively). Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ (1937 kg ha⁻¹, 3701 kg ha⁻¹ and 34.60%; respectively) and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ (1904 kg ha⁻¹, 3666 kg ha⁻¹ and 34.37%; respectively) were showed significantly effective and at par values over

rest of the treatments. The next effective results showed under Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ (1783 kg ha⁻¹, 3569 kg ha⁻¹ and 33.26%; respectively) and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ (1761 kg ha⁻¹, 3551 kg ha⁻¹ and 33.22%; respectively) over rest of the treatments (Table 4).

Table-3 : Effect of herbicides on weed control efficiency in soybean (Pooled).

Symbol	Treatment	WCE (%)			
		At 20 DAS	At 40 DAS	At 60 DAS	At Harvest
T ₁	Propaquizafop (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	8.39	100.00	97.16	97.48
T ₂	Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha ⁻¹ PoE	10.22	98.28	95.40	95.71
T ₃	Haloxypop-r-methyl (10.5%) 135 g ha ⁻¹ PoE + HW at 30 DAS	4.19	100.00	96.79	96.99
T ₄	Quizalofop-ethyl (5%) 60 g ha ⁻¹ PoE + HW at 30 DAS	10.02	100.00	96.26	96.64
T ₅	Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha ⁻¹ PoE	16.05	97.95	94.94	95.29
T ₆	Imazethapyr (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	21.98	100.00	98.17	98.29
T ₇	Imazethapyr (35%) + Imazamox (35%) 70 g ha ⁻¹ PoE	10.29	97.46	94.59	94.90
T ₈	Imazethapyr (70%) 70 g ha ⁻¹ PE + HW at 30 DAS	100.00	100.00	98.79	98.88
T ₉	Chlorimuron-ethyl (25%) 9.37 g ha ⁻¹ PoE + HW 30 DAS	15.79	100.00	97.68	97.91
T ₁₀	Sodium-acifluorfen (16.5%) + Clodinafop-propargyl (8%) 245 g ha ⁻¹ PoE	21.32	97.35	94.06	94.47
T ₁₁	Fenoxaprop-p-ethyl (10%) + Chlorimuron-ethyl (25%) 100+9.37 g ha ⁻¹ PoE	15.74	96.65	93.68	93.99
T ₁₂	Quizalofop-ethyl (5%) 50 g ha ⁻¹ PoE + HW 30 DAS	14.55	100.00	95.82	96.17
T ₁₃	Quizalofop-ethyl (5%) + Chlorimuron-ethyl (25%) 50+9.37 g ha ⁻¹ PoE	11.60	96.34	93.19	93.62
T ₁₄	Diclosulam (84%) 26 g ha ⁻¹ PE + HW 30 DAS	100.00	100.00	98.99	99.08
T ₁₅	Weeds free check	100.00	100.00	100.00	100.00
T ₁₆	Weedy check	10.45	0.00	0.00	0.00
SEm±		1.00	0.04	0.09	0.09
CD @5%		2.83	0.10	0.26	0.24

Table-4 : Effect of Post-emergence herbicides on yield and harvest index of soybean (Pooled).

Symbol	Treatment	Seed yield	Stover yield	HI (%)
		(kg ha ⁻¹)	(kg ha ⁻¹)	
T ₁	Propaquizafop (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	1746	3533	33.19
T ₂	Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha ⁻¹ PoE	1561	3348	31.89
T ₃	Haloxypop-r-methyl (10.5%) 135 g ha ⁻¹ PoE + HW at 30 DAS	1724	3507	32.89
T ₄	Quizalofop-ethyl (5%) 60 g ha ⁻¹ PoE + HW at 30 DAS	1704	3498	32.87
T ₅	Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha ⁻¹ PoE	1546	3331	31.71
T ₆	Imazethapyr (10%) 100 g ha ⁻¹ PoE + HW at 30 DAS	1783	3569	33.26
T ₇	Imazethapyr (35%) + Imazamox (35%) 70 g ha ⁻¹ PoE	1527	3313	31.59
T ₈	Imazethapyr (70%) 70 g ha ⁻¹ PE + HW at 30 DAS	1904	3666	34.37
T ₉	Chlorimuron-ethyl (25%) 9.37 g ha ⁻¹ PoE + HW 30 DAS	1761	3551	33.22
T ₁₀	Sodium-acifluorfen (16.5%) + Clodinafop-propargyl (8%) 245 g ha ⁻¹ PoE	1500	3269	31.49
T ₁₁	Fenoxaprop-p-ethyl (10%) + Chlorimuron-ethyl (25%) 100+9.37 g ha ⁻¹ PoE	1483	3251	31.45
T ₁₂	Quizalofop-ethyl (5%) 50 g ha ⁻¹ PoE + HW 30 DAS	1686	3472	32.72
T ₁₃	Quizalofop-ethyl (5%) + Chlorimuron-ethyl (25%) 50+9.37 g ha ⁻¹ PoE	1471	3246	31.41
T ₁₄	Diclosulam (84%) 26 g ha ⁻¹ PE + HW 30 DAS	1937	3701	34.60
T ₁₅	Weeds free check	2060	3851	35.17
T ₁₆	Weedy check	931	2987	24.31
SEm±		41	87	0.81
CD @5%		115	245	2.28

Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ (1561 kg ha⁻¹, 3348 kg ha⁻¹ and 31.89%; respectively) and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ (1546 kg ha⁻¹, 3331 kg ha⁻¹ and 31.71%; respectively) were most effective over rest of the treatments. It can be explained in the light of the facts that these treatments control the weeds effectively, therefore more nutrients available to crop and consequently encouraged higher value of yield. These results are in

tune with the findings of Yadav *et al.* (2009), Umbarkar and Pandhure (2018) and Patel *et al.* (2019).

Conclusions

For Nimar Valley Agro-climatic zone; effective value of weeds management as well as yield were recorded significantly under Weeds free check - T₁₅ over all the treatments, while lower value was noted under Weedy check - T₁₆. Among Integrated methods; Diclosulam (84%) 26 g ha⁻¹ PE + HW 30 DAS - T₁₄ and Imazethapyr (70%) 70 g ha⁻¹ PE + HW at 30 DAS - T₈ were showed

significantly effective and at par values over rest of the treatments. The next effective results showed under Imazethapyr (10%) 100 g ha⁻¹ PoE + HW at 30 DAS - T₆ and Chlorimuron-ethyl (25%) 9.37 g ha⁻¹ PoE + HW 30 DAS - T₉ over rest of the treatments. Among herbicides; Propaquizafop (2.5%) + Imazethapyr (3.75%) 125 g ha⁻¹ PoE - T₂ and Fluazifop-p-butyl (11.1%) + Fomesafen (11.1%) 250 g ha⁻¹ PoE - T₅ were most effective over rest of the treatments.

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Nutrigenetic Hybrids Investigation for Nutrigenetic Parameters during Spring season under Subtropical condition of Jammu (J&K)

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Abstract

The present investigation for screening and evaluation of nutrigenetic traits of bivoltine silkworm hybrids was done for two years during spring season (2021 and 2022). During spring (2021), the consumption index was very less in hybrids viz., CSR50×BHR3 & RSJ14×B.con4 (0.26) followed by CSR50×B.con1 and CSR50×B.con4 (0.27) and RSJ14×B.con1 (0.29) compared to other hybrids. The efficiency conversion for ingesta to cocoon (%) was highest in the hybrids viz., FC₁×FC₂ (30.05) followed by RSJ14×B.con4 (29.53), CSR50×BHR3 (29.04), CSR50×B.con4 (28.94), CSR50×B.con1 (28.29) and RSJ14×B.con1 (26.62) whereas efficiency conversion for ingesta to shell (%) was highest in the hybrids viz., FC₁×FC₂ (21.13) followed by RSJ14×B.con4 (19.30) followed by CSR50×BHR3 (19.20), CSR50×B.con4 (18.90), CSR50×B.con1 (18.71) and RSJ14×B.con1 (17.60). The ingesta per gram of the cocoon (g) is very less compared to other hybrids viz., FC₁×FC₂ (3.33) followed by RSJ14×B.con4 (3.39) followed by CSR50×BHR3 (3.44), CSR50×B.con4 (3.46), CSR50×B.con1 (3.54) and RSJ14×B.con1 (3.76) whereas the ingesta per gram of the shell (g) is very less compared to other hybrids viz., FC₁×FC₂ (4.73) followed by RSJ14×B.con4 (5.18) followed by CSR50×BHR3 (5.21), CSR50×B.con4 (5.29), CSR50×B.con1 (5.35) and RSJ14×B.con1 (5.68). During spring (2022), the consumption index was very less in hybrids viz., CSR50×B.con1 & RSJ14×B.con4 (0.56), CSR50×B.con4, CSR50×BHR2 and CSR50×NB₄D₂ (0.57) compared to other hybrids. The efficiency conversion for ingesta to cocoon (%) was highest in the hybrids viz., CSR50×B.con1 (9.03), CSR50×B.con4 (8.57), CSR50×BHR2 (8.49), CSR50×NB₄D₂ (8.39) and CSR50×BHR3 (8.05) and efficiency conversion for ingesta to shell (%) was highest in the hybrids viz., CSR50×B.con1 (4.56), CSR50×B.con4 & CSR50×BHR3 (4.29), CSR50×BHR2 (4.16) and CSR50×NB₄D₂ (4.15). The ingesta per gram of the cocoon (g) was very less compared to other hybrids viz., CSR50×B.con1 (11.07), CSR50×B.con4 (11.66), CSR50×BHR2 (11.77), CSR50×NB₄D₂ (11.92) and CSR50×BHR3 (12.42) and ingesta per gram of the shell (g) was very less compared to other hybrids viz., CSR50×B.con1 (21.92), CSR50×BHR3 (23.29), CSR50×B.con4 (23.33), CSR50×BHR2 (24.07) and CSR50×NB₄D₂ (24.11). Based on the overall nutrigenetic traits utilized as index, five bivoltine silkworm hybrids viz., CSR50×BHR3, RSJ14×B.con4, CSR50×B.con1, CSR50×B.con4 and RSJ14×B.con1 during spring (2021) and CSR50×B.con1, RSJ14×B.con4, CSR50×B.con4, CSR50×BHR2 and CSR50×NB₄D₂ during spring (2022) respectively were identified as having the potential for nutrition efficiency conversion and can be utilized for further study as on station trial at different institutes. The data from the present study advances our knowledge for the development of nutritionally efficient silkworm hybrids and their effective commercial utilization in the sericulture industry.

Key words : Nutrigenetic traits, hybrids, food consumption, efficiency conversion, spring.

Introduction

Sericulture is one of the important agro-based economy generating industry as it contributes and offers great opportunities to the farming community including women and the farmers with small land holdings in the rural areas for their livelihood (Trivedi and Sarkar, 2015). One of the most important characteristics of the silkworm (*Bombyx mori* L.) (Lepidoptera: Bombycidae) is its ability to convert plant proteins to produce silk. The mulberry silkworm, *B. mori* is a monophagous insect that feeds exclusively on the mulberry foliage for its nutrition and produces the natural proteinous fibre. Mulberry, the sole food plant of *B. mori*, which contains all the nutrients for its growth and development (Nasreen *et al.*, 1999); plays a pivotal role in the overall development of silkworms, resulting in better

cocoon production. The ability of silk synthesis by the silkworm is inferred by the genetic constitution as well as the quality of mulberry feeding (Ramesha *et al.*, 2012; Zhang *et al.*, 2019) and varies with the mulberry varieties as well as silkworm breeds/hybrids (Kumar *et al.*, 2014). Among many factors attributed to reduction in silk production, the major one is the lack of nutrition efficiency conversion in silkworm breeds in tropical/subtropical areas. Therefore, one of the key considerations in developing hybrids for subtropical regions could be the need for nutrition efficiency conversion in silkworm breeds. The recent advances in silkworm breeding and those with nutrition efficiency conversion have opened up new avenues to evolve nutritionally efficient productive silkworm hybrids (Hamano *et al.*, 1986; Mano *et al.*, 1991; Ding *et al.*, 1992; Tzenov *et al.*, 1999; Zhang *et al.*, 2002;

Rahmathulla *et al.*, 2004; Ramesha *et al.*, 2010). Mulberry nutritional values are augmented in the silkworms' growth through the energy cycles and stored as a reserve for subsequent metamorphic events. They are simultaneously used for the silk synthesis required for spinning the cocoon shell. Through breeding programmes in both mulberry and silkworm, researchers have focused on these aspects and developed molecular introversion for improving silk conversion ability. Thus, nutritional intake has a direct impact on larval, cocoon, silk output, pupation, and reproduction traits.

It is a known fact that in silkworms, quantitative and qualitative traits of cocoons improve with enhanced nutrition (Legay, 1958; Adolkar *et al.*, 2007; Gangwar, 2010; Andadari *et al.*, 2021). For the sustainability of a breed/hybrid in the field, it should be nutritionally efficient as reflected by shell conversion, besides being disease resistant and exhibiting superior survival, yield and quality (Ramesha *et al.*, 2010). The leaf consumption efficiency of the silkworm depends on the genetic background and varies with the gene expression of physiological or nutritional unit in gene regulation (Giacobino *et al.*, 2003; Milner, 2004; Kang, 2008; Ogunbanwo and Okanlawon, 2009). The introduction of hybrids significantly improved the yield and quality of the silk and brought a new revolution in the sericulture industry. The silkworm breeds/hybrids with improved cocoon yield and superior quality silk made sericulture more sustainable in India (Ramesha *et al.*, 2010). Rupakshi and Goyal (2022) Hence, nutritional physiology plays an imperative role in the identification of genetic responses related to nutrient metabolism through conversion efficiency. Hence, the present study aims to assess the nutritional indices and conversional traits of the mulberry silkworm hybrids under subtropical condition of Jammu (J&K).

Materials and Methods

In the present investigation, fifteen nutrigenetic bivoltine hybrid combinations *viz.*, RSJ14×BHR2, RSJ14×BHR3, RSJ14×B.con1, RSJ14×B.con4, RSJ14×NB₄D₂, ATR16×BHR2, ATR16×BHR3, ATR16×B.con1, ATR16×B.con4, ATR16×NB₄D₂, CSR50×BHR2, CSR50×BHR3, CSR50×B.con1, CSR50×B.con4, CSR50×NB₄D₂ were prepared from the shortlisted breeds from the previous study *viz.*, BHR 2, BHR 3, B.con 1, B.con 4, CSR 50, ATR 16, NB₄D₂ and RSJ 14 at Regional Sericultural Research Station, Jammu and evaluation study was conducted during spring (2021 and 2022) season respectively along with CSR2×CSR4 and FC₁×FC₂ used as controls. The layings of all the hybrid combinations was incubated in properly disinfected rearing room while maintaining optimum 80-85 (%) humidity and 25°C temperature. The newly hatched larvae

were brushed with finely chopped fresh mulberry leaves and chawki worms were reared at a temperature of 26°C to 28°C and relative humidity of about 85-90 (%). The rearing of all the hybrids were carried out in a completely randomized design (CRD) with three replications each consists of 300 larvae maintained after third molt by following the standard rearing techniques reported by Krishnaswami (1978). While rearing larvae were provided with four feedings of fresh mulberry leaves harvested from the well maintained garden of the station till the onset of spinning. Further certain disinfectants like lime, bleaching powder etc. were used as precautionary measures to keep the rearing environment disease free. Once the larvae attains maturity were mounted in plastic collapsible mountages following all the standard protocol of mounting. Finally harvesting of the cocoons was carried out on 6th/7th day of spinning.

Estimation of nutritional traits : The nutrigenetic traits evaluation study was carried out for identification of suitable nutrigenetic hybrids during spring season (2021 and 2022) of the year in a completely randomized block design. Silkworm rearing was conducted following the standard method under the recommended temperature and relative humidity until the 4th molt. On the 1st day of fifth instar, 100 healthy silkworm larvae per hybrid in three replications of 300 larvae were selected for estimation of nutritional traits analysis. Accurately weighed fresh mulberry leaves were fed 3 times a day to the experimental batch. Simultaneously, an additional batch of larvae for each hybrid were maintained to determine the dry weight on subsequent daily increments in larval weight was recorded separately as suggested by Maynard and Loosli (1962). Silkworm rearing continued using appropriate plastic trays, the healthy larvae were counted daily in each replicate, and any missed larvae were replaced from the reserved batch. Left over leaves and excreta were collected on each subsequent day, separated manually and dried in a hot air oven daily at about 100°C until they reached constant weight using an air-tight electronic balance. When the larvae finished feeding they were shifted to the mountage for spinning at normal ambient temperature of 25±2°C and RH 65±5%. Cocoons were harvested 5 days later after completion of cocoon spinning. Harvested cocoons were analyzed for quantitative traits using the equations detailed below. The dry weight of left over leaves, excreta, larvae, cocoon, and shell in each of the breed were recorded. The nutrigenetic traits interaction was obtained by utilizing standard gravimetric analysis methods for consecutive seasons.

During the silkworm nutritional study, data was collected on the biomass of larvae and cocoons for the 19 nutrigenetic traits on ingesta, digesta, excreta, approximate digestibility (AD), reference ratio (RR),

consumption indices (CI), relative growth rate (RGR), respiration and metabolic rate (MR), efficiency conversion of ingesta (ECI) and digesta (ECD) for larva, cocoon, and shell. Further, the ingesta and digesta required for producing one gram of cocoon and shell (I/g and D/g) were to be collected and calculated as described by standard gravimetric methods (Waldbauer, 1968; Scriber and Feeny, 1979; Kogan and Parra, 1981; Slansky and Scriber, 1985), the equations with brief description of the nutrigenetic traits evaluated was given below.

Ingesta (g) : Total intake of the dry weight (g) of mulberry leaves by silkworm larvae during the 5th stage up to spinning or ripening stage : (Dry weight of leaf fed - Dry weight of left over leaf).

Digesta (g) : Total assimilated dry food from the intake or ingesta of dry weight of mulberry leaves by silkworm larva during the 5th stage until spinning or ripening: (Dry weight of leaf ingested - dry weight of litter).

Excreta (g) : Refers to the non-utilized mulberry leaves in the form of litter from the ingested mulberry leaves of a silkworm: (Ingesta - Digesta).

Approximate digestibility (%) : Directly indicates the assimilation efficiency of mulberry leaves and depends on the passage rate of food through gut in silkworm: ($AD = \text{Dry weight of digesta} / \text{Dry weight of food ingested} \times 100$).

Reference ratio : An indirect expression of absorption and assimilation of food. Expresses the ingesta required per unit excreta produced: ($RR = \text{Dry weight of food ingested} / \text{Dry weight of excreta}$).

Consumption index : Relates the rate of food intake to the mean weight of the larvae during the feeding period: ($CI = \text{Ingesta} / 5^{\text{th}} \text{ stage mean fresh larval weight (g)} \times 5^{\text{th}} \text{ stage larval duration in days}$).

Relative growth rate : Refers to larval gain biomass and indicates the efficiency of conversion of nutrition into larval biomass: ($RGR = \text{Weight gain of the larva during feeding period} / 5^{\text{th}} \text{ stage mean fresh larval weight (g)} \times 5^{\text{th}} \text{ stage larval duration in days}$).

Respiration : A catabolic reaction in which total oxidation of the digested or assimilated food for releasing energy required for the entire biological activities by break down of macromolecules into simpler molecules: (Dry weight of food digested - Maximum dry weight of larvae).

Metabolic rate : Measure of total biochemical reactions involving both catabolic and anabolic reactions of an organism, associated with the degradation of macromolecules into smaller unit and *vice versa*: ($MR = \text{Respiration} / 5^{\text{th}} \text{ stage mean fresh larval weight (g)} \times 5^{\text{th}} \text{ stage larval duration in days}$).

Efficiency conversion of ingesta to larva (%) : Associated with the efficiency conversion of ingested nutrition into biomass or body matter at different stages and expressed in percentage. ECI to larva was the efficiency of conversion of ingested food into larva: ($ECI \text{ larvae} = \text{Maximum dry weight of larva} / \text{Dry weight of ingesta} \times 100$).

Efficiency conversion of digesta to larva (%) : The expression of efficiency conversion of digesta into larval biomass: ($ECD \text{ larvae} = \text{Maximum dry weight of larva} / \text{Dry weight of digesta} \times 100$).

Efficiency conversion of ingesta to cocoon (%) : This is the most economically important trait used by the sericulture industry. It was the expression of efficiency conversion of ingesta into cocoon, also referred to as the leaf-cocoon conversion rate. This nutrigenetic trait was kept as the ultimate index for assessing the superiority of breed for nutritional efficiency in this investigation: ($ECI \text{ cocoon} = \text{Dry weight of cocoon} / \text{Dry weight of ingesta} \times 100$).

Efficiency conversion of digesta to cocoon (%) : It was the expression for efficiency conversion of digesta into cocoon: ($ECD \text{ cocoon} = \text{Dry weight of cocoon} / \text{Dry weight of digesta} \times 100$).

Efficiency conversion of ingesta to shell (%) : This was the expression efficiency conversion of ingesta into shell. It is also referred to as the leaf-shell conversion rate and is the ultimate index to evaluate superiority of breed in nutritional efficiency: ($ECI \text{ shell} = \text{Dry weight of shell} / \text{Dry weight of ingesta} \times 100$).

Efficiency conversion of digesta to shell (%) : The expression of efficiency conversion of digesta into shell: ($ECD \text{ shell} = \text{Dry weight of shell} / \text{Dry weight of digesta} \times 100$).

Ingesta per gram cocoon (g) : This was another important trait of economical significance to assess silkworm breed performance in nutrigenetic analysis. It was the expression of total ingesta required for the production of one gram of cocoon: ($I/g \text{ cocoon} = \text{Dry weight of ingesta} / \text{Dry weight of cocoon}$).

Digesta per gram cocoon (g) : The total digesta requisite for the production of one gram of cocoon: ($D/g \text{ cocoon} = \text{Dry weight of digesta} / \text{Dry weight of cocoon}$).

Ingesta per gram shell (g) : The total ingesta requisite for the production of one gram of shell: ($I/g \text{ shell} = \text{Dry weight of ingesta} / \text{Dry weight of shell}$).

Digesta per gram shell (g) : The total digesta requisite for the production of one gram of shell: ($D/g \text{ shell} = \text{Dry weight of digesta} / \text{Dry weight of shell}$).

The data on nutritional traits of the experimental hybrids were recorded on 19 nutrigenetic traits for each replicate were subjected to suitable statistical analysis.

Results and Discussion

Silkworm hybrids plays most influential factor in the development of sericulture industry. J&K has different agro-climatic conditions as compared to the different parts of the country and it requires special diligence to develop and evaluate specific hybrids suitable for J&K. In the above context an attempt was made to study the performance of all the selected single hybrids along with double hybrid and single hybrid used as control and the experimental results of all the selected hybrids for different parameters are presented in following Tables.

Performance on nutrigenetic traits : Considerable differences were found for 19 nutrigenetic traits among the bivoltine hybrids on nutritional parameters. Data were obtained for ingesta, digesta, excreta, AD, RR, CI, RGR, respiration, MR, ECI, and ECD to larval biomass, ECI and ECD to cocoon and shell, I/g and D/g to cocoon and shell for fifteen hybrids along with two controls under standard nutritional traits estimation. There was evidence of significant variation in consumption of mulberry leaf and food conversion to biomass for major nutrigenetic traits in all experimental bivoltine hybrids.

Ingesta, digesta, excreta, AD and RR : During spring season (2021), the data collected for ingesta ranged between highest in RSJ14×BHR2 (5.64 g) and lowest in FC₁×FC₂ (4.26 g) whereas the maximum digesta recorded in CSR50×BHR2 (2.53 g) with minimum in ATR16×BHR2 (0.99 g) whereas highest excreta observed in RSJ14×BHR2 (3.67 g) and lowest in CSR50×NB₄D₂ (2.60 g). Approximate digestibility ranged between CSR50×BHR2 (49.05%) to ATR16×BHR2 (23.10%) and the reference ratio with maximum value in CSR50×BHR2 (1.96) and minimum in ATR16×BHR2 (1.30) (Table-1) and all the parameters were showed statistically significant differences among them.

All the parameters were showing statistically significant differences during spring season (2022), the observation recorded for ingesta ranged between maximum in ATR16×BHR3 (11.39 g) and lowest in CSR50×B.con4 (10.73 g). The maximum digesta was recorded in ATR16×B.con1 (9.40 g) with minimum in CSR50×B.con1 (8.42 g) whereas highest excreta recorded in CSR50×NB₄D₂ (2.35 g) and lowest in ATR16×B.con4 (1.82 g). Approximate digestibility ranged between ATR16×B.con4 (83.69%) to CSR50×NB₄D₂ (78.34%) and the reference ratio with maximum value in ATR16×B.con4 (6.13) and minimum in CSR50×NB₄D₂ (4.62) (Table 3).

CI, RGR, Respiration and MR : During spring season (2021), the Consumption Index (CI) found to be highest in ATR16×NB₄D₂ (0.40) and lowest in CSR50×BHR3 & RSJ14×B.con4 (0.26). There was significant difference observed in Relative Growth Rate (RGR) with maximum in FC₁×FC₂ (0.05) and minimum in CSR2×CSR4 (0.03). A momentous difference were recorded with respect to respiration and found relatively more in ATR16×BHR3 (1.34 g) and less in FC₁×FC₂ (0.13 g). There is distinguishable divergence for Metabolic Rates (MR) among bivoltine selected hybrids which ranged between maximum in ATR16×BHR3 (0.09) and lowest in RSJ14×B.con4 (0.00) (Table-1).

During spring season (2022), the Consumption Index (CI) observed to be highest in ATR16×BHR2 (0.66) and lowest in RSJ14×B.con4 & CSR50×B.con1 (0.56) whereas there was significant differences observed in Relative Growth Rate (RGR) with maximum in ATR16×BHR3 & FC₁×FC₂ (0.04) and minimum in all other hybrids (0.03). A momentous difference were recorded with respect to respiration and found relatively more in ATR16×BHR2 (8.31 g) and less in CSR50×B.con1 (7.10 g). There is distinguishable divergence for Metabolic Rates (MR) among bivoltine selected hybrids which ranged between maximum in ATR16×BHR2 (0.48) and lowest in CSR50×B.con1 (0.37) (Table-3).

ECI and ECD to larval biomass : During spring season (2021), the data collected for efficiency of mulberry leaves ingested and converted into silkworm larval biomass varied significantly among the selected bivoltine hybrids (Table-2). The highest efficiency conversion of ingesta (ECI) to larva recorded in FC₁×FC₂ (35.21%) and lowest in CSR2×CSR4 (12.92%). With regard to Efficiency Conversion of Digesta (ECD) to larva significant variation was observed and more efficient conversion of digested food into larval biomass is recorded in RSJ14×B.con4 (96.02%) and less efficient in CSR2×CSR4 (35.96%).

During spring season (2022), the observation collected for efficiency of mulberry leaves ingested and converted into silkworm larval biomass varied significantly among the evaluated bivoltine hybrids (Table 4). The highest efficiency conversion of ingesta (ECI) to larva recorded in CSR50×B.con1 (12.29%) & lowest in ATR16×BHR2 (9.00%). With regard to Efficiency Conversion of Digesta (ECD) to larva significant variation was observed and more efficient conversion of digested food into larval biomass is recorded in CSR50×B.con1 (15.68%) and less efficient in ATR16×BHR2 (10.93%).

ECI and ECD to cocoon and shell : During spring season (2021), the data observed for Efficiency Conversion of Ingesta (ECI) to cocoon revealed that

Table-1 : Nutrigenetic traits recorded for different hybrid combinations (Late Spring, 2021).

Hybrids	I/larva (g.)	D/larva (g.)	E/larva (g.)	AD (%)	RR	CI	RGR	R (g.)	MR
RSJ14×BHR2	5.64	1.97	3.67	34.86 (36.17)	1.54	0.30	0.03	0.78	0.04
RSJ14×BHR3	5.61	2.09	3.52	37.18 (37.55)	1.59	0.37	0.04	0.95	0.06
RSJ14×B.con1	4.55	1.22	3.32	26.86 (31.20)	1.37	0.29	0.04	0.23	0.01
RSJ14×B.con4	4.30	1.28	3.02	29.79 (33.06)	1.42	0.26	0.04	0.05	0.00
RSJ14×NB4D2	4.63	1.41	3.22	30.37 (33.43)	1.44	0.30	0.04	0.44	0.03
ATR16×BHR3	5.52	2.25	3.27	40.69 (39.62)	1.69	0.38	0.04	1.34	0.09
ATR16×BHR2	4.29	0.99	3.30	23.10 (28.71)	1.30	0.35	0.04	0.28	0.02
ATR16×B.con1	4.67	1.24	3.42	26.60 (31.03)	1.36	0.33	0.04	0.41	0.03
ATR16×B.con 4	4.52	1.45	3.07	32.08 (34.48)	1.47	0.33	0.04	0.55	0.04
ATR16×NB4D2	5.42	2.10	3.32	38.67 (38.43)	1.63	0.40	0.04	1.31	0.10
CSR50×BHR2	5.15	2.53	2.62	49.05 (44.44)	1.96	0.34	0.04	1.19	0.08
CSR50×BHR3	4.27	1.47	2.80	34.45 (35.92)	1.53	0.26	0.04	0.18	0.01
CSR50×B.con1	4.49	1.69	2.80	37.66 (37.83)	1.60	0.27	0.04	0.43	0.03
CSR50×B.con4	4.29	1.41	2.87	32.93 (35.00)	1.49	0.27	0.04	0.26	0.02
CSR50×NB4D2	4.96	2.36	2.60	47.60 (43.60)	1.91	0.32	0.04	1.21	0.08
FC1×FC2 (Control)	4.26	1.63	2.63	38.31 (38.22)	1.62	0.32	0.05	0.13	0.01
CSR2×CSR4 (Control)	5.27	1.89	3.37	35.92 (36.81)	1.56	0.35	0.03	1.21	0.08
CD@ 5(%)	0.01	0.01	0.01	0.009	0.01	0.01	0.004	0.01	0.007
Sem±	0.00	0.005	0.005	0.003	0.005	0.005	0.001	0.005	0.002
CV (%)	0.14	0.41	0.22	0.01	0.45	2.20	4.31	1.10	7.88

Note : I – Ingesta, D – Digesta, E – Excreta, AD – Approximate Digestibility, RR- Reference ratio, CI – Consumption Index, RGR- Relative Growth Rate, R- Respiration, MR - Metabolic rate; SD-Standard Deviation.

higher in FC₁×FC₂ (30.05%) followed by RSJ14×B.con4 (29.53%) and lower in RSJ14×BHR3 (19.61%). Efficiency Conversion of Digesta (ECD) to cocoon varied significantly among the hybrids which ranged between 99.14 *per cent* (RSJ14×B.con4) to 46.32 *per cent* (CSR50×BHR2). ECI to shell observed to be maximum in FC₁×FC₂ (21.13%) and minimum in RSJ14×BHR3 (13.37%). With regard to ECD for shell high conversion rate was recorded in ATR16×BHR2 (65.59.00%) followed by RSJ14×B.con 4 (64.79%) and lowest in CSR50×NB₄D₂ (33.04) (Table-2).

Efficiency Conversion of Ingesta (ECI) to cocoon revealed that higher in CSR50×B.con1 (9.03%) followed by CSR50×B.con 4 (8.57%) and lower in ATR16×B.con1 (6.40%). Efficiency Conversion of Digesta (ECD) to cocoon varied significantly among the hybrids which ranged between 11.52 *per cent* (CSR50×B.con1) to 7.77 *per cent* (ATR16×B.con1). ECI to shell observed to be maximum in CSR50×B.con1 (4.56%) and minimum in

ATR16×B.con1 (3.07%). With regard to ECD for shell high conversion rate was recorded in CSR50×B.con1 (5.82%) followed by CSR50×B.con4 (5.46%) and lowest in ATR16×B.con1 (3.72%) during spring season (2022) (Table 4).

I/g and D/g to cocoon and shell : During spring season (2021), the ingesta per gram cocoon (I/g) was observed ranged between maximum in ATR16×BHR3 (4.97 g) and minimum in FC₁×FC₂ (3.33 g). The amount of digesta per gram cocoon (D/g) observed was highest in CSR50×BHR2 (2.16 g) and lowest in RSJ14×B.con1 & RSJ14×B.con4 (1.01 g). With regard to ingesta per gram (I/g) shell was noticed to be ranged between RSJ14×BHR3 (7.48 g) and lowest in FC₁×FC₂ (4.73 g). The digesta required to one gram (D/g) shell revealed that ranged between maximum in CSR50×NB₄D₂ (3.03 g) and minimum in ATR16×BHR2 (1.52 g) (Table-2). All the parameters were showed statistically significant differences among them.

Table-2 : Nutritional efficiency conversion parameters recorded for different hybrid combinations (Late Spring, 2021).

Hybrids	Larva (%)		Cocoon (%)		Shell (%)		Cocoon (g.)		Shell (g.)	
	ECI	ECD	ECI	ECD	ECI	ECD	I/g	D/g	I/g	D/g
RSJ14×BHR2	21.10 (27.33)	60.53 (51.06)	23.23 (28.80)	66.63 (54.68)	15.78 (23.39)	45.27 (42.27)	4.31	1.50	6.34	2.21
RSJ14×BHR3	20.32 (26.77)	54.65 (47.64)	19.61 (26.27)	52.73 (46.54)	13.37 (21.44)	35.95 (36.82)	5.10	1.90	7.48	2.78
RSJ14×B.con1	21.78 (27.80)	81.08 (64.18)	26.62 (31.04)	99.10 (84.53)	17.60 (24.79)	65.52 (54.01)	3.76	1.01	5.68	1.53
RSJ14×B.con4	28.60 (32.31)	96.02 (78.46)	29.53 (32.90)	99.14 (84.62)	19.30 (26.04)	64.79 (53.57)	3.39	1.01	5.18	1.54
RSJ14×NB4D2	20.95 (27.22)	68.99 (56.13)	25.05 (30.01)	82.50 (65.24)	17.71 (24.87)	58.32 (49.76)	3.99	1.21	5.65	1.71
ATR16×BHR3	16.49 (23.95)	40.52 (39.52)	20.11 (26.63)	49.42 (44.64)	13.59 (21.62)	33.39 (35.28)	4.97	2.02	7.36	2.99
ATR16×BHR2	16.55 (23.99)	71.64 (57.79)	22.14 (28.05)	95.86 (78.22)	15.15 (22.89)	65.59 (54.05)	4.52	1.04	6.60	1.52
ATR16×B.con1	17.79 (24.93)	66.88 (54.84)	21.86 (27.86)	82.19 (65.00)	15.01 (22.78)	56.41 (48.66)	4.57	1.22	6.66	1.77
ATR16×B.con 4	19.91 (26.48)	62.07 (51.96)	22.06 (28.00)	68.76 (55.99)	15.27 (22.99)	47.59 (43.60)	4.53	1.45	6.55	2.10
ATR16×NB4D2	14.58 (22.44)	37.69 (37.85)	21.22 (27.42)	54.87 (47.77)	14.39 (22.28)	37.21 (37.57)	4.71	1.82	6.95	2.69
CSR50×BHR2	26.02 (30.66)	53.05 (46.73)	22.72 (28.45)	46.32 (42.87)	16.31 (23.80)	33.25 (35.19)	4.40	2.16	6.13	3.01
CSR50×BHR3	30.21 (33.32)	87.70 (69.44)	29.04 (32.59)	84.30 (66.63)	19.20 (25.97)	55.74 (48.27)	3.44	1.19	5.21	1.79
CSR50×B.con1	28.06 (31.97)	74.51 (59.65)	28.29 (32.12)	75.10 (60.03)	18.71 (25.62)	49.67 (44.79)	3.54	1.33	5.35	2.01
CSR50×B.con4	26.84 (31.19)	81.50 (64.49)	28.94 (32.53)	87.88 (69.59)	18.90 (25.75)	57.41 (49.24)	3.46	1.14	5.29	1.74
CSR50×NB ₄ D ₂	23.19 (28.77)	48.71 (44.24)	25.00 (29.98)	52.52 (46.42)	15.73 (23.36)	33.04 (35.07)	4.00	1.90	6.36	3.03
FC1×FC2 (Control)	35.21 (36.38)	91.91 (73.44)	30.05 (33.23)	78.43 (62.29)	21.13 (27.35)	55.15 (47.94)	3.33	1.28	4.73	1.81
CSR2×CSR4 (Control)	12.92 (21.06)	35.96 (36.83)	21.84 (27.84)	60.81 (51.21)	13.68 (21.70)	38.08 (38.09)	4.58	1.64	7.31	2.63
CD@ 5(%)	0.01	0.01	0.01	0.01	0.01	0.009	0.01	0.01	0.01	0.01
Sem±	0.004	0.004	0.003	0.006	0.004	0.003	0.005	0.005	0.005	0.005
CV(%)	0.01	0.01	0.01	0.01	0.02	0.009	0.16	0.48	0.11	0.32

Note : ECI - Efficiency conversion for Ingesta, ECD - Efficiency conversion for Digesta; SD-Standard Deviation.

The data for ingesta per gram cocoon (I/g) was observed ranged between maximum in ATR16×B.con1 (15.62 g) and minimum in CSR50×B.con1 (11.07 g). The amount of digesta per gram cocoon (D/g) observed was highest in ATR16×B.con1 (12.88 g) and lowest in CSR50×B.con1 (8.68 g). With regard to ingesta per gram (I/g) shell noticed to be ranged between ATR16×B.con1 (32.57 g) and lowest in CSR50×B.con1 (21.92 g). The digesta required to one gram (D/g) shell revealed it ranged between maximum in ATR16×B.con1 (26.86 g) and minimum in CSR50×B.con1 (17.18 g) (Table-4). All the parameters were showed statistically significant differences among them during spring season (2022).

In sericulture, the silkworm breeds and mulberry varieties play an important role in its sustainability. The nutritional efficiency of the mulberry, the digestive and the conversion efficiency of silkworm has collective impact on silk productivity. A large volume of literature is available

on the development of breeds in respect of digestibility, disease tolerance, silk productivity, stress tolerance (Basavaraja, 1995; Ramesh babu *et al.*, 2002; Suresh kumar *et al.*, 2003; Ramesha *et al.*, 2012). Similarly, the mulberry varietal influences on the cocoon productivity have been reported by several investigators (Maribhashetty *et al.*, 1991; Raman *et al.*, 1995; Zhang *et al.*, 2019). In the present study bivoltine hybrids were assessed over with FC₁×FC₂ and CSR₂×CSR₄ for their nutritive and conversional traits.

Silkworm breeding is aimed at improving the genetic entity of silkworms in relation to their economic utility, physiological aspects contribute a lot in the selection of breeds/hybrids (Trivedy and Nair, 1999). Among the different physiological aspects, feed conversion traits that reflect on the silkworm biomass and silk associated with active consumption and conversion of mulberry leaf to proteinaceous silk gland, are considered most important.

Table-3 : Nutrigenetic traits recorded for different hybrid combinations (Spring, 2022).

Hybrids	I/larva (g.)	D/larva (g.)	E/larva (g.)	AD (%)	RR	CI	RGR	R (g.)	MR
ATR16×B.con 4	11.16	9.34	1.82	83.69 (66.15)	6.13	0.63	0.03	8.25	0.47
RSJ14×BHR2	10.93	8.88	2.05	81.24 (64.30)	5.33	0.58	0.03	7.59	0.40
RSJ14×NB4D2	11.09	9.04	2.05	81.51 (64.50)	5.41	0.60	0.04	7.93	0.43
ATR16×NB4D2	10.83	8.81	2.02	81.35 (64.39)	5.36	0.62	0.03	7.77	0.44
ATR16×B.con1	11.40	9.40	2.00	82.46 (65.21)	5.70	0.62	0.03	8.26	0.45
ATR16×BHR3	11.39	9.27	2.12	81.39 (64.42)	5.37	0.64	0.04	8.22	0.46
ATR16×BHR2	11.33	9.33	2.00	82.35 (65.13)	5.67	0.66	0.03	8.31	0.48
RSJ14×BHR3	10.88	8.88	2.00	81.62 (64.59)	5.44	0.58	0.03	7.65	0.41
RSJ14×B.con1	11.13	9.11	2.02	81.85 (64.75)	5.51	0.58	0.03	7.88	0.41
RSJ14×B.con4	11.23	9.06	2.17	80.68 (63.90)	5.18	0.56	0.03	7.81	0.39
CSR2×CSR4	11.21	9.04	2.17	80.64 (63.86)	5.17	0.61	0.03	7.88	0.43
CSR50×BHR2	10.83	8.53	2.30	78.76 (62.52)	4.71	0.57	0.03	7.23	0.38
CSR50×BHR3	11.18	8.98	2.20	80.32 (63.63)	5.08	0.58	0.03	7.65	0.40
CSR50×B.con1	10.74	8.42	2.32	78.40 (62.28)	4.63	0.56	0.03	7.10	0.37
CSR50×B.con4	10.73	8.43	2.30	78.56 (62.38)	4.67	0.57	0.03	7.13	0.38
CSR50×NB4D2	10.85	8.50	2.35	78.34 (62.23)	4.62	0.57	0.03	7.38	0.39
FC1×FC2	11.19	9.07	2.12	81.05 (64.16)	5.28	0.59	0.04	7.88	0.42
CD@5%	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sem±	0.005	0.005	0.005	0.004	0.005	0.005	0.005	0.005	0.005
CV (%)	0.06	0.07	0.30	0.008	0.13	1.18	23.80	0.08	1.69

Note: I – Ingesta, D – Digesta, E – Excreta, AD – Approximate Digestibility, RR- Reference ratio, CI – Consumption Index, RGR- Relative Growth Rate, R- Respiration, MR – Metabolic rate; SD-Standard Deviation.

Significant variations were recorded in respect of nutritional conversion traits such as efficiency conversion of ingesta, and digesta for larva, cocoon, shell and ingesta and digesta required for producing one gram of cocoon and shell (Table-2). The efficiency of mulberry ingested, digested and converted to body weight varied prominently among the breed/hybrids.

In order to achieve greater success in this regard, it is important to understand the level of nutrition efficiency in bivoltine silkworm hybrids. The main objective of the investigation was to identify bivoltine silkworm hybrids with nutrition efficiency among eighteen bivoltine hybrids evaluated for 19 important nutrigenetic traits. The results obtained for conversion index and efficiency of conversion of ingesta to biomass through standard gravimetric method during spring season (2018 and 2019) is supported by earlier observations (Hassanein *et al.*, 1972; Sumioka *et al.*, 1982; Anantharaman *et al.*, 1994; Trivedy and Nair, 1999; Kumaresan *et al.*, 2000). Our emphasis was on the phenotypic manifestation of 19 nutrigenetic

traits. The results revealed highly significant ($p = 0.001$) variability among the bivoltine hybrids with respect to 19 nutrigenetic traits for the experimental hybrids prepared from the shortlisted germplasm breeds from different regions.

From the present investigation, the observation revealed that, the screening and evaluation of nutrigenetic traits of bivoltine silkworm hybrids was done for two years for spring season (2021 and 2022). During spring (2021), the consumption index was very less in hybrids viz., CSR50×BHR3 & RSJ14×B.con4 (0.26) followed by CSR50×B.con1 & CSR50×B.con4 (0.27) and RSJ14×B.con1 (0.29) compared to other hybrids respectively. The efficiency conversion for ingesta to cocoon was highest in the hybrids viz., FC₁×FC₂ (30.05) followed by RSJ14×B.con4 (29.53), CSR50×BHR3 (29.04), CSR50×B.con4 (28.94), CSR50×B.con1 (28.29) and RSJ14×B.con1 (26.62) whereas efficiency conversion for ingesta to shell was highest in the hybrids

Table-4 : Nutritional efficiency conversion parameters recorded for different hybrid combinations (Spring, 2022).

Hybrids	LARVA (%)		COCOON (%)		SHELL (%)		COCOON (g)		SHELL (g)	
	ECI	ECD	ECI	ECD	ECI	ECD	Ingesta/g	Digesta/g	Ingesta/g	Digesta/g
ATR16×B.con 4	9.77 (18.21)	11.67 (19.96)	6.54 (14.80)	7.82 (16.23)	3.14 (10.21)	3.75 (11.16)	15.29	12.79	31.89	26.69
RSJ14×BHR2	11.80 (20.07)	14.53 (22.40)	6.86 (15.17)	8.45 (16.89)	3.29 (10.43)	4.05 (11.59)	14.57	11.84	30.36	24.67
RSJ14×NB ₄ D ₂	10.01 (18.44)	12.28 (20.51)	6.76 (15.05)	8.30 (16.74)	3.25 (10.39)	3.98 (11.49)	14.79	12.05	30.81	25.11
ATR16×NB ₄ D ₂	9.60 (18.03)	11.80 (20.07)	6.93 (15.26)	8.51 (16.94)	3.42 (10.66)	4.20 (11.82)	14.44	11.75	29.27	23.81
ATR16×B.con1	10.00 (18.42)	12.13 (20.37)	6.40 (14.64)	7.77 (16.18)	3.07 (10.07)	3.72 (11.10)	15.62	12.88	32.57	26.86
ATR16×BHR3	9.22 (17.67)	11.33 (19.66)	6.76 (15.05)	8.31 (16.75)	3.34 (10.53)	4.10 (11.68)	14.79	12.04	29.97	24.39
ATR16×BHR2	9.00 (17.44)	10.93 (19.29)	6.62 (14.90)	8.04 (16.47)	3.80 (11.24)	4.61 (12.40)	15.11	12.44	26.35	21.70
RSJ14×BHR3	11.31 (19.64)	13.85 (21.83)	7.54 (15.93)	9.23 (17.68)	3.95 (11.46)	4.84 (12.69)	13.27	10.83	25.30	20.65
RSJ14×B.con1	11.05 (19.40)	13.50 (21.54)	7.37 (15.75)	9.00 (17.44)	3.41 (10.62)	4.17 (11.77)	13.57	11.11	29.29	23.97
RSJ14×B.con4	11.13 (19.47)	13.80 (21.80)	7.12 (15.46)	8.83 (17.27)	3.56 (10.86)	4.42 (12.13)	14.04	11.33	28.08	22.65
CSR2×CSR4	10.35 (18.76)	12.83 (20.97)	6.78 (15.09)	8.41 (16.85)	3.21 (10.31)	3.98 (11.49)	14.75	11.89	31.14	25.11
CSR50×BHR2	12.00 (20.25)	15.24 (18.57)	8.49 (16.92)	10.79 (19.17)	4.16 (11.77)	5.28 (13.28)	11.77	9.27	24.07	18.96
CSR50×BHR3	11.90 (20.17)	14.81 (22.62)	8.05 (16.47)	10.02 (18.44)	4.29 (11.94)	5.35 (13.37)	12.42	9.98	23.29	18.71
CSR50×B.con1	12.29 (20.51)	15.68 (23.32)	9.03 (17.47)	11.52 (19.82)	4.56 (12.31)	5.82 (13.96)	11.07	8.68	21.92	17.18
CSR50×B.con4	12.12 (20.36)	15.42 (23.10)	8.57 (17.01)	10.91 (19.27)	4.29 (11.95)	5.46 (13.51)	11.66	9.16	23.33	18.33
CSR50×NB ₄ D ₂	10.32 (18.72)	13.18 (21.28)	8.39 (16.83)	10.71 (19.10)	4.15 (11.75)	5.29 (13.28)	11.92	9.34	24.11	18.89
FC ₁ ×FC ₂	10.63 (19.01)	13.12 (21.22)	7.15 (15.50)	8.82 (17.26)	3.49 (10.77)	4.30 (11.97)	13.99	11.34	28.69	23.26
CD@5%	0.01	-	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
Sem±	0.005	1.06	0.006	0.005	0.007	0.007	0.005	0.005	0.005	0.005
CV (%)	0.03	7.15	0.05	0.04	0.009	0.08	0.04	0.06	0.02	0.03

Note : ECI - Efficiency conversion for Ingesta, ECD - Efficiency conversion for Digesta; SD-Standard Deviation.

viz., FC₁×FC₂ (21.13) followed by RSJ14×B.con4 (19.30) followed by CSR50×BHR3 (19.20), CSR50×B.con4 (18.90), CSR50×B.con1 (18.71) and RSJ14×B.con1 (17.60). The ingesta per gram of the cocoon is very less compared to other hybrids viz., FC₁×FC₂ (3.33) followed by RSJ14×B.con4 (3.39) followed by CSR50×BHR3 (3.44), CSR50×B.con4 (3.46), CSR50×B.con1 (3.54) and RSJ14×B.con1 (3.76) whereas the ingesta per gram of the shell is very less compared to other hybrids viz., FC₁×FC₂ (4.73) followed by RSJ14×B.con4 (5.18) followed by CSR50×BHR3 (5.21), CSR50×B.con4 (5.29), CSR50×B.con1 (5.35) and RSJ14×B.con1 (5.68). All the parameters taken for the study showed statistically significantly different from each other. Ramesha et al. (2010) investigated systematic nutrigenetic traits, analysis for bivoltine silkworm germplasm breeds achieved as first report of this kind and utilized as biomarkers to identify nutritionally efficient breed, which opt the lower consumption and higher conversion of nutrition into

cocoon and shell, would attract the attention of the sericulturists. Henceforth, the study sturdily suggested the four bivoltine silkworm germplasm breeds viz., RBD1, RBD4 (peanut type cocoon), RBO2, RBO3 (oval type cocoon) as nutritionally efficient breeds were shortlisted based on the nutrigenetic traits analysis for future synthesis of nutritionally efficient hybrids in hybridization program. Similar results reported for polyvoltine breeds by Ramesha et al. (2012) concluded that polyvoltine breeds with minimum consumption index and maximum efficiency of conversion of ingesta/cocoon identified strains RMG4, RMW2, and RMW3 as potential polyvoltine breeding resource material for the development of nutritionally efficient breeds/hybrids in Asia and Pacific regions. Similar results were observed from the present investigation that bivoltine hybrids with minimum consumption index and maximum efficiency of conversion of ingesta/cocoon identified/shortlisted as hybrids viz., CSR50×BHR3, RSJ14×B.con4, CSR50×B.con1,

CSR50×B.con4 and RSJ14×B.con1 having potential for nutritionally efficient hybrids under North Western India during spring season (2021).

Similar results were obtained during spring (2022), the data revealed that, the consumption index was very less in hybrids viz., CSR50×B.con1 and RSJ14×B.con4 (0.56), CSR50×B.con 4, CSR50×BHR2 and CSR50×NB₄D₂ (0.57) compared to other hybrids. The efficiency conversion for ingesta to cocoon was highest in the hybrids viz., CSR50×B.con1 (9.03), CSR50×B.con4 (8.57), CSR50×BHR2 (8.49), CSR50×NB₄D₂ (8.39) and CSR50×BHR3 (8.05) and efficiency conversion for ingesta to shell was highest in the hybrids viz., CSR50×B.con1 (4.56), CSR50×B.con4 & CSR50×BHR3 (4.29), CSR50×BHR2 (4.16) and CSR50×NB₄D₂ (4.15). The ingesta per gram of the cocoon was very less compared to other hybrids viz., CSR50×B.con1 (11.07), CSR50×B.con4 (11.66), CSR50×BHR2 (11.77), CSR50×NB₄D₂ (11.92) and CSR50×BHR3 (12.42) and the ingesta per gram of the shell was very less compared to other hybrids viz., CSR50×B.con1 (21.92), CSR50×BHR3 (23.29), CSR50×B.con4 (23.33), CSR50×BHR2 (24.07) and CSR50×NB₄D₂ (24.11).

The result obtained from the study revealed a highly significant variance on nutritional traits between the breeds and within the breed during different seasons as reported (Magadum *et al.*, 1996; Gokulamma and Reddy, 2005). Comparatively quite variable digesta among all the breeds might be due to variation in genetic components and agreement on degree of food digestion in silkworm differs from one race to another when fed on same variety of mulberry leaves (Hassanein *et al.*, 1972). Accumulation of nutrients in insect greatly influenced by the nutritional richness of the host plant or diet fed and this storage nutrition function as the reservoirs for the supply both at the time of larval moult and during metamorphosis. The silkworm feeds voraciously at larval stages only and such abundant dietary intake acts as reserve during non feeding phase of development in the life cycle. Further, it was also observed that increase in ingestion and digestion suggests the possibility of increase in the accumulation of organic constituents in the body tissue of the silkworm as biomass but it varied among breeds in this study. Maximum excreta obtained in breeds than those of other silkworm breeds indicate that breeds were more efficient on biomass conversion of ingested and digested food. The Approximate Digestibility (AD) analyzed in the study stated that certainly it was racial trait as higher food intake does not necessarily result in higher digestibility. Reference Ratio (RR) as indicative of the retention efficiency of food reported between 1.56-1.59 in silkworm larvae except in one breed in concord with the studies of the Anantharaman *et al.* (1995) and

Rahmathulla *et al.* (2003). The passage of food through gut became slow when consumption index decreases to facilitate increased digestion and assimilation with ultimate result of improved approximate digestibility and corresponding traits. It was registered that the consumption index values of polyvoltine was slightly higher when compared to the bivoltine breeds may be due to less 5th stage larval duration (Rahmathulla *et al.*, 2003). A slant variation observed in relative growth rate between the breeds was due to less difference in larval duration among bivoltine germplasm breeds. From the present study during spring (2022) the hybrids viz., CSR50×B.con 1, RSJ14×B.con4, CSR50×B.con4, CSR50×BHR 2 and CSR50×NB₄D₂ respectively based on consumption index and efficiency conversion of ingesta to larva, ingesta per gram of the cocoon and shell. It also noted firmly that bivoltine breeds of semi exotic races found to be better converter than the polyvoltine breeds of indigenous races in harmony to prior observation (Periaswamy *et al.*, 1984).

Conclusions

The quality and quantity of silk output are directly related to the nutritional intake by silkworm. The selection of silkworms based on their efficient conversion traits *i.e.*, the ones with relatively low consumption of mulberry and higher conversion ratio is highly preferred. The consumption and conversion traits are genetically controlled and physiological studies support to assess the superiority over the existing ones. From the present study during spring season (2021 and 2022), the data concluded that bivoltine hybrids with minimum consumption index and maximum efficiency conversion of ingesta/cocoon was identified/shortlisted as hybrids viz., CSR50×BHR3, RSJ14×B.con4, CSR50×B.con1, CSR50×B.con4 & RSJ14×B.con1 (Spring, 2021) and CSR50×B.con1, RSJ14×B.con4, CSR50×B.con4, CSR50×BHR2 & CSR50×NB₄D₂ (Spring, 2022) respectively having potential for commercial exploitation of nutritionally efficient hybrids under North Western India.

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Foliar Application of Insecticides for Management of Whitefly *Bemisia tabaci* Genn. and Mungbean Yellow Mosaic Virus (MYMV) in Mungbean (*Vigna radiata* (L.) Wilczek)

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Abstract

Studies were conducted at Agricultural Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh, India, during *Kharif* 2010-11 and 2011-12 to know the efficacy of eight insecticides, viz., azadirachtin, endosulfan 35% EC, thiodicarb 75%WP, spinosad 45%SC, lambda cyhalothrin 5%EC, indoxacarb 14.5% SC, profenophos 50%EC and acetamiprid v20%SP against whitefly on mungbean. The mean efficacy of insecticides on whitefly population showed that the acetamiprid (1.27 whitefly/cage/plant) followed by endosulfan (1.69 whitefly/cage/plant) after first spray. The maximum whitefly population was recorded in azadirachtin treated plot (3.33 whitefly/cage/plant) while highest in control (4.60 whitefly/cage/plant). MYMV incidence recorded at 50 DAS showed that the low MYMV incidence was recorded in acetamiprid treatment (12.50 %) followed by endosulfan treatment (18.33 %), profenophos (18.33%), lambda cyhalothrin (20.83%), thiodicarb (23.33 %) and indoxacarb (25.00%) and Maximum MYMV incidence was recorded in *in azadirachtin* (29.17%) while highest MYMV incidence was in control (40.00%). The maximum yield was recorded in indoxacarb (11.85 q/ha) followed by spinosad (11.12 q/ha) and thiodicarb (10.91q/ha) and profenophos (10.88 q/ha). The lowest yield was recorded in azadirachtin (9.93 q/ha) and in control 7.66 q/ha).

Key words : Insecticides, management, mungbean, MYMV, whitefly.

Introduction

Mungbean, *Vigna radiata* (L.) Wilczek is an important pulse crop of many Asian countries including India. It is originated from India and Central Asia. It is a rich source of protein (22-24%). Losses due to insect pests are very high in mungbean. Whitefly (*Bemisia tabaci* Genn.) is an important insect pest of mungbean. Whitefly sucks the sap from leaves and in case severe damage, it secretes honeydew which causes sooty mould and affects photosynthesis. It also vector of MYMV (Mungbean Yellow Mosaic Virus). Yellow mosaic is the major constraint upon improving production of mungbean (Nene, 1973, 1988). The occurrence of MYMV was first reported from Delhi by Nariani in 1960. Since then, its occurrence has been reported from all over India and other Indian subcontinent countries (Varma and Malathi, 2003). An annual yield loss of US Dollar 350 million is caused yellow mosaic in mung bean, urd bean and soybean in India as estimated by Varma *et al.*, (1992). The yield loss caused by this disease was estimated to be upto 47% (Amin and Singh, 1987). MYMV disease incidence decreased the yield by 25 to 78 per cent (Vir, 1984). The present investigation therefore was for management of vector and mung bean yellow mosaic in mungbean using various insecticides.

Materials and Methods

Field trials were conducted in two consecutive years

during *Kharif* of 2010-11 and 2011-12 at Agricultural Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh India in Randomized Block Design having nine treatments replicated in thrice including control. Plot size was 3m x 3m with row to and plant to plant spacing of 30 and 10 cm, respectively. The mung bean variety HUM-12 was sown in last week of July 2010 and 2011. Various treatments shown in table consisting of insecticides viz., azadirachtin, endosulfan 35% EC, thiodicarb 75% WP, spinosad 45%SC, lambda cyhalothrin 5%EC, indoxacarb 14.5% SC, profenophos 50%EC and acetamiprid 20%SP and control were evaluated. Observations on the population of whitefly were counted one day before and after 1, 3, 7 and 15 days of spray in each plot in 5 randomly selected plants. The whitefly population was recorded with help of rectangular spilt cage. The observations on whitefly population recorded one day before spray and after 1, 3, 7 and 15 days of spray were subjected to statistical analysis after square root transformation ($\sqrt{x+0.5}$). The per cent reduction over control was calculated by using Henderson and Tilton (1955) formula. Total number plants and MYMV infected plants were counted 10 days of spray from each plot and percentage of MYMV infected plants was calculated and transformed into arc sin transformed values. Grain yield was also recorded and converted it in to quintal per hectare.

