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Effect of Drying Method, Pre-Treatment and Temperature on Physical Properties of Garlic (*Allium sativum* L.)

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Abstract

The present investigation entitled "Effect of Drying Method, Pre-treatment and Temperature on Physical Properties of Garlic (*Allium Sativum* L.)" was conducted at the Post Harvest Technology Laboratory, Department of Horticulture, Rajasthan College of Agriculture and Department of Processing and Food Engineering, College of Technology and Engineering, MPUAT, Udaipur, Rajasthan during August to December, 2022. The study consisted of 2 different drying methods (tray drying, heat pump drying), pretreatments (water blanching, KMS) and different temperatures (50°C, 55°C and 60°C). The experimental design used for this study was completely randomized design with three replications. The various physical observations were also recorded after drying. among different types of drying methods, pre-treatment and temperatures, heat pump drying method pre-treated with KMS at 0.5% at 50°C has maximum dehydration ratio (0.298) and recovery % (29.81). but in case of rehydration ratio (2.97) tray drying method pre-treated with KMS at 0.5% at 55°C found best.

Key words : Tray drying, heat pump drying, KMS, pre-treatment, water blanching.

Introduction

Garlic (*Allium sativum* L.) is a nutritional herbaceous plant belongs to the family Alliaceae. It is known for its medicinal as well as culinary benefits. It is cultivated in temperate as well as tropical climate. The native palace of garlic said to be central Asia and southern Europe, especially the Mediterranean region (Thompson and Kelly, 1957). Garlic has the property of reducing serum cholesterol level. Allicin, which has a hypercholesterolemia action, is present in aqueous extract of garlic and reduces the cholesterol concentration in human blood (Augusti, 1977).

The blood sugar lowering effect of garlic was ascribed to allicin and related disulphide containing compounds. All these findings supported the claim that garlic is beneficial to diabetics. Garlic possesses insecticidal action and repellent property. It inhibits the growth of some bacterial cultures which are resistant to commonly used antibiotics. About 10 per cent dilution of aqueous extract of garlic completely inhibits the bacterial growth. Pretreatment is widely used before drying of agro-products to inactivate enzymes, enhance drying process and improve quality of products. It is an essential step in the processing of food materials (Senadeera *et al.*, 2000). Various methods of pretreatment consist of chemical pretreatment, blanching, and osmotic

dehydration (Ade-Omowaye *et al.*, 2003). Pretreatment can speed up drying rate, improve the quality of dried product, prevent browning, and help retain volatile compounds (Jayaraman and Gupta, 2006). Chemical pretreatment could significantly accelerate the drying process and remarkably improve the quality of dried products such as sweet potatoes, mushrooms, red pepper and plums (Xiao *et al.*, 2009).

Drying is one of the traditional methods of preservation, which converts the vegetables into light weight, easily transportable and storable product. Advantage of this method is that the vegetable can be easily converted into fresh like form by rehydrating it and can be used throughout the year. In addition to increasing variety in the menu, reducing losses, labour and storage space, dehydrated vegetables are simple to use and have longer shelf-life than fresh vegetables along with concentration of nutrients (Chauhan and Sharma, 1993). Air / contact drying, freeze drying, or vacuum drying methods are used to achieve this. Mechanical hot air dryers (tray dryers, tunnel dryers, drum dryers, *etc.*), microwave dryers, solar dryers, freeze dryers, and vacuum dryers are used for drying purposes. Tray dryer is widely used in agricultural drying because of its simple design and capability to dry products at high volume.

Implementing the proper design of a tray dryer system may eliminate or decrease the non-uniformity of drying and, hence, increase its drying efficiency. Heat pump system has been research and developed for different applications and mostly in space heating, cooling and dehumidifying (drying). To improve the performance of the heat pump system, research on modifying heat pump system and combining to other mechanism has been done widely. By improving the development of heat pump dryer will help increase the product quality and reducing operation cost of drying industry (Goh *et al.*, 2011).

Materials and Methods

The experiment was carried out in the Post-Harvest Technology Laboratory of Department of Horticulture, Rajasthan College of Agriculture and Department of Processing and Food Engineering, College of Technology and Agricultural Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan. Fresh garlic were used for this investigation. These were procured from local market. Garlic were sorted on the basis of uniformity in size, shape and colour. For the improvement in colour and shelf life, the garlic cloves were water blanched. The prepared samples were pretreated with chemicals before drying. The ratio of garlic to the pretreatment solution was maintained as 1:5. After soaking, the samples were immediately removed and blotted gently using tissue paper. Then the cloves were weighed again. The experiment included 18 treatments with 3 replications using Completely Randomized Design (CRD).

Moisture content : Moisture content of the sample during experiments at various times was determined on basis of dry matter of sample. Moisture content (%db) during tray drying was calculated (Brooker *et al.*, 1997) as :

$$\text{Moisture content (\% db)} = \frac{W - DM}{DM} \times 100 \dots (3.2)$$

Where,

W = Weight of sample at time , g DM = Dry matter of the sample, g

Drying rate : The moisture content data recorded during experiments were analysed to determine the moisture lost from the samples of garlic in particular time interval. The drying rate of samples were calculated by following equation.

$$\text{Drying rate} = \frac{\text{Amount of water removed (g / g)}}{\text{Time taken in min. Amount of dry matter (g)}}$$

Dehydration ratio : The dehydration ratio of garlic cloves was calculated by measuring initial and final mass of garlic cloves as :

$$\text{Dehydration ratio} = \frac{\text{Weight of dehydrated sample}}{\text{Initial weight of fresh clove}}$$

Rehydration ratio : The dehydrated sample of (2 g each) were soaked in water at room temperature for 25 min and then drained. The drained material was spread on butter paper few minutes to remove adhering water on cloves. The weight of rehydrated garlic cloves was taken. The rehydration ratio (RR) was computed using the equation.

$$RR = \frac{M}{M_o}$$

Where,

RR- Re-hydration ratio

M – Drained weight of rehydrated sample (g)

M_o – Weight of dehydrated sample (g)

Final weight : A sample of 250 g garlic cloves was dried and the final weight of sample at constant drying rate was noted.

Product recovery percent : The weight of fresh garlic at the end of drying obtained from each treatment was noted down and the percentage recovery of dried cloves was calculated by using the following formula :

$$\text{Recovery \%} = \frac{\text{Weight of dried product}}{\text{Weight of fresh product}} \times 100$$

Results and Discussion

Effect of drying methods, pre-treatment and temperatures on moisture content (%) : In Figs. 1 to 6, the impact of pre-treatment, temperatures and drying methods (heat pump and tray drying) on the drying time and moisture content of garlic is depicted. 273.13, 291.49, 278.03, 275.94, 278.26, 276.30, 273.13, 291.01, 281.23, 264.96, 275.41, 274.07, 264.96, 275.22, 273.38, 262.32, 274.13 and 274.82 (%db) were the average initial moisture contents for the garlic samples for tray drying and heat pump drying, respectively. Drying was kept up until the samples constant weight was reached. After drying to constant weight for tray and heat pump drying, the final moisture contents were reduced to 4.07, 4.00, 4.00, 3.97, 4.01, 3.62, 4.05, 4.10, 4.97, 4.39, 4.88, 4.58, 5.03, 4.90, 4.51, 5.14, 4.72, and 5.08 (%db) respectively. Similar results have been reported by Madamba *et al.* (1993) and Sagar (2001) in his experiment of determining the moisture content of garlic slices.

Effect of drying methods, pre-treatment and temperatures on dehydration ratio of garlic : Table 2 shows the impact of various drying techniques, pre-treatments and temperatures on the dehydration ratio of dried garlic. Regardless of drying techniques, it was discovered that the impact of various dryers,

Table-1 : Effect of drying methods, pre-treatment and temperature on moisture content (%db) of garlic.

Treatment	Moisture Content (%db)	
	Before drying	After drying
T ₁ = Tray drying + No pre-treatment (<i>i.e.</i> , control) + 50°C drying temperature	273.13	4.07
T ₂ = Tray drying + No pre-treatment (<i>i.e.</i> , control) + 55°C drying temperature	291.49	4.00
T ₃ = Tray drying + No pre-treatment (<i>i.e.</i> , control) + 60°C drying temperature	278.03	4.00
T ₄ = Tray drying + Water blanching for 3 minutes + 50°C drying temperature	275.94	3.97
T ₅ = Tray drying + Water blanching for 3 minutes + 55°C drying temperature	278.26	4.01
T ₆ = Tray drying + Water blanching for 3 minutes + 60°C drying temperature	276.30	3.62
T ₇ = Tray drying + KMS at 0.5% + 50°C drying temperature	273.13	4.05
T ₈ = Tray drying + KMS at 0.5% + 55°C drying temperature	291.01	4.10
T ₉ = Tray drying + KMS at 0.5% + 60°C drying temperature	281.23	4.97
T ₁₀ = Heat pump drying + No pre-treatment (<i>i.e.</i> , control) + 50°C drying temperature	264.96	4.39
T ₁₁ = Heat pump drying + No pre-treatment (<i>i.e.</i> , control) + 55°C drying temperature	275.41	4.88
T ₁₂ = Heat pump drying + No pre-treatment (<i>i.e.</i> , control) + 60°C drying temperature	274.07	4.58
T ₁₃ = Heat pump drying + Water blanching for 3 minutes + 50°C drying temperature	264.96	5.03
T ₁₄ = Heat pump drying + Water blanching for 3 minutes + 55°C drying temperature	275.22	4.90
T ₁₅ = Heat pump drying + Water blanching for 3 minutes + 60°C drying temperature	273.38	4.51
T ₁₆ = Heat pump drying + KMS at 0.5% + 50°C drying temperature	262.32	5.14
T ₁₇ = Heat pump drying + KMS at 0.5% + 55°C drying temperature	274.13	4.72
T ₁₈ = Heat pump drying + KMS at 0.5% + 60°C drying temperature	274.82	5.08

Table-2 : Effect of drying methods, pre-treatment and temperatures on dehydration ratio, rehydration ratio and recovery (%) of garlic.

Treatments	Dehydration ratio	Rehydration ratio	Recovery (%)
T ₁ = Tray drying + No pre-treatment (<i>i.e.</i> , control) + 50°C drying temperature	0.274	2.53	27.40
T ₂ = Tray drying + No pre-treatment (<i>i.e.</i> , control) + 55°C drying temperature	0.277	2.50	27.72
T ₃ = Tray drying + No pre-treatment (<i>i.e.</i> , control) + 60°C drying temperature	0.275	2.46	27.51
T ₄ = Tray drying + Water blanching for 3 minutes + 50°C drying temperature	0.276	2.71	27.65
T ₅ = Tray drying + Water blanching for 3 minutes + 55°C drying temperature	0.278	2.62	27.89
T ₆ = Tray drying + Water blanching for 3 minutes + 60°C drying temperature	0.275	2.61	27.53
T ₇ = Tray drying + KMS at 0.5% + 50°C drying temperature	0.278	2.49	27.88
T ₈ = Tray drying + KMS at 0.5% + 55°C drying temperature	0.261	2.97	26.12
T ₉ = Tray drying + KMS at 0.5% + 60°C drying temperature	0.275	2.70	27.53
T ₁₀ = Heat pump drying + No pre-treatment (<i>i.e.</i> , control) + 50°C drying temperature	0.279	2.75	27.92
T ₁₁ = Heat pump drying + No pre-treatment (<i>i.e.</i> , control) + 55°C drying temperature	0.276	2.58	27.63
T ₁₂ = Heat pump drying + No pre-treatment (<i>i.e.</i> , control) + 60°C drying temperature	0.279	2.50	27.95
T ₁₃ = Heat pump drying + Water blanching for 3 minutes + 50°C drying temperature	0.275	2.72	27.58
T ₁₄ = Heat pump drying + Water blanching for 3 minutes + 55°C drying temperature	0.274	2.58	27.45
T ₁₅ = Heat pump drying + Water blanching for 3 minutes + 60°C drying temperature	0.282	2.59	28.26
T ₁₆ = Heat pump drying + KMS at 0.5% + 50°C drying temperature	0.298	2.43	29.81
T ₁₇ = Heat pump drying + KMS at 0.5% + 55°C drying temperature	0.281	2.65	28.10
T ₁₈ = Heat pump drying + KMS at 0.5% + 60°C drying temperature	0.280	2.70	28.00
SEm±	0.004	0.04	0.34
CD (P=0.05)	0.012	0.12	0.97
CV	2.695	2.810	2.088

pre-treatments and temperatures on the dehydration ratio of dried garlic was significant. The heat pump drying pre-treated with KMS at 0.5% at 50°C produced the garlic samples with the highest dehydration ratio (0.298) and the tray drying pre-treated with KMS at 0.5 % at 55°C

produced the lowest dehydration ratio (0.261). Shukla *et al.* (2019) provide support for the current findings.

Effect of drying methods, pre-treatment and temperatures on rehydration ratio of garlic : The effect of different drying methods, pre-treatment and

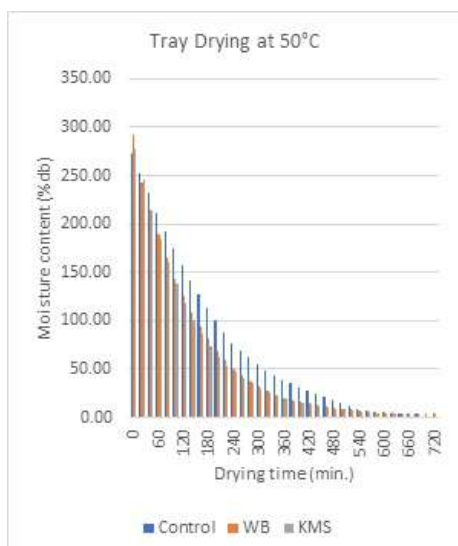


Fig.-1 : Variation in moisture content (%db) with time (min.) for tray drying of dried garlic at 50°C air temperature.

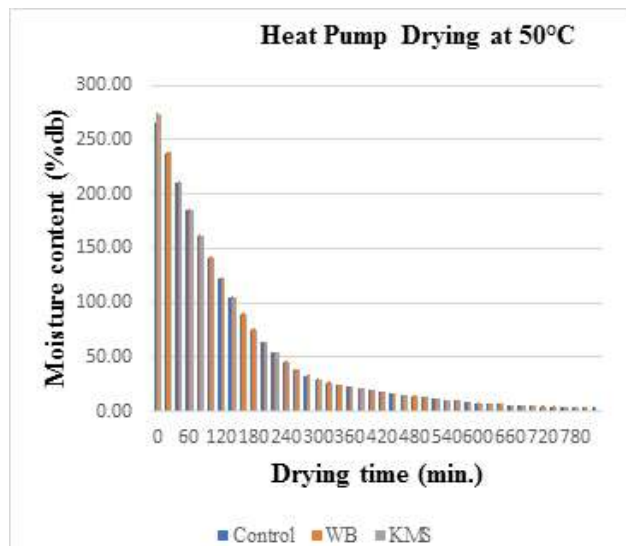


Fig.-4 : Variation in moisture content (%db) with time (min.) for heat pump drying of dried garlic at 50°C air temperature.

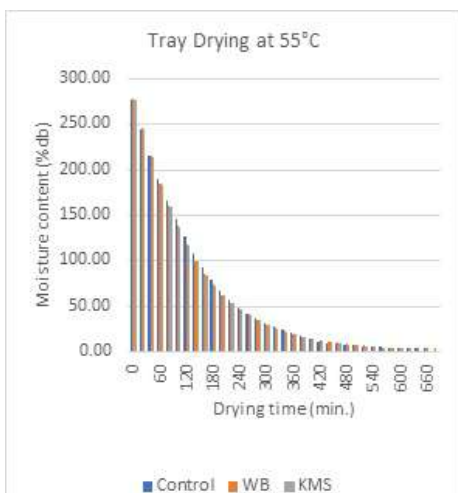


Fig.-2 : Variation in moisture content (%db) with time (min.) for tray drying of dried garlic at 55°C air temperature.

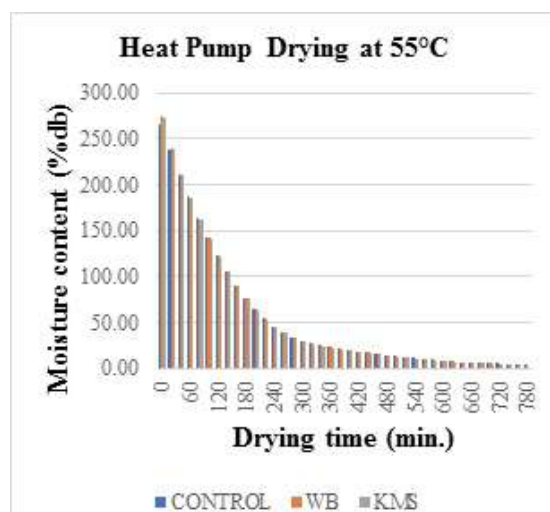


Fig.-5 : Variation in moisture content (%db) with time (min.) for heat pump drying of dried garlic at 55°C air temperature.

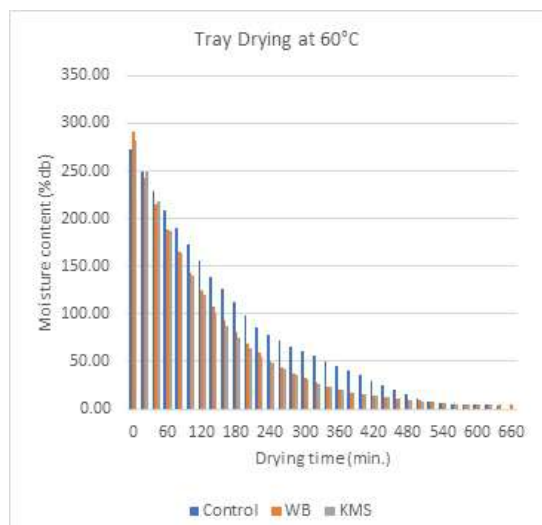


Fig.-3 : Variation in moisture content (%db) with time (min.) for tray drying of dried garlic at 60°C air temperature.

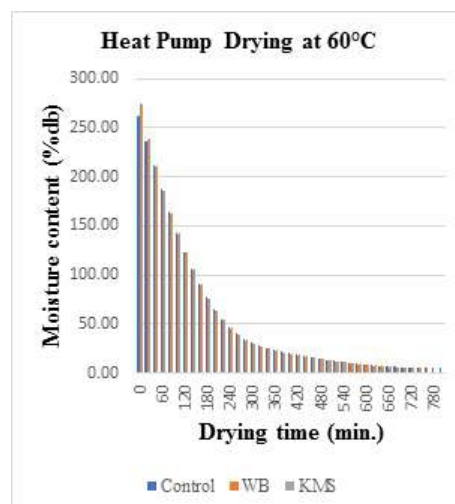


Fig.-6 : Variation in moisture content (%db) with time (min.) for heat pump drying of dried garlic at 60°C air temperature.

temperatures on rehydration ratio of dried garlic is presented in Table-2. The effect of different dryers, pre-treatment and temperatures on rehydration ratio of dried garlic was found significant, irrespective of drying methods. Among the garlic samples superior rehydration ratio (2.97) was found in tray drying pre-treated with KMS at 0.5 % at 55°C and inferior rehydration ratio (2.43) was noticed in heat pump drying pre-treated with KMS at 0.5% at 50°C. These results are obvious and confirmation with the results obtained by Patel *et al.* (2020) and Shukla *et al.* (2019).

Effect of drying methods, pre-treatment and temperatures on recovery (%) of garlic : The influence of various drying techniques, pre-treatments and temperatures on dried garlic recovery (%) is shown in Table 2. Whatever the drying techniques, the effect of different dryers, pre-treatment and temperatures on recovery (%) of dried garlic was found significant. The heat pump drying pre-treated with KMS at 0.5% at 50°C produced the maximum recovery per cent (29.81) of the garlic samples, whereas the tray drying pre-treated with KMS at 0.5% at 55°C produced the minimum recovery per cent (26.12). Khurana *et al.* (1997), Patel *et al.* (2020) and Singh *et al.* (1959) both confirm the current findings.

Conclusion

On the basis of the results of the present investigation entitled “Effect of Drying Method, Pre-treatment and Temperature on Physical Properties of Garlic (*Allium sativum* L.)” it may be concluded that among different types of drying methods, pre-treatment and temperatures, heat pump drying method pre-treated with KMS at 0.5% at 50°C has maximum dehydration ratio (0.298) and recovery % (29.81). but in case of rehydration ratio (2.97) tray drying method pre-treated with KMS at 0.5% at 55°C found best.

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Effect of Dietary Supplementation of Ashwagandha (*Withania somnifera*) on Carcass Characteristics of 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 dietary supplementation of different levels of ashwagandha root powder on carcass traits in 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. In the first treatment (control group, T1) chicks were fed maize and soya bean Deoiled cake basal diet, while ashwagandha root powder was supplemented @ 0.5, 1.0 and 1.5 % in the basal diet in T2, T3 and T4 groups respectively. At the end of the experiment i.e. at 8th weeks of age, carcass characteristics viz. live weight, dressed weight, dressing percentage, eviscerated weight, giblet weight and individual organ as percent of live weight (heart, gizzard or liver) were studied. The live weight (1980 g), dressing weight (1475.50 g), eviscerated weight (1311.50 g) and giblet weight (92.45 g) were found to be significantly ($P<0.05$) higher in dietary group supplemented with ashwagandha powder at 0.5% and it declined at higher level of supplementation, however, it remained higher ($P<0.05$) as compared to control group.

Key words : Ashwagandha, carcass, broiler, eviscerated, vaccinated.

Introduction

The poultry sector was major emerging industry in agriculture. In poultry various species of birds can be reared like chicken, duck, quail, turkey etc. Broilers kept major part in poultry sector followed by duck. Broiler meat and egg is most preferable product of poultry sector. Meat and egg production completely depended on feed. Day by day increasing rate of demand of meat and egg create a pressure on poultry sector to produce more production. Chemical feed additives were used to get better production but it causes harmful effect on birds as well as consumer health. Due to harmful effect of feed additives, herbal and medicinal plants, as feed additive are gaining more popularity as they have many beneficial properties like antimicrobial, antibiotic, immunomodulatory, anticoccidial and antistress that improve production of poultry birds. Many herbal and medicinal plants like ashwagandha, turmeric, tulsi, ginger, garlic, shatavari etc. have been used as feed supplements in poultry feed.

Ashwagandha (*Withania somnifera*) is one of the most valuable plants in Indian tradition system used as a ayurvedic medicine. Ashwagandha is small evergreen shrub that has 4-5 feet tall. It is cultivated on commercial scale, in the states of Rajasthan, Gujarat, Punjab and MP (Krutika *et al.*, 2016). The roots and leaves of ashwagandha are used as drugs due to its anti-oxidative and antistress, anticoccidial, immunomodulatory and antimicrobial properties (Ansari *et al.*, 2013). Hence, due

to these properties ashwagandha improves growth rate and carcass characteristics of poultry birds. The present study was designed to study the effect of ashwagandha root powder at graded levels on carcass characteristics of coloured broiler chicks.

Materials and Methods

Experimental bird and diet : The present study was carried out in poultry farm of Department of Animal Production, Rajasthan College of Agriculture, Udaipur. One hundred sixty day old broiler chicks (coloured broiler) were randomly divided into four treatment groups comprising four replicates of 10 birds each. The dietary treatment included T1- control (maize-50, soya doc-36, dorb-21 kg per 100 kg and premix @ 2.5 kg per tonne) with no feed additive, T2 – basal diet supplemented with ashwagandha powder @ 0.5%, T3 – ashwagandha @ 1% and T4 – ashwagandha @ 1.5% supplemented diet. All the diets were iso-nitrogenous and iso-caloric during the entire experimental period, diets contained 23% and 20% CP and 2800 and 2600 Kcal ME per kg for starter and finisher diets respectively. All the birds were reared in deep litter system with similar management practices except the experimental diet. The birds were vaccinated against Ranikhet and Marek's at the age of 1st and 7th day, respectively. The broilers starter rations were fed from 0-3 weeks followed by finisher ration from 4-8 weeks of age.

Traits studied : At the end of experiment (56 days), 4 birds from each treatment (one bird per replication) was

Table-1 : Carcass parameters of broiler chick diet supplemented with ashwagandha root powder.

Particulars	Treatments				SEm	CD
	T ₁	T ₂	T ₃	T ₄		
Live 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**
Dressed weight (g)	1170.00 ^c ± 76.38	1475.50 ^a ± 30.33	1300.00 ^b ± 12.17	1250.00 ^{bc} ± 6.11	27.83	120.20**
Eviscerated weight (g)	1040.00 ^b ± 30.28	1311.50 ^a ± 51.19	1115.00 ^b ± 23.15	1012.50 ^b ± 6.33	32.96	142.37**
Dressing (%)	73.31 ± 2.24	74.49 ± 1.66	72.14 ± 0.54	73.72 ± 1.08	0.98	NS
Giblet weight (g)	73.76 ^c ± 0.82	92.45 ^a ± 1.86	83.4 ^b ± 1.03	81.54 ^b ± 1.75	1.33	5.75**
Liver (%)	2.16 ± 0.11	2.22 ± 0.08	2.22 ± 0.17	2.23 ± 0.13	0.13	NS
Gizzard (%)	1.83 ± 0.08	1.87 ± 0.05	1.86 ± 0.14	1.94 ± 0.05	0.09	NS
Heart (%)	0.66 ± 0.05	0.58 ± 0.03	0.62 ± 0.04	0.65 ± 0.02	0.03	NS

selected randomly and allowed to fast overnight. Live weights of birds were recorded before slaughtering, birds were bled four minutes following slaughtering and each bird was dipped in hot water bath and feathers were removed manually. After the removal of head, feathers and shank, dressed weight was determined. Eviscerated weight, giblet weight and weight of individual organs (heart, gizzard and liver) were also recorded.

Statistical analysis : The data recorded for evaluation of different treatments were statistically analyzed using standard procedure as suggested by Snedecor and Cochran (1994).

Results and Discussion

The data pertaining to different carcass characteristics of broiler chicks fed ashwagandha root powder is presented in Table 1. The live weight of the birds was significantly ($P<0.01$) highest in T₂ (1980.00 g) as compared to T₁ (1595.00 g) while the live weight in T₃ (1800.00 g) and T₄ (1695.00) groups did not differ with rest of the treatment groups. The dressed weights were significantly highest ($P<0.01$) in T₂ followed by T₃ and lowest in T₁ while the dressed weight in T₄ did not differ with T₁, T₂ and T₃ groups. The eviscerated weight was also significantly higher ($P<0.01$) in T₂ as compared to T₁, T₃ and T₄ which did not differ significantly among themselves. The difference in dressing percentage was found to be statistically non-significant among different treatment groups. The giblet (liver, heart and gizzard) weight was significantly highest ($P<0.01$) in T₂ followed by T₃ and T₄ and lowest in T₁, however the giblet weight in T₃ and T₄ did not differ significantly.

The weight of individual organ expressed as per cent of live weight was also studied. The difference in weights of liver, heart and gizzard as per cent of live weight were found to be non significant.

Singh *et al.* (2017) evaluated the effect of supplementation of ashwagandha and selenium on growth performance and carcass quality of broilers and reported that the inclusion of ashwagandha and selenium in the broiler diet improved carcass parameters. Similar

results were also reported by many researchers (Tayeb and Qader, 2012; Kale *et al.*, 2014 and Tawfeek *et al.*, 2014) and concluded that the supplementation of ashwagandha improved various carcass traits in broilers. Samarth *et al.* (2002) and Pedulwar *et al.* (2007) found that the dietary supplementation of ashwagandha root powder increased the dressing percentage and meat yield of broiler birds.

Conclusion

It may be concluded from present study that the supplementation of ashwagandha root powder in the broiler diet at level of 0.5% was found to be beneficial in terms of improving carcass traits in broiler chicken.

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Effect of Supplementation of Tulsi (*Ocimum Sanctum*) and Ginger (*Zingiber Officinale*) Powder on Cumulative Feed Intake and Feed Conversion Ratio of Japanese Quail (*Coturnix Japonica*)

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Abstract

An experiment was conducted to assess the effect of supplementation of tulsi and ginger on performance of Japanese quails. Two-hundred ten, day old Japanese quails chicks were randomly divided into seven treatment groups with three replications (10 chicks in each replication) for 56 days. The treatment groups consisted of control group (T₁) fed only basal diet, T₂ supplemented with 0.5% tulsi powder, T₃ supplemented with 0.5% ginger powder, T₄ supplemented with 0.25 % tulsi powder + 0.25 % ginger powder, T₅ supplemented with 1 % tulsi powder, T₆ supplemented with 1 % ginger powder and T₇ supplemented with 0.5 % tulsi powder + 0.5 % ginger powder in the diet. Significant effect on feed intake and feed conversion ratio was observed among different groups due to supplementation of feed additives. Significantly lowest feed intake and improved feed conversion ratio ($P < 0.05$) were observed in T₇ group (supplemented with 0.5% tulsi powder + 0.5 % ginger powder) during the period of experiment it could be concluded that 0.5 % tulsi powder + 0.5 % ginger powder supplementation enhance the feed efficiency and feed conversion ratio of Japanese quails.

Key words : Tulsi, ginger, japanese quail, feed conversion ratio, feed efficiency.

Introduction

More than 75% of the overall cost in terms of money in poultry production is spent on feed. Chemical feed additives have been used as growth promoter in poultry since past 50 years. A feed additive is a chemical or mixture of substances, which is used in very small amount other than basal diet, to enhance the quality of feed stuff and the production of birds. To increase production parameter, various antibiotic and chemical compounds are added in feed. If chemicals used in excessive amount then there safe quantity, these substances may have a various negative effects, including stress, toxicity and immunological suppression on birds as well as bad effects on consumer health.. The addition of herbal products to poultry feed not only benefits the health of the birds but also that of the consumer. Supplementation of herbal products in poultry feed not only promote bird health but also health of consumers. Herbs and spices are valuable in feeding in adding flavour to food. In addition to its flavouring property, spices and condiments in poultry products will improve human health because of its antioxidant, antimicrobial and anti-inflammatory properties. Tulsi, ginger, cinnamon, ashwagandha, aloe vera, amla, garlic, moringa etc. are some example of herbal feed additives that are used in present time.

Tulsi (*Ocimum sanctum*), is described as sacred and medicinal plant in ancient literature. It is one of the holiest

and most cherished herbs in our country. Tulsi, as a new class of additives to animal and poultry feeds, have beneficial properties such as anti-oxidant, anti-microbial and anti-fungal, immunomodulatory and anticoccidial effects, which enhance to performance of birds. Ginger (*Zingiber officinale*) is a perennial herb which is used widely as a spice, for pickles, candies, preservatives and many medicinal purposes. The ginger rhizome contains curcumin, gingerol, zingiberene, bisabolone and several other types of lipids that have beneficial effects on birds performance. Therefore, the present study was carried out by supplementation of tulsi and ginger powder as herbal feed additive in Japanese quails.

Materials and Methods

Experimental Birds : The current study was conducted at the poultry farm of department of Animal Production, Rajasthan College of Agriculture, Udaipur. 210, day-old unsexed Japanese quail chicks were randomly divided into seven treatments, 30 chicks in each treatment with three replicates having 10 chicks each. A feeding trial of 56 days was conducted under cage system from august to October, 2022. Housing conditions were (cage system) were same for chicks throughout the experiment.

Experimental Diets : The dietary treatment consists of basal diet T₁ (Control) feeding without additives, T₂ (T₁ + Tulsi powder @ 0.5%), T₃ (T₁ + Ginger powder @ 0.5%), T₄ (T₁ + Tulsi powder @ 0.25% + Ginger powder @ 0.25

%), T₅ (T₁ + Tulsi powder @ 1 %), T₆ (T₁ + Ginger powder @ 1 %) and T₇ (T₁ + Tulsi powder @ 0.5% + Ginger powder @ 0.5%). The compounded feed was formulated as per the recommendation of NRC, 1994. The feed of Japanese quails contained 24% crude protein and 2900kcal/kg ME.

Observations recorded : Daily feed consumption of each replication was recorded daily and average feed intake in gram/chick/day was calculated by total amount of feed consumed in that day, divided by the number of chicks in particular replication. The daily data were converted into average weekly figures by using a factor of 7. The weekly gain in weight and weekly feed intake was used to calculate the weekly feed conversion ratio by using the following formula.

$$\text{Feed conversion ratio} = \frac{\text{Feed consumption per bird per week (g)}}{\text{Body weight gain per bird per week (g)}}$$

Statistical Analysis : Data collected during the present investigation were subjected to statistical analysis by adopting appropriate methods of analysis of variance as described by Snedecor and Cochran (1994). Probabilities values of less than 0.05 ($P < 0.05$) were considered significant.

Results and Discussion

The cumulative feed intake (g/bird) and feed conversion ratio of Japanese quail reared from day-old to eight weeks of age as influenced by supplementation of tulsi and ginger powder are presented in Table-1.

Significant effect on feed intake was observed among different treatments throughout the study period. Among the supplemented groups, it was observed that the mean cumulative feed intake (g) decreased on feeding of tulsi and ginger powder in birds. At eight weeks of age, the group T₁ recorded higher feed intake (777.63 g) followed by T₂ (747.91 g), T₃ (747.49 g), T₅ (744.45 g), T₆ (743.72 g), T₄ (738.87 g) and lowest in T₇ (723.44g). The difference among T₂, T₃, T₅ and T₆ was found statistically non-significant.

Table-1 : Cumulative feed intake (g/bird) and feed conversion ratio of Japanese quail reared for 8 weeks of age as supplemented by tulsi and ginger powder in the feed.

Treatment groups	Cumulative feed intake (g/bird)	Cumulative feed conversion ratio
T ₁	777.63 ^a ± 2.11	3.15 ^a ± 0.05
T ₂	747.91 ^b ± 1.14	2.90 ^b ± 0.05
T ₃	747.49 ^b ± 1.19	2.93 ^b ± 0.04
T ₄	738.87 ^c ± 1.36	2.67 ^c ± 0.04
T ₅	744.45 ^b ± 1.50	2.89 ^b ± 0.04
T ₆	743.72 ^b ± 1.37	2.90 ^b ± 0.05
T ₇	723.44 ^d ± 1.46	2.44 ^d ± 0.05

Figures bearing different superscript in a column differ significantly ($P < 0.05$) from each other

The results revealed that there was significant difference in feed conversion ratio between the treatment groups. The cumulative feed conversion ratio was significantly lowest in T₇ (2.44) and highest in control group T₁ (3.15). It was observed that the feed conversion ratio was improved with supplementation of tulsi and ginger powder.

Similarly, Luqman *et al.* (2021) conducted studies to evaluate neem and tulsi supplementation on growth performance parameters of Japanese quail. They found that the feed intake decreased with the level of supplementation of the tulsi leaves in the basal diet. Shende *et al.* (2021) evaluated the effect of dietary supplementation of tulsi (*Ocimum sanctum*) leaf and ginger (*Zingiber officinale*) powder as feed additives on broiler performance and reported that feed intake was significantly decreased with level of supplementation of tulsi and ginger in alone and in combination as compared to control group. This confirms the results of present investigation.

The results of the present study are in close agreement with the findings of Shende *et al.* (2021) who reported the feed conversion ratio of broiler improved with supplementation of tulsi and ginger in alone and in combination. Naeen *et al.* (2021) also observed that the increasing levels of tulsi in diet improved FCR in Japanese quails. Rahman *et al.* (2015) conducted the study to determine the effects of neem leaf and ginger extracts as a growth promoter in broilers and concluded that feeding of neem leaf and ginger extract improved FCR and feed efficiency in broilers. However, Eltazi (2014) studied the response of broiler chicks to containing mixture of garlic and ginger powder as a natural feed additive and reported that the mixture of garlic and ginger powder improved FCR in birds. These reports are in agreement with the findings of present study.

Conclusion

From the results, it may be concluded that feeding of 0.5% tulsi + 0.5% ginger powder supplementation is beneficial in improving feed efficiency and feed conversion ratio of Japanese quails.

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Socio-Economic Status of Dairy Farmers of Chittorgarh District of Rajasthan

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Abstract

Dairy farming plays an important role in social and economic livelihood of the Chittorgarh dairy farmers. The present study was conducted in Chittorgarh district of Rajasthan. Three tehsils (Dungla, Badi Sadri, Chittorgarh) were selected from district. Two villages were selected from each tehsil and from each village 30 respondents who possess minimum five dairy animals were selected randomly. The data was collected from 180 dairy farmers with the help of a well- structured pre-tested interview schedule by personal interview. The collected data were analyzed by using simple statistical methods like frequency, percentage, mean, standard deviation. The results indicate that majority (66.11%) of the Chittorgarh dairy farmers belonged to middle age group followed by old age (22.78%), young age (11.11%) group, 71.66 per cent of them educated up to primary level and 47.22 per cent from them belonged to OBC category followed by ST (30.0%), SC (12.22%), General (10.56%). Majority (80.56%) of Chittorgarh dairy farmers had medium annual income, majority (79.44%) of dairy farmers had agriculture plus animal husbandry as main occupation.

Key words : Chittorgarh dairy farmers, age, income, occupation, education.

Introduction

Dairy farming plays a pivotal role in the economy of our country. It helps in augmenting food supply, generating employment and raising nutritional level. Indian dairy represents one of the largest and fastest growing sectors. Dairy enterprise is a solution to many problems of agricultural, besides being an effective tool to improve socio-economic condition of rural income to farmer. India possesses 535.8 million of total livestock population with an increase of 4.6% over the 2012 livestock census. The total number of cattle in the country is 192.5 million, showing an increase of 0.8% over the previous Census. The total buffaloes in the country are 109.9 million and showing an increase of about 1.1% over previous Census (20th livestock Census, G.O.I -2019). India has emerged as the largest producer of milk with 20.17 per cent share in total milk production in the world. Milk production during 2020-21 and 2021-22 is 210.0 million tonnes and 221.1 million tonnes respectively showing an annual growth of 5.29 per cent (DAHD, 2021-22). Among the livestock products, milk consists of the highest share, and it accounted for 67.20 per cent of the livestock sector in 2017. Moreover, milk and milk products contributed more than 20.60 per cent of the combined output of paddy, wheat and pulses in 2017. Annually, 8.4 million farmers depend on the dairy sector for their livelihoods, out of which 71 per cent are women (Agriculture Skill Council of India). In India today, there are more than 32,000 cooperatives that are led by women and around 17 million farmers are members of the country's 1,860 village-level cooperatives. In India, small farmers who follow mixed

farming systems are mostly responsible for milk production. In this case, studying the socio-economic characteristics of dairy farmers would offer guidance in creating dairy development strategies to enhance their standard of living.

Materials and Methods

Dairy farming plays a very important role in the economy and in the socio-economic development of the agrarian country like India. The study was conducted in the Chittorgarh district of Rajasthan. Three tehsils (Dungla, Badi Sadri, Chittorgarh) were selected from district. Two villages were selected from each tehsil and from each village 30 respondents who possess minimum five dairy animals were selected randomly. The data was collected from 180 dairy farmers with the help of a well- structured pre-tested interview schedule by personal interview. The collected data were analyzed by using simple statistical methods like frequency, percentage, mean, standard deviation.

Results and Discussion

Age : Age is an important factor, which determines the role of farmers in adoption of improved practices. The distribution of the dairy farmers according to the age was ascertained and has been presented in Table-1. which revealed that (66.11%) of respondents were in middle age group followed by old age (22.78%) and young age (11.11%) group. The average age of the dairy farmers in the study area was 47.63 years. The average age of the dairy farmers in the study area was very high (47.36 years) and it might be due to the reason that they were

Table-1 : Socio economic status of the dairy farmers. (n = 180)

S. No.	Variables	Categories	Frequency	Percentage
1.	Age	Young age (up to 34 years)	20	11.11
		Middle age (34 to 59 years)	119	66.11
		Old age (Above 59 years)	41	22.78
2.	Caste	SC	22	12.22
		ST	54	30.00
		OBC	85	47.22
		General	19	10.56
3.	Education	Illiterate	28	15.56
		Primary	129	71.66
		Secondary	11	6.11
		Sr. Secondary	7	3.89
4.	Occupation	Graduation & above	5	2.78
		Animal husbandry alone	10	5.56
		Agriculture + Animal husbandry	143	79.44
		Govt. job	3	1.67
		Other occupation	24	13.33
5.	Annual income	Low (<46000)	17	9.44
		Medium (46000-166000)	145	80.56
		High (166000)	18	10.00

involved in dairying and agriculture since their childhood and it was also their livelihood activity since their childhood. The present results are well supported by the findings of Dhaka *et al.* (2011) and Sharma *et al.* (2012) who also observed that the majority of the animal owners were from middle age group followed by old age and young age.

Caste : Distribution of farmers according to their caste is presented in Table 1. The results revealed that about 47.22 per cent of the dairy farmers belongs to OBC, followed by ST (36.84%), SC (12.22%) and General (10.56%). In the study area the majority of the respondents were OBC, it may be due to, the area selected for the research (study) was highly populated with concerned category. The present findings are in agreement with the findings of Ashwar *et al.* (2011) who reported that majority (60.83%) of the respondents of north Gujrat belonged to Other Backward Caste (OBC), followed by 22.92, 12.50 and 3.75 per cent belonged to non-reserve category, SC and ST category, respectively.

Education : Formal education increases the problem-solving capacities of an individual. It helps to broaden the outlook of a person and is important in determining his attitude towards the development. The results revealed that 71.66 per cent of the dairy farmers were educated up to primary level, followed by illiterate (15.56%), Secondary (6.11%), Sr. Secondary (3.89%) and Graduation & above (2.78%). Similar findings were reported by Meena *et al.* (2012) where, highest (50.34%) respondents were studied up to 5th standard (primary) followed by illiterate (26.00 %), 13.00 per cent educated up to 8th standard and only

few farmers had secondary and higher educational qualification.

Occupation : It could be depicted from Table-1 that, majority (79.44%) of dairy farmers were having main occupation as agriculture + animal husbandry, followed by Other occupation (13.33%), animal husbandry alone (5.56%) and only 1.67 per cent of dairy farmers were having Govt. job as main occupation. Similar findings were observed by Sabapara *et al.* (2014) who reported that 61.67 per cent of respondents had agriculture and animal husbandry as their livelihood while 14.33 per cent had only animal husbandry as their livelihood. Above findings are supported by the study of Kotresh Prasad *et al.* (2017) who had reported that the main source of income for 80 percent of the farmers was agriculture which included livestock farming.

Annual income : Annual income refers to the total amount of money earned from different sources *i.e.*, from agriculture, dairy etc. in a year. The average annual income of the dairy farmers was 78,185 rupees. Table 1 revealed that, the majority (73.34%) of the dairy farmers were having medium level of annual income, followed by low level of annual income (18.33%). Whereas, 8.33 per cent of the dairy farmers were having high level of annual income. Low level of the size of land holding and the poverty might be the reason for medium level of annual income of the dairy farmers in the study area. These results were similar to the findings as reported by Manivannan *et al.* (2009) who stated that majority (62.0%) of dairy farmers belong to medium annual income group. Above findings are supported by the study of Meena *et al.*

(2017) who reported that most of the respondents belonged to medium income category.

Conclusions

From the results of the study, it can be concluded that majority of the dairy farmers in the study area are belonged to middle age group, OBC caste, studied up to primary level and had medium annual income. Hence this study clearly shows that there is a need of educational / training programmes to dairy farmers in the study area for improving of their livestock management and livelihood activity.

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Socio-Economic Status of Dairy Farmers of Udaipur District of Rajasthan

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Abstract

Dairy farming plays an important role in social and economic livelihood of the Udaipur dairy farmers. The present study was conducted in Udaipur district of Rajasthan. Four tehsils (Mavli, Vallabh Nagar, Kotra and Jhadol) were selected from district. Four villages were selected from each tehsil and from each village 10 respondents who possess minimum five dairy animals were selected randomly. The data was collected from 160 dairy farmers with the help of a well-structured pre-tested interview schedule by personal interview. The collected data were analyzed by using simple statistical methods like frequency, percentage, mean, standard deviation. The results indicate that majority (65.62%) of the Udaipur dairy farmers belonged to middle age group followed by old age (21.25%), young age (13.13%) group, 27.50 per cent of them educated up to primary level and 60.00 per cent from them belonged to OBC category followed by ST (10.63%), SC (16.25%), General (13.12%). Majority (50.63%) of Udaipur dairy farmers had low annual income, majority (66.25%) of dairy farmers had agriculture plus animal husbandry as main occupation.