The insecticidal spray solutions were prepared by the following formula :

$$\text{Amount of formulation} = \frac{\text{Concentration required (\%)} \times \text{Volume required (Litre)}}{\text{Concentration of toxicant in insecticidal formulation}}$$

Per cent reduction over control calculated by using following modified formula given by Henderson and Tilton (1955).

Per cent reduction over control

$$= 1 - \frac{\frac{\text{post treatment population in treatment}}{\text{pre treatment population in treatment}}}{\frac{\text{pre treatment population in control}}{\text{post treatment population in control}}} \times 100$$

MYMV disease incidence calculated by using following formula.

MYMV disease incidence %

$$= \frac{\text{Total No. of infected plants}}{\text{Total No. plants}} \times 100$$



Fig.-1 : Rectangular split cage used for whitefly population.



Fig.-2 : MYMV infected plant.

Results and Discussion

It is evident from table-1 that the white fly population before spraying was statistically uniform varied from 4.30 to 4.57 whiteflies per cage per plant. Mean population counts of whitefly recorded at 1 DAS after application revealed that the acetamiprid sprayed plot proved significantly superior in suppressing whitefly population (1.37 whiteflies/ cage/plant) with 71.2 per cent reduction over control followed by endosulfan (1.77 whiteflies/ cage/plant) with 63.0 per cent reduction over control. The treatments lambda cyhalothrin, profenphos, thiodicarb, indoxacarb, spinosad and azadirachtin were recorded 2.10, 2.73, 2.97, 3.07, 3.50 and 3.93 whiteflies/cage/plant with 53.3, 42.3, 37.8, 33.3, 21.5 and 15.7 per cent reduction in population over control, respectively. Treatment azadirachtin was recorded higher whitefly population (3.93 whiteflies/ cage/plant) but superior over control (4.63 whiteflies/ cage/plant). After 3 days of spray showed acetamiprid (1.07 whiteflies/cage/plant) was most superior among the treatments with 78.3 per cent reduction in population followed by endosulfan (1.50 whiteflies/cage/plant) with 69.7 per cent reduction over control. Data taken after 7 DAS of application showed that the acetamiprid, profenphos and endosulfan were recorded the low population (0.80, 1.27 and 1.33 whiteflies, respectively) with 84.1, 74.7 and 73.6 per cent reduction in population, respectively. The treatments profenphos and endosulfan were at par with each other. The treatments indoxacarb and lambda cyhalothrin recorded the whitefly population (1.63 and 1.77 whiteflies/ cage/plant, respectively) and were at par with each other with 66.4 and 62.8 per cent reduction over control, respectively. Thiodicarb and spinosad treatments recorded the whitefly population (2.07 and 2.47 whiteflies/ cage/plant, respectively) with 59.1 and 47.7 per cent reduction in population. The maximum population was recorded in azadirachtin treatment (2.83 whiteflies/ cage/plant) with 42.6 per cent reduction over control. Observation at 15 DAS application showed minimum whitefly population was recorded in acetamiprid (1.83 whiteflies/cage/plant) with 55.9 per cent reduction in population over control, while maximum white fly population recorded in azadirachtin (3.47 whiteflies/ cage/plant) with 15.4 per cent reduction in population over control. Overall mean efficacy of insecticides on whitefly population showed that the acetamiprid (1.27 whitefly/ cage/plant) with 72.4 per cent reduction in population over control followed by endosulfan (1.69 whitefly/cage/plant) with 63.5 per cent reduction in population over control. The least effective treatment was azadirachtin (3.33 whiteflies/cage/plant) but superior to control with 27.6 per cent reduction in population over control. The present

Table : Evaluation of insecticides for management whitefly and MYMV disease incidence in Mungbean during Kharif (Pooled).

Treatments	White fly population per cage at different days after spray											MYMV Incidence (%)	Yield (q/ha)
	Pre-spray	1DAS	PROC	3DAS	PROC	7DAS	PROC	15DAS	PROC	Mean	PROC		
	50 DAS												
T1:Azadirachtin @2 ml/lit.	4.47 (2.23)	3.93 (2.10)	15.7	3.07 (1.88)	36.6	2.83 (1.82)	42.6	3.47 (1.99)	15.4	3.33 (1.96)	27.6	29.17 (32.69)	9.69
T2:Endosulfan @0.07%	4.57 (2.25)	1.77 (1.50)	63.0	1.50 (1.41)	69.7	1.33 (1.35)	73.6	2.17 (1.63)	48.3	1.69 (1.48)	63.5	18.33 (25.35)	10.23
T3:Thiodicarb @0.04%	4.57 (2.25)	2.97 (1.86)	37.8	2.63 (1.76)	46.7	2.07 (1.60)	59.1	3.03 (1.88)	27.6	2.68 (1.78)	42.8	23.33 (28.88)	10.91
T4:Spinosad @0.2ml/lit	4.27 (2.18)	3.50 (2.00)	21.5	3.00 (1.86)	35.1	2.47 (1.71)	47.7	2.63 (1.77)	32.7	2.90 (1.84)	34.3	26.67 (31.09)	11.12
T5:cyhalothrin @0.004%	4.30 (2.18)	2.10 (1.61)	53.3	1.83 (1.52)	60.6	1.77 (1.50)	62.8	2.33 (1.68)	40.8	2.01 (1.58)	54.4	20.83 (27.16)	10.50
T6:Indoxacarb @50 g a.i./ha	4.40 (2.21)	3.07 (1.89)	33.3	2.20 (1.63)	53.8	1.63 (1.46)	66.4	2.57 (1.75)	36.4	2.37 (1.69)	47.5	25.00 (30.00)	11.85
T7:Profenophos @1lit/ha	4.53 (2.24)	2.73 (1.80)	42.3	1.97 (1.57)	59.9	1.27 (1.33)	74.7	2.27 (1.66)	45.5	2.06 (1.60)	55.6	18.33 (25.35)	10.88
T8: Acetamiprid @0.004%	4.53 (2.24)	1.37 (1.36)	71.2	1.07 (1.25)	78.3	0.80 (1.14)	84.1	1.83 (1.53)	55.9	1.27 (1.33)	72.4	12.50 (20.70)	10.31
T9: Control (WaterSpray)	4.43 (2.22)	4.63 (2.26)		4.80 (2.29)		4.90 (2.32)		4.07 (2.14)		4.60 (2.26)		40.00 (39.23)	7.66
S.Em±		(0.02)		(0.02)		(0.02)		(0.02)		(0.02)		(0.80)	0.02
CD @5%	NS	(0.05)		(0.07)		(0.06)		(0.05)		(0.06)		(2.40)	0.61

Note : Figure in parenthesis are vx+0.5 transformed value, DAS: Days after spraying, PROC: Per cent reduction over control.

findings are agrrement with the report of Panduranga *et al.*, (2011); Patel *et al.*, (2010); Ganapathy and Karuppiiah (2004); who reported acetamiprid was found superior for control of whitefly.

MYMV incidence recorded at 50 DAS showed that the low MYMV incidence was recorded in acetamiprid treatment (12.50 %) followed by endosulfan treatment (18.33 %), profenophos (18.33%), lambda cyhalothrin (20.83%), thiodicarb (23.33%) and indoxacarb(25.00 %). Maximum MYMV incidence was recorded in azadirachtin (29.17%) and highest MYMV incidence was in control (40.00%). The treatments endosulfan and profenophos were at par. The maximum yield was recorded in indoxacarb (11.85 q/ha) followed by spinosad (11.12 q/ha) and thiodicarb (10.91 q/ha). The treatments profenophos, lambda cyhalothrin, acetamiprid endosulfan were recorded yield 10.88, 10.50, 10.31, 10.23 q/ha, respectively. The low yield was recorded in azadirachtin (9.69 q/ha) while control recorded lowest yield (7.66 q/ha). The present findings are agreement with the reports of Panduranga *et al.*, 2011 who reported the acetamiprid 20% SP was effective against the MYMV disease incidence with 14.29%. Ganapathy and Karuppiiah (2004) who reported the low whitefly and MYMV disease incidence in acetamiprid.

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Survey for Disease Incidence against Alternaria Leaf Blight of Bitter Gourd in Eastern U.P.

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Abstract

Bitter gourd (*Momordica charantia* L.) is a important vegetable in the family of Cucurbitaceae. Is widely popular vegetable grown extensively in severals parts of India, countries like, China, Africa Caribian and South East, Eastern Asian regions. Bitter gourd is herbaceous climbing annual plant with ridged stem that grows up to 5 meter long. January to March and September to December are the seasons. There are various type diseases which affect the leaves of bitter gourd plant, Fusarium wilt, Collar rot, Powdery mildew, Downy mildew, Alternaria blight, Anthracnose and Common Mosaic. During the crop season of 2020-21 and 2021-22 a survey for the severity of Alternaria blight of bitter gourd was conducted in each two village of two tehsil in selected the seven districts of Eastern Uttar Pradesh i.e. Azamgarh, Sultanpur, Varanasi, Jaunpur, Ambedkarnagar, Bhadohi and Ghazipur. The result of year 2020-21 the maximum average percent disease incidence (PDI%) was recorded in Jaunpur (25.00%) followed by Amebedkar Nagar (24.37%) , Sultanpur (23.37%), Ghazipur (21.37%), Bhadohi (20.75%) and mnumim average PDI was recorded in Azamgarh (18.75%) in year 2020-21. Similarly in year 2021-22 the maximum average PDI (%) was recorded in Varanasi(26.25%) followed by Azamgarh (25.12%), Ghazipur (19.12%), Jaunpur (18.75%), Sultanpur (16.75%), Bhadohi (16.50%) and minimum was recorded in Ambedkar Nagar District with PDI (16.00%).

Key words : Alternaria blight, Bitter gourd, survey, occurrence, percent disease incidence.

Introduction

Bitter gourd (*Momordica charantia* L.) is an important vegetable crop and is grown for its immature tuberculate fruits which have a unique bitter taste. Fruit are considered as a rich source of vitamins and minerals and 88 mg vitamin c per 100 g. (Aykroyd, W.R. 1963). *Momordica charantia* a member of the cucurbitaceae family, is also known as bitter melon, bitter gourd, balsam pear, pare or karela. Asia and Africa and is regarded as noxious weed in south America Numerous medical uses have been documented or claimed such as stomachic carminative and for diabetes treatment and there are claims that it can also be used for prevention of breast cancer. Bitter gourd leaves are a good source of vitamin A. (Abascal and yormell 2005).

Most plant diseases are caused by Fungi, bacteria, and viruses . Fungi are identified primary from their Morphology with emphasis placed on their reproductive structures. There are various type diceases which affect the leaves of bitter gourd plant , Fusarium wilt, Collar rot, Powdery mildew, Downey mildew, Alternaria blight, Anthracnose and Mosaic are common disease found in southern part of India. (Krik *et al.*, 2008).

According to the survey conducted and opinion of experts from agricultural. Alternaria blight is most common disease in leaves of bitter gourd pant found in Southern and Easter part of U.P. in India. Growth of bitter

gourd plant devided into five stages which are germination, Branching, flowering, fruiting and maruting (seeding) stages. (Bhargava and Singh 1985).

Hence the present study was undertaken to survey of Alternaria blight of Bitter gourd under natural field conditions during. *Kharif* season of the year (2020-21) and 2021-22 in Eastern Uttar Pradesh.

Materials and Methods

During the crop season of 2020-21 and 2021-22 a survey for the severity of Alternaria blight of bitter gourd was conducted in each two village of two tehsil in selected Seven districts of Eastern Uttar Pradesh i.e. Azamgarh, Sultanpur, Varanasi, Jaunpur, Ambedkar Nagar, Bhadohi and Ghazipur.

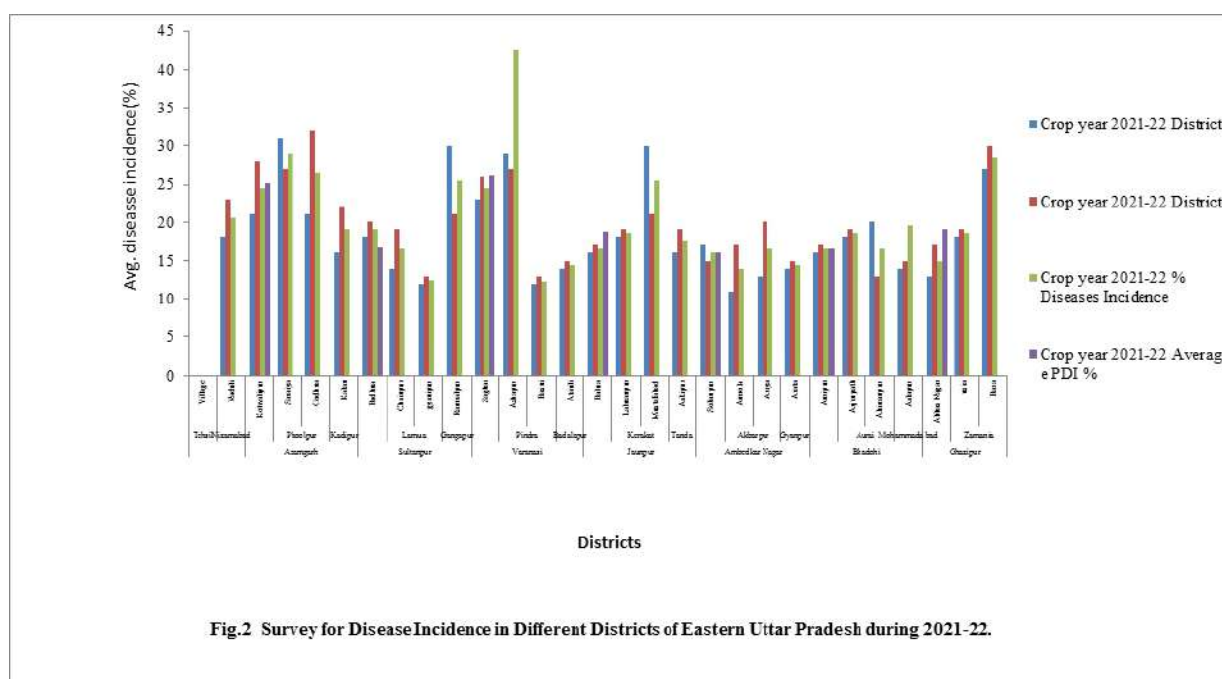
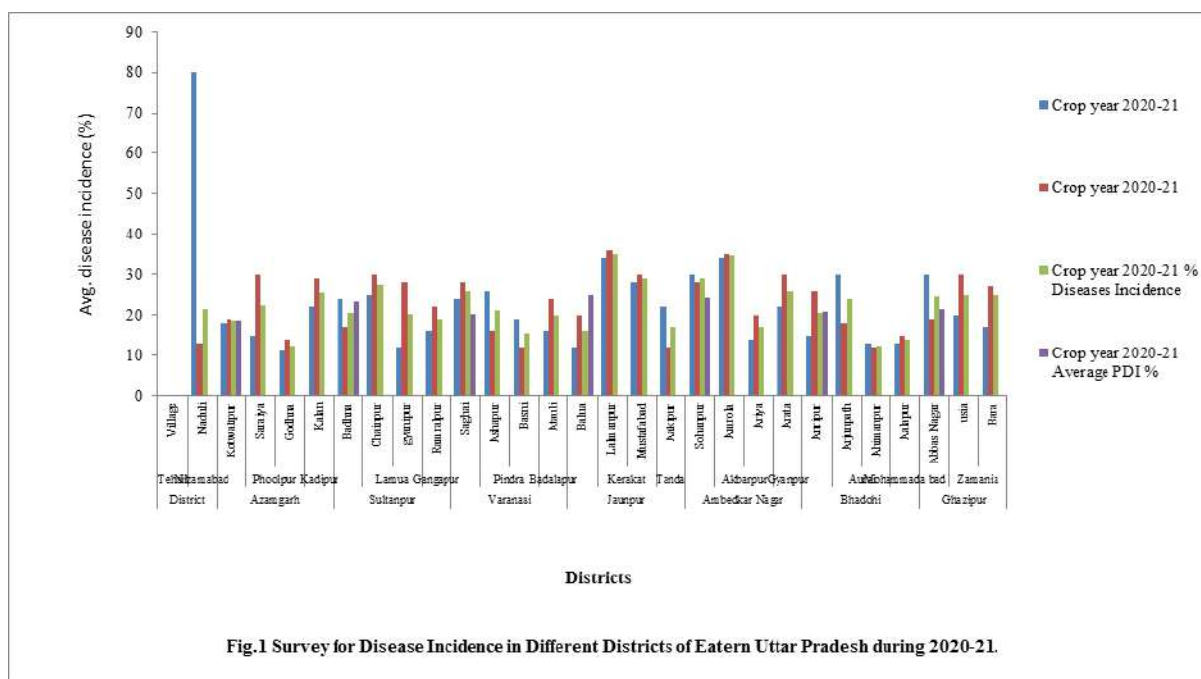
Naturally infected leaf of bitter gourd were recorded of the at different locations. Samples of diseased leaf bitter gourd sowing characteristics symptom of Allernaria blight caused by *Alternaria cucumerina* were collected from seven districts viz- Azamgarh, Sultanpur, Varanasi, Jaunpur, Ambedkar Nagar, Bhadohi, Ghazipur. During season 2020-21 and 2021-22 . Diseases incidence (%) of Alternaria blight each district was estimated with the formula given below.

Percent Disease incidence

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

Table-1 : Survey for Disease Incidence against Alternaria Leaf Blight of Bitter gourd in Eastern, U.P. (2020-21 and 2021-22).

Crop year 2020-21												Crop year 2021-22				
District	Tehsil	Village	60 DAS	90 DAS	% Diseases Incidence	Average PDI %	District	Tehsil	Village	60 DAS	90 DAS	% Diseases Incidence	Average PDI %			
Azamgarh	Nizamabad	Naduli	80	13	21.50	18.75				18	23	20.50	25.12			
		Kotwalipur	18	19	18.50	21				28	24.50					
Sultanpur	Phoolpur	Saraiya	15	30	22.50					31	27	29.00				
		Godhna	11	14	12.50	21				32	26.50					
	Kadipur	Kalan	22	29	25.50	23.37				16	22	19.00	16.75			
		Badhna	24	17	20.50					18	20	19.00				
Varanasi	Lanua	Chainpur	25	30	27.50					14	19	16.50				
		gyanipur	12	28	20.20	12				13	12.50					
	Gangapur	Ramralpur	16	22	19.00	20.25				30	21	25.50	26.18			
		Saghai	24	28	26.00					23	26	24.50				
Jaunpur	Pindra	Ashapur	26	16	21.00					29	27	42.50				
		Basni	19	12	15.50	12				13	12.25					
	Badalapur	Atauli	16	24	20.00	25.00				14	15	14.50	18.75			
		Balua	12	20	16.00					16	17	16.50				
Ambedkar Nagar	Kerakat	Lalmanpur	34	36	35.00					18	19	18.50				
		Mustafabad	28	30	29.00	30				21	25.50					
	Tanda	Aakipur	22	12	17.00	24.37				16	19	17.50	16.00			
		Sohanpur	30	28	29.00					17	15	16.00				
Bhadohi	Akbarpur	Amrola	34	35	34.50					11	17	14.00				
		Ariya	14	20	17.00	13				20	16.50					
	Gyanpur	Arata	22	30	26.00	20.75				14	15	14.50	16.50			
		Anripur	15	26	20.50					16	17	16.50				
Ghazipur	Aurai	Arjunpath	30	18	24.00					18	19	18.50				
		Ahimanpur	13	12	12.50	20				13	16.50					
	Mohammada bad	Aalapur	13	15	14.00	21.37				14	15	19.50	19.12			
		Abbas Nagar	30	19	24.50					13	17	15.00				
	Zamania	Usia	20	30	25.00					18	19	18.50				
		Bara	17	27	25.00	27				30	28.50					



Disease severity (%) was determined according to the scale of (Biswas *et al.*, 1982).

Results and Discussion

In order to know the disease incidence of *Alternaria* blight of bitter melon, a survey was conducted for collection of natural disease samples during the season 2020-21 and 2021-22 from different districts of Eastern Uttar Pradesh . During the survey, it was found that most farmers grow local variety of bitter melon. The less infections of *Alternaria* blight may be due to crop rotation followed by

the farmers of resistance was present in local variety. The result of year 2020-21 presented in Table 1 with corresponding histogram fig.1 reveals that the maximum average percent disease incidence was recorded in Jaunpur (25.00%) followed by Amedbedkar Nagar (24.37%) , Sultanpur (23.37%), Ghazipur (21.37%), Bhadohi (20.75%) and Varanasi (20.25 %). The minimum average percent disease incidence was recorded in Azamgarh (18.75%) in year 2020-21. The maximum (35.00%) disease incidence was recorded in Lalmanpur Kerakat district of Jaunpur and minimum (12.5%) disease

incidence were recorded in Godhna, in Phoolpur tehsil, Azamgarh in 2020-21.

Similarly in year 2021-22 result presented in Table 1 with corresponding histogram fig.2 reveals that the maximum average PDI (%) was recorded in Varanasi (26.18%) followed by Azamgarh (25.12%), Ghazipur (19.12%), Jaunpur (18.75%), Sultanpur (16.75%), Bhadhoi (16.50%) and minimum was recorded in Ambedkar Nagar District with PDI (16.00%). The maximum disease incidence was recorded in Saraiyan village (29.00%) of Azamgarh district and minimum incidence was recorded in Gyanipur village (12.50%) of Sultanpur district. Similar result have also been recorded by previous worker (Ojiambo, P.S. 2011) and (Rai *et al.*, 2008) the survey for disease in different Cucurbits in India.

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Performance of Wheat (*Triticum aestivum* L.) Cultivars at Various Sowing Dates

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Abstract

A field experiment was conducted during the *Rabi* season of session 2022-23 at the Agricultural research farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab to study the "Performance of wheat (*Triticum aestivum* L.) cultivars at various sowing dates." The experiment was comprised of four sowing dates, viz., 5th November, 20th November, 5th December and 20th December, as main plot treatments, and two wheat varieties, viz., HD 2967 and PBW 725, as sub plot treatments. The experiment was laid out in a factorial randomized block design with three replications. Based on the research investigation, it was found that sowing dates and wheat varieties both significantly influenced the growth, development, yield attributes and yield of the wheat crop. The results revealed that significantly higher plant height (110.87 cm), number of effective tillers per m² (87.67), dry matter accumulation (355.20 g/m²), number of spikelets per spike (26.00), number of grains per spike (45.00), 1000-grain weight (47.73 g), biological yield (123.17 q ha⁻¹), grain yield (58.25 q ha⁻¹) and harvest index (46.78 %) were found under D₁V₂ (5th November + PBW 725) sown crop as compared to other treatments D₁V₁ (5th November + HD 2967), D₂V₁ (20th November + HD 2967), D₂V₂ (20th November + PBW 725), D₃V₁ (5th December + HD 2967), D₃V₂ (5th December + PBW 725), D₄V₁ (20th December + HD 2967) and D₄V₂ (20th December + PBW 725) sown crops. Variety HD 2967 required a higher number of days to anthesis (100.33) and days to maturity (158.67) as compared to the PBW 725 cultivar. The interaction between the sowing dates and varieties was found to be non-significant among all perspectives. Delay in sowing date from 5th November with each 15-day interval up to 20th December declined growth, yield attributes and yield of the wheat crop. Among sowing dates, 5th November was found to be better as compared to 20th November, 5th December and 20th December sowing dates. In conclusion, establishment of variety PBW 725 showed an excellent result on the 5th November sowing date as compared to 20th November, 5th December, and 20th December sowing dates in all perspectives. Among varieties, PBW 725 performed better as compared to HD 2967 in terms of growth and yield.

Key words : Wheat, sowing dates, varieties, growth parameters, yield attributes and yield.

Introduction

Wheat (*Triticum aestivum* L.) being world first ranked grain crop is the mainstay of the agricultural economy and is also known as 'King of cereals' (Habibi and Fazily, 2020). Wheat is Punjab's most important cereal crop (Anonymous, 2023a). In India, wheat was produced on a gross area of 30.5 mha from 2022 to 2023, producing 106.8 mt with an average yield of 3.51 t ha⁻¹. Three states - Uttar Pradesh (31.77%), Madhya Pradesh (20.98%), and Punjab (13.87%) - produce the majority of India's significant wheat, accounting for around 66.62% of the nation's overall production. (Anonymous, 2023b). Punjab produced 17.62 mt of wheat during 2021-22 on a 3.52 mha area with a productivity of 5.01 t ha⁻¹ (Anonymous, 2022a). Haryana has a wheat area of 2.31 mha with a production of 10.45 mt and a productivity of 4.85 t ha⁻¹ (Anonymous, 2022b).

In India, the northern region has long dominated wheat cultivation. States like Punjab and Haryana plains is producing a lot of wheat as irrigated crop but in southern region parts of Madhya Pradesh and Maharashtra it is grown largely under rainfed conditions

with little or no irrigation support (Tomar *et al.*, 2014). The best time for wheat sowing is first fortnight of November. Late sown wheat matures a little later, and temperature rise high enough to influence grain filling rate and duration, culminating in a yield. Early sown wheat has a shorter germination phase than late sown wheat, but days to start anthesis and booting stages are significantly shorter in late sown wheat (Farooq *et al.*, 2012). The sowing date varies from region to region depending on location and rainfall pattern (frequency, duration, and quantity) as well as maturity period of the particular wheat variety (Aslani and Mehrvar, 2020).

Proper sowing date and varietal selection could be responsible for higher production. Appropriate sowing date of various field crops results in higher economic yield without involving extra cost as it helps varieties to express their full growth potential. The sowing date of wheat crop plays a pivotal role in a country like India, where climatic conditions vary throughout the country (Netam *et al.*, 2020). Through management of the sowing date, environmental conditions and selection of cultivars, the increase in wheat grain by 10% to 80% has been reported by (Coventry *et al.*, 2019). Improper variety selection

affects crop yield because variety performance varies correspondingly with their genetic potential and adaptable environment, so there is potential for increasing wheat yield by cultivating climate resilient varieties. Wheat yield can be increased 10% to 80% by selecting the right sowing dates and varieties (Yusuf *et al.*, 2019). Therefore, this study was conducted to evaluate the performance of wheat cultivars sown on different sowing dates under Punjab conditions.

Materials and Methods

The experiment was conducted during *Rabi* season 2022-23 at the Agricultural Research Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab. The experimental site is situated in Punjab at 30.6465° N latitude and 76.3379° E longitude, at an altitude of 268 m above mean sea level. The climate of the location is sub-tropical to semi-arid. The maximum temperature during the crop season was 36.1°, and the minimum temperature was 4.3°. The total rainfall during the crop season was 106.3 mm. The experiment was laid out in factorial randomized block design with nine treatment and three replications. The treatments comprised of D₁V₁ (5th November + HD 2967), D₁V₂ (5th November + PBW 725), D₂V₁ (20th November + HD 2967), D₂V₂ (20th November + PBW 725), D₃V₁ (5th December + HD 2967), D₃V₂ (5th December + PBW 725), D₄V₁ (20th December + HD 2967) and D₄V₂ (20th December + PBW 725). The gross plot size was 5.25 m², and the net plot size was 3.00 m². Observations during the research period were recorded on morphological characters, viz., plant height (cm), number of effective tillers per meter row length, dry matter accumulation (g/mrl), days to anthesis and days to maturity. Yield attributes and yield, viz., number of spikelets per spike, number of grains per spike, 1000-grain weight (g), biological yield (q ha⁻¹), grain yield (q ha⁻¹) and harvest index (%), were recorded. The formula used to calculate the harvest index was given by Nichiporovich (1960).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Results and Discussion

Morphological Characters

Plant height (cm) : Plant height is a reliable index of growth and development, representing the infrastructure built up over a period of time (Table-1). Plant height was substantially higher (110.87 cm) under treatment D₁V₂ (5th November + PBW 725) sown crop, and it was statistically significant with all other treatments, i.e., D₁V₁ (106.40 cm), D₂V₁ (101.50 cm), D₂V₂ (104.60 cm), D₃V₁ (94.27 cm), D₃V₂ (97.53 cm) and D₄V₂ (93.87 cm) sown crops. The

minimum periodic plant height (91.00 cm) was recorded under the treatment D₄V₁ (20th December + HD 2967) sown crop. On average basis variety PBW 725 performed significantly better (94.92 cm) as compared to HD 2967 (90.84 cm) in all perspectives. Plant height is mainly controlled by the genetic makeup, but it is also affected by environmental conditions. The results have been supported by several workers (Fazily 2021, Al-Jayashi *et al.*, 2021, Liu *et al.*, 2023). Interaction between sowing dates and varieties with respect to plant height was found non-significant.

Number of effective tillers per meter row length :

Sowing dates and varieties significantly influenced the number of effective tillers per meter row length (Table-2). Greater number of effective tillers per meter row length (87.67) was under treatment D₁V₂ (5th November + PBW 725) sown crop, and it was statistically significant with all other treatments, i.e., D₁V₁ (85.67), D₂V₁ (76.00), D₂V₂ (81.67), D₃V₁ (69.67), D₃V₂ (74.00) and D₄V₂ (67.00) sown crops. The minimum number of effective tillers (64.67) was recorded under the treatment D₄V₁ (20th December + HD 2967) sown crop. On average basis variety PBW 725 performed significantly better (77.59) as compared to HD 2967 (74.00) in all perspectives. It might be because there was a sufficient amount of assimilates available throughout the reproductive stage, which resulted in increase in number of effective tillers. The results have been supported by several workers (Singh *et al.*, 2021, Kumari *et al.*, 2022, Kaur 2017). Interaction between sowing dates and varieties was found to be non-significant.

Dry matter accumulation (g/mrl) : Dry matter accumulation (g/mrl) shows significant difference among sowing dates and varieties (Table-3). Higher dry matter accumulation (g/mrl) was observed on under treatment D₁V₂ (5th November + PBW 725) (344.20 g/mrl) sown crop and it was statistically significant with all other treatments, i.e., D₁V₁ (336.97 g/mrl), D₂V₁ (330.27 g/mrl), D₂V₂ (336.50 g/mrl), D₃V₁ (324.77 g/mrl), D₃V₂ (330.70 g/mrl) and D₄V₂ (324.53 g/mrl) sown crops. The minimum dry matter accumulation (321.93 g/mrl) was recorded under the treatment D₄V₁ (20th December + HD 2967) sown crop. On average basis variety PBW 725 performed significantly better (332.05 g/mrl) as compared to HD 2967 (319.26 g/mrl) in all perspectives. The increased dry-matter accumulation in sown crop was mainly because of favorable cool weather available for longer period than what was available for the late sown crop. The results have been supported by several workers (Reddy *et al.*, 2020, Chauhan *et al.*, 2019, Thakur *et al.*, 2021). The interaction effect of sowing dates and wheat varieties in relation to dry matter accumulation was found to be non-significant.

Table-1 : Plant height (cm).

Date of sowing × Variety	Date of sowing				Variety	
	5 th November (D ₁)	20 th November (D ₂)	5 th December (D ₃)	20 th December (D ₄)	Mean	CD (5%) and Sem±
HD 2967 (V ₁)	106.40	101.50	94.27	91.00	98.29	1.53
PBW 725 (V ₂)	110.87	104.60	97.53	93.87	101.72	0.50
Mean	108.64	103.05	95.90	92.44		
	Date of sowing		Date of sowing × Variety		CV %	
CD (5%)	2.17		NS		6.97	
Sem±	0.71		1.00			

Table-2 : Number of effective tillers per meter row length.

Date of sowing × Variety	Date of sowing				Variety	
	5 th November (D ₁)	20 th November (D ₂)	5 th December (D ₃)	20 th December (D ₄)	Mean	CD (5%) and Sem±
HD 2967 (V ₁)	85.67	76.00	69.67	64.67	74.00	1.95
PBW 725 (V ₂)	87.67	81.67	74.00	67.00	77.59	0.64
Mean	86.67	78.84	71.84	65.84		
	Date of sowing		Date of sowing × Variety		CV %	
CD (5%)	2.75		NS		11.32	
Sem±	0.90		1.27			

Table-3 : Dry matter accumulation (g/mrl).

Date of sowing × Variety	Date of sowing				Variety	
	5 th November (D ₁)	20 th November (D ₂)	5 th December (D ₃)	20 th December (D ₄)	Mean	CD (5%) and Sem±
HD 2967 (V ₁)	336.97	325.27	312.88	301.93	319.26	2.34
PBW 725 (V ₂)	355.20	336.97	325.27	310.77	332.05	0.77
Mean	364.09	331.12	319.08	306.35		
	Date of sowing		Date of sowing × Variety		CV %	
CD (5%)	3.31		NS		5.28	
Sem±	1.08		1.53			

Days to anthesis : Sowing dates and varieties significantly influenced days to anthesis (Figure-1). The maximum days to anthesis (100.33) was recorded under the treatment D₁V₁ (5th November + HD 2967) sown crop and it was statistically significant with all other treatments, i.e., D₁V₂ (99.33), D₂V₁ (97.33), D₂V₂ (95.67), D₃V₁ (90.67), D₃V₂ (89.33) and D₄V₁ (86.33) sown crops. The minimum days to anthesis (77.33) was recorded under the treatment D₄V₂ (20th December + PBW 725) sown crop. On average basis variety PBW 725 performed significantly better (90.42) as compared to HD 2967 (93.67) in all

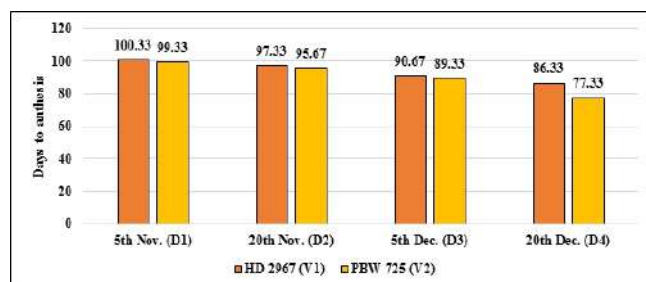


Figure-1 : Effect of sowing dates and varieties on the days to anthesis of wheat.

perspectives. The increase in days to anthesis might be due to a longer reproductive phase, optimum temperature at the vegetative stage and scarce soil moisture. Similar results have been observed by several workers (Habibi and Fazily 2020, Madhu *et al.*, 2018). The interaction effect of sowing dates and wheat varieties in relation to days to anthesis was found to be non-significant.

Days to maturity : Sowing dates and varieties significantly influenced days to maturity (Figure-2). The maximum days to maturity (158.67) was recorded under the treatment D₁V₁ (5th November + HD 2967) sown crop and it was statistically significant with all other treatments, i.e., D₁V₂ (154.33), D₂V₁ (147.67), D₂V₂ (143.67), D₃V₁ (139.33), D₃V₂ (135.67) and D₄V₁ (128.67) sown crops. The minimum days to maturity (126.33) was recorded under the treatment D₄V₂ (20th December + PBW 725) sown crop. On average basis variety PBW 725 performed significantly better (140.00) as compared to HD 2967 (143.59) in all perspectives. The increase in days to maturity might be due to a longer reproductive phase and a more suitable temperature than in the late sown crop. The results have been supported by several workers

(Gupta *et al.*, 2017, Amrawat *et al.*, 2017, Kaur and Kaur 2017). The interaction effect of sowing dates and wheat varieties in relation to days to maturity was found to be non-significant.

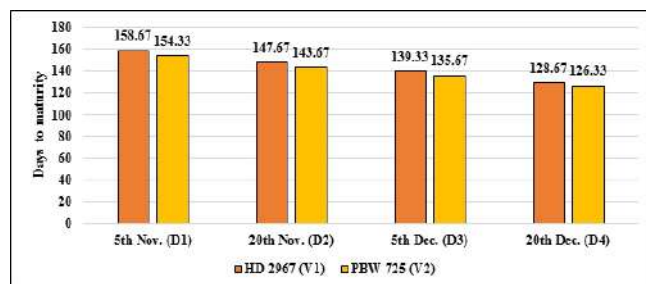


Figure-2 : Effect of sowing dates and varieties on the days to maturity of wheat.

Yield and Yield Attributes

Number of spikelets per spike : Sowing dates and varieties significantly influenced number of spikelets per spike (Figure-3). Greater number of spikelets per spike (26.00) was under treatment D₁V₂ (5th November + PBW 725) sown crop and it was statistically significant with all other treatments, i.e., D₁V₁ (22.00), D₂V₁ (19.00), D₂V₂ (23.00), D₃V₁ (18.00), D₃V₂ (20.00) and D₄V₂ (18.00) sown crops. The minimum number of spikelets per spike (16.00) was recorded under the treatment D₄V₁ (20th December + HD 2967) sown crop. On average basis variety PBW 725 performed significantly better (22.00) as compared to HD 2967 (19.00) in all perspectives. Increasing planting density can result in an increase in number of spikelets per spike, which could be attributed to a greater number of plants. The results have been supported by several workers (Singh *et al.*, 2022a, Amrawat *et al.*, 2017). Interaction between sowing dates and varieties showed non-significant differences in the number of spikelets per spike.

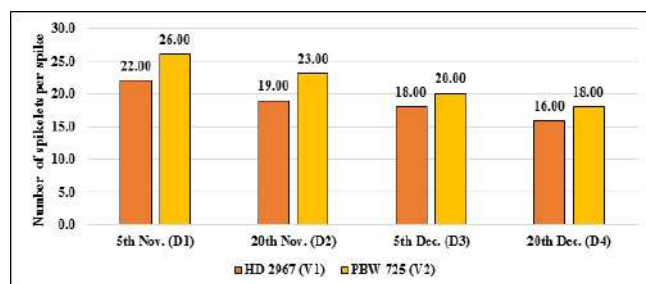


Figure-3 : Effect of sowing dates and varieties on the number of spikelets per spike of wheat.

Number of grains per spike : Number of grains per spike shows significant variation among sowing dates and varieties (Table-4). The higher number of grains per spike (45.00) was under treatment D₁V₂ (5th November + PBW

725) sown crop and it was statistically significant with all other treatments, i.e., D₁V₁ (42.00), D₂V₁ (40.00), D₂V₂ (43.00), D₃V₁ (38.00), D₃V₂ (41.00) and D₄V₂ (38.00) sown crops. The minimum number of grains per spike (33.00) was recorded under the treatment D₄V₁ (20th December + HD 2967) sown crop. On average basis variety PBW 725 performed significantly better (42.00) as compared to HD 2967 (38.00) in all perspectives. The increase in number of grains per spike might be due to a suitable temperature and the translocation of more photosynthesis, resulting in a greater number of grains per spike than in the late sown crop. Similar results have been recorded by several workers (Kamrozzaman *et al.*, 2016, Baloch *et al.*, 2017). Interaction between sowing dates and varieties showed non-significant differences among number of grains per spike.

1000-grain weight (g) : Test weight is a parameter through which the development of a seed can be judged (Table-5). The test weight is a good index of seed development, grain quality and crop yield. The higher test weight (47.73 g) was observed under treatment D₁V₂ (5th November + PBW 725) sown crop and it was statistically significant with all other treatments, i.e., D₁V₁ (43.43 g), D₂V₁ (42.20 g), D₂V₂ (44.70 g), D₃V₁ (37.40 g), D₃V₂ (39.23 g) and D₄V₂ (37.40 g) sown crops. The minimum 1000-grain weight (34.00 g) was recorded under the treatment D₄V₁ (20th December + HD 2967) sown crop. On average basis variety PBW 725 performed significantly better (42.27) as compared to HD 2967 (39.26) in all perspectives. The increase in test weight might be due to better yield-contributing characters. The application of fertilizer enhances overall crop development and has a significant impact on the morphological and photosynthetic components of growth as well as nutrient buildup of grain. The results have been supported by several workers (Kaur 2017, Liu *et al.*, 2023). The interaction effect of sowing dates and wheat varieties with respect to test weight was found to be non-significant.

Biological yield (q ha⁻¹) : Sowing dates and varieties significantly influenced the biological yield of wheat crops (Table-6). The maximum biological yield was recorded under treatment D₁V₂ (5th November + PBW 725) (123.17 q ha⁻¹) sown crop and it was statistically significant with all other treatments, i.e., D₁V₁ (116.41 q ha⁻¹), D₂V₁ (109.33 q ha⁻¹), D₂V₂ (121.57 q ha⁻¹), D₃V₁ (106.98 q ha⁻¹), D₃V₂ (116.96 q ha⁻¹) and D₄V₂ (109.30 q ha⁻¹) sown crops. The minimum biological yield (100.06 q ha⁻¹) was recorded under the treatment D₄V₁ (20th December + HD 2967) sown crop. On average basis variety PBW 725 performed significantly better (117.75 q ha⁻¹) as compared to HD 2967 (108.20 q ha⁻¹) in all perspectives. The interaction effect of sowing dates and wheat varieties was non-significant in relation to biological yield. The results

Table-4 : Number of grains per spike.

Date of sowing × Variety	Date of sowing				Variety	
	5 th November (D ₁)	20 th November (D ₂)	5 th December (D ₃)	20 th December (D ₄)	Mean	CD (5%) and Sem±
HD 2967 (V ₁)	42.00	40.00	38.00	33.00	38.00	2.20
PBW 725 (V ₂)	45.00	43.00	41.00	38.00	42.00	0.71
Mean	44.00	42.00	40.00	36.00		
	Date of sowing		Date of sowing × Variety		CV %	
CD (5%)	3.10		NS		9.26	
Sem±	1.01		1.43			

Table-5 : 1000-grain weight (g).

Date of sowing × Variety	Date of sowing				Variety	
	5 th November (D ₁)	20 th November (D ₂)	5 th December (D ₃)	20 th December (D ₄)	Mean	CD (5%) and Sem±
HD 2967 (V ₁)	43.43	42.00	37.40	34.00	39.26	1.76
PBW 725 (V ₂)	47.73	44.70	39.23	37.40	42.27	0.25
Mean	45.58	43.45	38.32	35.70		
	Date of sowing		Date of sowing × Variety		CV %	
CD (5%)	1.08		NS		11.12	
Sem±	0.35		0.50			

Table-6 : Biological yield (q ha⁻¹).

Date of sowing × Variety	Date of sowing				Variety	
	5 th November (D ₁)	20 th November (D ₂)	5 th December (D ₃)	20 th December (D ₄)	Mean	CD (5%) and Sem±
HD 2967 (V ₁)	116.41	109.33	106.98	100.06	108.20	1.41
PBW 725 (V ₂)	123.17	121.57	116.96	109.30	117.75	0.46
Mean	119.79	115.45	111.97	104.68		
	Date of sowing		Date of sowing × Variety		CV %	
CD (5%)	1.99		NS		7.01	
Sem±	0.65		0.92			

have been supported by several workers (Singh *et al.*, 2022b, Spink *et al.*, 2018, Mahajan *et al.*, 2018, Liu *et al.*, 2023).

Grain yield (q ha⁻¹) : Grain yield is the end product and the net result of various agronomic inputs influencing growth and yield-attributing characteristics during life cycle of the crop. Sowing dates and varieties significantly influenced the grain yield of wheat crop (Figure-4). The higher grain yield was under treatment D₁V₂ (5th November + PBW 725) (58.25 q ha⁻¹) sown crop and it was statistically significant with all other treatments, i.e., D₁V₁ (53.87 q ha⁻¹), D₂V₁ (49.50 q ha⁻¹), D₂V₂ (56.20 q ha⁻¹), D₃V₁ (47.36 q ha⁻¹), D₃V₂ (52.87 q ha⁻¹) and D₄V₂ (47.64 q ha⁻¹) sown crops. The minimum grain yield (42.72 q ha⁻¹) was recorded under the treatment D₄V₁ (20th December + HD 2967) sown crop. On average basis variety PBW 725 performed significantly better (53.74 q ha⁻¹) as compared to HD 2967 (48.36 q ha⁻¹) in all perspectives. The increase in grain yield might be due to favourable environmental conditions at all growth stages. So, it recorded significantly better yield of contributing characters, viz., number of spikelets per spike, number of

grains per spike and test weight. The results have been supported by several workers (Netam *et al.*, 2020, Singh *et al.*, 2022a, Yusuf *et al.*, 2019). Interaction effect of sowing dates and wheat varieties was found to be non-significant in terms of grain yield.

Figure-4 : Effect of sowing dates and varieties on the grain yield (q ha⁻¹) of wheat.

Harvest index (%) : The harvest index is an important parameter indicating the efficiency of the partitioning of dry matter to the economic parts of the crop. The harvest index was significantly influenced by sowing dates and varieties (Figure-5). The significantly higher harvest index

(47.29 %) was recorded under the treatment D₁V₂ (5th November + PBW 725) sown crop and it was statistically significant with all other treatments, i.e., D₁V₁ (46.27 %), D₂V₁ (45.27 %), D₂V₂ (46.22 %), D₃V₁ (44.26 %), D₃V₂ (45.20 %) and D₄V₂ (43.58 %) sown crops. The minimum harvest index (42.69 %) was recorded under the treatment D₄V₁ (20th December + HD 2967) sown crop. On average basis variety PBW 725 performed significantly better (117.75 q ha⁻¹) as compared to HD 2967 (108.20 q ha⁻¹) in all perspectives. The increase in harvest index might be due to the harvest index being greatly affected by wheat cultivars due to genetic variability. The results have been supported by several workers (Kamrozzaman *et al.*, 2016, Baloch *et al.*, 2017, Singh *et al.*, 2021). The interaction effect of sowing dates and wheat varieties in relation to the harvest index was found to be non-significant.

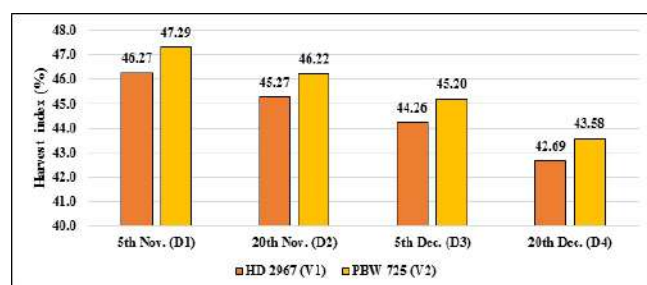


Figure-5 : Effect of sowing dates and varieties on the harvest index (%) of wheat.

Conclusions

Based on research experiment, it was concluded that delay in sowing date from 5th November with each 15-day interval up to 20th December declined growth, yield attributes and yield of the wheat crop. Among sowing dates, 5th November was found to be most economical and suitable as compared to 20th November, 5th December and 20th December sowing dates. Among varieties, PBW 725 showed an excellent result on the 5th November sowing date as compared to HD 2967 cultivar in all perspectives.

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E-Learning Methods used by Post-Graduate Students in RDVV, Jabalpur

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Abstract

Now internet has shown new paths to learning. The educational resources are accessible to students. Learner needs are increasingly seen to be continuous throughout the working life. Education is a means of empower their lives and future within workplace. In India e-Learning systems and online courses are already started. This paper covers the issues of developing e-Learning system its requirement, and its implication in e learning. For this purpose, random sampling procedure had been followed and total of 100 questionnaires had been distributed among the PG students of various faculties of the Rani Durgavati University, Jabalpur. The study focus on time spent by the user, nature of library use by respondents and response to use of modern library software in the library. The results majority of students (62.5 %) uses library 1 to 5 hours per week, most of the students (75.0 %) were agreed that there library are equipped with modern library software and majority of students (75.0 %) preferred research work to do in the library.

Key words : E service, library, PG STUDENTS and RDVV Jabalpur

Introduction

New developments in technology are becoming important part of the teaching and learning all over the world. It is commonly thought that new technologies can make a big difference in education. In particular, students can interact with new media, and improve their skills, knowledge, and perception of the world, under their teachers' monitoring, of course. E-learning for instance, is the computer and network-enabled transfer of skills and knowledge. E-learning applications and processes include web-based learning, computer-based learning, virtual education opportunities and digital collaboration. Content is delivered via the Internet, intranet/extranet, audio or video tape, satellite TV, and CD-ROM (Kumhar 2023). It can be self-paced or instructor-led and includes media in the form of text, image, animation, streaming video and audio (Nishanthi and Merlin UT. 2021). Many supporters of e-learning believe that everyone must be equipped with basic knowledge in technology, as well as use it as a medium to reach a particular goal. The concept of e-service (electronic service), represents one prominent application of utilizing the Information and communication. Technologies (ICT's) in different areas. However, there is no exact definition of e-service, as students and researchers have been using different definitions to describe e-service. Despite these different definitions, it can be argued that they all agree about the role of technology in facilitating the delivery of services which make them more users friendly. However, an apt definition seems to be one given by Adopt Rowley (2006), who

defines e-services, as: deeds, efforts or performances whose delivery is mediated by information technology. Such e-service includes the service element of e-tailing, customer support, and service delivery". This definition reflects three main components- (i) service provider, (ii) service receiver and (iii) the channels of service delivery. For example, as concerned to public e-service, public agencies are the service provider and citizens as well as businesses are the service receiver. The channel of service delivery is the 2 third requirement of e-service. Internet is the main channel of e-service delivery while other classic channels (e.g. telephone, call centre, public kiosk, mobile phone, television) are also considered. Gradually, the teaching and learning practices of our country are undergoing a shift from the traditional methods to extensive usage of e learning resources. The Universities are laying more stress on utilizing the web based resources, for teaching and learning, to improve the quality of education. The goal is to create quality manpower on par with the developed countries. In such a situation, analysis of the impact of e-services, and e-learning on the learning ability of the students in higher education institutes is apt it can be helpful in understanding the problems faced by the students and teachers, besides giving guidelines of making meaningful improvements in the existing methods, to help the students in improving their academic performances through advanced technology in education. The following paragraphs provide the brief about advanced developments in e-learning. E-learning term covering the wide set of applications and processes such as web based

learning; computer based learning and virtual classrooms. It includes the delivery of content via internet, Intranet, Extranet (LAN/WAN), audio and video tapes, Satellite broadcast or CD-ROM *etc.* It refers to learning and other supportive resources that are available through computer. E-Learning is developed to apply information technology applications to education. E-learning is a continuous process when the learner is unable to attend the traditional methods of learning; the distance mode of learning was introduced. The student needs to learn syllabus from nearby libraries or materials sent by the course organiser. Modern Media such as radio and television were also used in the distance mode of learning process. These media benefit a lot the learner, but they have their own limitations. The distance mode of learning process is further 3 strengthened by video conference mode. The nodal centre will have studio where the experts assemble and deliver the lecture. This will reach audience through different media. This technique will create the environment of the classroom and enables direct interaction between the teacher and learner. Now internet has shown new paths to learning. The educational resources are accessible to students. Learner needs are increasingly seen to be continuous throughout the working life. Education is a means to empower their lives and future within workplace, at least in the advanced market led societies. The person who acquires and applies the knowledge and skills will be sustained in the future. One should require learning for updating their knowledge, skills and competencies (Vatnal *et al.*, 2004). E-learning is basically the computer and network enabled transfer of skills and knowledge. It includes the electronic applications and processes applied to teaching and learning (Allen and Olkin 1999). E-learning applications may include web-based learning, computer-based learning, virtual classrooms, and digital collaboration. The libraries acquired various e-learning resources and deposited them in the local server. The resources are networked to provide access to these resources via internet or intranet.

Research Methodology

Every research needs some research methodologies as scientific method, historical method, survey method *etc.* Survey method is most popular method of research in humanities and social sciences. In the beginning of the study it will be desirable to make literature search for the contribution of theoretical and practical aspect of the impact of e-learning and e-services among the students in India and abroad. For the purpose of the study survey method has been used. There are so many techniques of surveys but in this study the questionnaire has been used as a tool of the survey and the responses of the

respondents have been collected on several questions. The primary data has been collected by the researcher with the help of questionnaire and personal interview with the PG Students of the RDVV, Jabalpur. A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. The questionnaire method of gathering of valuable data is the most effective methods and for this purpose, a well-structured questionnaire had been designed for the users for filling up the relevant information. The questionnaire had been used in the study is so designed that this could be answered by respondents within shortest time. For this purpose, random sampling procedure had been followed and total of 100 questionnaires had been distributed among the PG students of various faculties of the Rani Durgavati University, Jabalpur.

Data analysis : The present study rotates around the Impact of E-Learning and E-Services among the Students of RDVV, Jabalpur and also the level of satisfaction received from the use of library. After a rigorous effort only 100 respondents could be contacted. Copies of a well-designed questionnaire were distributed among the PG students with a request to return it back after filling up properly. Out of 100 questionnaires only 90 duly filled in could be collected back. This reveals that only 90 % respondents were interested in showing their needs for information on the schedule.

Results and Discussion

Span of time spent by the user : Data revealed (Table-1) that the majority of students (62.5 %) uses library 1 to 5 hours per week, (25 %) members 6 to 10 hours per week and (12.5%) members 10 to 15 hours per week in the library. This is a healthy sign that the users prefer to spend more and more time for various purposes. Similar results found by Laitlanzova and Chanchinmawia. 2021 in terms of duration of time spent in the library depicts the use of the library in many ways such as borrowing of books, consultation of journals, use of electronic resources, exchange of ideas, 121(57%) majority of the respondents prefer to spend 1 hour or less in the library, followed by 61(28%) 2 hours, 20 (10%) 3 hours and 9(5%) respondents 4 hours.

Table-1 : Span of time spent by the user at RDVV, Jabalpur.

Span of time	No. of Respondents	Per cent
1-5 Hours	56	62.5
6-10 Hours	23	25.0
11-15 Hours	11	12.5
16-20 Hours	0	0.0
More than 20 Hours	0	0.0
Total	90	100

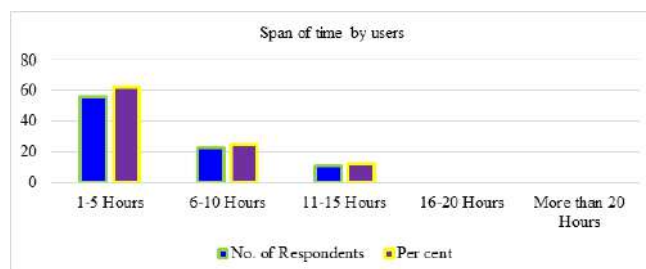


Fig-1 : Span of time spent by the user at RDVV, Jabalpur.

Response to use of modern library software in the library : Data given in table-2 showed that most of the students (75.0 %) were agreed that there library are equipped with modern library software while (25.0 %) members were not satisfied. This results agreement with Salubi *et al.*, 2018 in terms with E-librarians revealed that undergraduate students account for no more than 6% of total users of electronic databases with 62.3% of the respondents preferring print information resources.

Table-2 : Response regarding the use of modern library software in the library.

Response	No. of Respondents	Per cent
Yes	67	75.0
No	23	25.0
Total	90	100.0

Nature of library use by respondents : Table-3 indicates that a majority of students (75.0 %) preferred research work to do in the library 12.5% prefer to prepare teaching pedagogy followed by 7.5% writing of books and 5% to prepare paper for workshop and conference. Similar results found by Michael *et al.*, 2015 in terms of most of the student used e-learning to upload lecture notes (28 %) and submit assignment (30 %). Vrana, 2011 researcher reported that, an institutional digital repository can contain e-prints of scientific papers, research data, but also e-learning materials and other forms of institutional intellectual outputs.

Table-3 : Nature of the library use by respondents.

Use of Library	No. of Respondents	Per cent
Research Work	67	74.45
Writing in Books	7	7.78
To prepare teaching pedagogy	11	12.22
To prepare for workshop and conference	5	5.55
Total	90	100.0

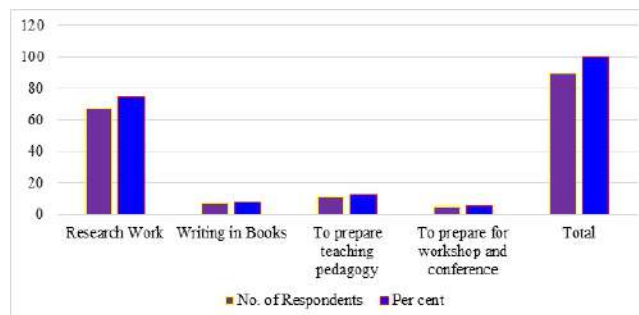


Fig-2 : Nature of the library use by respondents.

Conclusions

The present study has been conducted to evaluate responses available in the Central Library of RDVV, Jabalpur, Madhya Pradesh and to find out what type of information, their user require and the problems in searching them they fall. RDVV, Jabalpur, library should be required relevant document related the subject interest to fulfil the information needs of all students. On the whole study it is felt that there was in general scope for improvement in library arrangement, automation, facilities and services. Proper should be taken for arrangement of books, journals on shelves and misplaced reading materials are arranged properly, so that difficulties in locating books may be minimize and faculty member could not waste their time in searching the materials. Better library facilities and services required and more cooperation and help from the side of library staffs is needed. One of the respondents wants the periodicals to be issued to the uses for one to four weeks. It is a matter of great strange that being a faculty member that respondent does not know the importance of periodicals. The importance of journal/periodical is in its currency. If a journal/periodical is issued for a week or few weeks to the users it will not be available currently in the library. It is against the rule of library. Journal are the reading materials of the study in library itself, it is not the material of issuing because old journal lacks, its importance library initiation programme is essential to keep the user aware with the use of documents and the rules of library.

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E-Services Methods Satisfaction and Barrier by Post-Graduate Students in RDVV, Jabalpur

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Abstract

In India e-Learning systems and online courses are already started. This paper covers the issues of developing e-Learning system its requirement, and its implication in e learning. For this purpose, random sampling procedure had been followed and total of 100 questionnaires had been distributed among the PG students of various faculties of the Rani Durgavati University, Jabalpur. The study focus on degree of satisfaction of users in services by RDVV PG Students, barrier of communication in between faculty member and library staff and Users' opinion about the library facilities available to them. The results revealed have partially satisfied (75%) with the services provided by the library, maximum 50% respondents were agreed for timing as a barrier between library and them and 87.5% students were average satisfied from library services.

Key words : E-service, library, PG students and RDVV Jabalpur

Introduction

The concept of e-service (electronic service), represents one prominent application of utilizing the Information and communication. Technologies in different areas. However, there is no exact definition of e-service, as students and researchers have been using different definitions to describe e-service (Binu and Baskaran 2012). Despite these different definitions, it can be argued that they all agree about the role of technology in facilitating the delivery of services which make them more users friendly. E-services, as deeds, efforts or performances whose delivery is mediated by information technology. Such e-service includes the service element of e-tailing, customer support, and service delivery". This definition reflects three main components—(i) service provider, (ii) service receiver and (iii) the channels of service delivery (i.e., technology). For example, as concerned to public e-service, public agencies are the service provider and citizens as well as businesses are the service receiver. The channel of service delivery is the 2 third requirement of e-service. Internet is the main channel of e-service delivery while other classic channels (telephone, call centre, public kiosk, mobile phone, television) are also considered (Madhusudhan, 2010). Gradually, the teaching and learning practices of our country are undergoing a shift from the traditional methods to extensive usage of e learning resources. The Universities are laying more stress on utilizing the web based resources, for teaching and learning, to improve the quality of education. The goal is to create quality manpower on par with the developed countries. In such a

situation, analysis of the impact of e-services, and e-learning on the learning ability of the students in higher education institutes is apt. it can be helpful in understanding the problems faced by the students and teachers, besides giving guidelines of making meaningful improvements in the existing methods, to help the students in improving their academic performances through advanced technology in education (Naidu *et al.*, 2007). The following paragraphs provide the brief about advanced developments in e-learning. The libraries are also forced to adopt new technologies in the library to provide e-services to satisfy the information requirements of the users. The following are a few of the merits of e-services based library services principles that are framed for creating library services. They are such as access to information sources, information literacy, methods of using information, convenient access, speed in access, integration in access to information, quality of information and knowledge and updating information. In a library a significant proportion of the resources is available in machine-readable format (as opposed to print or microform), accessible by means of computer. The digital content may be locally held or accessed remotely via computer networks. A digital library is popularly viewed as an electronic version of a library where storage is in digital form, allowing direct communication to obtain material and copying it from a master version (Singh, 1979). The digital library is an assemblage of digital computing, storage and communication machinery together with the content and software needed to reproduce, emulate, and extend the services provided by conventional libraries based on paper and other materials means of collecting,

cataloguing, finding and disseminating information (Gladney, 1994). Digital library provides a variety of digital information sources. It reduces the physical space, user can access to information remotely, and it also provides access to distributed information resources. Its advantage is that it has the ability to handle multilingual content. The libraries are implementing e-service based Inter Library Lending (ILL) using networks to deliver copies of journal articles and other documents in digital format like PDF (Portable Document Format) to the users' desktops. It helps the users to access to information which is not available in their respective libraries. It is one of the most useful services for users, specifically research scholars of remote areas.

About the RDVV, Jabalpur : The University is privileged to have the blessings and good wishes of many important and distinguished Indians. The first Prime Minister of India Pt. Jawahar Lal Nehru inaugurated the administrative building of the university on 11th July 1961. Dr. Kunji Lal Dubey was the founder Vice-Chancellor of the University. Subsequently, a good number of renowned academicians also taught in this University. For the growth and development in field of education, research and extension, the Rani Durgavati Vishwavidyalaya, Jabalpur is deeply involved since last 5 decades. The University has produced a large number of internationally acclaimed academicians and scientists, a number of distinctions and awards have been given to its teachers and students and many international fellowships have been bagged by the Faculty members. The university was renamed Rani Durgavati Vishwa Vidyalaya on 7 June 1983 by Act No. 23 of 1983 to honour the well known valorous Gond Queen of Garha Mandla. It was reconstituted under M.P. Vishwavidyalaya Adhiniyam, 1973 and given jurisdiction over Jabalpur, Mandla, Seoni, Balaghat and Narsinghpur, Katni, Dindori, Chindwara Campus. It accommodates an Administrative Block, Art Faculty building, Teaching and Research buildings of Physics, Chemistry, Mathematics, Bioscience, System Science and Physical education departments. It has a Central Library, Computer Centre, USIC, University Institute of Management, University Law Department and other facilities like one boys' and one girls' hostels, University Health Centre, University Guest House, Canteen and residential quarters. Other facilities like post office, bank and printing press are on the campus.

Research Methodology

Every research needs some research methodologies as scientific method, historical method, survey method etc. Survey method is most popular method of research in humanities and social sciences. In the beginning of the study it will be desirable to make literature search for the contribution of theoretical and practical aspect of the

impact of e-learning and e-services among the students in India and abroad. For the purpose of the study survey method has been used. There are so many techniques of surveys but in this study the questionnaire has been used as a tool of the survey and the responses of the respondents have been collected on several questions. The primary data has been collected by the researcher with the help of questionnaire and personal interview with the PG Students of the RDVV, Jabalpur. A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. The questionnaire method of gathering of valuable data is the most effective methods and for this purpose, a well-structured questionnaire had been designed for the users for filling up the relevant information. The questionnaire had been used in the study is so designed that this could be answered by respondents within shortest time. For this purpose, random sampling procedure had been followed and total of 100 questionnaires had been distributed among the PG students of various faculties of the Rani Durgavati University, Jabalpur. The questionnaire was design according to learner dimension, course dimension and design dimension (Sun *et al.*, 2008).

Data analysis : The present study rotates around the Impact of E-Learning and E-Services among the Students of RDVV, Jabalpur and also the level of satisfaction received from the use of library. After a rigorous effort only 100 respondents could be contacted. Copies of a well-designed questionnaire were distributed among the PG students with a request to return it back after filling up properly. Out of 100 questionnaires only 90 duly filled in could be collected back. This reveals that only 90 % respondents were interested in showing their needs for information on the schedule.

Results and Discussion

The above Table-1 showed that most of the students have partially satisfied (i.e.75%) with the services provided by the library, 12.5% respondents fully satisfied and 12.5% sometimes. Similar results observed by (Laltlanzova and Chanchinmawia, 2021) in terms of (65%) respondents are satisfied with the availability of resources whereas (35%) respondents are not satisfied.

Table-1 : Degree of satisfaction of users in services by RDVV PG Students.

Degree of satisfaction	No. of Respondents	Per cent
Fully	11	12.5
Partially	68	75.0
Some time	11	12.5
Never	0	0.0
Total	90	100.0

Table-2 showed that a maximum 50 % respondents were agreed for timing as a barrier between library and them. 25 % students feel barrier in less no. of books, followed by 12.5 % in seating arrangement and technical information of library staff. Elyssa and Jennifer, 2021 researcher reported that understanding the expectations and internal communication that underlies these themes can provide insight into how to better work toward a shared goal across departments.

Table-2 : Barrier of communication in between faculty member and library staff.

Barriers	No. of Respondents	Percentage
Timing	45	50.0
Less no. of books	23	25.0
Seating Facilities	11	12.5.0
Technical incompetence of Library Staff	11	12.5
Discipline	0	0.0
Total	90	100.0

Data appearing in table-3 shows that 87.5% students were average satisfied from library services while 12.5% members scored well for providing services by the library. Similar finding agreement with (Rayapudi and Irrinki, 2021) in terms of Excellent followed by 298 (18.17%) PG-Students and 94 (5.73%) Research scholars feels as good.

Table-3 : Users' opinion about the library facilities available to them.

Respondents	No. of Respondents	Per cent
Excellent	0	0.0
Good	11	12.5
Average	79	87.5
Moderate	0	0.0
Poor	0	0.0
Very poor	0	0.0
Total	90	100

Conclusions

The present study has been conducted to evaluate responses available in the Central Library of RDVV, Jabalpur, Madhya Pradesh and to find out what type of information, their user require and the problems in searching them they fall. Proper should be taken for

arrangement of books, journals on shelves and misplaced reading materials are arranged properly, so that difficulties in locating books may be minimize and faculty member could not waste their time in searching the materials. Better library facilities and services required and more cooperation and help from the side of library staffs is needed. One of the respondents wants the periodicals to be issued to the uses for one to four weeks. It is a matter of great strange that being a faculty member that respondent does not know the importance of periodicals. The importance of journal/periodical is in its currency.

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Effect of Weed Management Practices on Nitrogen Uptake in Clusterbean [*Cyamopsistetragonoloba* (L.) Taub]

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Abstract

A field experiment was conducted to find out the effect of weed management practices on nitrogen content and uptake by clusterbean [*Cyamopsis tetragonoloba* (L.) Taub]. An investigation was conducted at Agricultural Research Station, Mandor, Agriculture University, Jodhpur, Rajasthan during Kharif 2018. The experiment laid down in a randomized block design (RBD) with three replications. The experiment comprising of ten treatments i.e. W₁-weedy check, W₂-weed free, W₃-pendimethalin at 750 g/ha (PE), W₄-imazethapyr at 40g/ha (early post-emergence), W₅-pendimethalin + imazethapyr at 750 g/ha (PE), W₆-imazethapyr + imazamox at 50 g/ha (early post-emergence), W₇-pendimethalin at 750 g/ha (PE) + 1 HW at 25 DAS, W₈-imazethapyr at 40 g/ha (early post-emergence) + 1 HW at 35 DAS, W₉-pendimethalin + imazethapyr at 750 g/ha(PE) + 1 HW at 25 DAS and W₁₀-imazethapyr + imazamox at 50 g/ha (early post-emergence) + 1 HW at 35 DAS. Early post-emergence application of imazethapyr + imazamox 50 g/ha + HW at 35 DAS was found the most effective treatment with recorded significantly higher nitrogen content and uptake by seed and stover. Although, weed free recorded higher total nitrogen uptake (112.06 kg/ha) by crop but it was statistically at par with early post-emergence application of imazethapyr + imazamox 50 g/ha + HW at 35 DAS (106.58).

Key words : Clusterbean, early-post emergence, nitrogen content and nitrogen uptake

Introduction

Clusterbean [*Cyamopsistetragonoloba* (L.) Taub] is commonly known as “Guar”. The primary centre of origin of clusterbean is India (Vavilov, 1951). It is recognized as one of the most important commercial crop of arid and semi-arid regions. It is well adapted to the conditions existing in Rajasthan and is being grown in areas receiving annual rainfall from 350 to 750 mm. Rajasthan is a major clusterbean growing state of India having area of 2.39 million hectares and production 1.0 million tonnes and productivity of 419 kg/ha of clusterbean. (Anon., 2022). Clusterbean is grown for different purposes viz., vegetable, green fodder, green manuring and seed. Tender pods of clusterbean are nutritionally wealthy in energy (116 k cal.), protein (3.2 g), fat (1.4 g), carbohydrate (10.8 g), vitamin-A (65.31 I.U.), vitamin-C (49 mg), calcium (57 mg) and iron (4.5 mg) per 100 g of edible portion (Kumar and Singh, 2002).

There is an acute crop-weed competition during early crop growth stage due to slow initial crop growth and weeds grow at faster speed. Weeds infect vigorously due to frequent rains and presence of weeds beyond critical period of crop-weed competition results in yield reduction to the tune of 40-45 per cent (Sangwan *et al.*, 2016). The competition is set in three leaf stage of weeds. The competition between crop and weeds caused 53.7 per cent reduction in grain yield (Singh *et al.*, 2008). Due

to unpredictability of rain, entailing to non-workable conditions of soil in rainy days and unavailability of labour at peak time, weed management in clusterbean is really a challenging task (Singh *et al.*, 2020). Weeds play a substantial role in the decline of clusterbean production. Poor fertility of soil and lack of nutrients are considered the major reasons of low productivity. Therefore, augmenting of nutrient supply assumes prime significance to improve crop productivity. Among different plant nutrients, nitrogen is the most important for plant growth and development. Nitrogen plays key role in synthesis of chlorophyll, amino acid and other organic compounds of physiological significance in plant system. Therefore proper nutrient management is of prime importance (Kumawat *et al.*, 2017). The present investigation was undertaken the influence of weed management practices on nitrogen uptake in clusterbean.

Materials and Methods

The experiment was carried out at Agricultural Research Station, Mandor-Jodhpur during kharif season of 2018. Geographically, Jodhpur is situated between 26° 15' N to 26° 45' North latitude and 73° 00' E to latitude 73° 29' East longitude at an altitude of 231 meter above mean sea level. Soil of the experimental field was loamy sand in texture, slightly alkaline in nature (pH 8.2), low in organic carbon (0.13%) and available nitrogen (174 kg/ha), whereas medium in phosphorus (22.0 kg P₂O₅ ha⁻¹) and

Table-1 : Weed flora of the experimental plot observed during experimentation.

Botanical name	Category of weed	Family
<i>Digera arvensis</i>	BLW	Amaranthaceae
<i>Tribulus terrestris</i>	BLW	Zygophyllaceae
<i>Corchorus trilocularis</i>	BLW	Tiliaceae
<i>Phyllanthus niruri</i>	BLW	Euphorbiaceae
<i>Portulaca oleracea</i>	BLW	Portulacaceae
<i>Amaranthus viridis</i>	BLW	Amaranthaceae
<i>Celosia argentea</i>	BLW	Amaranthaceae
<i>Dactyloctenium aegyptium</i>	NLW	Poaceae
<i>Cyperus rotundus</i>	NLW	Cyperaceae
<i>Eragrostis minor</i>	NLW	Poaceae
<i>Cynodon dactylon</i>	NLW	Poaceae

available potassium (325 kg K₂O/ha). The bulk density of soil of the experimental field is 1.77 mg/m³ and EC (0.13 dS/m).

The experiment laid down in a randomized block design (RBD) with three replications. The experiment comprising of ten treatments *i.e.* W₁-weedy check, W₂-weed free, W₃-pendimethalin at 750 g/ha (PE), W₄-imazethapyr at 40g/ha (early post-emergence), W₅-pendimethalin + imazethapyr at 750 g/ha (PE), W₆-imazethapyr + imazamox at 50 g/ha (early post-emergence), W₇-pendimethalin at 750 g/ha (PE) + 1 HW at 25 DAS, W₈-imazethapyr at 40 g/ha (early post-emergence) + 1 HW at 35 DAS, W₉-pendimethalin + imazethapyr at 750 g/ha(PE) + 1 HW at 25 DAS and W₁₀-imazethapyr + imazamox at 50 g/ha (early post-emergence) + 1 HW at 35 DAS. In rainy season, clusterbean variety RGC-1017 was used as a test crop in rows 30 cm apart using a seed rate of 15 kg/ha. General recommended dose of nutrients were *i.e.* 10 kg N and 40 kg P₂O₅/ha was applied through urea and DAP. Complete dose of nitrogen and phosphorus were applied as a basal application. All the recommended package of practices of the zone were followed for growing the crop except weed management.

According to treatments, pendimethalin and its ready mix with imazethapyr was applied as pre-mergence (within 2 DAS), while imazethapyr and its ready mix with imazamox was applied as early post-emergence (20 DAS). A knap-sack sprayer was used for spraying the herbicides using a spray volume of 800 litre/ha. In the plots ear marked for hand weeding, the operation was done at 25 and 35 days after sowing as per the treatments. The representative dry sample of seeds and stover were analyzed for ascertaining nitrogen content. The nitrogen content were analyzed by N analyzer fully automatic by Kelplus Classic DX-VA unit using kjeldahl method (Singh and Praharaj, 2017). The climate of this region is a typically semi-arid, characterized by extremes of temperatures during both summers and winters.

Comprehensive statistical analysis (treatment mean, standard error mean, critical difference and range of variation) and test of significance test (F-test) were carried out for each trait. For this, entire biometric data recorded during the course of investigation were compiled in proper tables and statistically analyzed by using the standard procedures of statistical analysis for randomized block design suggest by Gomez and Gomez (1984).

Nitrogen uptake by crop (kg/ha)

$$= \frac{\text{Nitrogen content in seed / stover yield} \times \text{seed / stover (\%)}}{100} \quad (\text{kg / ha})$$

Results and Discussion

It is obvious from the data presented in Fig.-1 that there was predominance of BLW weeds (92.86 %) in weedy check plots of clusterbean crop at ARS Mandor. Among the BLW weeds, the *Digera arvensis*, *Tribulus terrestris*, *Corchorus trilocularis*, *Phyllanthus niruri*, *Portulaca oleracea*, *Amaranthus viridis* and *Celosia argentea* were most dominant and among the NLW weeds like *Dactyloctenium aegyptium*, *Cyperus rotundus*, *Eragrostis minor* and *Cynodon dactylon* also marked their presence in lesser numbers during experimentation as they contributed 7.14%.

Nitrogen content in clusterbean seed and stover :

Results revealed that all the weed management treatments recorded significantly higher nitrogen content compared to weedy check. The highest nitrogen content in seed (4.826%) and stover (1.495%) was observed in weed free followed by imazethapyr + imazamox 50 g/ha + HW at 35 DAS (4.823 and 1.491%). The maximum nitrogen content in seed and stover was observed in weed free treatment. This might be due to: (i) Increased supply of nitrogen directly to the crop; (ii) indirectly through checking the loss of nutrients by weeds; (iii) increased nitrogen use efficiency (Kumar *et al.*, 2022). These results corroborate the findings of Kumawat *et al.*, (2022) and Rathore *et al.*, (2007) in clusterbean.

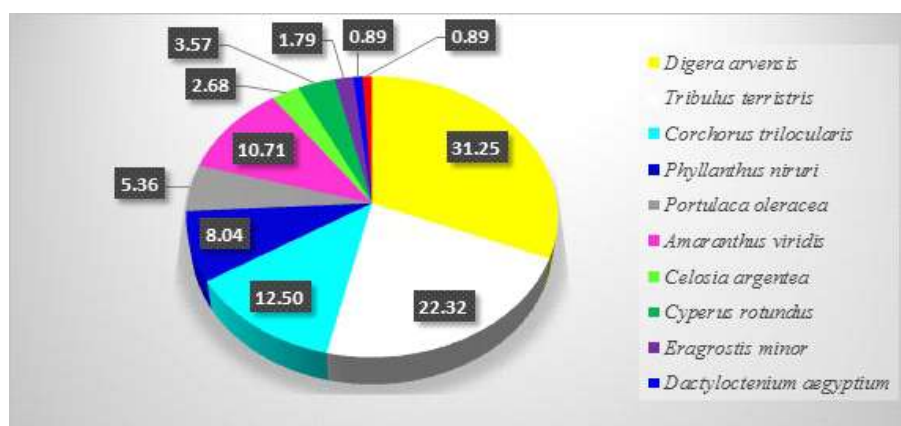


Fig-1 : Relative weed density of clusterbean.

Table-1 : Nitrogen uptake, seed yield and stover yield as influenced by various weed management practices in clusterbean.

Treatments	N content in seed (%)	N content in stover (%)	N Uptake by seed (kg/ha)	N Uptake by stover (kg/ha)	Total N uptake by crop (kg/ha)	Seed yield (kg/ha)	Stover yield (kg/ha)
Weedy check	4.500	1.330	9.48	8.54	18.02	210.0	641.0
Weed free	4.826	1.495	59.69	52.36	112.06	1237.0	3503.0
Pendimethalin 750 g/ha (pre-em.)	4.761	1.476	33.01	30.95	63.96	694.0	2097.0
Imazethapyr 40 g/ha (early post-em.)	4.763	1.477	33.96	31.61	65.57	713.0	2140.0
Pendimethalin + imazethapyr 750 g/ha (pre-em.)	4.764	1.477	35.81	33.30	69.12	752.0	2257.0
Imazethapyr + imazamox 50 g/ha (early post-em.)	4.800	1.480	42.85	39.45	82.31	893.0	2670.0
Pendimethalin 750 g/ha (pre-em.) + 1 HW at 25 DAS	4.801	1.483	43.35	40.20	83.55	903.0	2711.0
Imazethapyr 40 g/ha (early post-em.) + 1 HW at 35 DAS	4.821	1.489	53.96	48.08	102.20	1120.0	3240.0
Pendimethalin + imazethapyr 750g/ha (pre-em.)+ 1 HW at 25 DAS	4.803	1.485	46.81	43.40	90.22	975.0	2923.0
Imazethapyr + imazamox 50 g/ha (early post-em.) + 1 HW at 35 DAS	4.823	1.491	56.92	49.65	106.58	1180.0	3340.0
S Em ±	0.029	0.011	2.05	1.48	3.05	44.23	106.02
CD (P=0.05)	0.09	0.03	6.10	4.42	9.07	131.44	315.03

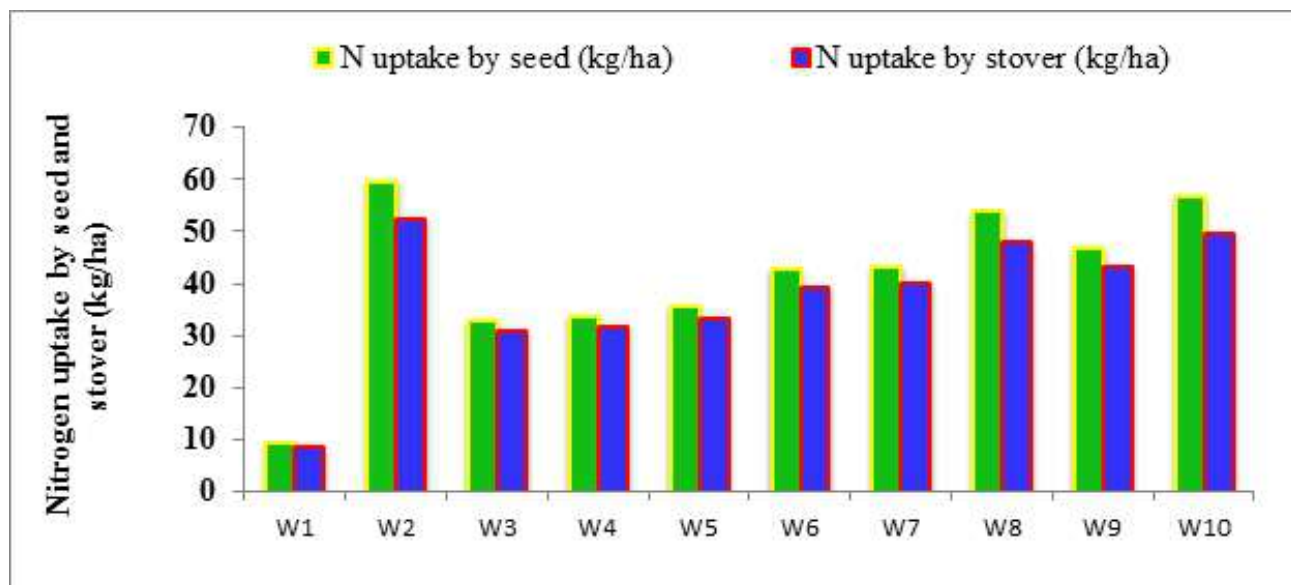


Fig-2 : Nitrogen uptake by seed and stover of clusterbean as influenced by various weed management practices.

Nitrogen uptake by crop : Among various herbicidal treatments, application of imazethapyr + imazamox 50 g/ha + HW at 35 DAS recorded significantly higher nitrogen uptake by seed, stover and total uptake (56.92, 49.65 and 106.58 kg/ha) but it was differed statistically at par with imazethapyr 40 g/ha at 20 DAS+ HW at 35 DAS (53.96, 48.08 and 102.20 kg/ha). Weed free was found superior among different treatments. The weedy check plot recorded minimum nitrogen uptake by crop (seed, stover and total) which was significantly lower than all other nutrients. Nutrient uptake by any crop is primarily a function of yield and nutrient concentration. Thus, higher nitrogen uptake by crop might be due to decreased crop-weed competition concurrently increased nutrient availability, better crop growth and higher crop biomass production coupled with more nutrient content. The lower density of weeds under the treatments might be another valid reason for higher nutrient uptake by crop plants (Verma *et al.*, 2015). The results are in close findings with Singh *et al.* (2015) in clusterbean and Singh *et al.*, (2015) in mungbean crop.

Conclusions

It may be concluded that early post emergence application of imazethapyr + imazamox 50 g/ha at 20 DAS+ HW at 35 DAS was recorded higher nitrogen uptake by seed and stover. The above findings are based on one year experimentation, which needs to be validated through further experimentation to formulate a recommendation.

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Effect of Different Osmoprotectants on Amelioration of Terminal Heat Stress in Wheat (*Triticum aestivum* L.)

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Abstract

The field experiment was carried out during the *Rabi* season of 2022-23 at Agricultural Research Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab to study "Effect of different osmoprotectants on amelioration of terminal heat stress in wheat (*Triticum aestivum* L.)". The experiment was laid out in a randomized block design with eight treatments and three replications. The treatments are: (T0) Unsprayed (control), (T1) Water sprayed, (T2) Salicylic acid (50 $\mu\text{g ml}^{-1}$), (T3) Salicylic acid (75 $\mu\text{g ml}^{-1}$), (T4) KNO_3 (0.5%), (T5) KNO_3 (1%), (T6) $\text{ZnSo}_4 \cdot 7\text{H}_2\text{O}$ (0.5%) and (T7) $\text{ZnSo}_4 \cdot 7\text{H}_2\text{O}$ (1%). Two foliar sprays of osmoprotectants were applied at anthesis and 10 days after anthesis stage. The result revealed that significantly higher plant height (104.33 cm), number of effective tillers per meter row length (105.66), number of spikelets per spike (18.33), number of grains per spike (44.33) was observed with foliar spray of (T4) KNO_3 0.5% which significantly gives higher grain yield (53.33 q ha^{-1}) compared to all other treatments but was at par with (T2) salicylic acid 50 $\mu\text{g ml}^{-1}$ (52.10 q ha^{-1}) and (T5) KNO_3 1% (52.70 q ha^{-1}). Hence, it is possible that osmoprotectants can mitigate heat stress. Although wheat crop has the ability to withstand heat stress with their natural mechanism such as avoiding, tolerating but adding of osmoprotectants will greatly improve the yield and avoid further oxidative damage of crops.

Key words : Osmoprotectants, terminal heat stress, wheat, yield

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important and widely grown cereal crops in the world, which makes a major contribution to both global cereal production (28%) and trade (41.6%) (FAO 2020). Wheat is known as the king of cereals and they contain spongy protein i.e., gluten which is essential for baking purposes. Wheat is mostly consumed in the form of bread as chapati, puri, cookies, upma, cakes, biscuits, etc. Wheat straw is used for the purpose of feeding cattle. The protein percentage of wheat grain is about 13%, 1.5–2.0% fat, 2.0–2.5% cellulose, 60–68% starch, and 1.5–2.0% minerals (Prasad, 2015). India contains the highest percentage of its land cultivated in wheat (14%), followed by Russia (12.43%), China (11.4%), and the USA (6.90%), all which make up about 45% of the world's area. (Ramdas *et al.* 2019). Wheat ranks first in productivity among all cereal crops. It is one of the major cereal crops cultivated in India, especially in Punjab. It was grown in an area of 37.30 lakh hectares during 2020-2021 with production of 171.85 lakh tonnes and productivity of 48.68 quintals per hectare (Anonymous 2022).

Due to rise in high temperature worldwide, it gives a grave threat to wheat in India especially Punjab as late planting of wheat is commonly practice by the farmers in the state. As a result, the crop suffers from terminal heat stress. The reproductive phase of the wheat crop has been found to be sensitive to temperature because it can

change the source-sink relationship, which lowers yield. Reactive oxygen species (ROS) build up brought on by high temperature stress is a significant factor in crop productivity loss worldwide (Tuteja 2010). Globally, terminal heat stress of wheat i.e., abrupt rise in temperature from the normal condition greatly disturb the grain filling period of the crop which is reported to unfavourably affect wheat grown on 36 million ha area, comprising 40 percent of the temperate environment (Hays *et al.* 2007). Osmoprotectants include chemical substances such as sodium nitroprusside, potassium nitrate, and thiourea. Plants are said to be able to effectively scavenge hydroxyl radicals using 3 thiourea, protecting crops from oxidative damage brought on by heat stress (Asthir *et al.* 2012).

The maximum grain yield in wheat was recorded after foliar application of KNO_3 (0.5%) and Salicylic acid (50 $\mu\text{g ml}^{-1}$), all of which were significantly higher than the control (Shabnum *et al.* 2019). Wheat management of terminal heat stress involves chemical substances like cobalt chloride, potassium nitrate, and calcium chloride (Sarlach *et al.* 2013). Therefore, this study was conducted to evaluate the effect of different osmoprotectants on amelioration of terminal heat stress in wheat under Punjab condition.

Materials and Methods

The experimental study was conducted at the Agricultural

Research Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab during the *rabi* season of 2022-2023. Geographically, Mandi Gobindgarh is situated in Punjab at 30.6465° N latitude and 76.3379° E longitude, at an altitude of 268 metres above mean sea level. The maximum temperature during crop season was 36.1?, and the minimum temperature was 4.3?. The experimental field was laid out in a randomized block design with three replications and the wheat crop variety (HD-2967) was sown by *pora* method using 100kg ha⁻¹ seed and row spacing of 20.0 cm. The treatment comprised of control, water sprayed, Salicylic acid (50 µg ml⁻¹), Salicylic acid (75 µg ml⁻¹), KNO₃ (0.5%), KNO₃ (1%), ZnSo₄.7H₂O (0.5%), ZnSo₄.7H₂O (1%). Two foliar sprays of osmoprotectants were applied at anthesis and ten days after anthesis. The following growth parameters and yield attributes viz; Periodic plant height, Effective tillers per meter row length, Spikelets per spike, Grains per spike, 1000 grain weight, Grain yield q ha⁻¹, Harvest Index were recorded.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

The statistical analysis was done by using the statistical software OPSTAT, 1998 (Sheoran *et al.* 1998).

Results and Discussion

Growth Parameters

Plant height (cm) : Plant height is an important index for plant development. The data recorded on plant height at 60, 90, 120 days after sowing (DAS) and at harvest indicated that plant height increased with foliar spray of osmoprotectants. The maximum plant height (104.33 cm) was recorded by the foliar spray of KNO₃ 0.5% which was significantly higher than foliar spray of ZnSo₄.7H₂O 0.5% (100.66 cm), ZnSo₄.7H₂O 1% (101.33 cm), water sprayed (100.33 cm) and unsprayed control (99.00 cm) but was at par with foliar spray of KNO₃ 1% (103.00 cm), salicylic acid 50 µg ml⁻¹ (102.66 cm) and salicylic acid 75 µg ml⁻¹ (102.00 cm). (Table 1). High heat stress can cause serious concern in plant growth and development which may be due to membrane disruptions, metabolic alteration and generation of oxidative stress (Mittler 2002).

Number of effective tillers per meter row length : The maximum number of effective tillers per meter row length (105.66 cm) was recorded in foliar application of KNO₃ 0.5% compared to salicylic acid 75 µg ml⁻¹ (102.00 cm), ZnSo₄.7H₂O 0.5% (101.66 cm), ZnSo₄.7H₂O 1% (101.00 cm), water sprayed (100.66 cm) and unsprayed control (99.66 cm) but was at par with salicylic acid 50 µg ml⁻¹ (103.66 cm) and KNO₃ 1% (103.00 cm) (Table-2).

Yield attributes

Number of spikelets per spike : Maximum number of spikelets per spike (18.33) was recorded in foliar spray of KNO₃ 0.5% which was significantly higher than treatments with KNO₃ 1% (16.40), ZnSo₄.7H₂O 0.5% (16.33), ZnSo₄.7H₂O 1% (16.33), water sprayed (16.33) and unsprayed control (16.00) but was at par with salicylic acid 50 µg ml⁻¹ (17.66) and salicylic acid 75 µg ml⁻¹ (17.33) (Table-3).

According to Sarlach *et al* (2013), the number of spikelets per spike influences the spike length, and if all of the spikelets are adequately filled, the number of grains per spike increases.

Number of grains per spike : The higher number of grains per spike (44.33) was recorded with foliar application of KNO₃ 0.5% which was significantly higher than salicylic acid 75 µg ml⁻¹ (42.33), ZnSo₄.7H₂O 0.5% (40.33), ZnSo₄.7H₂O 1% (41.20), water sprayed (39.00) and unsprayed control (38.33) but was at par with KNO₃ 1% (43.33) and salicylic acid 50 µg ml⁻¹, (42.53) (Table-3).

Heat stress appears to have affected on both grain weight and grain quantity in many temperate cereal crops, with a decrease in grain number directly proportionate to increasing temperature during flowering and grain filling (Porter and Semenov, 2005).

1000 grain weight (g) : The maximum 1000 grain weight (46.66 g) was observed with foliar spray of KNO₃ 0.5% which was significantly higher than treatment with KNO₃ 1% (43.33 g), ZnSo₄.7H₂O 0.5% (41.66 g), ZnSo₄.7H₂O 1% (42.00 g), water sprayed (40.00 g) and unsprayed control (39.00 g) but was at par with foliar spray of salicylic acid 50 µg ml⁻¹ (44.66 g) and salicylic acid 75 µg ml⁻¹ (43.66 g) (Table-3).

Dias and Lidon (2009) reported that high grain-filling rate and potential grain weight might be beneficial selection factors for enhancing heat tolerance.

Grain yield (q ha⁻¹) : The higher grain yield (53.33 q ha⁻¹) was recorded with foliar spray of KNO₃ (0.5%) compared to treatments with salicylic acid 75 µg ml⁻¹ (48.00 q ha⁻¹), ZnSo₄.7H₂O 0.5% (47.00 q ha⁻¹), ZnSo₄.7H₂O 1% (41.66 q ha⁻¹), water sprayed (47.00 q ha⁻¹) and unsprayed control (44.00 q ha⁻¹) but was at par with salicylic acid 50 µgml⁻¹ (52.10 q ha⁻¹) and KNO₃ 1% (52.70 q ha⁻¹) (Table-3).

The higher salicylic acid concentration (75 µgml⁻¹) was ineffective in increasing wheat yield. (Table 3). As a result, it is clear that a lower dose of salicylic acid, as well as both concentrations of KNO₃, had a discernible effect on wheat crop. The potassium nitrate was found to aid in photosynthesis, carbohydrate distribution, and starch synthesis in storage organs, resulting in a high grain yield (Imas and Magen, 2007).

Table-1 : Effect of different osmoprotectants on periodic plant height of wheat at 60, 90, 120 DAS and at harvest.

Treatments	Periodic Plant Height (cm)			
	60 DAS	90 DAS	120 DAS	At harvest
T ₀ - Unsprayed (control)	41.66	80.00	90.66	99.00
T ₁ - Water sprayed	41.13	80.66	91.66	100.33
T ₂ - Salicylic acid (50 µg ml ⁻¹)	42.00	83.80	97.00	102.66
T ₃ - Salicylic acid (75 µg ml ⁻¹)	42.00	82.66	94.66	102.00
T ₄ - KNO ₃ (0.5%)	43.40	84.33	98.33	104.33
T ₅ - KNO ₃ (1%)	42.66	83.00	96.00	103.00
T ₆ - ZnSO ₄ .7H ₂ O (0.5%)	41.33	81.66	93.66	100.66
T ₇ - ZnSO ₄ .7H ₂ O (1%)	41.33	81.44	93.00	101.33
C.D. at 5%	NS	1.80	2.5	2.0
C.V.	12.66	5.83	6.72	5.95

Table-2 : Effect of different osmoprotectants on number of effective tillers per metre row length of wheat at 60, 90, 120 DAS and at harvest.

Treatments	Effective tillers per meter row length			
	60 DAS	90 DAS	120 DAS	At harvest
T ₀ - Unsprayed (control)	66.33	78.00	92.33	99.66
T ₁ - Water sprayed	67.00	79.33	93.66	100.66
T ₂ - Salicylic acid (50 µg ml ⁻¹)	68.66	83.33	98.00	103.66
T ₃ - Salicylic acid (75 µg ml ⁻¹)	69.00	82.00	95.66	102.00
T ₄ - KNO ₃ (0.5%)	74.66	86.66	100.00	105.66
T ₅ - KNO ₃ (1%)	67.33	82.33	96.66	103.00
T ₆ - ZnSO ₄ .7H ₂ O (0.5%)	68.33	80.66	95.00	101.66
T ₇ - ZnSO ₄ .7H ₂ O (1%)	69.00	81.33	94.33	101.00
C.D. at 5%	NS	4.00	3.5	2.7
C.V.	4.32	6.90	7.69	6.34

Table-3 : Effect of different osmoprotectants on number of spikelets per spike, grains per spike, 1000 grain weight, grain yield and harvest index.

Treatments	No. of spikelets per spike	No. of grains per spike	1000 grain weight (g)	Grain yield (q ha ⁻¹)	Harvest index (%)
T ₀ - Unsprayed (control)	16.00	38.33	39.00	44.00	44.90
T ₁ - Water sprayed	16.33	39.00	40.00	47.00	45.78
T ₂ - Salicylic acid (50 µg ml ⁻¹)	17.66	42.53	44.66	52.10	48.14
T ₃ - Salicylic acid (75 µg ml ⁻¹)	17.33	42.33	43.66	48.00	46.15
T ₄ - KNO ₃ (0.5%)	18.33	44.33	46.66	53.33	48.20
T ₅ - KNO ₃ (1%)	16.40	43.33	43.33	52.70	47.66
T ₆ - ZnSO ₄ .7H ₂ O (0.5%)	16.33	40.33	41.66	47.00	46.43
T ₇ - ZnSO ₄ .7H ₂ O (1%)	16.33	41.20	42.00	41.66	43.10
C.D. at 5%	1.21	1.8	3.2	1.3	1.52
C.V.	7.09	5.95	6.89	5.92	5.81

Harvest index (%) : The harvest index and other yield parameters was greatly influenced by the foliar spray of different osmoprotectants (Table-3).

The maximum harvest index 48.20 %) was recorded with foliar spray of KNO₃ 0.5% which was significantly higher than treatment with salicylic acid 75 µg ml⁻¹ (46.15 %), ZnSO₄.7H₂O 0.5% (46.43 %), ZnSO₄.7H₂O 1% (43.10 %), water sprayed (45.78 %) and unsprayed

control (44.90 %) but was at par with salicylic acid 50 µg ml⁻¹ (48.14 %) and KNO₃ 1% (47.66 %).

Conclusions

It may be concluded that the application of different osmoprotectants influenced all yield related parameters viz; Periodic plant height (cm), number of effective tillers per meter row length, spikelets per spike, grains per spike, 1000 grain weight (g), grain yield (q ha⁻¹), harvest index (%) etc. under terminal heat stress in wheat. The

knowledge acquired from these traits throughout the trials could be used to develop high-yielding cultivars capable of producing economic output and assisting with yield sustainability in locations where terminal heat stress is a big danger.

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Effect of Various Cutting Intervals on Yield and Yield Attributes of Different Bajra Napier Hybrids

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Abstract

Field experiment was conducted to study the effect of different Bajra Napier Hybrids and cutting intervals on the growth and yield during 2021. An experiment was conducted in Factorial Randomized Block Design. which consist five Bajra Napier Hybrids (IGFRI-7, Supriya, CO-5, KKM-1, NB-37) and three cutting interval (30, 45 and 60 days) and replicated three times during February to June, 2021 at Forage farm, Department of Livestock Production Management S.K.N. College of Agriculture, Jobner (Rajasthan). Result indicated that bajra napier hybrid CO-5 being at par with hybrid Supriya, have significantly higher the number of leaves per plant, number of tillers per plant, leaf stem ratio, green fodder yield, dry fodder yield. Result further indicated that 45 days cutting interval has significantly higher number of leaves per plant, number of tillers per plant, green fodder yield, dry fodder yield as compared to 30 days interval. But recorded significantly highest plant height under 60 days cutting interval. Combined treatment of bajra napier hybrid varieties and cutting intervals of CO-5 with 45 days cutting interval also has significantly higher number of tillers per plant and number of leaves per plant over rest of the treatments of bajra napier hybrid. However hybrid Supriya is also at par with CO-5.

Key words : Bajra Napier hybrids, Cutting interval, yield and yield attribute

Introduction

The fodder crops are economic source of nutrients for the livestock. The success of dairy farming largely depends on the feed and fodder of high nutritional value, which accounts for 65-70 per cent of total expenses incurred in animal production (Kumar *et al.*, 2012). The supply of quality green fodder in India is unstable and there is huge variation. In India, a very limited land area is just 8.6 mha available for fodder cultivation (Kumar *et al.*, 2012). It is estimated that the present green fodder availability is only 400.60 million tonnes while the total requirement is 1097 million tonnes. The country faces a deficit of 63.50 per cent of green fodder and 23.56 per cent of dry fodder (Rathod and Dixit, 2019). Availability of green forage is essential for better animal health, production and economical viability of ruminant animals. The major fodder crops cultivated in India are Lucerne, Barseem, Cowpea, Oat, Bajra, Sorghum, Maize and grasses. The main grasses are Anjan grass, Dinanath grass, Guinea grass, Para grass, Bajra napier hybrid etc.

Among the various fodder crops, the bajra napier hybrid is an important high yielding and nutritive fodder crop for ruminants. Bajra Napier Hybrid is a triploid, inter-specific hybrid between pearl millet and Napier (*Pennisetum glaucum* x *Pennisetum purpureum*) having chromosome number $2n = 21$. Bajra napier hybrid is

widely distributed in tropical and sub-tropical regions of Asia, Africa, southern Europe and India. The optimum temperature for growth of bajra napier hybrid is about 31°C and total water requirement is about 800–1000 mm. The light showers alternated with bright sunshine are favourable weather conditions for better crop growth. The crop prefers light loams and sandy soils with pH ranging from 5 to 8. The crop susceptible to waterlogged and flood prone lands. It is tall growing (200-300 cm), erect, stout, deep rooted and perennial grass which can be retained on field for 3-4 years. Among the improved fodder grass species, hybrid napier is multicut perennial grass with profuse tillering and very good tonnage throughout the year (Pandey and Roy, 2011). The stem and root cuttings are used for propagation because crop is sterile in nature. It produces numerous leaves and high number of tillers. It is fast growing and produces high herbage and plants are less persistent due to hard stem. Cutting interval is other most important aspect since it governs the quality as well as quantity of green fodder yield. The aim of the present study was to further investigate the effects of different Bajra Napier Hybrids and cutting intervals on the number of leaves per plant, number of tillers per plant, leaf stem ratio, green fodder yield, dry fodder yield and determine the optimum stage of harvesting. The cutting intervals were chosen in an attempt to identify the interval which might optimize forage yield and quality of these cultivars.

Materials and Methods

The field study was carried out at forage farm, Department of Livestock Production Management, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan). The region is located in agro-climatic zone III-A (semi-arid eastern plain zone of Rajasthan). The characteristic semi-arid climate of this area is marked by temperature extremes in both the summer and the winter. The experiment was initiated in February (2021) and completed in June (2021). The experimental plot's initial soil study revealed that the soil was loamy sand with low accessible nitrogen ($132.60 \text{ kg ha}^{-1}$), medium phosphorus (18.78 kg ha^{-1}), and high potassium ($152.03 \text{ kg ha}^{-1}$) levels as well as a pH of 8.2 that was just slightly alkaline in reactivity.

The Bajra Napier hybrids is sterile and does not produce viable seeds although it could indicate an inflorescence or spike. It is vegetatively propagated by stem cutting. The field experiment was laid out in Factorial design. The treatment consist of fifteen plot of combinations including five cultivars (IGFRI-7, Supriya, CO-5, KKM-1, NB-37) planting material and three cutting intervals C1- 30 days, C2- 45 days and C3-60 days. Thus, there were forty five treatment combinations replicated three times. Stem cuttings were planted at $60 \times 60 \text{ cm}^2$ apart from row to row and plant to plant on February. Gap filling was done at 12 days after planting of stem cutting to maintain optimum plant population. The first weeding was done at 20 days after planting of Bajra napier hybrid and second weeding was done immediately after 1st common cut. During trial kept the experimental plot free from weed infestation. Manures and fertilizers during land preparation, farm yard manure @ 25 t/ha was applied uniformly and incorporated well into the soil. Fertilizer recommendation followed was $60:50:40 \text{ kg N, P}_2\text{O}_5 \text{ and K}_2\text{O/ha}$ respectively as per the package of practices recommendations (IGFRI, Jhansi 2007) After each cutting 30 kg N/ha was applied.

At harvest time during the experiment yield attributes and fodder yield were measured. After harvest, fresh biomass yield of each plot was determined and 100 gram of chopped bajra napier hybrids samples were dried in oven separately at 70° C to a constant weight for dry matter content to calculate dry fodder yield. Dry fodder yield were calculated by multiplying of green fodder yield and dry matter content of bajra napier hybrid. At each plot observations regarding yield attributes like Number of tillers, Number of leaves, Plant height, Leaf stem ratio (LSR) were recorded. For leaf stem ratio, leaves and stem were separated from the plant and dry weight was recorded separately and leaf stem ratio (LSR) calculated from leaf dry weight (gm) divided by stem dry weight (gm).

Statistical analysis : The data recorded during the experimentation were statistically analysed by technique of Analysis of variance? (Fisher, 1950) and test of significance was carried out as given by Panse and Sukhatme (1978). In tabular data in text C.D. values have been given for comparison.

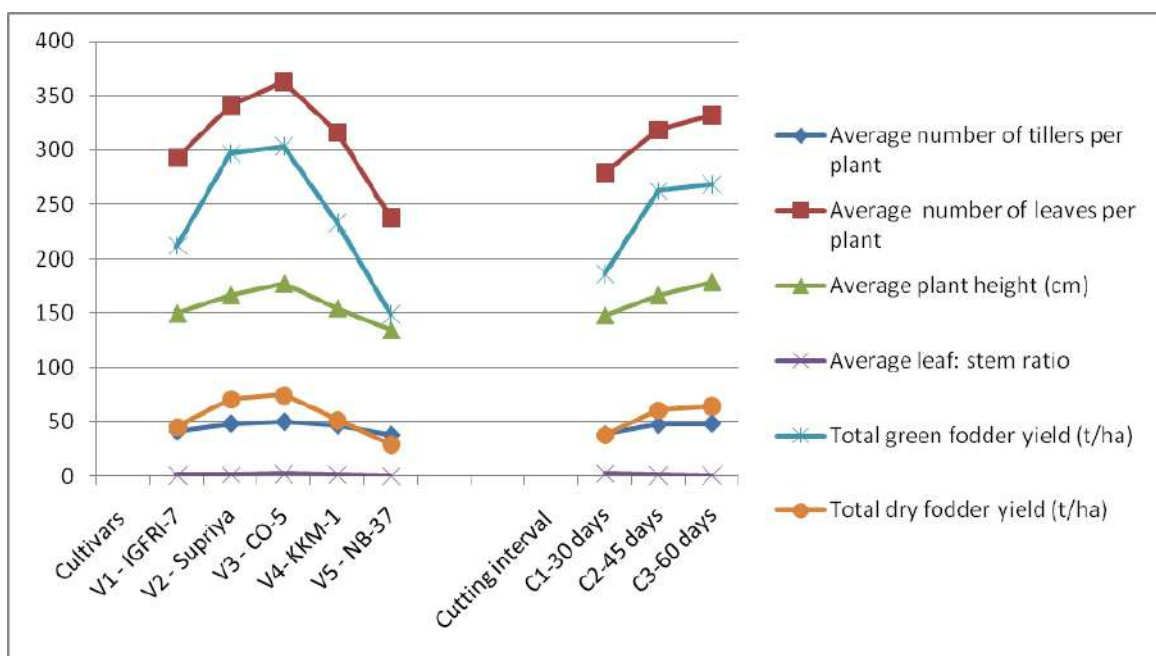
Results and Discussion

On the basis of present investigation significantly higher number of tiller per plant (49.86), number of leaves per plant (362.72), plant height (177.40), leaf: stem ratio (2.09), highest total green fodder yield (303.81 t/ha) and highest dry fodder yield (74.99 t/ha) recorded in Hybrid CO-5 over Supriya, KKM-1, IGFRI-7, NB-37 Hybrids. However, number of leaves per plant, plant height, leaf: stem ratio of CO-5 was found at par with hybrid Supriya. Hybrid CO-5 recorded significantly higher number of tiller per plant (49.86) as compared to rest of the bajra napier hybrids. However, it was at par with hybrid Supriya (Table 1). The average number of tillers per plant of Bajra Napier hybrids was significantly higher (47.31) in 45 days cutting interval over 30 days cutting interval which was at par with 60 days cutting interval. During the experiment tiller production was less in initial stage then significantly increased. Higher tillers per plant emerged with frequent cutting interval, tiller compete with each other for their survival for longer duration with increased cutting intervals. Because of this competition some tillers were unable to survive under these condition and due to overcrowding in plants and mortality observed in some tillers. Thus, self-thinning in plant might be reason for decreased tiller numbers with delay in cutting interval. Kaneko *et al.* (1990) also found that number of tillers of *Panicum maximum* decreased by increased cutting period.

Hybrid CO-5 was recorded significantly higher number of leaves per plant (362.72) as compared to rest of the bajra napier hybrids. However, it was at par with hybrid Supriya (Table 1). The average number of leaves per plant of bajra napier hybrids was significantly higher (318.32) at 45 days cutting interval over 30 days cutting intervals which was at par with 60 days cutting interval. Other possible reason for producing higher number of leaves per plant is that, with delay in cutting the plant had more photosynthesis, which is essential for development and growth of the plant. The similar results were also reported by Tessema Zewdu *et al.* (2003) and Tessema and Alemayehu (2010). Significantly higher plant height recorded in Hybrid CO-5 as compared to NB-37, IGFRI-7, KKM-1 which was at par with hybrid Supriya (Table 1). The average plant height of bajra napier hybrid was significantly higher (178.89cm) at 60 days cutting interval over 30 and 45 days cutting interval. This might be due to

Table-1 : Effect of Bajra Napier hybrids and cutting interval on number of tillers per plant, number of leaves per plant, plant height, leaf stem ratio and green fodder and dry fodder yield.

Treatments	Average number of tillers per plant	Average number of leaves per plant	Average plant height (cm)	Average leaf: stem ratio	Total green fodder yield (t/ha)	Total dry fodder yield (t/ha)
Cultivars						
V ₁ - IGFR1-7	41.33	292.93	149.69	1.18	212.00	45.32
V ₂ - Supriya	48.20	340.34	166.67	1.83	297.14	71.07
V ₃ - CO-5	49.86	362.72	177.40	2.09	303.81	74.99
V ₄ - KKM-1	46.52	316.07	154.88	1.70	233.70	51.62
V ₅ - NB-37	38.06	237.57	134.32	0.74	148.90	29.32
SEm+	1.040	7.497	4.297	0.050	5.184	0.491
CD (P=0.05)	3.00	21.65	12.41	0.14	14.97	1.42
Cutting interval						
C ₁ - 30 days	38.82	279.51	148.20	2.40	186.33	37.69
C ₂ - 45 days	47.31	318.32	166.66	1.25	262.67	61.14
C ₃ - 60 days	48.25	331.94	178.89	0.88	268.33	64.56
SEm+	0.805	5.808	3.33	0.039	4.015	0.381
CD (P=0.05)	2.32	16.77	9.61	0.11	11.59	1.09

**Figure-1 : Effect of Bajra Napier hybrids and cutting interval on number of tillers per plant, number of leaves per plant, plant height, leaf stem ratio and green fodder and dry fodder yield.**

sufficient time was available for apical growth of stem resulted in higher height at 60 days cutting interval. Plant height increased with increasing cutting intervals which might be also due to advance apical growth of stem increased till flowering, a delay in cutting time, probably gives sufficient time for continued growth and development resulting in higher plant height being recorded at 60 days cutting interval. Growth of bajra napier hybrid had a significant parabolic relation with crop age and plant height was increased with increasing cutting intervals. Similar results found with those reported by Singh *et al.* (1995) and Zewdu *et al.* (2002).

The average value of leaf: stem ratio of bajra napier hybrid was significantly higher in CO-5 (2.09) as compared to rest of hybrids. Higher value of leaf: stem ratio is indicator of quality of the fodder. leaf: stem ratio is a qualitative character affecting the succulence and palatability.

The average leaf: stem ratio of bajra napier hybrid was significantly higher in 30 days cutting interval (2.40) over 45 and 60 days cutting intervals. The lowest leaf: stem ratio (0.88) was recorded in 60 days cutting interval during the period of investigation. The decline in fodder quality with maturity is directly related to the leaf: stem

ratio. This might be due to the fact that plant matures its leaf: stem ratio decreases and the stem becomes more fibrous. The average leaf:stem ratio decreased with increasing cutting interval and reach at the lower value at 60 days cutting interval. Similar results are also reported by Queiroz-Filho *et al.* (2000), Singh *et al.* (2002) and Tessema and Alemayehu (2010).

Planting total green fodder yield was recorded significantly higher (303.81 t/ha) in CO-5 over rest of the hybrids during the period of investigation. The cutting interval had significant effect on total green fodder yield. The total green fodder yield (262.67 t/ha) was significantly higher at 45 days cutting interval over 30 days cutting interval which was at par with 60 days cutting interval. Yield contributing characters such as number of tillers per plant, number of leaves per plant, plant height, dry matter accumulation through whole plant, dry matter content per cent etc. are increased with increasing in the cutting interval from 30 to 60 days. However, the total green fodder yield in investigation were increased significantly with increasing in cutting interval.

The Crop cutting at 45 days interval provides adequate time for assimilation of organic constituents and photosynthesis activity. This photosynthesis were utilized by plants for vegetative growth and developments which in turn of more number of tillers and leaves resulted higher green forage yield. Whereas, 30 days interval was not sufficient to full fill the requirement of the plants while crops remain for more than 45 days slow down the process and assimilated organic constituents are converted in to long chain compounds like cellulose, hemi-cellulose, starch and lignin etc. Hence, both 30 and 60 days interval of cutting management was not produced comparable green forage yield to that of 45 days of interval of cutting management. These results are in the conformity with the findings of Singh *et al.* (2000) as they reported that, extending the cutting interval from 5, 6 to 7 weeks resulted in significant higher in green fodder yield at each cutting. Higher green fodder yield of grasses with increasing in cutting interval has also been reported by Zewdu *et al.* (2002), Mwangi *et al.* (2004), Magalhaes *et al.* (2006) and Ram *et al.* (2007).

Hybrid CO-5 was recorded significantly the higher dry fodder yield (74.99 t/ha) as compared to Supriya, KKM- 1, IGFRI-7, and NB-37. Significantly lower dry fodder yield was observed with hybrid NB-37 (29.32 t/ha). The total dry matter yield was significantly higher with increasing in cutting interval. The average dry fodder yield of bajra napier hybrids were significantly higher at 45 days cutting interval (61.14 t/ha) over 30 days cutting interval which was at par with 60 days cutting interval. Considerable variation in herbage yield (green and dry)

with extended cutting interval might be attributed to the improvement in yield attributes such as higher number of tillers per plant, number of leaves per plant, plant height, leaf: stem ratio and dry matter accumulation. Increase in dry matter yield of grasses with increasing in cutting interval has also been reported by Zewdu *et al.* (2002), Ngo-Van- Man and Wiktorsson (2003), Mwangi *et al.* (2004), Magalhaes *et al.* (2006) and Ram *et al.* (2007).

Conclusions

During the study, result indicated that CO-5 was superior to other bajra napier hybrids (Supriya, KKM-1, IGFRI-7, NB-37) but at par with Hybrid Supriya with respect to total green fodder yield and total dry fodder yield and other yield attributes like number of tiller per plant, number of leaves per plant, plant height and leaf: stem ratio with 45 days cutting interval. Therefore it may be concluded that among the hybrids CO-5 and Supriya are best for fodder cultivation in Semi arid region of Rajasthan.

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To Find Out the Economics of Dietary Supplementation of Amla Powder in Broiler Chicks

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Abstract

An experiment was conducted at poultry farm, department of Animal Production, Rajasthan College of Agriculture, Udaipur. The study was conducted to investigate the effect of feeding amla (*Embllica officinalis*) powder on performance and carcass characteristics of broiler chicks. A total of 160-day-old vaccinated broiler chicks (coloured broiler) were randomly divided into four treatment groups with four replicates of 10 chicks each. The feed intake expressed as g /chick / day or g /bird / week was studied during the experiment. The treatment included the (T₁) control, (T₂) control group supplemented with amla powder @ 0.5%, (T₃) control group supplemented with Amla powder @ 1.0%, (T₄) control group supplemented with Amla powder @ 1.5%. The effect of supplementation was observed on the body weight, body weight gain, feed intake, FCR, nutrient utilization, nutrient balance, carcass traits viz., live weight, slaughter weight, eviscerated weight, dressing weight, weight of heart, liver, gizzard, and economics in broiler chicks.

Key words : supplement, Amla powder, chicks

Introduction

Poultry sector contributes to the tune of 1% in national GDP of livestock (14% GDP). The growth potential of poultry sector is bright attributed to the constant flow of income annually in the rural economy of India (Ashmita *et al.*, 2022). Though the term poultry includes wide range of species, however, the Indian poultry industry mainly revolves around the chicken due to low investment and quick returns (Shivaji, 2012). In both rural as well as urban areas irrespective of culture and region, chicken production has significant contribution in terms of protein source, food security, employment generation, and income in resource-constrained communities (Kabir *et al.*, 2015; Ngongolo *et al.*, 2019). In 2020, the global chicken population was over 33 billion birds with 46 percent of contribution from Asian countries (FAO, 2023). In 2022, the figures of Indian poultry market reached a value of USD 28.18 billion and annual growth rate of 8.1% as out predicted in next 5 years, making it USD 44.97 billion by 2028. Broiler production dominates the sector, with contribution of nearly 90% of the total output (Anonymous, 2023).

Amla or Indian Gooseberry (*Embllica officinalis*), with its origin in India has extensive adaptability to grow in diverse climatic and soil conditions (Pokharkar 2005). The fruits of the plants has early history of use in Ayurveda as a potant rasayana (revitalisers, biological response modifiers) in which the amla was added as anti-stress agent. Amla is one of the richest sources of ascorbic acid, minerals, amino acids, tannins, and phenolic compounds. Amla, richest source of vitamin-C and it's active tannoid

principles have antimicrobial, antidiabetics, anticarcinogenic properties and enhances immune property (Anjaria *et al.*, 2002). It is a great nutritional supplement with several medicinal benefits. Due to the abundance of phenolic compounds, Emblic fruit could be regarded as a plant source for natural antioxidants and nutraceuticals or medicinal components. In various animal and human investigations, amla has been proven to have anti-hyperglycemic, hypoglycemic, anti-inflammatory, anti-hyperlipidemic, and antioxidant activity that helps the body's immune systems and digestion (Gul *et al.*, 2022).

Rapid growth rate in commercial broilers accelerate the metabolic rate and make them vulnerable to oxidative stress owing to increased free radical generation. Phenolic acid content *i.e.* Gallic acid and tannic acid present in Amla contribute to the antioxidant activity, in addition, to ascorbic acid. Phyto-chemical analysis of amla fruit powder provided evidence of presence of the medicinally important bioactive compounds which can be exploited beneficially to improve productivity in broilers. Amla (*Embllica officinalis*) fruit powder is one of the herbs which have potential to boost broiler production (Patel *et al.*, 2016). Amla powder is an important source of ascorbic acid, minerals, amino acids, tannins, and phenolic compounds. Indian Research shows that 8.75 mg of natural vitamin C complex from amla is equivalent to 100 mg of the most commonly used synthetic vitamin C (Shivaji, 2012). Use of amla as feed additives for enhancing growth, reducing feed cost by improving feed efficiency and for building better immunity has already reported (Ghavate, 2009). The information on effect of

feeding amla powder on performance of coloured broiler chicks is very limited. Therefore, the present research work was designed to study the effect of feeding amla powder at 0.5, 1.0 and 1.5% in the diet on growth performance, nutrient utilization and carcass characteristics of broiler chicks.