Key words : *Udaipur dairy farmers, age, income, occupation, education.*

Introduction

Dairy farming plays a pivotal role in the economy of our country. It helps in augmenting food supply, generating employment and raising nutritional level. Indian dairy represents one of the largest and fastest growing sectors. Dairy enterprise is a solution to many problems of agricultural, besides being an effective tool to improve socio-economic condition of rural income to farmer. Total milk production in the country during 2021-22 was 221.06 million tonnes. In the year 2021-22, the milk production has registered an annual growth rate of 5.29%. Top five milk producing States are Rajasthan (15.05%), Uttar Pradesh (14.93%), Madhya Pradesh (8.06%), Gujarat (7.56%) and Andhra Pradesh (6.97%). The per-capita availability of milk is 444 gram/day during 2021-22, which was increased by 17 gram/day over previous year. In 2020-21, the share of Livestock at constant prices in Agriculture Sector and total GVA was 30.13% and 4.9% respectively. As per the figures of 20th livestock census, India has over 535.78 million total livestock population in 2019 and out of which cattle population of India is 192.49 million which contribute, around 35.94 per cent of the livestock population. The buffalo population of India is 109.85 million which accounts for 20.45 per cent of livestock population. Among the livestock products, milk consists of the highest share, and it accounted for 67.20 per cent of the livestock sector in 2017. Moreover, milk and milk products contributed more than 20.60 per cent of the combined output of paddy, wheat and pulses in 2017. Annually, 8.4 million farmers depend on the dairy sector for their livelihoods, out of which 71 per cent are women

(Agriculture Skill Council of India). In India today, there are more than 32,000 cooperatives that are led by women and around 17 million farmers are members of the country's 1,860 village-level cooperatives. In India, small farmers who follow mixed farming systems are mostly responsible for milk production. In this case, studying the socio-economic characteristics of dairy farmers would offer guidance in creating dairy development strategies to enhance their standard of living.

Materials and Methods

Dairy farming plays a very important role in the economy and in the socio-economic development of the agrarian country like India. The study was conducted in the Udaipur district of Rajasthan. Four tehsils (Mavli, Vallabh Nagar, Kotra, Jhadol) were selected from the district. Four villages were selected from each tehsil and from each village 10 respondents who possess minimum five dairy animals were selected randomly. The data was collected from 160 dairy farmers with the help of a well-structured pre-tested interview schedule by personal interview. The collected data were analyzed by using simple statistical methods like frequency, percentage, mean, standard deviation.

Results and Discussion

Age : Age is an important factor, which determines the role of farmers in adoption of improved practices. The distribution of the dairy farmers according to the age was ascertained and has been presented in Table 1. which revealed that (65.62%) of respondents were in middle age group followed by old age (21.25%) and young age

Table-1 : Socio economic status of the dairy farmers (n = 160).

S. No.	Variables	Categories	Frequency	Percentage
1.	Age	Young age (up to 34 years)	21	13.13
		Middle age (34 to 60 years)	105	65.62
		Old age (Above 60 years)	34	21.25
2.	Caste	SC	26	16.25
		ST	17	10.63
		OBC	96	60.00
		General	21	13.12
3.	Education	Illiterate	57	35.62
		Primary	44	27.50
		Secondary	42	26.25
		Sr. Secondary & above	17	10.63
4.	Occupation	Animal husbandry alone	11	5.56
		Agriculture + Animal husbandry	106	79.44
		Labour	35	1.67
		Services (Govt./private)	8	13.33
5.	Annual income	Low (< Rs.1,50,00)	81	50.63
		Medium (Rs.1,50,000-2,50,000)	27	16.87
		High (> Rs.2,50,00)	52	32.50

(13.13%) group. These results indicated that middle aged farmers taking up dairying as income generating activity as they are more capable physically and could shoulder more family responsibilities. Another factor is that labour and skill are not properly preferred in both the young and old age groups in both the survey areas. The present results are well supported by the findings of Shankar *et al.* (2019) who reported that majority of respondents in the Palakkad district area belonged to middle and old ages.

Caste : Distribution of farmers according to their caste is presented in Table-1. The results revealed that about 60.00 per cent of the dairy farmers belonged to OBC, followed by ST (10.63%), SC (16.25%) and General (13.12%). In the study area the majority of the respondents were OBC, it may be due to the area selected for the research (study) was highly populated with concerned category. The results of the present study are similar to that reported by Mahesh *et al.* (2020) who found that 61.00 per cent of the dairy farmers were from OBC category followed by 24.00 and 15.00 per cent from SC/ST and general category, respectively. Similar results were reported by Aulakh *et al.* (2011).

Education : The results revealed that 27.50 per cent of the dairy farmers were educated up to primary level, followed by illiterate (35.62%), Secondary (26.25%), Sr. Secondary (3.89%) and Graduation & above (10.63%). It is evident from the results that, majority of farmers had middle to low income and their financial condition did not allow to avail higher education due to lack of educational institutes and so far from residence hence, the said results were obtained. Similar results were reported by the Khode

et al. (2009) in hills of Himachal Pradesh, who reported that majority of respondents and their family members received education up to primary school level.

Occupation : It could be depicted from Table 1 that, majority (66.25%) of dairy farmers were having main occupation as agriculture + animal husbandry, followed by labour (21.87%), animal husbandry alone (6.88%) and only 5.00 per cent of dairy farmers were having Govt. job as main occupation. Similar findings were observed by Sabapara *et al.* (2013) who reported that 61.67 per cent of respondents had agriculture and animal husbandry as their livelihood while 14.33 per cent had only animal husbandry as their livelihood. Similar findings were obtained by Eyazhini *et al.* (2021) who found that 29 per cent of the respondents had agriculture + livestock as their main occupation. A very minimal per cent of the respondents (5.00 per cent) were having livestock farming alone as their main occupation.

Annual income : Annual income refers to the total amount of money earned from different sources *i.e.*, from agriculture, dairy etc. in a year. The average annual income of the dairy farmers was 1,50,000- 2,50,000 rupees. Table 1 revealed that, the majority (50.63%) of the dairy farmers were having low level of annual income, followed by high level of annual income (32.50%). Whereas, 16.87 per cent of the dairy farmers were having medium level of annual income. Low level of the size of land holding and the poverty might be the reason for low level of annual income of the dairy farmers in the study area. The present results are in agreement with the

findings of Meena *et al.* (2017) who reported that most of the respondents belonged to low income category.

Conclusions

The study revealed that middle-aged farmers dominate the dairy farming sector, likely due to their physical capabilities and family responsibilities. The majority of dairy farmers belonged to the OBC caste, while education levels were generally low, with limited access to higher education. Agriculture combined with animal husbandry was the main occupation for most farmers, and their annual income was largely low, likely influenced by small landholdings and overall poverty levels. These findings provide valuable insights for targeted interventions to improve dairy farming practices and livelihoods in similar contexts.

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Occurrence and Distribution of Root-Knot Nematode, *Meloidogyne javanica*, Dausa and Tonk District of Rajasthan

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Abstract

Chickpea (*Cicerarietinum* L.) is one of the important pulse crop grown in India. Root-knot nematode, *Meloidogyne javanica* is widely distributed in India. It has been found frequently associated with pulses and responsible for severe economic losses. Considering the economic importance of root-knot nematode as disease causing organism of chickpea, the present investigation was carried out to know per cent occurrence of root knot of chickpea in Dausa and Tonk district of Rajasthan. A survey was carried out during Rabi season 2021-22 from January to March months. Total 280 soil and root samples were collected from 17 localities in Dausa and Tonk of Rajasthan. The results observed during survey showed that chickpea is susceptible to the attack of root-knot nematode. The results indicate that the 100% infection of root-knot nematode was recorded in 3 localities i.e., Ramgarh Pachwara, Barh Barwa and Beechha.

Key words : Chickpea, nematode, *Helicotylenchus* spp., *Pratylenchus* spp. and *Tylenchorhynchus* spp.

Introduction

Chickpea (*Cicerarietinum* L.) is a nutritionally rich cool season pulse crop that plays an important role in ensuring global food security, as it is an important source of dietary protein. Chickpea also plays an important role in farming systems by fixing atmospheric nitrogen, contributing to soil fertility, acting as a disease break and controlling weeds. Apart from India, Australia (12.35%) Myanmar (3.25%) and Ethiopia (2.92%) are the major chickpea producing countries of the world (Sumriti *et al.*, 2020)(1). In India, chickpea is grown on residual moisture with low input management by resource poor farmers (Singh and Reddy, 1991)(2). The world average chickpea yield is less than 1 t/ha which is far less than the potential yield of 6 t/ha under favorable and irrigated conditions (Varshney *et al.*, 2017)(3). This enormous disparity between the actual and expected yield of chickpea is due to biotic stresses, caused by insects, bacteria, fungi, nematodes and viruses and abiotic stresses, such as drought, nutrient deficiencies, salinity and chilling (Roorkiwal *et al.*, 2016)(4). Application of a nematicide is required in each growing Globally, the loss of chickpea productivity due to plant parasitic nematodes is estimated to be 14 per cent (Sasser and Freckman, 1987)(5). Important elements for effective integrated management of plant parasitic nematodes in cropping systems include (a) correct diagnosis of the nematode species, (b) effective rotations with non-hosts or fallow periods and (c) use of tolerant and resistant crop cultivars (Thompson *et al.*, 2000)(6).

Materials and Methods

Present research work entitled "Survey and management of root-knot nematode (*Meloidogyne javanica*) on chickpea (*Cicerarietinum* L.)" was carried out at Division of Nematology, Rajasthan Agricultural Research Institute (S.K.N. Agriculture University, Jobner), Durgapura, Jaipur, under the sick field conditions during Rabi season 2021-2022. Survey of root-knot nematode of chickpea was carried out in Dausa and Tonk of Rajasthan. All the materials used and methods pursued for its execution is furnished herein.

An intensive survey was carried out during Rabi season 2021-22 from January to March months on presence of root-knot nematode and other plant parasitic nematode from 34 localities in Dausa and Tonk of Rajasthan. Total 280 soil and root samples were collected from chickpea field. Samples were collected randomly from fields using khurpi. Collected soil and root samples were processed under laboratory and counted the presence nematode population in 200 cc soil and 5g roots calculate the occurrence, absolute frequency, absolute density and prominence value with the help of formula.

Sampling : Soil sampling was done at flowering stage during survey from chickpea crop areas where crop were grown intensively in Dausa and Tonk of Rajasthan. Sample size was 200 cc soil + 5g roots collect at depth upto 9 inches from zone of Rhizosphere. Collected soil samples and roots were processed under laboratory and

counted the presence plant parasitic nematode population in 200 cc soil and 5g roots.

Estimation of soil population : Initially 200 cc soil of each sample was refined by using Cobb's decanting and sieving technique (Cobb's 1918)(7), followed by Baermann's funnel technique (Cristie and Perry, 1951)(8). After 48 hours in winter season, suspension was drawn in a beaker from funnel and it was kept for some hours to allow the nematode to settle down at the bottom. The supernatant was gently removed for a concentrated nematode population. The suspensions were made up to 100 ml, bubbled and only 5 ml was drawn with the help of a pipette and poured in a counting disc. An average of three times were taken and then multiple to total suspension counts were taken. The root-knot nematode and other plant parasitic juveniles were counted under a stereoscopic binocular microscope.

Estimation of root population : Infested roots were washed thoroughly and stained with 0.1 per cent acid fuchsinlactophenol at 80 °C for 2-3 minutes (Mc Beth et al. 1941)(9). After a gentle wash in tap water, roots were kept in clear lactophenol for at least 24 hours and then it was examined under stereoscopic binocular microscope. After staining the roots were teased out, the number of root-knot nematode and other plant parasitic nematodes were recorded under a stereoscopic binocular microscope.

Per cent occurrence of plant parasitic nematodes : The frequency of occurrence percentage of the plant parasitic nematode infection in each locality was calculated by the following formula :

$$(a) \text{ Absolute frequency} = \frac{\text{No. of samples containing a species}}{\text{Total no. of samples collected}} \times 100$$

$$(b) \text{ Absolute density} = \frac{\text{No. of individuals of a species in a sample}}{\text{Volume of sample}} \times 100$$

$$(c) \text{ Prominence value} = \frac{\text{Absolute density} \times \sqrt{\text{Absolute frequency}}}{100}$$

Results and Discussion

Root-knot nematode is one of the most important polyphagous nematode and attack on almost all the cultivation crop plants of economic importance throughout the world. However, due to their small size, shorten life cycle and higher fecundity rate, root-knot nematode is more serious to others. In view of importance of the nematode the present investigations were carried out to study the per cent occurrence of root-knot nematode in Dausa and Tonk of Rajasthan.

A survey was conducted to determine the distribution and occurrence root-knot nematode, *Meloidogyne* spp. and other plant parasitic nematodes

associated with chickpea in Dausa and Tonk of Rajasthan. A total of 280 soil and root samples were collected from 17 different localities of Dausa and Tonk of Rajasthan in Rabi season 2021-22 from January to March months. The samples were processed by using Cobb's decanting and sieving technique followed by Baermann's funnel assembly. The extracted nematodes were examined under stereoscopic binocular microscope. Observations on number of root-knot nematode, *Meloidogyne* spp. and other plant parasitic nematodes per 200 cc soil, were recorded and presented in Table-2. Observations were recorded on nematode population parameters viz., nematode reproduction number of galls (females) per 5g roots, egg masses per 5 g roots and nematode population per 200 cc soil.

Toonga : Seventeen samples were collected from Toonga(L-1). Out of these *Meloidogyne* spp. was reported in 15 samples with 88.24 per cent occurrence, 17.93 per cent absolute density and 1.68 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (625/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (18/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Tylenchorhynchus* spp. (Table-3).

Siyaka Bas : Sixteen samples were collected from Siyaka Bas (L-2). Out of these *Meloidogyne* spp. was reported in 14 samples with 87.50 per cent occurrence, 14.79 per cent absolute density and 1.38 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (485/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (26/200 cc soil). *Helicotylenchus* spp. and *Tylenchorhynchus* spp. were also detected in 7 and 4 samples, respectively (Table-3).

Akhaipura : Fifteen samples were collected from Akhaipura (L-3). Out of these *Meloidogyne* spp. was reported in 14 samples with 93.33 per cent occurrence, 13.66 per cent absolute density and 1.31 per cent prominence value and it was recorded in maximum number (420/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (12/200 cc soil). *Pratylenchus* spp. and *Helicotylenchus* spp. were also detected, the number of these species were 17/200 cc soil and 18/200 cc soil, respectively (Table-3).

Rewari : Seventeen samples were collected from Rewari (L-4). Out of these *Meloidogyne* spp. was reported in 16 samples with 94.12 per cent occurrence, 13.26 per cent absolute density and 1.28 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (462/200 cc soil), while *Helicotylenchus* spp. was reported in minimum number (12/200 cc soil). The other nematodes detected in the soil samples were

Tylenchorhynchus spp. (14/200 cc soil) and *Pratylenchus* spp. (16/200 cc soil) (Table-3).

Sawalyawala : Thirteen samples were collected from Sawalyawala (L-5). Out of these *Meloidogyne* spp. was reported in all 13 samples with 100 per cent occurrence, 12.76 per cent absolute density and 1.27 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (340/200 cc soil), while *Helicotylenchus* spp. reported in minimum number (16/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. (18/200 cc soil) and *Tylenchorhynchus* spp. (16/200 cc soil) (Table-3).

Hameerpur : Sixteen samples were collected from Hameerpur(L-6). Out of these *Meloidogyne* spp. was reported in 15 samples with 93.75 per cent occurrence, 12.50 per cent absolute density and 1.21 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (410/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (18/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. (25/200 cc soil) and *Tylenchorhynchus* spp. (22/200 cc soil) (Table-3).

Ramgarhpachwara : Fifteen samples were collected from Ramgarhpachwara (L-7). *Meloidogyne* spp. was reported in all 15 samples with 100 per cent occurrence, 15.61 per cent absolute density and 1.5 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (480/200 cc soil), while *Helicotylenchus* spp. was reported in minimum number (14/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. (18/200 cc soil) and *Tylenchorhynchus* spp. (22/200 cc soil) (Table-3).

Barh Barwa : Sixteen samples were collected from BarhBarwa(L-8). *Meloidogyne* spp. was reported in all 16 samples with 100 per cent occurrence, 14.88 per cent absolute density and 1.48 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (488/200 cc soil), while ***Helicotylenchus*** spp. was reported in minimum number (16/200 cc soil). The other nematodes detected in the soil samples (Table- 4.3) were *Pratylenchus* spp. (22/200 cc soil) and *Tylenchorhynchus* spp. (20/200cc soil).

Madhogarh : Eighteen samples were collected from Madhogarh (L-9). Out of these *Meloidogyne* spp. was reported in 17 samples with 94.44 per cent occurrence, 15.18 per cent absolute density and 1.47 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (560/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (16/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Tylenchorhynchus* spp. (Table-3).

Beecha : Sixteen samples were collected from Beecha (L-10). Out of these *Meloidogyne* spp. was reported in 15 samples with 93.75 per cent occurrence, 18.90 per cent absolute density and 1.83 per cent prominence value. The ***Meloidogyne*** spp. was reported in maximum number (620/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (24/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Malpura : Seventeen samples were collected from Malpura (L-11). Out of these *Meloidogyne* spp. was reported in 15 samples with 88.24 per cent occurrence, 12.34 per cent absolute density and 1.15 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (430/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (12/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. and *Helicotylenchus* spp. (Table-3).

Diggi : Eighteen samples were collected from Diggi (L-12). Out of these *Meloidogyne* spp. was reported in 14 samples with 77.78 per cent occurrence, 11.38 per cent absolute density and 1.00 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (420/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Helicotylenchus* spp. (Table-3).

Nemeda : Seventeen samples were collected from Nemeda (L-13). Out of these *Meloidogyne* spp. was reported in 16 samples with 94.12 per cent occurrence, 13.49 per cent absolute density and 1.30 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (470/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (6/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Chainpura : Sixteen samples were collected from Chainpura (L-14). Out of these *Meloidogyne* spp. was reported in 15 samples with 93.75 per cent occurrence, 10.58 per cent absolute density and 1.06 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (360/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Phagi : Nineteen samples were collected from Phagi (L-15). Out of these *Meloidogyne* spp. was reported in 18 samples with 94.74 per cent occurrence, 7.32 per cent

absolute density and 0.71 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (285/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (8/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. and *Helicotylenchus* spp. (Table-3).

Chosla : Sixteen samples were collected from Chosla (L-16). Out of these *Meloidogyne* spp. was reported in 14 samples with 87.50 per cent occurrence, 8.54 per cent absolute density and 0.79 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (280/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (12/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Helicotylenchus* spp. (Table-3).

Harnoda : Eighteen samples were collected from Harnoda (L-17). Out of these *Meloidogyne* spp. was reported in 15 samples with 83.33 per cent occurrence, 8.67 per cent absolute density and 0.79 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (320/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (13/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Seventeen samples were collected from Toonga (L-1). Out of these *Meloidogyne* spp. was reported in 15 samples with 88.24 per cent occurrence, 17.93 per cent absolute density and 1.68 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (625/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (18/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Tylenchorhynchus* spp. (Table-3).

Siyaka Bas : Sixteen samples were collected from Siyaka Bas (L-2). Out of these *Meloidogyne* spp. was reported in 14 samples with 87.50 per cent occurrence, 14.79 per cent absolute density and 1.38 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (485/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (26/200 cc soil). *Helicotylenchus* spp. and *Tylenchorhynchus* spp. were also detected in 7 and 4 samples, respectively (Table-3).

Akhaipura : Fifteen samples were collected from Akhaipura (L-3). Out of these *Meloidogyne* spp. was reported in 14 samples with 93.33 per cent occurrence, 13.66 per cent absolute density and 1.31 per cent prominence value and it was recorded in maximum number (420/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (12/200 cc soil). *Pratylenchus* spp. and *Helicotylenchus* spp. were also

detected, the number of these species were 17/200 cc soil and 18/200 cc soil, respectively (Table-3).

Rewari : Seventeen samples were collected from Rewari (L-4). Out of these *Meloidogyne* spp. was reported in 16 samples with 94.12 per cent occurrence, 13.26 per cent absolute density and 1.28 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (462/200 cc soil), while *Helicotylenchus* spp. was reported in minimum number (12/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. (14/200 cc soil) and *Pratylenchus* spp. (16/200 cc soil) (Table-3).

Sawalyawala : Thirteen samples were collected from Sawalyawala (L-5). Out of these *Meloidogyne* spp. was reported in all 13 samples with 100 per cent occurrence, 12.76 per cent absolute density and 1.27 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (340/200 cc soil), while *Helicotylenchus* spp. reported in minimum number (16/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. (18/200 cc soil) and *Tylenchorhynchus* spp. (16/200 cc soil) (Table-3).

Hameerpur : Sixteen samples were collected from Hameerpur (L-6). Out of these *Meloidogyne* spp. was reported in 15 samples with 93.75 per cent occurrence, 12.50 per cent absolute density and 1.21 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (410/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (18/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. (25/200 cc soil) and *Tylenchorhynchus* spp. (22/200 cc soil) (Table-3).

Ramgarhpachwara : Fifteen samples were collected from Ramgarh pachwara (L-7). *Meloidogyne* spp. was reported in all 15 samples with 100 per cent occurrence, 15.61 per cent absolute density and 1.5 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (480/200 cc soil), while *Helicotylenchus* spp. was reported in minimum number (14/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. (18/200 cc soil) and *Tylenchorhynchus* spp. (22/200 cc soil) (Table-3).

BarhBarwa : Sixteen samples were collected from BarhBarwa (L-8). *Meloidogyne* spp. was reported in all 16 samples with 100 per cent occurrence, 14.88 per cent absolute density and 1.48 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (488/200 cc soil), while *Helicotylenchus* spp. was reported in minimum number (16/200 cc soil). The other nematodes detected in the soil samples (Table- 4.3) were

Table-1 : List of localities from where soil samples were taken.

S. No.	Locality	Village	District
1.	L ₁	Toonga	Dausa
2.	L ₂	SiyaKa Bas	Dausa
3.	L ₃	Akhaipura	Dausa
4.	L ₄	Rewari	Dausa
5.	L ₅	Sawalyawala	Dausa
6.	L ₆	Hameerpur	Dausa
7.	L ₇	Ramgarh Pachwara	Dausa
8.	L ₈	BarhBarwa	Dausa
9.	L ₉	Madhogarh	Dausa
10.	L ₁₀	Beechha	Dausa
11.	L ₁₁	Malpura	Tonk
12.	L ₁₂	Diggi	Tonk
13.	L ₁₃	Nimeda	Tonk
14.	L ₁₄	Chainpura	Tonk
15.	L ₁₅	Phagi	Tonk
16.	L ₁₆	Chosla	Tonk
17.	L ₁₇	Harnoda	Tonk

Table-2 : Per cent occurrence of root-knot nematode and other phyto-nematodes in chickpea in Dausa and Tonk of Rajasthan.

S. No.	Nematode Genera	No. of Sample collected	Samples containing Nematodes spp.	Absolute frequency	No. of individuals of a spp.	Absolute Density	Prominence Value
1.	<i>Meloidogyne</i> spp.	280	257	91.79	7455	12.99	1.24
2.	<i>Helicotylenchus</i> spp.		90	32.14	315	0.55	0.03
3.	<i>Pratylenchus</i> spp.		109	38.93	281	0.49	0.03
4.	<i>Tylenchorhynchus</i> spp.		98	35.00	275	0.48	0.03

Pratylenchus spp. (22/200 cc soil) and *Tylenchorhynchus* spp. (20/200cc soil).

Madhogarh : Eighteen samples were collected from Madhogarh (L-9). Out of these *Meloidogyne* spp. was reported in 17 samples with 94.44 per cent occurrence, 15.18 per cent absolute density and 1.47 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (560/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (16/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Tylenchorhynchus* spp. (Table-3).

Beecha : Sixteen samples were collected from Beecha (L-10). Out of these *Meloidogyne* spp. was reported in 15 samples with 93.75 per cent occurrence, 18.90 per cent absolute density and 1.83 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (620/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (24/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Malpura : Seventeen samples were collected from Malpura(L-11). Out of these *Meloidogyne* spp. was reported in 15 samples with 88.24 per cent occurrence, 12.34 per cent absolute density and 1.15 per cent

prominence value. The *Meloidogyne* spp. was reported in maximum number (430/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (12/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. and *Helicotylenchus* spp. (Table-3).

Diggi : Eighteen samples were collected from Diggi (L-12). Out of these *Meloidogyne* spp. was reported in 14 samples with 77.78 per cent occurrence, 11.38 per cent absolute density and 1.00 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (420/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Helicotylenchus* spp. (Table-3).

Nimeda : Seventeen samples were collected from Nimeda(L-13). Out of these *Meloidogyne* spp. was reported in 16 samples with 94.12 per cent occurrence, 13.49 per cent absolute density and 1.30 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (470/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (6/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Chainpura : Sixteen samples were collected from Chainpura (L-14). Out of these *Meloidogyne* spp. was reported in 15 samples with 93.75 per cent occurrence, 10.58 per cent absolute density and 1.06 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (360/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Phagi : Nineteen samples were collected from Phagi (L-15). Out of these *Meloidogyne* spp. was reported in 18 samples with 94.74 per cent occurrence, 7.32 per cent absolute density and 0.71 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (285/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (8/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. and *Helicotylenchus* spp. (Table-3).

Chosla : Sixteen samples were collected from Chosla (L-16). Out of these *Meloidogyne* spp. was reported in 14 samples with 87.50 per cent occurrence, 8.54 per cent absolute density and 0.79 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (280/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (12/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Helicotylenchus* spp. (Table-3).

Harnoda : Eighteen samples were collected from Harnoda (L-17). Out of these *Meloidogyne* spp. was reported in 15 samples with 83.33 per cent occurrence, 8.67 per cent absolute density and 0.79 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (320/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (13/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Chickpea is major pulse crop of India and it is grown in maximum states. Chickpea suffers from various diseases caused by fungus, bacteria, viruses and nematodes which affect the growth and yield. Among all the diseases, root-knot nematode (*Meloidogyne* spp.) is also considered as a major destructive pest of chickpea for limiting chickpea production. It has emerged as a major threat throughout the world. Therefore, present investigations were under taken to study the per cent occurrence of root-knot nematode in Total 280 soil and root samples were collected from 17 localities in Dausa and Tonk of Rajasthan. of Rajasthan, source of resistance in chickpea germplasm and management (through newly available nematicide) of *M. javanica*. During the course of investigations, many significant results have been obtained, which have been discussed and interpreted in the light of work done by earlier workers on these aspects.

A survey was carried out during Rabi season

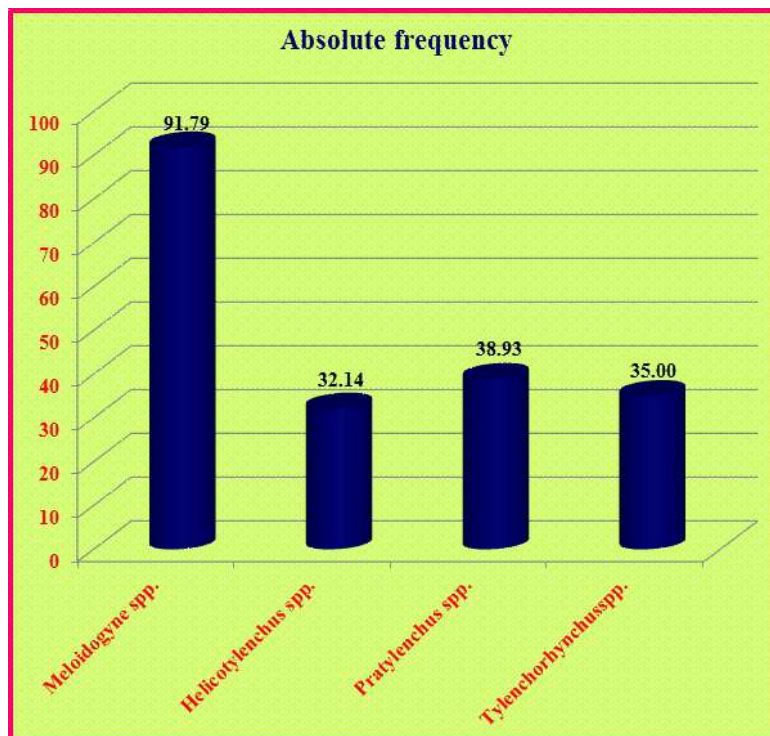


Fig.-1 : Absolute frequency of root-knot nematode and other plant parasite nematode.

Table-3 : Distribution and occurrence of root-knot nematode, *Meloidogyne javanica* and other plant parasitic nematodes in Dausa and Tonk of Rajasthan.

Locality	Nematode Genera	No. of Samples	Samples Con. Nema. Spp.	Absolute Freq.	No. of Ind. Spp. (200 CC soil + 5g roots)	Absolute den.	PV
Toonga	<i>Meloidogyne</i>	17	15	88.24	625	17.93	1.68
	<i>Helicotylenchus</i>	17	6	35.29	25	0.72	0.04
	<i>Pratylenchus</i>	17	5	29.41	18	0.52	0.02
	<i>Tylenchorhynchus</i>	17	7	41.18	22	0.63	0.04
SiyaKa Bas	<i>Meloidogyne</i>	16	14	87.5	485	14.79	1.38
	<i>Helicotylenchus</i>	16	7	43.75	30	0.91	0.06
	<i>Pratylenchus</i>	16	6	37.50	26	0.79	0.04
	<i>Tylenchorhynchus</i>	16	4	25.00	28	0.85	0.04
Akhaipura	<i>Meloidogyne</i>	15	14	93.33	420	13.66	1.31
	<i>Helicotylenchus</i>	15	5	33.33	18	0.59	0.03
	<i>Pratylenchus</i>	15	5	33.33	17	0.55	0.03
	<i>Tylenchorhynchus</i>	15	6	40.00	12	0.39	0.02
Rewari	<i>Meloidogyne</i>	17	16	94.12	462	13.26	1.28
	<i>Helicotylenchus</i>	17	6	35.29	12	0.34	0.02
	<i>Pratylenchus</i>	17	5	29.41	16	0.46	0.02
	<i>Tylenchorhynchus</i>	17	7	41.18	14	0.40	0.02
Sawalyawala	<i>Meloidogyne</i>	13	13	100.00	340	12.76	1.27
	<i>Helicotylenchus</i>	13	6	46.15	16	0.60	0.04
	<i>Pratylenchus</i>	13	6	46.15	18	0.68	0.04
	<i>Tylenchorhynchus</i>	13	5	38.46	16	0.60	0.03
Hameerpur	<i>Meloidogyne</i>	16	15	93.75	410	12.50	1.21
	<i>Helicotylenchus</i>	16	6	37.50	25	0.76	0.04
	<i>Pratylenchus</i>	16	5	31.25	18	0.55	0.03
	<i>Tylenchorhynchus</i>	16	6	37.50	22	0.67	0.04
Ramgarh Pachwara	<i>Meloidogyne</i>	15	15	100.00	480	15.61	1.5
	<i>Helicotylenchus</i>	15	6	40.00	14	0.46	0.02
	<i>Pratylenchus</i>	15	4	26.67	18	0.59	0.03
	<i>Tylenchorhynchus</i>	15	5	33.33	22	0.72	0.04
BarhBarwa	<i>Meloidogyne</i>	16	16	100.00	488	14.88	1.48
	<i>Helicotylenchus</i>	16	7	43.75	16	0.49	0.03
	<i>Pratylenchus</i>	16	5	31.25	22	0.67	0.03
	<i>Tylenchorhynchus</i>	16	6	37.50	20	0.61	0.03
1 Madhogarh	<i>Meloidogyne</i>	18	17	94.44	560	15.18	1.47
	<i>Helicotylenchus</i>	18	8	44.44	22	0.60	0.03
	<i>Pratylenchus</i>	18	8	44.44	16	0.43	0.02
	<i>Tylenchorhynchus</i>	18	7	38.89	17	0.46	0.02
Beechha	<i>Meloidogyne</i>	16	15	93.75	620	18.90	1.83
	<i>Helicotylenchus</i>	16	5	31.25	36	1.10	0.06
	<i>Pratylenchus</i>	16	4	25.00	30	0.91	0.04
	<i>Tylenchorhynchus</i>	16	8	50.00	24	0.73	0.05
Malpura	<i>Meloidogyne</i>	17	15	88.24	430	12.34	1.15
	<i>Helicotylenchus</i>	17	6	35.29	16	0.46	0.02
	<i>Pratylenchus</i>	17	8	47.06	13	0.37	0.02
	<i>Tylenchorhynchus</i>	17	4	23.53	12	0.34	0.01
Diggi	<i>Meloidogyne</i>	18	14	77.78	420	11.38	1
	<i>Helicotylenchus</i>	18	7	38.89	12	0.33	0.02
	<i>Pratylenchus</i>	18	10	55.56	10	0.27	0.02
	<i>Tylenchorhynchus</i>	18	3	16.67	13	0.35	0.01
Nimeda	<i>Meloidogyne</i>	17	16	94.11	470	13.49	1.3
	<i>Helicotylenchus</i>	17	7	41.18	12	0.34	0.02
	<i>Pratylenchus</i>	17	8	47.06	8	0.23	0.01
	<i>Tylenchorhynchus</i>	17	8	47.06	6	0.17	0.01
Chainpura	<i>Meloidogyne</i>	16	15	93.75	360	10.98	1.06
	<i>Helicotylenchus</i>	16	8	50	20	0.61	0.04
	<i>Pratylenchus</i>	16	7	43.75	12	0.37	0.02
	<i>Tylenchorhynchus</i>	16	6	37.5	10	0.30	0.01
Phagi	<i>Meloidogyne</i>	19	18	94.74	285	7.32	0.71
	<i>Helicotylenchus</i>	19	9	47.37	12	0.31	0.02
	<i>Pratylenchus</i>	19	7	36.84	10	0.26	0.01
	<i>Tylenchorhynchus</i>	19	7	36.84	8	0.21	0.01
Chosla	<i>Meloidogyne</i>	16	14	87.50	280	8.54	0.79
	<i>Helicotylenchus</i>	16	8	50.00	14	0.43	0.03
	<i>Pratylenchus</i>	16	7	43.75	12	0.37	0.02
	<i>Tylenchorhynchus</i>	16	4	25.00	16	0.49	0.02
Harnoda	<i>Meloidogyne</i>	18	15	83.33	320	8.67	0.79
	<i>Helicotylenchus</i>	18	8	44.44	15	0.41	0.02
	<i>Pratylenchus</i>	18	9	50.00	16	0.43	0.03
	<i>Tylenchorhynchus</i>	18	5	27.78	13	0.35	0.01

2021-22 from January to March months. Total 280 soil and root samples were collected from 17 localities in Dausa and Tonk of Rajasthan. The results observed during survey showed that chickpea is susceptible to the attack of root-knot nematode. The results indicate that the 100% infection of root-knot nematode was recorded in 3 localities i.e., Ramgarh Pachwara, BarhBarwa and Beechha. Roy et al. (2007) (10) surveyed the leguminous vegetables crops in West Bengal, India. Results showed the occurrence of 17 species of plant parasitic nematodes belonging to 8 genera in which *Rotylenchulus reniformis* was the most dominant species. Other genera observed in the localities included *Meloidogyne*, *Tylenchorhynchus*, *Criconemoides*, *Pratylenchus*, *Hoplolaimus*, *Helicotylenchus* and *Hirschmanniella*.

Chandrawat et al. (2013)(11) conducted a survey to find out distribution, occurrence and population density of *Hoplolaimus* spp. Results indicated that out of 245 soil samples collected, 169 samples showed the presence of *Hoplolaimus* spp. with 68.97 per cent of occurrence, 15.61 per cent population density and 129.61 per cent prominence value in and around Udaipur.

Zalpuri et al. (2013)(12) reported *Xiphinema* from Samba district (Vijaypur, Dhainnsar, Bari-Brahmana), Kathua district (Barnoti and Hiranagar) and Rajouri (Siot) district where the population of *Xiphinema* was prevalent and were found to retard the growth of the plant and leads to various deformities.

Singh (2015) (13) reported that thirteen nematode genera (*Hoplolaimus*, *Tylenchorhynchus*, *Helicotylenchus*, *Tylenchus*, *Heteroderacajani*, *Pratylenchus*, *Basiria*, *Aphelenchus*, *Meloidogyne*, *Filenchus*, *Boleodorus*, *Rotylenchulus* and *Scutellonema*) were associated with pigeon pea from a survey in Bundelkhand region of Uttar Pradesh. Patel and Patel (2017)(14) observed five genera including *Meloidogyne* spp. in mungbean during the survey conducted in Gujarat.

Kant et al. (2017)(15) collected 90 cumin (*Cuminumcyminum* L.) plant samples from 18 villages across 5 development blocks. Among all collected samples, 63 were found infested with different species of nematodes. Highest numbers of samples contain nematodes populations recorded from Pisangan block of Ajmer district, whereas minimum number of samples infested with nematodes population was found in Kekri block. There were three different species of nematodes associated with cumin root namely *Pratylenchus thornei*, *Hoplolaimus indicus* and *Meloidogyne incognita*. The nematode species *P. thornei* and *H. indicus* were found for first time in cumin field causing damage to the root of the plant.

Conclusions

A survey was carried out in 17 localities in Dausa and Tonk of Rajasthan during January to March, 2022 to determine the population status of root-knot nematode in chickpea fields. Total 280 soil and root samples were collected from 17 localities in Dausa and Tonk of Rajasthan. Out of 280 samples *Meloidogyne* spp. was found highest in 257 samples with 91.79% absolute frequency, 12.99% absolute density and 1.24% prominence value. The *Helicotylenchus* spp., *Pratylenchus* spp. and *Tylenchorhynchus* spp. also reported from surveyed localities. The results observed during survey showed that chickpea is susceptible to the attack of root-knot nematode. The results indicate that the 100% infection of root-knot nematode was recorded in 3 localities i.e., Ramgarh Pachwara, BarhBarwa and Beechha.

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Prevalence of Chickpea Root Knot Nematode in Northern Rajasthan

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Abstract

Chickpea (*Cicer arietinum* L.) is one of the important pulse crop grown in India. Root-knot nematode, *Meloidogyne javanica* is widely distributed in India. It has been found frequently associated with pulses and responsible for severe economic losses. Considering the economic importance of root-knot nematode as a disease causing organism of chickpea, the present investigation was carried out to know per cent occurrence, to find source of resistance in chickpea germplasm and to devise management. Total 280 soil and root samples were collected from 17 localities in Jaipur and Sikar of Rajasthan. Out of 280 samples *Meloidogyne* spp. was found highest in 259 samples with 92.50% absolute frequency, 11.15% absolute density and 1.07% prominence value and found most predominant in different surveyed localities in Jaipur and Sikar of Rajasthan. The *Helicotylenchus* spp., *Pratylenchus* spp. and *Tylenchorhynchus* spp. also reported from surveyed localities. The results indicate that the 100% infection of root-knot nematode was recorded in 3 localities i.e., Ranoli, Ladhana, and Mundiya Ramsar.

Key words : Chickpea, nematode, *Meloidogyne javanica*, and root knot nematodes

Introduction

Chickpea (*Cicer arietinum* L.) is a nutritionally rich cool season pulse crop that plays an important role in ensuring global food security, as it is an important source of dietary protein. Chickpea also plays an important role in farming systems by fixing atmospheric nitrogen, contributing to soil fertility, acting as a disease break and controlling weeds. Apart from India, Australia (12.35%) Myanmar (3.25%) and Ethiopia (2.92%) are the major chickpea producing countries of the world (Sumriti *et al.*, 2020)(1).

Madhya Pradesh is leading state in terms of area and production as it contributes around 34 and 40 per cent share to the total area and production of chickpea in the country (Agricultural statistics at a glance 2021)(2), followed by Maharashtra and Rajasthan. Rajasthan contributes 15 per cent share to the total area and production of chickpea. In Rajasthan it was grown on 24.63 Lakh hac. area with the total production of 26.60 million tonnes during 2019-20. (Commissionerate of Agriculture, Rajasthan Jaipur 2019-20)(3). In Rajasthan it is mainly grown in the districts of Ajmer, Bikaner, Jaipur, Pali, Nagaur and Tonk.

Application of a nematicide is required in each growing season of a susceptible crop. Nematicide persistence in soil for 6-8 weeks is desired for effective initial plant protection. A few nematicides exist and currently are not used for control of nematodes in India. Therefore, the present study was conducted to evaluate the efficacy of the nematicides available in India. Farmers growing chickpea follow furrow applications at

recommended rates in winter for effective economic and judicious nematode management. Chickpea was selected in this study as the crops to be tested in view of the extensive nematode damage observed in these crops. The objective of current study was to mitigate nematode damage in these crops by promoting sudden suppression of nematode populations in soil.

Looking to the economic importance of the disease and very meagre information available related to disease in Rajasthan, the present nematological studies were undertaken to generate the information on various aspects of disease.

Materials and Methods

Present research work entitled "Survey and management of root-knot nematode (*Meloidogyne javanica*) on chickpea (*Cicer arietinum* L.)" was carried out at Division of Nematology, Rajasthan Agricultural Research Institute (S.K.N. Agriculture University, Jobner), Durgapura, Jaipur, under the sick field conditions during Rabi season 2021-2022. Survey of root-knot nematode of chickpea was carried out in Jaipur and Sikar district of Rajasthan. All the materials used and methods pursued for its execution is furnished herein.

An intensive survey was carried out during Rabi season 2021-22 from January to March months on presence of root-knot nematode and other plant parasitic nematode from 17 localities in Jaipur and Sikar of Rajasthan. Total 280 soil and root samples were collected from chickpea field. Samples were collected randomly from fields using khurpi. Collected soil and root samples

were processed under laboratory and counted the presence nematode population in 200 cc soil and 5g roots calculate the occurrence, absolute frequency, absolute density and prominence value with the help of formula.

Soil sampling was done at flowering stage during survey from chickpea crop areas where crop were grown intensively in Jaipur and Sikar district of Rajasthan. Sample size was 200 cc soil + 5g roots collect at depth upto 9 inches from zone of Rhizosphere. Collected soil samples and roots were processed under laboratory and counted the presence plant parasitic nematode population in 200 cc soil and 5g roots.

Estimation of soil population : Initially 200 cc soil of each sample was refined by using Cobb's decanting and sieving technique (Cobb's 1918) (4), followed by Baermann's funnel technique (Cristie and Perry, 1951)(5). After 48 hours in winter season, suspension was drawn in a beaker from funnel and it was kept for some hours to allow the nematode to settle down at the bottom. The supernatant was gently removed for a concentrated nematode population. The suspensions were made up to 100 ml, bubbled and only 5 ml was drawn with the help of a pipette and poured in a counting disc. An average of three times were taken and then multiple to total suspension counts were taken. The root-knot nematode and other plant parasitic juveniles were counted under a stereoscopic binocular microscope.

Estimation of root population : Infested roots were washed thoroughly and stained with 0.1 per cent acid fuchsin lactophenol at 80 °C for 2-3 minutes (Mc Beth et al. 1941)(6). After a gentle wash in tap water, roots were kept in clear lactophenol for at least 24 hours and then it was examined under stereoscopic binocular microscope. After staining the roots were teased out, the number of root-knot nematode and other plant parasitic nematodes were recorded under a stereoscopic binocular microscope.

Per cent occurrence of plant parasitic nematodes : The frequency of occurrence percentage of the plant parasitic nematode infection in each locality was calculated by the following formula :

$$(a) \text{ Absolute frequency} = \frac{\text{No. of samples containing a species}}{\text{Total no. of samples collected}} \times 100$$

$$(b) \text{ Absolute density} = \frac{\text{No. of individuals of a species in a sample}}{\text{Volume of sample}} \times 100$$

$$(c) \text{ Prominence value} = \frac{\text{Absolute density} \times \sqrt{\text{Absolute frequency}}}{100}$$

Results and Discussion

Root-knot nematode is one of the most important polyphagous nematode and attack on almost all the

cultivation crop plants of economic importance throughout the world. However, due to their small size, shorten life cycle and higher fecundity rate, root-knot nematode is more serious to others. In view of importance of the nematode the present investigations were carried out to study the per cent occurrence of root-knot nematode in Jaipur and Sikar district of Rajasthan, source of resistance in chickpea germplasm and management of root-knot nematode, *Meloidogyne javanica* on chickpea through use of newer nematicide. Observations were recorded on nematode population parameters viz., nematode reproduction number of galls (females) per 5g roots, egg masses per 5 g roots and nematode population per 200 cc soil. The results are presented in this chapter under the following succeeding paragraphs.

A survey was conducted to determine the distribution and occurrence root-knot nematode, *Meloidogyne* spp. and other plant parasitic nematodes associated with chickpea in Jaipur and Sikar district of Rajasthan. A total of 280 soil and root samples were collected from 17 different localities in Jaipur and Sikar district of Rajasthan in Rabi season 2021-22 from January to March months. The samples were processed by using Cobb's decanting and sieving technique followed by Baermann's funnel assembly. The extracted nematodes were examined under stereoscopic binocular microscope. Observations on number of root-knot nematode, *Meloidogyne* spp. and other plant parasitic nematodes per 200 cc soil, were recorded and presented in Table 2.

Total 280 soil and root samples were collected from 17 in Jaipur and Sikar of Rajasthan. Out of 280 samples *Meloidogyne* spp. was found highest in 259 samples with 92.50% absolute frequency, 11.15% absolute density and 1.07% prominence value (Table-2).

The results observed during survey showed that chickpea is susceptible to the attack of root-knot nematode. The results indicate that the 100% infection of root-knot nematode was recorded in 3 localities i.e Ranoli, Ladhana, and Mundiya Ramsar.

Dhodhsar : Sixteen samples were collected from Dhodhsar (L-1). Out of these *Meloidogyne* spp. was reported in 14 samples with 87.50 per cent occurrence, 12.87 per cent absolute density and 1.2 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (422/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Sargoth : Fourteen samples were collected from Sargoth (L-2). Out of these *Meloidogyne* spp. was reported in 12

Table-1 : List of localities from where soil samples were taken.