Materials and Methods

The research work was undertaken to study the effect of feeding amla (*Embllica officinalis*) powder on growth performance and carcass characteristics of broiler chicks. The experiment was conducted for a period of 60 days including metabolism trial.

Experimental birds : This research work was carried out with 160 broiler day old straight run chicks procured from the Poultry farm, Department of Animal Production, Rajasthan College of Agriculture Udaipur. The chicks were wing banded and distributed randomly in four treatment groups, consisting of 40 chicks in each treatment group with replication of 10 birds each.

Experimental details :

1. Season : May to June (2022)
2. Breed : Coloured broiler chicks
3. Total treatment : 4
4. Replications : 4 (10 birds in each replication)
5. Total number of birds : 160
6. Experimental design : CRD
7. Housing : Deep litter system

Economics of production : The cost for complete experiment period (0-8 weeks of age) was calculated by taking into consideration the sum of the variable cost such as feed cost with supplementation and other miscellaneous cost. The return was calculated by multiplying final body weight with prevailing sale price of chicken. The chicks were fed starter ration from 0-3 weeks and the fed finisher ration from 4th week till end of the experiment. The chicks were fed with the composition mixture of maize, soya DOC, DORB, and vitamin premix with different inclusion of amla powder in different treatment groups. The feed cost for starter were 26.33, 26.75, 27.26 and 27.68 per kg in T1, T2, T3 and T4 respectively and finisher ration the feed costs were 26.45, 26.88, 27.30 and 27.73 per kg in T1, T2, T3 and T4 respectively. The benefit cost ratio was calculated as under following formula.

$$\text{B.C ratio} = \frac{\text{Total return}}{\text{Total cost}}$$

Results and Discussion

Economics of Supplementation of Amla Powder : The data with respect to effect of feeding amla powder to broiler chicks on feed cost, gross returns, net returns and benefit cost ratio is presented in Table 4.8. The dayold straight run chicks of coloured broiler were procured from hatchery unit at Rs 40/- per chick. They were fed basal ration and graded levels of amla root powder in different dietary treatments. The feed cost was calculated from composition of different feed ingredients in the respective ration and prevailing market rates of individual feed ingredients. The final body weight at the time of slaughter was considered for gross returns which was calculated by body weight and sale price at Rs 125 per kg live weight. The cost incurred on labour, medicines etc. were also considered as miscellaneous cost to work out total cost of rearing of chicks. The miscellaneous cost of was considered at Rs. 15 for the entire experimental period. The net returns were calculated by subtracting total cost from gross returns and benefit cost ratio was calculated as ratio of gross return and total cost.

The body weights were 1726.75±25.11, 1894.25±12.13, 2034.50±25.16 and 1818.25±18.27 g in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the body weight was significantly higher ($P<0.01$) in T3 as compared to T2 and T4 which did not differ between themselves while the body weight found in T1 and T4 group was found to be statistically non-significant.

The total feed intakes were 3.19±0.02, 3.33±0.02, 2.94±0.01 and 2.79±0.01 kg in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the feed intake was significantly higher ($P<0.01$) in T2 followed by T1, T3 and lowest in T4.

The feed costs were 84.40±0.49, 89.59±0.50, 80.42±0.54 and 77.42±0.30 rupees respectively in T1, T2, T3 and T4 groups. The perusal of data revealed that the feed cost was significantly highest ($P<0.01$) in T2 followed by T1, T3 and T4.

The total cost including chick, feed and miscellaneous cost in were found to be 139.40±0.49, 144.59±0.50, 135.42±0.54 and 132.42±0.30 rupees in T1, T2, T3 and T4 groups respectively. The total cost was significantly highest in T2 followed by T1, T3 and T4.

The gross returns (Rs./bird) were 216.25±0.75, 236.25±1.11, 253.75±0.65 and 226.24±0.93 in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the gross returns were significantly highest ($P<0.01$) in T3 followed by T2, T4 and lowest in T1.

The net returns (Rs./bird) were 76.85±1.02,

91.66±0.52, 118.33±0.33 and 93.83±0.76 rupees in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the net returns were significantly highest ($P<0.01$) in T3 followed by T2, T4 and lowest in T1.

The benefit cost ratio was also calculated and the values were 1.55±0.01, 1.63±0.01, 1.87±0.02 and 1.71±0.02. It was revealed from the data that the benefit cost ratio was significantly highest ($P<0.01$) in T3 followed by T4, T2 and lowest in T1.

The benefit cost ratio, net return, gross return was observed significantly highest in T3 as compared to rest of the treatment groups. The findings of the present study corroborated the findings of Patel *et al.* (2016) who revealed higher net profit per bird in *E. officinalis* supplemented groups attributed to higher body weights compared to the unsupplemented group and similar feed intakes among all the treatment groups. Tiwari *et al.* (2016) also support our findings as they have reported that the ration supplemented with Vit. C @ 100g/kg feed was found the best compared to all the treatments. Begum *et al.* (2019) have also undertaken the studies regarding the economics of dietary supplementation of amla and recorded that the gross profit per broiler was found to be the highest in T3 group i.e. supplementation with 0.75% amla powder (INR 17.81), followed by T2 (INR 17.46), T1 (INR 17.44) and T0 (INR 13.06) group.

Conclusions

The feed conversion ratio was significantly improved with supplementation of basal diet with 1.0% amla powder.

The supplementation of amla powder at 1.0% may improve the nutrient intake, live weight, dressed weight, eviscerated weight, giblet weight and digestibility coefficient in broiler chicks.

The supplementation of 1.0% amla powder may be useful in improving carcass traits in broiler chicks.

The higher benefit cost ratio in the present study on supplementation of amla powder at 1.0% may be useful in improving utilization of feed and hence, gives higher economic returns with net return of 118.33 Rs. per bird and B: C ratio of 1.87.

The supplementation of amla powder at different level was found to be beneficial over control. However, there is a need to carry out the research further for optimization of level of supplementation and meat quality parameters in broiler chicks.

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Effects of Different Levels of NPK and Molybdenum on Soil Physico-Chemical Properties of Black Gram (*Vigna mungo* L.) Var. Tau-1

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Abstract

The experiment was carried out at Department Soil Science and Agricultural Chemistry research farm SHUATS, Allahabad during summer season 2017-2018. The experiment was laid out in 3x3 factorial randomized block design with three replications, consisting of nine treatments. Treatment T8 @ [50% NPK + 50% Mo] was to be best in data were recorded in post-harvest soil as pH, EC (dSm⁻¹), O.C (%), Pore space (%), Bulk density (g/cm³), particle density (g/cm³), water holding capacity (%), nitrogen (kg ha⁻¹), phosphorus (kg ha⁻¹), potassium (kg ha⁻¹) and molybdenum (g ha⁻¹) which were as 7.20, 0.24, 0.74, 48.18, 1.19, 2.31, 59.05, 340.23, 30.80, 205.83, 0.3 respectively. Treatment T4 @ [25% NPK + 25% Mo] was to be best in pore space (%) which were as 50.80. The treatment T1 was to be best in particle density was as 2.54 (g/cm³). Soil chemical properties as available N, P, K, MO and O.C were found to be significant but pH and Ec was non-significant. Soil physical properties as bulk density (g/cm³), particle density (g/cm³), pore space (%) and water holding capacity (%) were found to be significant.

Key words : Particle density, water holding capacity, physical properties.

Introduction

Black gram (*Vigna mungo* L.) is one of the important pulse crops grown throughout India. Proper fertilization is essential to improve the productivity of black gram. It can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur. Black gram is very much responsive to sulphur application. Both phosphorus and sulphur can improve the quality and quantity of the crop. Hence, the present investigation was undertaken to find out the response of black gram to different levels of phosphorus, sulphur and PSB application. Black gram is also used as green manuring crop, being a leguminous crop; it has the capacity to fix atmospheric nitrogen. It also helps in preventing soil erosion. Being a short duration crop and adaptability to off-season, it fits well in many intensive crop rotations.

Pulses are one of the second most important segments of Indian Agriculture after cereals as they are rich in protein and play a vital role in human diet. Pulses improve soil health by enriching nitrogen status, long-term fertility and sustainability of the cropping systems. It meets up to 80% of its nitrogen requirement from symbiotic nitrogen fixation from air. In India, production of pulses is around 19.3 million tonnes with a very low average productivity of 764 kg ha⁻¹. Pulses are least preferred by farmers because of high risk and less remunerative than cereals;

consequently, the production of the pulses is sufficiently low. Black gram (*Vigna Mungo* L.), is one of the important pulse crops, grown throughout the country. Among pulses, black gram has increased from 1.87 m ha in 1971–72 to 3.11 m ha during 2012-13 with production level of 1.90 MT (ESI 2015). This increase in production is mainly attributed to additional area brought under the crop as well as productivity gains (from 0.5 to 1.3 t ha⁻¹). Summer cultivation in northern India and winter cultivation in rice fallows in southern and coastal areas of the country also added to additional acreage. Black grams are widely considered as an excellent source of high quality protein with good digestibility and also contain water soluble vitamins and minerals of dietary significance. The factors attributed for low yields of pulses in India as compared to the world productivity are non-availability of quality seeds of improved and short duration varieties, growing of pulses under marginal and less fertile soil with low inputs and without pest and disease management, growing of pulses under moisture stress, unscientific post harvest practices and storage under unfavourable conditions. Hence, there is a scope for improving the production potential of this crop by use of organic manures, inorganic manures and biofertilizers. (Shrikant M. Vadgave, 2010). Integrated nutrient management includes the intelligent use of organic, inorganic, and on-line biological resources so as to sustain optimum yields, improve or maintain the soil physical and chemical properties, and provide crop

nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe. The existing state blanket recommendation for crops does not ensure efficient and economic use of fertilizers, as it does not take into account the fertility variations resulting in imbalanced use of fertilizer nutrients. Among the various methods of fertilizer recommendations, the soil test based fertilizer recommendations is also appropriate practices to improve yield as well as soil nutrient status (Gayathri *et al.*, 2009). The present investigation was therefore initiated to work out the response of FYM, soil test based NPK, Sulphur and Mo along with Rhizobium on yield and yield attributes of black gram.

Urdbean [*Vigna mungo* (L.) Hepper] is among the major pulses grown throughout the country during both in summer and rainy season. It is a self pollinated leguminous crop containing 24% protein, 60% carbohydrate, 1.3% fat, 3.2% minerals, 0.9% fibre, 154 mg calcium, 385 mg phosphorus, 9.1 mg iron and small amount of vitamin B-complex. Being a short duration crop, it fits well in various multiple and intercropping systems. After removing pods, its plant may be used as good quality green or dry fodder or green manure. Being a legume, it also enriches soil by fixing atmospheric nitrogen. Urdbean contributes about 13 per cent of total area and 10 per cent production of pulses in our country. It is grown on 3.06 million hectares area with a production of 1.70 m t and productivity of 555 kg ha⁻¹ in the country (DAC, 2014). This crop is extensively grown in the states of Maharashtra (23.36%), Andhra Pradesh (18.50%), Uttar Pradesh (12.29%), Madhya Pradesh (11.86%), Tamil Nadu (8.64%) and Rajasthan (4.29%). It can be grown on all type of soils ranging from sandy loam to heavy clay except alkaline and saline soils. However, it does well on heavier soils such as black cotton soils which retain higher moisture for longer time.

Materials and Methods

The experiment was conducted during summer season of 2017 at research field of Department of Soil Science and Agricultural Chemistry, Allahabad School of Agriculture SHUATS Allahabad. The experimental site is located in the sub-tropical region with 25° 0' 28.46.14" N latitude 81° 0' 54.49.95" E longitudes and 98 meter above sea level altitudes. The experiment was laid out in a 3x3 RBD factorial design with each three levels of NPK and Molybdenum with nine treatments, each consisting of three replicates. The total number of plots was 27 Black gram (*Vigna mungo* L.) were sown in summer season plots of size 2 x 2 m in order of Inceptisol and is alluvial in nature, both the mechanical and chemical analysis of soil was done before starting of the experiment to ascertain

the initial fertility of the soil. The soil samples were randomly collected from 0- 15 cm depths at randomly prior to tillage operations. The treatment consisted of nine combinations of inorganic source of fertilizers.

T ₀	[@ 0% NPK + @ 0% Mo]
T ₁	[@ 25% NPK + @ 0% Mo]
T ₂	[@ 50% NPK + @ 0% Mo]
T ₃	[@0% NPK + @ 25% Mo]
T ₄	[@25% NPK + @ 25% Mo]
T ₅	[@50% NPK + @ 25% Mo]
T ₆	[@0% NPK + @ 50% Mo]
T ₇	[@25% NPK + @ 50% Mo]
T ₈	[@50% NPK + @ 50% Mo]

The source of NPK and Molybdenum as Urea, SSP, MOP and Sodium molybdate (Na₂MoO₄.2H₂O) respectively.

Results and Discussion

Physical properties : The data presented in Table-3 clearly shows the Bulk density (g/cm³) of soil as influenced by N P K and Molybdenum. The response Bulk density (g/cm³) of soil was found to be non-significant in levels of N P K and Molybdenum. The maximum Bulk density (g/cm³) of soil was recorded 1.22 g/cm³ in treatment T₂ (N P K @50%+ Molybdenum @0%) and minimum Bulk density (g/cm³) of soil was recorded 1.07 g/cm³ in treatment T₆ (N P K @0%+ Molybdenum @50%). Particle density (g/cm³) of soil as influenced by N P K and Molybdenum. The response Particle density (g/cm³) of soil was found to be non-significant in levels of N P K and Molybdenum. The maximum Particle density (g/cm³) of soil was recorded 2.54 g/cm³ in treatment T₁ (N P K @25%+ Molybdenum @0%) and minimum Particle density (g/cm³) of soil was recorded 2.23 g/cm³ in treatment T₀ (control). Similar results were also reported by Kumar *et al.*, (2008) and Reddy *et al.*, (2005).

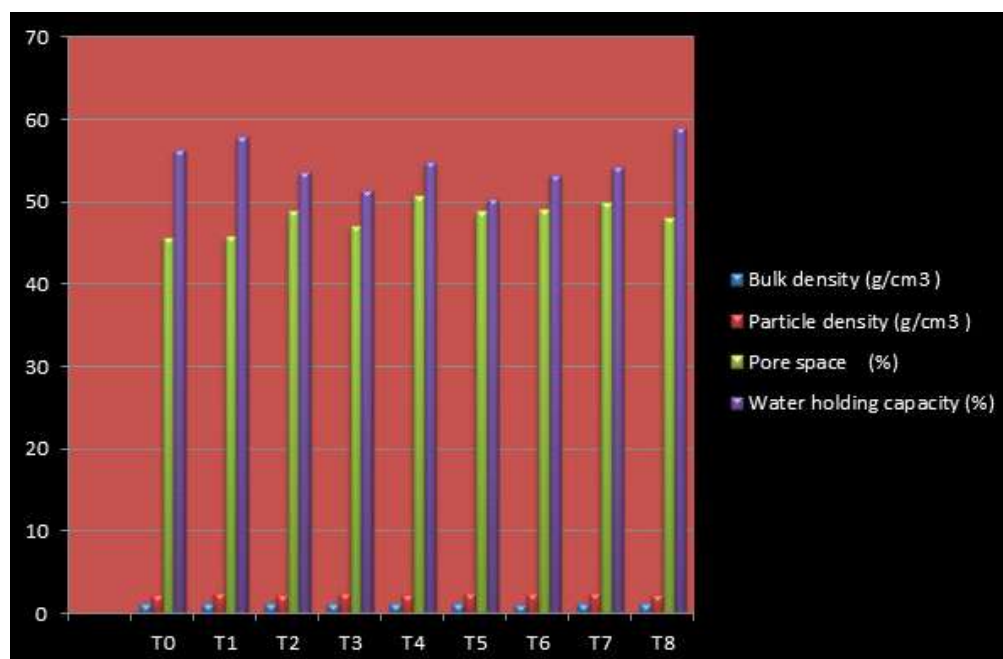
The data presented in Table-3 shows the % Pore space of soil as influenced by N P K and Molybdenum. The response of soil pore space was found to be significant in levels of N P K and Molybdenum. The maximum soil pore space was recorded 50.80 % in treatment T₄ (N P K @25%+ Molybdenum @25%) and minimum soil pore space was recorded 45.72 % in treatment T₀ (Control). water holding capacity of soil as influenced by N P K and Molybdenum. The response of soil water holding capacity was found to be significant in levels of N P K and Molybdenum. The maximum soil water holding capacity was recorded 59.05 % in treatment T₈ (N P K @50%+ Molybdenum @50%) and minimum soil water holding capacity was recorded 50.27 % in treatment T₅ (N P K @50%+ Molybdenum @25%). Similar results were also reported by Kumar *et al.*, (2008) and Reddy *et al.*, (2005).

Table-1 : Mechanical analysis of pre sowing soil samples (Sample taken before sowing).

Particulars	Results	Method employed
Sand (%)	62.71	Bouyoucos Hydrometer method (1952)
Silt (%)	23.10	
Clay (%)	14.19	
Textural class	Sandy loam	
Soil Colour		Munsell Colour Chart (1908)
Bulk density (Mgm ⁻³)	1.23	Core method (Muthuaval, 1992)
Particle density (Mgm ⁻³)	2.27	Graduated Measuring Cylinder (Muthuaval, 1992)
Pore Space (%)	48.53	Graduated Measuring Cylinder (Muthuaval, 1992)
Water holding capacity (%)	53.53	Graduated Measuring Cylinder (Muthuaval, 1992)

Table-2 : Chemical analysis of pre sowing soil samples (Sample taken before sowing).

Parameters	Method employed	Results
Soil pH (1 : 2)	Digital pH meter (Jackson 1958)	7.59
Soil EC (dSm ⁻¹)	EC meter (Digital Conductivity meter) (Wilcox, 1950)	0.177
Organic Carbon (%)	Walkley and Black's method (1947)	0.48
Available Nitrogen (Kg ha ⁻¹)	Alkaline potassium permanganate method (Subbaih and Asija, 1956)	215.23
Available Phosphorus (Kg ha ⁻¹)	Colorimetric method (Olsen et al., 1954)	20.33
Available Potassium (Kg ha ⁻¹)	Flame photometric method (Toth and Price, 1949)	127.65
Available Molybdenum (Kg ha ⁻¹)	Colorimetric method (C.H Williams, 1955)	11.25

**Graph-1: Effect of Different Levels of NPK and Molybdenum on their interaction on physical properties in soil of Black gram (*Vigna mungo* L.) Var. TAU-1.**

Chemical properties

Response on pH and EC of soil after crop harvest :

The result depicted in Table-3. shows that the pH and EC of soil shows that the maximum pH and EC of soil was found in T8 which were 7.20 and 0.24 and minimum was found in T0 which were 7.00 and 0.16. The interaction effect of NPK and Molybdenum on pH and EC was found non-significant.

Response of organic carbon, available nitrogen, phosphorus, potassium and molybdenum (kg ha⁻¹, g ha⁻¹) of soil after crop harvest :

The maximum % Organic carbon in soil was recorded 0.74 % in treatment T₈ (N P K @50%+ Molybdenum @50%) which was significantly higher than any other treatment combination and the minimum % Organic carbon in soil was recorded 0.55% in treatment T₀ (control). (Table-3)

Table-3 : Effect of Different Levels of NPK and Molybdenum on their interaction on soil pH after harvest of Black gram (*Vigna mungo* L.) var. TAU-1.

Treatment	pH (w/v)	EC (d Sm ⁻¹)	Bulk density (g/cm ³)	Particle density (g/cm ³)	Pore space (%)	Water holding capacity (%)	Organic Carbon (%)	Nitrogen (Kg ha ⁻¹)	Phosphorus (Kg ha ⁻¹)	Potassium (Kg ha ⁻¹)	Molybdenum (g ha ⁻¹)
T ₀	7.00	0.16	1.17	2.23	45.72	56.28	0.55	295.55	20.90	130.98	0.05
T ₁	7.03	0.18	1.19	2.54	45.82	58.03	0.58	286.22	24.11	145.95	0.05
T ₂	7.00	0.18	1.22	2.30	49.00	53.56	0.64	286.20	27.50	153.43	0.05
T ₃	7.01	0.20	1.17	2.52	47.05	51.38	0.60	295.50	27.40	157.18	0.2
T ₄	6.80	0.22	1.18	2.32	50.80	54.81	0.64	284.26	27.90	168.40	0.2
T ₅	7.01	0.21	1.20	2.50	48.89	50.27	0.69	319.45	29.25	172.14	0.2
T ₆	6.62	0.20	1.07	2.40	49.02	53.27	0.67	320.65	29.05	190.86	0.29
T ₇	7.16	0.20	1.16	2.52	50.00	54.21	0.73	326.93	29.20	197.27	0.29
T ₈	7.20	0.24	1.19	2.31	48.18	59.05	0.74	340.23	30.80	205.83	0.3
F-test	NS	NS	NS	NS	S	S	S	S	S	S	S
S.Ed.(±)	0.12	0.04	0.07	0.165	1.323	2.497	0.02	1.55	0.55	1.61	0.00
C.D. (at 5%)	0.25	0.09	0.15	0.341	2.730	5.154	0.05	3.29	1.16	3.44	0.00

The available nitrogen, phosphorus, potassium and molybdenum (kg ha⁻¹, g ha⁻¹) in soil were found maximum in T₈ which were 340.23, 30.80, 205.83, 0.3 and minimum was found in T₀ which were 295.55, 20.90, 130.98, 0.05, respectively. The interaction effect of NPK and Molybdenum on available nitrogen, phosphorus, potassium and molybdenum was found significant. Combined application of NPK and Molybdenum brings significantly increase in available Nitrogen, phosphorus, Potassium and molybdenum. The results are conformity with the finding of Khambalkar *et al.*, (2012).

It is concluded that Treatment combination T₈ was to be best in pH, EC (dSm⁻¹), O.C (%), and pore space (%) bulk density (g/cm³), particle density (g/cm³), water holding capacity (%) available nitrogen (kg ha⁻¹), phosphorus (kg ha⁻¹), potassium (kg ha⁻¹) and molybdenum (g ha⁻¹) which were as 7.39, 0.21, 0.77, 50.33, 1.19, 2.44, 59.14, 345.93, 32.10, 661.41, 15.81 respectively. Treatment T₄ was to be best in pore space (%) which were as 50.80 and treatment T₁ was to be best in particle density (g/cm³) as 2.54. Soil chemical properties as available N, P, K, Mo and O.C. were found to be significant but pH and EC were found to be non-significant. Soil physical properties as bulk density (g/cm³), particle density (g/cm³) were found non significant and percent pore space (%) and water holding capacity were found to be significant.

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Effects of Different Levels of NPK and Molybdenum on Growth and Yield of Black Gram (*Vigna mungo* L.) Var. Tau-1

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Abstract

A field experiment was conducted during the *kharif* season of 2017 in black gram (var. TAU-1) at Research farm, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, SHUATS, Allahabad (U.P.). The experiment was laid out in a Randomized Block Design with nine treatment combinations, consisting of three N P K levels (0, 25 and 50%) and Molybdenum (0, 25 and 50%). The treatment T₈ [50% NPK ha⁻¹ + 50% Molybdenum] showed that plant height (40.80 cm), no. of leaves plant⁻¹ (30.10) and pod length (9.90 cm), no. of seed pod⁻¹ (10.10) and it also gave highest yield (6.80 q ha⁻¹).

Key words : Black gram, NPK levels, molybdenum, *kharif* season

Introduction

Black gram (*Vigna mungo* L.) is one of the important pulse crops grown throughout India. Proper fertilization is essential to improve the productivity of black gram. It can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur. Black gram is very much responsive to sulphur application. Both phosphorus and sulphur can improve the quality and quantity of the crop. Hence, the present investigation was undertaken to find out the response of black gram to different levels of phosphorus, sulphur and PSB application. Blackgram is also used as green manuring crop, being a leguminous crop; it has the capacity to fix atmospheric nitrogen. It also helps in preventing soil erosion. Being a short duration crop and adaptability to offseason, it fits well in many intensive crop rotations.

Pulses are one of the second most important segments of Indian Agriculture after cereals as they rich in protein and play vital role in human diet. Pulses improve soil health by enriching nitrogen status, long-term fertility and sustainability of the cropping systems. It meets up to 80% of its nitrogen requirement from symbiotic nitrogen fixation from air. In India, production of pulses is around 19.3 million tonnes with a very low average productivity of 764 kg ha⁻¹. Pulses are least preferred by farmers because of high risk and less remunerative than cereals; consequently, the production of the pulses is sufficiently low. Black gram (*Vigna mungo* L.), is one of the important pulses crop, grown throughout the country. Among

pulses, black gram has increased from 1.87 m ha in 1971–72 to 3.11 m ha during 2012-13 with production level of 1.90 MT. This increase in production is mainly attributed to additional area brought under the crop as well as productivity gains (from 0.5 to 1.3 t ha⁻¹). Summer cultivation in northern India and winter cultivation in rice fallows in southern and coastal areas of the country also added to additional acreage. Black grams are widely considered as an excellent source of high quality protein with good digestibility and also contain water soluble vitamins and minerals of dietary significance. The factors attributed for low yields of pulses in India as compared to the world productivity are non-availability of quality seeds of improved and short duration varieties, growing of pulses under marginal and less fertile soil with low inputs and without pest and disease management, growing of pulses under moisture stress, unscientific post harvest practices and storage under unfavourable conditions. Hence, there is a scope for improving the production potential of this crop by use of organic manures, inorganic manures and biofertilizers. (Shrikant M. Vadgave, 2010). Integrated nutrient management includes the intelligent use of organic, inorganic, and on-line biological resources so as to sustain optimum yields, improve or maintain the soil physical and chemical properties, and provide crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe. The existing state blanket recommendation for crops does not ensure efficient and economic use of fertilizers, as it does not take into account the fertility variations resulting in imbalanced use of fertilizer nutrients. Among the various methods of

fertilizer recommendations, the soil test based fertilizer recommendations is also appropriate practices to improve yield as well as soil nutrient status (Gayathri *et al*, 2009). The present investigation was therefore initiated to work out the response of FYM, soil test based NPK, Sulphur and Mo along with Rhizobium on yield and yield attributes of black gram.

India is a major pulse growing country with a production of 15.24 million tones from an area of 24.45 million hectares with an increase of 36 % over the last year production of 11.14 million tones (Anonymous, 2005). However, the decreasing per capita availability of pulses from 69 g in 1961 to 37 g in 2004 in the country has been a serious concern. To make up a minimum of 50 g pulse per capita per day and further demand from burgeoning population at least 23.88 m tonnes of pulses are required by 2015 which is expected to touch 29.30 million tonnes by 2020. Black gram (*Vigna mungo* L.) is one of the important pulse crops containing about 23.9 % protein, 1.3 % fat and 60.4 % carbohydrates. In recent years the importance of S in pulse nutrition has been well recognized. It is required for protein formation and also involved in various metabolic and enzymatic processes including photosynthesis, legume Rhizobium symbiotic nitrogen fixation. Mo is an important element to help in protein synthesis and fixation of atmospheric nitrogen in the root of legume by nodule bacteria. Pulse crops contribute significantly to human nutrition, provide high quality fodder and enrich the soil fertility through diazotrophy (biological nitrogen-fixation).

Nutrient management is an important aspect in increasing the productivity of pulses. It is closely related to availability of nutrients to plants. It has short and long terms effects on the absorption, mobilization and utilization of nutrient from the soil. Phosphorus is a key nutrient for increasing productivity of pulses and the most important single factor responsible for poor productivity of pulses (Deo and Khaldelwal, 2009). The adequate supply of phosphorus to legume is more important than that of nitrogen. Because it has been beneficial effect on root development, nodulation, growth and yield. It plays an important role in energy transfer reactions and in oxidation-reduction processes. Phosphorus application increase cell division, as a result of which growth is increased in legumes.

Materials and Methods

The experiment was conducted during summer season of 2017 at research field of Department of Soil Science and Agricultural Chemistry, Allahabad School of Agriculture SHUATS Allahabad. The experimental site is located in the sub-tropical region with 25° 28' 46.14" N latitude 81° 0

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T ₀	[@ 0% NPK + @ 0 % Mo]
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T ₅	[@50% NPK + @ 25% Mo]
T ₆	[@0% NPK + @ 50% Mo]
T ₇	[@25% NPK + @ 50% Mo]
T ₈	[@50% NPK + @ 50% Mo]

The source of NPK and Molybdenum as Urea, SSP, MOP and Sodium molybdate (Na₂MoO₄.2H₂O) respectively. Several plant growth data were recorded at numerous intervals from germination to harvest, as well as several yield parameters after harvest. These parameters include growth parameters, plant height, plant dry weight and fresh weight, no. of leaves per plant. The yield data, such as nodules per plant, no. of pods per plant, seeds per pod, test weight (1000 seeds), and seed yield (q/ha), were recorded and statistically evaluated using analysis of variance (ANOVA) as applied to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984).

Results and Discussion

Growth attribute

Plant height/plant (cm) : The data presented in table-1 clearly shows the response of plant height of Black gram recorded at 25 DAS, 50 DAS and 65 DAS as influenced by different levels of N P K and Molybdenum. The plant height of Black gram was found to be increased significantly with the increase in levels of N P K and Molybdenum. The maximum plant height was recorded as 10.22 cm, 30.90 cm and 40.80 cm in T₈ (N P K@50%+ Molybdenum @50%) at 25 DAS, 50 DAS and 65 DAS respectively and the minimum plant height was recorded as 8.10 cm, 27.90 cm and 35.80 cm in T₀ (control) at 25 DAS, 50 DAS and 65 DAS respectively. Increase in plant height due to increase in N P K and Molybdenum may be due to adequate supply of nutrients which in turn helps in vigorous vegetative growth of plants and subsequently increase the plant through cell elongation, cell division,

Table-1 : Effect of Different Levels of NPK and Molybdenum on their interaction on plant height (cm) plant⁻¹ and no. of leaves plant⁻¹ at 25, 50 and 65 DAS of Blackgram (*Vigna mungo* L.) Var. TAU-1.

Treatments		25 DAS	50 DAS	65 DAS	25 DAS	50 DAS	65 DAS
T ₀	[@ 0% NPK + @ 0% Mo]	8.10	27.90	35.80	5.99	16.50	21.80
T ₁	[@ 25% NPK + @ 0% Mo]	8.90	28.51	35.90	6.90	17.00	22.50
T ₂	[@ 50% NPK + @ 0% Mo]	9.00	28.89	36.90	7.05	17.17	23.90
T ₃	[@0% NPK + @ 25% Mo]	9.67	29.44	38.70	7.50	17.10	25.05
T ₄	[@25% NPK + @ 25% Mo]	9.75	29.44	39.22	8.08	18.60	25.80
T ₅	[@50% NPK + @ 25% Mo]	10.17	29.97	40.40	7.99	19.07	27.00
T ₆	[@0% NPK + @ 50%Mo]	10.10	30.10	40.37	8.43	19.10	29.00
T ₇	[@25% NPK + @ 50%Mo]	10.02	29.73	39.10	8.70	18.83	29.90
T ₈	[@50% NPK + @ 50%Mo]	10.22	30.90	40.80	9.20	19.30	30.10
F-test		S	S	S	S	S	S
S. Ed. (±)		0.48	1.28	0.78	0.387	0.39	0.56
C.D. (P = 0.05)		1.02	2.71	01.66	0.80	0.82	1.19

photosynthesis and turbidity of plant cell. The increase in nodulation and nitrogen fixation leads to more plant height. Similar findings were reported by Bandani *et al.*, (2014), Jat *et al.*, (2012), Koushal and Singh (2011).

Number of leaves/plant : The number of leaves plant⁻¹ of Black gram was found to be increased significantly with the increase in levels of N P K and Molybdenum seed inoculation. The maximum number of leaves was recorded as 9.20, 19.30 and 30.10 in T₈ (N P K @50%+ Molybdenum@50%) at 25 DAS, 50 DAS and 65 DAS respectively and the minimum number of leaves were recorded as 5.99, 16.50 and 21.80 in T₀ (control) at 25 DAS, 50 DAS and 65 DAS respectively. Increase in number of leaves may be due to adequate nutrients supply which enhanced the vegetative growth of plant and subsequently the number of leaves. Similar findings were reported by Koushal and Singh (2011) and Shete *et al.*, (2010).

Yield attributes and Yield

Number of Pods/Plant : The number of pod plant⁻¹ of Black gram was found to be increased non-significantly with the increase in levels of NPK and Molybdenum. The maximum number of pods was recorded as 25.97 and 30.80 cm in T₈ (NPK@50% + Molybdenum @50%) at 50 DAS and 65 DAS respectively and the minimum number of pods were recorded as 15.70 and 25.02 in T₀ (control) at 50 DAS and 65 DAS respectively. Increase in number of pod due to increasing in adequate supply of NPK and Molybdenum. which in turn help in vigorous vegetative growth of plants and subsequently increase the number of pod plant⁻¹ through cell elongation, cell expansion, cell division, photosynthesis and turbidity of plant cell. Similar findings were also reported by Aslam (2010) and Bhaskara (2015).

No. of length pod⁻¹ : The number of length pod⁻¹ of Black gram was show in table no. 2 to be increased non-significantly with the increase in levels of NPK and Molybdenum. The maximum number of length pod⁻¹ was recorded as 9.90 cm in T₈ (NPK@50% + Molybdenum @50%) and the minimum number of length pod⁻¹ were recorded as 5.10 in T₀ (control).

Number of Seeds/Pod : The number of seed pod⁻¹ of Black gram was found to be increased non-significantly with the increase in levels of NPK and Molybdenum. The maximum number of seed pod⁻¹ was recorded as 10.10 in T₈ (NPK@50% + Molybdenum @50%) and the minimum number of seed pod⁻¹ were recorded as 5.70 in T₀ (control). Increase in number of seed pod⁻¹ due to increasing in adequate supply of NPK and Molybdenum. which in turn help in vigorous vegetative growth of plants and subsequently increase the number of seed pod⁻¹ through cell elongation, cell expansion, cell division, photosynthesis and turbidity of plant cell. Similar findings were also reported by Aslam (2010) and Bhaskara (2015).

No. of nodules plant⁻¹ : The number of nodules plant⁻¹ of Black gram was found to be increased non-significantly with the increase in levels of NPK and Molybdenum. The maximum number of nodules plant⁻¹ was recorded as 22.98 cm in T₈ (NPK@50% + Molybdenum @50%) and the minimum number of nodules plant⁻¹ were recorded as 13.05 in T₀ (control). Increase in number of nodules plant⁻¹ due to increasing in adequate supply of NPK and Molybdenum. which in turn help in vigorous vegetative growth of plants and subsequently increase the number of nodules plant⁻¹ through cell elongation, cell expansion, cell division, photosynthesis and turbidity of plant cell. Similar findings were also reported by Aslam (2010) and Bhaskara (2015).

Table-2 : Effect of Different Levels of NPK and Molybdenum on their interaction on yield attribute and yield of Blackgram (*Vigna mungo* L.) Var. TAU-1.

Treatments	No. of pods plant ⁻¹	Pod length	No. of seed pod ⁻¹	No. of nodules plant ⁻¹	Fresh weight plant ⁻¹	Dry weight plant ⁻¹	Test weight (g) 1000 seed	Seed yield (q ha ⁻¹)
T ₀	25.02	5.10	5.70	13.05	12.10	8.10	39.20	3.50
T ₁	25.73	6.07	6.10	14.90	13.90	8.60	39.97	4.05
T ₂	26.25	6.90	6.40	18.12	14.50	9.57	41.35	4.60
T ₃	27.02	7.23	7.43	19.50	15.10	9.92	42.40	5.20
T ₄	27.80	7.80	8.45	19.99	15.98	10.17	42.75	5.15
T ₅	28.72	8.40	8.80	20.80	17.05	10.75	43.60	5.35
T ₆	30.01	8.80	9.25	22.10	17.99	10.67	45.01	5.33
T ₇	30.45	9.10	9.30	22.70	19.10	11.01	45.85	6.08
T ₈	30.80	9.90	10.10	22.98	20.70	11.70	47.01	6.80
F-test	S	S	S	S	S	S	S	S
S. Ed. (±)	0.53	1.68	0.23	0.38	0.42	0.25	0.34	0.13
C. D. (P = 0.05)	1.13	3.56	0.48	0.80	0.90	0.53	0.72	0.28

Fresh weight (g) plant⁻¹ : The maximum fresh weight plant⁻¹ was recorded as 20.70 gm in T₈ (NPK@50% + Molybdenum @50%) and the minimum fresh weight plant⁻¹ were recorded as 12.10 in T₀ (control). Increase in fresh weight plant⁻¹ due to increasing in adequate supply of NPK and Molybdenum. which in turn help in vigorous vegetative growth of plants and subsequently increase the fresh weight plant⁻¹, cell expansion, cell division, photosynthesis and turbidity of plant cell. Similar findings were also reported by Aslam (2010) and Bhaskara (2015).

Dry weight plant⁻¹ (g) : The maximum dry weight plant⁻¹ was recorded as 11.70 in T₈ (NPK@50% + Molybdenum @50%) and the minimum dry weight plant⁻¹ were recorded as 8.10 in T₀ (control).

Test weight (g) (1000-seeds weight) : The maximum test weight of seed (g) was recorded as 47.01 in T₈ (NPK@50% + Molybdenum @50%) and the minimum test weight seed (g) were recorded as 39.20 in T₀ (control). Increase in test weight of seed (g) due to increasing in adequate supply of NPK and Molybdenum. which in turn help in vigorous vegetative growth of plants and subsequently increase the test weight of seed, cell expansion, cell division, photosynthesis and turbidity of plant cell. Similar findings were also reported by Aslam (2010) and Bhaskara (2015).

The seed yield (q ha⁻¹) : The maximum seed yield was recorded as 6.80 (q ha⁻¹) T₈ (N P K@50%+ Molybdenum @50%) which was higher than any other treatment combination and the minimum seed yield was recorded as 3.50 (q ha⁻¹) in T₀ (control). The combined application of NPK and Molybdenum played a very important role. Application of NPK increased supply of major assimilated

as well as micro nutrient to plants, Molybdenum also performs better when soil is well applied with nutrients. Similar results were also reported by Sivakumar *et al.*, (2013), Jat *et al.*, (2012), Koushal and Singh (2011).

Conclusions

It was concluded from trail that the effect of different levels in the experiment, The best treatment was T₈ [50% NPK ha⁻¹+50% Molybdenum] that showed the highest yield regarding, gave the best results with respect to plant height (40.80 cm), number of leaves plant⁻¹(30.10) and pod length (9.90 cm), no. of seed pod⁻¹(10.10), it gave highest yield, (6.80q ha⁻¹).

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Character Association Genetic Variability for Yield and its Contributing Traits in Potato (*Solanum tuberosum* L.) under Rice Based Cropping System

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Abstract

The experiment entitled Character association Genetic variability for yield and its contributing traits in potato (*Solanum tuberosum* L.) under rice based cropping system consisting twenty potato genotypes including one check variety was conducted under All India Coordinated Research project (AICRP) on potato at Research and Instructional Farm, Department of genetics and plant breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, in Rabi season of 2022-23. Potato genotypes were grown in Randomized Block Design (RBD) with three replication. Cropping sequences affects the rice and potato yield. All agronomic practices adopted to during the experiment maintain the crop. The analysis of variance (ANOVA) for yield and yield attributing traits revealed that there is sufficient amount of variability for all the characters. The presence of higher phenotypic coefficient of variance (PCV) was slightly higher than genotypic coefficient of variation (GCV) for all the parameters. High heritability coupled with high genetic advance was recorded for the traits viz. number of leaflets plant⁻¹, fresh weight of shoots plant⁻¹ it can be concluded that the selection will be effective for these traits for yield improvement.

Key words : Genetic variability, PCV, GCV, heritability and genetic advance

Introduction

Potato (*Solanum tuberosum* L.), $2n=4x=48$, autotetraploid is annual plant belongs to nightshade family Solanaceae grown for its starchy edible tubers. The potato is native to Peruvian-Bolivian Andes. It was introduced in India by the Portuguese sailors during early 17th century and its cultivation was spreads to north India by the British. It is known as “king of vegetables”. Potato is one of the most important staple food crop just after rice and wheat which is utilized throughout the year in India. Potato is an important starchy food crop in both sub-tropical and temperate regions. Even in tropical region it is widely grown during winter season. It occupies the largest area under any single vegetable crop in the world and it produces more food per unit area than cereals and that too in a short time. Potato plants produce small green fruits similar to green cherry tomatoes after flowering, each containing about 300 seeds. For other parts of the plant apart from the tubers, the fruit contains the toxic alkaloid solanine and thus, unfit for use. It's very suitable for use in multiple cropping systems, since cultivars capability of early bulking with higher yield have been identified for various region of the country through the “All India Coordinated Potato cultivar Project.” Tuber yield is complex character related with many interrelated components. Study of connection between various quantitative characters give a thought of affiliation that

could be adequately used in choosing a superior plant type in potato. The main breeding center focus has been to create varieties with brief length, high return, great keeping quality protection from biotic pressure exceptionally late scourge and viral maladies and appropriate for table and handling purpose (Luthura *et al.*, 2001). Character association and genetic parameter of variation provide information on expected character response and help in the development of a suitable breeding procedure for improvement. The nature and magnitude of variability in existing plant materials, or the role of various character and path coefficient analysis provides for permits further. The Partitioning of a correlation into direct and indirect effect components makes it easier to identify important traits. In the case of Chhattisgarh plains rice based cropping systems past the cultivation area for the potato has increased but there is lack of suitable cultivars for this state, therefore it is an urgent need to evolve the potato genotypes suitable for rice based cropping system Chhattisgarh plains.

Materials and Methods

The experiment material consisting of twenty genotypes including one check variety of potato was conducted under All India Coordinated Research project (AICRP) on potato at Research and Instructional Farm, Department of Genetics and Plant Breeding, College of Agriculture,

Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, in *Rabi* season of 2022-23. Potato genotypes were grown in Randomized Block Design (RBD) with three replication plot size 3.0 × 2.4 m and 60 × 30 spacing during *Rabi* 2022-23. All agronomic recommended practices adopted to maintain the crop. The data observation were recorded on five randomly selected competitive in each genotypes in each replication and the means were calculated. Data were subjected to analysis of variance (ANOVA) as per (Panse and Sukhatme, 1968). The GCV and PCV parameters estimated by (Burton, 1952), heritability suggested by (Johnson *et al.*, 1955) and genetic advance as percentage of mean calculated by (Johnson *et al.*, 1955). Coefficient of correlation was calculated for all possible combination of all the characters at genotypic, phenotypic and environmental levels (Al jibouri *et al.*, 1958) ^[1]. Path coefficients analysis was laid out to show the cause and effect relationship between yield and its attributing traits and there partition into direct and indirect effects.

Results and Discussion

Genetic variability : In the present study, the analysis of variance (ANOVA) presented in table-1 revealed that these is significant difference among the genotypes for all the traits the phenotypic variance was in general higher than the genotypic variance for all the characters. The higher magnitude of GCV fresh weight of shoots plant⁻¹ (g) and unmarketable tuber weight yield plot⁻¹ (kg) similarly higher magnitude of PCV was extracted by the fresh weight of shoots plant⁻¹ (g) and unmarketable tuber weight yield plot⁻¹ (kg). High heritability in broad sense was found in unmarketable tuber weight yield plot⁻¹ (kg), fresh weight

of shoots plant⁻¹ (g), number of leaflets plant⁻¹, number of shoots plant⁻¹, dry weight of shoots plant⁻¹(g), marketable tuber yield plot⁻¹ (kg), total tuber yield plot⁻¹ (kg), compound leaves plant⁻¹ and tuberization efficiency. Medium heritability in broad sense was observed plant height (cm) and number of tuber plant⁻¹ on the other hand plant emergence (%) followed by harvest index (%) showed lowest heritability. High heritability coupled with high genetic advance was recorded for the traits *viz.*, unmarketable tuber weight yield plot-1 (kg), fresh weight of shoots plant⁻¹ (g), total tuber yield plot⁻¹ (kg). Hence, these characters were predominantly governed by additive gene action and can be improved through simple selection. This results are also supported by the finding of (Lathura *et al.*, 2005) and (Barik, 2007) for genetic variability and heritability.

Correlation coefficient : The correlation coefficient reported that the tuber yield showed significant positive correlation with marketable tuber yield plot⁻¹ at both the genotypic and phenotypic levels, the result showed that tuber yield exhibited a positive significant association at genotypical level with fresh weight of shoots plant⁻¹ (g), dry weight of shoots plant⁻¹(g), number of tuber plant⁻¹, marketable tuber yield plot⁻¹ (kg) and total tuber yield plot⁻¹ (kg). Very strong (> 0.65) correlation coefficients upon fresh weight of shoots plant⁻¹, marketable tuber yield plot⁻¹ and total tuber yield plot⁻¹. Moderately strong (0.50 to 0.64) correlation coefficients found at dry weight of shoots. Moderately weak (0.30 to 0.49) correlation coefficients number of tuber plant⁻¹. Very weak (< 0.30) correlation coefficients found at plant emergence (%), number of shoots plant⁻¹, number of leaflets plant⁻¹, compound leaves plant⁻¹, tuberization efficiency and harvest

Table-1 : ANOVA for yield and yield attributing traits in potato.

Sl. No.	Source	Mean Sum of Squares (MSS)		
		Replication	Treatment	Error
	Degrees of freedom	2	19	38
1.	Plant emergence (%)	8.190	37.995*	15.76
2.	Plant height (cm)	18.905	32.499**	6.239
3.	Number of shoots plant ⁻¹	0.042	0.991**	0.054
4.	Number of leaflets plant ⁻¹	186.928	15217.765**	710.576
5.	Compound leaves plant ⁻¹	9.592	151.941**	9.663
6.	Fresh weight of shoots plant ⁻¹ (g)	1.797	9142.054**	194.239
7.	Dry weight of shoots plant ⁻¹ (g)	5.117	47.641**	2.563
8.	Number of tubers plant ⁻¹	1.504	4.255**	0.756
9.	Tuberization efficiency	0.032	0.662**	0.047
10.	Harvest index (%)	0.812	48.681*	20.195
11.	Marketable tuber yield plot ⁻¹ (kg)	1.861	67.226**	3.517
12.	Unmarketable tuber weight yield plot ⁻¹ (kg)	0.001	0.188**	0.003
13.	Total tuber yield plot ⁻¹ (kg)	1.767	69.063**	3.515
14.	Total tuber yield plant ⁻¹ (kg)	0.001	0.03**	0.002

*Significance at 5 percent level of significance, **Significance at 1 percent level of significance.

Table-2 : Mean performance of genotypes for various yield and yield attributing traits in potato.

S. No.	Genotypes	Plant emergence (%)	Plant height (cm)	Number of shoots plant ⁻¹	Number of leaflets plant ⁻¹	Compound leaves plant ⁻¹	Fresh weight of shoots plant ⁻¹ (g)	Dry weight of shoots plant ⁻¹ (g)	Number of tubers plant ⁻¹	Tuberization efficiency	Harvest index	Marketable tuber yield plot ⁻¹ (kg)	Unmarketable tuber weight plot ⁻¹ (kg)	Total tuber yield plot ⁻¹ (kg)	Total tuber yield plant ⁻¹ (kg)
1.	AICRPP-1	93.04	42.00	5.00	333.13	49.27	190.67	22.00	9.00	3.01	75.06	27.00	0.57	27.57	0.57
2.	AICRPC-5	93.13	45.13	3.87	442.53	52.53	165.67	19.00	8.00	2.23	68.94	17.55	0.20	17.75	0.37
3.	AICRPC-14	92.30	48.00	5.13	357.57	51.47	193.33	18.67	9.00	2.50	71.40	22.79	0.41	23.19	0.48
4.	AICRPP-67	84.50	50.93	4.87	343.67	50.74	295.00	23.67	10.00	2.27	69.43	31.24	0.95	32.19	0.67
5.	AICRPC-6	95.14	46.47	4.73	392.37	53.87	305.00	25.00	10.00	2.26	69.30	32.25	0.85	33.10	0.69
6.	AICRPP-83	85.12	52.60	4.70	357.74	52.40	242.66	19.00	10.33	2.12	67.96	24.17	0.56	24.72	0.51
7.	AICRPC-17	93.46	45.47	4.07	366.53	53.60	182.00	22.33	8.00	3.13	75.74	27.17	0.15	27.32	0.57
8.	AICRPP-75	90.27	47.67	3.53	424.27	47.40	283.67	26.34	9.00	1.51	60.07	20.04	0.46	20.50	0.43
9.	AICRPP-89	89.89	48.20	4.67	371.10	37.53	185.33	22.67	10.33	2.89	74.25	25.13	0.58	25.71	0.53
10.	AICRPP-96	83.45	46.13	3.47	358.00	39.67	161.33	13.33	9.33	3.32	76.77	25.23	0.49	25.72	0.54
11.	AICRPP-88	88.25	42.00	3.93	384.50	40.73	158.00	16.33	9.00	3.04	75.21	22.41	0.65	23.06	0.48
12.	AICRPP-79	84.44	49.40	4.74	462.03	54.27	167.67	20.33	11.00	3.18	76.01	24.73	0.85	25.58	0.53
13.	AICRPP-68	87.21	47.27	5.00	414.93	54.53	199.67	20.33	10.33	2.53	71.55	23.57	0.63	24.20	0.50
14.	AICRPP-76	87.25	50.40	3.70	533.97	58.87	291.00	28.00	9.00	2.45	70.99	33.93	0.28	34.21	0.71
15.	AICRPP-66	85.55	49.33	3.57	548.43	66.13	205.00	26.00	9.00	2.55	71.74	24.30	0.75	25.05	0.52
16.	AICRPH-2	92.88	46.33	4.50	530.80	58.47	187.33	19.00	9.00	2.19	68.42	18.68	0.91	19.59	0.41
17.	AICRPC-15	87.57	50.13	3.87	428.80	53.63	144.00	19.00	10.33	3.12	75.58	21.26	0.25	21.51	0.45
18.	AICRPP-90	90.21	54.87	4.13	384.47	54.14	195.00	22.00	12.33	2.74	73.28	24.76	0.93	25.69	0.54
19.	AICRPP-9	88.45	47.40	4.57	423.47	47.87	323.33	28.33	12.33	2.24	68.97	33.79	0.82	34.61	0.72
20.	Kufri Garima	92.62	52.33	5.20	556.73	62.60	208.33	26.33	10.33	2.12	67.84	20.61	0.54	21.15	0.44

Sl. No.	Characters	Variation Environmental	ECV	Variation Genotypical	GCV	Variation Phenotypical	PCV	h ² (Broad Sense)	Genetic Advance ment 5%	Genetic Advance ment as % of Mean
1.	Plant emergence (%)	15.76	4.449	7.412	3.051	23.172	5.394	31.985	3.172	3.554
2.	Plant height (cm)	6.239	5.192	8.753	6.151	14.992	8.049	58.387	4.657	9.681
3.	Number of shoots plant ⁻¹	0.054	5.312	0.312	12.812	0.366	13.869	85.33	1.063	24.38
4.	Number of leaflets plant ⁻¹	710.576	6.335	4835.729	16.527	5546.306	17.7	87.188	133.76	31.791
5.	Compound leaves plant ⁻¹	9.663	5.98	47.426	13.247	57.089	14.534	83.073	12.93	24.873
6.	Fresh weight of shoots plant ⁻¹ (g)	194.239	6.507	2982.605	25.496	3176.844	26.314	93.886	109.01	50.892
7.	Dry weight of shoots plant ⁻¹ (g)	2.563	7.315	15.026	17.714	17.589	19.165	85.43	7.381	33.728
8.	Number of tubers plant ⁻¹	0.756	8.887	1.166	11.039	1.922	14.172	60.678	1.733	17.714
9.	Tuberization efficiency	0.047	8.475	0.205	17.61	0.252	19.544	81.196	0.84	32.689
10.	Harvest index (%)	20.195	6.292	9.495	4.314	29.69	7.629	31.982	3.59	5.026
11.	Marketable tuber yield plot ⁻¹ (kg)	3.517	7.492	21.236	18.411	24.753	19.877	85.792	8.793	35.128
12.	Unmarketable tuber weight yield plot ⁻¹ (kg)	0.003	9.546	0.062	42.024	0.065	43.095	95.093	0.499	84.419
13.	Total tuber yield plot ⁻¹ (kg)	3.515	7.318	21.849	18.244	25.365	19.657	86.141	8.937	34.881
14.	Total tuber yield plant ⁻¹ (kg)	0.002	9.229	0.009	17.975	0.012	20.206	79.139	0.176	32.941

[illegible]

Table-5 : Phenotypic correlation coefficients for tuber yield and its component in potato.

Characters	Plant height (cm)	Number of shoots plant ⁻¹	Number of leaflets plant ⁻¹	Compound leaves plant ⁻¹	Fresh shoots weight of plant (g)	Dry shoots weight of plant ⁻¹ (g)	Number of tubers plant ⁻¹	Tuberization efficiency	Harvest index	Marketable tuber yield plot ⁻¹ (kg)	Unmarketable tuber weight yield plot ⁻¹ (kg)	Total tuber yield plot ⁻¹ (kg)
Plant emergence (%)	-0.1755	0.1890	0.0130	0.1236	0.0330	0.0893	0.1598	0.1315	0.0784	0.1160	-0.1431	0.1218
Plant height (cm)		0.0734	0.2268	0.337*	0.1719	0.274*	-0.431**	-0.1608	-0.0362	-0.0904	-0.1641	-0.0976
Number of shoots plant ⁻¹			0.1927	0.0909	0.1184	0.0947	0.332*	0.0915	0.0113	0.1190	0.321*	0.1338
Number of leaflets plant ⁻¹				0.662**	0.0222	0.372*	0.0533	0.2477	0.1496	0.1663	0.0294	0.1628
Compound leaves plant ⁻¹					0.1096	0.378*	0.0570	0.2437	0.1368	0.0252	0.0715	0.0213
Fresh weight of shoots plant ⁻¹ (g)						0.694**	0.2073	0.635**	0.522**	0.621**	0.275*	0.607**
Dry weight of shoots plant ⁻¹ (g)							0.1984	0.445**	0.317*	0.473**	0.1270	0.474**
Number of tubers plant ⁻¹								0.0331	0.0037	0.2090	0.509**	0.2322
Tuberization efficiency									0.905**	0.1773	-0.1163	0.1693
Harvest index (%)										0.275*	-0.0410	0.269*
Marketable tuber yield plot ⁻¹ (kg)											0.2157	0.996**
Unmarketable tuber weight yield plot ⁻¹ (kg)												-0.260*
Total tuber yield plot ⁻¹ (kg)												0.997**

Table-6 : Genotypic path analysis for yield and yield attributing traits in potato.

Characters	PE (%)	PH (cm)	NOSP	NOLP	CLPP	FWSP	DWSP	NOTP	TE	HI	MTYP	UTYP	TTYP	TTYP
Plant emergence (%)	0.0020	-0.0004	0.0004	0.0000	0.0003	-0.0001	0.0002	0.0003	0.0003	0.0002	0.0002	0.0003	0.0002	0.1174
Plant height (cm)	0.0005	-0.0027	-0.0002	-0.0006	-0.0009	-0.0005	-0.0007	-0.0012	0.0004	0.0001	-0.0002	-0.0004	-0.0003	-0.1024
Number of shoots plant ⁻¹	0.0001	0.0000	0.0006	-0.0001	0.0001	0.0001	0.0001	0.0002	-0.0001	0.0000	0.0001	0.0002	0.0001	0.1311
Number of leaflets plant ⁻¹	0.0000	-0.0008	0.0006	-0.0034	-0.0022	-0.0001	-0.0013	0.0002	0.0008	0.0005	0.0006	-0.0001	0.0005	0.1567
Compound leaves plant ⁻¹	0.0006	0.0015	0.0004	0.0030	0.0045	0.0005	0.0017	0.0003	-0.0011	0.0006	0.0001	0.0003	-0.0001	0.0183
Fresh weight of shoots plant ⁻¹ (g)	-0.0060	0.0314	0.0216	0.0041	0.0200	0.1824	0.1267	0.0378	0.1158	-0.0951	0.1133	0.0502	0.1144	0.607**
Dry weight of shoots plant ⁻¹ (g)	0.0009	0.0027	0.0009	0.0037	0.0038	0.0069	0.0100	0.0020	-0.0045	-0.0032	0.0047	0.0013	0.0047	0.466**
Number of tubers plant ⁻¹	0.0012	-0.0032	-0.0024	0.0004	0.0004	-0.0015	-0.0015	-0.0073	0.0002	0.0000	-0.0015	-0.0037	-0.0017	0.2239
Tuberization efficiency	-0.0007	-0.0009	-0.0005	-0.0014	-0.0014	-0.0036	-0.0025	-0.0002	0.0057	0.0051	0.0010	-0.0007	0.0010	0.1932
Harvest index (%)	0.0146	-0.0067	0.0021	0.0278	0.0254	0.0969	0.0589	-0.0007	0.1681	0.1858	0.0510	-0.0076	0.0500	0.315*
Marketable tuber yield plot ⁻¹ (kg)	0.0200	-0.0156	-0.0205	0.0287	0.0043	-0.1071	-0.0816	-0.0360	-0.0306	-0.0474	-0.1725	-0.0372	-0.1723	0.996**
Unmarketable tuber weight yield plot ⁻¹ (kg)	-0.0008	-0.0009	-0.0018	-0.0002	-0.0004	-0.0016	-0.0007	-0.0029	-0.0007	-0.0002	-0.0012	-0.0057	-0.0015	-0.260*
Total tuber yield plot ⁻¹ (kg)	-0.1221	0.0978	0.1341	-0.1631	-0.0213	0.6285	0.4745	0.2326	0.1696	0.2697	0.9200	0.2641	0.9450	0.997**

PE- Plant emergence (%), **PH**- Plant height (cm), **NOSP**- Number of shoots plant⁻¹, **NOLP**- Number of leaflets plant⁻¹, **CLPP**- Compound leaves plant⁻¹, **FWSP**- Fresh weight of shoots plant⁻¹ (g), **DWSP**- Dry weight shoots plant⁻¹ (g), **NOTP**- Number of tubers plant⁻¹, **TE**- Tuberization efficiency, **HI**- Harvest index (%), **MTYP**- Marketable tuber yield plot⁻¹ (kg), **UTYP**- Unmarketable tuber weight yield plot⁻¹ (kg), **TTYP**- Total tuber yield plot⁻¹ (kg), **TTYP**- Total tuber yield plot⁻¹ (kg)

index(%). Whereas, negative significant correlation at genotypic level was observed for plant height (cm), unmarketable tuber weight yield plot⁻¹ (kg). At phenotypic level tuber yield exhibited positive significant correlation with fresh weight of shoots plant⁻¹ (g), dry weight of shoots plant⁻¹ (g), harvest index (%), marketable tuber yield plot⁻¹ (kg) and total tuber yield plot⁻¹ (kg). Whereas, negative significant correlation at phenotypic level with unmarketable tuber weight yield plot⁻¹ (kg). According to above result, this can be concluded that increase in the fresh weight of shoots plant⁻¹, dry weight of shoots per plant, marketable tuber yield plot⁻¹ and total tuber yield plot⁻¹ will contribute to the greater yield of tuber. Similar result observed in the present study was also found in research of Fekadu *et al.*, (2020), Ummiyah and Khan. (2013), Ara and Haydar. (2009) and Zelalem. (2009).

Path coefficient analysis : Path coefficients analysis revealed positive and direct effect of total tuber yield plot⁻¹, number of tuber plant⁻¹, harvest index, plant height, plant emergence, number of leaflets plant⁻¹. However negative direct effect on tuber yield was showed by characters viz., compound leaves plant⁻¹, number of shoots plant⁻¹, fresh weight of shoots plant⁻¹, dry weight of shoots plant⁻¹, tuberization efficiency marketable tuber yield plot⁻¹, unmarketable tuber weight yield plot⁻¹ these results are also supported by the (Desai and Jamini 1997), (Barik, 2007) and (Barik *et al.*, 2010).

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Influence of Abiotic Factor on Aphid Population under Mustard Ecosystem

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Abstract

Mustard (*Brassica juncea*) is the most important rabi oilseed crops in india. Mustard aphid is the major insect-pest of rapeseed mustard. It causes 66% to 99% loss in *B. campestris* L. and 27-28% in *B. juncea* L. with losses in oil content of 15%. In mustard the incidence and spread of aphid is largely influenced by weather condition such as temperature, humidity, rainfall, sunshine etc. similarly other severe pest such as mustard sawfly and beetle also attack the rapeseed mustard crops at the seeding stage in severe losses to the germinating crops.

Key words : *B. juncea*, *B. campestris*, temperature, humidity, rainfall, sunshine.

Introduction

Oil seed crops are the second most important determinant of agricultural economy after cereals. All the nine annual oil seeds crops are grown in diverse agro – ecological situations of the country. Major oil seeds production came from soybean, rapeseeds' – mustard, groundnut, sunflower and castor (HOR, 2015). Rapeseed and mustard seed is a rich source of oil and protein which is 46% to 48% and 43.6% respectively in whole seed meal (Frank, 1990) and their green leaves both are used for human food and animal fodder (Levy, 1992). The leaves of young mustard plants are used as green vegetables as they contain sulphur and minerals in the diet. Oil is used as condiments in the preparation of pickles and for flavouring curry. The oil is utilized as edible oil throughout northern India. It is also used for preparation of hair oils and medicines. Industrially it is used for preparation of soaps, lubricants, leather softeners and preservatives. Its oil cake is used as cattle feed.

Mustard aphid is the most serious pest of mustard. It causes 66% to 99% loss in *B. campestris* L. and 27-28 % in *B. juncea* L. (Bakhetia, 1987) with losses in oil content of 15% (verma and singh, 1987). Aphid infested the crop from vegetative stage to pod stage (sachan, 1990). The nymphs and adults suck the sap from leaves, stem, inflorescences and pods resulting in stunted growth of plants, withering of flower and development of deformed pod (Atwal Dhaliwal 1996). This pest is more abundant from December to March when it infests various cruciferous oilseeds and vegetables. The cloudy and cold weather with high relative humidity are very favourable condition for the multiplication of mustard aphid. In favorable climatic condition for aphid favour increases in population to many fold which is varied from 5 to 9

young/day/ female and total number of young produced by single female varied from 76 to 188 depending on weather condition (Nair, 1986). In mustard the incidence and spread of aphid is largely influenced by weather condition such as temperature, humidity, rainfall, sunshine etc. similarly other severe pest such as mustard saw fly and flea beetle also attack the rapeseeds mustard crops at the seedling stage resulting in severe losses to the germinating crops. Climatic factors like temperature, relative humidity and rainfall, sunshine etc. play a positive role in growth and development of both pest and host plants.

Materials and Methods

The experiments were conducted to study the Influence of a biotic factor on aphid population under mustard ecosystem. The varuna variety was selected for present study. It is high yielding and moderately susceptible to mustard aphids. It matures in 120-125 days. It is bold seeded fertilizer responsive variety. Plants are tall and semi spreading type. Seeds are bold brownish – black with an average oil content of 42.0 per cent. The plant is moderately branched with good number of pods and petiolated smooth leaves. The yield under ideal condition is 15-20 q/ha. It is widely grown in U.P, Gujarat, Bihar and W.B.

Among the various insect- pest associated with mustard crop mustard aphid is the most important insect pest. The insect possesses serious threat to successful cultivation of this very important oil seed crop. Its infestation on the physiological maturity of the crop. Both nymph and adults suck the sap from leaves, flower, pods and tender shoots. It is mostly confined to the apical parts of the plants. This insect also has parthenogenesis mode of reproduction. So it attains very high population in very

short period under favorable weather condition. Severely infested plants either dry or unprotected crop fail to produce any seed under severe infestation condition.

To record the aphid population, 5 plants were randomly selected and tagged in each plot. The aphid population was recorded at 3 days intervals starting with their first appearance till harvesting of the crop. The aphid population was recorded from top 10 cm. of terminal shoot. thus the data obtained on average number of aphid per plant have been subjected to log transformation, $\log(x+1)$ singh and rai (1994) for the sake of statistical analysis and correlated to study the combined influenced of various weather parameters on aphid population recorded on that particular day of observation.

Growth and distribution of aphid population in the field is greatly influenced by abiotic factors vis. Temperature, relative humidity, sunshine and rainfall etc. the present scenario of change in climatic condition. Over the globe has affected the occurrence, distribution and multiplication of the pest species. The present study is thus envisaged to study the influence of change in climatic condition on aphid population in mustard and the subsequent succession of its bioagent population.

Results and Discussion

The impact of major abiotic factor on the infestation of aphid *L. erysimi* in rabi season of 2017-2018, particularly during January, February and march month are given in table.

It can be seen from table that the occurrence of aphid population starts during second week of January, but the population was not recorded due to its very low number. However, the population increased significantly after the second week of January with mean population 8.47 aphids / 10 cm terminal shoot. The maximum and minimum temperature on this observation day was 23.61 °C and 8.05 °C, maximum and minimum relative humidity was 94% and 78% respectively. The aphid population attained it's peaked during second week of February with 42.42 aphids/ 10cm terminal shoot. Thereafter, the population declined more or less gradually being minimum observed on second week of March recording 0.14 aphids/ 10 cm terminal shoot. The mean of aphid were comparatively less when the maximum and minimum temperature was 35.12 °C and 17.98 °C obviously showing negative effect of temperature and maximum and minimum relative humidity was 57.28% and 36% respectively.

The succession of aphid on the crop that was observed at interval of days till 2nd week of February was gradually increased reaching a peak population of 42.42 aphid/ 10 cm terminal shoot, the population started

decreasing with significant increase in temperature and reduction in relative humidity. Thus, the aphid population decrease to 0.14 individuals per 10 cm terminal shoot on second week of march with a maximum and minimum temperature of 35.12 °C and 17.98 °C and maximum and minimum relative humidity of 57.28% and 36% respectively. The correlation between aphid population and maximum and minimum temperature showed a negative correlation with r value of 0.749 and -0.266, respectively. The temperature range have a positive correlation with the test insect correlation $r = -0.251$ and the correlation between test insect population with temperature range were statistically non- significant. The other factor such as maximum and minimum relative humidity has positive correlation with r value of 0.269 and 0.023 respectively.

The incidence of aphid starts at the vegetative phase of the crop but the major infestation occurs during the reproductive phase. It causes about 35.4% to 73.3% loss depending upon the different agro- climatic condition (Bhakheta, 1989). The infestation of aphid not only result in reducing yield of mustard seeds but also causes reduction in the oil content up to 66.87% (Singhvi *et al.*, 1973). The influence of weather parameters on aphids' population was well studies in various places across the country where ever mustard is grown. The unfavorable and favorable climatic condition in a given region greatly contributed for population growth of aphid. Such population fluctuations results in pest status of aphids and further requisition for pest management tactics to initiate.

Therefore the present study was aimed to evaluate the influence of a biotic factors against this very important insect – pest, mustard aphid, *L. erysimi*, and the results obtains were logically discussed here under.

The study conducted to determine the influence of different abiotic factors viz; maximum and minimum temperature, maximum and minimum relative humidity and rainfall clearly showed impact on relative abundance of *L. erysimi* and affected the growth and multiplication of mustard aphid. It was observed that the number of aphid population of peaked during second week of February recording 42.42 aphid / 10 cm terminal shoot, when maximum and minimum temperature were 25.98 °C and 51% respectively. The population decline more or less gradually and reached to minimum during third week of March, the number of aphid were comparatively less when the temperature was 35.12 °C and above showing a negative correlation. Whereas, a significant positive correlation was observed between aphid population and relative humidity. The finding of mishra and kanwat (2003) also support the present finding who reported that *L. erysimi* was most abundant during the last week of

Average of Aphid population and different abiotic factors during experimental period (January-March 2018) under mustard ecosystem.

Standard Week	Aphid pop. Per 10 cm terminal shoot	Temperature ($^{\circ}\text{C}$)			Humidity ($^{\circ}\text{C}$)			Rainfall (mm)
		Max.	Min.	Range	Max.	Min.	Range	
1 st	0.00	16.41	8.15	8.26	94.33	73.21	21.12	0
2 nd	3.25	20.45	7.42	13.03	98.00	81.01	16.99	0
3 rd	8.47	23.61	8.05	15.56	94.00	78.00	16.00	0
4 th	16.70	24.64	9.18	15.46	93.85	62.25	31.60	0
5 th	22.00	25.82	10.38	15.44	83.71	50.15	33.56	0
6 th	27.53	26.57	12.00	14.57	72.85	43.00	29.85	0
7 th	42.42	25.98	13.35	12.63	80.71	51.00	29.71	0
8 th	9.71	30.32	14.05	16.27	84.14	44.22	39.92	0
9 th	4.20	32.01	17.44	14.57	73.71	41.26	32.45	0
10 th	4.09	32.75	16.14	16.61	61.57	38.00	23.57	0
11 th	0.14	35.12	17.98	17.14	57.28	36.00	21.28	0
12 th	0.00	35.71	17.42	18.29	51.71	36.25	15.46	0
13 th	0.00	37.77	18.57	19.20	47.14	33.70	13.44	0

Average of 5 plants and three replication in both the cases *i.e* aphid.

January and the peak population was observed under mean maximum temperature of 23.1 and 21.4 $^{\circ}\text{C}$ and mean relative humidity of 53% 59% respectively. The sharp decline in aphid population in the February was attributed to rising temperature and production of a late form coupled with crop maturity. The finding of Jandial and Kumar (2007) also broadly supported the present finding. They found that the incidence of mustard aphid started in the last week of December and reached its peak in 2nd week of February with 384.15/10 cm terminal shoot during 2002- 2003. Their studies further indicated that mustard aphid incidence was higher when maximum and minimum temperature ranged between 20-27 $^{\circ}\text{C}$ and 5-10 $^{\circ}\text{C}$, respectively and relative humidity during morning and evening hours ranged from 72-90% and 53-61% respectively.

In our present studies the aphid population started decreasing with significant increase in temperature and reduction in relative humidity, and the period of rainfall also showed a negative correlation with the population. Thus, aphid population decreased to 0.14 / 10 cm terminal shoot during second week of March with a maximum and minimum temperature of 35.12 $^{\circ}\text{C}$ and 17.98 $^{\circ}\text{C}$ and maximum and minimum relative humidity of 57.28% and 36% respectively. These findings were also well in accordance with the studies carried out by Jat *et al.* (2006) who supported the present finding. Aphid infestation started in the 3rd week of January (48 aphid per 5 plant), which increased gradually and peaked (295 aphid per 5 plants) in the 2nd week of February and disappeared completely after the 2nd week of March. The incidence and

abundance of aphid population was significantly and positively correlated with both morning and evening relative humidity.

Conclusions

Rapeseed and mustard is most important rabi oilseed crop in India. Mustard aphid is the major insect pest of rapeseed mustard. It causes 66% to 99% loss in *B. campestris* L. and 27- 28% in *B. juncea* L. with losses in oil content of 15%. In mustard the incidence and spread of aphid is largely influenced by weather condition such as temperature, humidity, rainfall, sunshine etc. similarly other severe pest such as mustard sawfly and beetle also attack the rapeseed mustard crop at the seedling stage resulting in severe losses to the germinating crops. These all effects of synthetic insecticides can be overcome by the use of biological control agent. The finding of present investigation revealed that aphid population was greatly influenced by different abiotic factors. The maximum and minimum temperature showed a negative correlation with the mustard aphid population, whereas relative humidity had a positive correlation. The rainfall and bioagent population had shown the negative correlation with the test insect. A significant impact of temperature and relative humidity were also observed with the bioagent population. The temperature had a positive correlation with abundance of bioagent in mustard ecosystem. Never the less the abundance of bioagent was influenced by the abundance of host aphid population and ultimately a negative correlation was established between the prey and predatory population revealing their natural coexistence in mustard ecosystem.

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Effect of Potassium and Sulphur on Economics and optimum dose of Sesame (*Sesamum indicum* L.)

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Abstract

On loamy sand soil, a field experiment was done in kharif 2014 at the S.K.N. College of Agriculture, Jobner (Rajasthan), agronomy farm. The experiment included 16 treatment combinations with four levels of potassium and sulfur, respectively, at 0, 25, 50, and 75 kg ha⁻¹ and 0, 20, 40, and 60 kg ha⁻¹. The findings indicated that, based on economic and marginal analysis, gradual increases in potassium levels up to 50 kg K₂O ha⁻¹ and sulphur levels up to 40 kg S ha⁻¹ appeared to be highly practical because they would yield higher net returns. The benefit-cost ratio (BCR) and the optimal doses of potassium and sulphur for the sesame crop were calculated as 63.94 kg K₂O ha⁻¹ and 53.93 kg S ha⁻¹, respectively.

Key words : Potassium, sulphur, economics and optimum dose.

Introduction

Sesame is known as “the queen of oils” because of its extraordinary abilities to improve the appearance of the skin. It is cultivated throughout the year and, being a crop with a short growing season, fits well into a variety of cropping sequences and systems. Sesame is cultivated on 6.57 million hectares across the world, with a yield of 448 kg ha⁻¹ and a production of 2.94 million tonnes. It is grown on 17 lakh hectares in India, with a yield of 439 kg ha⁻¹ and a total production of 7.48 lakh tons (Anonymous, 2013). The activation of enzymes, as well as resistance to the cold, illness, water stress, and other harmful situations, depend heavily on potassium. Because it has a substantial impact on the quality and growth of oil seeds and is well recognized for its involvement in the synthesis of proteins, oils, and vitamins, sulphur, a vital plant nutrient, may play a big role in increasing the output and productivity of oilseeds in the nation. In light of this, a study was conducted to examine the impact of potassium and sulphur on the growth, yield characteristics, and yield of sesame crop.

Materials and Methods

Sesame cv. RT-46 was used in a field study at the S.K.N. College of Agriculture, Jobner (Raj.), utilizing a randomized block design and four replications. The experimental soil had a loamy sand texture, a high infiltration rate of 22.4 cm hr⁻¹, and a saturated hydraulic conductivity of 10.20 cm hr⁻¹. There were 16 treatments total, with four levels of K (0, 25, 50, and 75 kg K₂O/ha applied as gypsum) and four levels of S (0, 20, 40, and 60 kg S/ha applied as sulphate of potash). The soil had low

levels of organic carbon (0.21%), low levels of available nitrogen (125.64 kg N ha⁻¹), medium levels of available phosphorus (18.43 kg P₂O₅ ha⁻¹), and low levels of both available potassium and sulphur (7.95 mg kg⁻¹). The soil's response was 8.2 and it wasn't salty. All of the treatments—levels of sulfur after correcting sulfur obtained from potassium sulphate administered through gypsum 21 days before sowing—were applied before to sowing and physically integrated in the top 15 cm of soil. A broadcast application of urea and DAP, the required dosage of N and P, was made prior to planting. The crop was grown using a regular set of procedures. The crop was harvested when it reached maturity, and plot-level yield data for grain and fodder were recorded after sun drying. Additional data included plant height, the number of branches and capsules per plant, the number of seeds in each capsule, and the weight of 1,000 test seeds.

Economics was used to calculate the gross realization in terms of rupees per hectare for each treatment, taking into account the seed and stalk yields and the prices that were in effect in November 2014. Similarly, the cost of cultivation was calculated by taking into account the costs associated with regular tasks from pre-harvest tillage through cleaning and threshing as well as the cost of inputs such as seeds, fertilizers, etc. To determine the net revenue for each treatment combination, the entire cost of cultivation was subtracted from the gross realization and the net income was recorded appropriately. The following formula was used to compute the benefit cost ratio (BCR).

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Net returns}}{\text{Cost of cultivation}}$$

Results and Discussion

The results obtained from the present investigation are presented in Table-1 and 2.

Net return : The net return of the sesame crop was significantly impacted by the potassium and sulfur applications (Table-1). The crop's net return was measured at 39885 Rs ha⁻¹ after treatment K₅₀, compared to 29225 Rs ha⁻¹ under K₀ (control), which was substantially lower. With the treatment of potassium @ 50 kg K₂O ha⁻¹ (K₅₀), the net return increased by a maximum of 36.47% above the control. It was discovered that the treatments K₅₀ and K₇₅ were statistically equivalent to one another.

The application of sulphur has a considerable impact on the net return as well. Under treatment S₄₀, a net return of 40525.00 rupees per annum was recorded, whereas under control (S₀), a net return of 26955 rupees per annum was found. Statistics-wise, the treatments S₄₀ and S₆₀ were comparable.

B:C ratio : The data clearly indicated that application of potassium and sulphur at increasing level significantly influenced the B:C ratio of the sesame crop (Table 1). The significantly maximum B: C ratio of the crop was recorded as 2.29, 2.38 with the application of potassium @ 50 kg K₂O ha⁻¹ (K₅₀) and sulphur @ 40 kg ha⁻¹ (S₄₀) over control, respectively. While minimum B:C ratio was recorded as 1.88 and 1.59 under the treatment of potassium K₀ and sulphur S₀, respectively. The data further indicated that the per cent increase in B: C ratio was recorded as 21.80 % higher over control with the application of potassium @ 50 kg K₂O ha⁻¹ (K₅₀). The treatment K₅₀, K₇₅ and S₄₀, S₆₀ were found statistically at par.

The increase in net return might be due to the direct result of higher sesame yield (Table 1). Higher marginal rate of return with potassium and sulphur application @ 50 kg K₂O ha⁻¹ and 40 kg S ha⁻¹ indicated higher output per unit of K and S input at the level (Shah *et al.*, 2013).

Optimum dose : Response of seed yield to varying levels of potassium and sulphur was worked out and found to be the quadratic. The functional form of yield response to potassium and sulphur is given in table 2. The perusal of data (Table 2) showed that the economic optimum dose of potassium and sulphur was recorded as 63.94 kg ha⁻¹ and 53.65 kg ha⁻¹, respectively with their corresponding seed yields of 835.90 and 837.77 kg ha⁻¹.

The application of potassium at increasing rate significantly increased the available potassium status of the soil and significantly maximum available potassium was recorded with the application of potassium @ 75 kg ha⁻¹ (Table-2). The significant increase in available

Table-1 : Effect of potassium and sulphur on net returns and B : C ratio of sesame.

Treatments	Net returns (Rs. ha ⁻¹)	B : C ratio
Potassium levels		
K ₀	29225	1.88
K ₂₅	35815	2.17
K ₅₀	39885	2.29
K ₇₅	40175	2.20
SEm+	831	0.04
CD (P=0.05)	2401	0.11
Sulphur levels		
S ₀	26955	1.59
S ₂₀	36085	2.13
S ₄₀	40525	2.38
S ₆₀	41535	2.44
SEm+	831	0.04
CD (P=0.05)	2401	0.11

Table-2 : Seed yield (Y) as a function of potassium and sulphur fertilization ($Y = b_0 + b_1 X + b_2 X^2$)

Study parameters	Potassium	Sulphur
1. Partial regression coefficients		
b ₀	639.1	626.9
b ₁	5.324**	7.82**
b ₂	-0.036*	-0.072*
2. Coefficients of multiple correlation (R)		
	0.999**	0.999**
3. Optimum level (kg/ha)		
	63.94	53.65
4. Yield at optimum level (kg/ha)		
	832.34	837.76
5. Response of optimum level (kg/ha)		
	193.24	210.86

Note : The yield, K and S levels, responses and intercepts are given in kg ha⁻¹

* Significant at 5% level of significance, **Significant at 1% level of significance.

potassium nutrient status of soil due to application of potassium might be due to solubilization of native status of potassium (Gajghane *et al.*, 2015) and due to positive interaction with other supplemental nutrients (Veeramani *et al.*, 1989). Such increase in available potassium status of the soil at harvest of the crop may also be due to direct addition of potassium to available pool of the soil (Tandon, 1987).

The available sulphur status of the soil was significantly influenced with the application of sulphur at increasing rate (Table-2). The significantly maximum available sulphur status of the experimented soil at harvest of the crop was recorded with application of sulphur @ 60 kg ha⁻¹. The available status of S significantly increased with sulphur application. This increase might be due to amelioration effect of sulphur and improved physicochemical properties of soil. The higher amount of available sulphur coated be attributed to a greater mineralization of organic sulphur and release of

SO₄²⁻ ions on its gradual oxidation (Pathan and Nag, 2008). Similar findings were also reported by Vaghani et al. (2010), Najar et al. (2011) and Jena et al. (2006).

Conclusion

Based on the experimental results, it was determined that the application of potassium @ 50 kg K₂O ha⁻¹ and sulphur @ 40 kg S ha⁻¹ could produce a crop of sesame in a semi-arid region with a higher net return, whereas the optimum dose of potassium and sulphur for a sesame crop was calculated to be 63.94 kg K₂O ha⁻¹ and 53.93 kg S ha⁻¹, respectively.

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Performance of District Central Co-operative Bank Raipur in Chhattisgarh

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Abstract

The present study has been undertaken to examine the retrospects and prospects of DCCBs Raipur in Chhattisgarh. The attempt has been made to examine the performance of various financial indicators. The study is based on secondary data obtained from DCCBs Raipur in Chhattisgarh for the period of past 10 years i.e. from 2011-2022. The rates of compound growth were estimated for period 2011 to 2022. The performance of DCCBs based on number branches indicates that the performance of DCCBs in respect to branch expansion was positively increasing in the district and the total number of member in the DCCBs is also found positively growing year after years. The increasing in share capital of DCCBs Raipur in Chhattisgarh over the years was mainly due to the contribution of co-operative societies to the share capital. The significant growth was seen in the paid up share capital during the period under study.

Key words : Performance, branch, member, share capital, working capital.

Introduction

The word co-operation is derived from the latin word "cooperate" and its elementary sense it simple means "working together". The principle of co-operation is as old as human society. A co-operative bank is a financial entity which belongs to its member's owners and the customers of their banks. Agricultural sector plays a strategic role in the process of economic development. A co-operative bank is a financial entity which belongs to its members, who are at the same time the owners and the customers of their bank. Co-operative banks in India are registered under the states co-operative societies act. The co-operative banks are also regulated by the reserve bank of India (RBI) and governed by the banking regulation act 1949, banking laws (co-operative societies) act, 1955.

The District Central Co-operative Bank Raipur in Chhattisgarh establish in the year 1913 with 70 branch in 6 district of Chhattisgarh, there are 550 primary agricultural societies affiliated under the DCCB Raipur.

Materials and Methods

Desired results from any scientific study could be obtained only after planning and adoption appropriate methods and procedures during the investigation. The main purpose of the present study was to analyze and compare the performance of the DCCBs Raipur in Chhattisgarh during the period of last 10 years i.e. from 2011-12 to 2021-22.

Collection and source of data : The study will be based on secondary data of year 2011-2022. Secondary data will be collected from the district central co-operative bank Raipur in Chhattisgarh.

An attempt has been made to estimate period wise growth rates of performance of different indicators in DCCBs Raipur in Chhattisgarh over a period of last 10 years from 2011-2022. The time series data was used for analysis of the various aspects of the study. The time series data on various selected indicators were obtained from the published data of annual report of DCCBs to workout various performance indicators.

Meaning of terms and concepts used in the study

Membership : Membership of DCCBs is open to all individual farmers. Primary agricultural credit societies, Marketing co-operative societies, consumer store and farming societies etc.

Share capital : Share capital is one of the important sources of funds of the DCCBs; Member societies and individuals are the main sources of share capital.

Tabular analysis : Simple tabular analysis was employed to evaluate the performance of District Central Co-operative Banks amongst different period of time in Raipur. The following composition proportions and ratios of various cooperative performance indicators were calculated for each period from 2011-20.

Physical indicators : Number of branches (Nos.) 2. Number of members

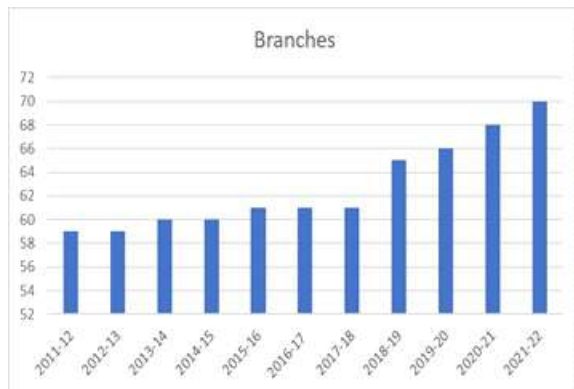
Financial Indicators : Share capital (In Lakhs) 2. Paid up share capital (In Lakhs).

Results and Discussion

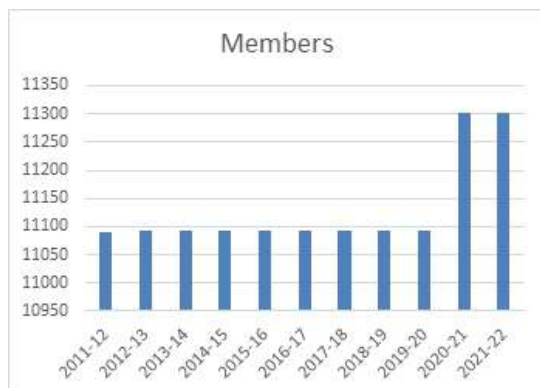
Region wise and period wise performance of DCCBs Raipur in Chhattisgarh During 2011-12 to 2021-22

Table-1 : Growth in number of branches in DCCB Raipur in Chhattisgarh.

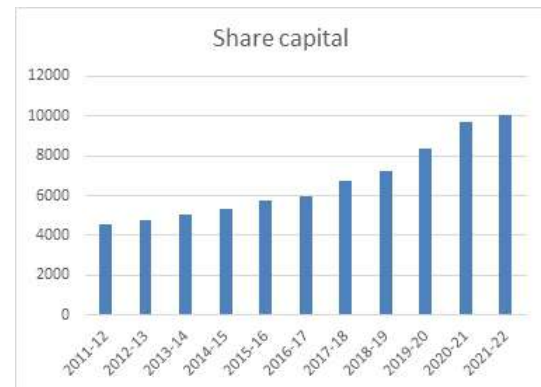
Serial number	Year	Branches
1.	2011-12	59
2.	2012-13	59
3.	2013-14	60
4.	2014-15	60
5.	2015-16	61
6.	2016-17	61
7.	2017-18	61
8.	2018-19	65
9.	2019-20	66
10.	2020-21	68
11.	2021-22	70

**Fig-1 : Growth in number of branches.****Table-2 : Growth of Total number of member in DCCB.**

Serial number	Year	Members
1.	2011-12	11090
2.	2012-13	11092
3.	2013-14	11093
4.	2014-15	11093
5.	2015-16	11093
6.	2016-17	11093
7.	2017-18	11093
8.	2018-19	11093
9.	2019-20	11093
10.	2020-21	11303
11.	2021-22	11303

**Fig-1 : Growth in number of branches.****Table-3 : Growth in share capital (in lakhs).**

Serial number	Year	Share capital
1.	2011-12	4576.58
2.	2012-13	4763.47
3.	2013-14	5062.01
4.	2014-15	5301.83
5.	2015-16	5768.89
6.	2016-17	5978.32
7.	2017-18	6725.68
8.	2018-19	7212.84
9.	2019-20	8350.79
10.	2020-21	9701.26
11.	2021-22	10083.56

**Fig-3 : Growth in share capital.****Table-4 : Growth in paid up share capital (in lakhs).**

Description	Paid up share capital
2016	5768.89
2017	5978.32
2018	6725.68
2019	7212.84
2020	8350.79
2021	9701.26
2022	10083.56

The region wise and period wise performance of DCCBs during 2011-12 to 2021-22 was studied for different indicators. The details of the analysis are presented as under.

Number of branches : The information on growth in number of branches of DCCB Raipur in Chhattisgarh is presented in Table 1. It can be observed from the table, the total number of branches of the DCCBs has increased from 59 in 2011-12 to 70 in the year 2021-22. The annual rate of compound growth in number of branches of DCCB in the district as a whole was 1.71 per cent, which was significant during the entire period under study.

Growth in membership : Period wise growth in membership of DCCB Raipur in Chhattisgarh during 2011-12 to 2022 is presented in Table-2. It can be revealed from table that there was a steady increase in the total membership of DCCBs during the period. The

number of members had increased from 11090 in 2011-12 to 11303 2021-22. This indicates that the satisfactory performance of DCCBs in respect of expansion and coverage.

The growth in membership of DCCBs as a whole witnessed a non-significant positive trend with annual rate of compound growth with low magnitude being 0.15 per cent during the entire period.

Growth in share capital : The detail information of share capital position of DCCBs Raipur in Chhattisgarh during 2011-2022 is presented in Table-3. The results revealed that the total share capital of the DCCBs Raipur in Chhattisgarh has steadily increased from 4576.58 lakhs in 2011-12 to 10083.56 lakhs in 2021-22. The total share capital of DCCBs Raipur in Chhattisgarh state as a whole, registered highly significant compound growth rate of 8.59 per cent during the entire period.

Growth in paid up share capital : The detailed paid up share capital of DCCBs is depicted in Table-4. The share capital of the DCCBs has witnessed a steady growth over a period. It can be observed from the table; the paid up share capital of DCCB in the district had increased from ₹ 5768.89 lakhs in 2016 to 10083.56 lakhs in 2022 2016-17.

Conclusion

1. Study as whole. The performance of DCCBs in terms of network coverage was satisfactory as the number of branches and membership had increased during the study period, but there is a scope of branch and member expansion.

2. A significant increase in the total share capital, paid up share capital during the study period indicated the financial soundness of DCCB Raipur in Chhattisgarh.

3. The number of branches of DCCB were increased from 59 to 70 with a growth rate of 1.71 percent for the period 2011-2022.

4. Total number of member affiliated to DCCB are found to be growing year after year i.e. from 11090 to 11303 during the period 2011-2022.

5. The largest variation present in share capital of bank for the period 2011- 2022 increases largely i.e. 27.70 percent reveals the good position of bank.

The policy implications based on the conclusions of the present study could be listed as under.

1. The number of staff and number of branch should be increased and trained.

2. Awareness programme should be more frequent among the borrowers to repay the loan on time.

3. There is need to eliminate loan waiver and interest waiver schemes.

4. The bank should give benefit to prompt payers of loan by giving them incentive like low interest by two-three percent for the new advance.

5. The DCCBs are required to be operated more transparently to minimize the level of percentage of NPAs as compared with international standards and disbursement may be strictly based up on repaying capacity of borrowers, technical efficiency and economical soundness of the societies.

6. Due importance is required to be given to borrower members which will lead to increase in the share capital and loan disbursement for agricultural purpose.

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Effect of Biofertilizer and Inorganic Fertilizers on Vegetative Growth of Okra

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Abstract

An experiment was carried out at the field laboratory of the Division of Nematology, Rajasthan Agricultural Research Institute Durgapura, Jaipur. To investigate the effect of biofertilizer on vegetative growth on okra. The experiment was laid out in a randomized block design with three replications. There were ten treatments such as T₀ - Recommended Dose of Fertilizers (RDF) @ 100%, T₁- Azospirillum + N + P&K @ 100%+ 50% +100% , T₂-Azospirillum + N + P&K @ 100% + 75% +100%, T₃-Azotobacter + N + P&K @ 100%+ 50% +100%, T₄. Azotobacter + N + P&K @ 100% + 75% +100%, T₅- PSB + P + NK @ 100%+ 50% +100%, T₆. PSB + P + NK @ 100% + 75% +100%, T₇. PSB + Azotobacter + P + NK @ 50% + 50% + 50%, T₈. PSB + Azospirillum + RDF @ 50% + 50% + 50% and T₉. Azospirillum + PSB + NK @ 50% + 50% + 100%. The experiment results revealed that significant variations exist among the treatments regarding vegetative growth e.g. plant height, number of leaves per plant, number of branches per plant, number of flowers per plant and number of fruits per plant were found higher in T₆ i.e. PSB + P + NK @ 100% + 75% +100% than the other treatments.

Introduction

Food the chief source of our energy can be regarded as the fuel to run the physiological process. Naturally, the need for food depends on the exhaustion of energy. So, a toilsome person spending more energy needs more food. Nutrient components of our food can be grouped in to five main divisions, namely Carbohydrate, Protein, Fat, Vitamins and Minerals. Balanced diet is the food containing all those nutrient components in balanced form to run the physiological process in good tune. So, only eating to one's heart's content may not be the criterion of a balanced diet. Our dietary constitution which is mostly cereal based is really alarming. Cereals, which supply chiefly carbohydrate, constitute only a part of the diet. Moreover, the present average carbohydrate supply through cereals is also adequate. Chief deficiencies in our diet are calories, protein, vitamin A and riboflavin. According to the studies of Indian Council of Medical Research, New Delhi and National Institute of Nutrition, Hyderabad, me agree intake of vegetables, the low cost protective foods, is largely responsible for malnutrition among the majority of our population. The dieticians advocate intake of 125 g leafy vegetables, 100 g root and tuber vegetables, 75g other vegetables (total 300g) everyday to make our diet balanced. But, the availability of vegetable in India is only 220 g (2009-2010) per capita per day, which is very low compared to the recommended dose. Overwhelming importance of vegetables in the balanced diet is perceivable by their enormous presence

in the daily diet schedule in some developed countries like Italy (593g), Japan (523g), UK (499), USA (469g), Canada (428g) and Australia (346g).

Vegetables plays a major role in Indian agriculture by providing food, nutritional and economic security and more importantly producing higher return per unit area and time. In addition, vegetables have higher productivity, shorter maturity cycle and high value and provide greater income leading to improve livelihoods with a production of less than 20 million tones before independence but after the green revolution, our country has made a tremendous progress in vegetable production. We are now second largest production in the world with a total production of 146.55 million tonnes from 8.49 million ha area. Vegetable occupies 2.08% of total cultivated land and share 13.38% of world production with a productivity of 17.3 tonnes per hectare (NHB data base 2011).

Thus, vegetables are getting higher importance in world and also in India due to their relevance in achieving nutritional security emerging nutritive problems in human beings. Among, the major contributing vegetables, Okra [*Abelmoschus esculents* (L.) Moench] are an important vegetables crop in India. It is most popular vegetable around the world in respect of area, production and availability. Okra is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds. The name okra is most often used in the United States, with a variant pronunciation, English Caribbean okra, the word okra is of

Table-1 : Treatment Combination.

S. No.	Treatments	Dose	Symbol
1.	Recommend Dose of Fertilizer (RDF)	100%	T ₀
2.	<i>Azospirillum</i> + N + P&K	100% + 50% + 100%	T ₁
3.	<i>Azospirillum</i> + N + P&K	100% + 75% + 100%	T ₂
4.	<i>Azotobacter</i> + N + P&K	100% + 50% + 100%	T ₃
5.	<i>Azotobacter</i> + N + P&K	100% + 75% + 100%	T ₄
6.	PSB + P + NK	100% + 50% + 100%	T ₅
7.	PSB + P + NK	100% + 75% + 100%	T ₆
8.	PSB + <i>Azotobacter</i> + NK	50% + 50% + 50%	T ₇
9.	PSB + <i>Azospirillum</i> + NK	50% + 50% + 50%	T ₈
10.	<i>Azospirillum</i> + PSB + RDF	50% + 50% + 100%	T ₉

Design : Randomized Block Design

Number of Treatment : 10

Number of replication : 03

West African origin and is cognate with Okwuru in the Igbo language spoken in Nigeria. Okra is often known as “lady’s finger” outside of the United States. In various Bantu languages, okra is called Kingombo or a variant thereof and this is the origin of its name in Portuguese (quiabo), Spanish (quimbombo or guigambo) Dutch and French and also possibly of name “gumbo” used in parts of the United States and English-speaking Caribbean for either the vegetable or a stew based on it. In India and Pakistan and often in the United Kingdom, it is called by its Hindi/Urdu name, Bhindi, Bhendi or “Bhinda”. In Southern Africa, mainly in Zimbabwe, it is known as derere. The geographical origin of okra is disputed, with supports of South Asian, Ethiopian and West African origin. *Okra* is an allopolyploid of uncertain parentage (proposed parents include *Abelmoschus ficulneus*, *A. tuberculetus* and a reported “diploid” form of okra), belong to family Malvaceae having chromosome No. 2n=130, which evolved by crossing *A. tuberculetus* (2n=58) with *A. ficulneus* (2n=72). Mainly three species of okra are cultivated are *A. esculentus*, *A. manihot* and *A. moschatus* are now cosmopolitan whereas the wild species (including *A. tuberculetus*) are confined to Asia and Australia with the exception of *A. ficulneus* which is also present in Tropical Africa.

Okra (Bhindi) is propagated by seeds; it is more remunerative than leafy vegetables. Fresh okra fruits are very important and used as vegetables. Nutritional value for 100 g edible unripe okra fruit contains 33 Kcal energy, 7.45 g carbohydrates, 3.2 g dietary fiber, 1.48 g sugars, 0.19 g fat, 2.00 g protein, 90.17 water, 0.08 mg thiamine, 0.06 mg riboflavin, 1 mg niacin, 23 mg ascorbic acid, 82 mg calcium, 0.62 mg iron, 57 mg magnesium, 299 mg potassium, 0.58 mg zinc, 8 mg oxalic acid (USDA Nutrient Database, 2007). The tender green fruit of okra are cooked in curry and are also used in soups. Round year consumption, sun-dried and frozen sterilized fruit of okra are also important market production. Okra has multiple

uses the extract from bhindi and stem used for cleaning cane juice in preparation of jaggery. The dry seeds of okra contain 14-23% edible oil and 21-25% protein (S. Thamburaj, 2005). The seed cake is also used as an animal feed. The present experiments entitled “Influence of Biofertilizers on vegetative growth of Okra [*Abelmoschus esculentus* (L.) Moench]”.

Materials and Methods

Treatments : The treatments combinations are shown in the Table-1.

Agronomical practices : Agronomical practices were followed as per standard practices and are given below :

Land preparation : A pre sowing irrigation was given to the field after harvesting of the preceding and at right tillage the soil was pulverized with the help of cultivator followed by planking all the weeds stubbles available in the field were collected manually and they were kept aside from the field finally leveling of field was done for facilitation of sowing.

Sowing : Sowing of seed was done during evening time in the third week of February 2013 at spacing 45 x 20 cm. and the field immediately irrigated the usual cultural operations and plant protection measures were followed. The irrigations were given as and when required.

Application of Treatments :

Application of Inorganic fertilizers : Treatment dose of inorganic fertilizers are applied before 25 days of sowing in the field.

Application of Biofertilizers : Thick slurry of each biofertilizer viz. *Azospirillum*, *Azotobacter* and Phosphate Solubilizing Bacteria was prepared before sowing; Okra seeds were inoculated by dipping them in the slurry of these biofertilizers for 24 hours. 10% solution of jaggery (Gur) or Sugar in water was made of quantity sufficient to

Table-1 : Effect of biofertilizer on plant height of okra at various stages of crop growth.

Treatments	Plant Height (cm)		
	30 DAS	45DAS	60DAS
T ₀ -Recommended Dose of Fertilizers (RDF)	10.250	19.000	40.000
T ₁ -Azospirillum + N + P&K	10.900	25.250	55.750
T ₂ -Azospirillum + N + P&K	12.470	28.750	45.750
T ₃ -Azotobacter + N + P&K	8.550	19.870	52.500
T ₄ -Azotobacter + N + P&K	11.470	24.620	45.500
T ₅ -PSB + P + NK	11.100	21.000	47.25
T ₆ -PSB + P + NK	11.300	24.500	41.500
T ₇ -PSB + Azotobacter + P + NK	10.100	29.100	60.50
T ₈ -PSB + Azospirillum + RDF	13.820	30.000	53.750
T ₉ -Azospirillum + PSB + NK	14.370	33.500	56.750
S.E. (m)	0.5292	0.8335	1.4898
C.D. (P=0.05)	1.5728	2.4273	4.4273

Table-2 : Effect of biofertilizers on no. of leaves / plant at various stage of growth.

Treatments	No. of leaves/plant		
	30 DAS	45 DAS	60 DAS
T ₀ -Recommended Dose of Fertilizers (RDF)	4.000	7.750	13.000
T ₁ -Azospirillum + N + P&K	5.520	10.250	31.250
T ₂ -Azospirillum + N + P&K	5.530	11.250	24.250
T ₃ -Azotobacter + N + P&K	4.000	7.800	29.500
T ₄ -Azotobacter + N + P&K	5.510	9.750	30.250
T ₅ -PSB + P + NK	6.250	11.750	24.25
T ₆ -PSB + P + NK	5.000	10.000	27.000
T ₇ -PSB + Azotobacter + P + NK	4.500	10.250	39.25
T ₈ -PSB + Azospirillum + RDF	5.100	9.500	18.500
T ₉ -Azospirillum + PSB + NK	8.000	9.550	28.500
S.E. (m)	0.2366	0.4878	0.8035
C.D.(P=0.05)	0.7030	1.4499	2.3877

dip the seed. The solution was prepared in cool but boiled water.

Source of biofertilizers : Azospirillum, Azotobacter and Phosphate Solubilizing Bacteria (PSB) cultures were obtained from the Division of Microbiology, Indian Agricultural Research Institute (IARI), New Delhi.

Irrigation and aftercare : The crop grows well under high moisture conditions. Field irrigated at an interval of 7-8 days or as required depending upon weather condition to get good harvest. The weeds found in plots as well as in the field were removed as and when required manually without any injury to the crop.

Observation under Recorded : In the field trail, the detailed study of entire plant population is very difficult, for convenience 4 plants were selected randomly in each plot and they were tagged for identification and future investigation.

(i) Plant height : The height of plants were recorded when last fruit picking was done from respective plant under investigation. Plant height was measured from the ground

to the top of the longest leaf of the plant with the help of meter scale.

(ii) Number of leaves per plant : The number of leaves was counted from tagged plant of regular intervals.

(iii) Number of branches per plant : Total number of branches emerges in from main shoot were counted in each plant while measuring the plant height and mean value was calculated.

(iv) Number of flower per plant : Number of flowers was counted from tagged plant at regular intervals.

(v) Number of fruits per branches : Numerous picking were done as all the fruits did not mature of the same time in each picking fruit were counted. Average numbers of fruits per branches were calculated.

Statistical analysis : A sample of 4 plants was taken to record the observations for each character. The mean value per plant for each plot in all the replication was used for detailed statistical analysis. The data were analyzed statistically by analysis of variance technique for RBD (Random Block Design).

Results and Discussion

The result of present research work entitled “Influence of Biofertilizer and inorganic fertilizers on growth of Okra [*Abelmoschus esculentus* (L.) Moench]” was conducted at Division of Nematology at Rajasthan Agricultural Research Institute, Durgapura, Jaipur during summer season from February, 2019- May, 2019. The influence of biofertilizers on vegetative growth of the okra have been described in this chapter with the help of tables and figures wherever considered necessary.

Effect of biofertilizers on vegetative growth of okra :

Plant height (cm) : The Plant heights in experimental plants were recorded at the interval of 15 days right from 30 DAS during the experimentation. It is apparent from the mean values summarized in Table-1, Appendix-i that application of biofertilizer proved significantly effective to improving during experimentation. The data obtained at 30 DAS, the maximum height of plant was noted under the treatment T₉ (14.37 cm.) followed by T₈ (13.82 cm), T₂ (12.47 cm) and minimum plant height was recorded under control T₀ (10.25 cm).

The data obtained at 45 DAS, the maximum height of plant was noted under the treatment T₉ (33.50 cm.) followed by T₈ (30 cm), T₂ (12.47 cm) and minimum plant height was recorded under control T₀ (19 cm).

The data obtained at 60 DAS, the maximum height of plant was noted under the treatment T₇ (60.50 cm.) followed by T₉ (56.75 cm), T₁ (55.75 cm) and minimum plant height was recorded under control T₀ (40 cm).

Number of leaves / plant : The numbers of leaves in experimental plants were counted at the interval of 15 days right from 30 DAS during the experimentation. It is apparent from the mean values presented in table-2, Appendix-ii that application of biofertilizer proved significantly effective to improving during experimentation. The data obtained at 30 DAS, the maximum number of leaves/ plant was noted under the treatment T₉ (8.0) followed by T₂ (5.5), T₈ (5.0) and minimum number of leaves was recorded under control T₀ (4.0).

The data obtained at 45 DAS, the maximum number of leaves/ plant was noted under the treatment T₅ (11.75) followed by T₂ (11.25), T₇ (10.25) and minimum number of leaves was recorded under control T₀ (7.75).

The data obtained at 60 DAS, the maximum number of leaves/ plant was noted under the treatment T₇ (39.25) followed by T₁ (31.25), T₉ (28.50) and minimum number of leaves was recorded under control T₀ (13.0).

Number of branches / plant : The number of branches / plant was recorded at 15 days interval during summer

season of experimentation trial. The data obtained at final observations (60 DAS) were processed statistically. The data presented in Table-3, indicates that biofertilizer increasing number of flower formation significantly. T₇ produced more number of branches (5.00) followed by T₁ (4.50), T₂ (4.00) and lowest branches were noted with control i.e. 1.75.

Table-3 : Effect of biofertilizers on the no. of branches/plant.

Treatment	No. of branches/plant
T ₀ - Recommended Dose of Fertilizers (RDF)	1.750
T ₁ - <i>Azospirillum</i> + N + P&K	4.500
T ₂ - <i>Azospirillum</i> + N + P&K	4.000
T ₃ - <i>Azotobacter</i> + N + P&K	3.750
T ₄ - <i>Azotobacter</i> + N + P&K	3.900
T ₅ - PSB + P + NK	3.250
T ₆ - PSB + P + NK	3.500
T ₇ - PSB + <i>Azotobacter</i> + P + NK	5.000
T ₈ - PSB + <i>Azospirillum</i> + RDF	2.000
T ₉ - <i>Azospirillum</i> + PSB + NK	2.750
S.E. (m)	0.2206
C.D.(P=0.05)	0.6556

Number of flower / plant : The number of flower / plant was recorded at 15 days interval during summer season of experimentation trial. It was clear from the mean values presented in Table-4, that biofertilizers increased number of flower formation significantly. Data obtained at 30 DAS, T₇ produced the highest number of flower / plant (2.00) followed by T₈ (1.80), T₂ (1.75) and the lowest number of flower / plant was noted under the control (T₀) i.e. 0.75.

Data obtained at 45 DAS, T₇ produced the highest number of flower / plant (10.11) followed by T₅ (9.75), T₈ (8.50) and lowest number of flower / plant was noted under the control (T₀) i.e. 6.15.

Data obtained at 60 DAS, T₇ produced the highest number of flower / plant (19.24) followed by T₄ (17.74), T₅ (13.12) and lowest number of flower / plant was noted under the control (T₀) i.e. 10.04.

Table-4 : Effect of biofertilizers on the no. of flower/plant.

Treatment	No. of flower/plant		
	30 DAS	45 DAS	60 DAS
T ₀ -Recommended Dose of Fertilizers (RDF)	0.750	6.15	10.04
T ₁ - <i>Azospirillum</i> + N + P&K	1.250	7.75	10.97
T ₂ - <i>Azospirillum</i> + N + P&K	1.750	7.88	11.67
T ₃ - <i>Azotobacter</i> + N + P&K	1.580	7.98	12.27
T ₄ - <i>Azotobacter</i> + N + P&K	1.250	8.24	17.74
T ₅ - PSB + P + NK	0.800	9.75	13.12
T ₆ - PSB + P + NK	1.500	6.78	12.68
T ₇ - PSB + <i>Azotobacter</i> + P + NK	2.000	10.11	19.24
T ₈ - PSB + <i>Azospirillum</i> + RDF	1.800	8.50	13.07
T ₉ - <i>Azospirillum</i> + PSB + NK	1.600	7.62	12.69
S.E. (m)	0.0707	0.85	5.27
C.D.(P=0.05)	0.2115	1.734	10.75

Number of fruit / branch : The numbers of fruit / branch in experimental plants were counted at the interval of 15 days right from 30 DAS during the experimentation. The data obtained at final observations (60DAS) were processed statistically to test the significance of different treatment on the parameter. It was clear from the mean values presented in Table-5, that biofertilizer increasing number of fruit / branch significantly. T₇ produced maximum number of fruits / branch (8.71) followed by T₈ (7.61), T₃ (7.20) and lowest no. of fruit / branch was noted with control (T₀) i.e. 3.20.

Table-5 : Effect of biofertilizer on the no. of fruits/branch.

Treatment	No. of fruits / branch
T ₀ - Recommended Dose of Fertilizers (RDF)	3.20
T ₁ - <i>Azospirillum</i> + N + P&K	5.71
T ₂ - <i>Azospirillum</i> + N + P&K	5.98
T ₃ - <i>Azotobacter</i> + N + P&K	7.20
T ₄ - <i>Azotobacter</i> + N + P&K	6.18
T ₅ - PSB + P + NK	5.78
T ₆ - PSB + P + NK	6.24
T ₇ - PSB + <i>Azotobacter</i> + P + NK	8.71
T ₈ - PSB + <i>Azospirillum</i> + RDF	7.61
T ₉ - <i>Azospirillum</i> + PSB + NK	6.97
S.E. (m)	3.27
C.D.(P=0.05)	6.87

The maximum plant height (60.50 cm) was recorded at the time of maturity of plants under treatment T₇ (PSB + P + NK, 100%+ 75% +100% respectively). A similar finding was reported by Manivannan and Singh (2004) that the maximum plant height was recorded with *Azospirillum*. This is might be due to the *Azospirillum* is the source of symbiotic nitrogen fixing bacteria and PSB phosphate solubilizing bacteria and helps in plant growth by increasing the biological activity of desired microorganism in root. Gupta *et al.* (2010) also found that *Azospirillum* inoculation significantly increased growth, yield, and quality characters over control; whereas the minimum plant height (40.00cm) was observed under control treatment T₀. The effects of different treatments on the number of leaves of okra plant were found significant.

However, the maximum (39.25) numbers of leaves/ plant were observed under the treatment T₇ (PSB + P + NK, 100%+ 75% +100% respectively) which were significant over the control treatment. T₀ showed minimum number of leaves (13.00). A similar finding was also recorded in their experiment by Kachari and Karla (2009) that the number of leaves was significantly maximum. The maximum number of branches/ plant was recorded in treatment T₇ (PSB + P + NK, 100%+ 75% +100% respectively) as compared to other treatment. The maximum number of flower (19.24) was recorded under the treatment T₇ (PSB + P + NK, 100%+ 75% +100% respectively) at 60 days after sowing. The maximum number of fruits/ branch (8.71) was recorded under the treatment T₇ (PSB + P + NK, 100%+ 75% +100% respectively) at 60 days after sowing.

Conclusions

On the basis of present investigation it may be concluded that the application of inoculants PSB + P + NK, 100%+ 75% +100%, respectively) increased vegetative growth of Okra.

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An Economics Analysis of Production and Marketing of Guava at Mahasamund District of Chhattisgarh

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Abstract

The present investigation was undertaken in order to depict the economics of production and marketing of guava in Mahasamund district So, present study was taken up with overall objective of enquiring into economics of guava production and marketing, with the objectives to examine the. Trend analysis of production of guava. To estimate the Marketing channel, surplus and price spread of guava in the study area. The methodology adopted was, on the basis of area production of guava, Mahasamund district was selected purposively. The data of year 2012-2013 to 2021-2022 was collected with the help of compound growth rates, the simple analytical tools like Estimation of compound growth rates marketing channels and price spread. On the basis of results it was Growth rate in production of Guava in the Mahasamund district of Chhattisgarh state was found positive significant i.e. 8.48 per cent. Growth rate of area of Guava was found to positive and significant in the district. The growth in Productivity of Guava in Mahasamund district of Chhattisgarh state was found positive significant i.e. 5.89 per cent. In the process of marketing channels viz., Channel-I: Producer –local wholesaler – retailer – consumer, Channel-II: Producer – Distant wholesaler - retailer – consumer (district and nearby market), Channel-III: Producer –retailer- consumer (local sale).

Key words : Compound growth rates, Marketing channel, and price spread.

Introduction

Guava (*Psidium guajava* L.) (family Myrtaceae) is one of the most important fruit crops of India. Guava is commonly called “Amrud” in the national language of India. Guava (*Psidium guajava* L.) is one of the important commercial fruits in India. It was the fourth most important fruit after mango, banana and citrus. It was originated in tropical America. It covers around 3.3% of the total area under fruit crops and contributes 3.3 % of the total fruit production in India. In India, Uttar Pradesh leads in production, while Allahabad region of U. P. produces best quality of guava in India as well as in the world. It can be processed into a number of products like jam, jelly, nectar, juice, guava cake, puree etc. Its roots, bark, leaves and fruits has great medicinal value In india occupies an area of 2.03 lac hectare with annual production of 22.7 lacs MT. Allhabad area in U.P. is reputed for the production of high quality of guava in India and the world. And also producing Madhyapradesh, Bihar, Andhrapradesh, Haryana, Punjab, West Bengal, Chhattisgarh, Gujrat and Karnatka. In Chhattisgarh occupies an area of 20.271 thousand hectare with annual production of 186.111 thousand MT. Farmers in Chhattisgarh are reaping big bucks from guava fruit cultivation as its cultivation and production has increased 67% in last five years and land area has expanded up to 47%. Guava is cultivated in around all districts of state but Korba, Bilaspur, Mahasamund, Raipur, Durg, Dhamtari, Kawardha, Bemetara and Rajnandgaon are major guava producing district of the Chhattisgarh state.

India is known as the “Fruit Basket” of the world. The country has witnessed increase in horticultural production over last few years. The guava (*Psidium guajava* L.) is the most significant, extremely productive fruit grown nowadays and is tasty and healthful. The guava production in India during financial year 2021 was 4582.30 (Metric Tonnes) and area under guava cultivation was 308.09 (Hectares).

Research Methodology

Estimation of compound growth rates

$$Y = t$$

$$\text{Log } Y = \log + t \log$$

Were,

$$Y = \text{Area/ production /productivity of guava}$$

$$= \text{Constant}$$

$$= \text{Regression coefficient}$$

$$t = \text{time in year}$$

$$\text{Compound growth rate (\%)} = (\text{Antilog } \hat{a} - 1)100.$$

Marketing channels and price spread concept

$$C = C_f + C_{m1} + C_{m2} + C_{m3} + \dots + C_{mn}$$

Were,

$$C = \text{Total cost of marketing of the commodity.}$$

$$C_f = \text{Cost paid by the producer from the time the produce leaves the farm till its selling.}$$

Cmi = Cost incurred by the ith middleman in the process of buying and selling of guava

Price spread

Price spread = Consumer price – price received by farmer

$$P_s = C_f - P_f$$

Were,

Cf = Consumers price Pf= Price received by farmer

Result and Discussion

The compound growth rates of area and production of Guava in Mahasamund district of Chhattisgarh : For the estimation of growth rates of Guava with respect to Area, Production and Productivity, compound growth rate model was selected and for the study secondary data from the year 2012-2013 to 2021-2022 was used and it was presented in the table1. Growth rate in production of Guava in the Mahasamund district of Chhattisgarh state was found positive significant i.e.8.48 per cent. Growth rate of area of Guava was found to positive and significant in the district. The growth in Productivity of Guava in

Mahasamund district of Chhattisgarh state was found positive significant i.e.5.89 per cent.

The compound growth rates of area, production and productivity of Guava in Chhattisgarh : The growth in production of Guava in Chhattisgarh state was found positive significant i.e. 2.64 per cent. Growth in area was attributed with positive significant increase i.e. 0.59 per cent and productivity of Guava was found 0.99 per cent in Chhattisgarh state.

Different marketing channels in guava marketing : Marketing channel are the way through which the commodity flow from producer to consumer. Producers prefer different marketing channels. Marketing channels followed by Guava producers in study area are as follows,

Channel-I : Producer –local wholesaler – retailer – consumer

Channel-II : Producer – Distant wholesaler — retailer – consumer (district and nearby market)

Channel-III : Producer –retailer- consumer (local sale).

The sample Guava farmers sold their produce through the Channel I, II and III

Table-1 : Compound Growth rates of Guava in Mahasamund district.