S. No.	Locality	Village	District
1.	L ₁	Dhodhsar	Jaipur
2.	L ₂	Sargoth	Sikar
3.	L ₃	Palsana	Sikar
4.	L ₄	Ranoli	Sikar
5.	L ₅	Thikariya	Sikar
6.	L ₆	Ladhana	Sikar
7.	L ₇	Goriya	Sikar
8.	L ₈	Bajor	Sikar
9.	L ₉	Begus	Jaipur
10.	L ₁₀	Himmatpura	Jaipur
11.	L ₁₁	MundiyaRamsar	Jaipur
12.	L ₁₂	Ramsinghpura	Jaipur
13.	L ₁₃	Awaniya	Jaipur
14.	L ₁₄	Neemera	Jaipur
15.	L ₁₅	Dhankya	Jaipur
16.	L ₁₆	ChakRamsar	Jaipur
17.	L ₁₇	Shyosinghpura	Jaipur

Table-2 : Per cent occurrence of root-knot nematode and other phyto-nematodes in chickpea in Dausa and Tonk of Rajasthan.

S. No.	Nematode Genera	No. of Sample collected	Samples containing Nematodes spp.	Absolute frequency	No. of individuals of a spp.	Absolute Density	Prominence Value
1.	<i>Meloidogyne</i> spp.	280	259	92.50	6399	11.15	1.07
2.	<i>Helicotylenchus</i> spp.		145	51.78	225	0.39	0.03
3.	<i>Pratylenchus</i> spp.		135	48.21	212	0.37	0.02
4.	<i>Tylenchorhynchus</i> spp.		82	29.28	209	0.36	0.02

samples with 85.71 per cent occurrence, 12.54 per cent absolute density and 1.16 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (360/200 cc soil), while *Helicotylenchus* spp. was reported in minimum number (12/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Pratylenchus* spp. (Table-3).

Palsana : Eighteen samples were collected from Palsana(L-3),*Meloidogyne* spp. was reported in 17 samples with 94.44 per cent occurrence, 9.97 per cent absolute density and 0.96 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (368/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Helicotylenchus* spp. (Table-3).

Ranoli : Fourteen samples were collected from Ranoli (L-4). Out of these *Meloidogyne* spp. was reported in all 14 samples with 100 per cent occurrence, 14.46 per cent absolute density and 1.44 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (415/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (12/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Thikariya : Seventeen samples were collected from

Thikariya (L-5). Out of these *Meloidogyne* spp. was reported in 16 samples with 94.12 per cent occurrence, 10.90 per cent absolute density and 1.05 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (380/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (9/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. and *Helicotylenchus* spp. (Table-3).

Ladhana : Twelve samples were collected from Nimodiya (L-6),*Meloidogyne* spp. was reported in all 12 samples with 100 per cent occurrence, 14.23 per cent absolute density and 1.42 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (350/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (8/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. and *Helicotylenchus* spp. (Table-3).

Goriya : Sixteen samples were collected from Goriya (L-7). Out of these *Meloidogyne* spp. was reported in 15 samples with 93.75 per cent occurrence, 12.80 per cent absolute density and 1.23 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (420/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (8/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Helicotylenchus* spp. (Table-3).

Bajor : Fourteen samples were collected from Bajor (L-8), *Meloidogyne* spp. was reported in all 14 samples with 100 per cent occurrence, 18.12 per cent absolute density and 1.81 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (520/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Begus : Sixteen samples were collected from Begus(L-9). Out of these *Meloidogyne* spp. was reported in 15 samples with 93.75 per cent occurrence, 13.11 per cent absolute density and 1.26 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (430/200 cc soil), while *Helicotylenchus* spp. was reported in minimum number (16/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Pratylenchus* spp. (Table-3).

Himmatpura : Eighteen samples were collected from Himmatpura (L-10). Out of these *Meloidogyne* spp. was reported in 15 samples with 83.33 per cent occurrence, 10.03 per cent absolute density and 0.91 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (370/200 cc soil), while *Helicotylenchus* spp. was reported in minimum number (12/200 cc soil). The other nematodes detected in the soil samples were *Pratylenchus* spp. and *Tylenchorhynchus* spp. (Table-3).

Mundiya Ramsar : Sixteen samples were collected from Mundiya Ramsar(L-11), *Meloidogyne* spp. was reported in all 16 samples with 100 per cent occurrence, 13.72 per

cent absolute density and 1.37 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (450/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (15/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Helicotylenchus* spp. (Table-3).

Ramsinghpura : Twenty samples were collected from Ramsinghpura (L-12). Out of these *Meloidogyne* spp. was reported in 18 samples with 90 per cent occurrence, 10.44 per cent absolute density and 0.99 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (428/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (8/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

Awaniya : Sixteen samples were collected from Awaniya (L-13). Out of these *Meloidogyne* spp. was reported in 15 samples with 93.75 per cent occurrence, 9.76 per cent absolute density and 0.94 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (320/200 cc soil), while *Helicotylenchus* spp. was reported in minimum number (5/200 cc soil). The other nematodes detected in the soil samples were **Pratylenchus** spp. and *Tylenchorhynchus* spp. (Table-3).

Neemera : Eighteen samples were collected from Neemera(L-14). Out of these *Meloidogyne* spp. was reported in 15 samples with 83.33 per cent occurrence, 11.11 per cent absolute density and 1.01 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (410/200 cc soil), while *Pratylenchus*

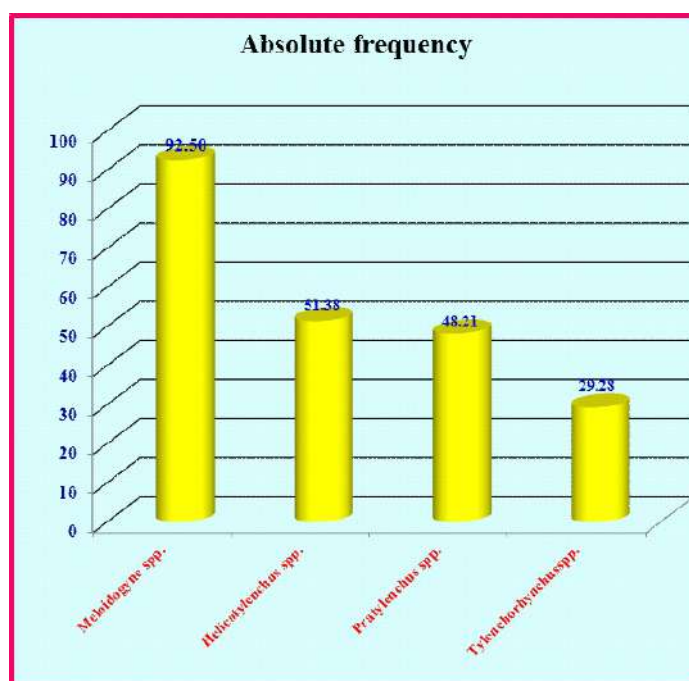


Fig.-1 : Absolute frequency of root-knot nematode and other plant parasite nematode.

Table-3 : Distribution and occurrence of root-knot nematode, *Meloidogyne javanica* and other plant parasitic nematodes in Jaipur and Sikar of Rajasthan.

Locality	Nematode Genera	No. of Samples	Samples Con. Nema. Spp.	Absolute Freq.	No. of Ind. Spp.(200 CC soil + 5g roots)	Absolute den.	PV
Dhodhsar	<i>Meloidogyne</i>	16	14	87.50	422	12.87	1.2
	<i>Helicotylenchus</i>	16	5	31.25	20	0.61	0.03
	<i>Pratylenchus</i>	16	3	18.75	15	0.46	0.01
	<i>Tylenchorhynchus</i>	16	7	43.75	10	0.30	0.02
Sargoth	<i>Meloidogyne</i>	14	12	85.71	360	12.54	1.16
	<i>Helicotylenchus</i>	14	6	42.86	12	0.42	0.02
	<i>Pratylenchus</i>	14	4	28.57	16	0.56	0.02
	<i>Tylenchorhynchus</i>	14	5	35.71	20	0.70	0.04
Palsana	<i>Meloidogyne</i>	18	17	94.44	368	9.97	0.96
	<i>Helicotylenchus</i>	18	7	38.89	12	0.33	0.02
	<i>Pratylenchus</i>	18	6	33.33	10	0.27	0.01
	<i>Tylenchorhynchus</i>	18	4	22.22	14	0.38	0.01
Ranoli	<i>Meloidogyne</i>	14	14	100.00	415	14.46	1.44
	<i>Helicotylenchus</i>	14	6	42.86	14	0.49	0.03
	<i>Pratylenchus</i>	14	4	28.57	17	0.59	0.03
	<i>Tylenchorhynchus</i>	14	3	21.43	12	0.42	0.01
Thikariya	<i>Meloidogyne</i>	17	16	94.12	380	10.90	1.05
	<i>Helicotylenchus</i>	17	6	35.29	14	0.40	0.02
	<i>Pratylenchus</i>	17	7	41.18	12	0.34	0.02
	<i>Tylenchorhynchus</i>	17	4	23.53	9	0.26	0.01
Ladhana	<i>Meloidogyne</i>	12	12	100.00	350	14.23	1.42
	<i>Helicotylenchus</i>	12	8	66.67	14	0.57	0.04
	<i>Pratylenchus</i>	12	6	50.00	15	0.61	0.04
	<i>Tylenchorhynchus</i>	12	5	41.67	8	0.33	0.02
Goriya	<i>Meloidogyne</i>	16	15	93.75	420	12.80	1.23
	<i>Helicotylenchus</i>	16	7	43.75	9	0.27	0.01
	<i>Pratylenchus</i>	16	6	37.50	8	0.24	0.01
	<i>Tylenchorhynchus</i>	16	6	37.50	10	0.30	0.01
Bajor	<i>Meloidogyne</i>	14	14	100.00	520	18.12	1.81
	<i>Helicotylenchus</i>	14	8	57.14	12	0.42	0.03
	<i>Pratylenchus</i>	14	8	57.14	14	0.49	0.03
	<i>Tylenchorhynchus</i>	14	5	35.71	10	0.35	0.02
Begus	<i>Meloidogyne</i>	16	15	93.75	430	13.11	1.26
	<i>Helicotylenchus</i>	16	7	43.75	16	0.49	0.03
	<i>Pratylenchus</i>	16	8	50.00	18	0.55	0.03
	<i>Tylenchorhynchus</i>	16	7	43.75	20	0.61	0.04
Himmatpura	<i>Meloidogyne</i>	18	15	83.33	370	10.03	0.91
	<i>Helicotylenchus</i>	18	8	44.44	12	0.33	0.02
	<i>Pratylenchus</i>	18	9	50.00	15	0.41	0.02
	<i>Tylenchorhynchus</i>	18	6	33.33	18	0.49	0.02
Mundiya Ramsar	<i>Meloidogyne</i>	16	16	100.00	450	13.72	1.37
	<i>Helicotylenchus</i>	16	7	43.75	20	0.61	0.04
	<i>Pratylenchus</i>	16	8	50.00	15	0.46	0.03
	<i>Tylenchorhynchus</i>	16	7	43.75	16	0.49	0.03
Ramsinghpura	<i>Meloidogyne</i>	20	18	90.00	428	10.44	0.99
	<i>Helicotylenchus</i>	20	8	40.00	12	0.29	0.01
	<i>Pratylenchus</i>	20	7	35.00	10	0.24	0.01
	<i>Tylenchorhynchus</i>	20	5	25.00	8	0.20	0.01
Awaniya	<i>Meloidogyne</i>	16	15	93.75	320	9.76	0.94
	<i>Helicotylenchus</i>	16	7	43.75	5	0.15	0.01
	<i>Pratylenchus</i>	16	8	50.00	6	0.18	0.01
	<i>Tylenchorhynchus</i>	16	5	31.25	8	0.24	0.01
Neemra	<i>Meloidogyne</i>	18	15	83.33	410	11.11	1.01
	<i>Helicotylenchus</i>	18	6	33.33	12	0.33	0.01
	<i>Pratylenchus</i>	18	8	44.44	10	0.27	0.01
	<i>Tylenchorhynchus</i>	18	4	22.22	16	0.43	0.02
Dhankya	<i>Meloidogyne</i>	17	16	94.12	450	12.91	1.25
	<i>Helicotylenchus</i>	17	7	41.18	12	0.34	0.02
	<i>Pratylenchus</i>	17	6	35.29	8	0.23	0.01
	<i>Tylenchorhynchus</i>	17	2	11.76	8	0.23	0.01
ChakRamsar	<i>Meloidogyne</i>	18	17	94.44	520	14.09	1.36
	<i>Helicotylenchus</i>	18	8	44.44	14	0.38	0.02
	<i>Pratylenchus</i>	18	10	55.56	10	0.27	0.02
	<i>Tylenchorhynchus</i>	18	4	22.22	12	0.33	0.01

spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Helicotylenchus* spp. (Table-3).

Dhankya : Seventeen samples were collected from Dhankya (L-15). Out of these *Meloidogyne* spp. was reported in 16 samples with 94.12 per cent occurrence, 12.91 per cent absolute density and 1.25 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (450/200 cc soil), while *Pratylenchus* spp. and *Tylenchorhynchus* spp. were reported in minimum number (8/200 cc soil). *Helicotylenchus* spp. was also detected in the soil samples (Table-3).

Chak Ramsar : Eighteen samples were collected from Chak Ramsar (L-16). Out of these *Meloidogyne* spp. was reported in 17 samples with 94.44 per cent occurrence, 14.09 per cent absolute density and 1.36 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (520/200 cc soil), while *Pratylenchus* spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Tylenchorhynchus* spp. and *Helicotylenchus* spp. (Table-3).

Syosinghpura : Twenty samples were collected from Syosinghpura (L-17). Out of these *Meloidogyne* spp. was reported in 18 samples with 90 per cent occurrence, 7.80 per cent absolute density and 0.74 per cent prominence value. The *Meloidogyne* spp. was reported in maximum number (320/200 cc soil), while *Tylenchorhynchus* spp. was reported in minimum number (10/200 cc soil). The other nematodes detected in the soil samples were *Helicotylenchus* spp. and *Pratylenchus* spp. (Table-3).

17 extensively chickpea growing villages in and around Jaipur and Sikar district were surveyed to record the occurrence of different diseases during *Rabi* season of 2021. The villages were surveyed from flowering and fruiting stages of the crop.

Chickpea is major pulse crop of India and it is grown in maximum states. Chickpea suffers from various diseases caused by fungus, bacteria, viruses and nematodes which affect the growth and yield. Among all the diseases, root-knot nematode (*Meloidogyne* spp.) is also considered as a major destructive pest of chickpea for limiting chickpea production. It has emerged as a major threat throughout the world. Therefore, present investigations were under taken to study the per cent occurrence of root-knot nematode in Jaipur and Sikar district of Rajasthan, source of resistance in chickpea germplasm and management (through newly available nematicide) of *M. javanica*. During the course of investigations, many significant results have been

obtained, which have been discussed and interpreted in the light of work done by earlier workers on these aspects.

A survey was carried out during *Rabi* season 2021-22 from January to March months. Total 280 soil and root samples were collected from 17 localities in Jaipur and Sikar of Rajasthan. 280 samples *Meloidogyne* spp. was found highest in 259 samples with 92.50% absolute frequency, 11.15% absolute density and 1.07% prominence value (Table-2). The results observed during survey showed that chickpea is susceptible to the attack of root-knot nematode. The results indicate that the 100% infection of root-knot nematode was recorded in 3 localities i.e., Ranoli, Ladhana, and Mundiya Ramsar.

The results of present investigation are similar to Ali and Sharma (2003) (7) who observed estimating 20-30 per cent yield loss due to infestations of *Meloidogyne incognita* and *M. javanica* in sandy soils of Jaipur, Jhunjhunu and Swai Madhaopur both in rainfed and irrigated situations. Monocropping of chickpea supported higher populations of root-knot nematodes than cereals-chickpea cropping system. *Heterodera swarupi* was reported for the first time on chickpea and its incidence was recorded from Ajmer, Alwar, Bikaner, Jaipur, Nagaur, Sikar, Jhunjhunu, Swai Madhopur and Tonk districts. The lesion nematodes (*Pratylenchus thornei* and *Pratylenchus* spp.) were predominant in north eastern region and were associated with *Rhizoctonia bataticola*.

Similarly, a survey of chickpea fields in 14 different locations of Allahbad, UP, India and reported that more than 50 per cent fields were infested with *Meloidogyne* spp. was conducted by Pandey et al. (2003) (8). They found that among 14 localities high inoculum density and gall indices were recorded from Holagarh, Dhanupur, Phulpur, Bahadurpur, Baharia and Mauaima. The maximum disease prevalence (80%) was noted at Holagarh and Karchana, while maximum relative density recorded at Phulpur followed by Dhanupur. Sharma et al. (1990) (9) observed the root-knot nematode disease of chickpea caused by *Meloidogyne* spp. was found to be wide spread in the tarai region of Nepal. The disease was moderate to severe in Bhairahawa, Gadari, Gopalkoti and Rampur. In Nawalpur, Nepalganj and Parwanipur, the disease incidence was low.

Rao and Krishnappa (1995) (10) conducted a survey in different chickpea growing areas of Karnataka indicated the occurrence of root-knot nematode with a variation in population levels among the district, with a mean inoculum level of 0.12 larvae per g of soil under field conditions. An inoculum level of 2 larvae per g soil was found as optimum damaging threshold level on cultivar Annegiri-1 under greenhouse conditions. The result was

also more or less similar to Olowe (2004)(11) who noted that *Meloidogyne incognita* was the most prevalent nematode followed by *Meloidogyne javanica* and *Meloidogyne arenaria* in cowpea area of Nigeria. Whereas, Saxena and Kaushik (2004)(12) found that among the soil samples of nematodes from chickpea and pigeon pea in Uttar Pradesh, *M. incognita* showed the highest occurrence, while *Helicotylenchus dihystra* showed the lowest. Other genera observed in the localities included *Hoplolaimus* spp., *Heterodera* spp., *Pratylenchus* spp., *Telotylenchus* spp. and *Rotylenchus* spp.

Moreover, Ali et al. (2006)(13) collected 174 soil samples around the roots of different pulse crops in Uttar Pradesh and found that 63 soil samples of chickpea noted presence of *Hoplolaimus indicus*, with the highest frequency, density prominence value and importance value followed by *Tylenchorhynchus mashhoodi*. While, Roy et al. (2007)(14) surveyed the leguminous vegetables crops in West Bengal, India and found the occurrence of 17 species of plant parasitic nematodes belonging to 8 genera in which *Rotylenchulus reniformis* was the most dominant species. Other genera observed in the localities included *Meloidogyne*, *Tylenchorhynchus*, *Criconeoides*, *Pratylenchus*, *Hoplolaimus*, *Helicotylenchus* and *Hirschmanniella*. The results were also in agreement with several workers like Amponsah et al. (2008)(15), Sawadogo et al. (2009)(16), Rathour et al. (2010)(17) and Korayem et al. (2011)(18).

Conclusions

A survey was carried out in 17 localities in Jaipur and Sikar of Rajasthan during January to March, 2022 to determine the population status of root-knot nematode in chickpea fields. Total 280 soil and root samples were collected from 17 localities in Jaipur and Sikar of Rajasthan. Out of 280 samples *Meloidogyne* spp. was found highest in 259 samples with 92.50% absolute frequency, 11.15% absolute density and 1.07% prominence value (Table-2). The *Helicotylenchus* spp., *Pratylenchus* spp. and *Tylenchorhynchus* spp. also reported from surveyed localities. The results observed during survey showed that chickpea is susceptible to the attack of root-knot nematode. The results indicate that the 100% infection of root-knot nematode was recorded in 3 localities i.e., Ranoli, Ladhana, and Mundiya Ramsar.

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Effect of Feeding Azolla (*Azolla pinnata*) Leaf Powder on Weekly Body Weight and Feed Intake in Turkey Poults

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Abstract

The present study was planned to assess the "Effect of feeding Azolla (*Azolla pinnata*) leaf powder on weekly body weight and feed intake in turkey poults (*Meleagris gallapavo*)" at Poultry Farm, Department of Animal Production, Rajasthan College of Agriculture, Udaipur (Raj.). One hundred and twenty-eight turkey poults (day-old) were used in a completely randomized design in 4 treatments with 4 replications, each consisting of 8 poults. The treatments were T1: control, T2: control group supplemented with Azolla leaf powder @ 2.5%, T3: control group supplemented with Azolla leaf powder @ 5% and T4: control group supplemented with Azolla leaf powder @ 7.5%. The body weight showed significant differences among different treatment groups. Significantly higher BW weight was found in T3 group which were fed with 5% Azolla leaf powder in diet. Feed intake was significantly higher in T4 which was supplemented with 7.5% Azolla leaf powder and significantly lowest feed intake was observed in T1 (control) group.

Key words : Azolla, turkey poult, body weight, feed intake.

Introduction

India today is the one of the world's largest producer of eggs and broiler meat. The poultry industry in India has undergone a major shift in structure and operation during the last two decades transforming from a mere backyard activity into a major industry with the presence of a large number of integrated players. Turkey (*Meleagris gallopavo*) is considered as natives of the New World. Fossils remains found in Mexico and North America date back to many thousands of years. Currently, turkeys form a part of festive food particularly during Christmas throughout the world. Azolla is very rich in protein, essential amino acids, vitamins (Vit. A, Vit. B12, Beta carotene), growth promoter intermediaries and minerals like calcium, phosphorus, potassium, ferrous, copper, magnesium, etc. (Kamalasanana *et al.*, 2002). Azolla is suitable for human consumption. It can be incorporated into the feed of broiler chickens (Basak *et al.* 2002 and Querubin *et al.* 1986 and Parthasarthy *et al.* 2002), duck (Becerra *et al.*, 1995), small ruminants (Tamang and Samanta, 1993) and ruminants (Nik-Khah and Motaghi-Talab, 1992). Azolla is considered to be most promising because of high productivity, good nutritive value and easiness of cultivation (Singh and Subudhi, 1978).

Materials and Methods

The experiment was conducted at poultry farm, Department of Animal production, Rajasthan College of Agriculture, MPUAT, Udaipur, location in humid region at latitude 24.57 North and longitude of 73.70 East. The

research work carried out with 128 day-old age turkey poults procured from the poultry farm, Department of Animal production, Rajasthan College of Agriculture, Udaipur.

Observations to be recorded

Weekly body weight : Body weight was measured in each treatment group at weekly interval by 1.0-gram accuracy weighing balance in the morning before offering the feed.

Feed intake : The feed intake was measured in each treatment group at weekly interval during 1st to 8th week of age. Total feed offered and residue was weighed to obtain feed intake.

Feed intake (g) = Feed offered during the current day (g) – Feed leftover at the next day (g)

Results and Discussion

Body weight : The body weight at 8th week of age was 907.92±3.08, 1014.50±15.67, 1215.76±19.85 and 1116.48±6.20 g in T1, T2, T3 and T4, respectively. Significantly highest body weight was observed in T3 (1215.76±19.85 g) followed by T4 (1116.48±6.20 g), T2 (1014.50±15.67g) and significantly lowest body weight was observed in T1 (907.92±3.08 g). The current study was closely related with the findings of Yadav *et al.* (2022) who found highest body weight on 5% inclusion of Azolla in diet of Narmadanidhi birds. Abdelatty *et al.* (2020) observed that sun-dried Azolla leaf meal (ALM) as an unconventional dietary protein source improved BW gain in broiler chicken diet up to 5% without any major

Table-1 : Effect of feeding Azolla leaf powder on weekly body weight (g/poult).

Week/Treatment	T ₁	T ₂	T ₃	T ₄	SEm±
Day-old	49.49±0.43	48.48±1.01	47.41±0.64	49.61±0.44	0.62
4 th	249.98±1.34 ^d	294.61±3.73 ^c	353.98±1.59 ^a	330.77±3.69 ^b	2.74
8 th	907.92±3.08 ^d	1014.50±15.67 ^c	1215.76±19.85 ^a	1116.48±6.20 ^b	9.99

Table-2 : Effect of feeding Azolla leaf powder on weekly feed intake (g/poult).

Week/Treatment	T ₁	T ₂	T ₃	T ₄	SEm±
1 st	61.25±0.29 ^c	63.14±0.94 ^c	67.62±0.53 ^b	72.94±0.81 ^a	0.66
4 th	223.98±2.15 ^c	259.91±3.17 ^b	263.76±4.58 ^a	266.29±4.35 ^a	1.06
8 th	545.20±6.10 ^b	592.87±6.41 ^a	599.76±12.55 ^a	609.51±4.90 ^a	6.30

negative effect. Similar results were also reported by Ara *et al.* (2015) the dietary inclusion of Azolla up to 5% enhance the body weight but beyond this level slowly depression in growth performance was noted.

Feed intake : At 8th week of age feed intake was 545.20±6.10, 592.87±6.41, 599.76±12.55 and 609.51±4.90 g per poult in T₁, T₂, T₃ and T₄, respectively. At 8th week of age lowest feed intake was observed in T₁ as compared to rest of the treatment groups. However, difference in feed intake among T₂, T₃ and T₄ was small and found statistically non-significant. The results of present study are in close agreement with the findings of Kumar *et al.* (2018) who reported significant effect on feed consumption which was highest in 7.5% Azolla fed treatment. Samad *et al.* (2020) found no significant differences ($P > 0.05$) among 0, 5, 10 and 15% Azolla fed treatments. Balaji *et al.* (2009) reported that feed intake did not differ significantly in different treatment groups fed with 0, 1.5, 3 and 4.5 % Azolla up to six weeks of age.

Conclusions

Findings of current study revealed that, replacement of 5% Azolla in diet of turkey poult improved body weight which was at par with standard basal diet. Feed intake was observed higher in Azolla fed groups in different treatments as compared to control group.

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Population Dynamics of Aphid, *Aphis gossypii* (Glover) on Tomato and its Correlation with Abiotic Factors

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Abstract

The investigation on population dynamics of aphid, *Aphis gossypii* (Glover) on tomato and its correlation with abiotic factors under sub-humid condition was laid out in randomized block design at instructional agronomy farm, Rajasthan College of Agriculture, MPUAT, Udaipur during *kharif* 2022. The infestation of aphid population initiated in the 1st week of September (36th SMW) with mean population of 5 aphid per five plants and attained its peak with a mean of 11.20 aphid per five plants during 2nd week of September (37th SMW) when the mean atmospheric temperature, relative humidity and rainfall were recorded 27.67 °C, 68.64 per cent and 16.60 mm, respectively. The correlation study between weather parameters and aphid population revealed that mean temperature and mean relative humidity had positive significant correlation with aphid population whereas, total rainfall shows positive non-significant correlation.

Key words : aphid, population dynamics, correlation, weather parameter.

Introduction

Tomato, *Solanum lycopersicum* (L.) is one of the most important solanaceous crops of the world, ranking second followed by potato and it is a native to Central and South America (Vavilov, 1951). Tomato is one of the most important “protective foods” because of its special nutritive values, viz., beta-carotene, ascorbic acid, lycopene, vitamin A, C, E, fibers and minerals (Olaniyi *et al.*, 2010). In India the total area under tomato cultivation is 831 thousand hectares with an annual production of 20300 thousand metric tonnes and in Rajasthan, tomato was grown in area of 20.50 thousand hectares with production of 232.86 thousand metric tonnes but the Andhra Pradesh contributes to the maximum production *i.e.*, 2217 thousand metric tonnes (Anonymous, 2021-22). Tomato crop is being damaged by a total of 41 insect-pests species belonging to 21 families which included the fruit borer, *Helicoverpa armigera* (Hubner), tobacco caterpillar, *Spodoptera litura* (Fabricius), serpentine leaf miner, *Liriomyza trifolii* (Burgess), pin worm, *Tuta absoluta* (Meyrick), sucking insect- pests, White flies, *Bemisia tabaci* (Gennadius), Thrips, *Thrips tabaci* (Lindeman), and Aphid, *Aphis gossypii* (Glover), (Reddy and Kumar, 2004). The aphid, *Aphis gossypii* belongs to the family Aphididae of order Hemiptera, suborder Homoptera cause damage by sucking cell sap from leaves, petioles, tender stems, inflorescence and pods. Keeping this in view, the present investigation was undertaken to know the population dynamics of aphid on tomato and effects of abiotic factors on aphid.

Materials and Methods

The field experiment was conducted in randomized block design (RBD) with uniformly sized plots measuring 5 m x 3 m (15 sq. m.) with three replications at the Instructional farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. The seedlings of tomato variety “ANA (ETH 538)” were transplanted in the first week of August, 2022; maintaining a row to row and plant to plant spacing of 60 cm x 45 cm, respectively. Weekly meteorological data on atmospheric temperature, relative humidity, and total rainfall were obtained from the Meteorology Unit of Rajasthan College of Agriculture, Udaipur. The visual counting method was used to record the aphid population from the three leaves of upper, middle and lower portion from five randomly selected and tagged plants in each replication. The aphid population was counted from 5cm floral twigs during early hours of the day (7:30-9:30 a.m.) and data were expressed as numbers per three leaves. The population data was statistically analysed with abiotic parameters (Pearson, 1895)

Results and Discussion

The observations recorded and presented on the incidence of aphid reveal that the appearance started from third week after the transplanting and were observed to persist till the harvesting of tomato. The aphid first appeared in the crop during 1st week of September (36th SMW), with mean population of 6.80 aphids/5 plants and reached its peak of 11.20 aphids/5 plants during 2nd week of September (37th SMW), thereafter the population

[illegible]

declined and reached a minimum level of 2.20 aphids/5 plants during 4th week of December. During the peak period of incidence, the mean atmospheric temperature recorded was 27.67 °C, mean relative humidity was 68.64 per cent and mean rainfall was 16.60 mm. The incidence of aphid population showed a positive significant correlation with mean temperature ($r = 0.95^*$) and mean relative humidity ($r = 0.64^*$) and a positive non-significant correlation with mean rainfall ($r = 0.53$). The findings of present investigation are in conformity with Wade *et al.* (2020) who observed that the aphid during 2nd SMW, with peak population of 7.83 per three leaves in 16th SMW. Aphids was observed in 7th and 12th SMW, respectively. Similarly, research finding of Dhanda *et al.* (2020) with the population dynamics of aphid (*Myzus persicae*), incidence reached its peak population of 23.26 aphids per three leaves. Correlation study with abiotic factors was also conducted during the experiment. Similarly, the findings of Chavan *et al.* (2013) who recorded the population dynamics of major insect pests of tomato commenced from transplanting with 1.35 aphids, leaf⁻¹ reached to peak level (7.31 aphids' leaf⁻¹) at 11 WATS. When significant population of aphid reached maximum. Correlation between insect pest population/damage and weather parameters showed negative correlation with maximum temperature and negative correlation with minimum temperature.

Conclusion

The study on population dynamics of aphid and its correlation with abiotic factors revealed that aphid found to be the major sucking insect pests of tomato and results showed that the infestation of aphid population initiated in the 1st week of September (36th SMW) with population of 5

aphid per five plants. The population increased gradually and attained its peak with a mean of 11.20 aphid per five plants during 2nd week of September (37th SMW). Thereafter, pest population declined gradually and reached its minimum level in month of December. The abiotic factors showed a positive significant correlation with mean temperature and mean relative humidity and a positive non-significant correlation with mean rainfall.

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Dynamic Profile of Beneficiaries of Pratapdhan Breed under Backyard Poultry in Udaipur District of Rajasthan

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Abstract

Indian poultry industry, as it exists today is a mixture of traditional backyard system of poultry keeping and modern space age technology. Poultry has a crucial place in India as the eggs and chicken meat are rich source of protein, vitamin and minerals. AICRP on Poultry Breeding running at MPUAT, Udaipur has developed a dual-purpose chicken breed to cater the needs of rural poultry keepers coined as Pratapdhan which bear a resemblance to local birds of Rajasthan. The study regarding personal profile of farmers about Pratapdhan breed under backyard poultry was conducted in Udaipur district of Rajasthan. The four villages from two tehsils, Girwa and Gogunda of Udaipur district were selected. It was observed that out of the 120 respondents, majority (65.83 %) of respondents were in middle age group, with majority (95.83 %) falling in less income category (< Rs 2.5 lakhs). While, (86.67 %) had medium backyard poultry income (Rs.10137 to 25549). In case of (93.33 %) respondents were in ST category and 47.50 % had primary education level. More than half (71.67 %) of the respondents were engaged in agriculture/animal husbandry as major occupation and only 50.83 % had membership in one organization of social participation group. In case majority (64.17 %) of the beneficiary farmers had marginal size of land holding. Also, majority (60.83 %) of the beneficiaries belonged to nuclear type of family and (56.66 %) of the respondents had medium level of extension contact.

Key word : Pratapdhan breed, backyard poultry, MPUAT area.

Introduction

Poultry, farming plays an important role in national economy and socio-economic development of the country. Poultry, especially chickens are the most widely reared species of livestock. Total poultry in the country is 851.80 million, out of which 534.74 million number commercial poultry and 317.07 million number in backyard poultry. The backyard poultry has increased by around 46% and commercial poultry has increased by 4.5% as compared to previous census. Backyard poultry farming is a traditional extensive system of rearing poultry with an average flock size of 5 to 20 native breeds or non-descript fowls or improved backyard birds by farm families to meet their dietary needs or small cash needs.

AICRP on Poultry Breeding running at MPUAT, Udaipur has developed a dual-purpose chicken breed to cater the needs of rural poultry keepers coined as Pratapdhan which bear a resemblance to local birds of Rajasthan.

Research Methodology

The present study was conducted in Udaipur district of southern Rajasthan. Udaipur district comprises of fifteen tehsils, out of these, two tehsils namely Girwa and Gogunda were randomly selected on the basis of maximum numbers of Pratapdhan breed beneficiaries.

According to data provided by Department of Animal Husbandry & Dairying (2016-22), Udaipur, maximum number of Pratapdhan breed beneficiary were present in Dedkiya and Jawla of Girwa tehsil and Hanyla and Vishma of Gogunda tehsil. Thus, these four villages were selected purposely on the basis of maximum beneficiaries. Proportionate number of respondents i.e., 40 from Dedkiya, 36 from Jawla, 36 from Hanyla and 8 from Vishma were selected randomly. Thus, total 120 respondents were selected for the investigation.

Results and Discussion

Age : With regards to age group of respondents, Table 1 reveals that majority (65.83 %) of the beneficiary farmers were belonging to 31 to 52 years age group, followed by 17.50 per cent and 16.67 per cent of the farmers who were belonging to above 52 years and less than 31 years age group, respectively. Among the respondents from Girwa tehsil, 68.42 per cent were belonging to 'Age between 31 to 52 years' age group, followed by 15.79 per cent from both 'Age less than 31 years' and 'Age above 56 years' age group of the beneficiary farmers. In case of Gogunda tehsil, 61.36 per cent respondents were belonging to 'Age between 31 to 52 years' age group, followed by 20.45 per cent and 18.18 per cent of the beneficiary farmers who were belonging to 'Age above 52 years' and 'Age less than 31 years' age group.

Annual family income : With regards to annual income of respondents, Table 2 shows that majority (95.83 %) of the beneficiary farmers belonged to 'Less than Rs 2.5 lakhs' annual income group. Whereas, only 4.17 per cent respondents had their annual income between Rs. 2.50 to 5.0 lakhs. Out of total 120 respondents, no respondent from the study area belonged to 'More than 5.0 lakhs' annual income category. In case of Girwa tehsil, majority (97.37 %) of the beneficiary farmers belonged to 'Less than Rs 2.5 lakhs' annual income group. It was followed by 'Rs. 2.50 to 5.0 lakhs' annual income group with only 2.63 per cent. In case of Girwa tehsil, majority (97.37 %) of the beneficiary farmers belonged to 'Less than Rs 2.5 lakhs' annual income group. It was followed by 'Rs. 2.50 to 5.0 lakhs' annual income group with only 2.63 per cent. From Girwa tehsil, no respondents have their annual income 'More than 5.0 lakhs'. Among the respondents from Gogunda tehsil, majority (93.18 %) of the beneficiary farmers belonged to 'Less than Rs 2.5 lakhs' annual income group. It was followed by 'Rs. 2.50 to 5.0 lakhs' annual income group with only 6.82 per cent. In Gogunda tehsil, it was also found that no respondent had their annual income 'More than 5.0 lakhs'.

Income from backyard poultry : With regards to income of the respondents from backyard poultry, Table 3 shows that majority (86.67 %) of the beneficiary farmers belonged to 'Medium level (Rs.10137 to 25549)' backyard poultry income group. It was followed by 'High level (more than Rs. 25549)' and "Low level (Less than Rs.10137)" backyard poultry income with 10.00 and 3.33 per cent, respectively. Among the respondents from Girwa tehsil, majority (86.84 %) of the beneficiary farmers belonged to 'Medium level (Rs.10137 to 25549)' backyard poultry income. It was followed by High level (more than Rs.25549) and Low level (Less than Rs.10137) backyard poultry income with 10.53 and 2.63 per cent, respectively. Among the respondents from Gogunda tehsil, majority (86.36 %) of the beneficiary farmers belonged to medium level (Rs.10137 to 25549) annual income. It was followed by High level (more than Rs.25549) and Low level (Less than Rs.10137) backyard poultry income with 9.09 and 4.55 per cent, respectively.

Caste : A perusal of data incorporated in Table 4 reveals that out of total respondents, 93.33 per cent respondents were from Scheduled Tribe (ST), while, only 6.67 per cent respondents were from Schedule Caste (SC). Whereas, no respondents belonged to the OBC and General caste from the study area. Further analysis of table shows that among the respondents of Girwa tehsil, majority (92.11 %) of the respondents were from ST caste, while, only 7.89 per cent respondents belonged to SC caste. Whereas, no respondent belonged to OBC and General caste from

Girwa tehsil. Similarly, among the respondents from Gogunda tehsil, majority (95.45 %) of the respondents belonged to ST caste, while, only 4.55 per cent of the respondents belonged to SC caste. In Gogunda also no respondents belonged to the OBC and general caste.

Education : It can be observed from Table 5 that majority (47.50 %) of the beneficiary farmers had 'Primary' level of education followed by 'Illiterate', 'Senior Secondary' and 'Secondary' level of education with 33.33, 13.33 and 5.83 per cent, respectively. No respondent belonged to 'Graduation and above' education level category. Among the respondents from Girwa tehsil, 52.63 per cent had 'Primary' level of education followed by 'Illiterate', 'Senior Secondary' and 'Secondary' level of education with 21.05, 17.11 and 9.21 per cent, respectively. Among the respondents from Gogunda tehsil, 54.55 per cent beneficiary farmers were illiterate according to their level of education followed by 'Primary' and 'senior secondary' level of education with 38.64 and 6.82 per cent, respectively. In Gogunda no respondent belonged to 'Secondary' and 'Graduation and above' education level category.

Occupation : The data presented in the Table 6 regarding the main occupation of the beneficiary farmers shows that 71.67 per cent were engaged in 'Agriculture/Animal husbandry' as main occupation followed by 'Labour/ Landless labour' with 25.00 per cent. While, only 3.33 per cent respondents were engaged in 'service' sector. From the study area, no respondent was engaged in caste occupation and business. Among the respondents from Girwa tehsil, majority (81.58 %) of the beneficiary farmers were engaged in 'Agriculture/Animal husbandry' as main occupation followed by 'Labour/ Landless labour' with 14.47 per cent. While, only 3.95 per cent respondents were engaged in 'service' sector. From the study area no respondents engaged in caste occupation and business. In case of Gogunda tehsil, majority (54.55 %) of the respondents engaged in 'Agriculture/Animal husbandry' as main occupation followed by 'Labour/ Landless labour' with 43.18 per cent. While, only 2.27 per cent respondents were engaged in 'Service' sector. Among the respondents from Gogunda tehsil no respondents engaged in caste occupation and business.

Social participation : The data presented in Table-7 reveals that majority (50.83 %) of the respondents had membership in one organization of social participation group, followed by 49.17 per cent of beneficiary farmers who were 'Not member of any organization'. Among the respondents from study area, no respondent was having participation in 'Member of more than one organization', 'Member of committed organization', 'Leader in organization' and 'Public leader'. Among the respondents

Table-1 : Distribution of respondents as per their age.

S. No.	Age group	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	Young (<31 years)	12	15.79	8	18.18	20	16.67
2.	Middle (31 to 52 years)	52	68.42	27	61.36	79	65.83
3.	Old (> 52 years)	12	15.79	9	20.45	21	17.50
	Total	76	100	44	100	120	100

f= frequency, %=per cent, mean-41.53, S.D.-10.39

Table-2 : Distribution of respondents according to their annual family income.

S. No.	Annual family income	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	< Rs. 2.5 lakhs	74	97.37	41	93.18	115	95.83
2.	Rs. 2.50 to 5.0 lakhs	2	2.63	3	6.82	5	4.17
	Total	76	100	44	100	120	100

f= frequency, %=per cent

Table-3 : Distribution of respondents according to their income from backyard poultry.

S. No.	Income from Backyard poultry	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	Low level (< Rs.10137)	2	2.63	2	4.55	4	3.33
2.	Medium level (Rs.10137 to 25549)	66	86.84	38	86.36	104	86.67
3.	High level (> Rs.25549)	8	10.53	4	9.09	12	10.00
	Total	76	100	44	100	120	100

f= frequency, %=per cent, mean-17843.33, S.D.-7706.32

Table-4 : Distribution of respondents according to their caste.

S. No.	Caste	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	ST	70	92.11	42	95.45	112	93.33
2.	SC	6	7.89	2	4.55	8	6.67
	Total	76	100	44	100	120	100

f= frequency, %=per cent

Table-5 : Distribution of respondents according to their education level.

S. No.	Educational level	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	Illiterate	16	21.05	24	54.55	40	33.33
2.	Primary	40	52.63	17	38.64	57	47.50
3.	Secondary	7	9.21	0	0.00	7	5.83
4.	Senior Secondary	13	17.11	3	6.82	16	13.33
	Total	76	100	44	100	120	100

f= frequency, %=per cent

from Girwa tehsil, no respondent was 'Member of more than one organization', 'Member of committed organization', 'Leader in organization' and 'Public leader'. In case of respondents from Gogunda tehsil, majority (79.55 %) of the respondents were 'Not member of any organization' followed by 'Member of one organization' with 20.45 per cent. Among the respondents from Gogunda tehsil, no respondent was 'Member of more than one organization', 'Member of committed organization', 'Leader in organization' and 'Public leader'.

Land holding : Table 8 reveals that majority (64.17 %) of the beneficiary farmers had marginal size of land holding, followed by small and semi-medium size of land holding with 30.00 per cent and 5.83 per cent, respectively. Whereas, no respondents from study area having their land holding size medium and large. Among the respondents from Girwa tehsil, 48.68 per cent respondents had marginal size of land holding, followed by small farmers with 42.11 per cent. Only 9.21 per cent respondents were had semi-medium land holding size. While, no respondents were had their land holding size

Table-6 : Distribution of respondents according to their occupation.

S. No.	Occupation	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	Labour/ Landless labour	11	14.47	19	43.18	30	25.00
2.	Agriculture / Animal Husbandry	62	81.58	24	54.55	86	71.67
3.	Service	3	3.95	1	2.27	4	3.33
	Total	76	100	44	100	120	100

f= frequency, %=per cent

Table-7 : Distribution of respondents according to their social participation.

S. No.	Social participation	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	Not member of any organization	24	31.58	35	79.55	59	49.17
2.	Member of one organization	52	68.42	9	20.45	61	50.83
	Total	76	100	44	100	120	100

f= frequency, %=per cent

Table-8 : Distribution of respondents according to their land holding.

S. No.	Land holding	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	Marginal farmers (<1.00 ha)	37	48.68	40	90.91	77	64.17
2.	Small farmers (1.01 to 2.00 ha)	32	42.11	4	9.09	36	30.00
3.	Semi-medium farmers (2.01 to 4.00)	7	9.21	0	0.00	7	5.83
	Total	76	100	44	100	120	100

f= frequency, %=per cent

Table-9 : Distribution of respondents according to their family type.

S. No.	Family type	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	Nuclear	52	68.42	21	47.73	73	60.83
2.	Joint	24	31.58	23	52.27	47	39.17
	Total	76	100	44	100	120	100

f= frequency, %=per cent

Table-10 : Distribution of respondents according to their extension contacts.

S. No.	Level of extension contact	Girwa (n ₁ =76)		Gogunda (n ₂ =44)		Overall (n=120)	
		f	%	f	%	f	%
1.	Low level (<3.49)	10	13.16	10	22.73	20	16.67
2.	Medium level (3.49 to 5.83)	46	60.52	22	50.00	68	56.66
3.	High level (>5.83)	20	26.32	12	27.27	32	26.67
	Total	76	100	44	100	120	100

f= frequency, %= per cent, mean=4.66, S.D. =1.17

semi-medium, medium and large. In case of Gogunda tehsil, majority (90.91 %) of the respondents have marginal size of land holding, while, 9.09 per cent respondents had small size of land holding. Among the respondents from Gogunda tehsil, no respondents have land holding size semi-medium, medium and large.