S.No.	Year	Area (Hactare)	Production (tonnes)	Productivity (T/h)
1.	2013	1138	10242	9
2.	2014	1255	8785	7
3.	2015	937	11244	12
4.	2016	1115	12495	11.2
5.	2017	1002	12024	12
6.	2018	1071	14019	13.08
7.	2019	1185	15405	13
8.	2020	1234	16659	13.5
9.	2021	1287	17375	13.5
10.	2022	1296	17497	13.5
CAGR		2.44**	8.48*	5.89**
P-VALUE		0.107	3.72	0.020

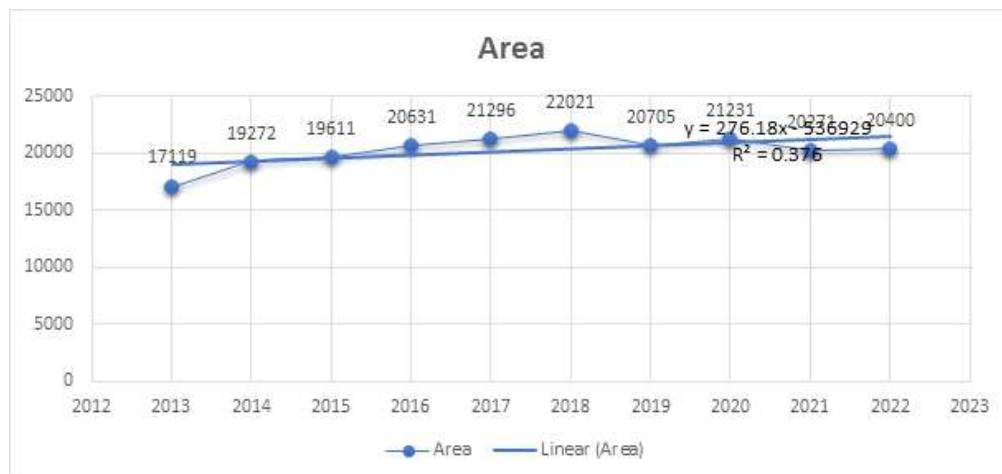


Fig.-1 : Trend of Area of Guava in Mahasamund (000' hac.)

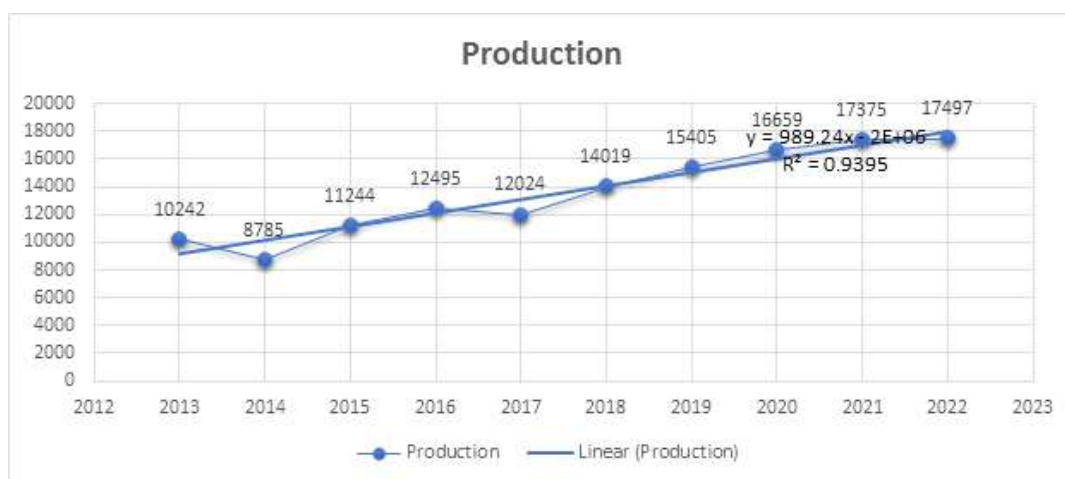


Fig-2 : Trend of Production of Guava in Mahasamund (000'tonnes).

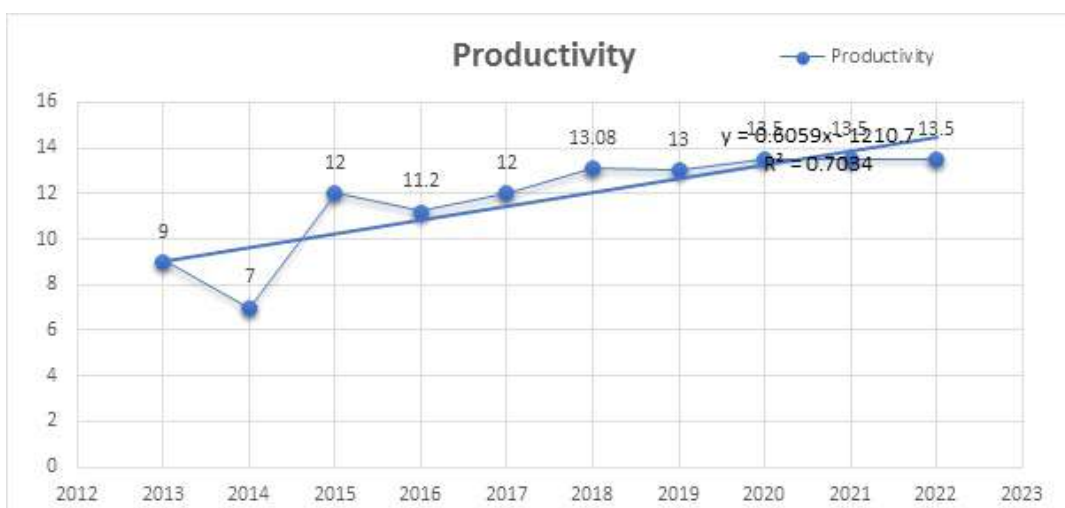


Fig-3 : Trend of Productivity of Guava in Mahasamund (tonnes /Ha.).

Marketing expenses incurred by Producer : The producer was responsible for paying the marketing expenses for guavas item-by-item per quintal, as given in Table-3. The producer paid the most, at ₹ 209.77 per quintal in Channel II, followed by ₹ 152.66 in Channel I, and the least amount, ₹ 95.33, in Channel III. Grading and packing requires a lot of labour and other things thus it made up the largest portion of Channel II's costs at ₹ 57.27, followed by commission fees at ₹ 54.11 which is comparatively higher than Channel I. The farmers had to take the produce to the market by themselves thus transporting cost was incurred by them. The transportation cost in Channel II was highest among the three channels at ₹ 50. The loading of crates or boxes in trucks and unloading them in markets and APMC's required much money. This expenses incurred were ₹ 22.51 and ₹ 20, respectively. The weighing of boxes and losses accounted ₹ 4.13 and ₹ 3.02. The comparable price of each item in Channel I made it distinct that grading and packing costs was ₹ 50.00 which were obviously

overpriced, followed by commission charges which were also exorbitant being ₹ 36.03 The unloading charges were ₹ 25 and loading charges were ₹ 19.34. Transportation charges were ₹ 15.35 which supervened with charges of loading. The weighing charges and losses contributed ₹ 5.50 and ₹ 1.47 respectively. In Channel III, grading and packing were the most high-priced at ₹ 24.16, followed by loading ₹ 15.8 and ₹ 20.6 unloading. ₹ 11.30 were the transport charges, ₹ 3.2 were weighing fees and ₹ 1.03 were losses.

Marketing expenses incurred by Wholesaler : The wholesalers marketing expenses in Channel I and Channel II for guava was worked out and shown in Table-4. The outcome showed that in the channel-II total cost was Rs.128.81 In Channel II, the storage charge had the highest percentage share as cold storage is sometimes needed. The cost of storage was ₹ 7.31, succeeded by ₹ 35 for labour required for all activities like shifting crates from place to place and ₹ 45 for transporting crates or boxes of fruits to the destined places or markets.

Table-2 : Compound Growth Rates of Guava in Chhattisgarh State.

S. No.	Year	Area (Hactares)	Production (tonnes)	Productivity (T/h)
1.	2013	17119	140908	8.23
2.	2014	19272	162772	8.44
3.	2015	19611	171881	8.76
4.	2016	20631	179591	8.7
5.	2017	21296	189688	8.9
6.	2018	22021	198778	9.02
7.	2019	20705	192173	9.28
8.	2020	21231	192005	9.04
9.	2021	20271	186111	9.18
10.	2022	20400	187288	9.18
CAGR		0.59***	2.64**	0.99***
P-VALUE		0.295	0.009	0.001

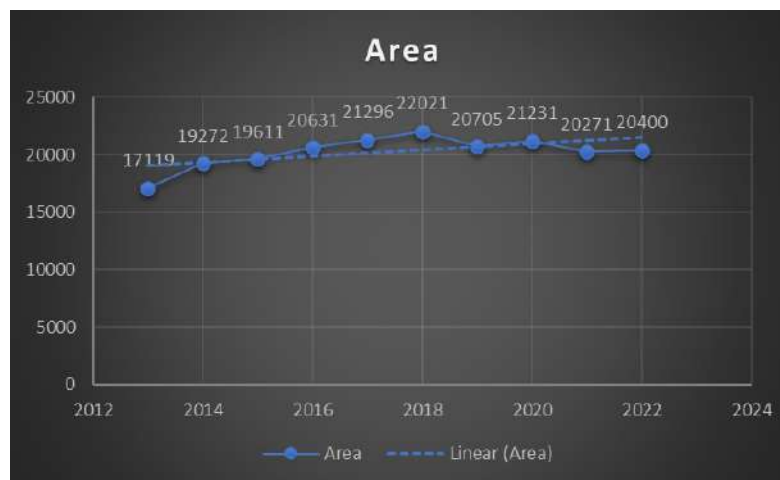


Fig-4 : Trend of Area of Guava in Chhattisgarh.

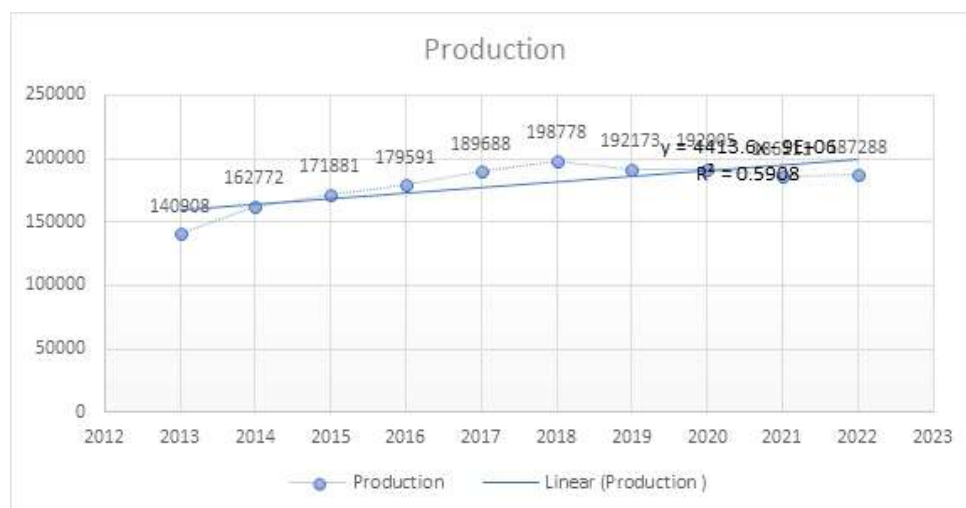


Fig-5 : Trend of Production of Guava in Chhattisgarh (000'tonnes).

The electricity charges were ₹ 8 and expenses for weighing the fruits were ₹ 4.5. The specific market fee was ₹ 12 and license fee was ₹ 12 taken as average because every markets fee differed. The Channel I, the cost incurred by local wholesaler was ₹ 68.97 per quintal. Out

of this in Channel I, the labour charge had the highest percentage share of ₹ 22 For transporting fruits to the market, ₹ 3 were needed. ₹ 35 were required for weighing the crates of fruits and ₹ 1.43 were needed for the storage of fruits. Electricity charges were needed to be paid by

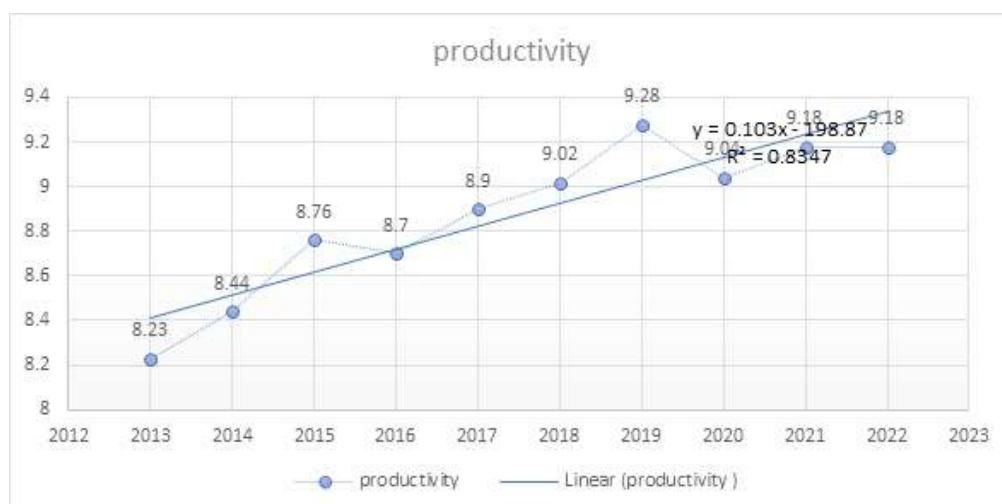


Fig-6 : Trend of Productivity of Guava in Chhattisgarh (tonnes /Ha.).

Table-3 : Marketing cost incurred by Producer (₹/quintal).

Sr. No.	Particulars	Channel-I	Channel-II	Channel-III
1.	Loading charges	19.34 (12.66)	22.51 (10.73)	15.8 (16.57)
2.	Unloading charges	25 (16.37)	20 (9.53)	20.6 (21.60)
3.	Transportation charges	15.35 (10.05)	50 (23.83)	11.30 (11.85)
4.	Weighing	5.50 (3.60)	4.13 (1.96)	3.2 (3.35)
5.	Grading and Packing	50 (32.75)	56 (26.69)	23.5 (0.24)
6.	Commission charges	36 (23.58)	54.11 (25.79)	-
7.	Losses	1.47 (0.96)	3.02 (1.43)	1.03 (1.08)
	Total cost incurred by producer	152.66	209.77	75.43

Table-4 : Marketing cost incurred by Wholesaler (₹/quintal).

Sr. No.	Particulars	Channel-I	Channel-II	Channel-III
1.	Labour charges	22	35	
2.	License charges	10	10	
3.	Weighing charges	35	4.5	
4.	Transportation charge	3	45	
5.	Electronic charges	4	8	
6.	Market fee	2	12	
7.	Storage charges	1.43	7.31	
	Total cost incurred by Wholesaler	77.43	123.81	

Table-5 : Marketing cost incurred by Retailer (₹/quintal)

Sr. No.	Particulars	Channel-I	Channel-II	Channel-III
1.	Labour charges	18	30	5
2.	Transport charges	15	50	10
3.	Weighing charges	6.5	4.3	4.3
4.	License charges	10	10	10
5.	Electronic charges	5.5	3.2	-
6.	Storage charges	3.57	2.63	-
	Total cost incurred by Retailer	66.87	102.33	29.3

wholesaler; it was ₹ 4 and ₹ 2 was the market fee. The wholesaler had to pay license fee which was ₹ 10.

Marketing expenses incurred by Retailer : The retailer's marketing expenses are listed in Table-4.6. Table-5. Shows that the total cost of marketing for

Channel II was ₹ 102.33, for Channel III was ₹ 94.24 and for Channel I was the least i.e. ₹ 66.87 Out of the summed up costs incurred by the Retailer, for Channel II, the cost of labour was ₹ 30 and the electronic charges were ₹ 3.2. The transportation charges requisite were ₹ 50 and

Table-6 : Price spread in different channels of guava. (Rs./qt)

Sr. No.	Particulars	Channel-I	Channel-II	Channel-III
1.	Selling price	4400	4800	5100
1.	Net price received by producer (producers share in consumer Rupee)	4103.04	4364.09	5012.43
2.	Expenses incurred by producer	152.66	209.77	75.43
3.	Price paid by Wholesaler	4255.70	4573.86	-
4.	Expenses incurred by Wholesaler	77.43	123.81	-
5.	Margin of Wholesaler	1321.77	1555.00	-
6.	Price paid by Retailer	5654.9	6252.67	5107.76
7.	Expenses incurred by Retailer	66.87	102.33	29.3
8.	Margin of Retailer	1786.33	1078.05	2789.00
9.	Price paid by Consumer	7508.1	7433.05	7989.00
10.	Marketing cost	296.96	435.91	187.57
11.	Market margin	3108.10	2633.05	2789.00
12.	Price spread	3405.06	3068.96	2976.57
	Producer share	54.64	58.71	62.74

weighing charges paid by him was ₹ 4.3, followed by license fee of ₹ 5.2 and storage charges of ₹ 11.01 (11.16 per cent). The communication charges paid were ₹ 0.42 (0.43 per cent). In the Channel-III, an all-inclusive marketing expense incurred were ₹ 89.15. Out of this, storages charges contributed the highest share i.e. ₹ 2.63 This was further followed by labour charges which were ₹ 16. The electronic charges were ₹ 19 and license fee was ₹ 13.46. The communication charges were nominal i.e. ₹ 6. For Channel I, the labour charge was ₹ 18, the weighing of fruits required ₹ 6.5 and the storage charge was ₹ 3.57. The storage cost was succeeded by license fee of ₹ 10 and for transporting the produce was ₹ 15. The miscellaneous charges were ₹ 5.

Market margin and price spread of Guava in Mahasamund district : The different marketing agencies are involved during the marketing process of different marketing channels of Guava, it is therefore to understand their share's involved in between price paid by consumer's rupee and price received by producers, the same is estimated by the difference between price paid by consumer and price received by producers is price spread and the share that goes to the different functionaries/agencies in the market is marketing margin (Table-6).

Conclusions

Maximum number of guava growers was middle aged (51.11 per cent) i.e. belonged to age group of 31 to 60 years. 84.44 per cent respondent farmers were literate and majority (28.88 percent) of them had completed higher and higher secondary school. The average family size was 5 percent. The average land with guava grower was 2.33 ha and average area of guava orchard was 0.93 ha. Majority of guava orchards were between ages of 2 to 5 years. The highest area during kharif season was under paddy (88.18 per cent), in rabi season it was under wheat

cultivation (16.67 per cent) and in summer it was under paddy cultivation (86.60 per cent). The gross cropped area was 337.3 ha. The cropping intensity was 128.25 percent. The highest marketing cost was required in Channel II i.e. ₹ 435.91 followed by Channel I which was ₹ 296.96 and Channel III ₹ 187.57. The highest marketing margin was in Channel I i.e. ₹ 3108.10 followed by Channel II which was ₹ 2633.05 and lastly Channel III ₹ 2789.00. The highest price spread was obtained in Channel I i.e. ₹ 3405.06 followed by Channel II which was ₹ 3068.96 and Channel III ₹ 2976.57. Channel III is the most profitable channel and should be used by farmers. Lack of technical information and non availability of labour were the major constraints faced by guava growers.

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Performance of Physiological Parameters and Yield of Blackgram under Different Environmental Conditions and Weed Management Practices

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Abstract

An experiment was conducted at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan) during *kharif* season of 2022. The experiment consists of three date of sowings (25th June, 2nd July and 9th July) in main plot and four weed management practices (Weedy check, imazethapyr @ 70 g a.i. ha⁻¹, imazethapyr + imazamox at 20 DAS @ 70 g a.i. ha⁻¹, imazethapyr 3.75 % + propaquizafop 2.5 % at 20 DAS) in sub plot of split plot design and replicated three times. Results revealed that the maximum chlorophyll content, canopy temperature, seed and haulm yield of blackgram was recorded with the sowing of crop on 25th June. Amongst weed management practices the application of imazethapyr + imazamox @ 70 g a.i. at 20 DAS recorded maximum chlorophyll content at 25 DAS and spray of imazethapyr 3.75 % + propaquizafop 2.5 % at 20 DAS recorded maximum chlorophyll content at 50 DAS as well as seed and haulm yield was also recorded highest.

Key words : Chlorophyll, yield, imazethapyr, SPAD

Introduction

Blackgram (*Vigna mungo* L.) is one of the important pulse crops grown throughout India and it had been originated from India. It is very important crop for vegetarian diet and it is excellent source of protein, consumed in the form of 'dal'. Blackgram is a richest source of phosphoric acid amongst pulses and its high value of essential amino acids *i.e.*, lysine, cystine and methionine makes an excellent complement to rice in terms of balanced human nutrition. The seed of blackgram has protein (24%), carbohydrate (59.6%), fat (1%), minerals (3.2%), fibre (0.9%), phosphoric acid (385 mg), calcium (154 mg), iron (9.1 mg) and beta-carotene per 100 g of dal (38 mg), thus blackgram occupies a distinctive place in human nutrition especially amongst vegetarians. Blackgram is an important pulse crop in India's intensive cropping system due to its quick growth, although its average yield is relatively low in India. The optimum time of sowing helps to maximize production by ensuring perfect harmony between the vegetative and reproductive stages on the one hand and the climatic rhythm on the other (Singh and Dhingra, 1993). In rainy season, timely sown crop perfectly utilized the longer period of time and had more time available for growth and development of crop in terms of vegetative and reproductive growth stages and if delay in sowing create problems in germination due to higher moisture, weed infestation and also less time available for

crop growth stages ultimately lesser in yield. Therefore, in order to increase the production of *kharif* blackgram, it is vital to choose the best time of sowing. The weeds are plants growing out of place and out of time and it considered as a major constraint in *kharif* season because of in rainy season provides the congenial environment for growth and development of weeds. Weeds are a key barrier to boosting blackgram yield, particularly during the *kharif* season because they compete with crop for space, nutrients, sun lights and moisture. The weed plants cause the maximum damage initially 25 to 35 days after sowing (Randhawa *et al.*, 2002). To get high yield of blackgram, weeds must be removed at the right time and with the right technique. Weeds in blackgram could be managed by hand weeding (Chand *et al.*, 2004). However, hand weeding is laborious, expensive and time-consuming. Additionally, labour is commonly unavailable during the critical weed removal season. Weed infestation, depriving the crop of its primary nutritional and moisture needs, which has a negative impact on crop growth and output. Chemical weed control has been found to be quite effective, efficient and economical in terms of time, money and labour. Due to their efficiency in terms of cost and time, herbicides are the main method used by growers to manage weeds in blackgram. Different herbicidal combinations are needed in blackgram to successfully manage the weed flora. Keeping these factors in view, a field was conducted during the season of *kharif*, 2022.

Table-1 : Effect of different environmental conditions and weed management practices on quality of blackgram.

Treatments	Chlorophyll content (SPAD)		Canopy temperature (°C)	
	25 DAS	50 DAS	25 DAS	50 DAS
Date of sowing				
D ₁	19.92	27.52	39.70	31.64
D ₂	19.75	24.53	38.81	32.80
D ₃	18.22	25.36	35.88	33.97
SEm±	0.18	0.58	0.76	0.68
CD (P= 0.05)	0.72	2.29	2.97	NS
Weed management practices				
W ₁	23.55	34.57	31.86	29.62
W ₂	26.71	38.71	33.24	29.55
W ₃	26.86	39.02	33.20	29.80
W ₄	26.08	40.23	32.91	29.90
SEm±	0.60	0.84	0.68	0.54
CD (P= 0.05)	1.78	2.48	NS	NS

Table-2 : Effect of different environmental conditions and weed management practices on yield and harvest index of blackgram.

Treatments	Seed Yield (kg ha ⁻¹)	Haulm Yield (kg ha ⁻¹)
Date of sowing		
D ₁	1075	1880
D ₂	972	1729
D ₃	867	1569
SEm±	30	54
CD (P= 0.05)	119	211
Weed management practices		
W ₁	674	1237
W ₂	855	1540
W ₃	1141	2019
W ₄	1215	2108
SEm±	26	46
CD (P= 0.05)	78	137

Materials and Methods

The experiment was carried out at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur, Rajasthan. The experiment was laid out in split plot design taking 3 dates of sowing (D₁: 25th June, D₂: 2nd July and D₃: 9th July) in main plot and four weed management practices (W₁: Weedy check, W₂: imazethapyr @ 70 g a.i. ha⁻¹, W₃: imazethapyr + imazamox at 20 DAS @ 70 g a.i. ha⁻¹, W₄: imazethapyr 3.75 % + propaquizafop 2.5 % at 20 DAS) in subplot and replicated thrice. Plot size was 4.0 x 3.0 m² and soil was clay-loam in texture, slightly alkaline in reaction and calcareous in nature, medium in available nitrogen and phosphorus. Data on parameters were taken from five selected plants and average was done for the result.

Chlorophyll content : The youngest fully expanded leaf of a plant was used for SPAD measurement. Readings were taken on one side of the leaf's midrib, halfway between the base and tip of the leaf.

Canopy temperature : Infrared thermometer was placed at height of 2.0 feet above the crop canopy and revolved over the plot.

Results and Discussion

Chlorophyll content : Table-1 depicts that maximum chlorophyll content (27.52 and 39.70 SPAD) at 25 and 50 DAS was recorded when crop sown on 25th June. It was statistically at par with crop sown on 9th July at 25 DAS (25.36 SPAD) and 2nd July at 50 DAS (38.81 SPAD), respectively. It was significantly superior over 2nd July (24.53 SPAD) at 25 DAS and 9th July (35.88 SPAD) at 50 DAS, respectively. Among weed management practices, highest chlorophyll content at 25 DAS was recorded with the application of imazethapyr + imazamox @ 70 g a.i. at 20 DAS (26.86 SPAD) which was statistically at par with the application of imazethapyr @ 70 g a.i. ha⁻¹ at 20 DAS and imazethapyr 3.75 % + propaquizafop 2.5 % at 20 DAS. At 50 DAS, maximum chlorophyll content (40.23 SPAD) was recorded under the application of imazethapyr

3.75 % + propaquizafop 2.5 % at 20 DAS, which was statistically at par with imazethapyr @ 70 g a.i. ha⁻¹ at 20 DAS and imazethapyr + imazamox @ 70 g a.i. at 20 DAS, but superior over weedy check (34.57 SPAD).

Canopy temperature : Different environmental condition had failed to show any significant effect on canopy temperature of blackgram at 50 DAS but it show significant effect at 25 DAS. The maximum canopy temperature at 25 DAS (39.70 °C) was noted with the early sowing of crop on 25th June, which was statistically at par with 2nd July sown crop. Canopy temperature was not influenced by various weed management practices at 25 and 50 DAS.

Yield : Table-2 indicate that among different date of sowing, significantly highest seed and haulm yield (1075 and 1880 kg ha⁻¹) of blackgram was recorded with the early sowing of the crop i.e., June 25th, which was statistically at par with second date of sowing i.e., 2nd July. Higher yield of 25th June sown crop was mainly owing to favourable temperature, adequate rainfall and humidity. The results confirm the findings of Kumar *et al.* (2008) and Gangwar *et al.* (2013).

Among the weed management treatments, maximum seed and haulm yield was reported under application of imazethapyr 3.75 % + propaquizafop 2.5 % at 20 DAS (1215 kg ha⁻¹) which was statistically at par with the application of imazethapyr + imazamox @ 70 g a.i at 20 DAS. The yield is govern by certain growth and yield attributing characters such as plant height, number of pods plant⁻¹, number of seed pod⁻¹ and test weight. Some of them were influenced by application of imazethapyr 3.75 % + propaquizafop 2.5 % at 20 DAS. Similar finding were also observed by Kumar *et al.* (2018) and Suryavanshi *et al.* (2018).

Conclusions

This study concluded that early sowing of blackgram gave higher physiological responses and maximum yield and by the application of imazethapyr 3.75 % + propaquizafop 2.5 % at 20 DAS and imazethapyr + imazamox @ 70 g a.i at 20 DAS recorded best results among the chemical weed control.

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Seasonal Incidence of Sucking Insect-Pest of Cowpea, *Vigna unguiculata* [Linn] Walpers in Relation to Abiotic Factors

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Abstract

The present research was aimed to study the seasonal incidence pattern of aphid, jassid, whitefly, thrips in cowpea ecosystem during kharif season of the year 2015-2016. The result revealed that the incidence of aphid started from the second week of August (33 SMW) with a mean population of 9.6 aphids/ plant. The population increased gradually and attained its peak with a mean of 21.67 aphids/ plant during the second week of October (41 SMW). The infestation of jassids and whitefly commenced in the first week of August (32 SMW) with a mean population of 0.87 jassids/ plant and 0.60 whiteflies/ plant. The population increased gradually and touched its peak with a mean of 11.20 jassids/ plant and 5.87 whiteflies/plant during the third week of September (38SMW). The infestation of thrips started in the fourth week of August (35 SMW) with a mean population of 3.87 thrips/flower. The population increased gradually and recorded its peak with a mean of 5.20 thrips/flower during the second week of September (37 SMW). The aphid population showed negative significant correlation with rainfall. However the population of whitefly and jassid showed positive significant correlation with temperature and whitefly showed negative significant correlation with rainfall.

Key words : Cowpea, aphid, jassid, whitefly, thrips, abiotic factors

Introduction

Cowpea, [*Vigna unguiculata* (Linn.) Wilczek; Leguminaceae] is one of the important pulse crops. It is also known as black eyed bean or Southern pea in English, while chola or choli, chavli, lobia in various vernacular languages in India. It is used as a vegetable, grain legume, fodder and as a green manure crop. The food legumes being the major source of protein have been grown by farmers for millennia providing nutritionally balanced food to the people of India ^[1]. The seeds of cowpea contain 23.4 per cent protein, 18 per cent fat, 60.3 per cent carbohydrate and are a rich source of lysine and tryptophan ^[2]. Like other legumes, cowpea has important beneficial effects in increasing soil fertility status because of their ability to fix atmospheric nitrogen. As many as 21 insect pests of different groups have been recorded damaging cowpea from germination to maturity ^[3]. Among them aphid, *Aphis craccivora* Koch; jassid, *Empoasca fabae* (Harris); thrips, *Megaleurothrips distalis* Karny; semilooper, *Thysanoplusia orichalcea* (Fab.); Leaf miner, *Phytomyza horticola* Meigen and pod borer, *Helicoverpa armigera* (Hubner) resulting in heavy yield losses ^[4, 5]. Considering all the above facts the present investigation is proposed to develop basic information on abundance and effective method of control. Hence, an attempt has been made to study the seasonal incidence of major insect pests of cowpea. Materials and methods To study the seasonal incidence of major insect pests of cowpea was

conducted at the agriculture research farm, institute of agricultural science Maharana Pratap University of Agriculture and Technology, Udaipur during kharif season 2015- 2016. Cowpea cultivar RC101 was used for the study and the crop field was kept free from pesticide sprays. The pest activities starting from the first appearance of insect-pests to till they disappeared were watched.

Materials and Methods

Population of major insect pests viz. aphid *Aphis craccivora* (Koch), jassids *Empoasca Kerri* (pruthi), whiteflies *Bemisia tabaci* (gennadius), thrips, *Megaleurothrips distalis* Karny; were recorded at weekly interval on five plants that were selected randomly and tagged as per techniques given as under: The aphid population was counted from 15 cm shoot tip of five randomly selected and tagged plants separately at weekly interval after upper, middle and lower portion gently shaking with the help of camel hair brush on a white paper sheet ^[6]. The jassid population was recorded by visual count on five randomly selected and tagged plants per plot at weekly intervals by gently turning the upper, middle and lower trifoliate and counted nymph and adults. Whitefly: The whitefly population was recorded on upper, middle and lower trifoliate by visual counting of five randomly selected and tagged plants per plot at weekly intervals. The thrips population was collected /dislocated from 10

Table-1 : Effect of abiotic factors on the seasonal incidence of sucking pests on cowpea during Kharif, 2016.

S.M.W.	Date of month	Abiotic factor			Mean population per plant			
		Mean temp.	Mean RH%	Mean Rainfall	aphid	Jassid	whitefly	Thrips
31	30-5 July	25.59	87.5	124.2	-	-	-	-
32	6-12 Aug	25.14	92	104.5	-	0.87	0.60	-
33	13-19 Aug	26.53	74.57	0.6	9.60	1.40	2.73	-
34	20-26 Aug.	25.4	85	61.2	6.40	0.67	1.27	-
35	27-2 Sept.	26.99	80.29	14.4	8.80	4.60	3.93	3.87
36	3-9 Sept.	26.05	68.21	0	16.40	4.33	4.80	4.13
37	10-16 Sept.	26.76	63.71	0	15.80	5.87	4.93	5.20
38	17-23 Sept.	28.93	64.57	3.4	17.27	11.20	5.87	3.87
39	24-30 Sept.	28.67	58.36	0	14.40	4.20	3.13	2.13
40	1-7 Oct.	27.47	76.79	62.4	7.47	0.60	0.87	2.33
41	8-14 Oct.	25.74	76.5	0	21.67	1.20	1.80	1.60
42	15-21 Oct.	25.17	51.21	0	20.47	1.00	0.40	1.67
43	22-28 Oct.	23.36	54	0	11.00	-	-	-
Coefficient of correlation (r1) for population and atm. temperature					.0308	0.915 [§]	0.600 [§]	0.201
Coefficient of correlation (r2) for population and relative humidity					-0.518	-0.437	-0.308	0.127
Coefficient of correlation (r3) for population and total rainfall					-0.683 [§]	-0.372	-0.581 [§]	-0.169

*Significant at 5% level of significance, respectively.

randomly selected flower buds of five tagged plants at weekly interval with the help of camel hair brush by gently shaking on a white paper sheet placed in a petri dish and counted ^[6]. For this, the data were subjected to correlation and regression analysis with weather parameters viz., maximum and minimum temperatures, average relative humidity, sunshine hours and wind velocity in respect of the distribution of pest in relation to weather parameter as it help determining appropriate time of action and suitable corresponding standard week. The meteorological data for the above analysis were obtained from the meteorological observatory of the university.

Statistical analysis : The correlation coefficient between the pest population and the abiotic factors of the environment using standard statistical formulae ^[7].

Results and Discussion

During 2015-16, the first incidence of aphids initiated in second week of August (33 SMW) with a mean population of 9.6 aphids/plant. The population increased gradually and attained its peak with a mean of 21.67 aphids/plant during second week of October (41 SMW) thereafter, pest population declined gradually and reached to a level of 11.00 aphids/plant in the last week of October (43 SMW). The pest showed positive correlation with temperature and negative significant correlation with rainfall. Present finding is in line with the finding of Gauns et al. (2014) [8] recorded that the cowpea aphid and jassid population in the middle of August that reached to its peak during 3rd week of October. Similarly the infestation of jassids and whitefly commenced in the first week of August (32 SMW)

with a mean population of 0.87 jassids/plant and 0.60 whiteflies/plant. The population increased gradually and touched its peak with a mean of 11.20 jassids/plant and 5.87 whiteflies/plant during the third week of September (38SMW). The infestation of thrips started in the fourth week of August (35 SMW) with a mean population of 3.87 thrips/flower. The Jessid population reduced gradually and reached to a level of 1.20/plants in second week of October (41th SMW). The population of whitefly decline 0.87/plant in first week of October (40 SMW). The Jessid population showed positive significant correlation with temperature, While negative correlation with rainfall and humidity. The population of whitefly positive significant correlation with temperature and negative significant correlation with rainfall. These findings are in close agreement with Sarode et al. (2003) ^[9] observed that Jassids population was found to be significantly influenced by the minimum temperature and morning relative humidity (RH). They observed leaf hopper incidence during the second fortnight of August, peaked during the first fortnight of September (23.8 and 16.3 leaf hopper/top three leaves). Similarly the incidence of thrips *Megaleurothrips distalis* Karny commenced in the fourth week of august (35 SMW) with a mean population of 3.87 thrips/flower. The population attained its peak during second week of September with a mean of 5.20 thrips/flower. Thereafter the pest population reduced gradually being lowest in the second week of October (41 SMW). The thrips population positive correlation with temperature and relative humidity and negative correlation with rainfall. These findings are close

agreement with Yadav and Singh (2006) ^[10] reported that maximum temperature had a significant positive effect on thrips population during the rainy season and the rainfall had an adverse affect on thrips population in greengram. In the present investigation it was found that positive correlation with temperature and relative humidity favour the multiplication of thrips.

Conclusions

The population of aphid, jassid, whitefly and thrips recorded in cowpea crop through the growing season. The incidence of Jassid and whitefly were commenced in the first week of august and aphid commenced in second week of august. While the incidence of thrips population commenced in last week of august. The population of jassid and whitefly attained its peak during the third week of September. While aphid and thrips attained its peak during the second week of October and second week of September, respectively. The aphid, jassid, whitefly exhibited a positive correlation with temperature and negative correlation with relative humidity and rainfall. The thrips population showed positive correlation with temperature and relative humidity

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Response of Sowing Date and Crop Spacing on Profitability and Economics of Chia (*Salvia hispanica* L.) in Western Rajasthan

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Abstract

The experiment was laid out in FRBD under two different factors viz sowing date (Factor A), crop spacing (Factor B) replicated three times to assess the profitability of Chia crop. The actual location of the experiment was ARS farm, (AU, Jodhpur, Rajasthan) during the year 2016-2017. Factor A comprised of four different sowing dates viz., 25th October (D₁), 05th November (D₂), 15th November (D₃) and 25th November (D₄) and factor B consisted of four varying crop spacing viz., 30 cm x 30 cm (P₁), 45 cm x 30 cm (P₂), 60 cm x 45 cm (P₃) 90 cm x 45 cm (P₄). Data on net return and B:C ratio revealed 25th October as best sowing date and 45 cm x 30 cm (P₂) best crop spacing for fetching out significantly higher net return and B:C ratio than rest of the treatments.

Key words : *Salvia hispanica*, net return, B:C ratio, gross return

Introduction

Although India is honoured with world's second-largest arable area (145 Mha) but ironically the net sown area = 70% of is notified for the graminaceous cereal-millet cultivation. The continuous efforts have brought revolution in cereal production in India and have made it self-reliant in food grain production. On the other hand the increasing gap in demand of edible oil and their supply has become a serious cause of concern nowadays. Crops like oilseeds fall under the category of climate-smart crops (Kumar 2009) because of their lower environmental footprint and emission of relatively lower greenhouse-gases due to low input needs. Oilseeds occupy an important place in the agricultural economy of India, considered an important crop immediately after cereals (Lalitha and Chhabra 2020).

Salvia hispanica L., popularly known by the name chia, is an annual herbaceous plant belonging to the Lamiaceae family, is native to the Southern Mexico and northern Guatemala. It has an extensive popularity for cultivation in tropical to subtropical regions. Information on chia management is fairly limited (Migliavacca et al., 2014; Busilacchi et al., 2013), especially regarding soil conditions, sowing times, and fertilization. In India and in the State of Rajasthan, chia is an emerging innovative crop. Inclusion of chia crop in diversified Indian agricultural system provided not only a wider choice in the production of a variety of crops but

also higher net returns per hectare of land. The exploitation of new crops and their genotypes has opened up new horizons in crop production. However, the potentiality of such crops can fully be realized only after determining their suitable sowing time and plant geometry in a growing region. The yield parameters and their components have been found to vary with planting dates and plant spacing (Freitas et al., 2016). Keeping in view, the inter competition of plants for nutrients, moisture and light; it is quite necessary to work out the optimum spacing indicating plant population/ha (Karim et al., 2015 and Yeboah et al., 2014). All these factors will lead to the enhance the production and productivity of the chia crop which will increase the economic output in-terms of net returns and cost benefit ratio. Therefore, the present investigation was carried out to study the appropriate sowing time and optimum crop spacing for chia in western region of Rajasthan.

Materials and Methods

The experiment was conducted at ARS farm of Agricultural Research Station, Jodhpur (Rajasthan). Geographically, this farm is situated at 26° 15' N to 26° 45' North latitude and 73° 00' E to latitude 73° 29' East longitude at an altitude of 231 meter above mean sea level. This is coming under the Agro-climatic zone I A i.e. Arid Western Plains Zone of Rajasthan. Factor A consisted of Four sowing dates viz., 25th October (D₁), 05th November (D₂), 15th November (D₃) and 25th November

Table-1 : Effect of sowing date and crop spacing on net returns (₹ ha⁻¹) and B:C ratio on chia.

Treatment	Cost of cultivation (₹ ha ⁻¹)	Gross returns (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	B : C ratio
Sowing date				
D ₁ (25 th October)	21437	76851	55415	2.51
D ₂ (05 th November)	21437	62630	41194	1.88
D ₃ (15 th November)	21437	57280	35843	1.63
D ₄ (25 th November)	21437	39794	18358	0.83
SEm ±	-	1679.15	1679	0.07
CD (P = 0.05)	-	4849.75	4849	0.21
Crop spacing				
P ₁ (30 cm x 30 cm)	25173	72398	47225	1.88
P ₂ (45 cm x 30 cm)	22523	79456	56933	2.53
P ₃ (60 cm x 45 cm)	19343	51767	32424	1.68
P ₄ (90 cm x 45 cm)	18707	32934	14227	0.76
SEm ±	-	1679.15	1679	0.07
CD (P = 0.05)	-	4849.75	4849	0.21



Fig.-1 : Effect of sowing date on Gross & Net Returns (₹ per ha) on chia.

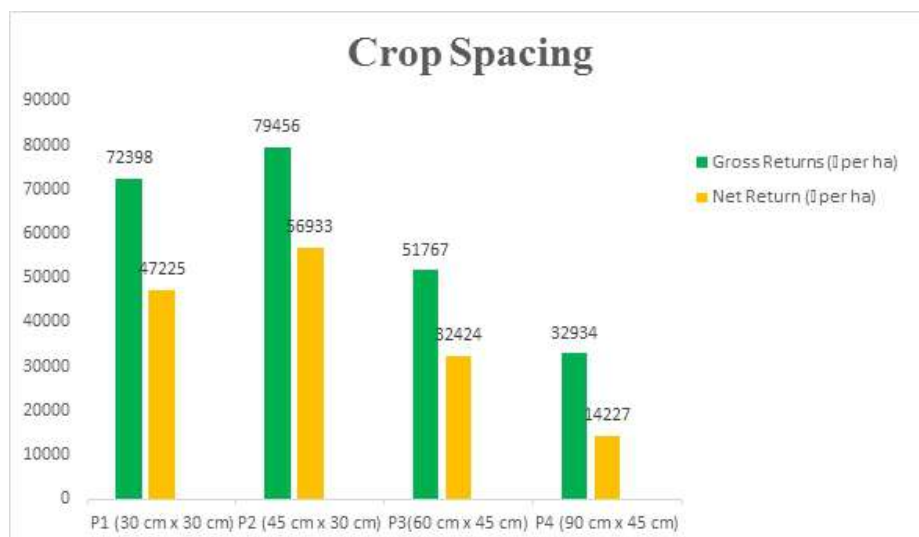


Fig.-2 : Effect of crop spacing on Gross & Net Returns (₹ per ha) on chia.

(D₄) and factor B consisted of four crop spacing viz., 30 cm x 30 cm (P₁), 45 cm x 30 cm (P₂), 60 cm x 45 cm (P₃) 90 cm x 45 cm (P₄).

The economics of various treatments was computed separately by taking into account the existing price of inputs and produce. The investment for fertilizers, labour and power for performing different operations such as ploughing, weeding, irrigation harvesting, threshing and winnowing etc., were worked out on per hectare basis prevalent at Agricultural Research Station, Mandor, Jodhpur. The cost of cultivation was taken into account for calculating economics of treatments and expressed as net returns per hectare (₹) and benefit cost ratio (B:C).

Gross returns (₹ ha⁻¹) : The yield of chia was converted into gross returns in rupees per hectare on the basis of current price of the produce.

Net returns (₹ ha⁻¹) : The net return was estimated by using following formula :

Net Returns (₹ ha⁻¹) = [Gross returns (₹ ha⁻¹)] – [Cost of cultivation (₹ ha⁻¹)]

Benefit cost ratio (B:C) : The output-input ratio was worked out on the basis of net returns and cost of cultivation

$$\text{Output input ratio (B:C)} = \frac{\text{Net returns (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

The obtained data was analysed for factorial randomized block design and result was produced for effect (Panse and Sukhatme, 1978).

Result and Discussion

Sowing date : Different sowing date (Table-1 and Fig.-1) also influenced the profitability and economic returns (net returns and B:C ratio) of chia. The first sowing date (25th October) (D₁) fetched significantly maximum net returns of ₹ 55415 per hectare as compared to rest of the treatments. Furthermore, the significantly maximum B:C ratio (2.51) was also obtained under the first sowing date (25th October) (D₁). The minimum net returns of ₹ 18358 per hectare and B:C ratio (0.83) was recorded when crop was sown on 25th November. These results corroborate the findings of Kumar *et al.* (2022) and Singh *et al.*, (2018).

Crop spacing : The data in the table-1 and Fig.-2 showed that crop spacing had significant effect on the net returns and B:C ratio. Crop spacing (P₂) 45 cm x 30 cm gave significantly, maximum net returns (₹ 56933/ha) and B:C ratio (2.53) as compared to remaining crop spacing. The minimum net returns of ₹ 14227 per hectare and B:C ratio (0.76) was obtained with 90 cm x 45 cm crop spacing. Similar result was also reported by Kumar *et al.* (2018).

Conclusions

Net returns and B:C ratio was recorded maximum with D₁ (25th October sowing) and P₂ (45 cm x 30 cm) which was significantly higher over rest of treatments.

Future Scope

Studies in this area may provide information regarding optimum sowing date and crop spacing and thus may be useful to improve profitability of chia.

More studies should be conducted on a regional level in consideration with the changing climate conditions.

Especially in areas where chia is not grown traditionally, studies in the areas may help the farmers to find out the optimum sowing date and crop geometry to follow.

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To Find Out the Economics of Feeding of Amla Powder on Growth Performance and Carcass Characteristics of Broiler Chicks

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Abstract

An experiment was conducted at a poultry farm at the Department of Animal Science, College of Agriculture, Rajasthan, Udaipur. The aim of this study is to investigate the effect of feeding with emblica powder on the performance and characteristics of broiler chickens. 160 days old vaccinated broilers (colored chickens) were divided into 4 treatment groups with 4 replicates each containing 10 chicks. During the experiment, food intake expressed as g/chicken/day or g/chicken/week was examined. The treatment consisted of (T1) control group and (T2) control group supplemented with amla powder @ 0.5% (T3) control group supplemented with 1.0% Amla powder, (T4) control group supplemented with 1.5% Amla powder. Body weight, weight gain, feed intake, FCR, nutrient availability, nutritional value, carcass quality (live weight, slaughter weight, visceral weight, slaughter weight, heart weight, heart weight, gizzard weight) and broiler economy.

Key words : value, amla, weight.

Introduction

Poultry sector contributes to the tune of 1% in national GDP of livestock (14% GDP). The growth potential of poultry sector is bright attributed to the constant flow of income annually in the rural economy of India (Ashmita *et al.*, 2022). Though the term poultry includes wide range of species, however, the Indian poultry industry mainly revolves around the chicken due to low investment and quick returns (Shivaji, 2012). In both rural as well as urban areas irrespective of culture and region, chicken production has significant contribution in terms of protein source, food security, India ranks 3rd in egg production and 5th in meat production in world. In 2021-22, the total egg production in the country was 129.60 billion nos which has increased by 6.19% as compared to previous year. The total meat production in the country was 9.29 million tonnes for the year 2021-22 with an annual growth rate of 5.62% (Ministry of Fisheries, Animal Husbandry & Dairying, 2023). Almost 51 percent of the total meat production across India was contributed by poultry during financial year 2022. This was followed by meat production from buffalo, while a mere three percent of the meat was produced by cattle (Anonymous, 2023). Over the last few decades, the health protection of birds and food safety were the priorities for poultry producers. Under the consumer pressure, the utilization of artificial feed additives is banned, and extreme solutions related to intensive rearing are mitigated to ensure the environment safety (Jachimowicz *et al.*, 2022). A complete ban or time bound decline in use of antibiotic growth promoters (AGP) has drawn the concerns of researchers for other natural

substances like medicinal herbs, as a new class of additives to animal and poultry feeds growth promoters including herbal preparations for their use with myriad additional benefits (Ranade and Desai, 2005). Rapid growth rate in commercial broilers accelerate the metabolic rate and make them vulnerable to oxidative stress owing to increased free radical generation. Phenolic acid content i.e. Gallic acid and tannic acid present in Amla contribute to the antioxidant activity, in addition, to ascorbic acid. Phyto-chemical analysis of amla fruit powder provided evidence of presence of the medicinally important bioactive compounds which can be exploited beneficially to improve productivity in broilers. Amla (*Emblica officinalis*) fruit powder is one of the herbs which have potential to boost broiler production (Patel *et al.*, 2016). Amla powder is an important source of ascorbic acid, minerals, amino acids, tannins, and phenolic compounds. Indian Research shows that 8.75 mg of natural vitamin C complex from amla is equivalent to 100 mg of the most commonly used synthetic vitamin C (Shivaji, 2012). Use of amla as feed additives for enhancing growth, reducing feed cost by improving feed efficiency and for building better immunity has already reported (Ghavate, 2009).

Materials and Methods

The research work was undertaken to study the effect of feeding amla (*Emblica officinalis*) powder on growth performance and carcass characteristics of broiler chicks. The experiment was conducted for a period of 60 days including metabolism trial.

Experimental birds :

This research work was carried out with 160 broiler day old straight run chicks procured from the Poultry farm, Department of Animal Production, Rajasthan College of Agriculture Udaipur. The chicks were wing banded and distributed randomly in four treatment groups, consisting of 40 chicks in each treatment group with replication of 10 birds each.

Experimental details :

1. Season : May to June (2022)
2. Breed : Coloured broiler chicks
3. Total treatment : 4
4. Replications : 4 (10 birds in each replication)
5. Total number of birds : 160
6. Experimental design : CRD
7. Housing : Deep litter system

Economics of production : The cost for complete experiment period (0-8 weeks of age) was calculated by taking into consideration the sum of the variable cost such as feed cost with supplementation and other miscellaneous cost. The return was calculated by multiplying final body weight with prevailing sale price of chicken. The chicks were fed starter ration from 0-3 weeks and the fed finisher ration from 4th week till end of the experiment. The chicks were fed with the composition mixture of maize, soya DOC, DORB, and vitamin premix with different inclusion of amla powder in different treatment groups. The feed cost for starter were 26.33, 26.75, 27.26 and 27.68 per kg in T1, T2, T3 and T4 respectively and finisher ration the feed costs were 26.45, 26.88, 27.30 and 27.73 per kg in T1, T2, T3 and T4 respectively. The benefit cost ratio was calculated as under following formula.

$$B : C \text{ ratio} = \frac{\text{Total return}}{\text{Total cost}}$$

Results and Discussion

The daily feed intake was recorded for birds in different treatment groups and the data with respect to feed intake are presented in Table 4.3. The mean feed intake (g/chick/day) at 1st week of age were 10.63±0.05, 11.77±0.02, 11.24±0.02 and 9.98±0.02 g in T1, T2, T3 and T4 groups respectively. The feed intake was significantly higher ($P<0.01$) in T2 followed by T3, T1 and T4. The mean feed intake values at 2nd week of age were 29.73±0.04, 32.44±0.11, 30.09±0.44 and 29.66±0.10 g in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the mean feed intake

was significantly higher ($P<0.01$) in T2 as compared to rest of the treatment groups, however, the difference in mean feed intake in T3, T1 and T4 was found too small and statistically non-significant. The mean feed intakes at 3rd week of age were 34.94±0.07, 35.37±0.06, 35.05±0.05 and 33.06±0.06 g in T1, T2, T3 and T4 groups respectively. The data revealed that the mean feed intake was significantly highest ($P<0.01$) in T2 followed by T3, T1 and lowest in T4 while feed intake in T3 and T1 group was statistically non-significant. The mean feed intake at 4th week of age was 52.94±0.39, 55.93±0.09, 44.77±0.20 and 46.40±0.23 g in T1, T2, T3 and T4 groups respectively. From the perusal of data, it was found that the mean feed intake was significantly highest ($P<0.01$) in T2 followed by T1, T4 and lowest in T3.

The mean feed intake at 5th week of age was 66.55±0.14, 55.93±0.12, 44.77±0.16 and 46.40±0.18 g in T1, T2, T3 and T4 groups respectively. The data revealed that the mean feed intake was significantly highest ($P<0.01$) in T1 followed by T2, T4 and lowest in T3. The mean feed intakes at 6th week of age were 80.56±0.17, 85.84±0.10, 75.26±0.08 and 70.90±0.11 g in T1, T2, T3 and T4 groups respectively. The perusal of data indicated that the mean feed intake was significantly highest ($P<0.01$) in T2 followed by T1, T3 and lowest in T4. At 7th week of age, the birds consumed 83.75±0.19, 88.98±0.29, 73.09±0.22 and 69.47±0.15 g feed in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the mean feed intake was significantly highest ($P<0.01$) in T2 followed by T1, T3 and T4 groups. The mean feed intake at 8th week of age were 97.10±0.16, 95.96±0.32, 93.99±0.16 and 85.92±0.07 g in T1, T2, T3 and T4 respectively. The perusal of data revealed that the mean feed intake at 8th week of age was found to be significantly highest ($P<0.01$) in T1 followed by T2, T3 and lowest in T4. Weekly Feed Intake The data with respect to cumulative weekly feed intake per bird is presented in Table-1.

The mean weekly feed intake during first week was 74.39±0.35, 82.37±0.11, 78.65±0.15 and 69.83±0.15 g in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the weekly feed intake was significantly highest in T2 followed by T3, T1 and T4. The weekly feed intake at 2nd week of age was 208.13±0.28, 227.10±0.80, 210.65±3.05 and 207.62±0.67 g in T1, T2, T3 and T4 groups respectively. The data revealed that the mean weekly feed intake was significantly higher ($P<0.01$) in T2 as compared to rest of the treatment groups. The difference in weekly feed intake T3, T1 and T4 remained statistically non-significant. The mean weekly feed intake at 3rd week of age was 244.56±0.50, 247.56±0.44, 245.35±0.38 and 231.44±0.42 g

respectively in T1, T2, T3 and T4 groups. It was revealed from the data that the feed intake was significantly highest ($P<0.01$) in T2 followed by T3, T1 and lowest in T4 while weekly feed intake in T3 and T1 group was statistically non-significant with rest of the treatment groups.

The mean weekly feed intake during 4 th week was 370.56 ± 2.74 , 391.51 ± 0.62 , 313.39 ± 1.42 and 324.78 ± 1.64 g in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the feed intake was significantly highest ($P<0.01$) in T2 followed by T1, T4 and lowest in T3. The mean weekly feed intake at 5 th week of age 465.83 ± 0.95 , 491.54 ± 0.87 , 401.99 ± 1.09 and 375.17 ± 1.25 g in T1, T2, T3 and T4 groups respectively. The data revealed that the mean weekly feed intake was significantly highest ($P<0.01$) in T2 followed by T1, T3 and lowest in T4. At 6 th weeks of age, the mean weekly feed intake was found to be 563.89 ± 1.22 , 600.90 ± 0.71 , 526.82 ± 0.59 and 496.28 ± 0.75 g in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the mean feed intake was significantly highest ($P<0.01$) in T2 followed by T1, T3 and lowest in T4.

The mean weekly feed intake at 7 th week of age was 586.27 ± 1.36 , 622.84 ± 2.05 , 511.63 ± 1.52 and 486.29 ± 1.04 g respectively in T1, T2, T3 and T4 groups respectively. It was found that the weekly feed intake was significantly highest ($P<0.01$) in T2 followed by T1, T3 and lowest in T4. The weekly feed intake during 8 th weeks of age was 679.67 ± 1.10 , 671.70 ± 2.25 , 657.91 ± 1.10 and 601.41 ± 0.49 g respectively in T1, T2, T3 and T4 groups. The perusal of data revealed that the weekly feed intake was significantly highest ($P<0.01$) T1 followed by T2, T3 and lowest in T4.

The total feed intake (g/bird) up to 8th week was 3193.30 ± 3.21 , 3335.52 ± 5.78 , 2946.39 ± 3.96 and 2792.81 ± 3.63 g respectively in T1, T2, T3 and T4 groups. Cumulative feed intake per bird was significantly highest ($P<0.01$) in T2 followed by T1, T3 and lowest in T4.

The data pertaining to different carcass characteristics of broiler chicks fed amla powder is presented in Table 4.7. The carcass traits such as live weight, dressed weight, dressing percentage, eviscerated weight and organ weights were studied during the course of the study.

The weight of organs namely liver, gizzard and heart were expressed as percent of live weight. The live weight of the birds was 1726.75 ± 25.11 , 1894.25 ± 12.13 , 2034.50 ± 25.16 and 1818.25 ± 18.27 g in T1, T2, T3 and T4 groups respectively. The live weight was significantly ($P<0.01$) higher in T3 as compared to T2, T4 and T1 while the live weight in T2 and T4 groups did not differ

significantly. The dressed weights were 1273.48 ± 36.34 , 1415.25 ± 36.58 , 1604.86 ± 6.50 and 1408.18 ± 37.45 g respectively in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the dressed weight was significantly highest ($P<0.01$) in T3 followed by T2 and lowest in T1 while the dressed weight in T2 and T4 groups did not differ significantly.

The eviscerated weights were 1201.25 ± 15.28 , 1318.50 ± 15.62 , 1420.75 ± 18.01 and 1243.00 ± 27.74 g in T1, T2, T3 and T4 respectively. The perusal of data revealed that the eviscerated weight was significantly higher ($P<0.01$) in T3 as compared to T2, T4 and T1 while the eviscerated weights in T1 and T4 groups did not differ significantly.

The dressing percentage were 73.75 ± 1.29 , 74.70 ± 1.17 , 78.94 ± 1.62 and 77.41 ± 1.23 in T1, T2, T3 and T4 respectively. It was revealed from the data that the difference in dressing percentage was found to be statistically non-significant amongst different treatment groups.

The giblet weight (weight of liver, heart and gizzard) was 76.74 ± 0.57 , 84.89 ± 0.58 , 94.11 ± 0.25 and 82.58 ± 0.94 g in T1, T2, T3 and T4 groups respectively. The perusal of data revealed that the giblet weight was significantly highest ($P<0.01$) in T3 followed by T2 and T4 and significantly lowest in T1.

The weight of individual organ as per cent of live weight was also studied. The liver weights (% of live weight) were 2.24 ± 0.04 , 2.25 ± 0.01 , 2.29 ± 0.02 and 2.26 ± 0.02 in T1, T2, T3 and T4 respectively. The perusal of data revealed that the difference in the weight of liver was found to be non-significant.

The gizzard weight as per cent to live weight were 1.62 ± 0.01 , 1.64 ± 0.01 , 1.72 ± 0.03 and 1.68 ± 0.06 in T1, T2, T3 and T4 groups respectively. Similar trend was found with respect to heart weight (% of live weight), and the values were 0.58 ± 0.02 , 0.59 ± 0.01 , 0.63 ± 0.01 and 0.61 ± 0.01 in T1, T2, T3 and T4 groups respectively the gizzard weight did not differ significantly amongst different treatment groups.

The feed intake expressed as g /chick / day or g /bird / week was studied during the experiment. The overall feed intake was significantly higher ($P<0.05$) in T2 followed by T1, T3 and T4. The weekly feed intake increased with supplementation of Amla powder at different levels in the present study. Similar, observations were also recorded by Gaikwad *et al* (2014) on feeding of amla powder and shatavri root; Tiwari *et al.* (2016) on feeding Amla powder; Dalal *et al.* (2018) on supplementation of amla powder and Mandal *et al.* (2017)

on feeding amla powder. Supplementation of amla powder did not have effect on the palatability of the feed and the feed intake was not affected by the level of supplementation.

The overall FCR was significantly lowest ($P<0.01$) in T1 followed by T2 and T4 and highest in T3 indicating that the supplementation of amla powder has improved feed conversion efficiency as compared to control where no supplementation was done. The findings of Maini et al. (2007) on supplementation of vit-E @200mg per kg feed, amla, electrolyte and mint (*Mentha longifolia*) @ 10g per kg and 30g per kg feed; Nakajothi et al. (2009) on feeding *Emblica officinalis* fruit @ 5, 10 or 20 g amla dry powder or 250 mg synthetic vitamin C /kg; Nakajothi et al. (2009) on feeding broilers with amla, tulsi and turmeric @ 0.25 and 0.5 per cent levels and Kumar et al. (2013) on diet supplementation with 1% amla+0.05% multi-enzyme have also observed that the feed conversion ratio was improved with supplementation of amla powder.

Studies by Naik et al. (2020) also positively correlates with our findings as they recorded that supplementation of amla fruit powder @0.5% level enhances the FCR in broiler chickens without any adverse effect and at 1% and 2% level of inclusion. Sandeep et al. (2022) have also observed significant better FCR in the T1, T2, and T3 groups (supplemented with amla powder) compared to the control group and concluded is that 1% amla powder supplementation improved FCR in broilers.

In the present study the supplementation of amla powder has significantly improved all the carcass traits in broilers. The live weight, dressed weight, dressing percentage, eviscerated weight and giblet weight was highest observed in T3 group as compared to the rest of the treatment groups. Kumar et al. (2014) reported that the dressing percentage was significantly higher ($P=0.05$) in Ayucee liquid supplemented group (70.15 ± 0.5) followed by vitamin C (amla powder) supplemented group (67.15 ± 0.9) and lowest in control (64.78 ± 0.9). Dalal et al. (2018) reported that highest eviscerated percentage was obtained with supplementation of basal diet with 0.75% amla supplemented group (T5). Findings of Mandal et al. (2019) are also in line with the findings of the present

study as they have found that carcass traits viz. shrinkage-loss, blood loss and relative weight of heart remained comparable but feather loss, giblet, liver, gizzard, eviscerated yield and dressed yield with reduction of back yield ($P<0.001$) on dietary addition of Amla fruit powder. Sharma et al. (2020) found that supplementation of phyto-genic mixture consisting of 0.5%

amla and 0.5% ashwagandha with 0.25% or 0.125% turmeric powder (T2 and T7) gave best results and improved the giblet percentage, eviscerated weight percentage and drawn percentage in winter season and can be effectively supplemented as an alternative to antibiotics growth promoter in poultry ration in winter for improving the carcass characteristics.

Conclusions

The mean body weight and body weight gains in broiler chicks at weekly intervals were significantly highest in T3 (1953.56) group as compared to rest of the treatment groups.

The total feed intake was significantly higher ($P<0.01$) in the groups fed with 0.5% amla powder as compare to other treatment groups.

The supplementation of amla powder @1% significantly improved the overall feed conversion ratio (1.51). The supplementation of amla powder was improved FCR over control.

The total feed intake in T2 was 4.45% higher than T1, 11.67 % higher than T3 and 19.43 % higher than T4.

The feed conversion ratio was significantly improved with supplementation of basal diet with 1.0% amla powder.

The supplementation of amla powder at 1.0% may improve the nutrient intake, live weight, dressed weight, eviscerated weight, giblet weight and digestibility coefficient in broiler chicks.

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Effect of Biochar, Vermicompost and Microbial Inoculants on Economic feasibility of Wheat

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Abstract

The aim of this present investigation is to study the "Effect of Biochar, Vermicompost and Microbial Inoculants on Economic feasibility of Wheat (*Triticum aestivum* L.) crop". The field experiment was conducted for two consecutive years during Rabi season of the year 2020-21 and 2021-22 at Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur which lies in agro-climatic zone IV-A of Rajasthan, India. The field was designed in a randomized block design having 11 treatments which were replicated thrice. The treatment included 5 t ha⁻¹ Vermicompost + Azotobacter + PSB (T₂) was recorded significantly maximum net return of wheat (₹116161, 120785 and 118473 ha⁻¹) as compared to other treatments.

Introduction

Wheat (*Triticum aestivum* L.) is the second most important cereal crop of India and plays a vital role in food and nutritional security of the country. Nearly 55 per cent of the world population depends on wheat for about 20 per cent of calories intake. It is one of the major food grains of the country and a staple food of the people of North India, where people have preference for chapatti. It is rich in vitamins, proteins and carbohydrates and provide balanced diet. India is the fourth largest producer of wheat in the world after Russia, USA and China and accounts for 8.7 per cent of the world's total production of wheat. During 2020-21 in India, wheat occupied over 31.13 million hectare area with a production level of 109.59 million tonnes of grain with a productivity of 3521 kg ha⁻¹ (E&S Division, DA&FW, Govt. of India, 2021). In the state of Rajasthan, wheat occupied an area of 3.00 million hectare and produced 11.04 million tonnes of grain with a productivity of 3676 kg ha⁻¹ (E&S Division, DA&FW, Govt. of India, 2021).

Biochar is a carbon-rich solid material derived from the pyrolysis of agricultural and forest residual biomass. Biochar, in the recent years, is gaining importance as a good source of amendment because it helps in stabilizing photosynthetic carbon. Since it has a superb characteristic of absorbance, when it is put to soil, it absorbs moisture, agricultural chemicals, and plant nutrients, hence reducing nutrient loss through leaching and water surface runoff. Moreover biochar is relatively low density material that helps in lowering the bulk density

of high clay soil along with increasing aeration and root penetration. Also, it increases the ability of sandy soils to retain water and nutrients.

Vermicompost is considered an ideal manure for organic agriculture as it is nutrient rich and contains high quality humus, plant growth hormones, enzymes, and substances that are able to protect crops against pests and diseases. Moreover, vermicompost has high porosity, aeration, drainage, and water-holding capacity. Vermicompost is finely divided peat-like material with low C:N ratio, high porosity, aeration, drainage, water holding capacity, microbial activity and is the end product of non-thermophilic biodegradation of organic materials by combined action of earthworms and associated microbes (Edwards and Burrows, 1988). In addition to increased N availability, C, P, K, Ca and Mg plant nutrient availability in the earthworm casts are also found. Plant growth hormones namely cytokinins and auxins are found in organic wastes processed by earthworms.

Microbial inoculants can reenergize the soil by improving the soil health and hence can be used as a powerful tool for sustainable agriculture, rendering agro-ecosystems more stress-free. Microbial inoculants are the miniature organisms which are helpful to the plant growth, quality and liable for maximum yield production. It is evident that microbial inoculants like Azotobacter, PSB and azospirillum alone or in the combination have great vision for increasing productivity of wheat. Use of biofertilizers such as biological nitrogen fixative and phosphate solubilizing micro-organisms is also gaining

Table-1 : Effect of Biochar, vermicompost and microbial inoculants on gross and net return and B:C ratio of wheat.

Treatment	GR (₹)		
	2020-21	2021-22	Pooled
T ₁ : Control	91704	96765	94235
T ₂ : 5 t ha ⁻¹ Vermicompost + Azotobacter + PSB	162161	171285	166723
T ₃ : 10 t ha ⁻¹ Vermicompost + Azotobacter + PSB	178662	183523	181093
T ₄ : 0.5 t ha ⁻¹ Biochar + Azotobacter + PSB	111995	115579	113787
T ₅ : 1.0 t ha ⁻¹ Biochar + Azotobacter + PSB	117328	122007	119668
T ₆ : 1.5 t ha ⁻¹ Biochar + Azotobacter + PSB	121953	128275	125114
T ₇ : 2.0 t ha ⁻¹ Biochar + Azotobacter + PSB	129186	134078	131632
T ₈ : 2.5 t ha ⁻¹ Biochar + Azotobacter + PSB	135477	138650	137063
T ₉ : 3.0 t ha ⁻¹ Biochar + Azotobacter + PSB	142069	145088	143578
T ₁₀ : 3.5 t ha ⁻¹ Biochar + Azotobacter + PSB	147872	150233	149053
T ₁₁ : 4.0 t ha ⁻¹ Biochar + Azotobacter + PSB	155288	157550	156419
SEm±	5303	5464	5383
CD at 5 %	15550	16022	15786

Table-2 : Effect of Biochar, vermicompost and microbial inoculants on net return of wheat.

Treatment	NR (₹)		
	2020-21	2021-22	Pooled
T ₁ : Control	51704	54765	53235
T ₂ : 5 t ha ⁻¹ Vermicompost + Azotobacter + PSB	116161	120785	118473
T ₃ : 10 t ha ⁻¹ Vermicompost + Azotobacter + PSB	115662	119523	117593
T ₄ : 0.5 t ha ⁻¹ Biochar + Azotobacter + PSB	64995	68579	66787
T ₅ : 1.0 t ha ⁻¹ Biochar + Azotobacter + PSB	68428	74007	71218
T ₆ : 1.5 t ha ⁻¹ Biochar + Azotobacter + PSB	72953	78275	75614
T ₇ : 2.0 t ha ⁻¹ Biochar + Azotobacter + PSB	78686	83078	80882
T ₈ : 2.5 t ha ⁻¹ Biochar + Azotobacter + PSB	83977	86650	85313
T ₉ : 3.0 t ha ⁻¹ Biochar + Azotobacter + PSB	89569	91588	90578
T ₁₀ : 3.5 t ha ⁻¹ Biochar + Azotobacter + PSB	93872	96033	94953
T ₁₁ : 4.0 t ha ⁻¹ Biochar + Azotobacter + PSB	100288	101550	100919
SEm±	3303	3436	3369
CD at 5 %	9687	10075	9881

Table-3 : Effect of Biochar, vermicompost and microbial inoculants on B:C ratio of wheat.

Treatment	B:C Ratio		
	2020-21	2021-22	Pooled
T ₁ : Control	1.29	1.30	1.30
T ₂ : 5 t ha ⁻¹ Vermicompost + Azotobacter + PSB	2.45	2.50	2.47
T ₃ : 10 t ha ⁻¹ Vermicompost + Azotobacter + PSB	1.87	1.91	1.89
T ₄ : 0.5 t ha ⁻¹ Biochar + Azotobacter + PSB	1.38	1.42	1.40
T ₅ : 1.0 t ha ⁻¹ Biochar + Azotobacter + PSB	1.44	1.49	1.47
T ₆ : 1.5 t ha ⁻¹ Biochar + Azotobacter + PSB	1.49	1.54	1.51
T ₇ : 2.0 t ha ⁻¹ Biochar + Azotobacter + PSB	1.56	1.60	1.58
T ₈ : 2.5 t ha ⁻¹ Biochar + Azotobacter + PSB	1.61	1.67	1.64
T ₉ : 3.0 t ha ⁻¹ Biochar + Azotobacter + PSB	1.70	1.73	1.71
T ₁₀ : 3.5 t ha ⁻¹ Biochar + Azotobacter + PSB	1.77	1.79	1.78
T ₁₁ : 4.0 t ha ⁻¹ Biochar + Azotobacter + PSB	1.85	1.89	1.87
SEm±	0.11	0.10	0.10
CD at 5 %	0.31	0.29	0.30

reputation since biofertilizers are cost effective, eco-friendly and renewable source of plant nutrient to supplementary chemical fertilizers.

Biofertilizers play an imperative role in the growth of plants as well as they lower the cost of chemical fertilizers like phosphorous, nitrogen and potassium. Biofertilizers contains infinitesimal microorganisms which are used as fertilizers for the growth of plants e.g. *azospirillum* sp. and *azotobacter* sp. the combined application of *azospirillum*, *azotobacter* suggestively increases the spikes, no of tillers, grain weight, grain size, spike let per plants, spike length etc, consequently the use of 75 % mineral nitrogen and biofertilizer with *azospirillum* and *azotobacter* surges all the growth character in wheat.

Materials and Method

Study area : The experiment was conducted during rabi 2021-22 at the Instructional Farm, Rajasthan College of Agriculture, Udaipur. The region falls under the agro-climatic zone-IVA (Sub-humid Southern Plains and Aravalli Hills) of Rajasthan. The climate of the study area is sub-humid with an average minimum and maximum temperature during growth period of wheat ranging between 3.2° to 31.4°C.

Experimental design and treatments : The experiment was laid out in a randomized block design with three replications. The treatments were randomly allotted to different plots using random number table (Fisher and Yates, 1963). The gross plot size was 14.4 m² (6.0 m x 2.4 m). The experiment consisted of eleven treatments viz., T₁: Control, T₂: 5 t ha⁻¹ Vermicompost + Azotobacter + PSB, T₃: 10 t ha⁻¹ Vermicompost + Azotobacter + PSB, T₄: 0.5 t ha⁻¹ Biochar + Azotobacter + PSB, T₅: 1.0 t ha⁻¹ Biochar + Azotobacter + PSB, T₆: 1.5 t ha⁻¹ Biochar + Azotobacter + PSB, T₇: 2.0 t ha⁻¹ Biochar + Azotobacter + PSB, T₈: 2.5 t ha⁻¹ Biochar + Azotobacter + PSB, T₉: 3.0 t ha⁻¹ Biochar + Azotobacter + PSB, T₁₀: 3.5 t ha⁻¹ Biochar + Azotobacter + PSB, T₁₁: 4.0 t ha⁻¹ Biochar + Azotobacter + PSB were applied to wheat crop in rabi session, 2020-21 & 2021-22. The recommended dose of fertilizer was 120 kg N, 60 kg P₂O₅, 40 kg K₂O and 25 kg ha⁻¹ ZnSO₄ and also other agronomic practices recommended for Zone IVA were followed as per Package of Practices, Government of Rajasthan.

Statistical analysis : The experimental data were statistically analysed for analysis of variance through the procedure appropriate to the experiment laid out in factorial randomised design as described by Panse and Sukhatme (1985). Interpretation of results was based on 'F' test. The comparison among means was made by calculating critical difference (CD) at 5 per cent level of

significance. Summary tables along with SEM_± and CD were prepared and presented in the text of the chapter entitled "Experimental Results" and their analysis of variance for different parameters are given in "Appendices" at the end. The pooled analysis of data for two years was done by the method described by Panse and Sukhatme (1985).

Results and Discussion

The effect of biochar, vermicompost and microbial inoculants on gross returns of wheat was found to be significant during 2020-21, 2021-22 and in pooled analysis. The significantly maximum gross returns of wheat was fetched with the application of 10 t ha⁻¹ Vermicompost + Azotobacter + PSB (T₃) (₹ 178662, 183523 and 181093 ha⁻¹) as compared to rest of the treatment except application of 5 t ha⁻¹ Vermicompost + Azotobacter + PSB (T₂) during 2nd the years and on pooled basis, respectively. The magnitude of increase in gross returns due to application of T₃ was 92.18 per cent over control, on pooled basis. Whereas, The significantly maximum net returns (₹ 116161, 120785 and 118473 ha⁻¹) and BC Ratio (2.45, 2.50 and 2.47) was recorded with the application of 5 t ha⁻¹ Vermicompost + Azotobacter + PSB (T₂) as compared to other treatments. However, it was found statistically at par with application of 10 t ha⁻¹ Vermicompost + Azotobacter + PSB (T₃) during both the years and on pooled basis, respectively. This trend in economic return is mainly due to the higher cost and treatment effect on the grain and straw yield of wheat. Similar findings were given by Thirunavukkarasu *et al.* (2013); Verma *et al.* (2014); Kumar *et al.* (2017) and Singh *et al.* (2019).

Conclusions

On the basis of experimental results of the present investigation conducted during Rabi 2020-21 and 2021-22, it was concluded that application of 5 t ha⁻¹ Vermicompost + Azotobacter + PSB (T₂), had significant effect with respect to economic feasibility as compared to other treatments.

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Effect of Co-Inoculation of Biofertilizers on Growth, Yield and Yield Attributes of Soybean (*Glycine max* (L) Merrill) in Vertisol

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Abstract

During the 2019-20 kharif season, a field experiment was done at the Research Farm, RAK College of Agriculture, Sehore (M.P.), India to investigate the effect of biofertilizer co-inoculation on soybean growth, yield, and yield-attributes. The combination of 50% RDF+Glomus geosporum (AMF) + PGRS (*Paenibacillus polymyxa*) + *Rhizobium japonicum* (T7) was found to be the most advantageous for soybean growth symbiosis characteristics, yield-attributes, and productivity in vertisol. This was followed by 50% RDF + Glomus geosporum (AME) + PGPR (*Paenibacillus polymyxa*) (T6) and 50% RDF + *Rhizobium japonicum* (T5), in that order. T7, T6, and T5 treatments yielded 14.60, 13.99, and 13.44 q/ha of grain, respectively.

Key words : Biofertilizers, inoculation, soybean.

Introduction

Soybean (*Glycine max* L) is a major oilseed-cum-pulse crop. Soybean has 40% protein and 20% oil by weight. Soybean can fix up to 65-115 kg N/ha/year of atmospheric N through a symbiotic relationship with the microbe *Rhizobium japonicum*. The effect of co-inoculation with different strains of Bradyrhizobium japonicum and arbuscular mycorrhizal fungus (AMF) species on soybean development, root colonization, and N, P, Zn, Fe, and Cu supplement take-up. Co-inoculation with various AMF species and rhizobia increased soybean biomass production (HemmatJou, 2017).

The soil microbial community is critical for supporting soil and plant health, which in turn helps to sustain agricultural output and food security. Plant growth-promoting rhizobacteria (PGPR) are a type of bacteria that populate the rhizosphere, at root surfaces, and in conjunction with roots, and can either directly or indirectly boost plant growth. Several PGPR inoculants are available to stimulate plant development through diverse mechanisms such as improved nutrient acquisition, plant disease control, and phytohormone synthesis (Anonymous, 2017). (Jain and Dhote, 2019) demonstrated a significant residual effect of PGPR in vertisol in enhancing the physico-chemical characteristics, nutrient availability in soil, growth, nodulating traits, nutrient uptake, and yield of soybean. Based on the foregoing facts, the current study was conducted on the growth, yield, and yield-attributes of soybean.

Materials and Methods

The field experiment was conducted during kharif season of 2019-20 at the Research Farm, RAK College of Agriculture, Sehore (M.P.), India. The soil of the experimental field was medium black (Vertisol) having clay loam texture, low in available nitrogen (208 N kg/ha), medium in available phosphorus (13 P kg/ha), high in available potassium (420 kg K/ha) and Normal in available sulphur (8.80 S kg/ha) with pH of 7.5. The experiment consisted of 7 treatments laid out in randomized block design keeping 3 replications. The treatment included absolute control (T₁), 100% RDF (T₂), 50% RDF + *Glomus geosporum* (AMF culture) (T₃), 50% RDF + PGPR (*Paenibacillus polymyxa*) (T₄), 50% RDF + *Rhizobium japonicum* (T₅), 50% RDF + *Glomus geosporum* (AMF) + PGPR (*Paenibacillus polymyxa*) (T₆), 50% RDF + *Glomus geosporum* (AMF) + PGPR (*Paenibacillus polymyxa*) + *Rhizobium japonicum* (T₇). The soybean var. RVS-24 was sown on 2nd July 2019. The 50 percent recommended doses of fertilizers were applied as per package of practices for soybean @ 20:60:20:20 kg/ha N, P₂O₅, K₂O and S, respectively. The crop was harvested on 15th October, 2019.

Results and Discussion

Growth parameters : Table-1 shows that the branches per plant, root length, dry weight/plant, number and dry weight of root nodules/plant were significantly superior when 50% RDF + *Glomus geosporum* (AME) + PGPR (*Paenibacillus polymyxa*) + *Rhizobium japonicum* (T7) was used, followed by T6, T5, and then T4. The plant height, on the other hand, did not alter considerably.

Table-1 : Growth, nodulation, yield-attributes and yield of soybean as influenced by combined inoculation of biofertilizers.

Treatments	Plant height (cm)	Branches/ plant	Dry weight/ plant(g)	Root length (cm)	Root nodules/ plant (45DAS)	Dry weight of Root nodule/ plant(mg)	Pods/ plant	Seeds/ Pod	Seed index(g)	Grain yield/ plant(g)	Grain yield/ (q/ha)	Straw yield (q/ha)
T1	51.40	3.62	17.66	22.07	23.13	49.72	34.37	1.98	9.59	7.89	10.26	12.47
T2	52.97	4.01	18.88	24.50	24.88	52.98	36.82	2.20	10.00	9.41	11.79	14.05
T3	53.82	4.42	20.00	26.47	25.88	55.42	38.35	2.39	10.11	10.19	12.00	15.35
T4	56.73	4.69	20.48	27.43	27.50	58.29	40.57	2.52	10.66	10.95	12.25	15.48
T5	57.69	4.96	21.88	28.21	29.21	62.59	43.73	2.71	10.94	12.29	13.44	16.13
T6	58.63	5.38	23.01	29.96	30.94	65.71	46.03	2.89	11.45	12.53	13.99	16.45
T7	60.19	5.89	24.02	32.13	33.21	68.63	48.04	3.19	11.88	13.71	14.60	17.12
C.D.(P=0.05)	NS	0.57	1.87	2.495	2.99	NS	7.14	0.355	0.625	1.5	1.20	1.36

The application of plant growth promoting rhizobacteria (PGPR) in combination provides a better alternative input for increasing yields. They are critical in improving soil fertility, promoting plant growth, and suppressing dangerous phytopathogens for the development of environmentally friendly sustainable agriculture. These findings support the findings of Gupta *et al.* (2015), Jain (2015), Jain and Virendra (2017), and Jain and Singh (2018). Plant-PGPR interactions with AMF resulted in increased rhizospheric dynamics, which resulted in improved nutrient availability, root development, shoot and root weights, leaf area, chlorophyll content, protein content, and nutrient uptake (Adesemoye *et al.* 2009; Sharma *et al.* 2012).

Yield-attributes : Yield attributing characters viz., pods/plant, seed per pod, grain yield/plant, grain yield kg/ha and straw yield kg/ha were significantly influenced by the combined application of 50% RDF + *Glomus geosporum* (AMF) + PGPR (*Paenibacillus polymyxa*) + *Rhizobium japonicum* (T₇) over absolute control (T₁) followed by 50% RDF + *Glomus geosporum*(AMF) + PGPR (*Paenibacillus polymyxa*) (T₆) and then 50% RDF + *Rhizobium japonicum*. The increased yield-attributes in T₇, T₆ and T₅ treatments may be on account of significant increases in growth parameters which translocated maximum photosynthates towards reproductive parts (sink). These results support the findings of Estrade *et al.* (2013), Jain (2015), Jain and Singh (2018) and Jain and Dhote (2019).

Productivity parameters : Grain yield is a complex process which depends on the different yield attributing characters such as number of pods/plant, number of seeds/pod, seed index. The treatment T₇ (50% RDF + *Glomus geosporum* + PGPR + *Rhizobium japonicum*) exerted the maximum seed yield (14.60 q/ha) which was found at par with the treatment T₆ (13.99) and then T₅ (13.44q/ha). The straw yield was 17.12, 16.45 and 16.13 q/ha, respectively.

Crop management, sustained production, adequate soil moisture maintenance, and crop-weed competition reduction all rely on physiological phenomena and plant growth patterns.

The increment and mobilization in the supply of essential elements through AM fungi colonies population and PGPR sources could be the concomitant mineralization, their availability, mobilization and influx into the plant tissues increased and thus improved growth, yield components and finally the grain yield of soybean. These results corroborate with the findings of Jain (2015), Jain and Virendra (2017), Jain and Singh (2018) and Jain and Dhote (2019).

The findings conclude that the combined application of 50% RDF + *Glomus geosporum* (AMF) + PGRS (*Paenibacillus polymyxa*) + *Rhizobium japonicum* (T₇) proved most beneficial for growth symbiotic traits, yield-attributes and productivity of soybean in vertisol. This was equally followed by 50% RDF + *Glomus geosporum* (AME) + PGPR (*Paenibacillus polymyxa*) (T₆) and then 50% RDF + *Rhizobium japonicum* (T₅).

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Socioeconomic Condition of Pratapdhan and Desi Poultry Breeds Rearers of Banswara District of Rajasthan

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Abstract

The present study was carried out in two tehsil viz; Banswara and Bagidora in Banswara district of Rajasthan. Six villages from each tehsil were selected on the basis of highest bird population of poultry. A total number of 120 respondents were selected for the present investigation from both tehsil. Out of total 120 respondents of both pratapdhan and desi poultry breed it was found that maximum 94.17 % backyard poultry rearers belonged to scheduled tribe, 80.00 per cent of the rearer of both pratapdhan and desi poultry birds were educated or literate, main occupation of poultry farmers was observed agriculture + animal husbandry of both pratapdhan and desi poultry rearers. The literacy rate of rearers of both poultry bird viz; pratapdhan and desi poultry was found that overall male children were 98.21 % literate, female children i.e. 91.81 % were literate and 80.69 per cent male adult was found literate, Female adult were found 67.12 per cent illiterate, 60.00 % poultry rearer have medium size land holding between 1-2 ha Total land holding of all the poultry rearers was observed 138.68 ha in overall study area out of which 128.62 ha land was cultivated. Maximum 59.16 % rearer of both pratapdhan and desi poultry were living in mixed type of house, 82.50 % were found living in nuclear family, 79.17 % had small size family less than 5 members, livestock maintained by the poultry farmers were found that maximum 66.03 per cent of farmers were rearing poultry, 54.16 per cent farmers liked to rear poultry and 78.33 % were liked to rear pratapdhan poultry birds.

Key words : Pratapdhan, poultry, banswara, livestock, husbandry, rural.

Introduction

The poultry industry in India is a very old practice and this food industry is one the important contributors to the economy of rural and semi-urban India. Indian Poultry Industry is 5,000 years old, since last 4 decades it began to witness remarkable growth from backyard to poultry industry. India ranks seventeenth in the world poultry production index. Further, India is the fifth largest producer of eggs and ninth largest producer of poultry meat amongst all the countries. The organized sector of poultry industry is contributing nearly 70 % of the total output and the rest 30 % in the unorganized sector. The broiler industry is well dominated in southern states in our country with nearly 60 %-70 % total output coming from these states. The layer industry once again is represented more in southern states especially, Andhra Pradesh, Tamil Nadu and Maharashtra producing nearly 70 % of the country's egg production. India's 75 % of egg produce is consumed by the 25 % population living in urban and semi-urban areas.

India has emerged as the only country in the developing world a self-reliant, technology driven industry, with capability to produce every essential input for successful poultry farming including indigenous genetic resource and breeding, world class poultry

vaccines and medicines specific pathogen free eggs (SPF), farms and hatchery automation system, pelleted feed, egg processing, poultry processing, nationwide network of disease diagnostic laboratories and facilities for entrepreneurial development and training in both private and public sectors. In last 4 decades, Poultry farming in India has transformed from a mere tool of supplementary income and nutritious food for the family to the major commercial activity generating the required revenue. The growth of the industry with steady production of 1,800 million kg of poultry meat, 40 billion eggs per year and employment generation of about 3 million people indicates the future prospects for the industry. Poultry egg and meat, in recent years have become important and popular food for the 68% of the non-vegetarian population of the country. Consequently, their consumption is increasing day by day. At present poultry and poultry products command a major share of food of animal origin produced and consumed in the country because of their cost effectiveness, easy availability, superior protein quality and wider acceptance by all sections of the society irrespective of cost, creed and religion. Poultry production at present is the fastest growing sub- sector of Indian agriculture with a quantum jump both in respect of poultry production and productivity.

India has made a considerable progress in broiler production in the last three decades and the eighties was a golden decade in the growth of broiler farming in India. Broiler industry has now been a well-established business and is one of the most promising sectors of agriculture. Broiler production has reached a record production of 95 million in 1986 from a meager figure of 4 million in 1971. The meat production from poultry was 2, 25,000 tones, which was more than 25 percent of the total meat, produced in the country. The main reasons behind this broiler boom are less requirement of capital, less space required for starting broiler farm, quick and early returns, higher demand of broiler meat due to its low price and high remunerative value in comparison to other types of meat.

Method and Materials

The present investigation was conducted in Banswara district of Rajasthan and geographically characterized by the Aravali ranges. The district lies between 23.11° N to 23.56° N latitude and 73.58° E to 74.49° E longitudes and at an elevation of 302 meter above mean sea level. Farmers are rearing desi poultry breeds in Banswara district. Banswara district consists of 11 tehsil and on the basis of poultry farmers and population of poultry, two tehsils were selected viz. Bagidora and Banswara, on the basis of highest birds population. Villages having backyard poultry farming were selected in consultation with KVK, Banswara. Six villages were selected from each tehsil on the basis of maximum number of birds. For selection of respondents, comprehensive list of farmers engaged in backyard poultry farming was prepared from each identified village with the help of agriculture supervisor, gram sevak and extension agent KVK'S/NGO'. Ten farmers from each village were selected randomly. Among ten farmers, 10-15 having 10-15 rearing desi birds were selected.

The interview was scheduled with the general information of poultry farmers i.e. caste, education level, occupation, family members, land holding, type of house, type of family, livestock species and livestock holding. The second part of schedule was specially designed to assess the knowledge of the poultry farmers about prevailing feeding and breeding practices of backyard poultry production. Before conducting the interview and collection of data from poultry farmers, specific objectives and the purpose of the survey was explicitly explained to them. The question of the schedule were presented to them in their own dialect and Hindi ensuring that they perceived the questions correctly so as to avoid any interpretational variation of the question by the poultry farmers. The data was collected by personal interview

from of the selected farmers using pretested interview schedule.

Results and Discussion

The data offered in the table illustrates that 3.33 % respondents who were rearing Pratapdhan poultry birds belonged to SC & OBC category and majority (93.34 %) of respondents were observed in ST category, while, none of the respondents were found in general category. Further it was noted that 3.33 % respondents who were rearing desi poultry bird belonged to SC category and majority (96.67 %) of the respondents were observed in ST category. While none of the respondents in OBC and general category of caste were found rearing desi poultry birds in Bagidora tehsils. (Table-1). The figure presented in the table indicates that all the respondent rearing Pratapdhan poultry bird belonged to ST category. Further it was noted from the data that none of the rearer of desi poultry birds belonged to SC and OBC category and majority (86.67 %) of respondents were observed in ST category. While, 13.33 % respondents were found in general category who were rearing desi poultry breed in Banswara tehsil. (Table-2). The data of overall study area existing in the table points out only that 1.67 % of the respondent belonged to SC category, while, majority (94.17 %) of the respondents were scheduled tribes who were rearing pratapdhan poultry bird. The respondents of OBC and general category were found to be 0.83 % and 3.33 %, respectively (Table 3). The data presented in Table 4 illustrates that 56.67 % respondents were literate and 43.33 % illiterate who were rearing pratapdhan in Bagidora tehsils, while, the corresponding values for rearer of desi poultry breed were 86.67 % and 13.33 %, respectively in the Bagidora tehsil. The figures existing in the table shows result regarding the rearer of pratapdhan poultry bird that 83.33 % were literate and 16.67 % illiterate in Banswara tehsils, while, 93.33 % and 6.67 % rearer of desi poultry bird were literate and illiterate, respectively in Banswara tehsil. (Table 5). The data presented in the table 4.6 indicated that overall 80.00 % of the respondents irrespective of rearing pratapdhan or desi poultry birds were literate and 20.00 % were illiterate in study area. The data presented in the Table 4.7 regarding the main occupation of pratapdhan poultry rearer shows that 16.67 per cent were engaged in agriculture as main occupation, 73.33 per cent were engaged in agriculture + animal husbandry and 10.00 per cent were in other occupation and none of the pratapdhan poultry rearer were found engaged in animal husbandry only as main occupation, respectively in Bagidora tehsil. Whereas 16.67 per cent respondents who were rearing desi poultry breed engaged in agriculture as main occupation, 6.67 per cent were in animal husbandry, 63.33 per cent were in

Table-1 : Caste wise distribution of respondents in Bagidora tehsil.

S. No.	Caste	Pratapdhan		Desi	
		F	%	F	%
1.	SC	1	3.33	1	3.33
2.	ST	28	93.34	29	96.67
3.	OBC	1	3.33	0	0.00
4.	General	0	0.00	0	0.00
	Total	30	100	30	100

F = number of the respondents, % = Per cent

Table-2 : Caste wise distribution of respondents in Banswara tehsil.

S. No.	Caste	Pratapdhan		Desi	
		F	%	F	%
1.	SC	0	0.00	0	0.00
2.	ST	30	100	26	86.67
3.	OBC	0	0.00	0	0.00
4.	General	0	0.00	4	13.33
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-3 : Caste wise distribution of respondents in overall study area.

S. No	Caste	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	SC	1	1.67	1	1.67	2	1.67
2.	ST	58	96.66	55	91.66	113	94.17
3.	OBC	1	1.67	0	0.00	1	0.83
4.	General	0	0.00	4	6.67	4	3.33
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-4 : Education wise distribution of respondents in Bagidora tehsil.

S. No	Education	Pratapdhan		Desi	
		F	%	F	%
1.	Literate	17	56.67	26	86.67
2.	Illiterate	13	43.33	4	13.33
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-5 : Education wise distribution of respondents in Banswara tehsil.

S. No.	Education	Pratapdhan		Desi	
		F	%	F	%
1.	Literate	25	83.33	28	93.33
2.	Illiterate	5	16.67	2	6.67
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-6 : Education wise distribution of respondents in overall study area.

S. No.	Education	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Literate	42	70.00	54	90.00	96	80.00
2.	Illiterate	18	30.00	6	10.00	24	20.00
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-7 : Occupation wise distribution of respondents in Bagidora tehsil.

S. No.	Occupation	Pratapdhan		Desi	
		F	%	F	%
1.	Agriculture	5	16.67	5	16.67
2.	Animal husbandry	0	0.00	2	6.67
3.	Agriculture + animal husbandry	22	73.33	19	63.33
4.	Others	3	10.00	4	13.33
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-8 : Occupation wise distribution of respondents in Banswara tehsil.

S. No.	Occupation	Pratapdhan		Desi	
		F	%	F	%
1.	Agriculture	4	13.33	2	6.67
2.	Animal husbandry	3	10.00	5	16.66
3.	Agriculture + animal husbandry	21	70.00	21	70.00
4.	Others	2	6.67	2	6.67
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-9 : Occupation wise distribution of respondents in overall study area.

S. No.	Occupation	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Agriculture	9	15.00	7	11.67	16	13.33
2.	Animal husbandry	3	5.00	7	11.67	10	8.33
3.	Agriculture + animal husbandry	43	71.67	40	66.66	83	69.17
4.	Others	5	8.33	6	10.00	11	9.17
	Total	60	100	60	100	120	100

F = number of the respondents, % = Per cent

Table-10 : Education level of family members in Bagidora tehsil.

S. No.	No. of members		Pratapdhan		Desi	
			F	%	F	%
1.	Male children	Literate	40	97.56	46	100.00
2.		Illiterate	1	2.44	0	0
		Total	41	100	46	100
1.	Female children	Literate	23	88.46	41	95.35
2.		Illiterate	3	11.54	2	4.65
		Total	26	100	43	100
1.	Male Adult	Literate	33	67.35	26	86.67
2.		Illiterate	16	32.65	4	13.33
		Total	49	100	30	100
1.	Female adult	Literate	24	47.06	7	22.58
2.		Illiterate	27	52.94	24	77.42
		Total	51	100	31	100

F= number of the respondents, % = Per cent

Table-11 : Education level of family members in Banswara tehsil.

S. No.	No. of members		Pratapdhan		Desi	
			F	%	F	%
1.	Male children	Literate	38	95.00	41	100.00
2.		Illiterate	2	5.00	0	0
		Total	40	100	41	100
1.	Female children	Literate	30	85.71	37	94.87
2.		Illiterate	5	14.29	2	5.13
		Total	35	100	39	100
1.	Male adult	Literate	30	85.71	28	90.32
2.		Illiterate	5	14.29	3	9.68
		Total	35	100	31	100
1.	Female adult	Literate	9	26.47	8	26.67
2.		Illiterate	25	73.53	22	73.33
		Total	34	100	30	100

F= number of the respondents, % = Per cent

Table-12 : Education level of family members in overall study area.

S. No.	No. of members		Pratapdhan		Desi		Overall	
			F	%	F	%	F	%
1.	Male children	Literate	78	96.30	87	100	165	98.21
2.		Illiterate	3	3.70	0	0	3	1.79
		Total	81	100	87	100	168	100
1.	Female children	Literate	53	86.89	78	95.12	131	91.61
2.		Illiterate	8	13.11	4	4.88	12	8.39
		Total	61	100	82	100	143	100
1.	Male adult	Literate	63	75	54	88.52	117	80.69
2.		Illiterate	21	25	7	11.48	28	19.31
		Total	84	100	61	100	145	100
1.	Female adult	Literate	33	38.82	15	24.59	48	32.88
2.		Illiterate	52	61.18	46	75.41	98	67.12
		Total	85	100	61	100	146	100

F= number of the respondents, % = Per cent

Table-13 : Size of land holding of respondents in Bagidora tehsil.

S. No.	Size of land holding	Pratapdhan		Desi	
		F	%	F	%
1.	Small < 1 ha	13	43.33	11	36.67
2.	Medium 1-2 ha	14	46.67	19	63.33
3.	Large > 2 ha	3	10.00	0	0.00
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-14 : Size of land holding of respondents in Banswara tehsil.

S. No	Size of land holding	Pratapdhan		Desi	
		F	%	F	%
1.	Small < 1 ha	16	53.33	5	16.67
2.	Medium 1-2 ha	14	46.67	25	83.33
3.	Large > 2 ha	0	0.00	0	0.00
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-15 : Size of land holding of respondents in overall study area.

S. No.	Size of land holding	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Small < 1 ha	29	48.33	16	26.67	45	37.50
2.	Medium 1-2 ha	28	46.67	44	73.33	72	60.00
3.	Large > 2 ha	3	5.00	0	0.00	3	2.50
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-16 : Type of land holding of respondents in Bagidora tehsil.

S. No.	Type of land	Pratapdhan		Desi	
		F	%	F	%
1.	Uncultivated (ha)	2.72	7.26	3.1	9.35
2.	Cultivated (ha)	34.76	92.74	30.07	90.65
	Total	37.48	100	33.17	100

F= number of the respondents, % = Per cent

Table-17 : Type of land holding of respondents in Banswara tehsil.

S. No.	Type of land	Pratapdhan		Desi	
		F	%	F	%
1.	Uncultivated (ha)	1.44	4.75	2.8	7.43
2.	Cultivated (ha)	28.89	95.25	34.90	92.57
	Total	30.33	100	37.70	100

F= number of the respondents, % = Per cent

Table-18 : Type of land holding of respondents in overall study area.

S. No.	Type of land	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Uncultivated (ha)	4.16	6.13	5.9	8.33	10.06	7.25
2.	Cultivated (ha)	63.65	93.87	64.97	91.67	128.62	92.75
	Total	67.81	100	70.87	100	138.68	100

F= number of the respondents, % = Per cent

Table-19 : Type of house of respondents in Bagidora tehsil.

S. No.	Type of house	Pratapdhan		Desi	
		F	%	F	%
1.	Kaccha	12	40.00	2	6.66
2.	Pacca	3	10.00	7	23.34
3.	Mixed	15	50.00	21	70.00
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-20 : Type of house of respondents in Banswara tehsil.

S. No.	Type of house	Pratapdhan		Desi	
		F	%	F	%
1.	Kaccha	14	46.67	4	13.33
2.	Pacca	2	6.66	5	16.67
3.	Mixed	14	46.67	21	70.00
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-21 : Type of house of respondents in overall study area.

S. No.	Size group	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Kaccha	26	43.33	6	10.00	32	26.67
2.	Pacca	5	8.34	12	20.00	17	14.17
3.	Mixed	29	43.33	42	70.00	71	59.16
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-22 : Family type of respondents in Bagidora tehsil.

S. No.	Family type	Pratapdhan		Desi	
		F	%	F	%
1.	Nuclear	13	43.33	30	100
2.	Joint	17	56.67	0	0.00
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-23 : Family type of respondents in Banswara tehsil.

S. No.	Family type	Pratapdhan		Desi	
		F	%	F	%
1.	Nuclear	26	86.67	30	100
2.	Joint	4	13.33	0	0.00
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-24 : Family type of respondents in overall study area.

S. No.	Family type	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Nuclear	39	65.00	60	100	99	82.50
2.	Joint	21	35.00	0	0.00	21	17.50
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-25 : Size of family of respondents in Bagidora tehsil.

S. No.	Family size	Pratapdhan		Desi	
		F	%	F	%
1.	Small (<5 members)	18	60.00	23	76.67
2.	Medium (6-8 members)	12	40.00	7	23.33
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-26 : Size of family of respondents in Banswara tehsil.

S. No.	Family size	Pratapdhan		Desi	
		F	%	F	%
1.	Small (<5 members)	26	86.67	28	93.33
2.	Medium (6-8 members)	4	13.33	2	6.67
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-27 : Size of family of respondents in overall study area.

S. No.	Family size	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Small (<5 members)	44	73.33	51	85	95	79.17
2.	Medium (6-8 members)	16	26.67	9	15	25	20.83
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-28 : Livestock holding of respondents in Bagidora tehsil.

Livestock		Sex	Pratapdhan		Desi	
			F	%	F	%
Cow	Young	Male	5	0.43	6	0.39
		Female	10	0.86	21	1.35
	Adult	Male	39	3.34	41	2.64
		Female	47	4.02	62	3.99
		Total	101	8.65	130	8.37
Buffalo	Young	Male	7	0.60	5	0.32
		Female	22	1.88	23	1.48
	Adult	Male	1	0.09	2	0.13
		Female	57	4.88	53	3.41
		Total	87	7.45	83	5.34
Sheep	Young	Male	0	0	0	0
		Female	1	0.09	0	0
	Adult	Male	0	0	0	0
		Female	1	0.09	0	0
		Total	2	0.18	0	0
Goat	Young	Male	13	1.11	10	0.64
		Female	24	2.05	89	5.73
	Adult	Male	42	3.60	120	7.72
		Female	109	9.33	132	8.49
		Total	188	16.09	351	22.58
Poultry	Chicks		421	36.04	525	33.78
	Adult	Male	89	7.62	125	8.04
		Female	280	23.97	340	21.88
		Total	190	67.63	990	63.70
	Overall		1168	100	1554	100

F= number of the respondents, % = Per cent

Table-29 : Livestock holding of respondents in Banswara tehsil.

Livestock		Sex	Pratapdhan		Desi	
			F	%	F	%
Cow	Young	Male	12	0.83	9	0.55
		Female	16	1.11	15	0.91
	Adult	Male	44	3.04	49	2.98
		Female	59	4.08	63	3.83
		Total	131	9.06	136	8.27
Buffalo	Young	Male	5	0.35	9	0.55
		Female	19	1.31	16	0.97
	Adult	Male	6	0.41	5	0.30
		Female	44	3.04	54	3.28
		Total	74	5.11	84	5.10
Sheep	Young	Male	1	0.07	0	0
		Female	0	0	0	0
	Adult	Male	0	0	0	0
		Female	1	0.07	0	0
		Total	2	0.14	0	0
Goat	Young	Male	14	0.97	17	1.03
		Female	58	4.01	69	4.19
	Adult	Male	85	5.87	95	5.78
		Female	120	8.29	148	9.00
		Total	277	19.14	329	20
Poultry	Chicks		533	36.83	630	38.30
	Adult	Male	97	6.70	103	6.26
		Female	333	23.01	363	22.07
		Total	963	66.54	1096	66.63
	Overall		1447	100	1645	100

F= number of the respondents, % = Per cent

Table-30 : Livestock holding of respondents in overall study area.

Livestock		Sex	Pratapdhan		Desi		Overall	
			F	%	F	%	F	%
Cow	Young	Male	17	0.65	15	0.47	32	0.55
		Female	26	0.99	36	1.12	62	1.07
	Adult	Male	83	3.17	90	2.81	173	2.98
		Female	106	4.05	125	3.90	231	3.97
		Total	232	8.87	266	8.31	498	8.57
Buffalo	Young	Male	12	0.46	14	0.44	26	0.45
		Female	41	1.55	39	1.22	80	1.38
	Adult	Male	7	0.27	7	0.22	14	0.24
		Female	101	3.86	107	3.34	208	3.58
		Total	161	6.16	167	5.22	328	5.64
Sheep	Young	Male	1	0.038	0	0	1	0.02
		Female	1	0.038	0	0	1	0.02
	Adult	Male	0	0	0	0	0	0
		Female	2	0.076	0	0	2	0.03
		Total	4	0.15	0	0	4	0.07
Goat	Young	Male	27	1.03	27	0.84	54	0.93
		Female	82	3.13	158	4.93	240	4.13
	Adult	Male	127	4.85	215	6.72	342	5.88
		Female	229	8.75	280	8.75	509	8.75
		Total	465	17.78	680	21.26	1145	19.69
Poultry	Chicks		954	36.48	1155	36.10	2109	36.27
	Adult	Male	186	7.11	228	7.13	414	7.12
		Female	613	23.44	703	21.97	1316	22.64
		Total	1753	67.03	2086	65.21	3839	66.03
	Overall		2615	100	3199	100	5814	100

F= number of the respondents, % = Per cent

Table-31 : Choice of livestock among respondents in Bagidora tehsil.

S. No.	Species	Pratapdhan		Desi	
		F	%	F	%
1.	Cow	9	30.00	3	10.00
2.	Buffalo	3	10.00	2	6.67
3.	Sheep	0	0.00	0	0.00
4.	Goat	4	13.33	9	30.00
5.	Poultry	14	46.67	16	53.33
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-32 : Choice of livestock among respondents in Banswara tehsil.

S. No.	Species	Pratapdhan		Desi	
		F	%	F	%
1.	Cow	6	20.00	5	16.67
2.	Buffalo	2	6.67	2	6.67
3.	Sheep	0	0.00	0	0.00
4.	Goat	6	20.00	4	13.33
5.	Poultry	16	53.33	4	63.33
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-33 : Choice of livestock among respondents in overall study area.

S. No.	Species	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Cow	15	25.00	8	13.33	23	19.17
2.	Buffalo	5	8.33	4	6.67	9	7.50
3.	Sheep	0	0.00	0	0.00	0	0.00
4.	Goat	10	16.67	13	21.67	23	19.17
5.	Poultry	30	50.00	35	58.33	65	54.16
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-34 : Species liking of poultry by respondents in Bagidora tehsil.

S. No.	Liking of Poultry	Pratapdhan		Desi	
		F	%	F	%
1.	Pratapdhan	24	80.00	25	83.33
2.	Desi	6	20.00	5	16.67
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-35 : Species liking of poultry by respondents in Banswara tehsil.

S. No.	Liking of Poultry	Pratapdhan		Desi	
		F	%	F	%
1.	Pratapdhan	22	73.33	23	76.67
2.	Desi	8	26.67	7	23.33
	Total	30	100	30	100

F= number of the respondents, % = Per cent

agriculture + animal husbandry and 13.33 per cent were engaged in other occupation, respectively in Bagidora tehsil. The data presented in the table regarding the main occupation of pratapdhan poultry rearer shows that 13.33 per cent were engaged in agriculture as main occupation, 70.00 per cent were in agriculture + animal husbandry, 10.00 per cent were in animal husbandry and 6.67 per cent were engaged in other as main occupation, respectively in Bagidora tehsil. Whereas respondents

6.67 per cent who were rearing desi poultry breed engaged in agriculture as a main occupation, 16.66 per cent were in animal husbandry, 70.00 per cent were in agriculture + animal husbandry and 6.67 per cent were in other occupation, respectively in Bagidora tehsil. (Table 8) The data of overall study area presented in the table shows that majority of the respondents 69.17 % were engaged in agriculture + animal husbandry, 13.33 % were in agriculture, engaged in other occupation were 9.17 %

and 8.33 % were in animal husbandry in both tehsil of study area (Table 9). To study the education level of family members, it was categorized into four strata i.e. male and female children, male adult and female adult. The distribution of literate and illiterate family members of different strata have been presented in table 10. The data presented in the table 11 showed that 97.56 % and 100.00 % male children of pratapdhan and desi poultry rearer were literate. While 2.44 % male children of pratapdhan poultry rearer and none of male children of desi poultry rearer were illiterate. Likewise, 88.46 % and 95.35 % female children were literate of pratapdhan and desi poultry rearer. While, 11.54 % and 4.65 % female children of pratapdhan and desi poultry rearer were illiterate, respectively. Further, 67.35 % and 86.67 % male adult of rearer of pratapdhan and desi poultry bird were literate, respectively. Whereas, 32.65 % and 13.33 % male adult of pratapdhan and desi poultry rearer were illiterate. In case of female adult 47.06 % and 22.58 % were literate and 52.94 % and 77.42 % female adult of pratapdhan and desi poultry rearer were illiterate, regarding in Bagidora tehsil. The data presented in the table 12 indicates that 95.00 % and 100.00 % male children of pratapdhan and poultry rearer were literate, while, 5.00 % and none of male children of pratapdhan and desi poultry bird rearer were illiterate in Banswara tehsil. Likewise, 85.71 % and 94.87 % female children were literate and 14.29 % and 5.13 % female children of pratapdhan and desi poultry rearer were illiterate, respectively. In education level of male adult 85.71 % and 90.32 % were literate and 14.29 % and 9.68 % male adult of pratapdhan and desi poultry reare were illiterate, respectively. In case of female adult 26.47 % and 26.67 % were literate and 73.53 % and 73.33 % female adult of pratapdhan and desi poultry rearer were illiterate, respectively in Banswara tehsil. The data presented in Table 13 showed the overall result of education level of both pratapdhan and desi poultry rearer that 98.21 % and 1.79 % male children were literate and illiterate, while, 91.61 % and 8.39 % female children of pratapdhan and desi poultry rearer were literate and illiterate, respectively. In case of male adult 80.69 % and 19.31 % were literate and illiterate and in female adult 32.88 % and 67.12 % of pratapdhan and desi poultry rearer were literate and illiterate, respectively in the study area. The data presented in the Table 14 shows that 43.33 % respondents had small size land holding, 46.67 % had medium size land holding and 10.00 % had large size land holding who were rearing pratapdhan poultry birds. Further, it was noted that respondents who were rearing desi poultry birds had land holding as small 36.67 %, medium 63.33 % and none of the respondent had large sized land holding, respectively in Bagidora tehsil. The data presented in the table shows that 53.33 %

respondents had small size land holding, 46.67 % had medium size land holding and none of the respondents who were rearing pratapdhan poultry birds had large size land holding. Further, it was noted that respondents who were rearing desi poultry birds had land holding as small 16.67 %, medium 83.33 % and none of the respondent had large sized land holding, respectively in Banswara tehsil (Table 15). The data presented in table indicates overall result of size of land holding that overall 37.50 % poultry farmers who were rearing both pratapdhan and desi poultry birds had less than 1 ha land holding, 60.00 % had 1-2 ha land holding and 2.50 % had more than 2 ha land holding, respectively in study area (Table 16). The data presented in Table 17 shows that total 37.48 ha land possessed by pratapdhan poultry rearer out of which 2.72 ha (7.26 %) land was uncultivated and rest 34.76 ha (92.74 %) land was cultivated. Whereas total 33.17 ha land possessed by rearer of desi poultry bird out of which 3.1 ha land (9.35 %) was uncultivated and 30.07 ha land (90.65 %) was cultivated in Bagidora tehsil. The data presented in Table 18 shows that out of total 30.33 ha land possessed by rearer of pratapdhan poultry, 1.44 ha land (4.75 %) was uncultivated and 28.89 ha (95.25 %) was cultivated. Whereas out of total 37.70 ha land possessed by rearer of desi poultry birds 2.8 ha (7.43 %) land was uncultivated and 34.90 ha (92.57 %) land was cultivated in Banswara tehsil. The data presented in Table 19 shows overall results of type of land holding that the total land holding of all the respondents was 138.68 ha in both tehsil. The total uncultivated land was 10.06 ha (7.25 %) and remaining 128.62 ha (92.75 %) was cultivated land possessed by rearer of pratapdhan and desi poultry in overall study area. The data presented in the Table 20 shows that 40.00 % respondents who were rearing pratapdhan poultry had kaccha house, 10.00 % had pacca house and 50.00 % had mixed type house, respectively in Bagidora tehsil. The corresponding values for respondents who reared desi poultry were 6.66 %, 23.34 % and 70.00 %, respectively. The data presented in Table 21 indicates that 46.67 % respondents who were rearing pratapdhan poultry birds had kachha and mixed type house and 6.67 % had pacca house, respectively. Further, 13.33 % respondents who were rearing desi poultry birds had kaccha house , 16.67 % had pacca house and 70.00 % had mixed type house, respectively in Banswara tehsil. The data presented in Table 22 shows that 26.67 % poultry rearer had kaccha house, 14.17 % had pacca house and 59.16 % had mixed type house, respectively in the study area. In surveyed study area it was observed that all the rearer of pratapdhan and desi poultry birds were having kaccha floor of poultry house in farmers. The data presented in table 23 shows that 43.33 % respondents who were rearing pratapdhan poultry birds

were living in nuclear family and 56.67 % respondents were living in joint family. Further table shows that all (100.00 %) of desi poultry rearer was living in nuclear family in Bagidora tehsil. The data presented in Table 24 shows that 86.67 % rearer of pratapdhan poultry birds were living in nuclear family and 13.33 % respondents were living in joint family. Further it was noted that rearer of desi poultry birds (100.00 %) were living in nuclear family in Banswara tehsil. The data presented in Table 4.24 shows that majority (82.50 %) of the poultry rearer were living in nuclear family and 17.50 % respondents were living in joint family in overall study area. The data presented in Table 25 shows that 60.00 % of respondents who were rearing pratapdhan poultry birds belonged to small size family and 40.00 % of the respondents belonged to medium size family, whereas desi poultry rearer 76.67 % belonged to small size family and 23.33 % belonged to medium size family in Bagidora tehsil. The data presented in Table 26 shows majority (86.67 %) of respondents rearing pratapdhan poultry birds belonged to small size family and 13.33 % of the respondents belonged to medium size family, whereas in desi poultry rearer 93.33 % belonged to small size family and only 6.67 % belonged to medium size family in Banswara tehsil. The data presented in Table 27 revealed that 79.17 % respondents of both pratapdhan and desi poultry were from small family (less than 5 members) and 20.83 % respondents were from medium family (6-8 members) in study area. The data in livestock holding is presented in Table 28 the data revealed out of total 1168 livestock holding the percentage of cow, buffalo, sheep, goat and poultry were 8.65 %, 7.45 %, 0.18 %, 16.09 % and 67.63 %, respectively in respondents rearing Pratapdhan poultry. While respondents who were rearing desi poultry birds, out of total 1554 livestock holding the percentage of cow, buffalo, sheep, goat and poultry were 8.37 %, 5.34 %, 0.00 %, 22.58 % and 63.70 %, respectively in Bagidora tehsil. Out of total 1447 livestock holding of respondents who were rearing Pratapdhan poultry birds, the percentage of cow, buffalo, sheep, goat and poultry were 9.06 %, 5.11 %, 0.14 %, 19.14 % and 66.54 %, respectively (Table 29) . while, in case of respondents who were rearing desi poultry birds, out of total 1645 livestock holding the percentage of cow, buffalo, sheep, goat and poultry were 8.27 %, 5.10 %, 0.00 %, 20.00 % and 66.63 %, respectively. The data with respect to livestock holding of overall study area is presented in Table 30. The livestock holding in overall study area were 8.57 % cow, 5.64 % buffalo, 0.07 % sheep, 19.69 % goat and 66.03 % were poultry birds. The data given in Table 31 exhibits the choice of livestock of pratapdhan rearer that 30.00 % respondents showed their choice for cow, 10.00 % for buffalo, none of the respondents showed choice for

sheep, 13.33 % showed choice for goat and 46.67 % respondents showed their choice for poultry. Further, it was noted that desi poultry rearer showed their choice as 10.00 % for cow, 6.67 % for buffalo, none for sheep, 30.00 % for goat and 53.33 % respondents showed their choice for poultry, respectively in Bagidora tehsil. The data in Table 32 explained that respondents who were rearing pratapdhan poultry birds showed their choice of livestock as 20.00 % for cow, 6.67 % for buffalo, 20.00 % for goat and 53.33 % and none of the respondents showed choice for sheep in Banswara tehsil. Further it was noted that respondents who were rearing desi poultry birds showed their choice as 16.67 % for cow, 6.67 % for buffalo, 13.33 % for goat, 63.33 % for poultry and none of the respondents showed their choice for sheep, respectively in Banswara tehsil. The figures offered in Table 33 shows choice of livestock in overall study area that 19.17 % poultry rearer showed their choice for cow, 7.50 % for buffalo, 19.17 % for goat, 54.16 % for poultry and none of the respondents showed their choice for sheep in overall study area. The data of the Table 34 illustrates that 80.00 % of the respondents who were rearing pratapdhan poultry birds liked to rear pratapdhan bird and remaining 20.00 % respondents liked to rear desi bird. Further desi poultry rearer showed their choice of species liking that 83.33 % liked to rear pratapdhan and 16.67 % liked to rear desi poultry bird in Bagidora tehsil. Table 35 explains that 73.33 % pratapdhan poultry rearer liked to rear pratapdhan bird and 26.67 % liked to rear desi poultry bird, whereas 76.67 % desi poultry rearer liked to rear pratapdhan bird and 23.33 % liked to rear desi poultry bird in Banswara tehsil. Similarly, Verma *et al.* (2020) worked in Canker district of Chhattisgarh found that all the respondents belonged to Hindu religion and were from the other backyard class category. The data shows that 80.00 per cent of the selected backyard poultry rearer of both pratapdhan and desi poultry birds were educated or literate. Similarly, Verma *at al.* (2020) revealed that majority of farmers had male in middle age with high school level of education. The main occupation of all the poultry farmers covered under present investigation was observed agriculture + animal husbandry of both pratapdhan and desi poultry rearers. The results obtained in the present investigation are not in agreement with the work of Sharma *et al.* (2018) who reported that main occupation of respondents was agriculture. The literacy rate of rearers of both poultry bird viz; pratapdhan and desi poultry was found that overall male children were 98.21 % literate and only 1.79 % of the selected respondents were found illiterate in study area, the percentage of female children were 91.81 % who were literate and the percentage of literate male adult was found 80.69 per cent. Female adult of selected study area were found

67.12 per cent illiterate, this may be possible due to the reason that the respondents of study area were not aware about education of female or they had not given importance for female education in their previous time of life. Alam *et al.* (2014) reported average number of children per farmer attends to primary school, high school, college and university were 0.7, 0.75, 0.1 and 0.01 in case of boys and 0.5, 0.45, 0.07 and 0.01 in case of girls, respectively. Majority of respondents 60.00 % have medium size land holding between 1-2 ha and very less number of the respondents 3 (2.50 %) were found having large size land holding more than 2 ha in overall study area so this shows that maximum numbers of the poultry rearers are marginal farmers. Total land holding of all the poultry rearers was observed 138.68 ha in overall study area out of which 128.62 ha land was cultivated because most of the farmers are marginal and they manage sources of irrigation to cultivate their land holding for their livelihood. Balamurugan *et al.* (2017) revealed that backyard poultry farmers had less than one hectare of land. Maximum 59.16 % rearer of both pratapdhan and desi poultry were living in mixed type of house in study area and only 14.17 % poultry rearer were living in pucca house because of the fact that most of the farmers are marginal and agriculture + animal husbandry is the only source of their income so they can't bear the expenditure of pucca house and they use mixed type house for living. Similarly, Varma *et al.* (2020) revealed that majority of the farmer lived in mixed type house. Most (82.50 %) of the farmers lived in nuclear family. The information collected from the study area indicated that most (79.17 %) of the backyard poultry rearers had small size family less than 5 members that mean they may live with their parents, wife and children only. These observations are similar with the observation of Pratap *et al.* (2017) that 66.66 % had joint family with 50.00 % had medium size family in joint family, while in nuclear type 64.00 % had large family and with respect to medium sized and nuclear was also in agreement with Sharma *et al.* (2018).