Family type : Data presented in Table 9 shows that majority (60.83 %) of the beneficiary farmers belonged to nuclear type of family, whereas 39.17 per cent beneficiary farmers belonged to joint family. Among the respondents from Girwa tehsil, 68.42 per cent belonged to the nuclear

type of family followed by joint type of family with 31.58 per cent respondents. In case of Gogunda tehsil, 52.27 per cent respondents belonged to joint type of family, while, 47.73 per cent beneficiary farmers belonged to nuclear type of family.

Extension contacts : Data presented in Table 10 reveals that out of total respondents, majority (56.66 %) of the respondents had medium level of extension contact followed by high and low level of extension contact with 26.67 and 16.67 per cent respondents, respectively. Among the respondents from Girwa tehsil, 60.52 per cent

beneficiary farmers had medium level of extension contact followed by high level of extension contact with 26.62 per cent beneficiary farmers, whereas, 13.16 per cent beneficiary farmers had low level of extension contact. In case of Gogunda tehsil, half (50.00 %) of the beneficiary farmers had medium level of extension contact while, 27.27 and 22.73 per cent beneficiary farmers had high and low level of extension contact, respectively.

Conclusions

From the above discussion it can be concluded that almost half (49.17 %) of the respondents had no social participation with any organization. It may be the reason of the medium knowledge and adoption of various practices about Pratapdhan breed under backyard poultry. Therefore, it that beneficiary farmers should be exposed to the agriculture university for information through the extra efforts made by extension personnel of agriculture university. Proper and more intensive training programmes should be organized by the concerned extension agencies for better practices by the beneficiary farmers of different practices under backyard poultry. We conclude that majority of farmers had poor social participation with one or two organisations. We also,

conclude medium to high extension contacts and income from backyard poultry.

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Assessing the Morphological Mutagenic Effects of Diethyl Sulphate on Cowpea (*Vigna unguiculata* L.)

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Abstract

The present study titled "Assessing the morphological mutagenic effects of Diethyl Sulphate on Cowpea (*Vigna unguiculata* L.)" was conducted during the Zaid season of 2022-23 at Horticulture Farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. The experiment comprised eleven treatments involving different concentrations of diethyl sulphate, which were replicated three times and randomly applied to 33 plots using a Randomized Block Design (RBD). The recommended dose of the chemical mutagen diethyl sulphate for cowpea was 0.4%. The results of the study revealed that among the various concentrations of diethyl sulphate, treatment DES₄ (0.4%) exhibited significantly higher values for germination percentage (91.11%), leaf length (12.26cm), leaf width (6.63cm), number of branches per plant (10.53), plant height (49.53 cm), number of pods per cluster (2.77), and pod length (22.85cm). Conversely, treatment DES₁₀ (1.0%) showed the lowest values for germination percentage (57.78%), leaf length (6.27cm), leaf width (4.55cm), number of branches per plant (8.33), plant height (39.13 cm), number of pods per cluster (1.93), pod length (18.65cm), and delayed days to 50% flowering (54.13 days).

Key words : Assessing, mutagenic effects, recommended dose.

Introduction

Cowpea (*Vigna unguiculata* L.) holds significant importance as a leguminous food crop, playing a vital role in traditional cropping systems within the semi-arid tropics (Ayisi *et al.*, 2000). It belongs to the genus *Vigna*, specifically the Phascolinae tribe and Phascolastrae group of the Fabaceae family. The species is diploid, characterized by a chromosomal count of $2n=2x=22$. Originating in West Africa, particularly the sub-humid savanna grasslands of Nigeria, cowpea thrives in these regions.

Often referred to as the "poor man's meat," cowpea stands out due to its remarkable protein content found in both its seeds and leaves. However, it does contain certain anti-nutritional elements such as phytic acid and protease inhibitors, which reduce its overall nutritional value. To address this concern, various techniques like fermentation, soaking, germination, debranning, and autoclaving are employed to increase the bioavailability of nutrients and counteract the anti-nutritional properties associated with cowpea.

The seeds of cowpea are a rich source of proteins, calories, minerals, and vitamins, making them a valuable complement to predominantly cereal-based diets in countries where cowpea is a major food crop. These seeds contain a significant amount of protein (22-24%),

carbohydrates (55-66%), iron (0.005%), calcium (0.08-0.11%), as well as essential amino acids (lysine 7.3-8.74g 100 g⁻¹, leucine 6.45-8.5 g 100 g⁻¹, cysteine 0.84-1.08g 100 g⁻¹, isoleucine 4.17–5.46g 100 g⁻¹, and threonine 3.89–5.12g 100g⁻¹). Notably, cowpea seeds maintain a low-fat content (Jayathilake *et al.*, 2018).

Materials and Methods

The present investigation, titled "Assessing the morphological mutagenic effects of Diethyl Sulphate on Cowpea (*Vigna unguiculata* L.)" was carried out between February 2023 and June 2023 at the Horticulture Farm, Department of Horticulture, Rajasthan College of Agriculture MPUAT, Udaipur.

This chapter provides a comprehensive account of the experimental site, materials used, and the methodology employed during the experimentation.

Preparation of Mutagenic Solutions: A one percent stock solution of DES (diethyl sulfate) was prepared in phosphate buffer by adding citric acid and disodium hydrogen phosphate, resulting in a pH value of 7.0. From this stock solution, the desired concentrations of DES were prepared using the following formula :

$$S1V1 = S2V2$$

Where,

S1 = strength of stock solution

V1 = Volume of stock solution

S2 = Strength of desired solution

V2 = Volume of desired solution

It is important to note that the specificity of action of the chemical mutagen depends on specific treatment conditions, including temperature, treatment duration, and hydrogen ion concentration. Only freshly prepared solutions of DES were used due to the high reactivity of alkylating agents, even with water. Hydrolysis of DES can result in compounds that are no longer mutagenic but toxic to biological tissues. Therefore, the mutagen solution was prepared immediately before use and not stored.

Pretreatment: Prior to the mutagenic treatments, healthy and uniformly sized cowpea seeds were presoaked in distilled water for 6 hours at room temperature ($25 \pm 1^\circ\text{C}$) to activate the embryos.

Treatment with Mutagens: After the presoaking period, the seeds were placed on blotting paper to remove excess moisture. Subsequently, the seeds were treated with different concentrations of DES for 4 hours. A set of untreated seeds was kept as a control for comparison with the treated populations.

During the chemical mutagenic treatments, intermittent shaking was performed throughout the treatment period to ensure sufficient aeration. To ensure uniform absorption, large quantities of mutagenic solutions, approximately three times the volume of the seeds, were used. After the 4-hour treatment period, the treated seeds were thoroughly washed in running tap water for 1 hour before sowing to remove any residual effects of the mutagen adhering to the seed coat.

Observations Recorded: All the characteristics were periodically recorded according to the objectives of the experiment. To record the observations, five plants were randomly selected, and the average was calculated to assess the effect of chemical mutagen on the morphological characters of cowpea.

Germination percentage (%): The germination percentage of seeds was recorded starting from the emergence of the first shoot in each treatment and the control group in the field, on alternate days, until maximum germination was achieved. After recording the germination, the percentage of seed germination was calculated using the following formula :

$$G\% = \frac{\text{Number of seed germinated}}{\text{Number of seed sown}} \times 100$$

Days to 50 percent flowering: The data for the number of days required for 50% of the plants to reach flowering

stage was measured from the date of seed sowing in the field until the date when 50% of the plants completed the opening of their first flower.

Leaf length (cm): The length of leaves was measured in centimeters from five randomly selected plants in each treatment.

Leaf width (cm): The width of leaves was measured in centimeters from five randomly selected plants, and the mean value was calculated.

Number of branches per plant: The number of branches emerging directly from the main stem was counted for five randomly selected plants.

Plant height (cm): The height of each plant was recorded in centimeters at maturity using a scale, measuring the distance from the ground level to the tip of the main shoot.

Number of pods per cluster: The number of pods per cluster was counted for each plant, and the mean value was calculated.

Pod length (cm): Pod length was measured by measuring the length of five randomly selected pods from each selected plant in each treatment, and then the mean value for each selected plant was calculated.

Results and Discussion

Germination Percentage : The data presented in Table 1 regarding the effect of diethyl sulphate on the germination percentage of cowpea revealed its significant impact. According to the data, the highest germination percentages were observed under the following treatments: DES₁ (0.1%) with 86.67%, DES₂ (0.2%) with 81.67%, and DES₃ (0.3%) with 76.67%. Conversely, the lowest germination percentage of 36.67% was observed under the DES₁₀ (1.0%) treatment.

Days to 50 Percent Flowering : The data presented in Table-1 revealed that the various concentrations of diethyl sulphate significantly affected the number of days to reach 50 percent flowering. The treatment DES₄ (0.4%) resulted in early flowering, with an average of 43.20 days. On the other hand, the treatment DES₁₀ (1.0%) exhibited late flowering, taking an average of 54.13 days.

Leaf Length (cm) : The data concerning the effect of diethyl sulphate on leaf length were presented in Table 1. The data clearly indicate that different concentrations of diethyl sulphate had a significant impact on leaf length. The highest leaf length of 12.26 cm was observed in the DES₄ (0.4%) treatment, followed by DES₃ (0.3%) with a leaf length of 11.05 cm. Conversely, the lowest leaf length of 6.27 cm was recorded in the DES₁₀ (1.0%) treatment.

Leaf Width (cm) : The data presented in Table 1 focused on the effect of diethyl sulphate on leaf width. It is evident

from the data that the variation in leaf width was significant due to different concentrations of diethyl sulphate. The highest leaf width of 6.63 cm was recorded in the DES₄ (0.4%) treatment, followed by DES₃ (0.3%) with a leaf width of 6.57 cm. On the other hand, the lowest leaf width of 4.55 cm was observed in the DES₁₀ (1.0%) treatment.

Number of Branches per Plant : The data regarding the effect of diethyl sulphate on the number of branches per plant were presented in Table 1. The results indicated a significant effect of diethyl sulphate on the number of branches per plant. The treatment DES₄ (0.4%) showed the highest number of branches, with an average of 10.53, followed by the DES₃ (0.3%) treatment with 10.23 branches per plant. In contrast, the treatment DES₁₀ (1.0%) exhibited the lowest number of branches per plant, with an average of 8.33.

Plant Height (cm) : The data presented in Table 1 demonstrated the significant effect of diethyl sulphate on plant height. According to the data, the maximum plant height of 49.53 cm was observed in the DES₄ (0.4%) treatment, followed by the DES₃ (0.3%) treatment with a plant height of 45.10 cm. In contrast, the minimum plant height of 39.13 cm was recorded in the DES₁₀ (1.0%) treatment.

Number of Pods per Cluster : The data regarding the effect of different concentrations of diethyl sulphate on the number of pods per cluster were presented in Table 1. The results indicated a significant effect of diethyl sulphate on the number of pods per cluster. The treatment DES₄ (0.4%) exhibited the highest number of pods per cluster, with an average of 2.77, followed by the DES₃ (0.3%) treatment with 2.73 pods per cluster. Conversely, the lowest number of pods per cluster, averaging 1.93, was observed under the DES₁₀ (1.0%) treatment.

Pod Length (cm) : The results from the data presented in Table 1 revealed a significant effect of different concentrations of diethyl sulphate on pod length. The treatment DES₄ (0.4%) showed the highest pod length of 22.85 cm, followed by the DES₃ (0.3%) treatment with a pod length of 22.46 cm. On the other hand, the lowest pod length of 18.65 cm was found under the DES₁₀ (1.0%) treatment.

Effect on Morphological Parameters : In the present experiment, Assessing the morphological mutagenic effects of Diethyl Sulphate on Cowpea (*Vigna unguiculata* L.) showed significant results on morphological parameters. The treatment DES₄ (0.4%) exhibited the highest values for various parameters including maximum germination percentage (91.11%), leaf length (12.26 cm), leaf width (6.63 cm), number of branches per plant (10.53), plant height (49.53 cm), pods per cluster (2.77),

pod length (22.85 cm) and earlier days to 50% flowering (43.20 days). Conversely, treatment DES₁₀ exhibited the lowest values for these parameters, including minimum germination percentage (57.78%), leaf length (6.27 cm), leaf width (4.55 cm), number of branches per plant (8.33), plant height (39.13 cm), pods per cluster (1.93), pod length (18.65 cm), delayed days to 50% flowering (54.13 days). Treatments DES₃, DES₂, and DES₁ showed similar results to the control treatment (DES₁₁).

The increase in plant height may be attributed to the effects of certain chemical mutagens that induce single base substitutions, resulting in a broad variation in morphological parameters compared to the control, as mentioned by Abdullah *et al.* (2009). Dhakshanamoorthy *et al.* (2010) suggested that early flowering at lower doses of mutagens could be due to physiological changes in the plant, while delayed flowering occurs at higher doses due to inhibitory effects. Delayed germination can be caused by a depression in the rate of mitotic proliferation. Inhibition of seed germination has been linked to chromosomal deletions and changes in various biochemical and physiochemical systems, as reported by Khan *et al.* (2006). The height of the plant decreases progressively with increasing doses of mutagen, as noted by Sikder *et al.* (2015). This reduction could be attributed to chromosomal damage or inhibition of cell division, which may cause gross injury at the cellular level, affecting gene-controlled biochemical processes.

These findings are consistent with previous studies by Khan *et al.* (2006) in mung bean, Gopinath and Pavadai (2015) in soybean, Padmapriya and Rajamani (2019) in glory lily, Yaseen *et al.* (2020) in cowpea, and Nair and Gayathri (2022) in cowpea.

Details of treatment

Treatments	Treatments level (%)
DES ₁	DES@ 0.1
DES ₂	DES@ 0.2
DES ₃	DES@ 0.3
DES ₄	DES@ 0.4
DES ₅	DES@ 0.5
DES ₆	DES@ 0.6
DES ₇	DES@ 0.7
DES ₈	DES@ 0.8
DES ₉	DES@ 0.9
DES ₁₀	DES@1.0
DES ₁₁	Control

Table-1 : Concentrations of diethyl sulphate on different yield attributes.

Treatments	Germination percentage	Days to 50% flowering	Leaf length (cm)	Leaf width (cm)	Branches per plant	Plant height (cm)	Pods per cluster	Pod length (cm)
DES ₁	91.11%	45.87	10.38	6.36	10.13	42.23	2.60	21.74
DES ₂	87.78%	45.00	10.41	6.41	10.20	43.08	2.63	22.36
DES ₃	84.44%	44.13	11.05	6.57	10.23	45.10	2.73	22.46
DES ₄	78.89%	43.20	12.26	6.63	10.53	49.53	2.77	22.85
DES ₅	66.67%	45.00	8.91	5.16	9.70	41.01	2.27	21.38
DES ₆	64.44%	49.60	7.78	5.11	9.13	40.93	2.20	20.81
DES ₇	62.22%	49.73	7.61	4.89	8.87	39.82	2.17	20.50
DES ₈	61.11%	50.53	7.48	4.79	8.80	39.63	2.13	20.13
DES ₉	58.89%	53.40	7.41	4.69	8.53	39.23	2.00	19.97
DES ₁₀	57.78%	54.13	6.27	4.55	8.33	39.13	1.93	18.65
Control	95.56%	48.20	10.37	6.33	10.00	42.12	2.57	20.74
SEm±	0.31	1.94	0.32	0.21	0.42	1.40	0.11	0.77
CD (P=0.05)	0.93	5.73	0.95	0.63	0.24	4.14	0.32	2.28
CV (%)	2.49	7.00	6.16	6.70	7.68	5.79	8.18	6.36

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Economics of Organic and Inorganic Cultivated Wheat in Southern Rajasthan

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Introduction

Organic farming is a production system that avoids or largely excludes the use of synthetic compound fertilizers, pesticides, growth-regulators and livestock-feed additives, and thus offers some solutions to the problems currently afflict the agricultural sector of industrialized or green revolution countries. Increasing awareness towards health and environmental issues associated with the intensive use of chemical inputs has led to alternate forms of agriculture. Organic farming is one among the production methods that are supportive of the environment (Kavitha *et al.* 2013).

Organic farming is in a nascent stage in India. About 2.78 million hectare of farmland was under organic cultivation, according to the Union Ministry of Agriculture and Farmers' Welfare. This is two per cent of the 140.1-million-hectare net sown area in the country. Madhya Pradesh tops the list with 0.76 million hectares of area under organic cultivation- that is over 27 per cent of India's total organic cultivation area. The top three states- Madhya Pradesh, Rajasthan and Maharashtra- account for about half the area under organic cultivation. A majority of the states have only a small part of their net sown area under organic farming. Even the top three states that account for the largest area under organic cultivation- Madhya Pradesh, Rajasthan and Maharashtra- have only around 4.9, 2.0 and 1.6 per cent of their net sown area under organic farming respectively (Yogi *et al.* 2022).

The most important constraints identified by the organic growers in productivity of organic crops were non availability of labor and organic certification whereas conventional growers' constraints were non availability of labor and high wage rate (Amarnath and Sridhar, 2012). The negative consequences of higher use of chemical fertilizers and pesticides are reduction in crop productivity and deterioration in the quality of natural resources. Pretty and Ball (2001) have pointed out that the environment will be affected by the carbon emission of the agricultural system through: a) Direct use of fossil fuel in farm operations, b) Indirect use of embodied energy for

producing agricultural inputs and c) Loss of soil organic matter during cultivation of soils. Joshi (2010) has also pointed out that intensive agriculture and excessive use of external inputs are leading to degradation of soil, water and genetic resources and negatively affecting agricultural production.

Research Methodology

The research is based on primary data which were collected for *Rabi* season of 2022-23 by personal interview method. From the study area, primary data was gathered from organic and inorganic farmers, respectively. The pertinent information about organic wheat cultivation was collected from individual farmer. The study pertains to the southern Rajasthan districts of Bhilwara and Chittorgarh where more number of organic farmers within the service area of MPUAT, Udaipur. Based on the concentration of organic growers, two tehsils from each district, namely Bhilwara and Shahpura from Bhilwara whereas Bhadesar and Chittorgarh from Chittorgarh were selected for the field survey. The organic farmers selected from each village were 15 organic and 15 inorganic farmers randomly. Total numbers of organic farmers from sample area were 60 and besides, 60 inorganic growers were also randomly chosen from the area that formed the control group for a comparison. A comparative study was also made between organic wheat and inorganic wheat. Thus, the study was based on the total sample of 120 farmers (60 organic wheat growers and 60 inorganic wheat growers).

Cost of cultivation : The total cost of cultivation was addition of total variable cost and fixed cost. The variable costs were the farm expenditure on seed, manure, fertilizers, human labour, machine labour and other inputs. The fixed costs were total rental value of land and depreciation on fixed assets etc. (Adhikari, 2011)

Benefit cost ratio analysis : Benefit cost ratio is ratio between the gross return and total cost of any enterprise. In this study, benefit cost ratio was calculated by using the formula :

$$B : C \text{ ratio} = \frac{\text{Gross return}}{\text{Total cost}}$$

Results and Discussion

Input use pattern of organic and inorganic wheat cultivation : From the table 1 it can be observed that for wheat cultivation mainly, seed, FYM, vermicompost, fertilizer, plant protection chemicals, biopesticides, human labour, machine labour and irrigation were used as input. In study area for organic wheat cultivation seed was used 97.18 kg/ha and 105.16 kg/ha for inorganic wheat cultivation, on average basis. On an average, per hectare 58.27 man days of human labour were used for organic wheat cultivation and 61.23 man days of human labour were used for inorganic wheat cultivation.

The overall per hectare use of machine labour was 10.44 hours per hectare for organic wheat cultivation and 11.63 hours per hectare for inorganic wheat cultivation. The total amount of FYM used per hectare for organic wheat cultivation was 54.5 quintals and for inorganic wheat cultivation was 49.68 quintals. On average, per hectare use of plant protection chemicals was observed to be 1.16 liters per hectare and biochemical for per hectare was observed to be 2.71 litres.

Cost of cultivation of wheat under organic and inorganic cultivation : The overall cost of cultivation of organic wheat was estimated as Rs. 59508.27 per hectare out of which total fixed cost was Rs. 20258.5 and total variable cost was Rs. 39249.7 from selected farms as depicted in table 4.10. In percentage terms, fixed costs accounted for 34.04 per cent of total costs, while variable costs accounted for 65.96 per cent. Among the overall cost human labour has maximum share 19.80 per cent to the total cost and minimum share by bio-pesticides 0.91 per cent. In input cost FYM has maximum share 11.24 per cent, followed by cost of vermicompost 8.61 per cent, cost of seed 4.77 per cent, cost of irrigation 1.54 per cent and cost of bio-pesticide 0.91 per cent to the total cost respectively. In case of labour cost there was contribution of human labour 19.80 per cent and machine labour 17.27 per cent respectively.

In inorganic wheat cultivation total cost was Rs. 64020.34 per hectare out of which total fixed cost was Rs. 21223.7 and total variable cost was Rs. 42896.6. In percentage terms, fixed costs accounted for 33.15 per cent of total costs, while variable costs accounted for 67.00 per cent. Among the overall cost human labour has maximum share 20.57 per cent to the total cost and minimum share by irrigation cost 1.54 per cent. Among other items of the cost, the second one was machine labour followed by, depreciation, rental value of owned land, chemical fertilizers, FYM, seed, interest on working capital, plant protection chemicals, interest on fixed capital and irrigation cost accounting for 17.24, 16.09,

15.41, 9.38, 9.24, 4.62, 2.22, 2.18, 1.65 and 1.54 per cent of total cost, respectively.

The cost of cultivation of organic wheat cultivation was Rs. 59508.27 per hectare and Rs. 64020.34 per hectare for inorganic wheat cultivation. The reasons for higher cost in inorganic wheat cultivation were use of high seeds, high chemical fertilizers and high plant protection chemicals.

Operation wise labour cost of wheat under organic and inorganic cultivation : The result of the table 3 showed that labour cost for all operations required for organic wheat cultivation was Rs.22057.99 per hectare. The highest labour cost incurred in threshing Rs. 5603.37 (25.40 per cent) followed by preparatory tillage, irrigation cost, harvesting cost, sowing cost, Interculture operations and manuring cost, which was accounted for 22.92, 16.51, 13.54, 10.22, 7.17, and 4.23 per cent, respectively. The cost of human labour comprising owned and hired labour incurred in organic wheat cultivation was Rs. 11781.74 which was 53.41 per cent of total labour cost. The total cost incurred on machine labour use per hectare was Rs. 10276.25 that was 46.59 per cent of total labour cost.

The total labour cost for all operations required for inorganic wheat cultivation was Rs. 24205.46 per hectare. The maximum labour cost incurred in threshing Rs. 5691.21 (23.51 per cent) and minimum labour cost incurred in chemical application cost Rs. 660.58 (2.73 per cent) per hectare. Among other operation costs, second was preparatory tillage followed by irrigation, harvesting cost, sowing cost, interculture operations, manuring cost, fertilizer application and chemical application cost, which was accounted for 21.76, 16.12, 13.66, 9.53, 5.44, 3.89, 3.34 and 2.73 per cent, respectively. The cost of human labour comprising owned and hired labour incurred in inorganic wheat cultivation was Rs. 13165.45 which was 54.39 per cent of total labour cost. The total cost incurred on machine labour use per hectare was Rs. 11040.01 that was 45.61 per cent of total labour cost. Higher cost of labour incurred in inorganic wheat cultivation due to high uses of inputs and compactness of soil.

Economics of wheat production under organic and inorganic farms : Table-4 depicts that the average yield of organic wheat was 27.13 quintals per hectare that was relatively lower than that of inorganic wheat having yield of 41.37 quintals per hectare. For organic wheat, the average market price was Rs. 3270 per quintal while for inorganic wheat it was Rs. 2056.25 per quintal in the study area. The average yield of by product of wheat was 34.87 quintals per hectare of organic wheat farms and 49.4 quintals per hectare from inorganic wheat farms. By product price of both organic and inorganic farms was

Table-1 : Input use pattern of organic and inorganic wheat cultivation. (Per hectare)

S. No.	Particulars	Organic farms	Rs/Unit	Inorganic farms	Rs/Unit
1.	Human labour (man days)				
a.	Owned	32.72		35.37	
b.	Hired	25.55		25.86	
	Total	58.27	252	61.23	254
2.	Machine labour (hrs/ha)				
a.	Owned	4.2		5.14	
b.	Hired	6.24		6.49	
	Total	10.44		11.63	
3.	Seed (Kg)	97.18	29.2	105.16	28.11
4.	FYM (quintals)	54.5	123	49.68	119
5.	Vermicompost (quintals)				
a.	Owned	5.45		0.00	
b.	Purchased	3.87		0.00	
	Total	9.32		0.00	
6.	Bio pesticides (lit/ha)	2.71	200.5	0.00	
7.	Chemical fertilizers (kg/ha)	0.00			
a.	Fertilizer nutrients (N, P, K) (kg/ha)	0.00		153.14	
b.	Micro nutrients (Zn) (kg/ha)	0.00		5.83	105
8.	Plant protection chemicals (lit/ha)	0		1.16	1205
9.	Irrigation charges (Rs.)	919.17		986.66	

Table-2 : Cost of cultivation of wheat under organic and inorganic. (Rs/ha)

S. No.	Particulars	Organic farms	Inorganic farms
I.	Variable cost (Rs./ha)		
1.	Human labour		
a.	Owned	6532.37 (10.98)	7510.15 (11.74)
b.	Hired	5249.37 (8.82)	5658.69 (8.83)
	Total	11781.74 (19.80)	13168.84 (20.57)
2.	Machine labour		
a.	Owned	2838.12 (4.77)	3434.59 (5.36)
b.	Hired	7438.12 (12.50)	7605.42 (11.88)
	Total	10276.24 (17.27)	11040.01 (17.24)
3.	Seeds	2838.6 (4.77)	2957.5 (4.62)
4.	FYM	6688.33 (11.24)	5916.92 (9.24)
5.	Vermicompost		
a.	Owned	2997.5 (5.04)	0
b.	Purchased	2126.67 (3.57)	0
	Total	5124.17 (8.61)	0
6.	Bio pesticides	543.32 (0.91)	0
7.	Chemical fertilizers	0	6004.2 (9.38)
8.	Plant protection chemicals	0	1397.75 (2.18)
9.	Irrigation charges	919.17 (1.54)	986.66 (1.54)
10.	Interest on working capital*	1078.15 (1.81)	1424.68 (2.22)
	Total variable cost	39249.7 (65.96)	42896.6 (67.00)
II.	Fixed cost		
1.	Rental value of owned land	9758.33 (16.40)	9866.67 (15.41)
2.	Rent paid for leased in land	0.00	0.00
3.	Land revenue	0.00	0.00
4.	Depreciation	9490.51 (15.95)	10298.8 (16.09)
5.	Interest on fixed capital**	1009.69 (1.70)	1058.27 (1.65)
	Total fixed cost	20258.5 (34.04)	21223.7 (33.15)
III.	Total cost	59508.27 (100.00)	64020.34 (100.00)

* at 7% and ** at 10%.

Note : Figures in parentheses indicates percentage of total values.

Table-3 : Operation wise labour cost of wheat under organic and inorganic cultivation. (Rs/ha)

S. No.	Farm operations	Organic farms		Total	Inorganic farms		Total
		Human labour	Machine labour		Human labour	Machine labour	
1.	Preparatory tillage	1054.5 (8.95)	4002.5 (38.94)	5057 (22.92)	1099.8 (8.35)	4168.7 (37.76)	5268.5 (21.76)
2.	Sowing	743.2 (6.30)	1511.2 (14.70)	2254.5 (10.22)	657.6 (4.99)	1649.3 (14.94)	2306.9 (9.53)
3.	Manuring	933.4 (7.92)	0	933.4 (4.23)	942.3 (7.16)	0	942.3 (3.89)
4.	Fertilizers application	0	0	0	809.1 (6.14)	0	809.1 (3.34)
5.	Interculture	1581.7 (13.42)	0	1581.7 (7.17)	1316.9 (10.00)	0	1316.8 (5.44)
6.	Chemical application	0	0	0	660.6 (5.02)	0	660.6 (2.73)
7.	Irrigation	3641.2 (30.90)	0	3641.2 (16.51)	3902.1 (29.64)	0	3902.1 (16.12)
8.	Harvesting	2556.7 (21.70)	430 (4.18)	2986.7 (13.54)	2464.5 (18.72)	843.5 (7.64)	3307.8 (13.66)
9.	Threshing	1270.8 (10.79)	4332.5 (42.16)	5603.4 (25.40)	1312.6 (9.97)	4378.6 (39.66)	5691.2 (23.51)
	Total labour cost	11781.5 (53.41)	10276.2 (46.59)	22057.9 (100.00)	13165.5 (54.39)	11040.1 (45.61)	24205.3 (100.00)

Table-4 : Economics of wheat production under organic and inorganic farms. (Rs/ha)

S. No.	Particulars	Organic farms	Inorganic farms
1.	Cost of cultivation (Rs/ha)	59728.27	64262.35
2.	Wheat yield (Q/ha)	27.13	41.37
3.	Main product price (Rs/qt)	3270	2056.25
4.	Straw (Q/ha)	34.87	49.4
5.	By product price (Rs/qt)	207.25	210.91
6.	Gross return (Rs/ha)	95965.83	95486.33
7.	Net income (Rs/ha)	36237.58	31223.99
8.	B : C ratio	1.60	1.48

similarly as Rs. 207.25 and Rs. 210.91 per quintal, respectively.

The returns arrangement revealed that the gross return in organic wheat cultivation was Rs. 95965.83 per hectare which was higher as compared to inorganic wheat cultivation having gross returns of Rs. 95486.33 per hectare. The net returns over the cost C2 under both systems of cultivation were discovered to be positive i.e. Rs. 36237.58 and Rs. 31223.99 per hectare for organic and inorganic cultivation of wheat, respectively. In spite of 34 per cent lower yield from inorganic wheat, the net return is approximately 16 per cent higher than the net return realized from inorganic wheat cultivation. This was due to premium price which is 37 per cent higher for organically produced wheat in the market. Return per rupee of expenditure was found higher for organic wheat (1.60) compared to inorganic wheat (1.48) in surveyed area.

Conclusions

The study has revealed that major crop of the sample area was wheat. The total cost on per hectare basis for the cultivation of organic wheat has been found less as compared to inorganic wheat. The net return over total cost have been found higher for organic (Rs 36237.58/hectare) than inorganic (Rs 31223.99/hectare) wheat for organic growers. The lower crop yield in organic wheat (27.13 qt/hectare) was well compensated by the higher price it fetched in the market. The total cost of cultivation of wheat crop for organic farmers in study area was ₹ 59508.27 which constituted 65.96 per cent of variable cost (₹ 39249.7) and 34.04 per cent of fixed cost (₹ 20258.5) whereas for inorganic farmers in study area was ₹ 64020.34 which constituted 67.00 per cent of variable cost (₹ 42896.6) and 33.15 per cent of fixed cost (₹ 21223.7). Benefit Cost ratio was found higher in organic

(1.60) wheat cultivation compared to inorganic (1.48) wheat cultivation.

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Effect of Indole-3-Butyric Acid (IBA), Cow Urine and Vermiwash during Rainy Season on Tomato Stem Cuttings

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Abstract

Investigation carried during 2022-23 at Hi-Tech Unit, RCA, Udaipur. CRD layout followed with control, IBA 50 ppm, IBA 100 ppm, cow urine 5%, cow urine 10%, cow urine 15%, vermiwash 5%, vermiwash 10% and vermiwash 15% treatments replicated three times. Experiment conducted during July-August. Observations were taken at 15 and 30 days after planting (DAP). Maximum shoot growth at 15 DAP observed *i.e.*, number of leaves at IBA 150 ppm and cow urine 15%, shoot diameter at IBA 50 ppm, shoot length and fresh weight of cutting at IBA 150 ppm. Maximum shoot growth at 30 DAP *i.e.*, number of leaves at cow urine 15%, shoot length at cow urine 5%, shoot diameter at IBA 50 ppm and fresh weight of cutting at IBA 150 ppm. Majority of root parameter *i.e.*, number of roots per cutting, length of root, fresh and dry weight of roots, root volume, survival percentage and chlorophyll content influenced by IBA 50 ppm. Tomato cutting propagated using various treatments but overall best result seen with IBA treatment.

Key words : IBA, cow urine, vermiwash, tomato, cutting, propagation.

Introduction

Tomato (*Solanum lycopersicum* L.) is most commonly grown, widely available and popularly used fruit-type vegetable. It is a member of Solanaceae family, which embraces more than 3000 species including significant food, spice and drug plants (Ganaie *et al.*, 2018). According to National Horticulture Board's Statistical Report 2020-21 (Final), the area of tomato cultivation is 0.84 million hectare and has a production of 21.18 million metric ton across India. The tomato crop is generally propagated through seed however we can also propagate the tomato plant through cutting. It may compensate for seeds in the case of the hybrid crop (Ossai *et al.*, 2020). There is no doubt that auxin controls the formation of adventitious root in cuttings with other function such as regulating plant height, parthenocarpy, early flowering, apical dominance, root formation in the callus, cell elongation and phototropism in a plant (Guan *et al.*, 2019). Cow urine contains 95 per cent water, 2.5 per cent urea and the remaining 2.5 per cent a mixture of salts, hormones, enzymes and minerals (Jandaik *et al.*, 2015). Vermiwash is a rich source of different types of compounds such as vitamins, hormones, enzymes, macronutrients and micronutrients hence helpful in efficient growth when applied to plants (Verma *et al.*, 2018).

Materials and Methods

The investigation entitled "Influence of IBA, cow urine and vermiwash on shoot growth of tomato (*Solanum lycopersicum* L.) stem cuttings" was undertaken during July 2022 to August 2022

at Hi-Tech Horticulture Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. The research conducted in nursery having size of 126.4 m², where top covered with UV stabilized polyethylene film and sides with 40 mesh net in Udaipur is located at 24° 58' N latitude and 73° 70' E longitude with an elevation of 582.17 meter above mean sea level.

The experiment was laid in completely randomized design with T₁ (control), T₂ (IBA 50 ppm), T₃ (IBA 100 ppm), T₄ (IBA 150 ppm), T₅ (cow urine 5%), T₆ (cow urine 10%), T₇ (cow urine 15%), T₈ (vermiwash 5%), T₉ (vermiwash 10%) and T₁₀ (vermiwash 15%) treatments replicated three times. The experiment conducted during rainy (July-August). Observation were recorded at 0, 15 and 30 days after planting (DAP) for various parameter *i.e.*, number of leaves per cutting, shoot length (cm), shoot diameter (mm), fresh weight of cutting (g), number of roots per cutting, length of root, fresh weight and dry weight of roots, root volume and survival percentage.

The tomato mother plant of variety "Heem Sohna" was used for cutting preparation having an age of 45-60

Table-1 : Influence of IBA, cow urine and vermiwash on number of leaves and shoot length (cm) on tomato cutting.

Treatment	Number of leaves					Shoot length (cm)				
	0 DAP	15 DAP	% increase from 0 DAP	30 DAP	% increase from 0 DAP	0 DAP	15 DAP	% increase from 0 DAP	30 DAP	% increase from 0 DAP
T1	3.47	3.67	5.8	3.87	11.5	11.32	11.69	3.3	12.35	9.1
T2	3.4	3.73	9.7	4.2	23.5	11.56	12.55	8.6	13.03	12.7
T3	3.53	3.87	9.6	4.33	22.7	11.46	11.96	4.4	12.72	11.0
T4	3.33	3.67	10.2	4.07	22.2	11.71	13.06	11.5	14.32	22.3
T5	3.67	3.93	7.1	4.2	14.4	11.79	13.10	11.1	14.51	23.1
T6	3.47	3.73	7.5	4.07	17.3	11.71	12.62	7.8	13.81	17.9
T7	3.33	3.67	10.2	4.13	24.0	11.47	12.32	7.4	13.13	14.5
T8	3.6	3.87	7.5	4.07	13.1	11.43	11.91	4.2	12.94	13.2
T9	3.47	3.73	7.5	4	15.3	11.39	12.31	8.1	13.31	16.9
T10	3.47	3.73	7.5	4	15.3	11.71	12.65	8.0	13.21	12.8
SE(m) $\pm$	0.052	0.063	-	0.060	-	0.193	0.261	-	0.222	-
C.D. (p = 0.05)	N.S.	0.188	-	0.177	-	N.S.	0.777	-	0.660	-

Table-2 : Influence of IBA, cow urine and vermiwash on shoot diameter (mm), fresh weight of cutting (g) and number of roots per cutting on tomato cutting.

Treatment	Shoot diameter (mm)				Fresh weight of cutting (g)			Number of roots per cutting	
	0 DAP	15 DAP	% increase from 0 DAP	30 DAP	% increase from 0 DAP	15 DAP	30 DAP	15 DAP	30 DAP
T1	3.81	3.97	4.2	4.22	10.8	2.73	3.21	9.00	13.93
T2	3.97	4.78	20.4	5.71	43.8	4.51	5.46	14.53	20.27
T3	4.33	4.55	5.1	4.71	8.8	3.75	4.43	12.73	18.93
T4	4.28	4.82	12.6	5.58	30.4	4.54	5.9	11.93	18.60
T5	4.13	4.53	9.7	5.07	22.8	4.16	5.78	11.47	18.47
T6	4.33	4.63	6.9	5.08	17.3	4.16	5.31	11.53	17.07
T7	4.10	4.69	14.4	5.33	30.0	3.92	4.64	11.47	17.07
T8	4.39	4.64	5.7	4.98	13.4	2.97	3.69	9.13	15.13
T9	3.47	3.97	14.4	4.48	29.1	2.88	3.72	9.13	14.80
T10	3.63	3.96	9.1	4.33	19.3	2.98	3.76	11.67	15.87
SE(m) $\pm$	0.061	0.060	-	0.082	-	0.050	0.069	0.756	0.894
C.D. (p = 0.05)	N.S.	0.177	-	0.243	-	0.147	0.206	2.247	2.656

days old. The size of the cutting was 10-13 cm with 3-4 leaves planted in the sole coco peat as media after treatment of cutting by dipping base in solution for 15 minutes. Commercial IBA solution prepared by dissolving desired amount of powder in absolute ethanol then after it mixed with 1 litre distilled water for completer formulation. Similarly, cow urine and vermiwash solution were prepared.

Results and Discussion

Number of leaves : Number of leaves (Table 1) at 15 DAP revealed that the maximum increase in number of leaves (3.67 *i.e.*, 10.2% percent increased as compared to

0 DAP) for treatment T₄ (IBA 150 ppm) and treatment T₇ (cow urine 15%). Results at 30 DAP showed that the maximum increase in number of leaves (4.13 *i.e.*, 24 percent increased as compared to 0 DAP) were observed for treatment T₇ (cow urine 15%). More number of leaves might be due to activation of auxin in vegetative parts by using IBA, as IBA reduces the level of stress and increase the photosynthetic pigments in vegetative parts like leaves. These results are conformity with the findings of Singh *et al.* (2014) while working with golden duranta. Positive effects of cow urine on number of leaves have also been observed by Santoso *et al.* (2016) while working on chrysanthemum.

Table-3 : Influence of IBA, cow urine and vermiwash on length of root, fresh weight and dry weight of roots and root volume on tomato cutting.

Treatment	Length of root (cm)		Fresh weight of roots (mg)		Root volume (cm ³)		Dry weight of roots (mg)	
	15 DAP	30 DAP	15 DAP	30 DAP	15 DAP	30 DAP	15 DAP	30 DAP
T1	3.65	9.09	191.97	479.00	0.77	1.37	13.37	27.07
T2	7.81	15.55	411.67	742.60	1.24	2.13	22.70	44.17
T3	6.20	12.45	326.93	652.30	0.86	1.69	18.87	39.13
T4	6.57	12.80	346.67	669.03	1.08	1.88	20.07	38.13
T5	5.12	11.69	268.87	611.93	1.00	1.63	16.50	34.20
T6	6.39	13.51	336.57	680.87	1.05	1.96	19.20	34.50
T7	5.50	11.65	289.87	614.47	0.97	1.67	17.47	34.93
T8	4.38	10.90	220.13	568.53	0.81	1.59	14.67	30.73
T9	4.80	9.59	200.30	505.33	0.81	1.40	13.80	27.83
T10	5.12	9.91	270.00	519.40	0.92	1.48	16.40	29.07
SE(m) ±	0.571	1.497	32.24	62.36	0.082	0.194	1.355	5.297
C.D. (p = 0.05)	1.696	N.S.	95.778	N.S.	0.243	N.S.	4.027	N.S.

Table-4 : Influence of IBA, cow urine and vermiwash on chlorophyll content (a, b and total) on tomato cutting.

Treatment	Chlorophyll a (mg/g)		Chlorophyll b (mg/g)		Chlorophyll Total (mg/g)		Survival Percentage
	15 DAP	30 DAP	15 DAP	30 DAP	15 DAP	30 DAP	30 DAP
T1	0.535	0.552	0.219	0.226	0.754	0.778	56
T2	1.482	1.503	0.598	0.607	2.08	2.115	78
T3	1.365	1.387	0.528	0.543	1.893	1.930	76
T4	1.241	1.267	0.472	0.487	1.713	1.758	75
T5	1.067	1.09	0.411	0.423	1.478	1.512	70
T6	1.036	1.07	0.392	0.403	1.428	1.476	72
T7	0.945	0.953	0.348	0.377	1.293	1.331	69
T8	0.912	0.943	0.336	0.34	1.248	1.283	68
T9	0.729	0.75	0.305	0.32	1.034	1.073	65
T10	0.709	0.737	0.254	0.27	0.963	1.003	67
SE(m) ±	0.016	0.014	0.007	0.007	0.021	0.021	1.197
C.D. (p = 0.05)	0.048	0.042	0.020	0.019	0.062	0.061	3.557

Shoot length : Shoot length (Table 1) at 15 DAP (13.06 cm *i.e.*, 11.5 percent increased as compared to 0 DAP) was recorded for treatment T₄ (IBA 150 ppm). Auxins activated shoot growth which might have caused hydrolysis and translocation of carbohydrates and nitrogenous substances at the base of cuttings and resulted in accelerating cell elongation and cell division (Singh *et al.*, 2003). These findings are in conformity with the work done by Manokari *et al.* (2016) while working on *Moringa*. Results at 30 DAP showed that the shoot length (14.51 cm *i.e.*, 23.1 percent increased as compared to 0 DAP) was recorded for treatment T₅ (cow urine 5%). These results are in agreement with findings of Santoso *et al.* (2016) while working on chrysanthemum.

Shoot diameter: Shoot diameter (Table 2) results at 15 DAP and at 30 DAP showed that the maximum increase in shoot diameter (4.78 mm *i.e.*, 20.4 percent increased as compared to 0 DAP and 5.71 mm *i.e.*, 43.8 percent increased as compared to 0 DAP) were recorded for

treatment T₂ (IBA 50 ppm), respectively. IBA might have resulted in assimilation of materials and result in thick shoot growth. These findings are supported by the results of Tien *et al.* (2020) while working on *Solanum procumbens*.

Fresh weight of cutting: Fresh weight of cutting at 15 DAP and at 30 DAP showed that maximum fresh weight (4.54 g and 4.90 g) were recorded for treatment T₄ (IBA 150 ppm), respectively. These results of IBA are in agreement with findings of Ayoub and El-Zeiny (2012) while working on cucumber.

Chlorophyll content: Chlorophyll content (Table 4) result at 15 DAP and 30 DAP revealed that maximum chlorophyll a, b and total (1.482, 0.598 and 2.08 mg/g) and (1.503, 0.607 and 2.115 mg/g) were for treatment T₂ (IBA 50 ppm), respectively.

Number of roots per cutting: Number of roots per cutting (Table 2) at 15 DAP and at 30 DAP showed that maximum

number of roots per cutting (14.53 and 20.27) were observed for treatment T₂ (IBA 50 ppm). De Klerk *et al.* (1999) reported that applied indole-3-butyric acid (IBA) increased adventitious root formation on vegetative stem cuttings. These results were supported by the findings of Kachru *et al.* (2017) while working on tomato.

Length of root: Length of root (Table 3) at 15 DAP showed that maximum length of root (7.81 cm) were observed for treatment T₂ (IBA 50 ppm). Results are in conformity with the findings of Kachru *et al.* (2017) while working on tomato. During cell division and auxin transport, auxins act primarily through selective proteolysis and cell wall loosening with receptor protein transporting inhibitor response 1 and auxin-binding protein 1 (da Costa *et al.*, 2013), which results in increase in length of root cells. Results of 30 DAP found non-significant.

Fresh weight and Dry weight of roots: Fresh weight of roots at 15 DAP showed that maximum fresh weight of roots (411.67 mg) were observed for treatment T₂ (IBA 50 ppm). Dry weight of roots at 15 DAP showed that maximum dry weight of roots (22.70 mg) was recorded for the treatment T₂ (IBA 50 ppm).

Root volume: Root volume (Table 3) at 15 DAP showed maximum (1.24 cm³) for T₂ (IBA 50 ppm). IBA treatment clearly increased the root volume in stem cuttings, which could be due to the fact that auxins aid in cell division and cell expansion resulting in longer roots and a greater mean volume of roots.

Survival percentage: From Table 4, Highest survival percentage (78%) was observed at T₂ (IBA 50 ppm), while lowest survival percentage (56%) was observed at T₁ (control). Cutting performance may be attributed to high carbohydrate reserves per cutting and optimal IBA concentration. These results are in conformity with the work done by Ayoub and El-Zeiny (2012) while working on cucumber.

Conclusion

From above investigation, we can conclude that the tomato propagation can be done with side stem cutting. The best result for highest survival percentage and root growth was obtained from treatment T₂ (IBA 50 ppm). However shoot growth responses can be observed for most of the treatments

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Biochemical Characterization of Local Mango Germplasms in Southern Rajasthan

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Abstract

The present investigation was conducted by collecting local mango germplasm from different locations in Udaipur and Rajsamand district of Southern Rajasthan during 2022. The experiment was carried out in Randomized Block Design (RBD) with sixteen local mango germplasm with three replications. In biochemical characteristics *i.e.*, TSS, pH and TSS/Acid ratio were maximum and minimum acidity was found in Jogiwad as compared to other germplasms under the experiment. Hence, it is concluded that Jogiwad germplasm was found overall best with respect to morphological and biochemical characteristics.

Key words : Mango, local germplasms and biochemical characteristics.

Introduction

Mangifera indica L. is a member of the genus *Mangifera*, which Linnaeus classified in the Plantarum category in 1754. It is a domesticated and monotypic species of mango. In the family Anacardiaceae, which is a member of the order Sapindales, containing 73 genera and about 830 species (Kostermans and Bompard, 1993). *Mangifera indica* L. evolved as an allopolyploid in eastern India, most specifically in Assam and Burma (Popenoe, 1920). Both domesticated and wild variants of the *Mangifera* species can be found in the ecosystem's natural environment. Its place of origin is in the South-East Asian and North-East Indian (monoembryonic or nucellar genotypes) parts of the world (Mukherjee, 1953). In India, mango is cultivated over an area of 2.34 million ha with an annual production of 20.34 million tonnes (Anonymous, 2021). India is the largest mango producer in the world.

Materials and Methods

The present investigation was carried out at two locations *i.e.*, Udaipur and Rajsamand. The different local mango genotypes selected for this study are situated between 24°17' to 25°01' North latitude, 73°10' to 73°34' East longitude having different village locations of Rajsamand and Udaipur districts. The experiment included 16 genotypes in RBD design. Five fruits were randomly selected for observations from each selected local mango germplasms. The observation was recorded for TSS, acidity, TSS/Acid ratio and fruit pH.

TSS was measured with the help of "digital refractometer". TSS/Acid ratio was calculated by dividing

TSS and acidity. The pH of mango pulp was measured directly with help of pH meter. Acidity of mango pulp was measured by diluting with distilled water using a known amount of the pulp of fruit and titrating the same against standard solution of N/10 sodium hydroxide, in which phenolphthalein is used as an indicator (A.O.A.C., 1995). The appearance of a light pink colour was taken as the end point.

Results and Discussion

In the present study on local mango germplasms wide range of TSS content was observed from 13.4°B to 20.0°B. The maximum TSS content was recorded in Jogiwad (20.5°B), while the minimum TSS was recorded in Bhanokara (13.4°B). Acidity of these local mango germplasms ranged from 0.21 per cent to 0.37 per cent. The maximum acidity was recorded in Uplawas (0.37 per cent), while the minimum acidity was recorded in Jogiwad (0.21 per cent). TSS/Acid ratio ranged from 45.16 to 85.66. The maximum TSS:Acid was found in Jogiwad (85.66), while the minimum TSS/Acid ratio was recorded in Dolariya-II (45.16). The fruit pH of these local mango germplasms ranged from 2.80 to 4.97. The maximum pH was recorded in Jogiwad (4.97) followed while, the minimum pH was recorded in Uplawas (2.80).

Fruit of these local mango germplasms varied for different biochemical characters *viz.*, TSS, acidity, TSS/Acid ratio and pH of fruit. Generally, as the pH of fruit decreases the acidity of fruit increases. The genotype, the time of fruit harvest, orchard management practises, the predominant agro-climatic conditions of the growing region are the key determinants of variation for the

Table-1 : TSS, acidity, TSS/Acid ratio and pH of local mango germplasm.

Germplasm	TSS (°Brix)	Acidity (%)	TSS/Acid ratio	pH
Manpur-I	19.6	0.23	85.51	4.24
Manpur-II	16.8	0.27	62.30	3.29
Dolariya-I	19.8	0.25	80.75	4.15
Dolariya-II	16.1	0.36	45.16	3.04
Subari	17.2	0.31	55.52	3.12
Palesar	14.4	0.24	72.37	4.17
Jogiwad	20.5	0.21	85.66	4.97
Jaswantgarh-I	19.6	0.26	75.47	3.90
Jaswantgarh-II	19.8	0.32	61.28	3.10
Jaswantgarh-III	19.5	0.25	78.05	4.33
Punawali	18.6	0.22	84.62	4.75
Sayara	19.2	0.30	63.99	3.19
Bhanokara	13.4	0.29	45.91	3.20
Uplawas	17.6	0.37	48.07	2.80
Ramawaton Ki Bhagal	20.0	0.28	71.17	3.28
Oda	15.6	0.26	60.02	3.30
SEm±	0.29	0.01	1.93	0.05
CD (P = 0.05)	0.85	0.02	5.57	0.14

variance among local mango germplasms for biochemical features (TSS, titrable acidity, TSS/Acid ratio, and pH). It is possible that genetic variation is responsible for the variation seen for various biochemical parameters since all other factors were the identical across all germplasms. Present research findings are in conformity with result recorded by Mannan *et al.* (2003); Dutta *et al.* (2008); Bakshi *et al.* (2013); Kaur *et al.* (2014) Naz *et al.* (2014); Kirankumar *et al.* (2015) and Kumar *et al.* (2022) for different biochemical characters of fruit of the locally available mango germplasms.

Conclusions

In biochemical characteristics *i.e.*, TSS, pH and TSS/Acid ratio were maximum and minimum acidity was found in Jogiwad as compared to other germplasms under the experiment. Hence, it is concluded that Jogiwad germplasm was found overall best with respect to morphological and biochemical characteristics.

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The Influence of NAA and Kinetin on Growth and Chlorophyll content of Broccoli (*Brassica oleracea* var. *italica* Plenck.)

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Abstract

In the presented investigation, consisted of ten treatments such as control, NAA (120 ppm), NAA (180 ppm), NAA (240 ppm), NAA (300 ppm), kinetin (30 ppm), NAA (120 ppm) + kinetin (30 ppm), NAA (180 ppm) + kinetin (30 ppm), NAA (240 PPM) + kinetin (30 ppm), NAA (300 ppm) + kinetin (30 ppm) was under taken in randomized block design with three replications. The results indicated that foliar application of NAA (240 ppm) + kinetin (30 ppm) at 20 and 40 DAT to the broccoli significantly increased the plant height, number of leaves per plant, plant spread, leaf area index and chlorophyll content in leaves (3.14mg/g), as compared to control.

Key Words : Growth regulators, kinetin, naphthalic acetic acid and broccoli.

Introduction

Broccoli (*Brassica oleracea* var. *italica* Plenck.) has originated in the Mediterranean region and commonly known as Hari gobhi. It belongs to family of cole group, Brassicaceae. Thamburaj and Singh, 2001 reported that broccoli is profusely consumed as fresh, soup, cooked vegetable, curry etc. It is a highly nutritious cool season vegetable crop. Nowadays, in modern era broccoli is immense consumed it has about 130 times more vitamin A than other cole group vegetable. It is the richest source of sulforaphane (SFN) compound to the range of 214 g (stem) to 499 g (inflorescence) per gram dry weight (Olga *et al.*, 2009), which has therapeutic potential for patients with high-risk prostate cancer (Kalia, 1995) as well as other cancers. NAA is synthetic plant hormone in the auxin group and is an ingredient in many commercial plants rooting horticultural product, it is rooting agent is use for vegetative propagation of plants, from stem and leaf cutting, plant tissue culture. NAA is a synthetic auxin that promotes cell elongation and is known for its influence on plant growth and development (Verma *et al.*, 2016). Kinetin, a type of cytokinin, plays a vital role in cell division, differentiation, and overall plant growth. Kinetin is a hormone, in combination with auxin, stimulates cell division and differentiation in plants (Alvarez *et al.*, 2008; Sakakibara *et al.* 2006). Most of the cytokinin are produced in the root apical meristems and transported throughout the plants. It is anti-aging hormones and counteracts apical dominance. It also induces flowering

induction in short day plants. It can stimulate water uptake, increase cell division, promote organ development, and lead to the regeneration and proliferation of shoots. Studies reported that, proper cultivation practices of broccoli can assist meet customer needs by assuring the market availability of high-quality, nutritional, and safe broccoli. The present study will contribute to closing this information gap by examining the effects of Naphthalene Acetic Acid (NAA) and Kinetin treatments on broccoli growth, yield, and quality. The usage of PGRs has the potential to promote sustainable farming practices.

Keeping in view the above-mentioned facts, an experiment entitled “The Influence of NAA and Kinetin on growth and chlorophyll content of Broccoli (*Brassica oleracea* var. *italica* Plenck.)”

Materials and Methods

Experimental Details : The experiment was conducted during *Rabi* 2022-2023 at the Horticulture Farm, Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur which is located at 24° 34' N latitude and 73° 42' E longitude at an elevation of 582.17 meters above mean sea level. The experiment consisted of ten treatments control, NAA (120 ppm), NAA (180 ppm), NAA (240 ppm), NAA (300 ppm), kinetin (30 ppm), NAA (120 ppm) + kinetin (30 ppm), NAA (180 ppm) + kinetin (30 ppm), NAA (240 PPM) + kinetin (30 ppm), NAA (300 ppm) + kinetin (30 ppm) as foliar spray was done by preparing the desired formulation in the plots as per treatments and

were sprayed at 20 and 40 DAT was under taken in randomized block design with three replications.

Planting Material and Sample Preparation : Cultivar Palam Haritika was procured from ICAR, New Delhi. Then nursery was laid in portraits during first week of October 2022. Total 30 plots were laid in size 3.60 m x 2.70 m were prepared and basic fertilizers were applied as the recommended dose of N, P, K. *i.e.* (120:60:40 kg ha⁻¹) along with 1 kg FYM, 90 gm urea, 120 gm SSP per plot was applied to soil application prior to transplanting. Transplanting as per treatment, 30 day-old and healthy seedlings of the broccoli variety Palam Haritika were transplanted at distance of 60 cm x 45 cm in five rows with 40 plants in each plot on November 8, 2022. For Foliar spray at 20 and 40 Days after transplanting, hormonal solution of NAA at 120, 180, 240 and 300 mg and Kinetin at 30 ppm, separate weighing were taken for each concentration by electric balance very carefully and then after they were put in separate test-tube. The 95 % proved ethyl alcohol was taken and added in test-tube to dissolve NAA and make up the volume 1000 ml separately and to dissolve kinetin, dimethyl sulfoxide was taken and added in test-tube. Later on, prepare the desired formulation for foliar spray.

Plant growth analysis : Plant height was measured at 30, 60 DAT and at harvest with the help of measuring scale in cm from ten selected broccoli plants. Number of leaves per plant measured by counting after foliar spray at 30, 60 DAT and at harvest. Plant spread was measured by measuring E-W and N-S length and multiply it and denoted in square centimeter. Leaf area index (LAI) of broccoli leaves was calculated by the given formula.

$$LIA = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Ground area (cm}^2\text{)}}$$

Chlorophyll content was recorded as per method suggested by (Sadasivam and Manickam, 1992) that one gram of sample was crushed in 20 ml of 80% acetone into mortar and pestle. Centrifuge (5000 rpm for 5 min), transfer the supernatant to 100 ml volumetric flask. Spectrophotometer (Dual beam (UV-VIS) 2002 XE with Xenon lamp) reading at 645 nm was recorded and calculated in mg g⁻¹.

Results and Discussion

Growth parameters : Data presented Table-1. It is evident that plant height, no. of leaves per plant, plant spread (cm²), leaf area index in broccoli were found significant as per treatments of NAA and Kinetin application. Moreover, twice foliar spray of NAA 240 ppm + Kinetin 30 ppm showed maximum plant height and number of leaves per plant *i.e.*, 19.59 cm, 8.71 (30 DAT),

37.83 cm, 14.72 (60 DAT) and 65.19 cm, 20.42 (at harvest) while minimum plant height *i.e.*, 13.38 cm, 4.30 (30 DAT), 31.16 cm, 8.64 (60 DAT) and 55.91 cm 12.62 (at harvest) were reported in control plants. Further, in Table no. 2. it was observed that maximum plant spread and leaf area index *i.e.*, 1549.16 cm², 0.16 at 30 DAT, 6672.32 cm², 0.27 at 60 DAT, 7066.21 cm², 0.42 at time of harvest were notice with the application of NAA 240 ppm + Kinetin 30 ppm respectively. While, minimum plant spread and number of leaves per plant *i.e.*, 1097.51 cm², 0.07 at 30 DAT, 4319.13 cm², 0.18 at 60 DAT, 5507.65 cm², 0.42 was observed in control treatment. Previous literature reports that NAA when applied in combination with kinetin, have a synergistic effect in enhancing the overall growth of broccoli. Mandingbam *et al.* (2020) foliar spray of NAA (120 ppm) significantly increases plant height (66.55 cm) and plant spread (85.73 cm) as compared to control. Similar, supporting results were also reported by Chaurasiy *et al.* (2014), Singh (2015), Pramanik and Mohapatra (2017), Vishwakarma *et al.* (2017), Singh *et al.* (2017), Kaur and Mal (2018), Tapdiya *et al.* (2018), Dixit *et al.*, (2020), Rickta (2020), Naher (2021) and Sony *et al.* (2022).

Chlorophyll content : Data presented in Figure 1 revealed that the foliar application of NAA (240 ppm) + Kinetin (30 ppm) at 20 and 40 DAT showed significant effect on chlorophyll content (2.36 mg g⁻¹ and 3.14 mg g⁻¹ respectively) as compared to control (1.06 mg g⁻¹ and 1.23 mg g⁻¹). Foliar application of NAA stimulates vegetative growth and leaf expansion in plants, which may enhance the synthesis of chlorophyll pigments, resulting in higher chlorophyll levels (Skalska 1992). Kinetin stimulates cell division and leaf expansion enhancing overall plant growth and development, which may positively influence chlorophyll content (Costa *et al.* 2005). This may also improve chlorophyll retention by delaying leaf senescence, thereby maintaining higher chlorophyll levels for a longer duration (Wu *et al.* 2021). The present findings were similar to previous studies, Chanwala *et al.* (2019) observed that foliar application of NAA @ 180 ppm to the sprouting broccoli significantly increased the chlorophyll content in leaves (2.99 mg 100 g⁻¹) as compared to control. Similarly, Jakhar *et al.* (2018) indicated that application of NAA @ 300 ppm to the sprouting broccoli significantly increased the chlorophyll content in leaves (3.01 mg/g) as compared to control.

Conclusions

Present finding revealed that NAA and Kinetin when applied at 20 and 40 DAT stimulate the plant growth traits and chlorophyll content in broccoli. Among ten treatments, foliar application of NAA 240 ppm + kinetin 30 ppm prove best for enhance the growth parameters and chlorophyll

Table-1: Effect of foliar application of NAA and Kinetin on plant height (cm) and number of leaves plant⁻¹ of broccoli

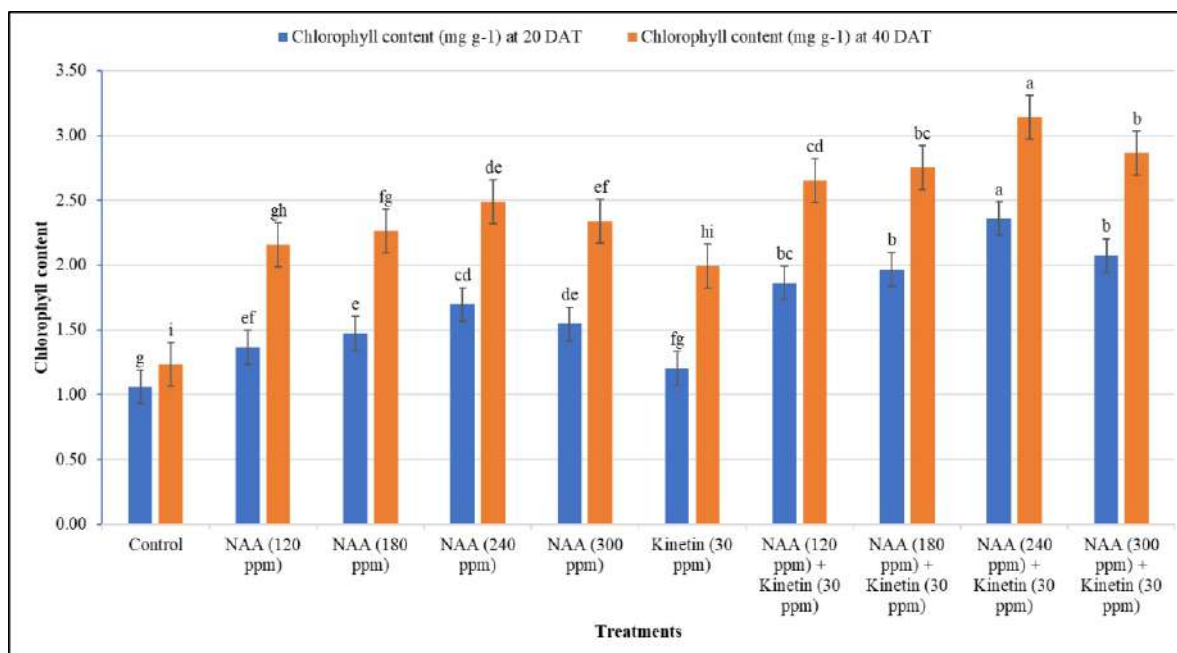
Treatments	Plant height (cm) 30 DAT	Plant height (cm) 60 DAT	Plant height (cm) At harvest	Number of leaves plant ⁻¹ 30 DAT	Number of leaves plant ⁻¹ 60 DAT	Number of leaves plant ⁻¹ At harvest
Control	13.38 ± 1.00 ^H	31.16 ± 0.92 ^H	55.91 ± 0.88 ^H	4.30 ± 1.00 ^G	8.64 ± 0.98 ^H	12.62 ± 0.98 ^H
NAA (120 ppm)	14.81 ± 0.02 ^F	32.96 ± 0.06 ^F	58.21 ± 0.02 ^F	5.63 ± 0.02 ^E	10.10 ± 0.03 ^F	14.80 ± 0.03 ^F
NAA (180 ppm)	15.33 ± 0.00 ^{EF}	33.44 ± 0.00 ^{EF}	58.73 ± 0.00 ^{EF}	6.06 ± 0.03 ^{DE}	10.60 ± 0.01 ^{EF}	15.32 ± 0.02 ^F
NAA (240 ppm)	16.48 ± 0.26 ^D	34.63 ± 0.22 ^D	59.88 ± 0.26 ^D	7.18 ± 0.02 ^C	11.76 ± 0.26 ^D	17.01 ± 0.12 ^D
NAA (300 ppm)	15.84 ± 0.04 ^E	34.00 ± 0.09 ^E	59.24 ± 0.04 ^E	6.51 ± 0.01 ^D	11.14 ± 0.05 ^E	15.91 ± 0.07 ^E
Kinetin (30 ppm)	14.15 ± 0.03 ^G	32.05 ± 0.05 ^G	56.71 ± 0.03 ^G	4.97 ± 0.03 ^F	9.42 ± 0.04 ^G	13.40 ± 0.04 ^G
NAA (120 ppm) + Kinetin (30 ppm)	17.47 ± 0.07 ^C	35.95 ± 0.02 ^C	63.28 ± 0.06 ^C	7.81 ± 0.02 ^B	12.63 ± 0.06 ^C	18.33 ± 0.06 ^C
NAA (180 ppm) + Kinetin (30 ppm)	18.05 ± 0.01 ^{BC}	36.48 ± 0.10 ^{BC}	63.80 ± 0.04 ^{BC}	8.16 ± 0.04 ^{AB}	13.20 ± 0.01 ^{BC}	18.90 ± 0.01 ^{BC}
NAA (240 ppm) + Kinetin (30 ppm)	19.59 ± 0.21 ^A	37.83 ± 0.07 ^A	65.19 ± 0.19 ^A	8.71 ± 0.43 ^A	14.72 ± 0.27 ^A	20.42 ± 0.27 ^A
NAA (300 ppm) + Kinetin (30 ppm)	18.61 ± 0.03 ^B	37.00 ± 0.30 ^B	64.30 ± 0.03 ^B	8.31 ± 0.01 ^{AB}	13.76 ± 0.03 ^B	19.46 ± 0.03 ^B

Tukey Levels (Mean ± SD) not connected by same alphabetic letters are significantly different at p=0.05 by Tukey-Kramer HSD test; DAT= Days After Transplanting.

Table-2 : Effect of foliar application of NAA and Kinetin on plant spread (cm²) and Leaf area index of broccoli.

Treatments	Plant spread (cm ²) 30 DAT	Plant spread (cm ²) 60 DAT	Plant spread (cm ²) At harvest	Leaf area index 30 DAT	Leaf area index 60 DAT	Leaf area index At harvest
Control	1097.51 ± 25.60 ^H	4319.13 ± 111.74 ^H	5507.65 ± 80.00 ^G	0.07 ± 0.002 ^H	0.18 ± 0.006 ^G	0.33 ± 0.007 ^G
NAA (120 ppm)	1255.20 ± 8.24 ^F	4803.33 ± 36.29 ^F	5843.33 ± 36.29 ^F	0.09 ± 0.002 ^F	0.20 ± 0.002 ^F	0.34 ± 0.002 ^F
NAA (180 ppm)	1276.19 ± 3.57 ^{EF}	4979.55 ± 15.74 ^E	6019.55 ± 15.74 ^E	0.10 ± 0.001 ^E	0.21 ± 0.001 ^E	0.36 ± 0.001 ^E
NAA (240 ppm)	1367.26 ± 18.55 ^D	5393.57 ± 83.56 ^D	6403.57 ± 83.56 ^D	0.12 ± 0.005 ^D	0.23 ± 0.006 ^D	0.37 ± 0.005 ^D
NAA (300 ppm)	1297.02 ± 11.18 ^E	5053.72 ± 49.28 ^E	6093.72 ± 49.28 ^E	0.10 ± 0.003 ^E	0.21 ± 0.003 ^E	0.36 ± 0.003 ^E
Kinetin (30 ppm)	1175.20 ± 4.17 ^G	4553.29 ± 17.96 ^G	5653.29 ± 17.96 ^G	0.08 ± 0.001 ^G	0.19 ± 0.001 ^{FG}	0.34 ± 0.001 ^{FG}
NAA (120 ppm) + Kinetin (30 ppm)	1451.73 ± 10.62 ^C	5824.87 ± 49.44 ^C	6624.87 ± 49.44 ^C	0.13 ± 0.003 ^C	0.24 ± 0.003 ^C	0.39 ± 0.003 ^C
NAA (180 ppm) + Kinetin (30 ppm)	1472.13 ± 6.38 ^{BC}	5982.78 ± 29.98 ^C	6782.78 ± 29.98 ^{BC}	0.14 ± 0.002 ^{BC}	0.25 ± 0.002 ^{BC}	0.39 ± 0.002 ^{BC}
NAA (240 ppm) + Kinetin (30 ppm)	1549.16 ± 14.55 ^A	6672.32 ± 71.98 ^A	7066.21 ± 75.72 ^A	0.16 ± 0.003 ^A	0.27 ± 0.003 ^A	0.42 ± 0.004 ^A
NAA (300 ppm) + Kinetin (30 ppm)	1501.81 ± 13.95 ^B	6212.85 ± 67.01 ^B	6872.85 ± 67.01 ^B	0.14 ± 0.004 ^B	0.25 ± 0.004 ^B	0.40 ± 0.004 ^B

Tukey Levels (Mean ± SD) not connected by same alphabetic letters are significantly different at p=0.05 by Tukey-Kramer HSD test; DAT= Days After Transplanting.

Figure-1 : Effect of foliar application of NAA and Kinetin on chlorophyll content (mg g⁻¹) of broccoli.

content thereby offering opportunities for growers to improve their agricultural practices and meet market demands.

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The Effect of Feeding Amla Powder on Growth Performance and Carcass Characteristics of 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 (*Emblia 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. In the first treatment (control group, T1) chicks were fed maize and soya bean Deoiled cake basal diet, while amla powder was supplemented @ 0.5, 1.0 and 1.5 % in the basal diet in T2, T3 and T4 groups respectively. At the end of the experiment i.e., at 8th weeks of age, carcass characteristics viz. live weight, dressed weight, dressing percentage, eviscerated weight, giblet weight and individual organ as percent of live weight (heart, gizzard or liver) were studied. The live weight (2034.50 g), dressing weight (1604.86 g), eviscerated weight (1420.75 g) and giblet weight (94.11 g) were found to be significantly (P,0.05) higher in dietary group supplemented with ashwagandha powder at 0.5% and it declined at higher level of supplementation, however, it remained higher (P<0.05) as compared to control group.

Key words : Amla, carcass, broiler, eviscerated, vaccinated.

Introduction

The poultry sector was major emerging industry in agriculture. In poultry various species of birds can be reared like chicken, duck, quail, turkey etc. Broilers kept major part in poultry sector followed by duck. Broiler meat and egg is most preferable product of poultry sector. Meat and egg production completely depended on feed. Day by day increasing rate of demand of meat and egg create a pressure on poultry sector to produce more production. There are plenty resources of different kinds of medicinal herbs which can be explored as natural feed additives for poultry. Commonly known herbs are Aloe vera, Fenugreek, Ashwagandha, *Moringa oleifera*, Cinnamon, Tulsi, Garlic, Pepper etc. Herbal preparations help in the digestion process, safe, cost effective and environment friendly with no side effect (Virus *et al.*, 2022). Herbal extracts are the powerful stimulators of the immune and animal digestive systems as well as highly beneficial effects in poultry nutrition due to their antioxidant, antimicrobial, antiviral, anticoccidial and anthelmintic properties (Akyildiz and Denli, 2016).

Amla or Indian Gooseberry (*Emblia officinalis*), with its origin in India has extensive adaptability to grow in diverse climatic and soil conditions (Pokharkar 2005). 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, *Emblia* 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).

Materials and Methods

Experimental bird and diet : The present study was carried out in poultry farm of Department of Animal Production, Rajasthan College of Agriculture, Udaipur. One hundred sixty day old broiler chicks (coloured broiler) were randomly divided into four treatment groups comprising four replicates of 10 birds each. The dietary treatment included T1- control (maize-50, soya doc-36, dorb-21 kg per 100 kg and premix @ 2.5 kg per tonne) with no feed additive, T2 – basal diet supplemented with Amla powder @ 0.5%, T3 – amla powder @1% and T4 – amla powder @1.5% supplemented diet. All the diets were iso-nitrogenous and iso-caloric during the entire experimental period, diets contained 23% and 20% CP and 2800 and 2600 Kcal ME per kg for starter and finisher diets respectively. All the birds were reared in deep litter system with similar management practices except the

Table-1 : Carcass parameters of broiler chicks diet supplemented with ashwagandha root powder.

Particulars	Treatments				SEm	CD
	T1	T2	T3	T4		
Live weight (g)	1726.75 ^c ±25.11	1894.25 ^b ±12.13	2034.50 ^a ±25.16	1818.25 ^b ±18.27	25.77	79.40**
Dressed weight (g)	1273.48 ^c ±36.34	1415.25 ^b ±36.58	1604.86 ^a ±6.50	1408.18 ^b ±37.45	24.13	74.36**
Eviscerated weight (g)	1201.25 ^c ±15.28	1318.50 ^b ±15.62	1420.75 ^a ±18.01	1243.00 ^c ±27.74	13.85	42.69**
Dressing (%)	73.75±1.29	74.70±1.17	78.94±1.62	77.41±1.23	1.34	NS
Giblet weight (g)	76.74 ^d ±0.57	84.89 ^b ±0.58	94.11 ^a ±0.25	82.58 ^c ±0.94	0.42	1.28**
Liver (%)	2.24±0.04	2.25±0.01	2.29±0.02	2.26±0.02	0.03	NS
Gizzard (%)	1.62±0.01	1.64±0.01	1.72±0.03	1.68±0.06	0.03	NS
Heart (%)	0.58±0.02	0.59±0.01	0.63±0.01	0.61±0.01	0.01	NS

experimental diet. The birds were vaccinated against Ranikhet and Marek's at the age of 1st and 7th day, respectively. The broilers starter rations were fed from 0-3 weeks followed by finisher ration from 4-8 weeks of age.

Traits studied : At the end of experiment (60 days), 4 birds from each treatment (one bird per replication) was selected randomly and allowed to fast overnight. Live weights of birds were recorded before slaughtering, birds were bled four minutes following slaughtering and each bird was dipped in hot water bath and feathers were removed manually. After the removal of head, feathers and shank, dressed weight was determined. Eviscerated weight, giblet weight and weight of individual organs (heart, gizzard and liver) were also recorded.

Statistical analysis : The data recorded for evaluation of different treatments were statistically analysed using standard procedure as suggested by Snedecor and Cochran (1994).

Results and Discussion

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.

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 phytogetic 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.

Conclusion

It may be concluded from present investigation that the supplementation of amla in the broiler diet at level of 1.0.% was more beneficial to improve carcass traits in broiler chicken.

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Occurrence of Root-Knot Nematode, *Meloidogyne incognita*, in Chilli-Grown Fields in Different Villages of Udaipur, Rajasthan

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Abstract

Survey was carried out to determine the occurrence of root-knot nematode in Chilli-grown fields in different villages of Udaipur, Rajasthan. Total 10 villages visited and collected 30 root and soil samples during survey. In results, it was keen observed that all samples of both soil and root were infected with root-knot nematode, *Meloidogyne incognita*. After the examination of roots 32.33 to 58.33 galls/plant and 22.67 to 47 egg masses/plant of chilli found in different locations. While, number of nematode ranging between 602 to 1133.33 per 200 cc soil in different villages. It was also recorded that 100% occurrence with above economic threshold level (ETL) of root-knot nematode found in visited fields of different villages.

Key words : Chilli, *Meloidogyne incognita*, occurrence, Rajasthan, Udaipur.

Introduction

Chilli (*Capsicum annum* L.) is a widely cultivated vegetable and belongs to family Solanaceae. It is highly nutritive vegetable and a good source of vitamins and minerals especially in vitamin-A and C every 100gm of dried pods yield about 160 calories of energy through 36gm carbohydrates, 18gm proteins, 16gm fat, 480mg calcium, 3.1mg phosphorus, 31mg iron, 2.5mg niacin, 640 I.U. vitamin-A and 40mg vitamin-C (Jagtap *et al.* 2012). Vegetables are excellent host for a wide range of plant parasitic nematodes. Different group of vegetables are prone to several species of nematode which causes economic losses to crops. Estimated overall annual losses to the major vegetable crops by nematode are 12.3%. Average losses for the 40 crops in the developed countries were estimated to be 8.8% compared to 14.6% losses in the developing countries (Ravichandra, 2008). The plant parasitic nematodes associated with vegetables are *Meloidogyne* spp., *Rotylenchulus reniformis*, *Heterodera* spp., *Pratylenchus* spp., *Helicotylenchus* spp. and *Hoplolaimus* spp. in India. Root-knot disease caused by *Meloidogyne incognita* is thus one of the limiting factors in the production of chilli. Annually national loss due to this nematode pest was worked out to be 12.85% and in monetary terms 210 million rupees (Jain *et al.*, 2007). Among plant parasitic nematodes, *Meloidogyne incognita* is most important and causing great damage to crops. Keeping this in view, present investigation was carried out to find out the occurrence of root-knot nematode, *Meloidogyne incognita*, in Chilli-grown fields in different villages of Udaipur, Rajasthan.

Materials and Methods

Collection and processing of samples : Survey was carried out to determine the occurrence and population status of root-knot nematode in chilli-grown field in different location of Udaipur viz., Kavita, Loyra, Iswal, Thoor, Chikalwas, Madar, Shri Maliyon Ki Kariyan, Nai, Undari Kalan and Upli Bari villages of Udaipur. Soil samples were collected from the 10 different villages of Udaipur. The sample taken from the rhizosphere of plants, well labeled and processed in laboratory. To identification and characterization of nematode species, pure culture of juveniles of root-knot nematode recovered from the egg mass obtained from the roots, mature females recovered from the gall of root and the male recovered from both galls and soil of the infested field.

To find out the population status of plant parasitic nematodes, 200cc soil samples were processed by using Cobb's sieving and decanting technique (Cobb, 1918) followed by Baermann's funnel assembly (Christie and Perry, 1951). Roots were stained in 0.1% acid fuchsin lacto phenol solution at 80°C for 2-3 minutes (McBeth *et al.*, 1941). Thereafter, soil extract and roots were examined under stereoscopic binocular microscope then the process of fixation, dehydration and the mounting of nematodes were performed (Seinhorst, 1959). For the identification of species of root-knot nematode the perineal patterns were prepared and the nematode species was identified.

Counting of galls and egg masses : Root sample collected from each field, labeled properly and brought to the laboratory. Root was gently washed in running tap

Table-1 : Occurrence and population status of root-knot nematode, *Meloidogyne incognita* inciting chilli cultivation in villages of Udaipur.

S. No.	Location	Galls/plant	Egg masses/plant	Nematodes/200cc soil	Occurrence (%)
1.	Loyra	51.33	42	1048.33	100
2.	Kavita	32.33	24.33	602.00	100
3.	Iswal	58.33	47	1133.33	100
4.	Thoor	35	24.67	658.00	100
5.	Chikalwas	42.67	33	703.00	100
6.	Madar	48	38	954.00	100
7.	Shri maliyon ki kariyan	35.33	22.67	802.67	100
8.	Nai	41	35.33	898.67	100.00
9.	Undari kalan	47	39	998.67	100
10.	Upli bari	50.67	34.33	756.67	100.00
	C.D.	2.394	2.617	3.847	
	SE(m)	0.8	0.874	1.285	

water to remove adhering soil particles. Well cleaned roots were taken and observed thorough under microscope for counting of galls and egg masses.

Results and Discussion

The plants chilli examined during the survey exhibited symptoms like stunted, patchy growth and yellowing of leaves etc. During survey, it was chilli is highly susceptible to the attack of root-knot nematode, because most of the plants uprooted showed innumerable knots in the root systems and severe damage. The results presented in table 1 indicates that the 100% occurrence of root knot nematode was recorded in all samples collected from different locations viz. Loyra, Kavita, Thoor, Nai, Madar, Chikalwas, Shrimaliyon ki kariyan, Undari Kalan, Upli Bari and Iswal. It is apparent from the number of galls/plant, number of egg masses/plant and nematode populations per 200cc soil counts given in the table-1 that the incidence of root-knot nematode was observed in all locations of Udaipur (Loyra, Kavita, Thoor, Nai, Madar, Chikalwas, Shrimaliyon ki kariyan, Undari Kalan, Upli Bari and Iswal). The highest incidence of root-knot nematode recorded from Iswal, Loyra, Undari Kalan, Madar, Nai, Upli Bari and Shri Maliyon ki kariyan Udaipur. Whereas, minimum infestation but above ETL was observed in Kavita, Thoor and Chikalwas villages of Udaipur. In results it was keen observed that 32.33 to 58.33 galls/plant and 22.67 to 47 egg masses/plant of chilli found different locations. While, number of larvae ranging between 602 to 1133 J2 per 200 cc soil.

Number of galls per plant : Results revealed that maximum 58.33 galls/plant found in the chilli growing field of Iswal village followed by 51.33 and 50.67 galls/plant in field of Loyra and Upli Bari village of Udaipur. While minimum 32.33 galls/plant observed in Kavita village of Udaipur.

Number of egg masses per plant : Results showed that maximum 47 egg masses/plant found in the field of Iswal village followed by 42 and 39 egg masses/plant in field of Loyra and Upli Bari village of Udaipur. While, minimum 22.67 egg masses/plant observed in field Shri maliyon ki kariyan village of Udaipur.

Final nematode population per 200cc soil : Results revealed that maximum 1133.33 juveniles/200cc soil found in the chilli growing field of Iswal village followed by 1048.33 and 998.67 juveniles/200 cc soil in field of Loyra and Undari Kalan village of Udaipur. While, minimum 602 juveniles/200 cc observed in field of Kavita village of Udaipur.

The results of the survey assured that root-knot nematodes are vastly dispersed in Udaipur, Rajasthan at different locations. During survey, it was observed that chilli was found very susceptible to the root-knot nematode and when plants uprooted there showed innumerable knots on the root systems. Root-knot nematode cause severe damage to the chilli and very high population ranging from 602 to 1133.33 IJs/200 cc soils were found in different locations during survey. Similar results were also reported by Indoulia et al. (2020) that the *Meloidogyne incognita* and *M. javanica* both species infect tomato in different areas. The species were either found singly or in mixed populations. Out of the two *M. javanica* was more frequent. Assess the incidence of root-knot sickness on tomato in 10 localities in and around Sanganer Tehsil, Jaipur confirmed that the plants of tomato in all the 10 localities have been inflamed with root-knot nematodes. Similarly Singh et al. (2012) found that among the different plant parasitic nematodes, *Meloidogyne* spp. was more frequently encountered in most localities of Jammu and Samba districts. Similarly Gautam et al. (2014) found that the *Meloidogyne* species are economically important pathogens, especially

infesting vegetable crops. In the tropics and subtropics, *Meloidogyne incognita* cause an estimated yield loss of 5-43% in vegetable crops. According to, Ralmi et al. (2016), the presence of RKN in the crops becomes one of the major problems nowadays because they cause great agriculture loss. Among the many genera of nematodes having some economic impact, *Meloidogyne* spp. is responsible for a large part of the annual 100 billion dollar losses attributed to nematode damage. According to Hussain et al. (2012) the four most common root-knot species, *M. incognita* constituted 74.74%, *M. javanica* 24.02%, *M. arenaria* 1.57% and *M. hapla* 0.78%.

Conclusions

A survey was carried in different villages of Udaipur to find the occurrence of root knot nematode in chilli field. Ten villages of Udaipur was surveyed viz., Loyra, Kavita, Thoor, Nai, Madar, Chikalwas, Shrimaliyon ki kariyan, Undari Kalan, Upli Bari and Iswal. Result exhibit that, all field of ten village of Udaipur was infected with root knot nematode. The highest incidence of root-knot nematode recorded from Iswal, Loyra, Nai, Upli Bari, Undari Kalan and Shri Maliyon ki kariyan. Whereas, minimum infestation but above ETL was observed in Kavita, Thoor, Chikalwas, and Madar villages of Udaipur.

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Seasonal Incidence of Cotton Aphid *Aphis gossypii* (Glover) and its Correlation with Weather Parameters

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Abstract

The investigation on “Seasonal incidence of cotton aphid *Aphis gossypii* (Glover) and its correlation with weather parameters” was conducted in RBD at Rajasthan College of Agriculture, MPUAT, Udaipur during *Kharif*, 2022. The incidence of pest started from first week of July (27th SMW) and remain continues upto throughout the growth period. The pest population reached its peak level during third week of September (38th SMW) with mean population of 48.60 aphids per plant, thereafter population decreased upto 46th SMW. The correlation study between weather parameters and aphid population shows that minimum temperature and morning relative humidity had positive significant correlation with aphid population, Whereas, total rainfall shows negative significant correlation.

Key words : Aphid, seasonal incidence, correlation, weather parameter

Introduction

Cotton (*Gossypium hirsutum* L.) is the most significant commercial cash and fibre crop, known as “White Gold” and the “King of Fibre.” Cotton is grown in over 100 countries worldwide (Anonymous, 2012). It is the most prominent mercenary fibre crop of India, providing natural fibre, fuel, and edible oil, and plays a vital role in the Indian economy (Prasad *et al.* 2018 ; Patil, 2003). In addition to textile manufacturing, It provides seeds has a potential multi-product base such as hulls, oil, lint and food for animals (Ozyigit *et al.* 2007). Cotton is grown on 33.1 lakh hectares of area worldwide, yielding 25.7 lakh bales with an average productivity of 775kg/ha . In India Cotton was grown on 120.69 lakh hectares area, yielding 362.18 lakh bales with a productivity of 510 kg/ha. In Rajasthan Cotton covers approximately 7.07 lakh hectares area, with a total production of 25.97 lakh bales and an average productivity of 624 kg/ ha (Anonymous, 2021-22).

Major losses in India in cotton production are due to its susceptibility to about 162 species of insect pests. In which few dozen are very serious, causing sufficient loss of cotton (Dhaliwal *et al.* 2004) . Among the major sucking pests the aphid (*Aphis gossypii*) causes significant damage to cotton plants during both the vegetative and reproductive stages. Infestation on vegetative stages causes shrivelled leaves, whereas infestation on reproductive stages, particularly at fruit opening, causes fouling and reduces fibre quality. Severe attacks of *A. gossypii* can reduce leaf area by 58% and shoot biomass 45%. Cotton plants which infested by cotton aphid are shorter and produce fewer vegetative branches than

non-infested plants which resulting highest yield loss (Slosser *et al.* 2001). Pest occurrence and growth are influenced by the crop stand and current environmental conditions. When the weather is good, these insects grow incredibly and cause great damage. The role of temperature and relative humidity is likely to affect the occurrence (Aheere *et al.* 1994).

Effective population monitoring is crucial for successfully implementing insect pest management programs, and making timely decisions against pests. Therefore, the present investigation was conducted to assess the seasonal incidence of aphid population.

Materials and Methods

The experiment was laid out in randomized block design in three replications with a plot size of 4.5 m x 3.6 m. The crop was grown without spraying of insecticides to allow the natural infestation of insect. Observations on the aphid activity were recorded at weekly interval. To record the observation of aphid population, per plot five plants were randomly selected and and tagged. The observation from each selected plant on three leaves each from the top, middle and lower part were recorded. The data was statistically analyzed by correlation analysis between weather parameters and aphid population (Gomez and Gomez, 1984).

Results and Discussion

According to the data observed during the investigation on seasonal incidence of aphid during *kharif*, 2022 revealed that the incidence of aphid was first noticed in the 27th SMW (3.10 aphids/plant) and reached the peak

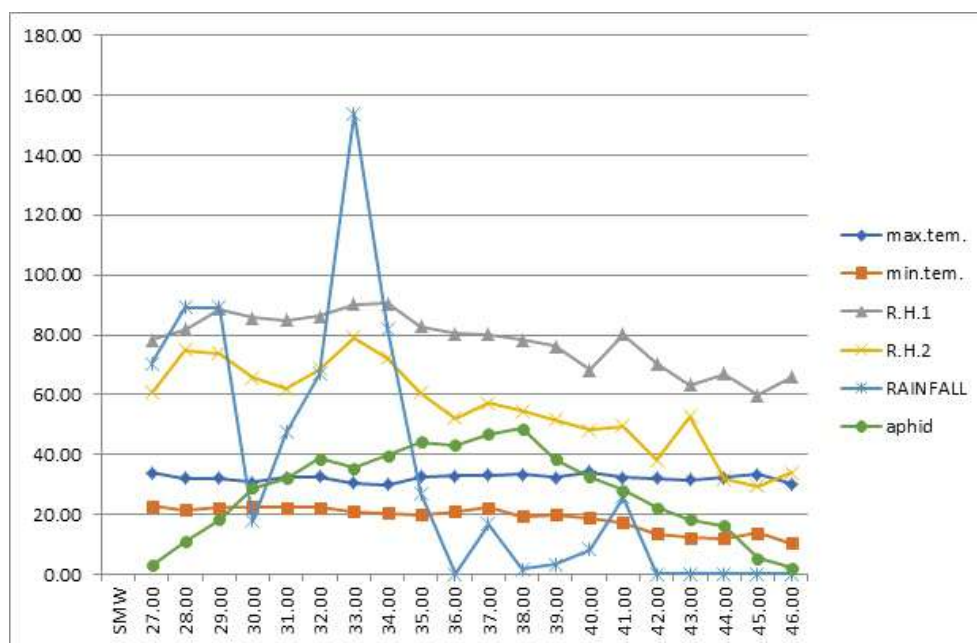


Figure-1 : Seasonal incidence of aphid and their relation with weather parameters.

Table-1 : Seasonal incidence of aphid on cotton during Kharif, 2022.