The livestock maintained by the poultry farmers were found as 8.57 per cent cow, 5.64 per cent buffalo, 0.07 per cent sheep, 19.69 per cent goat and maximum 66.03 per cent were poultry. It was found that overall choice of livestock for cattle and goat was 19.17 per cent, for buffalo it was 7.50 per cent and maximum 54.16 per cent farmers liked to rear poultry. Most of the poultry rearers 78.33 % liked to rear pratapdhan poultry birds rather than desi poultry breed because pratapdhan poultry birds have good egg production, body weight and growth rate in comparison of desi poultry birds. The results are similar as Yasmeen *et al.* (2019).

Conclusions

Tailor-made interview schedule in accordance with the specific objectives was prepared by the student researcher and was used for gathering the relevant information. Readymade tools as utilized in previous related studies were also utilized with slight modifications. The observations were collected through personal interview techniques. The collected data were tabulated and analyzed to draw meaningful inference. The involvement of men, women and children in different backyard poultry activities was also studied.

The entire selected respondent belongs to Hindu religion of scheduled tribe caste in the surveyed area. Literacy rate of pratapdhan and desi poultry rearers was 70.00 and 90.00 per cent, respectively. The pratapdhan poultry rearers and desi poultry rearer shows their occupation as Agriculture + Animal husbandry by 71.67 per cent and 66.66 per cent, 96.30 per cent male children of rearer of pratapdhan poultry birds and 100.00 per cent male children of rearers of desi poultry were found literate, 86.89 per cent female children of respondents who were rearing pratapdhan poultry birds and 95.12 per cent female children of rearers of desi poultry birds were found literate, 75.00 per cent male adult of rearer of pratapdhan poultry and 88.52 per cent male adult of rearer of desi poultry birds were literate, female adult 61.18 per cent of rearers of pratapdhan and 75.41 per cent female adult of rearers of desi poultry birds were found illiterate in overall study area.

Further 48.33 per cent pratapdhan poultry rearers had small size land holding less than one ha and 73.33 per cent respondents of desi poultry rearers had medium size land holding 1-2 ha, 93.87 per cent pratapdhan poultry rearers and 91.67 per cent desi poultry rearers had cultivated land, 43.33 per cent pratapdhan poultry rearers had Kaccha and mixed type house and 70.00 per cent desi poultry rearer had only mixed type house, 65.00 per cent of pratapdhan poultry rearers and all 100.00 per cent desi poultry rearers were living in nuclear family, 73.33 per cent pratapdhan poultry rearers and 85.00 per cent rearers of desi poultry birds had small size family.

It was observed that pratapdhan and desi poultry rearers had 8.87 per cent and 8.31 per cent cow, 6.16 per cent and 5.22 per cent buffalo, 0.15 per cent sheep were reared by pratapdhan poultry rearers and desi poultry rearers didn't have any sheep in their livestock, again it was noted that 17.78 per cent and 21.26 per cent goat were reared by pratapdhan and desi poultry rearers, maximum 67.03 per cent and 65.21 per cent pratapdhan and desi poultry birds had reared by the respondents of overall study area.

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Study the Feeding Practices for Pratapdhan and Desi Poultry Breeds Followed by Farmers of Banswara District of Rajasthan

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Abstract

The present study was carried out in two tehsil viz; Banswara and Bagidora in Banswara district of Rajasthan. Six villages from each tehsil were selected on the basis of highest bird population of poultry. A total number of 120 respondents were selected for the present investigation from both tehsil. The overall results regarding feeding and breeding practices shows that majority of the poultry rearers i.e. 76.67 per cent feed own produced feeding material to poultry, 72.50 per cent poultry rearers of both pratapdhan and desi poultry birds feed their birds twice a day, 74.17 % were found not using feeder to feed poultry birds, 58.33 per cent were using earthen waterer.

Key words : Pratapdhan, poultry, feeding, breeding, banswara, egg, waterer, husbandry.

Introduction

The poultry industry in India is a very old practice and this food industry is one the important contributors to the economy of rural and semi-urban India. Indian Poultry Industry is 5,000 years old, since last 4 decades it began to witness remarkable growth from backyard to poultry industry. India ranks seventeenth in the world poultry production index. Further, India is the fifth largest producer of eggs and ninth largest producer of poultry meat amongst all the countries. The organized sector of poultry industry is contributing nearly 70 % of the total output and the rest 30 % in the unorganized sector. The broiler industry is well dominated in southern states in our country with nearly 60 %-70 % total output coming from these states. The layer industry once again is represented more in southern states especially, Andhra Pradesh, Tamil Nadu and Maharashtra producing nearly 70 % of the country's egg production. India's 75 % of egg produce is consumed by the 25 % population living in urban and semi-urban areas.

India has emerged as the only country in the developing world a self-reliant, technology driven industry, with capability to produce every essential input for successful poultry farming including indigenous genetic resource and breeding, world class poultry vaccines and medicines specific pathogen free eggs (SPF), farms and hatchery automation system, pelleted feed, egg processing, poultry processing, nationwide network of disease diagnostic laboratories and facilities for entrepreneurial development and training in both private and public sectors. In last 4 decades, Poultry

framing in India has transformed from a mere tool of supplementary income and nutritious food for the family to the major commercial activity generating the required revenue. The growth of the industry with steady production of 1,800 million kg of poultry meat, 40 billion eggs per year and employment generation of about 3 million people indicates the future prospects for the industry. Poultry egg and meat, in recent years have become important and popular food for the 68% of the non-vegetarian population of the country. Consequently, their consumption is increasing day by day. At present poultry and poultry products command a major share of food of animal origin produced and consumed in the country because of their cost effectiveness, easy availability, superior protein quality and wider acceptance by all sections of the society irrespective of cost, creed and religion. Poultry production at present is the fastest growing sub- sector of Indian agriculture with a quantum jump both in respect of poultry production and productivity.

India has made a considerable progress in broiler production in the last three decades and the eighties was a golden decade in the growth of broiler farming in India. Broiler industry has now been a well-established business and is one of the most promising sectors of agriculture. Broiler production has reached a record production of 95 million in 1986 from a meager figure of 4 million in 1971. The meat production from poultry was 2, 25,000 tones, which was more than 25 percent of the total meat, produced in the country. The main reasons behind this broiler boom are less requirement of capital, less space required for starting broiler farm, quick and early returns,

higher demand of broiler meat due to its low price and high remunerative value in comparison to other types of meat.

Materials and Methods

The present investigation was conducted in Banswara district of Rajasthan and geographically characterized by the Aravali ranges. The district lies between 23.11° N to 23.56° N latitude and 73.58° E to 74.49° E longitudes and at an elevation of 302 meter above mean sea level. Farmers are rearing desi poultry breeds in Banswara district. Banswara district consists of 11 tehsil and on the basis of poultry farmers and population of poultry, two tehsils were selected viz. Bagidora and Banswara, on the basis of highest birds population. Villages having backyard poultry farming were selected in consultation with KVK, Banswara. Six villages were selected from each tehsil on the basis of maximum number of birds. For selection of respondents, comprehensive list of farmers engaged in backyard poultry farming was prepared from each identified village with the help of agriculture supervisor, gram sevak and extension agent KVK'S/NGO'. Ten farmers from each village were selected randomly. Among ten farmers, 10-15 having 10-15 rearing desi birds were selected.

The interview was scheduled with the general information of poultry farmers i.e. caste, education level, occupation, family members, land holding, type of house, type of family, livestock species and livestock holding. The second part of schedule was specially designed to assess the knowledge of the poultry farmers about prevailing feeding and breeding practices of backyard poultry production. Before conducting the interview and collection of data from poultry farmers, specific objectives and the purpose of the survey was explicitly explained to them. The question of the schedule were presented to them in their own dialect and Hindi ensuring that they perceived the questions correctly so as to avoid any interpretational variation of the question by the poultry farmers. The data was collected by personal interview from of the selected farmers using pretested interview schedule.

Results and Discussion

The data presented in Table-1 shows that 76.67 per cent pratapdhan poultry rearer used own produced feed and 23.33 per cent respondents used market feed for poultry birds, whereas 83.33 per cent desi poultry rearer used own produced feed and 16.67 per cent respondents used market feed for poultry birds in Bagidora tehsil. The data table-2 shows that 80.00 per cent of pratapdhan poultry rearer used own produced feed and 20.00 per cent

respondents used market feed for poultry birds, while 66.67 per cent desi poultry rearer used own produced feed and 33.33 per cent respondents used market feed for poultry birds in Banswara tehsil. The data indicated that majority (76.67 %) of poultry rearer used own produced feed for poultry birds, whereas, 23.33 % poultry rearer used market feed in study area. The data presented in table shows that 50.00 % respondents who were rearing pratapdhan poultry feed once a day to birds and 50.00 % respondents feed twice a day to poultry birds. Whereas desi poultry rearer 30.00 % feed once a day to poultry birds and 70.00 % respondents feed twice a day to poultry birds in Bagidora tehsil. The data presented in Table 4 shows that 16.67 % respondents who were rearing pratapdhan poultry fed to poultry birds once a day and 83.33 % respondents fed twice a day, while, among desi poultry rearer, 13.33 % fed once a day to poultry birds and 86.67 % poultry rearer fed twice a day in Banswara tehsil. The data given in table 5 indicated that 27.50 % respondents fed their birds once a day and 72.50 % respondents fed their twice a day in study area. The data in Table 6 revealed that 16.67 % respondents among pratapdhan poultry rearers used feeder and majority (83.33 %) of respondents do not use feeder, whereas among desi poultry, 23.33 % used feeder and 76.67 % do not use feeder for the poultry birds in Bagidora tehsil. The data presented in table indicated that 33.33 % respondents who were rearing pratapdhan poultry birds using feeder for their birds and 66.67 % poultry rearer do not use feeder for poultry birds, while, 30.00 % of desi poultry rearer were using feeder and 70.00 % did not use feeder for their poultry birds in Banswara tehsil. The data in Table 8 that majority (74.17 %) of poultry respondents were not using feeder and only 25.83 % respondent used feeder in overall study area. The data given in Table 9 describes that type of waterer used by rearer of pratapdhan poultry birds as 63.33 % used earthen waterer, 20.00 % used wooden waterer, 6.67 % used metallic waterer and 10.00 % poultry rearer used plastic waterer, respectively. Whereas 66.66 % desi poultry rearer used earthen waterer, 26.67 % used wooden waterer, 6.67 % used plastic waterer and none of the respondents used metallic waterer in Bagidora tehsil. The data offered in Table 10 describes that type of waterer used 53.33 % rearer of pratapdhan poultry birds used earthen waterer, 26.67 % used wooden waterer, 6.67 % used metallic waterer and 13.33 % poultry rearer used plastic waterer, respectively. Among 50.00 % desi poultry rearer used earthen waterer, 33.33 % used wooden waterer, 6.67 % used plastic waterer and 10.00 % of the respondents used metallic waterer in Banswara tehsil. The data presented in Table 11 revealed that majority (58.33 %) of poultry respondents used earthen waterer,

Table-1 : Feed used for feeding to poultry birds in Bagidora tehsil.

S. No.	Feed	Pratapdhan		Desi	
		F	%	F	%
1.	Own produced	23	76.67	25	83.33
2.	Market	7	23.33	5	16.67
	Total	30	100	30	100

Table-2 : Feed used for feeding to poultry birds in Banswara tehsil.

S. No.	Feed	Pratapdhan		Desi	
		F	%	F	%
1.	Own produced	24	80.00	20	66.67
2.	Market	6	20.00	10	33.33
	Total	30	100	30	100

Table-3 : Feed used for feeding to poultry birds in overall study area.

S. No.	Feed	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Own produced	47	78.33	45	75.00	92	76.67
2.	Market	13	21.67	15	25.00	28	23.33
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-4 : Frequency of feeding in Bagidora tehsil.

S. No.	Frequency	Pratapdhan		Desi	
		F	%	F	%
1.	Once a day	15	50.00	9	30.00
2.	Twice a day	15	50.00	21	70.00
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-5 : Frequency of feeding in Banswara tehsil.

S. No.	Frequency	Pratapdhan		Desi	
		F	%	F	%
1.	Once a day	5	16.67	4	13.33
2.	Twice a day	25	83.33	26	86.67
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-6 : Frequency of feeding in overall study area.

S. No.	Frequency	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Once a day	20	33.33	13	21.67	33	27.50
2.	Twice a day	40	66.67	47	78.33	87	72.50
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-7 : Use of feeder in Bagidora tehsil.

S. No.	Feeder	Pratapdhan		Desi	
		F	%	F	%
1.	Using	5	16.67	7	23.33
2.	Not using	25	83.33	23	76.67
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-8 : Use of feeder in Banswara tehsil.

S. No.	Feeder	Pratapdhan		Desi	
		F	%	F	%
1.	Using	10	33.33	9	30.00
2.	Not using	20	66.67	21	70.00
	Total	30	100	30	100

Table-9 : Use of feeder in overall study area.

S. No.	Feeder	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Using	15	25.00	16	26.67	31	25.83
2.	Not using	45	75.00	44	73.33	89	74.17
	Total	60	100	60	100	120	100

F= number of the respondents, % = Per cent

Table-10 : Type of waterer used in Bagidora tehsil.

S. No.	Type of waterer	Pratapdhan		Desi	
		F	%	F	%
1.	Earthen	19	63.33	20	66.66
2.	Wooden	6	20.00	8	26.67
3.	Metallic	2	6.67	0	0.00
4.	Plastic	3	10.00	2	6.67
	Total	30	100	30	100

F= number of the respondents, % = Per cent

Table-11 : Type of waterer used in overall study area.

S. No.	Type of waterer	Pratapdhan		Desi		Overall	
		F	%	F	%	F	%
1.	Earthen	35	58.33	35	58.33	70	58.33
2.	Wooden	14	23.33	18	30.00	32	26.67
3.	Metallic	4	6.67	2	3.33	6	5.00
4.	Plastic	7	11.67	5	8.34	12	10.00
	Total	60	100	60	100	120	100

26.67 % used wooden waterer 5.00 % used metallic waterer and 10.00 % used plastic waterer in overall study area. The overall results regarding feeding and breeding practices shows that majority of the poultry rearers i.e. 76.67 per cent feed own produced feeding material to poultry and remaining 23.33 per cent poultry rearers feed material purchased from market to poultry. It was observed that 78.33 per cent pratapdhan poultry rearer fed own produced feed and 21.67 per cent poultry rearer purchase feeding material from market. Desi poultry rearer 75.00 per cent fed own produced feed and 25.00 per cent poultry farmers purchase feeding material from market. Similarly, Chaturvedani *et al.* (2016) revealed feeding practice involved, left the birds for scavenging on insects, worms, grasses, seeds and flowers in the morning. In the evening birds were offered kitchen waste, broken rice and boiled rice to supplementary feed ingredients at average of 50.29±0.87 grams per birds per day. The data regarding frequency of feeding shows that 72.50 per cent poultry rearers of both pratapdhan and desi poultry birds feed their birds twice a day. Majority of the respondents 74.17 % were found not using feeder to feed poultry birds and only 25.83 % respondents were found using feeder to feed poultry birds because they feed own produced feeding material so they feed them directly on ground or left them in field for scavenging insects, worms grasses etc and they also feel that feeder is not easily available at their nearer. Majority (58.33 %) of the

respondents were using earthen waterer followed by wooden, plastic and metallic waterer. Perusal of data revealed that earthen waterer are easily available and are cost effective as compared to other which makes it most common among the respondents. The results are in contrast with Emebet (2015). The overall data regarding breeding male birds shows that 80.83 per cent were using own raised breeding male birds and 19.17 per cent were purchasing breeding male birds from outside, respectively.

In case of Pratapdhan poultry rearers 16.67 per cent were purchasing breeding male from outside and 83.33 per cent had raised own male bird for breeding, respectively. While, 21.67 per cent desi poultry rearers purchased breeding male from outside and 78.33 per cent had raised own breeding male bird, respectively. The overall percentage of selection criteria used by the respondents for hatching were found i.e. 14.17 % poultry rearers select eggs on the basis of only egg size, 6.67 % selects egg on the basis of egg shape and 79.16 per cent select eggs on the basis of both egg shape and size, respectively. The results are similar as Ewonet Kebede Senbeta (2017) that chicken producer may opt for medium sized eggs principally for the purpose of better hatchability and feed conversion ratio whereas large sized eggs for better hatching weight, weight gain and survivability. It was observed from the data that 20.83 per cent respondents used pucca house for poultry birds,

67.50 per cent used kacha house and 11.67 per cent used bamboo poultry house for poultry birds in overall study area. It was observed that all the respondents were having kacha floor of poultry house in overall study area because most of the respondents expressed that they constructs poultry house with locally available material viz., mud, wood, net and jute etc. Further it was observed that the ventilation facility in poultry house was good for both pratapdhan and desi poultry birds and they did not provide facility of light in poultry house. The finding of the study are similarly as Chaturvedani *et al.* (2016) revealed that 68.33 per cent poultry owners constructed separate small houses with locally available materials viz., bamboo, mud, wood, net, jute stalk, tiles, tin, straw etc. The results of role of human resources for the work of poultry in overall study area indicates that maximum 72.50 per cent women were involved in the work of poultry while 10.00 per cent male and 17.50 per cent children were also involved in work of poultry, respectively.

Conclusions

The result further shows that 78.33 per cent Pratapdhan poultry rearer and 75.00 per cent desi poultry rearers used own produced feed for poultry, 66.67 per cent rearers of pratapdhan poultry and 78.33 per cent rearers of desi poultry offered feed to birds twice a day. It was an evident from the data that 25.00 per cent rearer of pratapdhan poultry and 26.67 per cent rearers of desi poultry birds used the feeder for poultry. Majority 58.33 per cent of the Pratapdhan and desi poultry rearer used earthen waterer for poultry birds in study area.

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Advancing Crop Productivity Assessment through PGPR Analysis in Agriculture using Advanced GIS and Remote Sensing Techniques : A Comprehensive Review

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Abstract

This review delves into the synergistic integration of advanced Geographic Information System (GIS) and remote sensing techniques for a comprehensive assessment of crop productivity enhancements via Plant Growth Promoting Rhizobacteria (PGPR) analysis in agriculture. The review showcases the potential of PGPR in rejuvenating soil health and elevating crop yields, substantiated by the sophisticated utilization of modern electronic applications and database systems. The real-time capabilities of GIS facilitate accurate evaluations of crop nutrient status and physiological chemical concentrations, while remote sensing offers innovative alternatives to conventional chemical analyses. The process of constructing a GIS database tailored for agricultural use is explored, encompassing diverse datasets such as meteorological data, land use, infrastructure, water resources, pedology, and satellite information. GIS's adept data integration capabilities are highlighted, leading to improved data management and online access to geographic information presented in diverse models and formats, thus enhancing agricultural output efficiency. Furthermore, the review illuminates the role of GIS technology in understanding and observing PGPR mechanisms. Through GIS-based remote sensing tools, changes in plant morphology and crop physiology following PGPR application are meticulously tracked, enabling a thorough analysis of the positive impacts of these beneficial microbes on agricultural systems. The comprehensive range of parameters, techniques, and software tools discussed underscores the multidimensional nature of GIS remote sensing, enabling thorough investigations of soil parameters, land-use dynamics, decision-making processes, and microbial populations within rhizospheric soil. As technology continues to evolve, the harmonious integration of advanced GIS and remote sensing techniques is poised to play a pivotal role in agricultural research and practice. This review serves as a guiding roadmap, shedding light on the potential of PGPR-based agricultural innovations and fostering a more sustainable and productive agricultural future.

Key Words : Crop productivity assessment, PGPR, remote sensing, GIS.

Introduction

The base of all other sectors is the agricultural sector, which also serves as the economic engine of every nation by either directly or indirectly affecting its GDP. In the twenty-first century, the global agricultural system faces greater difficulties, such as a reduction in production and deterioration in the sustainability of the agro-ecosystem. According to UN projections, there will be 9.8 billion people on earth in 2050, and the number of people is expected to be close to 8.6 billion in 2030 (World Population Prospects 2017, www.un.org). At the same time, there has been a constant rise in the demand for food, which has led to a shortage of it (Alexandratos and Bruinsma, 2012; Kumar *et al.*, 2017a).

The OECD-FAO Agricultural Outlook 2023–32 maps major output, consumption, and trade trends as of 2023. According to the FAO (2023) report, total food consumption is predicted to increase by 1.3% year over year through 2032, showing an increase in the percentage of agricultural commodities consumed as food. At the same time, people are realizing the

importance of sustainable agriculture techniques in order to supply the world's food needs in the future (Altieri, 2004). Maintaining the soil's dynamic character is crucial for sustainable agriculture (Paustian *et al.*, 2016), not only to ensure enough food production but also to ensure the sustainability of the global environment for future generations (Ahmad *et al.*, 2016; Zahedi, 2016; Kumar *et al.*, 2017b).

According to Mahdi *et al.* (2010) and Xiang *et al.* (2012), the race to produce higher crop yields through the use of more intensive agronomic methods, such as the use of more inorganic fertilizers and pesticides, is considered to have negative consequences on the soil's health and the sustainability of the ecosystem. As a result, it is nearly impossible to expand the amount of agricultural area with healthy soil; As a result, scientists and researchers have focused their emphasis on developing more productive and safe farming procedures. Exploring unconventional resources is therefore crucial to preventing future ecological deterioration as well as reducing the demands of a growing population.

Under the current conditions, it is impossible to achieve sustainability in agricultural output without a healthy microbiome in the soil (Patil *et al.*, 2014; Vaxevanidou *et al.*, 2015). The most promising of these possible soil microorganisms are plant growth promoting rhizobacteria (PGPR). Accordingly, PGPR may be employed to improve plant health and raise plant growth rate without contaminating the environment (Fernando de Araujo, 2008; Calvo *et al.*, 2014; Singh *et al.*, 2017a, b).

Rhizobacteria that promote plant development and have antagonistic effects on phytopathogens are known as Plant Growth Promoting Rhizobacteria (PGPR) and are essential to soil fertility (Méndez-Bravo *et al.*, 2018). The rhizosphere is the region closest to the root surfaces where microorganisms are most active biologically (Choudhary *et al.*, 2018). PGPR are naturally occurring soil microorganisms that actively colonize plant roots and improve the health of plants (Parewa *et al.*, 2018). The breakdown of crop residues, the synthesis of soil organic matter, the mineralization of soil organic matter, and the immobilization of mineral nutrients, which aid in improving soil fertility, are all positive actions carried out within the soil by PGPR (Sharma *et al.*, 2017). To better comprehend the diversity, significance, and responsibilities of soil PGPR communities in improving vegetable production, several sorts of studies are continuously being conducted.

The role of PGPR in the agriculture field can be verified by various morphological and physiological methods, but the new advanced technology of remote sensing has enhanced and simplified the typical analysis of PGPR performance in the agricultural field. This is the most refined approach that allows for an in-depth analysis of the beneficial effects of PGPR microbes in the agricultural field. Various parameters, techniques, and software tools are engaged in the territory of GIS remote sensing, including soil parameters, Markov chains, CA-Markov chains, Multi-Criteria Decision Analysis (MCDA), Analytical Hierarchy Process (AHP), Land Use Land Cover (LULC) and Land Surface Temperature (LST), crop mapping sites, Hyperspectral imaging, Spectral reflectance Mantel test, investigation through soil samples, 16S rRNA, and sequencing.

Plant growth promoting rhizobacteria (PGPR) and Diversity

Rhizobacteria are free-living rhizospheric bacteria that support plant growth and development. These bacteria survive on root exudates and lysates and can flourish in the niche provided by plant roots. A microcolony of a different bacterial strain may cover up to 15% of the root

surface, and the rhizosphere may contain up to 1,000 times more bacteria than bulk soil does (van Loon., 2007). It has been determined that these rhizospheric microorganisms have a positive, negative, or neutral effect on the health of plants (Whipps., 2001; Bais *et al.*, 2006). However, PGPRs that have a positive impact on their host plant are crucial. About 2–5% of the rhizospheric bacteria are thought to be PGPR (Antoun and Kloepper, 2001).

Three key characteristics of PGPR include their capacity to colonize roots, their high survival and multiplicity in root environments, which promote plant development, and their suppression of phytopathogens. (Lugtenberg *et al.*, 2001; Gamalero *et al.*, 2004). According to Haghighi *et al.* (2011), PGPR not only coexists closely with plant roots but also enhances soil quality. Rhizosphere bacteria called plant growth-promoting rhizobacteria (PGPR) produce 1-Aminocyclopropane-1-carboxylate deaminase, phosphate solubilization products, siderophores, biological nitrogen fixation products, and rhizosphere engineering products. In addition to producing phytohormones, these bacteria also exhibit antifungal action, volatile organic chemicals, systemic resistance, advantageous plant-microbe symbioses, and disruption of pathogen toxin synthesis. As a desirable substitute for chemical fertilizers, herbicides, and vitamins, PGPR's potential in agriculture is expanding. These chemicals that encourage development are probably generated in enormous numbers and have an indirect impact on plant morphology (Bhattacharyya and Jha, 2012).

According to Tilak *et al.* (2005), PGPR are categorized on the basis of their functions and taxonomical position, PGPR strains are broadly categorized into five taxa: *Actinobacteria*, *Bacteroidetes*, *Cyanobacteria*, *Firmicutes*, and *Proteobacteria*. It is stated that the most commonly studied PGPRs of these taxa are *Azospirillum*, *Azotobacter*, *Bacillus*, *Enterobacter*, *Gluconacetobacter*, *Paenibacillus*, *Pseudomonas*, *Rhizobium*, and *Serratia* (Bhattacharyya and Jha., 2012; Arora., 2015).

In general, PGPR may be divided into two main types based on these associations: (i) extracellular (ePGPR) or rhizospheric and (ii) intracellular or endophytic (iPGPR) (Vessey 2003; Gray and Smith 2005; Martinez-Viveros *et al.*, 2010; Santoyo *et al.*, 2016). The extracellular (ePGPR) supports plant development and is renowned for producing secondary metabolites with high productivity that are effective plant growth promoting agents (Gray and Smith, 2005). These free-living ePGPR, e.g., *Achromobacter*, *Acetobacter*, *Alcaligenes*,

Arthrobacter, *Azospirillum*, *Azotobacter*, *Azomonas*, *Bacillus*, *Beijerinckia*, *Clostridium*, *Corynebacterium*, *Derxia*, *Enterobacter*, *Herbaspirillum*, *Klebsiella*, *Pseudomonas*, *Rhodospirillum*, *Rhodopseudomonas*, *Serratia*, and *Xanthobacter*, have great agricultural importance (Prithiviraj et al., 2003; Bhattacharyya and Jha, 2012). Intracellular (iPGPR), which is found inside plant cells as a specialized nodular structure. The most known and recognized members of this category of iPGPR are Rhizobia and *Frankia* species (Figueiredo et al., 2011; Gopalakrishnan et al., 2015).

Importance of PGPR in Agriculture

PGPRs are an important, essential, and alternate source of chemical fertilizers for plant growth and development. They enhance soil productivity and fertility naturally, and along the way, they manage biotic and abiotic stresses that reduce crop production. PGPR actively boosts the plant's immune system so that it is able to survive in pathogenic conditions. The main and important goals of PGPR are plant soil fertility and productivity restoration, plant growth enhancing activities, management of plant stress conditions, and biological control of phytopathogen activities (García-Fraile et al., 2015).

Plant Growth Enhancing Activities

The PGPR enhanced the plant overall growth and development by various direct and indirect mechanism.

Direct methods

There are two types of bacterial strains that can fix nitrogen. The first category includes bacteria that are symbiotic with the roots of legumes, such as strains of Rhizobium, which are specialized and infect roots to produce nodules. The so-called free-living nitrogen fixers are another type of bacteria that lives on or on the periphery of plants (Oberson et al., 2013). Examples of such free-living nitrogen fixers include *Azospirillum*, *Azotobacter*, *Burkholderia*, *Herbaspirillum*, *Bacillus*, and *Paenibacillus* (Seldin et al., 1984; Heulin et al., 2002; von der Weid et al., 2002; Goswami et al., 2015). Although free-living nitrogen fixers do not penetrate the plant's tissues, a very close relationship is established when these bacteria live close enough to the root for the plant to absorb the atmospheric nitrogen that the bacteria have fixed. Nitrogen fixation is regarded as a fundamental property of PGPRs since it directly delivers nitrogen to the plant. Nitrogen-fixing strains have been marketed as biofertilizers over the past 20 years and are considered essential for agriculture (Heulin et al., 2002; Goswami et al., 2015).

The second most limiting nutrient for plants is phosphorus. Despite having very large deposits,

phosphorus is not present in a form that plants can readily absorb (Jha et al., 2012; Jha and Saraf., 2015). By dissolving complex-structured phosphates such as tricalcium phosphate, rock phosphate, aluminum phosphate, etc., microorganisms mineralize organic phosphorus in soil, which eventually increases the availability of phosphate to plants. Organic acid release by bacteria as a result of sugar metabolism serves as the main mechanism for phosphate solubilization (Goswami et al., 2014a; Goswami et al., 2014b). A large part of these bacteria may be isolated from soil in the rhizosphere, and it is estimated that phosphate-solubilizing microorganisms make up 20–40% of the culturable population of soil microorganisms (Chabot et al., 1993). *Pseudomonas* and *Bacillus* strains found on roots and in rhizospheric soil, as well as endosymbiotic rhizobia found inside roots and nodules, have both been characterized as excellent phosphate solubilizers among soil bacterial communities (Goswami., 2014b).

In addition to N and P, PGPR also affects the absorption of other nutrients, including potassium (K), zinc (Zn), iron (Fe), and sulfur (S) (Peix et al., 2001; Wu et al., 2005; Adesemoye et al., 2008; Lukkani and Reddy, 2014). K is another crucial component that is necessary for plant growth and development. However, according to Li et al. (2006) and Bahadur et al. (2016), more than 90% of the potassium (K) in soil is found in insoluble forms (micas, illite, and orthoclases). *Pseudomonas*, *Burkholderia*, *Acidithiobacillus*, *Bacillus*, and *Paenibacillus* are known to solubilize K for plant absorption mostly by excreting organic acids (Rogers et al., 1998; Parmar and Sindhu., 2013).

Zn is a crucial element for plant development, however, fixed forms of Zn compounds cause around 50% of lands to be deficient in Zn (Iqbal et al., 2010; Hussain et al., 2015). PGPR aids plants in mobilizing the fixed form of the Zn compound and facilitating its simple absorption. *Bacillus*, *Pseudomonas*, *Rhizobium*, *Burkholderia*, *Acinetobacter*, *Mycobacterium*, *Stenotrophomonas*, *Enterobacter*, and *Xanthomonas* are among the bacterial genera that are currently recognized as Zn solubilizers (Vaid et al., 2014; Naz et al., 2016). According to Nahas (1996) and Seshadre et al. (2002), PGPR solubilizes Zn by a number of methods, including the formation of chelating agents, the extrusion of proteins, and the excretion of organic acids (2-ketogluconic acid and gluconic acid).

In addition to being a necessary nutrient for plant development, S is also absorbed primarily by plants as sulfate and sulfur dioxide (Marschner, 2012). According to Kertesz and Mirleau (2004), only 5% of S is accessible to

plants, with the majority (95%) being unavailable due to being bonded with organic complexes. According to Gahan and Schmalenberger (2014), sulfur-oxidizing PGPR can be employed to transform unavailable S into a form that is directly absorbable by plants. PGPRs are currently receiving a lot of attention in agriculture in order to meet the sulfur needs of plants (Salimpour *et al.*, 2010; Anandham *et al.*, 2014).

There are several classes of well-known phytohormones, including auxins, gibberellins, cytokinins, ethylene, and abscisic acid, and soil microorganisms, notably the rhizosphere bacteria, do have the ability to manufacture these hormones (Arshad and Frankenberger, 1998; Patten and Glick, 1996). Any phytohormone present in the rhizosphere, whether it has been added there naturally or as a result of microbial flora living there, can cause a plant to respond. These phytohormones have the ability to influence a variety of activities in both symbiotic and non-symbiotic roots, such as plant cell expansion, division, and extension (Glick, 2014; Patten and Glick, 1996).

Indirect Mechanisms

Indirect mechanism require the participation of the plants defensive metabolic processes, which respond to the signal sent from the bacteria influencing the plant. Two important mechanisms are included in this group: induction of systemic resistance to plant pathogens (biotic stress) and protection against unhealthy environmental conditions (abiotic stress) (Aeron *et al.*, 2011; Glick, 2014; Jha *et al.*, 2011; Ramos-Solano *et al.*, 2008).

A siderophore deficit results in severe metabolic changes since it serves as a cofactor in several enzymes necessary for vital physiological functions like respiration, photosynthesis, and nitrogen fixation. Although soils contain a lot of iron, neither plants nor soil microorganisms can always access it. Fe^{+3} is the chemical species predominantly in an oxidized state, which interacts to produce insoluble oxides and hydroxides that are inaccessible to plants and microorganisms. Some rhizospheric bacteria have the capacity to release iron-chelating compounds into the rhizosphere, which serve to draw iron to the rhizosphere where it may be absorbed by the plant (Payne, 1994). According to Shen *et al.* (2013), siderophore-producing rhizobacteria enhance plant health in a variety of ways, including by enhancing iron nutrition, inhibiting the growth of other microorganisms through the release of their antibiotic molecule, and limiting the iron available for pathogens.

The generation of cell wall-degrading enzymes is

one of the primary strategies utilized by biocontrol agents to control soil-borne diseases (Chet *et al.*, 1990; Kobayashi *et al.*, 2002). By destroying their cell wall, cell wall-degrading enzymes such as 1,3-glucanase, chitinase, cellulase, and protease released by biocontrol strains of PGPR have a direct inhibitory effect on the hyphal development of fungal pathogens. The primary building block of the fungal cell wall, chitin, an insoluble linear polymer of -1, 4-N-acetyl-glucosamine, is broken down by chitinase. The structural integrity of the target pathogen's walls is impacted by rhizobacteria's cell wall-degrading enzymes (Budi *et al.*, 2000). Thus, the PGPR's ability to produce these enzymes qualifies them as biocontrol agents for fungi.

Antibiotic-producing pathogenic microorganisms are actively suppressed by PGPRs from the *Bacillus* and *Pseudomonas* genera. These *Bacillus*-genus bacteria generate a wide range of antibiotics that are both antibacterial and antifungal. Others, including bacilysin, chlorotetain, mycobacillin, rhizotocins, bacillaene, difficidin, and lipopeptides belonging to the surfactin, iturin, and fengycin families, are formed by non-ribosomal peptide synthetases (NRPSs) and/or polyketide synthases (PKS) (Leclerc *et al.*, 2005). Numerous antibacterial and antifungal antibiotics are produced by the model organism *B. subtilis* and the plant root colonizing *B. amyloliquefaciens*. PGPR can also break down toxins generated by pathogens that live in the soil and by roots (Dutta and Podile., 2010).

Induced systematic resistance (ISR) offers a different approach to disease protection for plants. ISR, as defined by van Loon *et al.* (1998), is the process whereby PGPR treatment of plants results in host defense as demonstrated by a decrease in the severity or incidence of illness caused by pathogens that are geographically isolated from the inducing agent. While pseudobactin siderophores generated by *Pseudomonas* strains are known to elicit systemic resistance in carnation, radish, and *Arabidopsis*, they also do so in tobacco and *Arabidopsis*. *Pseudomonas pseudomanine*, a different kind of siderophore, stimulates the radish to manufacture salicylic acid, hence boosting the plant's defense (Van Loon and Bakker, 2006). As a result, rhizobacteria in plant roots induce the production of a signal that travels throughout the plant and strengthens the ability of distant tissues to fend off pathogen infections in the event that they do occur (Thakker *et al.*, 2013).

The precursor to the phytohormone ethylene is deaminase-1-aminocyclopropane-1-carboxylic acid (ACC). Although ethylene is naturally generated by plants, it is drastically increased in response to abiotic

conditions such as drought, salt, or water floods (Etesami *et al.*, 2015; Jha and Saraf, 2015). Abiotic stress causes plants to produce greater amounts of ACC, which is then broken down by bacterial ACC deaminase into ammonia and ketobutyrate, preventing the formation of ethylene. By generating ACC deaminase, PGPR shields plants under abiotic stress from the negative effects of ethylene (Glick, 2014). ACC deaminase-producing PGPR can guard plants from stress brought on by environmental factors such as high temperatures, water inundation, UV rays, and heavy metals (Mayak *et al.*, 2004; Ali *et al.*, 2012; Glick, 2014).

Biocontrol activities

According to Guo *et al.* (2013), a number of phytopathogens cause severe illnesses in crops and lower agricultural production. An efficient way to cure plant illnesses in an environmentally acceptable way without endangering the environment is through biocontrol of phytopathogens, which uses natural organisms (Compant *et al.*, 2005; Fatima *et al.*, 2009). Therefore, using biocontrol looks like a more advantageous and lucrative strategy than using synthetic chemicals. PGPR's biological management of phytopathogens is beneficial to both contemporary and traditional agriculture. PGPR exhibit a range of biocontrol activities against phytopathogens, including nutrient competition, antagonistic production of metabolites (antibiotics, hydrolytic enzymes, cyanide, and siderophores), and induction of systemic resistance (Siddiqui, 2006; Lugtenberg and Kamilova, 2009; Ramyasmruthi *et al.*, 2012; Mishra *et al.*, 2017). In addition to being particularly effective in controlling phytopathogens, the aforementioned processes also work in concert to help plants fend off pathogens (Jha *et al.*, 2011).

Abiotic Stress Management

According to Grayson (2013), abiotic stressors are the main factors limiting both the yield of crops and soil quality. According to Lugtenberg and Kamilova. (2009) and Egamberdieva (2012), PGPR can assist plants in coping with a variety of challenges and reducing their negative effects. According to Nadeem *et al.* (2010) and Tewari and Arora (2015), stress-tolerant PGP inoculants are efficient instruments for boosting crop output in unfavorable conditions. According to several researchers, applying PGPR to stressed soils lowers their negative impacts by controlling the synthesis of several metabolites such as phytohormones, antioxidants, enzymes, and EPS (Raghavendra *et al.*, 2010; Kong *et al.*, 2014; Arora and Mishra, 2016). It is well recognized that EPS generation may be a characteristic of reducing salt stress. By promoting osmotolerance activity, EPS generation by rhizobacteria aids in the effective survival of plants under

salt stress in rhizospheric soil (Grover *et al.*, 2010; Upadhyay *et al.*, 2011). According to Roberson and Firestone (1992) and Paul and Lade (2014), EPS generation by salt-tolerant PGPR leads to high soil particle accumulation around plant roots with high water retention activity and nutrients, which promotes plant development in saline soil. As a result of this activity, the metabolic and physiological characteristics of crops and soils both improve, increasing agricultural yield and quality. In order to lessen the negative impacts of temperature on plants, cold- and heat-tolerant PGPR are now being employed (Hoflich and Kuhn., 1996; Meena *et al.*, 2015). According to Glick (2004), drought is another significant stressor on agricultural output. Several drought-tolerant PGPR, such as *Azotobacter*, *Azospirillum*, *Bacillus*, *Rhizobium*, and *Serratia*, can reduce drought stress (Vurukonda *et al.*, 2016). According to Normile (2008), flooding is one of the main abiotic factors that inhibit crop development. By utilizing bacteria that can withstand osmotic stress, Chakraborty *et al.*, (2013) showed that wheat crops may be grown with good yields and less water stress. Similar to this, Tewari and Arora (2016) investigated the impact of flooding stress on soybean output and how PGPR may be used to mitigate such effects. Compared to creating stress-tolerant crops, Tewari and Arora (2013) contend that using microorganisms to reduce soil abiotic stressors is more advantageous and practical. Today, PGPR is employed as an effective and affordable strategy to reduce soil stressors (Batool *et al.*, 2014; Gontia-Mishra *et al.*, 2016).

Soil Renovation

According to estimates, soil erosion and degradation issues are now wasting a significant amount of land around the world. Out of the 5.2 billion hectares of dryland agriculture on the globe, 3.6 billion ha are reportedly impacted by the 145 issues of erosion and soil degradation (Koyro *et al.*, 2012) The interaction of many biotic and abiotic elements determines the characteristics of the soil and its fertility. According to Griffiths and Philippot (2012) and De Souza *et al* (2015), microbial community activity, richness, and variety are important indicators of soil fertility. Microbial load and nutrients are extremely low in low-quality pollutant-contaminated soil, and PGPR inoculation enhances both physicochemical and biological qualities (Sahoo *et al.*, 2013; Bhardwaj *et al.*, 2014). Due to their high sensitivity, tolerance, and sequestration capacity, microorganisms have emerged as an effective option for bioremediation (Burd *et al.*, 2000; Amora-Lazcano *et al.*, 2010). Several approaches have been developed for pollutant removal. For plants to develop as natural vegetation in a polluted site, the role of PGPR in pollutant degradation is particularly beneficial (Pérez-Montao *et al.*, 2014). According to reports (Huang

et al., 2005; Yang *et al.*, 2009), the use of PGPR may be widely implemented for crop enhancement combined with pollutant removal in degrading soils. The removal of pollutants such as pesticides, polyaromatic hydrocarbons, heavy metals, and other hazardous wastes is now being done using this bioremediation method, rhizoremediation (Bhalerao, 2012; Hansda *et al.*, 2014; Bisht *et al.*, 2015). Rhizoremediation process efficiency is influenced by a number of variables, including pollutant type and bioavailability, plant species and diversity, microbial activity, and ambient conditions (Wenzel, 2009). The geo-active action of soil bacteria can primarily eliminate metal pollution from soil (Mishra *et al.*, 2017a). Metal-mobilizing According to Hassan *et al.* (2016) and Mishra *et al.* (2017a), PGPR removes heavy metals from soil and serves a variety of purposes, including enhancing plant development, improving soil quality, and removing metals from soil.

Geographic Information System (GIS) for monitoring of crop improvement using PGPR on crop

Plant growth promoting rhizobacteria (PGPR) have shown significant potential in enhancing crop productivity and revitalizing soil health within the agricultural domain. This positive impact can be systematically analyzed and verified through the application of cutting-edge electronic technologies and database systems. Geographic Information System (GIS) emerges as a real-time solution for precisely evaluating crop nutrient levels and various physiological chemical concentrations. By leveraging remote sensing, a promising alternative to labor-intensive and costly traditional chemical analyses, a comprehensive understanding of these impacts can be achieved. The construction of a GIS database for agricultural utilization necessitates the integration of meteorological data, land use, infrastructure, water resources, pedology, and satellite data processing. This amalgamation of diverse datasets is intricate, but GIS systems are adept at integrating them, facilitating efficient management and online accessibility to geographic information across various models, formats, and maps. The thoughtful design of these maps has led to focused applications that contribute to heightened output efficiency for farmers.

The role of PGPR mechanisms and their impact on crop performance can be effectively observed and comprehended through the implementation of GIS technology. These microorganisms, whether directly or indirectly, influence plant morphology and crop physiology. Changes in plant attributes before and after PGPR application in the plant's rhizosphere are meticulously monitored using GIS-based remote sensing tools. This sophisticated approach allows for an in-depth analysis of the beneficial effects of PGPR microbes within

the agricultural context. Various parameters, techniques, and software tools are employed in the realm of GIS remote sensing (Kumawat *et al.*, 2023), encompassing on Soil parameters, Markov chains, CA-Markov chains, Multi-Criteria Decision Analysis (MCDA), Analytical Hierarchy Process (AHP), Land Use Land Cover (LULC) and Land Surface Temperature (LST), Crop mapping sites, Hyperspectral imaging, Spectral reflectance Mantel test, Investigation through soil samples, 16S rRNA, and sequencing. The studies conducted on all such parameters are listed as below:

Soil parameters

Measurement of soil chemical parameters is the primary task for GIS data analysis, collection of soil should be shallow depth and typically occupy small areas in gaps between rocks and under vegetation area. The Parameters included in soil analysis are total organic carbon, pH, the total contents (%) of N, P_2O_5 , and K_2O , and the concentrations ($mg\ kg^{-1}$) of Cu, Ni, Pb, Cd, Zn, Mn, and Fe. The other variables under studies were sodium adsorption ratio (SAR), chloride concentration (C^-), potential hydrogen (pH), and electrical conductivity. The relative activity of sodium ions in soil exchange processes is expressed by the SAR. This index analyzes how much sodium (Na^{2+}) is present in relation to calcium (Ca^{2+}) and magnesium (Mg^{2+}) (Zaidi *et al.*, 2016). The following equations determine how to compute the index: (1) the inverse distance weighting interpolation (IDW), one of the GIS analytic techniques, has been used to create maps of the geographical distribution of the various parameters under investigation. IDW selects the cell values by combining a collection of sample points that have been linearly weighted. The inverse of distance is the weighting. An area of a location-dependent variable must be interpolated. This technique is predicated on the idea that the effect of the tracer variable diminishes with increasing distance from the sampling site (Philip, 1985; Philip, 1986).

The IDW equation would be

The estimated value of the missing data is denoted by P_0 . P_i is the value of the similar parameter on a specific date at the closest station that is i . D_i is the separation between the station in question and its environs, and n is the count of the closest stations.

Studies on Markovchains

A theory based on stochastic Markov process systems. Markov's capacity to quantify states and conversion rates between land-use categories makes it potentially useful for land-use change modeling (Muller and Middleton., 1994). It is commonly used in geographic research to make predictions about geographic characteristics without

taking into account any secondary impacts (Sang *et al.*, 2011).

$$S(t + 1) = P_{ij} \times S(t)$$

Where P_{ij} is the transition probability matrix and $S(t)$, $S(t + 1)$ are the system's states at time t or time $t + 1$.

Studies on CA-Markovchains

The CA-Markov model combines cellular automata and Markov chains with the goal of introducing spatial elements to temporal elements and special elements to temporal components. In fact, the CA's spatial filter regulates the spatial dynamics via particular local rules, while the Markov chain manages the temporal dynamics between land-use categories (Jenerette and Wu, 2001; Maguire *et al.*, 2005).

The model of cellular automata is expressed by the following equation (Yong *et al.*, 2004) :

$$S(t, t + 1) = f(S(t), N)$$

Where t and $t + 1$ denote the various periods, S is the set of limited and discrete cellular states, N is the cellular field, and f is the rule for changing cellular states in local space.

Study on Multi Criteria Decision-making (MCDA)

MCDA The goal of operations research's multi-criteria decision analysis (MCDA) is to assess several, conflicting criteria while making decisions. These actions include of standardizing, calculating the weights, and summarizing the criteria taken into account during the decision-making process (Souidi *et al.*, 2020).

Studies on Analytical Hierarchy Processing (AHP)

The AHP method is one of the most current and widely used multi-criteria analysis approaches. The approach consists of representing a decision problem by a hierarchical structure reflecting interactions between the various elements of the problem, then making pair-wise comparisons of the elements in the hierarchy, and finally determining priorities for action (Saaty, 2008). The GIS-AHP model is used to analyze the several thematic layers that have been weighted and rated according to the size of the groundwater potential. The AHP is built using a set of pairwise comparison matrices, which rank or weight each criterion by comparing them to the others (Kaliraj *et al.*, 2014; 2017). The AHP method evaluates a comparison matrix, which is frequently used to calculate the geometric mean and normalized weight, by comparing a number of datasets. One of the main benefits of the AHP technique is the incorporation of consistency verification, which computes the consistency ratio to determine the degree of consistency through pairwise comparison. It is determined by dividing the consistency index (CI) by the random index (RI), using the formulas $CI = (\max - n)/(n - 1)$

$-(1)$ and $RI = (0)/0.148 = 0$ $-(2)$. The equations for the aforementioned measurements, Consistency Index (eq. 1) and Random Consistency Index (eq. 2), are based on the set of known values determined via Saaty (1980) techniques. Where 'n' is the overall number of factors and " is the Eigen value. The consistency ratio (CR) value is a key input for running the pair-wise comparison matrix of the AHP approach, and it is deemed to be sufficiently consistent at a value of $/ = 0.1$. If the consistency ratio value is 0, the degree of consistency has been perfectly attained. However, if the CR value significantly surpasses 0.10, the pair-wise comparison matrix calculation must often be reevaluated (Rao and Briz-Kishore, 1991; Prasad *et al.*, 2008).

Studies on Mantel test

This test is used to calculate how temperature affects the diversity of taxa in microbial communities in the rhizosphere. The average temperature geographical differences and the relative abundance of bacterial phyla were compared in pairs in different time interval. The Mantel test was used to compare these two matrices (Pollard, 1982; Legendre *et al.*, 2015). To identify the effect of soil surface temperatures on the compositions of microbial communities, the temperature spatial differences matrix is also compared with the Weighted Unifrac (a α -diversity measure that uses phylogenetic information to compare environmental samples) distance matrix computed for the rhizosphere microbial communities. The United Soil Surface Temperature Influence Index (UTII) for rhizosphere microbial communities, as reported by Miryuta *et al.*, (2019), was calculated using the extreme grouping approach.

Site-specific crop management

Remote sensing applications are widely utilized in agriculture field to enable site-specific crop management. These methods are made possible by hyper spectral imaging, which can capture pictures with spectral data for a variety of light-spectrum wavelengths, notably in the visible and near-infrared (400–1000nm) and shortwave infrared (1000–2500nm) spectral areas (Sankaran *et al.*, 2010). The extension of spectral information to regions of the light spectrum that is undetectable to the human eye is spatially resolved (Huang *et al.*, 2014).

Hyperspectral imaging

In order to enable non-destructive plant phenotyping, it can be employed to alleviate various plant stressors that alter the biochemical composition of leaf tissue (Brugger *et al.*, 2019). Depending on the biotic or abiotic stress, internal leaf structure and pigment composition differ and can produce different spectral signatures (Susic *et al.*, 2018), while chlorophyll and carotenoid pigment content

Table-1 : The different spectral indices utilized in this study are listed below with their formulas, index abbreviations, and references.

Spectral Reflectance Indices	Formula	References
Normalized index based on 780 and 550 nm	$(R_{780} - R_{550}) / (R_{780} + R_{550})$	Gutiérrez et al. (2010)
Normalized index based on 760 and 730 nm	$(R_{760} - R_{730}) / (R_{760} + R_{730})$	Barnes et al. (2000)
Normalized index based on 698 and 420 nm	$(R_{698} - R_{420}) / (R_{698} + R_{420})$	Elsayed et al. (2015a)
Normalized index based on 610 and 424 nm	$(R_{610} - R_{424}) / (R_{610} + R_{424})$	
Normalized index based on 500 and 460 nm	$(R_{500} - R_{460}) / (R_{500} + R_{460})$	

and spatial distribution can be used to detect the presence of leaf diseases (Zhao *et al.*, 2016).

Spectral reflectance measurements

A portable computer and a global positioning system (GPS) are attached to a passive bi-directional reflectance sensor with a bandwidth of 2 nm that measures wavelengths between 302 and 1,148 nm. Two components make up the portable FieldSpec sensor. One uses the light radiation from the diffuser as a reference signal while being connected to it. The outputs of the sensors were co-recorded with the GPS coordinates while gathering data in the field for the second unit, which used an optic fiber to measure the canopy reflectance (Mistele and Schmidhalter, 2008; Elsayed *et al.*, 2015a,b). The real sensor output was co-referenced for each point and recorded. Following that, readings within a plot were averaged to get a single number for each plot, with the use of the spectrometer unit measurements and a calibration factor that was derived from a reference grey standard, the canopy reflectance was computed. Mostly on bright days, nadir measurements of the spectrum were made at a height of 0.75 m or so over the canopy. When fruits and seeds ripened and their primary stems grew longer, readings were taken once.

Land Use Land Cover (LULC), and Land Surface Temperature (LST)

The study area's map is created using Landsat 8 Operational Land Imager (OLI) satellite data, which was captured in 2018 and is freely available through US Geological Survey (USGS) Earth Explorer (<http://earthexplorer.usgs.gov>). Indicated by human activities, which are primarily connected to the occurrence and development of groundwater, land use and land cover refers to the coverage and natural properties of land derived by human activity. The research region is home to many different forms of land use and land cover patterns, which may be broadly categorized as terisand, water bodies, mud land, vegetation, settlements, barren land, and shrub cover. The weighting is determined by the kind of land use, area covered, rate of infiltration, and surface water holding capacity. Due to the weak water holding capacity, agricultural land and water bodies are given a high priority, whereas settlements and arid terrain are

given a low priority. With the aid of IPI2WIN software version 3.0, which provides an automatic interpretation of the data about apparent resistivity, the field data were examined and interpreted. (Bobachev, 2002)

Investigated by soil sample, 16S rRNA and sequencing.

It is the main and important method for identifying the microbes and their population plant rhizospheric soil. For the investigation of microbes from rhizospheric soil samples, first construct the remote sensing map, collect the soil sample and geographical parameters, and then culture those soil microbes in suitable microbial media. Biyyani *et al.*, (2018) reported that they isolated rhizobacteria from the rhizosphere of selected agricultural plants that were chosen at random from the rhizosphere of 22 villages in the Parigi and Doma mandals of Rangareddy district, Telangana state. According to Vidhyasekaran and Rabindran, (1996), carefully selected rice plants were gently plucked, and rhizospheric soil was carefully extracted, labeled, and kept at 4°C. Geographic information system (GIS) software, Arc GIS version 9.3, was used for mapping the processed picture. For digital image processing and analysis of remote sensing data, HP desktop workstations with 4 GB of RAM were employed (Biyyani *et al.*, 2018). The PGPRs were isolated from the processed sample in the flask using the microbial cultured media, LB (Leuria Bertani) media, NB (Nutrient Broth) media, and King's medium B (King *et al.*, 1954), as reported by Vidhyasekaran and Rabindran (1996). According to Bergey's Manual of Determinative Bacteriology (Holt *et al.*, 1994), all the bacterial isolates were examined for their spore production, pigmentation, colony morphology, and cell morphology. The cultivated and selected bacterial DNA was extracted and electrophoresed in a 0.8% agarose gel. Purified DNA was utilized as the template for PCR amplification utilizing 16S rDNA universal primers. The final PCR result is sequenced using shotgun sequencing, and these sequences are then added to the SRA database of the NCBI. The discussed paragraph sheds light on the potential of integrating advanced Geographic Information Systems (GIS) and remote sensing techniques to enhance crop productivity through the analysis of Plant Growth Promoting Rhizobacteria (PGPR) in agriculture.

The utilization of modern electronic applications and database systems has proven to be instrumental in substantiating the positive impact of PGPR on soil health and crop yields. GIS's real-time capabilities allow for accurate assessments of crop nutrient levels and physiological chemical concentrations, while remote sensing provides a viable alternative to conventional chemical analyses.

The construction of a specialized GIS database for agricultural use is highlighted, encompassing a diverse array of datasets including meteorological data, land use, infrastructure, water resources, pedology, and satellite information. The seamless integration of these datasets within GIS facilitates effective data management and online accessibility, ultimately optimizing agricultural output efficiency.

Conclusions

In conclusion, the integration of advanced Geographic Information System (GIS) and remote sensing techniques has unveiled a transformative avenue for comprehensively assessing crop productivity enhancement through Plant Growth Promoting Rhizobacteria (PGPR) analysis in agriculture. This review has illuminated the immense potential of PGPR in revitalizing soil health and boosting crop yields, substantiated by the meticulous utilization of cutting-edge electronic applications and database systems. The real-time capabilities of GIS have provided an accurate and dynamic assessment of crop nutrient status and physiological chemical concentrations, while remote sensing techniques have opened doors to innovative alternatives to traditional chemical analyses. The intricate task of constructing a GIS database for agricultural use, involving diverse datasets such as meteorological data, land use, infrastructure, water resources, pedology, and satellite information, has been addressed through GIS's adept data integration capabilities. The ensuing benefits in terms of management and online access to geographic data, presented in various models and formats, have proven pivotal for enhancing the efficiency of agricultural output.

Moreover, the review has demonstrated how PGPR mechanisms can be understood and observed through the lens of GIS technology. By utilizing GIS-based remote sensing tools, the transformations in plant morphology and crop physiology post-PGPR application have been meticulously monitored, allowing for an in-depth analysis of the positive effects that these beneficial microbes have on agricultural systems. The diverse array of parameters, techniques, and software tools highlighted in this review underscores the multidimensional nature of GIS remote

sensing, enabling comprehensive analyses of soil parameters, land-use changes, decision-making processes, and even microbial populations within the rhizospheric soil. As technology continues to evolve, it is evident that the synergy between advanced GIS and remote sensing techniques will remain at the forefront of agricultural research and practice. This review serves as a guiding light, illuminating the path for scientists, researchers, and stakeholders to further unlock the potential of PGPR-based agricultural innovations and cultivate a more sustainable and productive future.

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