Standard Metrological Weeks (SMW)	Abiotic Factors					Population Aphids/plant
	Max. temp (°C)	Min. temp (°C)	Morning R.H. (%)	Evening R.H. (%)	Rainfall (mm)	
27	34.03	22.67	78.29	60.71	70.40	3.10
28	32.04	21.60	81.86	74.86	89.20	10.80
29	32.10	22.34	88.71	73.71	89.00	18.40
30	30.76	22.59	85.71	65.57	17.80	28.80
31	32.31	22.20	85.00	62.00	47.40	32.10
32	32.49	22.33	86.29	68.43	66.80	38.60
33	30.46	21.03	90.29	79.14	154.00	35.60
34	30.06	20.46	90.43	72.14	82.00	39.80
35	32.50	19.96	82.86	60.71	27.00	44.20
36	32.79	21.00	80.29	52.14	0.00	43.10
37	33.19	22.16	80.14	57.14	16.60	46.90
38	33.50	19.47	78.29	54.57	1.60	48.60
39	32.41	19.89	76.14	51.57	3.30	38.40
40	34.27	18.87	68.14	48.14	8.20	32.50
41	32.36	17.21	80.14	49.57	25.80	28.10
42	32.04	13.66	70.43	38.00	0.00	22.40
43	31.61	12.14	63.14	52.57	0.00	18.40
44	32.23	11.89	66.86	31.71	0.00	16.30
45	33.37	13.79	59.86	29.43	0.00	5.30
46	30.09	10.27	66.00	33.86	0.00	2.10
Coefficient of correlation (r) for population and maximum atm. Temperature (°C)						0.081
Coefficient of correlation (r) for population and minimum atm. Temperature (°C)						0.486*
Coefficient of correlation (r) for population and morning Relative humidity (%)						0.506*
Coefficient of correlation (r) for population and evening Relative humidity (%)						0.350
Coefficient of correlation (r) for population and total rainfall (mm)						-0.483*

*Significant (p=0.05)

population (48.60 aphids/plant) in the 38th SMW. After that the pest population decreased gradually till 46th SMW and reached the minimum level of 2.10 aphids/plant. Aphid population shows a positive significant correlation with minimum temperature ($r = 0.486^*$) and morning relative humidity ($r = 0.506^*$); positive non-significant correlation with maximum temperature ($r = 0.081$) and evening relative humidity ($r = 0.350$); while with the total rainfall ($r = -0.483^*$) the correlation was found to be negatively significant. These findings supported by Kulkarni *et al.* (2008) who observed that the occurrence of aphids from the end of August to early December, with major activity period during the second fortnight of September. Chauhan *et al.* (2017) as they observed that aphid invaded on the Bt. cotton from third week of July to second week of August and this caused damage continue throughout the crop season. Sarode *et al.* (2020) who reported that the incidence of aphids was highest (20.4 aphids/three leaves) during 40th SMW and the total rainfall was negatively significant correlated with aphid population which is in conformity with our findings of present investigation. Bhute *et al.*, (2012) observed that the peak incidence of aphid (75.40-86.45 aphids/3 leaves) was recorded during 35th and 37th (SMW). Correlation analysis revealed that the rainfall, rainy days, relative humidity had a significant negative correlation with aphids population.

Conclusions

Investigation was carried out to study the seasonal incidence of aphid on cotton. The incidence of aphid on cotton started from first week of July. The highest population was observed during third week of septmber (38th SMW) and after that population gradually decreased and reached its minimum level in month of november. Correlation coefficient between different weather parameters and population of aphid revealed that, maximum temperature, evening relative humidity showed positive non-significant correlation with population of aphid. Minimum temperature and morning relative humidity had significant positive correlation with aphid population while, significant negative correlation with total rainfall.

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A Study on Knowledge Level of Farmers About Bio-Pesticides

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Abstract

Bio-pesticides offer several advantages in sustainable agriculture systems as they are environmentally friendly and pose minimal harm to the soil, water supply and wildlife, including beneficial insects. The study regarding knowledge level of farmers about biopesticides was conducted in Udaipur district of Rajasthan which includes 4 villages from two tehsils, Badgaon and Girwa. It was observed that out of the 120 respondents, the majority (74.17%) had a medium level of knowledge about bio-pesticides. Additionally, 15.00 per cent of the respondents possessed a high level of knowledge, while the remaining 10.83 per cent had a low level of knowledge about bio-pesticides.

Key word : Knowledge, Bio-pesticides, MPUAT area.

Introduction

Bio-pesticides are defined as materials of natural origin derived from living organisms, such as bacteria, viruses, nematodes, pheromones and natural plant compounds, which are used in pest control. They are formulated and applied similar to chemical pesticides, often as biological control agents (BCAs) with the aim of rapidly reducing pest populations for short-term pest control. BCAs can be natural enemies, antagonists, competitors or other organisms used for pest control. Bio-pesticides are effective in low quantities and have no residual effects making them environmentally friendly and suitable for protecting crops from harmful plant pathogens. Unlike bio-control agents, which actively seek out pests to destroy, biopesticides act as passive agents. They eliminate organisms through specific biological effects rather than acting as broad chemical poisons, making them more likely to be selective and biodegradable.

According to the United States Environmental Protection Agency (EPA), Bio-pesticides are pesticides derived from natural materials, including animals, plants, bacteria and certain minerals (source: www.epa.gov). Bio-pesticides are considered biochemical pesticides, as they consist of naturally occurring substances that control pests through non-toxic mechanisms. They can be living organisms (referred to as natural enemies) or their products (such as phytochemicals and microbial products) as well as by-products (semi-chemicals) that are used for managing plant-damaging pests. Biopesticides play an important role in crop protection, often used in conjunction with other tools, including chemical pesticides, as part of Bio-intensive Integrated

Pest Management. Bio-pesticides based on pathogenic microorganisms that target specific pests provide an ecologically sound and effective solution to pest problems. They pose less risk to the environment and human health compared to traditional chemical pesticides. Living organisms, which are pathogenic to the target pest, are the most commonly used Bio-pesticides. Examples include bio fungicides (such as *Trichoderma*), bioherbicides (such as *Phytophthora*) and bioinsecticides (such as *Bacillus thuringiensis*). The use of Bio-pesticides has the potential to offer significant benefits to agriculture and public health programs (Mukesh *et al.*, 2019).

Research Methodology

The present study was conducted in Udaipur district of Rajasthan because Udaipur district comes under the jurisdiction MPUAT, Udaipur. Udaipur district comprised of 15 tehsils, out of which Girwa and Badgaon tehsils were selected based on having the maximum number of bio-pesticide users. Two villages from each selected tehsil were recognized based on the maximum number of beneficiary respondents. As a result, a total of four villages were chosen for the study. A proportionate number of respondents were selected from each selected village. Specifically, 33 respondents were randomly chosen from Madar, 35 from Kavita, 41 from Dakan Kotda, and 11 from Brahmanon ki Hunder. A total of 120 respondents were selected for the investigation.

Results and Discussion

Distribution of respondents according to knowledge about Bio-pesticides : To obtain an overview of the knowledge level, the respondents were categorized into

Table-1 : Distribution of respondents on the basis of level of knowledge about Bio-pesticides. n = 120

S. No.	Level of Knowledge	Badgaon (n ₁ =68)		Girwa (n ₂ =52)		Total (n=120)	
		f	%	f	%	f	%
1.	Low (<21.80)	08	11.77	05	09.61	13	10.83
2.	Medium (21.80 to 29.49)	50	73.53	39	75.00	89	74.17
3.	High (>29.49)	10	14.70	08	15.39	18	15.00
	Total	68	100	52	100	120	100

f = frequency, % = per cent, Mean = 25.65, S.D. = 3.84

Table-2 : Aspect wise knowledge of respondents about Bio-pesticides. n = 120

S.No.	Knowledge level	Badgaon (n ₁ =68)		Girwa (n ₂ =52)		Total (n=120)	
		MPS	RANK	MPS	RANK	MPS	RANK
1.	Knowledge level of farmers about biopesticides	85.29	I	82.69	I	84.16	I
2.	Knowledge about Protective measures while using Bio-pesticides	76.83	II	78.84	II	77.70	II
3.	Knowledge about timing of Bio-pesticides application	72.79	III	65.38	V	69.58	III
4.	Knowledge about the benefits of using Bio-pesticides in Agriculture	63.44	V	71.42	III	66.90	IV
5.	Knowledge about method of Bio-pesticide application	63.72	IV	68.58	IV	65.83	V
6.	Knowledge about stored of Bio-pesticides	56.25	VI	59.61	VI	57.70	VI
7.	Knowledge about precautions while handling Bio-pesticides	54.04	VII	57.21	VII	55.41	VII
8.	Knowledge about the different mode of application of Bio-pesticide	55.51	VII	52.88	VIII	54.73	VIII
9.	Knowledge about the name of the Bio-pesticides	30.71	IX	30.34	IX	30.55	IX
10.	Knowledge about the application rate of Bio-pesticides	24.06	X	21.15	X	22.65	X

MPS = Mean per cent score.

low, medium and high-level knowledge groups based on the calculated mean and standard deviation of the obtained knowledge scores. The distribution of respondents in each category is provided in Table-1.

According to Table-1, it is observed that out of the 120 respondents, the majority (74.17%) had medium level of knowledge about bio-pesticides. Additionally, 15.00 per cent of the respondents possessed a high level of knowledge, while remaining 10.83 per cent had low level of knowledge about bio-pesticides.

Further analysis of the data from Table-1 revealed that 11.77 per cent of respondents from Badgaon and 09.61 per cent of respondents from Girwa were observed to have low level of knowledge. Additionally, 73.53 per cent of respondents from Badgaon and 75.00 per cent of respondents from Girwa were observed to have medium level of knowledge. In the high level knowledge group, 14.70 per cent of respondents from Badgaon and 15.39 per cent of respondents from Girwa were observed.

Aspect wise knowledge of respondents about Bio-pesticides : In order to obtain a clear picture of the knowledge possessed by the respondents, aspect wise knowledge was calculated. Additionally, mean per cent scores were determined to assign ranks to activities associated with each aspect. The outcome of the study is presented in Table-2.

Based on the information presented in Table 2, the aspect of "Knowledge level of farmers about Bio-pesticides" had the highest level of knowledge among

the respondents with MPS of 84.86 and ranking it at first position. The pattern remained similar in both tehsils with it being ranked second in Badgaon tehsil with MPS of 85.29 and first in Girwa tehsil with MPS of 82.69.

Furthermore, the aspect of "Knowledge about protected measures while using Bio-pesticides" was ranked second overall with total MPS of 77.70. The ranking remained consistent in both tehsils with second position in Badgaon tehsil having MPS of 76.83, and in Girwa tehsil, with MPS of 78.00, respectively.

Further, it was observed that in the aspect of "Knowledge about timing of Bio-pesticides application" ranked third overall with total MPS of 69.58. In terms of tehsil wise ranking, it Badgaon with MPS of 72.79 was ranked third and Girwa with MPS of 68.38 was ranked fifth.

The overall knowledge on aspect "Knowledge about the benefits of using Bio-pesticides in Agriculture" stood at the fourth position with MPS of 66.90. However, in terms of tehsil wise ranking, it was ranked fifth in Badgaon with MPS of 63.44 and third in Girwa with MPS of 71.42.

Table 2 further illustrates that the respondents had a good level of knowledge on "Knowledge about method of Bio-pesticide application" with total MPS of 65.83 with position at fifth place. Similarly, it held the fourth position in Badgaon tehsil with MPS of 63.72 and in Girwa tehsil with MPS of 68.58.

The statement regarding "Knowledge about storage

of Bio-pesticides” was ranked sixth with total MPS of 57.70. In both tehsils, this aspect maintained the sixth position with MPS of 56.25 for Badgaon and MPS of 59.61 for Girwa tehsil. Following that, “Knowledge about precautions while handling Bio-pesticides” held the seventh position with total MPS of 55.41. It also maintained the seventh position in both tehsils with MPS of 54.04 for Badgaon and MPS of 57.21 for Girwa tehsil.

The data presented in Table 2 further indicates that the aspect of “Knowledge about the different modes of application of Bio-pesticides” received total MPS of 54.37 and was ranked eighth by the respondents. In terms of tehsil wise ranking, it received MPS of 55.51 and was placed at the seventh position in Badgaon, while in Girwa, it received MPS of 52.88 and held eighth position.

The statement “Knowledge about the name of the Bio-pesticides” received total MPS of 30.55 and was ranked ninth by the respondents. Similarly, in terms of tehsil wise ranking, it received MPS of 30.71 and held ninth position in Badgaon, while in Girwa, it received MPS of 30.34 and held the same position.

Another important knowledge aspect for the respondents was “Knowledge about the application rate of Bio-pesticides” which was placed it at the tenth position with total MPS of 22.65. In terms of tehsil wise ranking, it received MPS of 24.06 and held the tenth position in Badgaon, and received MPS of 21.15 and held the same tenth position in Girwa.

Conclusions

The study indicates that majority of respondents *i.e.* 74.16 per cent possessed medium level of knowledge, whereas, 10.83 per cent respondents possessed low level of knowledge and remaining 15.00 per cent respondents possessed high level of knowledge about Bio-pesticides.

Respondents stated that “Knowledge level of farmers about Bio-pesticides” was the most favoured aspect with total MPS 84.16 and was ranked first.

Further, it was observed that in the aspect of “Knowledge about Protective measures while using Bio-pesticides” with a total MPS of 77.70 which placed it at the second position.

Recommendations

The training program for farmers on Bio-pesticides is essential.

Both government and private organizations should regularly conduct promotional and awareness campaigns to increase and enhance the acceptance of organic pesticides among farming communities.

Organizations should ensure that information regarding support services and awareness activities reaches all small and medium farmers and encourage their active participation.

Enhance the capacity and motivation of farm laborers to minimize their exposure to potentially hazardous synthetic chemicals and improve worker-protection regulations, ensuring compliance with them.

Increase public awareness about the benefits of Bio-pesticides, including their positive impact on soil health, crop yield and their non-harmful effects on the natural environment.

Bio-pesticides do not incur significantly higher costs for farmers when used on a regular basis and they can contribute to increased profitability for their crops.

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Effect of Fertility Levels, Vermicompost and Biofertilizers on Nutrient Content and Uptake in Clusterbean {*Cyamopsis tetragonoloba* (L.) Taub}

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Abstract

A field experiment was conducted during the *kharif* season of 2022 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan) to evaluate the effect of Fertility Levels, Vermicompost and Biofertilizers on Productivity of Clusterbean. Result show that 100% RDF observed maximum nutrient content (seed and haulm) and uptake (seed, haulm and total by crop). A significant increase in nutrient (N and P) content in seed and haulm and uptake (N, P and K) by seed, haulm and total uptake by crop were recorded with application of 2.5 t vermicompost ha⁻¹. Highest N, P and K content (seed and haulm) and uptake (seed, haulm and total by crop) was recorded with NPK consortium + *Rhizobium*.

Key words : Biofertilizers, clusterbean, fertility levels, productivity and vermicompost.

Introduction

Clusterbean {*Cyamopsis tetragonoloba* (L.) Taub} popularly known by its indigenous name “Guar” belongs to the family *Fabaceae* (*Leguminosae*). It is an important cash crop, grown in semi-arid and arid regions of tropical India during *kharif* season. Among leguminous crops, it is comparatively more drought hardy crop due to its deep root system. Clusterbean is grown for various purpose since ancient time viz., vegetable, green fodder, production of seed and endospermic gum. It is also cultivated for hay, silage and green manure (Grestaa *et al.*, 2013). In the recent years, besides its conventional uses, it has emerged as an industrial crop due to presence of galactomannan (gum). The spherical shaped endosperm contains 28-33 % gum (Goldstein and Alter, 1959).

Mature clusterbean seed contain 23% protein, 1.7% fat, 6% carbohydrate and traces of vitamins and minerals. It is very good source of vitamin A, calcium, phosphorus, iron and ascorbic acid (Vijaylaxmi and Singh, 2011). Clusterbean enriches the soil by fixing atmospheric nitrogen almost 50-150 kg ha⁻¹, thus it helps in nitrogen economy (Lal, 1985). Sometimes it is used in reclamation of saline and alkaline soils (Kay, 1979).

A crop nutrient management plan is a tool that can increase the availability of all the nutrient. Among different plant nutrients, nitrogen plays an important role in synthesis of amino acid and chlorophyll, which contributes to the building units of protein and thus promotes the growth of plants. Insufficient nitrogen may deteriorate the

quality of produce and reduce yield drastically. The nitrogen application increased carbohydrates, crude fibre contents, crude protein, ash %, leaf area plant⁻¹, dry matter and green fodder yield of clusterbean cultivars (Mohammad *et al.*, 2011). Phosphorus increases the activity of rhizobia, formation of root nodules, stimulates early root development, help in more atmospheric nitrogen fixation and improve grain formation when applied to legumes. It also improves the crop quality and resistance to disease.

Organic manure (FYM and vermicompost) is the important component of the integrated nutrient management system. Manure supply plant nutrient in small quantities and provide organic matter in large quantities. When manure was applied in conjunction with chemical fertilizers for optimum growth of crop, the decline in organic carbon was arrested and the gap between actual yield and potential yield was bridged to a large extent (Singh *et al.*, 2007). According to Roy and Singh (2006), the use of vermicompost is being advocated for sustaining soil fertility in various field crops. Vermicompost is nutritionally rich organic fertilizer, which slowly release nutrients in the soil, to overcome the problem of leaching. Moreover, they also help in balancing the nutrient availability to growing as well as succeeding crop and boost up the quality and production of crop.

Biofertilizer is microbial inoculants of selective microorganisms which have the capacity to mobilize nutritionally important elements from non- available to available form through biological processes such as

atmospheric nitrogen fixation, phosphate solubilization, excretion of plant growth promoting substances or cellulose and lignin biodegradation in soil, compost and other environments. They are effective, renewable and low-cost source of plant nutrients to the supplement of chemical fertilizers (Boraste *et al.*, 2009). Biofertilizers help in the maintaining long term soil fertility and sustainability. It may increase yield of crops by 10-30 % (Khandelwal *et al.*, 2012). They play a significant role in improving availability of nutrient to the plants. They are recognised as a constituents of integrated plant nutrient supply system (Anonymous, 2020). Clusterbean being a legume crop which has the capacity to fix atmospheric nitrogen by its effective root nodules. Biofertilizer increases the number of such microorganism and effective root nodule. The major part of nitrogen is met through nitrogen fixation.

Materials and Methods

The experiment was conducted during the *kharif* season of 2022 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction (pH 8.3), medium in available nitrogen (284.19 kg ha⁻¹), organic carbon (0.68 %), available phosphorus (18.65 kg ha⁻¹) and high in available potassium (319.50 kg ha⁻¹). The experiment consisted of eighteen treatment combination of three fertility levels (50% RDF, 75% RDF and 100% RDF), two vermicompost level (control and 2.5 t vermicompost ha⁻¹) and three biofertilizer combination (*Rhizobium*, *Rhizobium* + PSB and NPK consortium + *Rhizobium*) were replicated three times in factorial randomized block design. RDF (Recommended dose of fertilizers)- 20 kg N+40 kg P₂O₅ was applied as per treatment. In the experiment, clusterbean (variety RGC- 1033) was sown. The nutrient content was determined by the following method Nitrogen by Nessler's reagent colorimeter method (Snell and Snell, 1949), Phosphorus by Ammonium vanadomolybdate yellow colour method (Richards, 1968), Potassium by Flame photometer method (Jackson, 1973). The uptake of N, P and K after harvest in seed and haulm was estimated by multiplying the nutrient concentration values with yield of crop. The data were statically analysed using standard procedure of ANOVA at 5% level of significance.

Results and Discussion

Nutrient content

Fertility levels : Increasing levels of fertility up to 100% RDF significantly increased N and P content in seed and haulm and K content in haulm also. However, application of 100% RDF increased the K content in seed which was

found at par with 75% RDF. The increased translocation of N, P and K in plant parts may be caused by an improved nutritional environment in the rhizosphere and in the plant system. The increase in the factors that contributed to the crop's ability to absorb nutrients under 100% RDF over 50% RDF and 75% RDF could be attributed. These outcomes closely matched the conclusions of Bahadur and Chaplot (2014), Kumawat *et al.* (2017) in clusterbean.

Vermicompost : A significant increase in N and P content in seed and haulm and K content in haulm were recorded with application of 2.5 t vermicompost ha⁻¹ (Table-1). This could be as a result of vermicompost, which increases the availability of nutrients during the early stages of development through chemical fertilisers and other means. Vermicompost not only delivers essential nutrients but also improves soil conditions close to the rhizosphere.

Biofertilizers : It was observed that seed treated with NPK consortium + *Rhizobium* significantly increased N and P content in seed, however, the aforesaid inoculation failed to increase in potassium content in seed and haulm. The application of biofertilizer might have enhanced the nutrient environment in the plant system and rhizosphere, resulting in increased uptake and translocation of nutrients in the reproductive structures, which in turn led to their larger content and intake.

Nutrient uptake

Fertility levels : N, P and K uptake by seed, haulm and crop of clusterbean significantly increased up to 100% RDF. Application of 100% RDF was superior over 50 and 75% RDF in this regard (Table 2). nutrient uptake depends on the amount of nutrients in crop plants, seed yield and haulm yield. These values may have increased as a result of enhanced N and P fertilisation, which increased nutrient uptake in the current study. The maximum nitrogen, phosphorus and potassium uptake was seen when fertilisers had higher levels of N, P₂O₅ and K₂O (Goud *et al.*, 2014).

Vermicompost : Significantly maximum N, P and K uptake by seed, haulm and crop of clusterbean were recorded with application of 2.5 t vermicompost ha⁻¹. Application of vermicompost enhances soil quality, provides nutrients to the crop, and directly affects yield traits, biomass, and dry matter, all of which increase nutrient uptake. The outcomes are quite similar to Khokhar and Nepalia (2010), Sheoran *et al.* (2015) and Banotra *et al.* (2021) findings.

Biofertilizers : Results of the investigation in Table 2 indicated that significantly highest N, P and K uptake by seed, haulm and total by clusterbean crop was recorded

Table-1 : Effect of fertility levels, vermicompost and biofertilizers on nutrient content of clusterbean.

Treatments	Nutrient content (%)					
	Nitrogen		Phosphorus		Potassium	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Fertility level (% RDF)						
F ₁ -50	3.998	0.806	0.592	0.149	0.426	0.966
F ₂ -75	4.239	0.815	0.624	0.156	0.440	0.982
F ₃ -100	4.452	0.826	0.662	0.175	0.454	1.099
S.Em.±	0.023	0.003	0.005	0.001	0.006	0.005
C.D.(P=0.05)	0.067	0.009	0.015	0.003	0.016	0.015
Vermicompost level (t ha⁻¹)						
V ₁ -0	4.190	0.809	0.616	0.158	0.440	0.994
V ₂ -2.5	4.270	0.823	0.636	0.163	0.455	1.038
S.Em.±	0.019	0.003	0.004	0.001	0.005	0.004
C.D.(P=0.05)	0.054	0.008	0.013	0.002	0.014	0.013
Biofertilizers						
B ₁ - <i>Rhizobium</i>	4.107	0.808	0.609	0.158	0.442	1.006
B ₂ - <i>Rhizobium</i> + PSB	4.230	0.816	0.626	0.161	0.435	1.022
B ₃ -NPK consortium + <i>Rhizobium</i>	4.352	0.823	0.642	0.162	0.443	1.019
S.Em. ±	0.023	0.003	0.005	0.001	0.006	0.005
C.D.(P=0.05)	0.067	0.009	0.015	0.003	NS	NS

Table-2 : Effect of fertility levels, vermicompost and biofertilizers on nutrient uptake by clusterbean.

Treatments	Nutrient uptake (kg ha ⁻¹)								
	Nitrogen			Phosphorus			Potassium		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Fertility level (% RDF)									
F ₁ -50	31.34	14.76	46.10	4.65	2.73	7.38	3.33	17.67	21.00
F ₂ -75	37.59	17.24	54.83	5.52	3.29	8.81	3.90	20.75	24.65
F ₃ -100	41.07	18.66	58.72	6.10	3.76	9.86	4.18	23.55	27.73
S.Em.±	0.86	0.38	0.99	0.13	0.07	0.15	0.10	0.43	0.45
C.D.(P=0.05)	2.48	1.09	2.83	0.38	0.19	0.43	0.28	1.24	1.30
Vermicompost level (t ha⁻¹)									
V ₁ -0	34.52	15.82	50.34	5.08	3.10	8.17	3.61	19.45	23.06
V ₂ -2.5	38.81	17.28	56.09	5.78	3.43	9.20	3.99	21.87	25.85
S.Em.±	0.70	0.31	0.81	0.11	0.05	0.12	0.08	0.35	0.37
C.D. (P=0.05)	2.02	0.89	2.31	0.31	0.16	0.35	0.23	1.01	1.06
Biofertilizers									
B ₁ - <i>Rhizobium</i>	33.00	15.26	48.26	4.91	2.98	7.90	3.54	19.05	22.60
B ₂ - <i>Rhizobium</i> + PSB	36.57	16.59	53.16	5.41	3.28	8.69	3.75	20.82	24.57
B ₃ -NPK consortium + <i>Rhizobium</i>	40.42	17.81	58.23	5.96	3.52	9.48	4.11	22.10	26.21
S.Em.±	0.86	0.38	0.99	0.13	0.07	0.15	0.10	0.43	0.45
C.D.(P=0.05)	2.48	1.09	2.83	0.38	0.19	0.43	0.28	1.24	1.30

with NPK consortium + *Rhizobium*. The total uptake of nitrogen, phosphorous and potassium increased significantly as a result of the increased concentration of nutrients as well as the higher seed and haulm yields because nutrient uptake is a function of seed and haulm yield and their nutrient content. These results are closely matched with those of Mahawar *et al.* (2014), Navsare *et al.* (2018) and Kumawat *et al.* (2020).

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Infestation of Fall Armyworm *Spodoptera frugiperda* (J.E. Smith) on Different Maize Cultivars

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Abstract

The investigation on “To investigate the field infestation of fall armyworm larvae on maize cultivars” was laid out in RBD at Rajasthan College of Agriculture, MPUAT, Udaipur during Kharif 2022. The present study was carried out to study the differences in the variation between different maize cultivars available locally by assessing the plant damage which might be used as parameters for FAW resistance. A field experiment was carried out with five cultivars (local, sweet corn, HQPM-1 (QPM), PHM-3 (Hybrid), and PMC-6 (composite) of maize to study the natural infestation of fall armyworm. Plant damage were recorded by Davis score (1-9) was recorded at 20, 40, 60, 80 days after sowing. Davis score of maize cultivars significantly varied between the treatments 0.16 to 0.62, 0.78 to 2.70, 2.48 to 4.84, 3.04 to 5.98 at 20, 40, 60, 80 DAS respectively.

Key words : Fall armyworm, davis score, FAW resistance.

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops in the world. It is known around the world as the “Queen of Cereals” because of its high genetic yield potential and ability to adjust (Ashok *et al.*, 2021). Around the world, maize is grown on 192.14 million hectares with the total amount of maize produced being 1,113.02 million tonnes and average productivity of 5,790 kg/ha. Maize is India's third most important food crop, after rice and wheat. About 93.80 million hectares are used to grow maize crop, which produces 280.80 MT and has an average yield of 3070 kg/ha (Ashok *et al.*, 2021). About 9.51 million hectares of maize are grown in Rajasthan. The average yield is 2,148 kg per hectare with a total production of 2.04 MT (DACNET, 2021-22).

The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera, Noctuidae), is native to the Americas. It is a pest that attacks more than 350 different kinds of plant species and is considered to polyphagous (Montezano *et al.*, 2018). Fall armyworm (FAW) was first detected in maize in the Indian state of Karnataka in May 2018 (Kalleshwaraswamy *et al.* 2018). In Rajasthan, FAW was discovered for the first time on rabi maize in early 2019 in the state's southern region, causing significant maize losses (Ramesh Babu *et al.* 2019). The occurrence of such *S. frugiperda* population in the Rajasthan region could be traced to its origin in the Florida-Caribbean region or African region (Ramesh Babu *et al.* 2022). Host plant resistance, cultural control, biological control, biopesticides, mating disruption technologies, synthetic pesticides, and agroecological management are just a

few of the many technologies and management techniques that have been developed over the years and are now available for the control of FAW (Prasanna *et al.*, 2018, 2021). The outbreak and spread of FAW have forced farmers to use chemical insecticides to control this pest on an emergency basis. Host plant resistance is a key component of Integrated Pest Management. Thus, finding any maize cultivars that are FAW-resistant could be a critical element for establishing sustainable strategies to control this voracious insect and minimize yield losses in maize (Chiriboga Morales *et al.*, 2021).

Materials and Methods

A field experiment was carried out using a Randomized Block design (RBD) with five varieties (local cultivar, sweet corn, HQPM-1, PHM-3, PMC-6) of maize with five replicates per maize cultivar in the natural infestation. Maize seeds were sown at 20 cm between plants and 60 cm between rows (Van Huis 1981, Morales *et al.*, 2021).

Observations : The first data recording was obtained 20 days after the sowing date, and thereafter every twenty days, four times during a season. Plant damage score was recorded, with an adapted visual scale of damage (0–9) used by van Huis (1981) evaluating 25 plants per plot (Morales *et al.*, 2021).

Statistical Analysis : Plant damage scores from field data was analysing with Two-way Repeated Measures ANOVA separately for natural infestation. All data was analysed, transformed, and checked for normality using 25 plots.

Table-1 : Davis score (1-9) of fall armyworm damage on maize cultivars during Kharif, 2022.

Treatment	Mean Davis score (1-9)			
	20 DAS	40 DAS	60 DAS	80 DAS
Local cultivar	0.50	1.72	4.08	5.48
PHM-3	0.38	1.52	3.18	3.76
PMC-6	0.62	2.70	4.84	5.98
Sweet Corn	0.16	0.78	2.48	3.04
HQPM-1	0.24	1.76	3.60	4.32
SeM+	0.03	0.15	0.20	0.21
CD 5%	0.09	0.45	0.61	0.63

DAS-Day after sowing.

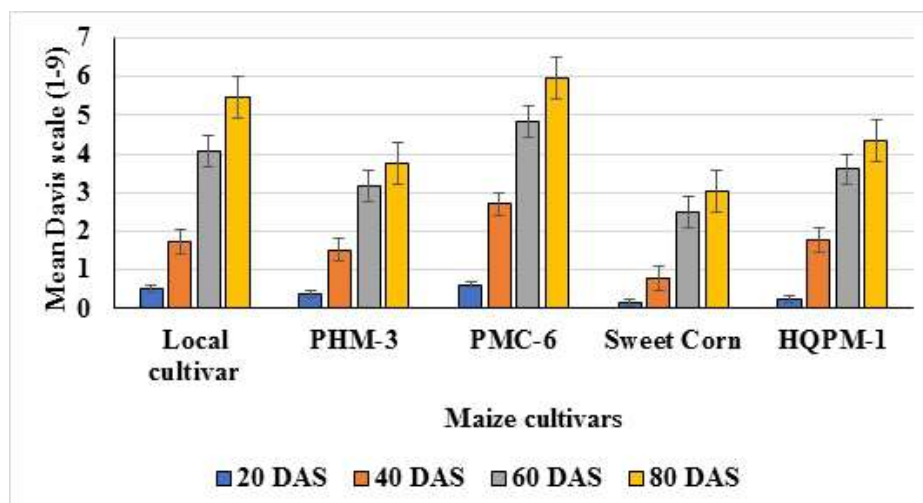


Figure : Davis score (1-9) of fall armyworm damaging on maize cultivars during Kharif, 2022 (+SEM).

Results and Discussion

In each plot, data were collected on the Davis scale (1-9), plant damage of *S. frugiperda* at 20, 40, 60, and 80 days after sowing. In each plot, data were collected on the Davis scale (1-9), *S. frugiperda* at 20, 40, 60, and 80 days after sowing.

Twenty days after sowing (20 DAS) : Davis score of maize cultivars significantly varied between the treatments at 20 days after sowing. The range of 0.16 to 0.62 Davis score was recorded in the different cultivars of maize. The significant maximum Davis score was recorded in the cultivar, PMC-6 (0.62) whereas the least Davis score was observed in sweet corn (0.16) which was at par with HQPM-1 (0.24). The other maize cultivars, PHM-3 and local variety recorded a Davis scale of 0.38 and 0.50, respectively which significantly differed from each other.

Forty days after sowing (40 DAS) : Significant differences were found in the Davis score in different cultivars of maize 40 days after sowing. The Davis score was in the range of 0.78 to 2.70 in different maize cultivars. The maximum Davis score was recorded in PMC-6 (2.70) and the least Davis score was in sweet corn (0.78) which

was significantly different from other maize cultivars. The Davis score of 1.52, 1.72 and 1.76 were recorded in the maize cultivars of PHM-3, local cultivar and HQPM-1, respectively which were at par with each other.

Sixty days after showing (60 DAS) : Davis score of maize cultivars significantly varied between the treatments at 60 days after sowing. The range of 2.48 to 4.84 was recorded in different maize cultivars. The maximum Davis score was recorded in the cultivar, PMC-6 (4.84) which was at par with the local cultivar (4.08) whereas the least Davis score was observed in sweet corn (2.48) and at par with PHM-3 (3.18). The other maize cultivar, HQPM-1 recorded a Davis scale of 3.60 which was at par with PHM-3.

Eighty days after sowing (80 DAS) : Significant differences were found in the Davis score in different cultivars of maize at 80 days after sowing. The Davis score was in the range of 3.04-5.98 in different maize cultivars. The maximum Davis score was recorded in PMC-6 (5.98) which was at par with the local cultivar (5.48). The least Davis score was in sweet corn (3.04) which was at par with PHM-3 (3.76). The Davis score of 4.32 was recorded in the maize cultivar, HQPM-1.

Conclusions

Plant damage were recorded by Davis score (1-9) and per cent plant damage were recorded at 20, 40, 60, 80 days after sowing. Davis score of maize cultivars significantly varied between the treatments 0.16 to 0.62, 0.78 to 2.70, 2.48 to 4.84, 3.04 to 5.98 at 20,40, 60, 80 DAS respectively. Highly damage was recorded in PMC-6 and lowest damage in sweet corn during the experiment.

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Estimation of Avoidable Losses Caused by Insect Pests of sorghum

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Abstract

The investigation on “Estimation of avoidable losses caused by insect pests of sorghum” was laid out in paired plot design at Rajasthan College of Agriculture, MPUAT, Udaipur during *Kharif* 2022. There will be 26 plots (13 paired plots), out of which one set of 13 plots were provided application of insecticides at regular interval to keep the crop pests free (Protected) and another set of 13 plot were exposed to natural infestation of insect pests (Unprotected). The insect pest infestation significantly influenced the yield attributing characters and sorghum grain yield. The insect pest infestation caused reduction in mean height of plant (26.62 %), test weight of sorghum grains (25.40 %), mean grain yield per plant (14.34 %), mean grain yield per plot (13.89 %), mean of per cent chaffy spikelets (74.78 %) and mean of shriveled grains (73.39 %) in unprotected plots.

Key words : Paired plot, chaffy spikelet's, shriveled grains, sorghum [*sorghum bicolor* (L.) monch], test weight.

Introduction

Sorghum (*Sorghum bicolor* L. Moench) belonging to family Graminae is the most important source of fodder and industrial raw material in various parts of the world. The major Sorghum growing countries are North America, Sub Subaran Africa, Northeastern China, India, Argentina, Egypt, Mexico, Spain and France. The productivity of Sorghum in India is 849.05 kg/ha, which is well below the worlds average (1444.6 kg/ha). India contributes 16 % of total world production and is fourth largest producer in the world (Anonymous 2019).

Sorghum can produce yields in different climatic conditions which makes it valuable cereal crop. Most of the varieties of Sorghum crop are generally heat and drought tolerant, making them suitable for cultivation in arid region and could be grown even under the water scarcity conditions. It is staple food of most of the poor people (Dehinwal *et al.*, 2016) of Maharashtra, Andhra Pradesh, Karnataka, Gujarat, Rajasthan, and Tamil Nadu which are the major sorghum growing areas in India (Satpal *et al.*, 2016). It is rich in carbohydrates (72.6 %), fat (1.9 %), crude fiber (1.6 %), protein (10.4 %) and mineral matter (1.6 %) with high digestibility. It is widely used to produce starch, biscuits, alcohol, and other beverages.

Despite of its wide use as food, feed and fodder its cultivation is reducing in past few years in the country because of its low productivity. The low productivity of Sorghum is attributed to various abiotic (Rainfall, humidity, temperature) and biotic factors. Among the

biotic factors, the losses caused by insect pests are very huge. Nearly 32 per cent of sorghum crop is lost due to insect pests in India (Borad and Mittal, 1983). About 150 species of insect pests infests the Sorghum crop from germination till harvesting (Jotwani *et al.*, 1980). Similarly, Garg and Singh (2002) recorded shoot fly (*Atherigona soccata* Rondani), grasshopper (*Hieroglyphus banian* Bolivar), grey weevil (*Myloccerus undecimpustulatus* Bohemann), stem borer (*Chilo partellus* Swinhoe), aphid (*Melanaphis sacchari* Zehntner) and termite (*Odontotermesobesus* Rambur) as major insect pests of sorghum.

Materials and Methods

The experiment on estimation of losses due to insect pests in sorghum was laid out in paired plot design at Rajasthan College of Agriculture, MPUAT, Udaipur. The sorghum, variety CSV 21 was sown in the plots each measuring size of each plot was 4.5m x 2m, having row to row and plant to plant spacing of 45 cm and 15 cm, respectively. There will be 26 plots (13 paired plots), out of which one set of 13 plots were provided application of insecticides at regular interval to keep the crop pests free (Protected) and another set of 13 plot were exposed to natural infestation of insect pests (Unprotected).

Observations :

1. The observations on various attributing character are :
1. Plant height (cm)
2. Test weight of 1000 sorghum grains (g)
3. Grain yield per plant (g)

4. Grain yield per plot (kg)
5. Per cent chaffy spikelet's
6. Per cent shriveled grain

At harvest, the grain yield per plot were recorded and converted into q per ha for comparison. Five randomly selected plants from protected and unprotected plots were observed and mean losses in grain yield was worked out. The yield data obtained from protected and unprotected plots was compared by using the formula as suggested by Leclerc (1971).

$$\text{Mean loss in yield \%} = \frac{X_1 - X_2}{X_1} \times 100$$

Where,

X_1 = Yield in treated (protected) Plot.

X_2 = Yield in untreated (unprotected) Plot.

The data will subjected to statistical analysis and significance will be tested by using appropriate statistical method.

$$t = \frac{|\bar{X}_1 - \bar{X}_2|}{\sqrt{Sp^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}}$$

$$\bar{X}_1 = \frac{\sum x_1}{n_1}$$

$$\bar{X}_2 = \frac{\sum x_2}{n_2}$$

$$Sp^2 = \frac{1}{n_1 + n_2 - 2} \left(\sum x_1^2 - \frac{(\sum x_1)^2}{n_1} + \sum x_2^2 - \frac{(\sum x_2)^2}{n_2} \right)$$

Where,

$\bar{X}_1$ = Average yield in treated plot (Protected)

$\bar{X}_2$ = Average yield in untreated plot (Unprotected)

Sp^2 = Pooled variance

n_1 = Sample size for Protected

n_2 = Sample size for Unprotected

Results and Discussion

The studies were conducted to estimate the losses due to insect pests in variety "CSV 21" of sorghum and experiment was carried out in paired plot design. The studies revealed that "CSV 21" variety of sorghum was infested by number of insect pests, which adversely effect the growth and yield of sorghum crop during Kharif 2022. The amount of quantitative loss inflicted by insect pests with their effects on yield attributing characters viz., plant height (cm), test weight of sorghum grains (g), grain yield (g) per plant, grain yield (kg) per plot, per cent chaffy

spikelet's and per cent shriveled grains was recorded and the results have been presented in table.

Plant height (cm) : The data enumerated in table reveals that in sorghum crop a significant reduction in plant height (cm) between protected and unprotected plots was observed due to pest infestation. In protected plots the height of plants ranged from 233.33 cm to 286.67 cm with a mean of 248.43 cm as compared to that of 163.33 cm to 196.67 cm with a mean of 181.90 cm in unprotected plots. The mean difference in plant height (cm) of protected and unprotected plants was 66.53 cm. The mean per cent reduction in plant height (cm) in untreated plot was 26.62 per cent.

Test weight of sorghum grains (g) : The data presented in table reveals that in sorghum crop a significant reduction in the test weight of sorghum grains was observed due to pest infestation. In protected plots ranged from 27.33 g to 31.33 g with a mean of 29.97 g, while in unprotected plots it ranged from 19.67 g to 24.67 g with a mean of 22.33 g. The mean difference in test weight of sorghum grains (g) of protected and unprotected plants was 7.63 g. The mean per cent reduction in test weight of sorghum grains (g) in unprotected plot was 26.62 per cent.

Grain yield (g) per plant : The data pertaining to table reveals that in sorghum crop a significant reduction in grain yield (g) per plant between protected and unprotected plots was observed due to pest infestation. The minimum and maximum grain yield (g) of each sorghum plant in protected plots were 70.00 g and 75.10 g, respectively with a mean of 72.45 g in comparison to a mean grain yield of 62.06 g and a minimum and maximum per plant grain yield (g) of 59.50 g and 65.80 g, respectively in unprotected plots. The mean difference in grain yield per plant of protected and unprotected plants was 10.39 g. The mean per cent reduction in Grain yield (g) per plant in unprotected plot was 14.34 per cent.

Grain yield (kg) per plot : The observations recorded from table reveals that in sorghum crop a significant reduction in grain yield (g) per plant between protected and unprotected plots was observed due to pest infestation. The minimum and maximum grain yield per plot in the protected plots were 4.75 kg and 4.89 kg respectively with a mean of 4.82 kg. Whereas the minimum and maximum grain yield per plot in the unprotected plots were 4.06 kg and 4.24 kg respectively with a mean of 4.15 kg. The mean difference in grain yield per plot between protected and unprotected plots was 0.67 kg and the mean per cent reduction in grain yield per plot in unprotected plots was 13.89 per cent.

Per cent chaffy spikelets : The data enumerated in table reveals that in sorghum crop a significant reduction in per

Table : Estimation of quantitative losses caused by insect pests of sorghum.

S. No.	Parameters	Range		Mean		"t" at 5%	Mean per cent reduction
		Protected	Unprotected	Protected	Unprotected	Tabulated	
1.	Plant height (cm)	233.33-286.00	163.33-196.67	248.43	181.90	15.30*	26.62
2.	Test weight of 1000 grains (g)	27.33-31.33	19.67-24.67	29.97	22.33	16.85*	25.40
3.	Grain yield per plant (g)	70.00-75.10	59.50-68.80	72.45	62.06	24.47*	14.34
4.	Grain yield per plot (Kg)	4.75-4.89	4.06-4.24	4.82	4.15	36.24*	13.89
5.	Percent chaffy spikelet's	2.77-3.81	10.30-14.80	3.26	13.00	32.91*	74.78
6.	Shriveled grain	2.54-3.72	10.36-13.31	3.06	11.57	39.35*	73.39

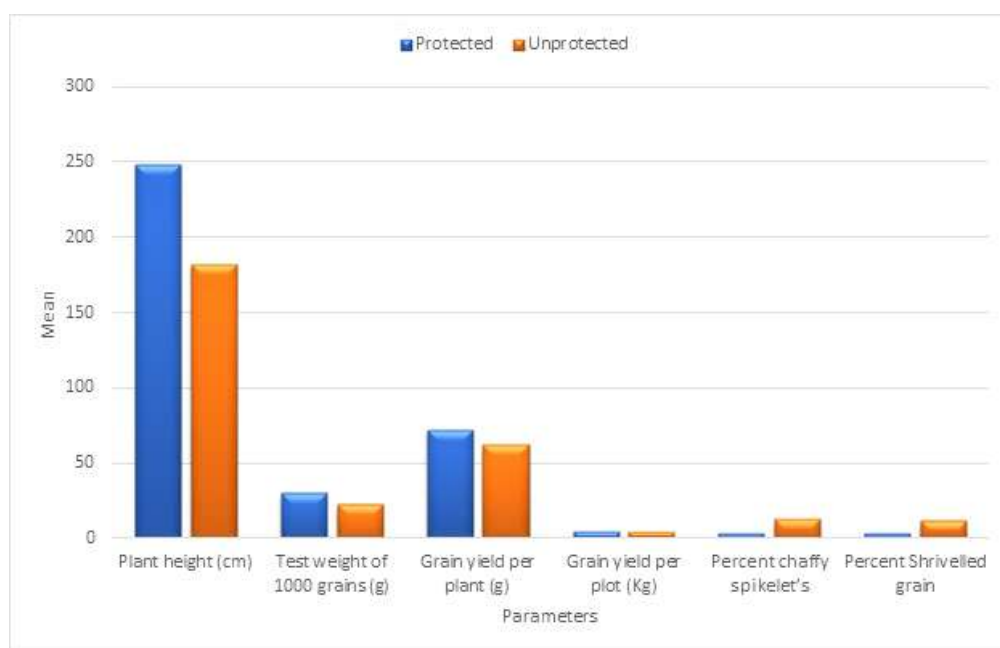


Fig. : Estimation of avoidable losses caused by insect pests of sorghum.

cent chaffy spikelet's between protected and unprotected plots was observed due to pest infestation. The minimum and maximum per cent chaffy spikelet's in the protected plots were 2.77 per cent and 3.81 per cent respectively with a mean of 3.26 per cent. Whereas the minimum and maximum per cent chaffy spikelet's in the unprotected plots were 10.30 per cent and 14.80 per cent respectively with a mean of 13.00 per cent. The mean difference in per cent chaffy spikelets between protected and unprotected plots was 9.74 per cent and the mean per cent reduction in per cent chaffy spikelet's in unprotected plots was 74.78 per cent.

Shriveled grains : The data represented in table reveals that in sorghum crop a significant reduction in shriveled grains between protected and unprotected plots was observed in sorghum crop due to pest infestation. The minimum and maximum shriveled grains in the protected plots was 2.54 and 3.72 respectively with a mean of 3.06. Whereas the minimum and maximum shriveled grains in the unprotected plots were 10.31 and 13.31 respectively with a mean of 11.57. The mean difference in shriveled grains between protected and unprotected plots was 8.50

and the mean per cent reduction in shriveled grains in unprotected plots was 73.39 per cent.

The present finding is in accordance with the results obtained by Vyas (2002), Dangi *et al.* (2005), Patra *et al.* (2013), Abudalai *et al.* (2012) and Vikrant *et al.* (2015).

Conclusions

Among the loss estimation parameters, plant height differed significantly between protected and unprotected plots during Kharif, 2022. In protected plots, the mean height of sorghum plants was 248.43 cm as compared to a mean of 181.90 cm in unprotected plots with a mean per cent reduction of 26.62 per cent in unprotected plot. The mean difference in the test weight of 1000 sorghum grains between protected and unprotected plots was 7.63 g and the mean per cent reduction was 25.40 per cent in unprotected plot. The mean per cent reduction of grain yield per plant was 14.34 per cent in unprotected plot. The mean difference in grain yield per plot between protected and unprotected plots was 0.67 kg and the mean per cent reduction of grain yield per plot was 13.89 per cent in unprotected plot. The mean difference in per cent chaffy

spikelets between protected and unprotected plots was 9.47 per cent and the mean per cent reduction of per cent chaffy spikelets was 74.78 per cent in unprotected plot. The mean difference in shriveled grains between protected and unprotected plots was 8.50 and the mean per cent reduction of shriveled grains was 73.39 per cent in unprotected plot.

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Seasonal Incidence of Insect Pests of Cabbage (*Brassica oleracea*, var. *capitata*) and Cauliflower (*Brassica oleracea*, var. *botrytis*) in Relation to Weather Parameters

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Abstract

Investigation on the seasonal incidence of major insect pests of cabbage and cauliflower, was carried out in the Horticulture Research Farm, Rajasthan Collage of Agriculture, MPUAT Udaipur during *Rabi*, 2022-2023. The cabbage and cauliflower crop were found to be infested by five major pests i.e., aphid (*Lipaphis erysimi* Kalt.), diamondback moth (*Plutella xylostella* L.), flea beetle (*Phyllotreta cruciferae* Goeze), painted bug (*Bagrada hilaris* L.) and head borer (*Hellula undalis* Feb.). The infestation of *L. erysimi* started in the second week of November and reached peak in third week of December in cabbage and cauliflower during *Rabi*, 2022-23. The infestation of diamondback moth started from the last week of November in cabbage and cauliflower. The DBM reached peak in the last week of December in cabbage. Whereas, reached peak in the third week of December of DBM larvae and second week of December of DBM adult in cauliflower. The infestation of painted bug and head borer started in the second week of November and first week of December in the cabbage and cauliflower, respectively. Whereas, the painted bug and head borer reached the peak incidence in the second week of December and larvae of head borer reached peak in the second week of December & adult of head borer reached peak in first week of January in cabbage and cauliflower, respectively. The painted bug and head borer reached the peak incidence in the third week of December and last week of December in cauliflower, respectively. The infestation of flea beetle started in the last week of November and third week of November, whereas the infestation of flea beetle reached peak in the first week of January and third week of December in cabbage and cauliflower. The population of major insect pests was correlated with maximum & minimum atmospheric temperature, morning & evening relative humidity and rainfall in cabbage and cauliflower during *Rabi*, 2022-2023.

Key words : Incidence, cauliflower, major insect pests, diamondback moth (dbm), weather parameters and correlation.

Introduction

Cole crops are one of the most abundantly consumed vegetables in the world belonging to the family Brassicaceae which comprises about 380 genera and over 3000 species of cultivated and wild plants that have almost similar insect pests complex (Heywood,1993). Cole crops is a general term used to describe many vegetables that belong to mustard family (Brassicaceae), including cabbage (*Brassica oleraceae capitata*), cauliflower (*Brassica oleraceae botrytis*), broccoli (*Brassica oleraceae italika*), Knol khol (*Brassica oleraceae gongylodes*), etc. Cabbage (*Brassica oleracea* var. *capitata* Linn) is an important cole crop and commercially grown as leafy vegetable in India. It occupies an area of about 413 thousand hectares with an annual production of 9606 metric tonnes (India Horticulture Database, 2021-22). Cauliflower (*Brassica oleracea* L. var. *botrytis*: Brassicaceae), is an important winter vegetable cultivated extensively in India. India is the second largest producer of vegetables (12.6%) and also one of the largest producers of cauliflower in the world. In 2015-2016, the area under cauliflower cultivation in India

was 473 ha with a production of 9283 MT. West Bengal, Bihar, Madhya Pradesh, Odisha, Gujarat, Haryana, Assam and Rajasthan are the major cauliflower growing states in India (India Horticulture Database, 2021-22).

Reduction in the yield of cauliflower is caused due to both biotic and abiotic factors. Among biotic factors insects are the major cause for yield reduction. A total of 51 insect pest's species damaging cruciferous crops have been reported throughout the world (Maison,1965). In India a total of 37 insect pest's species have been reported to feed on cruciferous crops (Lal,1975). Amongst all, diamondback moth (*Plutella xylostella* L.), cabbage head borer (*Hellula undalis* Fab), head caterpillar (*Crociodolomia bionotalis* Zell), aphids (*Bravicornye brassicae* L. and *Lipaphis erysimi* Kaltenbanch), painted bug (*Bagrada cruciferarum* kirk.) and flea beetle (*Phyllotreta cruciferae* Goeze.) are most common insect pests on cole crop in India (Srinivasan and Murthy, 1991).

Materials and Methods

The experiment to study the seasonal incidence of major insect pests of cabbage was laid out in three uniformly sized plots, each measuring 3 X 5m² (15 m²). The late

season variety of cabbage and cauliflower i.e., Puma and White XL was transplanted in the first week of November maintaining a spacing of 45 cm x 30 cm. To study the effect of weather parameters on the infestation of major insect pests, weekly meteorological data on maximum and minimum temperature ($^{\circ}\text{C}$), morning and evening relative humidity (%) and rainfall (mm) that prevailed, during the seasons (i.e., *Rabi*, 2022-23) were obtained from the meteorological unit of the Instructional Farm, Rajasthan College of Agriculture, Udaipur.

Observations : The observations on the abundance of major insect pests of cabbage and cauliflower will be recorded on their appearance on plants till harvesting of the crop. Populations of the major insect pests were recorded at weekly intervals during morning hours, between 7.00 A.M. to 10.00 A.M for pests.

Major insect pests : Populations of the major insect pests will be recorded at weekly intervals during morning hours, from ten randomly selected and tagged plants of cabbage and cauliflower in each plot.

The population of aphids (both nymphs as well as adults; alate and apterous) was recorded using a magnifying lens on three leaves of each tagged plants of cabbage and cauliflower.

The population of diamondback moth (both larvae as well as adult moth) and head borer (both larvae as well as adult moth) was recorded by visual counting method on ten randomly selected and tagged curd of cabbage and cauliflower.

The population of flea beetle (both grub as well as adult beetle) and painted bug (both nymph as well as adult bug) was recorded on ten randomly selected and tagged plants of cabbage and cauliflower.

Statistical analysis : Population data of major insect pests of cabbage and cauliflower thus obtained was subjected to statistical analysis to find out the coefficient of correlation with mean temperature, relative humidity and rainfall.

$$r_{xy} = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{n} \right] \left[\sum Y^2 - \frac{(\sum Y)^2}{n} \right]}}$$

Where :

r_{xy} = Simple correlation coefficient

X = Variable i.e., abiotic component (Average temperature and Average relative humidity, Total rainfall and Total sunshine hours)

Y = Variable i.e., mean number of insect pests

n = Number of paired observations.

Results and Discussion

Seasonal incidence of insect pests of cabbage and cauliflower during *Rabi*, 2022-2023.

Aphids : The infestation of aphids (nymph and adult) initiated in the 3rd week of November and reaching a peak (40.80 nymph/3 leaves and 28.00 adult/3 leaves) and (35.80 nymph/3leaves and 30.00 adult/3 leaves) during the 3rd week of December in both the crops. The result of the present investigation are in agreement with Venkateswarlu *et al.* (2011) who, recorded the incidence of cabbage aphid started from last week of December and peak incidence of cabbage aphid (16.90 aphid/plant), partially support the present findings. Similarly, Gopika *et al.* (2022) support our findings as the peak activity of cabbage aphid was observed during 51th SMW with mean population of 112.2 aphids/plant. Cabbage aphid (*Brevicoryne brassica*) were observed from 49th SMW to 8th SMW with peak incidence in 5th SMW (41.0 larva/plant) (Sharma *et al.*, 2022).

The results of the present investigations are in agreement with Singh *et al.* (2010) who indicated cauliflower aphid population was negative relationship with maximum, minimum and mean temperature, evening and morning relative humidity and wind velocity. According to the findings of Bana *et al.* (2012) who, recorded maximum and minimum temperatures showed significant negative correlation whereas, relative humidity showed non –significant correlation, partially support the present findings.

Diamondback moth : In the present study the diamondback moth larvae and moth started appearing from the last week of November, reaching its peak of 2.40 larvae/ plant and 0.30 adult/plant and 4.00 larvae/plant and 0.10 adult/plant during the last week of December in cabbage and cauliflower, respectively. According to Dalve *et al.* (2010) reported that the pest population of *Plutella xylostella* (Linnaeus) on cabbage appeared from third week December which gradually increased and attained a peak of 8.9 larvae per plant during the fourth week of January. Venkateswarlu *et al.* (2011) who, observed diamondback moth during first week of February and peak incidence of diamondback moth (18.68/ plant) was recorded during second week of march. Bana *et al.* (2012) observed diamondback moth started from the third week of November and reached peak in the first week of January almost similar to our findings. Saranya *et al.* (2017) recorded DBM initiated in December and reached their peak mean populations during February. Sharma *et al.* (2017) reported that the infestation of diamondback moth started from the third week of November and reached at peak (45.2 larvae/10 plants) in the first week of

January in the cole crops almost similar to our findings. Gaikwad *et al.* (2018) who, found that the incidence of DBM during 50th SMW with intensity of 0.55/plant and attained peak during 2nd SMW. Mishra *et al.* (2018) reported that diamond back moth (*Plutella xylostella*) was observed from 35th to 39th SMW with peak incidence in 39th SMW (7.32 larvae/plant). Major activity period of diamond back moth population appeared during 49th SMW and the peak incidence during 3rd SMW (9.0 larva/plant) (Sharma *et al.*, 2022). Gopika *et al.* (2022) observed that the peak activity of diamondback moth 5th SMW 5.8 larvae/plant. Kumar *et al.* (2023) who, found DBM first appeared during 50th SMW with intensity of 2.9/plant, then the population gradually increased and attained peak during 2nd SMW.

The observations also reveals that the DBM larvae incidence in cabbage had a significant negative correlation with maximum and minimum temperature and a significant positive correlation with morning relative humidity and non-significant positive with evening humidity, whereas, adult population of cabbage DBM with evening relative humidity and minimum temperature it had a non-significant negative correlation and morning relative humidity and maximum temperature it had a non-significant positive correlation. In cauliflower both larvae and adult incidence had a non-significant negative correlation with maximum and minimum temperature and a non-significant positive correlation with morning and evening relative humidity. Whereas, remaining all the weather parameters showed non-significant correlation with *P. xylostella*. According to Bana *et al.* (2012) maximum and minimum temperatures showed significant negative correlation with larvae population of diamondback moth, whereas, relative humidity showed non-significant correlation. Similarly, Saranya *et al.* (2017) who, observed that the population of the DBM was positively correlated with the mean atmospheric temperature and negatively correlated with relative humidity. Sharma *et al.* (2017) reported maximum and minimum temperature showed significant negative correlation with larval population of diamondback moth whereas, there was non-significant correlation with relative humidity. Similar results were reported by Gaikwad *et al.* (2018).

Flea beetle : In the present study the incidence of flea beetle in cabbage (maximum 2.40 grub/plant and 1.40 adult/plant during 1st SMW) and in cauliflower (maximum 5.10 grub/plant and 4.00 adult/plant during 51th SMW). Present observations were more or less similar with the results of earlier workers. Chaudhari (2001) reported that population of flea beetle reached its maximum during last week of March in cabbage crop. Maximum population of flea beetles, *Phyllotreta cruciferae* (0.78 beetles/ plant)

were found during the last week and 3rd week of December (Ghosh, 2000), which fully support the present findings. Saranya *et al.* (2017) found that the infestation initiated in the 2nd week of January.

Painted bug : The data of the present study pertaining to the painted bug infestation reveals that the infestation of painted bug initiated in the 46th SMW reaching to its highest mean population of 3.00 nymph/ plant and 2.40 adult/plant in the 50th SMW in cabbage. The incidence of painted bug in cauliflower (maximum 5.10 nymph/plant and 4.00 adult/plant during 51th SMW). Similar to the present findings, Nagar (2011) and Bhawaskar (2015) reported a significant positive correlation between the incidence of painted bug and atmospheric temperature and negative correlation between the incidence of painted bug and relative humidity. Saranya *et al.* (2017) recorded significant positive relationship with mean atmospheric temperature ($r = 0.71$), whereas, with mean relative humidity it had a significant negative relationship ($r = -0.69$).

Head borer : In the present study the incidence of head borer in cabbage (maximum 3.40 borer/plant during 52th SMW and 0.70 adult/plant during 1st SMW) and in cauliflower (maximum 2.20 borer/plant and 0.50 adult/plant during 52th SMW). Patait *et al.* (2008) revealed that the population of *Hellula undalis* on cabbage varied from 0.6 to 3.2 larvae/ quadrat during winter. Present observation was more or less similar with the results of earlier workers. Ojha *et al.* (2004) recorded the peak incidence of head borer in the second week of December with 8.66 larvae/plant. According to Gaikwad *et al.* (2018), the recorded incidence of *Hellula undalis* initiated from 50th SMW and population maximum 2.50 /plant in 8th SMW. Yadav *et al.* (2019) reported highest population of *Hellula undalis*, 0.67 larvae/plant during 10th SMW. The activity of cabbage head borer caterpillar initiated during 51th SMW with gradual increase its population and reach its peak (5.0/plant) 2nd SMW (Sharma *et al.*, 2020).

The data also showed that maximum and minimum temperature had a significant negative correlation with the head borer population in cabbage. The morning relative humidity had a non-significant positive correlation while evening relative humidity had a significant positive correlation with the head borer population in cabbage. The maximum and minimum temperature had a non-significant negative correlation whereas, morning and evening relative humidity had a non-significant positive correlation with the head borer population in cauliflower. Present observations were more or less in line with the results of earlier workers Patait *et al.* (2008) who revealed that relative humidity and maximum temperature had positive and negative effect on the

population of *H. undalis*. Conversely, Gaikwad *et al.* (2018) recorded correlation of head borer with evening relative humidity ($r=-0.628^*$) was negatively significant. However, maximum temperature (0.576^*) and evaporation (0.645^*) were positively significant.

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Effect of Weed Management on Growth of Lentil (*Lens culinaris* Medik. L.)

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Abstract

A field experiment entitled "Effect of Weed Management on Weed Density, growth, and Productivity of Lentil (*Lens culinaris* Medik. L.)" was conducted during *rabi* 2021-22 at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur. The experiment was laid out in Factorial Randomized Block Design consisting of 20 treatment combinations and three replications. Ten chemical weed management practices *i.e.*, pendimethalin 500 g ha⁻¹ PE, pendimethalin 750 g ha⁻¹ PE, pendimethalin 1000 g ha⁻¹ PE, imazethapyr 50 g ha⁻¹ PoE, imazethapyr 60 g ha⁻¹ PoE, imazethapyr 70 g ha⁻¹ PoE, pendimethalin + imazethapyr 500 g ha⁻¹ PE, pendimethalin + imazethapyr 750 g ha⁻¹ PE, pendimethalin + imazethapyr 1000 g ha⁻¹ PE and control (No herbicides) were taken as factor A and HW at 40 DAS and control treatment were taken as factor B. Lentil variety Kota Masoor-3 was used as test crop.

Key words : Lentil, weed management, pendimethalin, imazethapyr, plant height.

Introduction

Indian agriculture has made significant progress toward food grain self-sufficiency and has achieved a growth rate that is sufficient to meet the demands of a huge growing population. Despite the phenomenal increase, guaranteeing food and nutritional security for each home remains a monumental effort due to agriculture's unequal expansion, which favours wheat and rice. Though pulse output has increased in the last decade, it has not kept up with the growing population. Pulses are an important source of protein in the Indian diet, and because they are resource-efficient and environmentally friendly, increasing pulse production can help with issues like nutritional security and lowering foreign export. Pulses are the principal source of high-quality protein and necessary amino acids in our country, which is largely vegetarian. Pulses are members of the *Leguminosae* family, which is primarily grown for the production of edible seeds. Chickpea, moong bean, urd bean, pigeon pea, lentil, khesari, beans, and pea are all part of this group of 12 legume crops.

Weeds are one of the most significant constraints to the lentil crop worldwide, with weed infestation reducing yield by up to 80%. Weeds compete for nutrients, moisture, and space with lentils, as well as harbouring insects, pests, and pathogens that can harm the crop. Because of the crop's poor early development and short height, considerable care must be made to weed management up to 40-45 days after sowing (Yadav *et al.*,

2007). Lentil is extensively plagued with thin and broad-leaved weeds and sedges, which compete with the crop and reduce yields by up to 60% (Chandrakar *et al.*, 2016).

Chemical weed control could be an option to manual weed control due to the increasing cost of hand weeding, which can be a hardship on small and marginal farmers, as well as its low efficiency and lack of labour availability during the vital growth time. Isoproturon is one of the herbicides suggested for weed management in this crop, however, it is now unavailable due to non-manufacturing and there is a risk of herbicide resistance biotypes like *Phalaris minor* developing in wheat (Walia and Brar, 2006).

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 experiment field was clay loam in texture, slightly alkaline in reaction (PH 8.6), medium in available nitrogen (298.1 kg ha⁻¹) and phosphorus (22.12 kg ha⁻¹) while high in available potassium status (452.5 kg ha⁻¹). The experiment consisted of twenty treatments combinations *i.e.*, two levels of weeding (control, hoeing at 20 DAS and weeding at 40 DAS) and ten weed management chemicals *viz.*, Pendimethalin 500 g ha⁻¹, Pendimethalin 750 g ha⁻¹, Pendimethalin 1000 g ha⁻¹, Imazethapyr 50 g ha⁻¹, Imazethapyr 60 g ha⁻¹, Imazethapyr 70 g ha⁻¹,

Pendimethalin + Imazethapyr 500 g ha⁻¹, Pendimethalin + Imazethapyr 750 g ha⁻¹, Pendimethalin + Imazethapyr 1000 g ha⁻¹, and Control. These were replicated thrice in Factorial randomized Block Design (FRBD). Lentil variety kota Masoor-3 was used as test crop. A uniform dose of 20 kg N + 40 kg P₂O₅ ha⁻¹ was applied. Urea and DAP were used as a source of nitrogen and phosphorus.

Results and Discussion

Plant height : It is evident from Table-1) that the minimum crop height was observed under control (10.33 cm) while the maximum crop height was observed under with HW at 40 DAS (21.11 cm). Also, the minimum crop height was observed under control (12.88 cm) while the maximum crop height was observed under by with pendimethalin + imazethapyr 1000 g ha⁻¹ (17.71 cm). However, it was statistically at par pendimethalin + imazethapyr 750 g ha⁻¹ PE (17.29 cm) and pendimethalin + imazethapyr 500 g ha⁻¹ PE (16.29 cm). The magnitude of increase in plant height recorded under these three weed control treatments indicated a 37.5, 34.23 and 26.47 per cent increase in plant height as compared to control.

Plant dry matter : A perusal of the data (Table-2) indicates that in comparison to control (3.06 g), the application of various weed control treatments registered significantly superior dry matter. However, HW at 40 DAS (4.64 g) gave the maximum dry matter. Further, the least dry matter was observed under control (2.59 g) while the maximum dry matter was observed under pendimethalin + imazethapyr 1000 g ha⁻¹ PE (4.65 g). However, it was statistically at par with pendimethalin + imazethapyr 750 g ha⁻¹ PE (4.49 g), pendimethalin + imazethapyr 500 g ha⁻¹ PE (4.39 g).

It is clear from the results that all weed control treatments significantly increased plant height, dry matter accumulation among other morphological and biometric growth parameters. Pendimethalin + Imazethapyr 500 g ha⁻¹ PE observed the tallest plants (24.19 cm) at harvest. Pendimethalin + Imazethapyr 1000 g ha⁻¹ PE was observed maximum dry matter accumulation at 30 & 60 DAS and at harvest (0.52, 4.65 and 43.30 g plant⁻¹). The aforementioned gains often appear to be due to less crop-weed competition, although indirect effects may result from less competition for plant growth resources such as light, space, water, and nutrients, among others. The reduced crop-weed competition also led to less competition for growth resources, which improved resource availability and created favourable conditions for improved crop development, which ultimately led to an increase in plant height and dry matter accumulation of the plant. A similar line of results has also been reported by Singh *et al.* (2008), Kachhadiya *et al.* (2009) and Rupareliya *et al.* (2017).

Table-1 : Effect of weed management on plant height at 60 DAS in lentil.

Treatment	Plant height (cm)
Levels of manual weeding	60 DAS
Control	10.33
HW at 40 DAS	21.11
S.Em. ±	0.24
CD(P=0.05)	0.68
Chemical weed management	
Pendimethalin 500 g ha ⁻¹ PE	15.04
Pendimethalin 750 g ha ⁻¹ PE	15.82
Pendimethalin 1000 g ha ⁻¹ PE	14.82
Imazethapyr 50 g ha ⁻¹ PoE	16.10
Imazethapyr 60 g ha ⁻¹ PoE	15.38
Imazethapyr 70 g ha ⁻¹ PoE	15.88
Pendimethalin + Imazethapyr 500 g ha ⁻¹ PE	16.29
Pendimethalin + Imazethapyr 750 g ha ⁻¹ PE	17.29
Pendimethalin + Imazethapyr 1000 g ha ⁻¹ PE	17.71
Control (No herbicides)	12.88
S.Em. ±	0.53
CD(P=0.05)	1.52

Table-2 : Effect of weed management on plant dry matter at 60 DAS in lentil.

Treatment	Dry matter accumulation (g plant ⁻¹)
Levels of manual weeding	60 DAS
Control	3.06
HW at 40 DAS	4.64
S.Em. ±	0.05
CD(P=0.05)	0.14
Chemical weed management	
Pendimethalin 500 g ha ⁻¹ PE	3.65
Pendimethalin 750 g ha ⁻¹ PE	3.65
Pendimethalin 1000 g ha ⁻¹ PE	3.56
Imazethapyr 50 g ha ⁻¹ PoE	3.74
Imazethapyr 60 g ha ⁻¹ PoE	3.87
Imazethapyr 70 g ha ⁻¹ PoE	3.87
Pendimethalin + Imazethapyr 500 g ha ⁻¹ PE	4.39
Pendimethalin + Imazethapyr 750 g ha ⁻¹ PE	4.49
Pendimethalin + Imazethapyr 1000 g ha ⁻¹ PE	4.65
Control (No herbicides)	2.59
S.Em. ±	0.11
CD(P=0.05)	0.30

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Propagation of Dragon Fruit : A review

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Abstract

Dragon fruit belongs to family Cactaceae, and is a perennial semi epiphytic vine. Owing to its rich nutrient contents and antioxidant properties, it is gaining popularity as a super fruit. The skin is covered with bracts or scales and hence the name dragon fruit. Dragon fruit can be propagated both by seeds as well as cuttings. If propagated by cuttings, it must be taken out as soon as the segmentation of the stems is done as cuttings obtained of just-rooted sprouting plants presented better results in terms of root and shoot growth parameters. The seed viability obtained during the conduct of an experiment was 83% and germination varied between (71 and 83%) depending on the temperature. When cuttings were collected from middle part of three angled main stem during the month of November and December gave best results. Growth regulator auxin (IBA) proved successful for uniform rooting and well as for getting maximum survival percentage. When cuttings were treated with more than 1000 ppm IBA gave better root growth. Merten (2003) stated that dragon fruit is a veining epiphytic cactus and is native to the tropical forest region and Central and South America. The plants grow up tree trunks and are anchored by aerial roots.

Key words : Cutting, IBA, NAA, murashige skoog (MS) media self-incompatibility, vermicompost and biomix.

Introduction

Dragon fruit also known as Pitaya, Night blooming, Cereus Belle of the night, Cinderella plant, Jesus in the Cradle and Strawberry Pear. Fruit is named as pitaya because of the bracts or scales on the fruit skin and hence the name of pitaya meaning “the scaly fruit”. The burgeoning population and the health concern people are showing interest over this fruit due to its immense medicinal properties and health benefits. It helps in the prevention of cardiovascular diseases, controlling blood sugar level thus, considered to be outstanding fruit for diabetic patient (Le *et al.* 2021). It plays a vital role in fighting against cough, asthma, and wound healing, *etc.* Further, it requires very less water for growth and development due to its CAM pathway. Thus, it could be a lucrative fruit crop, particularly for degraded lands, abiotic stress and rainfed areas of the country. The fruit is used for table and processing purpose. Colorful bracts, dark red and white flesh and edible tiny black seeds embedded in it makes choicest fruit in salad. Value added products like jam, jelly, candy, syrup, and wine are be prepared from the pulp. Fruit skin is a rich source of pectin. It can be used as fruit coloring agent and raw material for food color industries. The fruit comes in four types, all with leathery, slightly leafy skin: *Hylocereus undatus* (white flesh with pink skin), *Hylocereus polyrhizus* (red flesh with pink skin), *Hylocereus costaricensis* (violet red flesh and pink skin) and *Hylocereus (Selenicereus) megalanthus* (white flesh with yellow skin).

Arivalagan *et al.* (2019) stated in the country report that dragon fruit (*Hylocereus spp.*) has recently drawn much attention among the Indian growers, because of its

excellent nutrient potentiation where farmers of Indian states like Karnataka, Kerala, Tamil Nadu, Maharashtra, Gujarat, Orissa, West Bengal, Andhra Pradesh and Andaman & Nicobar Islands have already taken up its cultivation, with an estimated total area of less than 400 ha. Majority of the dragon fruits available in Indian markets are imported from Vietnam, Thailand, Malaysia and Sri Lanka. There is a high demand of this fruit both in domestic and international markets, dragon fruit production could prove economical avocation to both backyard growers as well as entrepreneurs of medium and large scale plantations. The widely grown cultivars are red color epicarp with white and pink pulp. It proves to be a fast return perennial fruit crop with economic production in the first year after planting, and full production within three to five years. This crop is hardy and can survive in any type of climatic condition which is favorable for flowering and fruiting and soil condition provided with good drainage facility. The biggest advantage of this crop is that once planted, it will grow for about 20 years, and 1 hectare could accommodate about 800 dragon fruit plant. It has good demand in local as well as international markets. Farmers in the Indian states of Karnataka, Kerala, Tamil Nadu, Maharashtra, Gujarat, Orissa, West Bengal, Andhra Pradesh and Andaman & Nicobar Islands have already taken up its cultivation, and the estimated total area under dragon fruit cultivation in these regions may be less than 400 ha (Wakchaure *et al.* 2021). Dragon Fruit Market is projected to register a CAGR of 3.9% over the forecast period (2022-2027).

Perween *et al.* (2018) concluded that commercially dragon fruit appear to have numerous selling points; they

are attractive in shape and color, and very good nutraceutical property which attract growers from all over the India. The red flesh species i.e. *Hylocereus costaricensis* are additionally rich in betalains, meeting the increasing trade interest for antioxidant products and natural food colorant. Fruits are easy to keep fresh under room condition. The crop is hardy and can survive in any type of climatic condition favorable for flowering and fruiting and soil condition provided with good drainage. In general, they produce fruits quickly and few diseases and pests are encountered at the present time. Dragon fruit is a subtropical plant that needs very little water to survive and requires a minimum of six to eight hours of sunlight each day. Hence, this fruit provide a greater scope in maintaining national as well as international trade as by providing sufficient amount of produce required at excellent prices.

1. Method, role of growth regulators and media in propagation of Dragon Fruit :

Dragon fruit plants are generally propagated either by seeds or vegetatively by cutting. Both of these methods have their own merits and demerits. For commercial orcharding generally vegetative means of propagation are being adopted. Several advantageous have been made in case of asexual propagation of pitaya which are being reviewed here.

1.1. Sexual method of propagation : Seeds

The sexual method of propagating any plant is through seeds. Dragon fruit can be propagated by seeds but this method is not used commercially because it requires lots of patience as plant take years to come to fruiting. Lichtenzweig *et al.* (2000) conducted a pollination study and confirmed that there is self- incompatibility in *H. polyrhizus* and a weakened incompatibility in *H. undatus* and *S. megalanthus*. He observed that major crossability barriers did not exist between the *Hylocereus spp.* which were investigated. But reciprocal intergeneric crosses were successful between *Hylocereus spp.* and *Selenicereus megalanthus*, suggesting that a *Hylocereus spp.* might be one of the diploid progenitors of the tetraploid *S. megalanthus*. Hence, asexual method i.e. propagation by cuttings is the most adopted method for dragon fruit propagation.

1.2 Asexual method of propagation: Through cuttings

1.2.1 Effect of cutting type, size and media on growth parameters of Dragon Fruit : Andrade *et al.* (2007) conducted an experimented with red dragon fruit cuttings of different origins i.e. adult plant, cuttings of sprouting of just-rooted plants and plant in beginning of seed development originated from seeds, submitted to 3 periods of cicatrize: 0, 7 and 14 days. 5 replications were

taken with 10 cuttings in each. Observations were taken at 30 days for rooting, volume of root, length of the longest root (cm), fresh and dry masses of the roots (gm), number and size of the sprouting in the cuttings (cm). From this they conclude that the cutting must be taken out as soon as the segmentation of the stems is done as cuttings obtained of just-rooted sprouting plants presented better results.

Dachlan *et al.* (2020) conducted a research at the Teaching Farm of the Faculty of Agriculture, Universitas Hasanuddin from November 2018 to February 2019. They considered two types of cutting sources i.e. apical primary branch and basal primary branch and the concentration of shallots solution as sub plot were 0, 200, 400, and 600 gL⁻¹ water, and Rooton-F 10 gL⁻¹ water. The results showed that the growth of the dragon fruit seedlings from two different sources of cuttings at various concentrations of shallots did not show any significant difference. It was observed that cuttings from the basal of the primary branch gave the best results on the number of shoots (2.40 shoots). The application of various concentration of shallot solution proved beneficial as they resulted in the highest percentage of live cuttings (100%) compared to the control (75%). The concentration of shallot solution of 600 gL⁻¹ water showed the highest results in shoot length (28.33 cm), root length (31.09 cm) and root volume (66.67 mL) while the Rooton-F as a positive control gave the highest results in root length (31.09 cm) and root volume (66.67 mL).

EIObeidy (2006) did a research work at Department of fruit horticulture, Faculty of Agriculture, Cairo University, Giza, Egypt, where he has taken cuttings of 5, 15 and 25 cm length in three substrates: peat moss and sand mix (1:1) and sand. Three solutions of Indole-3-butyric acid (IBA) were prepared at 0, 5, 10 or 15 mM dissolved in 70% ethanol and observations were taken at 1, 2 or 3 weeks for cutting rooting, number and length. The following parameters were tested: germination of seeds at 16, 20, 24 and 28°C temperatures (by placing seeds on wetted filter papers in petri dishes), effect of different light intensities of 0, 500, 1000 or 2000 lx. seed viability was at 24°C in darkness with 1000 seeds. Finally, he concluded that after two weeks, 25-cm pitaya cuttings rooted successfully in the three substrates, but the number and length of the developed roots were affected by the type of substrate. Also there was a significant effect of cutting size on root initiation, number and length of the roots developed. IBA has proved to be successful in improving rooting percentage, root number and length. The seed viability was 83% and germination varied between (71 and 83%) depending on the temperature (after 6 days at 24 and 28°C). Reduced seed germination was observed at 1000 or 2000 lx. Hence

concluded that potted seedlings grew successfully in the greenhouse.

Fumuro (2011) has used cuttings of 4 year to 6 year-old plants. Main focus was given on the cutting type and auxin used on rooting of dragon fruit. It was observed that the rooting of the basal segments in both mature and immature herbaceous stems were superior than those of the upper or the middle segments. Rooting of 1 and 2 years old herbaceous stems was higher than that of immature ones. Rooting has increased with increase in the fresh weight of the cuttings. It was also concluded that cuttings size of more than 12 cm in length was necessary for effective rooting. Rooting % was increased by NAA or IBA treatment. Conclusively, fresh weight was increased by treatment with NAA.

Sudarjat *et al.* (2018) investigated the effects of different growing media compositions on dragon fruit (*H. undatus* and *H. polyrhizus*) propagation. They have used six growing media compositions: soil(v), soil+ sand (1:1/v:v), soil + compost(1:1/v:v), soil + vermicompost (1:1/v:v), soil + sand + compost (1:1:1/v:v:v) and soil + sand + vermin-compost (1:1:1/v:v:v). It was concluded that soil + vermicompost (1:1/v: v) and soil + sand + compost (1:1:1/v:v:v) gave best growth results for these two dragon fruit species and increased number and length of shoots. Hence, vermicompost proved to be a better growing media among all the media stated above.

1.2.2 Time of preparation of cuttings : Nandi *et al.* (2019) conducted a study on red fruit type of dragon fruit with a view to find out best propagation period in a year and which segment of the stem was suitable to gave higher plant stand. Results from one year of investigation revealed that maximum number of alive cuttings were obtained when cuttings were collected from middle part of three angled main stem during the month of November and December.

1.2.3 Effect of growth regulator auxin (IBA) on root and shoot parameters of Dragon Fruit : Ahmad *et al.* (2016) studied to evaluate the performance of different Indole Butyric Acid concentrations on rooting of Dragon fruit stem cuttings. IBA concentration viz. TC: Control, T50: 50ppm, T75: 75ppm, T100: 100ppm were used as treatments under Completely Randomized Design (CRD) with 3 replications. Results showed that increasing IBA concentration gave better results in all the studied parameters with the highest root number (13.2), root length (12.7cm), root diameter (1.5mm), fresh weight (2.7g) and dry weight (0.8g) in treatment T100 and the lowest were found in TC (6.3, 5.7cm, 0.9mm, 0.3g, 0.2g respectively). Hence, they concluded that treating dragon fruit stem cuttings with 100ppm of IBA solution proves best for successful establishment.

Seran *et al.* (2015) from their study concluded that the cuttings treated with 8000 ppm IBA showed best root growth without being significantly differed from cuttings treated with 6000 ppm IBA. In respect to shooting parameters, they concluded that maximum shoot length (9.5 cm), shoot fresh wt. (10.25 g) and dry wt. (0.59 g) were found in cuttings dipped in 6000 ppm concentration of IBA at 60 DAP. Hence, highest concentration of IBA was better for the establishment of the dragon fruit cuttings.

Lalit *et al.* (2018) evaluated the effect of IBA concentration at 2000ppm, 4000ppm and 6000ppm on different cultivar of dragon fruit viz. red pulped and white pulped variety for rooting and shooting parameter. They observed that IBA concentration have significant effect over control in both the varieties but red pulped variety gave better performance over white pulped. Best results were observed at 6000ppm concentration of IBA for all the root and shoot parameters as well as the survival %. Least performance was observed for white pulped variety for all the parameters except shoot length.

Kasim *et al.* (2019) conducted an experiment to find out the effect of phytohormones like BAP (6-benzylaminopurine) and NAA (Naphthalene Acetic Acid) on various parameters like callus formation, root and shoot formation of explant taken from stem cutting of dragon fruit. Results showed that the Murashige Skoog (MS) media containing 3mg/l BAP and 0.5mg/l NAA exhibited highest in-vitro response regarding callus formation with maximum number of shoots i.e. 13.2. Somatic shoots arised within 4 weeks and 70 days were taken for shoots to grow 2 cm long. These shoots were transferred to rooting media supplemented with 3mg/l BAP and 0.5mg/l NAA which has proved good for growth of roots (4.8) in-vitro.

Siddiqua *et al.* (2019) showed that the influence of different plant growth regulators and their combinations have greatly influenced the days taken for sprout initiation. Significant differences were seen between auxin concentrations for days taken to first sprout. Cuttings treated with treatment T₃ (IBA: 7000ppm) took less number of days for the sprout initiation (7.34) which was on par with T₂ (IBA: 6000 ppm) which took 7.65 days to sprout and T₁, IBA: 5000 ppm sprout at 8.39. Untreated cuttings (T₁₂) showed maximum number of days for first sprouting i.e. 16.33 days. was in untreated cuttings (T₁₂).

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Economic Feasibility of Solar Water Pump in Tribal region of Udaipur District, Rajasthan

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Abstract

Solar water pumps have come out as a dependable and cost-effective technology to increase energy access for sustainable agriculture. They have advanced to be a better substitute to electric and diesel pumps owing to increasing diesel prices and vulnerable state of electricity in India. Because of the increased affordability of solar pumps after subsidies, the popularity of solar pumps has increased in Rajasthan, which has resulted in an increased rate of adoption. Considering the role of solar pumps in current scenario and that of future, this study was conducted to analyse the economic feasibility of a 5 HP solar water pumps. The findings of the study revealed that the 5 HP solar water pump was economically feasible based on NPV, PBP and B:C ratio.

Key words : Solar water pump, payback period, net present worth and benefit-cost ratio

Introduction

The power sector is regarded as a core industry because it accelerates development in several sectors of the Indian economy, including agriculture, manufacturing, railways, and commercial enterprises. Hence, it is a critical pioneer for the nation's economic welfare, and has traditionally shown growth prospects in tandem with the overall growth of the economy, as evidenced by the strong correlation between the growth rate of GDP/GVA and the growth rate of the economy's power generation capacity (Kalamkar *et al.*, 2019).

India is the world's third largest electricity consumer and third largest renewable energy producer, with 40 per cent of energy capacity installed in 2022 (160 GW of 400 GW) coming from renewable sources.

As of April 2022, India's installed renewable energy capacity stood at 158.12 GW, accounting for 39.43 per cent of total installed power capacity. Solar energy is expected to supply 55.34 GW, with hydropower (46.72 GW), wind power (40.53 GW), biomass (10.68 GW), and small hydropower (4.85 GW). In addition, the volume of renewable energy was 8.2 GW in the first eight months of fiscal year 2022, compared to 3.4 GW in the first eight months of fiscal year 2021. (Indian Brand Equity Report, 2022).

According to Indian States Estimated Solar Energy Potential, Rajasthan state is the most advanced state in terms of solar energy potential with solar energy of 142.31 GW. The next two states are Maharashtra (64.32 GW) and Madhya Pradesh (61.66 GW). The total installed capacity of renewable power in Rajasthan (22398.05 MW)

stands at first rank, followed by Gujarat (19436.86 MW) and Tamil Nadu (17920.35 MW) respectively.

In case of solar power, Rajasthan has first rank with 17055.70 MW installed capacity, followed by Gujarat with 9254.57 MW capacity and Karnataka with 8241.41 MW installed capacity.

Solar water pumps have come out as a dependable and cost-effective technology to increase energy access for sustainable agriculture. They have advanced to be a better substitute to electric and diesel pumps owing to increasing diesel prices and vulnerable state of electricity in India. The advantages of SWPs are internationally recognized and their economic viability and feasibility have made them a topmost choice on the large ranches of the Western US, Mexico, Australia and Canada (Zhou and Abdullah, 2017).

Recognising the advantages of solar water pumps over other common irrigation systems in India, the Central government has placed a strong emphasis on solar water pumps by introducing schemes through the Ministry of New and Renewable Energy. The Jawaharlal Nehru National Solar Mission (JNNSM) established a solar energy target of 100 GW by 2022, with a total of 10 lakh solar pumps installed. However, in 2019, the Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM) scheme with three key components was launched. i) the installation of 10,000 MW of solar power capacity on barren land with capacities ranging from 1 MW to 2 MW; ii) the installation of 1.75 million stand-alone off-grid solar water pumps; and iii) the solarization of 1 million existing grid-connected irrigation pumps (Beaton *et al.*, 2019).

Materials and Methods

The research is based on primary data which were collected for rabi season of 2022-23 by personal interview method. From the study area, primary data was gathered from *beneficiary and non-beneficiary farmers, respectively. The pertinent information about installed solar water pumps were collected from individual farmer. To examine the economic feasibility of solar water pumps, the following evaluation techniques were employed.

Payback Period : This method is simple, old and famous technique for capital investment appraisal. It is calculated by the formula given below :

$$PBP = \frac{1}{R}$$

Where,

PBP = payback period (years)

I = initial investment on SWP (?)

R = Uniform annual cash inflow (?)

Benefit-Cost ratio (BCR) : It is also known as cost-benefit ratio or profitability index. It shows the association between present value of cash inflows and present value of cash outflows. In fact, it provides the return or benefits per unit of cost or investment during complete life period.

$$BCR = \frac{[Bt / (1 + r)^t]}{[Ct / (1 + r)^t]}$$

Where,

Bt = cash inflows in the year t,

Ct = cash outflows in year t

t = time period

r = discount rate

The benefit -cost ratio shows the return per rupee of investment. If the ratio is greater than 1, the approach is acceptable.

(C) Net Present Value (NPV)

The net present value of an investment can be defined as the sum of the present values of all the cash inflows minus the sum of present values of cash outflows related to the solar water pump. Discounting can be used to calculate the present value of future returns.

$$NPV = [(Bt - Ct) / (1 + r)^t]$$

A high NPV indicates the most efficient and economic investment on solar water pump.

Results and Discussion

Pay Back Period : The cost of installing solar water pump of 5 HP was ₹ 99,467. It was estimated that investment made for a 5 HP solar water pump, it would take 2.72 years for a farmer to get back the initial investment.

Table-1 : Estimation of Net Present Value (NPV) for 5 HP Solar Pump.

Year	Cash outflow (₹)	Discount factor @0.075	PW of cash outflow @0.075	Cash inflow (₹)	PW of cash inflow @ 0.075	NPW
0	99467.00	1.00	99467.00	0.00	0.00	-99467.00
1	14422.71	0.930	13413.12	50964.81	47397.27	33984.15
2	14422.71	0.869	12533.33	50964.81	44288.41	31755.08
3	14422.71	0.806	11624.70	50964.81	41077.63	29452.93
4	14422.71	0.751	10831.45	50964.81	38274.57	27443.12
5	14422.71	0.699	10081.47	50964.81	35624.40	25542.93
6	14422.71	0.649	9360.33	50964.81	33076.16	23715.83
7	14422.71	0.606	8740.16	50964.81	30884.67	22144.51
8	14422.71	0.561	8091.14	50964.81	28591.25	20500.11
9	14422.71	0.523	7543.07	50964.81	26654.59	19111.52
10	14422.71	0.485	6995.01	50964.81	24717.93	17722.92
11	14422.71	0.452	6519.06	50964.81	23036.09	16517.03
12	14422.71	0.420	6057.53	50964.81	21405.22	15347.69
13	14422.71	0.390	5624.85	50964.81	19876.27	14251.42
14	14422.71	0.363	5235.44	50964.81	18500.22	13264.78
15	14422.71	0.338	4874.87	50964.81	17226.10	12351.23
16	14422.71	0.314	4528.73	50964.81	16002.95	11474.22
17	14422.71	0.293	4225.85	50964.81	14932.68	10706.83
18	14422.71	0.272	3922.97	50964.81	13862.42	9939.45
19	14422.71	0.253	3648.94	50964.81	12894.09	9245.15
20	14422.71	0.235	3389.33	50964.81	11976.73	8587.40
Total	3,87,921.20		2,46,708.35	10,19,296.20	5,20,299.65	2,73,591.30

Table-2 : Estimation of Benefit cost ratio (B:C Ratio) for 5 HP Solar Pump.

Year	Cash outflow (₹)	Discount factor @ 0.075	PW of cash outflow @ 0.075	Cash inflow (₹)	PW of cash inflow @ 0.075
0	99467.00	1.00	99467.00	0.00	0.00
1	14422.71	0.930	13413.12	50964.81	47397.27
2	14422.71	0.869	12533.33	50964.81	44288.41
3	14422.71	0.806	11624.70	50964.81	41077.63
4	14422.71	0.751	10831.45	50964.81	38274.57
5	14422.71	0.699	10081.47	50964.81	35624.40
6	14422.71	0.649	9360.33	50964.81	33076.16
7	14422.71	0.606	8740.16	50964.81	30884.67
8	14422.71	0.561	8091.14	50964.81	28591.25
9	14422.71	0.523	7543.07	50964.81	26654.59
10	14422.71	0.485	6995.01	50964.81	24717.93
11	14422.71	0.452	6519.06	50964.81	23036.09
12	14422.71	0.420	6057.53	50964.81	21405.22
13	14422.71	0.390	5624.85	50964.81	19876.27
14	14422.71	0.363	5235.44	50964.81	18500.22
15	14422.71	0.338	4874.87	50964.81	17226.10
16	14422.71	0.314	4528.73	50964.81	16002.95
17	14422.71	0.293	4225.85	50964.81	14932.68
18	14422.71	0.272	3922.97	50964.81	13862.42
19	14422.71	0.253	3648.94	50964.81	12894.09
20	14422.71	0.235	3389.33	50964.81	11976.73
Total	3,87,921.20		2,46,708.35	10,19,296.20	5,20,299.65
	B:C Ratio				$\frac{520299.65}{246708.35}$ 2.10

Net Present Worth of Solar Water Pump : Net present worth of 5 HP solar water pump is presented in Table-1. The total cost of 5 HP solar water pump was found to be ₹ 2,48,668. Out of the total cost, Government provided subsidy of ₹ 1,49,201. Hence, the net cost of 5 HP solar water pump for a farmer was ₹ 99,467. The economic benefit for installation of solar water pump was diesel saving and environmental benefits. Total profit was estimated to be ₹ 50964.81. The 20-year expected life of the 5 HP SWP resulted in a net present worth of ₹ 2,73,591.30 at 7.5 per cent discount rate.

Benefit-Cost Ratio of Solar Water Pump : Benefit cost ratio of a 5 HP solar pump is shown in Table-2. The total cost of 5 HP solar water pump was ₹ 2,48,668. Out of total cost, Government provided subsidy of ₹ 1,49,201. The contribution of a farmer in total cost of a 5 HP solar pump was ₹ 99,467. Total cost of profit was found to be ₹ 50,964.81. Present worth of cash inflow and present worth of cash outflow were ₹ 5,20,299.65 and ₹ 2,46,708.35,

respectively. Benefit cost ratio was estimated to be 2.10. Since B-C ratio was greater than one so the investment on solar water pump was considered to be economically feasible.

Conclusions

Findings of the study suggested that the installation of a 5 HP solar water pump was economically feasible in the long run. From the result of estimation of net present worth of solar water pump, it was found out that the net present value of 5 HP solar water pump was ₹ 2,73,591.30 when estimated at 7.5 per cent discount rate. Also, the B:C ratio of 5 HP SWP was more than unity which indicated that the 5 HP solar water pump was economically feasible.

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Population Dynamics of Aphid, *Aphis craccivora* (Koch) on Greengram and its Correlation with Abiotic Factors

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Abstract

The investigation on Population dynamics of aphid, *Aphis craccivora* (Koch) on greengram and its correlation with abiotic factors under sub-humid condition was laid out in randomized block design at instructional agronomy farm, Rajasthan College of Agriculture, MPUAT, Udaipur during *kharif* 2022. The infestation of aphid population initiated in the 2nd week of August (32th SMW) with mean population of 5 aphid per five plants and attained its peak with a mean of 35.85 aphid per five plants during last week of August (35th SMW) when the mean atmospheric temperature, relative humidity and rainfall were recorded 26.25°C, 71.80 per cent and 27 mm, respectively. All abiotic factors showed non-significant correlation with aphid population.

Key words : Aphid, population dynamics, correlation, weather parameter

Introduction

Pulses are highly rich in nutrition and have a unique position in sustainable crop production, keeping the soil alive as well as productive and have a major role in the agricultural economy of India. It is the major source of protein in Indian dietary (Sujatha and Bharpoda 2017). Mungbean [*Vigna radiata* (L.) Wilczek] member of family Leguminosae is one of the principal pulse crops of tropics. It is a popular crop because of its excellent nutritional quality, including its high protein content (around 24%) and simple digestibility. It contains 24 per cent protein, 0.326 per cent phosphorus, 0.0073 per cent iron, 0.00039 per cent carotene, 0.0021 per cent of niacin and 334 cal energy /100g of green gram (Swaminathan *et al.*, 2012). It also aids in soil erosion prevention and cultivated in all seasons (Panigrahi *et al.*, 2021). The total world area under pulses is about 93.18 million ha with production of 89.82 million tonnes at 964 kg/ha yields level. India ranks first in area with more than 28 million ha (31%) and production with 25.46 million tonnes (28%) of pulses in world (Anonymous, 2022). Rajasthan is one of the major greengram growing state of India with 21.40 lakh ha area (46 %) and 10.97 lakh tonnes production (45 %) in the total mungbean contribution in the country (Anonymous, 2022). The insect pests reported on green gram comprises whitefly, *Bemisia tabaci* (Genn.); thrips, *Caliothrips indicus* Bagnall; jassid, *Empoasca motti* Pruthi; cutworm, *Agrotis ipsilon* (Hufn.); semilooper, *Plusia orichalcea* (Fab.); tortricid moth, *Cydia ptychota* (Meyr); galerucid beetle, *Madurasia obscurella* Jacoby; pod borer, *Helicoverpa armigera* (Hubner); spotted pod borer, *Maruca testulalis* (Geyer); green bug, *Nezara viridula*, (Linn.); stem fly,

Ophiomyia phaseoli (Tryon.); (Kumar *et al.*, 2004; Nitharwal and Kumawat 2013). The aphid, *A. craccivora* belongs to the family Aphididae of order Hemiptera, suborder Homoptera cause damage by sucking cell sap from leaves, petioles, tender stems, inflorescence and pods. Keeping this in view, the present investigation was undertaken to know the population dynamics of aphid on greengram and effects of abiotic factors on aphid.

Materials and Methods

The field experiment was conducted in randomized block design (RBD) with uniformly sized plots measuring 3 m x 3 m (9 sq. m.) with three replications at the Instructional farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. Greengram variety "virat" (IPM 205- 07) was sown during *kharif*, 2022 with the seed rate of 15 kg/ha; maintaining a row to row and plant to plant spacing of 30 cm x 10 cm, respectively. Weekly meteorological data on atmospheric temperature, relative humidity, sunshine hours and total rainfall were obtained from the Meteorology Unit of Rajasthan College of Agriculture, Udaipur. The visual counting method was used to record the aphid population from the three leaves of upper, middle and lower portion from five randomly selected and tagged plants in each replication. The aphid population was counted from 5cm floral twigs during early hours of the day (6:30-8:00 a.m.) and data were expressed as numbers per three leaves. The population data was statistically analysed with abiotic parameters (Fowler *et al.*, 1998).

Results and Discussion

The infestation of aphid population initiated in the 2nd week

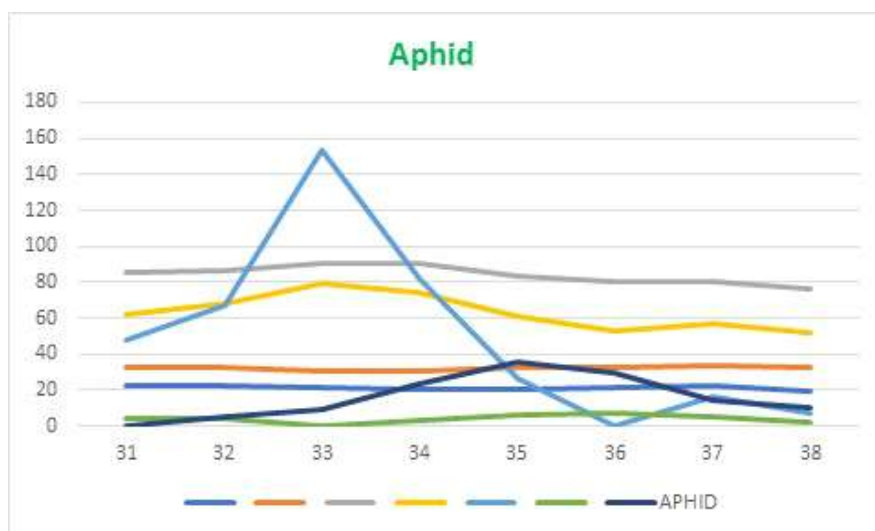


Fig-1 : Effect of abiotic factors on the population dynamics of aphid on greengram during kharif, 2022.

Table-1 : Effect of abiotic factors on the population dynamics of aphid on greengram during kharif, 2022.

S.M.W.	Abiotic factors								Mean population per five plants Aphid
	Min. temp. (°C)	Temp. Max. temp. (°C)	Mean temp. (°C)	Morning RH (%)	R.H. Evening RH (%)	Avg. RH (%)	Rainfall (In mm)	Sunshine (Hrs.)	
31	22.2	32.3	27.25	85	62	73.5	47.4	4.4	0
32	22.3	32.5	27.40	86.3	68.4	77.35	66.80	4.00	5
33	21	30.5	25.75	90.3	79.1	84.70	154.0	0.50	9.62
34	20.5	30.1	25.30	90.4	74.2	82.30	82.00	3.30	23.52
35	20	32.5	26.25	82.9	60.7	71.80	27.00	6.60	35.85
36	21	33.8	26.90	80.3	52.5	66.40	0.00	6.70	29.57
37	22.2	32.2	27.70	80.1	57.1	68.60	16.60	5.60	14.6
38	19.5	32.4	25.95	76.1	51.6	63.85	6.90	1.60	10.24
Coefficient of correlation (r_1) for population and Min. temp.									-0.54
Coefficient of correlation (r_2) for population and Max. temp.									0.02
Coefficient of correlation (r_4) for population and Morning R.H.									-0.12
Coefficient of correlation (r_5) for population and Evening R.H.									-0.20
Coefficient of correlation (r_7) for population and Total rainfall									-0.32
Coefficient of correlation (r_8) for population and Sunshine hours									0.56

of August (32th SMW) with population of 5 aphid per five plants. The population increased gradually and attained its peak with a mean of 35.85 aphid per five plants during last week of August (35th SMW). Thereafter, pest population declined gradually and reached to a level of 10.24 aphid per five plants in the 3rd week of September (38th SMW). The mean atmospheric temperature, relative humidity and rainfall during the peak population were 26.25°C, 71.80 per cent and 27 mm, respectively. The minimum atmospheric temperature, relative humidity (morning and evening) and rainfall showed a non-significant negative correlation whereas maximum temperature and sunshine hours showed a non-significant

positive correlation with aphid population. Present findings are in line with the findings of Gehlot and Prajapat (2021) recorded the peak mean population of aphid during 36th standard week. Borad *et al.*, (2020) recorded the aphid firstly appeared during 4th week of August and showed no significant impact of studied abiotic factors was observed on aphid population. Priyanka *et al.*, (2022) recorded the aphid population on groundnut started in the first week of August and reached its peak in last week of August.

Conclusion

The study on population dynamics of aphid and its correlation with abiotic factors revealed that aphid found to

be the major sucking insect pests of greengram and results showed that the infestation of aphid population initiated in the 2nd week of August (32th SMW) with population of 5 aphid per five plants. The population increased gradually and attained its peak with a mean of 35.85 aphid per five plants during last week of August (35th SMW). Thereafter, pest population declined gradually and reached to a level of 10.24 aphid per five plants in the 3rd week of September (38th SMW). All abiotic factors showed non-significant correlation with aphid population.

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Population dynamics of aphid, *Aphis gossypii* (Glover) on tomato and its correlation with abiotic factors

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Abstract

The investigation on "Population dynamics of brinjal aphid *Aphis gossypii* (Glover) and its correlation with weather parameters" was conducted in RBD at Rajasthan College of Agriculture, MPUAT, Udaipur during *Rabi*, 2022. The incidence of pest started from first week of December (49th SMW) and remain continues up to throughout the growth period. The pest population reached its peak level during second week of January (2th SMW) with mean population of 14.10 aphids per five plants, thereafter population decreased up to 11th SMW. The correlation study between weather parameters and aphid population shows that minimum temperature and evening relative humidity had negative significant correlation with aphid population, Whereas, total rainfall shows positive significant correlation.

Key words : aphid, population dynamics, correlation, weather parameter.

Introduction

India is the land of diverse agro-climatic conditions, which encourages and favours a myriad range of vegetable production. Brinjal (*Solanum melongena* Linnaeus), referred as the "King of vegetables", also known as eggplant, aubergine, map apple, or Guinea squash, is member of family Solanaceae (Nightshade) and native to Indian Subcontinent (Doijode, 2001; Tsao and Lo, 2006). It ranks among the three most important vegetable species cultivated in South Asian region (Bangladesh, India, Nepal, and Sri Lanka) accounting for almost 50% of world's vegetable growing area under its cultivation (Alam *et al.*, 2003). The crop is a frost tender herbaceous perennial, named as "poor man's vegetable" because of its low cost of production, ease of culture and availability throughout the year in almost all parts of India, except in higher altitudes (Som and Maity, 1986). The area under brinjal cultivation in India is about 741.0 m ha with production of 13000.0 m tonnes and productivity 17.5 m tonnes per ha. The major brinjal growing states in India are Andhra Pradesh, Karnataka, West Bengal, Maharashtra, Orissa, Madhya Pradesh, Bihar, Gujarat and Chhattisgarh (Anonymous, 2021). Brinjal crop is susceptible to a large magnitude of arthropod pest. The major and most destructive pests of eggplant in Asia are cotton leaf hopper (*Amrasca biguttula biguttula*) Ishida. The white fly (*Bemesia tabaci*) and epilachna beetle, *Henosepilachna* (*Epilachna*) *vigintioctopunctata* Fabricius. Rarely, brinjal crop is infested by red spider mite (*Tetranychus macfurlanei*) and aphids (*Aphis gossypii*) Glover, is one of the most important noninsect pest of brinjal (Ali *et al.*, 2017). The yield misfortune because of

these insects is to the degree of 2 70-92 percent. In many cases, there is 100 per cent yield loss due to viral diseases vectored by insects (Shivalingswami *et al.*, 2002). BSFB is the most serious pest in major brinjal cultivating regions due to concealed mode of life (Sardana *et al.*, 2004). As its larvae inhabits inside the plant shoots or fruits by forming tunnels, it not only affects the marketability of its fruit yield but also attribute to the obstacles in the management as the pesticide do not reach the pest directly (Alam *et al.*, 2003). Monoculture, off season cultivation, summer hybrids and other newly introduced varieties are the major factors leading to serious proportions of BSFB infestation on brinjal crops (Dhandapani *et al.*, 2003; Chakraborti and Sarkar, 2011). Further, reported fruit losses vary from 20.70 to 88.89 per cent and the maximum shoots infestation ranges from 73.33- 86.66 per cent (Raju *et al.*, 2007).

Materials and Methods

The field experiment was conducted in randomized block design (RBD) with uniformly sized plots measuring 3 m x 2.7 m (8.1 sq. m.) with three replications at the Instructional farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. The seedlings of brinjal variety "KAVACH" were transplanted in the first week of December, 2022; maintaining a row to row and plant to plant spacing of 60 cm x 45 cm, respectively. Weekly meteorological data on atmospheric temperature, relative humidity, and total rainfall were obtained from the Meteorology Unit of Rajasthan College of Agriculture, Udaipur. The visual counting method was used to record

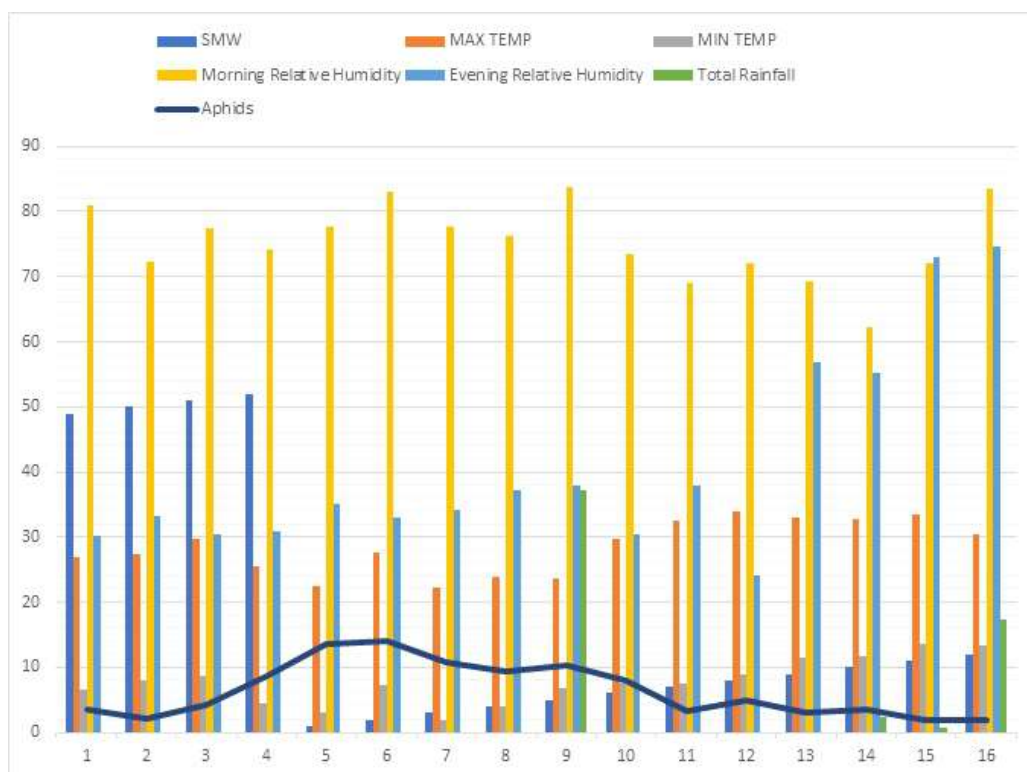


Fig-1: Influence of abiotic factors on the incidence of aphid in Brinjal during Rabi 2022.

Table-1 : Population dynamics of aphid in brinjal and its relation with abiotic factors during Rabi, 2022-2023.

Week after transplanting (WAT)	SMW	Abiotic factors					Aphids
		Max. Temp. (°C)	Min. Temp. (°C)	Morning Relative Humidity (%)	Evening Relative Humidity (%)	Total Rainfall (mm)	
1	49	27.0	6.5	80.9	30.1	0.0	3.50
2	50	27.4	7.9	72.3	33.3	0.0	2.03
3	51	29.7	8.6	77.4	30.3	0.0	4.12
4	52	25.4	4.5	74.1	30.8	0.0	8.70
5	1	22.5	3.1	77.6	35.2	0.0	13.50
6	2	27.5	7.2	83.1	32.9	0.0	14.10
7	3	22.3	1.9	77.7	34.1	0.0	10.80
8	4	23.9	3.9	76.3	37.3	0.0	9.43
9	5	23.7	6.8	83.7	37.9	37.2	10.20
10	6	29.8	7.5	73.4	30.3	0.0	7.90
11	7	32.5	7.5	68.9	38.0	0.0	3.20
12	8	33.9	9.0	72.1	24.1	0.0	4.84
13	9	33.1	11.5	69.3	56.9	0.0	2.95
14	10	32.7	11.7	62.1	55.3	2.4	3.63
15	11	33.4	13.5	72.1	72.9	0.8	1.96
16	12	30.5	13.3	83.4	74.7	17.4	1.80
Coefficient of correlation for population and max temperature							-0.733*
Coefficient of correlation for population and min temperature							-0.737*
Coefficient of correlation for population and morning relative humidity							0.447
Coefficient of correlation for population and evening relative humidity							-0.473
Coefficient of correlation for population and total rainfall							0.080

SMW-Standard meteorological weeks, *Significant at 5 per cent level

the aphid population from the three leaves of upper, middle and lower portion from five randomly selected and tagged plants in each replication. The aphid population was counted from 5cm floral twigs during early hours of the day (7:30-9:30 a.m.) and data were expressed as numbers per three leaves. The population data was statistically analysed with abiotic parameters (Pearson, 1895).

Results and Discussion

The observations recorded and presented on the incidence of aphid reveal that the appearance started from third week after the transplanting and were observed to persist till the harvesting of brinjal. The peak population of aphid (14.10/5 plant) was recorded in the second week of January (2nd SMW). Thereafter, the population of aphid was at a decreasing trend. The meteorological parameters during the peak population of the aphid exhibited 27.50C maximum temperature, 7.20C minimum temperature, 83.01 and 32.9 per cent morning and evening relative humidity. The aphid population with the maximum and minimum temperature had highly negative significant correlation ($r=-0.733$ and 0.737 , respectively). Whereas, morning relative humidity and total rainfall had non-significant positive correlation ($r=0.447$ and 0.080 , respectively) while, evening relative humidity had non-significant negative correlation ($r=-0.473$) with the population of aphid on brinjal crop. In present investigation the infestation of aphids (3.50/5plants), commenced in the first week of December (49th SMW) and persisted up to the last week of March, (12th SMW). The present results are in conformity with the earlier researchers, Chandrakumar *et al.* (2008), Borkakati *et al.* (2019) and Kumar *et al.* (2022) according to the aphid was observed throughout the year on brinjal crop. Incidence of the aphid on brinjal crop was first noticed on December, (0.4 aphids/5 leaves), (Rasid *et al.*, 2013), support the present findings. Further Shrivastava, (2016) reported that *A. gossypii* was first recorded in the second and third week of December. Shrivastava (2016) reported that *A. gossypii* was first recorded in the second and third week of December, fully support the present findings. Tupe *et al.* (2022) who reported that incidence of aphid on brinjal during 46th to 5th SMW.

Conclusions

The study on population dynamics of aphid and its correlation with abiotic factors revealed that aphid found to be the major sucking insect pests of brinjal and results showed that the infestation of aphid population initiated in the 1st week of December (49th SMW) with population of 5 aphid per five plants. The population increased gradually and attained its peak with a mean of 14.10 aphid per five

plants during 2nd week of January (2th SMW). Thereafter, pest population declined gradually and reached its minimum level in month of March. The abiotic factors showed a negative significant correlation with mean temperature and morning relative humidity and a positive non-significant correlation with total rainfall.

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Comprehensive Study of Naphthalene Acetic Acid and Gibberellic Acid on Growth and Yield of Onion (*Allium cepa* L.)

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Abstract

The present study was conducted to assess the morphological response and yield attributes of onion plants to different GA₃ and NAA levels (GA₃ @ 20, 80 and 130 ppm and NAA 40, 100 and 160 ppm and their combination). The foliar application of GA₃ and NAA at 30 and 60 days after transplanting. The result indicated when foliar application of NAA @ 100 ppm + GA₃ @ 80 ppm at 30 and 60 DAT had a significant impact on plant height (46.10 cm and (59.33 cm) at 60 and 90 DAT as well as neck thickness (15.65 mm), bulb diameter (7.73 cm) and fresh bulb weight (86.43g).

Key words : NAA, GA₃, Onion, growth, yield

Introduction

In worldwide, climate change had added great challenge in agriculture. Recent studies have shown that sudden rise in temperature, erratic rainfall, had significantly affect the yield loss. The combined effect of abiotic stresses effects biological and economical yield. PGRs play important role during stress conditions such as improving photosynthesis, accumulation of protein, reactive oxygen scavengers and may other metabolism related functions (Datta *et al*, 2020). The appropriate dosage of PGRs increases productivity over indigenous technologies. Small amount of PGRs is capable of modifying the physiological and biochemical mechanisms. Auxin (NAA) is involved in booting the development of lateral roots and changes in architecture of roots, which allow absorption of NO₃⁻ from soil and promoting the growth of organ. GA₃ play key roles in cell division, seed dormancy and germination. Studies suggested that the effect of gibberellic acid on onion increases the number of marketable bulbs in the total yield. (Asgharzadeh, 2014; Shaikh *et al.*, 2002). Additionally, its spray encourages shoot growth by quickening cell division and elongation in the sub apical meristem region. Gibberellin controls the sub apical meristem's mitotic activity. It makes leaves bigger, breaking dormancy and delays senescence.

The option of more expansion of the area under onion cultivation seems unlikely because of climate change. Improving the production of onion using modern agricultural practices need to be considered. Regarding this, the yield under abiotic stress can be maintained or

increased by using PGRS. Therefore, keeping in view this research was conducted to evaluate the effect of different concentration of Naphthalene Acetic Acid and Gibberellic Acid on Growth, Yield and Quality of Onion (*Allium cepa* L.)”

Materials and Methods

Materials and Site Description : The variety “Bhima Red Onion” was purchased from DOGR (ICAR-Directorate of Onion and Garlic Research Rajgurunagar, Maharashtra) and was tested at Horticulture Farm of Rajasthan College of Agriculture, MPUAT Udaipur in 24°25' N attitude, 73°44' E longitude and altitude 582.17 m above mean sea level during 2022-23. The experimental field is in Sub-humid climate characterized by scanty rain from November to March. Seedling were prepared during November 2022 and transplanted during December 2022. Plant Growth Regulator NAA and GA₃ and reagents for quality analysis were procured from Sigma-Aldrich, St Louis Mo, USA, SRL Mumbai and HiMedia, India.

Nursery raising and transplanting : Seed of Bhima Red variety onion were sown in raised bed and ready for transplanting till 15th December 2022. The planting distance for transplanting was 15 cm x 10 cm. Irrigation, weeding was done as per schedule.

Preparation of Treatments : Plant growth regulator GA₃ (20 ppm, 80 ppm and 130 ppm) and NAA (40, 100 and 160 ppm) were applied alone and in combination at 30 and 60 DAT. For preparation of GA₃ and NAA solution first dissolve each PGR in ethanol than after dissolve in water.

To prepare GA₃ 20 ppm (20 mg in 1000 ml of water), GA₃ 80 ppm (80 mg in 1000 ml water), GA₃ 130 ppm (130 mg in 1000 ml water), NAA 40 ppm (40 mg in 1000 ml water), NAA 100 ppm (100 mg in 1000 ml water) and NAA 160 ppm (160 mg in 1000 ml water) respectively.

Layout Details : The experiment field was cultivated by tractor drawn cultivator. Then field was operated with offset harrow on order to achieve proper tilth. It was followed by cross planking for surface smoothening, weeds and crops residues were removed manually from the field. There were thirty plots prepared (2m x 1.6 m) having 136 m² gross area. The plots are banded manually. Then two foliar applications of GA₃ and NAA and their combinations done at 30 and 60 days after transplanting.

Harvesting Details : Onion bulbs was harvested in first week of May 2023 manually with the help of labour.

Growth and yield parameters : Plant heights (cm) was

measured with measuring scale at 60 and 90 days after transplanting. Moreover, to measure Neck thickness (mm), bulb diameter (cm) was measured with the help of Vernier callipers centimetres. However, yield parameters fresh bulb weight (gm) were recorded with weighting balance.

Experiment design : Statistical analysis was performed in triplicates. Results of analysis were expressed as $\pm$ mean deviation. ANOVA was performed in JMP software version 12 (SAS, 2010) to access the significance effect of different level GA₃ and NAA alone and in combination at 30 and 60 DAT.

Results and Discussion

Effect of naphthalene acetic acid and gibberellic acid on Plant growth characters : The plant height at 60 and 90 days were increased significantly with spray of PGRs (NAA, GA₃) as single or in combination. The highest increase was found in plant height (fig.-1), neck thickness

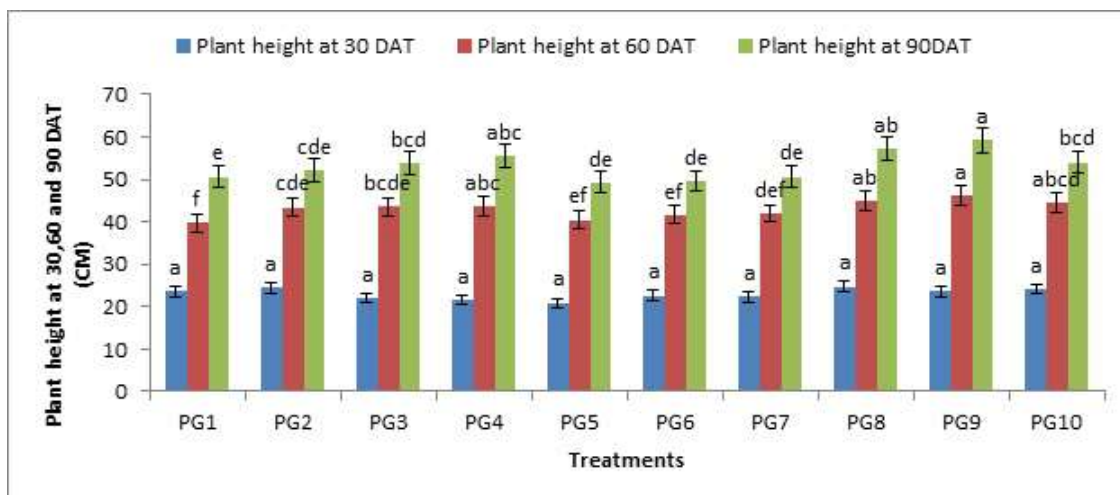


Fig.-1 : Effect of foliar application of naphthalene acetic acid and gibberellic acid at 30 and 60 DAT on plant height of onion at 30, 60 and 90 DAT.

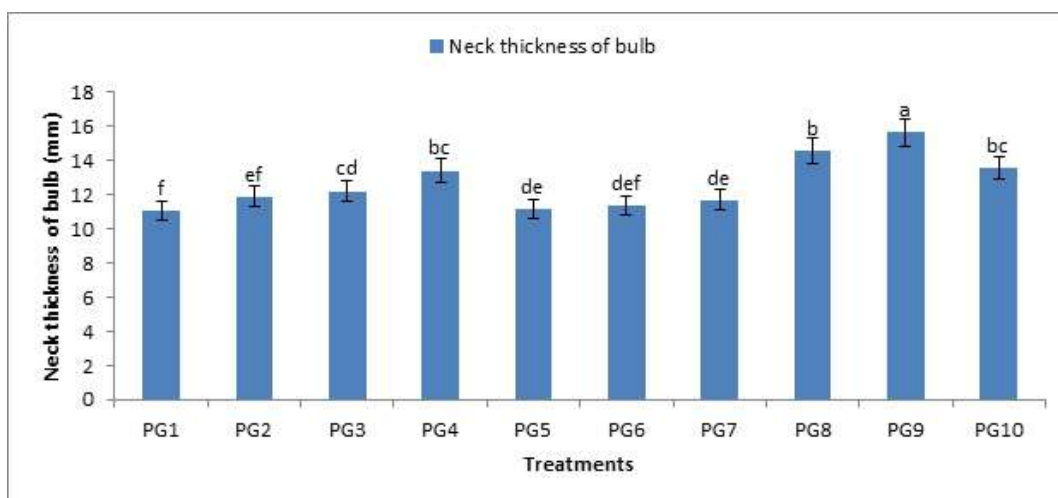


Fig.-2 : Effect of foliar application of naphthalene acetic acid and gibberellic acid at 30 and 60 DAT on neck thickness of onion bulb.

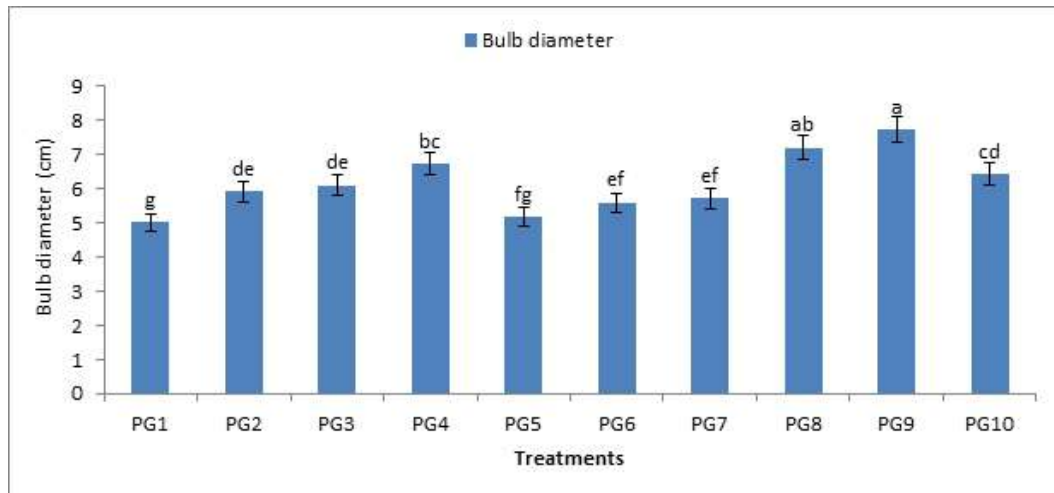


Fig.-3 : Effect of foliar application of naphthalene acetic acid and gibberellic acid at 30 and 60 DAT on onion Bulb diameter.

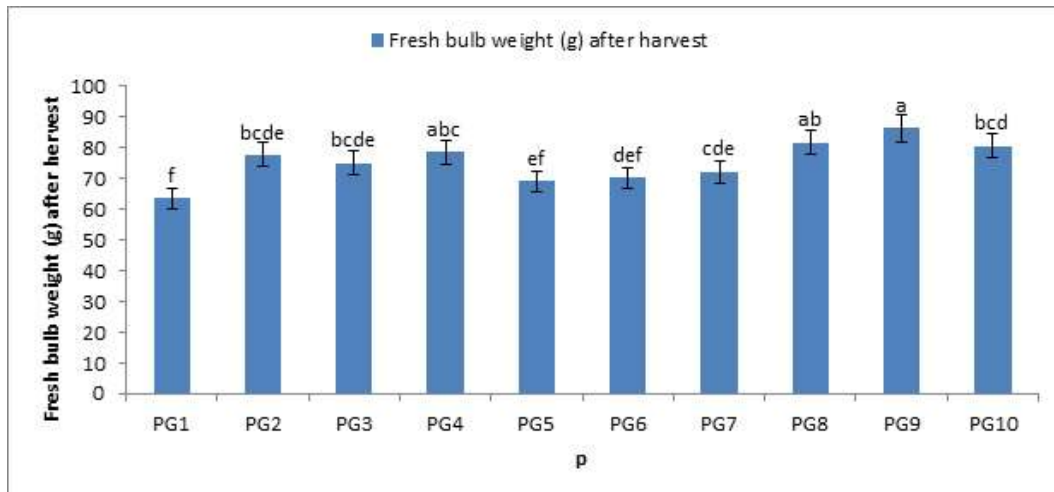


Fig.-4 : Effect of foliar application of naphthalene acetic acid and gibberellic acid at 30 and 60 DAT on Fresh bulb weight of onion.

(Fig.-2). The maximum plant height (46.1cm at 60 DAT and 59.33 cm at 90 DAT) and neck thickness (15.65 cm) was recorded under the effect of NAA at 100 ppm + GA₃ at 80 ppm (PG9). The lowest plant height (35.77cm at 60 DAT and 49.28 CM at 90 DAT) and neck thickness (11.02mm) in control. According to Fig.-1 and 2 PGR (NAA and GA₃) alone and combination. The increase in plant height and neck thickness can be attributed the effect of gibberellic acid and Naphthalic acetic acid enhance source sink interaction. During active vegetative growth and development, plant rely on energy gained from CO₂ fixation into carbohydrates via photosynthesis in source organ and the translocation of photo assimilates, mainly sucrose from the site of synthesis through the phloem to sink organs for their utilization. Bista *et al.* (2022) reported the use of plant growth regulators were significantly increased the plant height of onion both at 60 and 90 DAT due to NAA and GA₃ are found to enhance the vegetative growth of plants through cell division, cell elongation and vascular tissue differentiation. Kanwar and

Khandelwal (2013) reported the increase in plant height with the application of gibberellic acid by increasing the length of internodes of marigold. Dwivedi *et al.* (2019) revealed that increase in plant height by foliar spray of GA₃@100ppm and NAA @ 100 ppm might be due to rapid increase in cell division and cell elongation in the meristemic region. Physiological effect of auxins on growth of a plant is the elongation of cells so plant height and length of leaves can be increased by the foliar spray of NAA at different stages of growth. The favorable influence of growth regulators on increasing the plant height have been reported by Patel *et al.* (2010). The results are in conformity with findings of Patel *et al.* (2010). Chattopadhyay *et al.* (2015).

Effect of naphthalene acetic acid and gibberellic acid on yield parameters of onion : Data presented in Fig-3 and 4) Foliar spray of NAA @ 100 ppm + GA₃ @ 80 ppm (PG9) significantly increases the bulb diameter (7.73 cm), bulb weight (86.43g) followed by PG 8 (NAA @ 40 ppm +

GA₃ @ 20 ppm) and PG1 (control) had the smallest bulb diameter (5.03 cm), bulb weight (63g). Sharma, *et al.* (2013) supports the idea of increase in diameter of onion bulb and vegetative performance of onion plants by application of GA₃ and NAA or combination. The improved vegetative traits of onion improved the photosynthesis in plants leading to accumulation of more photosynthates which in turn increased the number of bulb scales, and ultimately accelerate weight of onions (Jyoti, 2017). These findings were also supported by findings of Chattopadhyay, *et al.* (2015) and Kumar and Shashidhar (2016) that showed improved performance of onion when treated with GA₃ and NAA plant growth regulators. They also reported increased total yield, bulb fresh weight and diameter which may be due to cell division and rapid cell elongation induced by GA₃ and NAA in the growing portion that helped increase the bulb size. GA₃ and NAA when applied together was found to stimulate the plant growth with significant effect on plant height which was reported in Ud-deen (2009). Sharma *et al.* (2013) supports the idea of increase in diameter and fresh weight of onion bulb and vegetative performance of onion plants by application of plant growth regulators.

Conclusions

On the basis of the results, it could be concluded that, the foliar application of PG9(NAA @ 100 ppm + GA₃ @ 80 ppm) at 30 and 60 DAT stage on the onion crop found to be superior treatment, where it recorded significantly maximum plant height, maximum neck thickness, highest bulb diameter, fresh weight of bulb.

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Studies on Genetic Variability using Metroglyph Analysis among Rice Genotypes

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Abstract

A study was carried out executed at the research farm of Agricultural Research Station, Ummmedganj, Kota, Rajasthan during the *Kharif* season of 2019. Ten parameters viz., days to 50 per cent flowering, days to maturity, number of productive tillers per plant, panicle per plant, plant height, panicle length, number of grains per panicle, 1000-grains weight, amylose content and protein content. 25 genotypes were subjected to metroglyph analysis. Among all the studied cultivars, significant genetic variability was recorded for different agro-morphological characters. Metroglyph framed total nine groups: largest with five and one were oligo-genotypic.

Introduction

Rice (*Oryza sativa* L.) is an annual monocotyledonous cereal grass encompassed within the genus *Oryza* and the family *Gramineae*. The genus *Oryza* comprises of the twenty wild species and 2 cultivated species i.e., *oryza sativa* (cultivated around the world) and *Oryza glaberrima* (mainly cultivated in Africa). Around the world, rice fill in as the staple nourishment for more than 2.5 billion individuals and it likewise fills in as day to day calorie intake upto 50 to 80%. Rice with a productivity of 2713 kg/ha, India ranks first in area (45.06 million hectares) and second in production output (122.27 million tonnes) (Anonymous, 2021-22). The success of any crop improvement programme is highly dependent on the efficient manipulation of the genetic variability present in the germplasm and the selection of genotypes with all possible desirable yield and quality contributing traits. Genotypic and different components of variance, heritability and genetic advance are always considered as a parameter for identification of genotypes having broad genetic variability and characters with high heritability to execute effective selection. The productivity of rice is quite low in our country as compare to top rice producing countries of the world which is probably due to narrow genetic base of the released varieties is the major reasons for low genetic yielding potential. Development of stable genotypes with enhanced seed yield is the most important goal of many rice breeding programmes. The information on genetic diversity helps in selecting parents for development of new varieties, continuous evaluation of germplasm for important traits, which in earlier days was exclusively based on the available morphological data. So to study genetic diversity and to select suitable selection criterion Metroglyph analysis method was used in this study.

Materials and Methods

The experimental plot was situated at Agricultural Research Station, Ummmedganj, Kota, Rajasthan situated at the north western part of India and lies between 23°30' and 30°11' North latitude and 69°29' and 78°17' East longitude. It has an average elevation of 271 meter (889 ft). All the 25 genotypes were sown in nursery on 20 June, 2019 and healthy seedling of 24 days old were transplanted in randomized block design with three replication on 14 July, 2019. Each genotype transplanted in plot of 10m² having ten rows of five meter in length. Row to row and plant to plant distance was maintained 20 cm. and 10 cm. respectively. The recommended agronomic practices and plant protection measures whenever necessary were applied for raising a good crop.

Metroglyph and Index score method proposed by Anderson (1957) were used for analysis of various traits. X and Y co-ordinates of octagon glyph represents number of productive tillers per plant (NPT) and number of grains per panicle (NGPP) respectively (Table-4). Rest of the traits were represented by rays in different position on octagon and octagon in turn represents genotypes whereas variable ray length represents the range of the character i.e., A genotype having low range by short, medium range by medium and high range by long ray length (3). Index score was calculated by summation of values (1, 2 and 3) given to short, medium and long ray length respectively (Table 3).

Results and Discussion

Mean performance of 25 Rice genotypes for 10 characters presented in Table-1. Ranges of low, medium and high levels for different traits were calculated (Table-2). Index score and signs used for various characters are given in

Table-1 : Mean performance of 25 genotypes of rice for 10 characters.

Sr. No.	Genotype	Days to 50% flowering	Days to Maturity	Plant height (cm.)	Number of productive tillers per plant	Panicle length (cm)	No. of grains per panicle	1000-grain weight (g)	Amylose content (%)	Protein content (%)	Grain yield per plant (g)
1.	RSK-1155-2-4-1	98.00	135.00	111.00	8.67	27.70	175.00	28.23	22.53	8.42	15.70
2.	RSK-1155-3-3-1	98.67	133.67	111.67	9.33	27.77	180.67	27.87	22.33	8.64	17.57
3.	RSK-1157-4-5-1	99.33	134.33	114.00	9.67	29.37	158.00	28.87	24.40	7.57	18.87
4.	RSK-1157-6-3-1	98.33	135.00	115.00	10.00	29.40	160.33	28.70	24.50	7.50	18.70
5.	RSK-1157-9-2-2	99.33	134.00	113.67	10.67	29.83	162.00	28.87	24.33	7.73	18.00
6.	RSK-1161-1-1	101.00	137.33	116.00	5.67	28.77	178.00	30.33	23.83	8.37	9.47
7.	RSK-1163-8-1	100.33	136.00	116.67	7.00	28.53	183.00	23.97	22.73	8.15	10.30
8.	RSK-1165-4-2	79.67	113.67	99.33	5.33	25.40	134.00	22.17	23.50	7.45	9.15
9.	RSK-1165-4-3	79.00	112.67	99.00	6.33	25.53	135.33	21.70	23.33	7.67	9.67
10.	RNSK-1167-11-1	88.33	126.00	107.33	10.33	28.03	155.67	27.63	26.77	9.09	15.90
11.	RNSK-1168-2-1	81.67	116.00	95.00	9.33	27.57	150.33	27.33	26.57	9.37	15.97
12.	RSK-1164-1-1	97.00	132.00	106.67	6.33	28.52	154.67	23.50	23.40	7.28	10.30
13.	RSK-1172-1-1	94.00	131.00	106.33	6.67	28.77	173.00	24.63	24.27	8.44	9.97
14.	RSK-1221-1-1	98.67	133.33	102.33	8.67	27.83	167.33	23.47	23.63	7.22	13.67
15.	RSK-1162-8-1	99.67	133.67	106.67	7.33	25.23	177.00	24.87	24.50	8.47	12.93
16.	RSK-1164-6-1	95.00	129.33	105.67	6.00	27.23	175.00	24.37	23.53	8.07	9.60
17.	RSK-1164-6-2	93.67	129.67	104.67	5.67	27.37	176.67	24.00	23.43	8.18	9.20
18.	RSK-1165-3-1	78.67	113.00	99.33	5.33	25.30	133.67	23.27	24.40	7.52	8.87
19.	RSK-1165-3-2	79.00	112.67	99.67	8.67	25.63	135.00	22.93	24.57	7.67	15.57
20.	RNSK-1167-5-1	88.67	123.33	106.00	7.33	27.81	149.67	27.67	26.80	9.05	14.97
21.	RSK-1155-6-1-2	98.67	135.00	111.33	10.67	27.70	174.00	27.47	22.87	8.60	17.90
22.	RSK-1155-6-3-1	99.67	135.33	110.67	11.00	27.93	179.67	27.43	22.97	8.58	19.03
23.	P-1121	104.00	140.00	117.33	8.33	27.33	180.33	24.13	22.43	7.45	14.50
24.	P-2511	101.33	135.67	115.33	8.67	28.13	199.00	24.73	23.57	6.86	15.30
25.	P-1460	100.67	133.67	110.00	7.67	27.03	159.00	22.10	22.37	8.20	12.27
	Min	78.67	112.67	95.00	5.33	25.23	133.67	21.70	22.33	6.86	8.87
	Max	104.00	140.00	117.33	11.00	29.83	199.00	30.33	26.80	9.37	19.03
	Range	25.33	27.33	22.33	5.67	4.60	65.33	8.63	4.47	2.51	10.16
	Range/3	8.44	9.11	7.44	1.89	1.53	21.78	2.88	1.49	0.84	3.39
	Min+(Range/3)	87.11	121.78	102.44	7.22	26.76	155.45	24.58	23.82	7.70	12.26
	Min+(Range*2/3)	95.56	130.89	109.89	9.11	28.30	177.22	27.45	25.31	8.53	15.64

Table-3. Total 9 groups have been constructed using 10 characters in scatter diagram (Table-4).

Group I represented by low number of productive tillers per plant and number of grains per panicle, included 4 genotypes two of them *i.e.* genotype 8 and 9 scored low for most of the traits whereas genotype 18 scored medium for Amylose content and genotype 12 scored high value for Days to 50% flowering, days to maturity, Panicle length and medium for Plant height but rest of the traits scored low. Group II represented by low number of productive tillers per plant and medium number of grains per panicle, comprises of two genotypes *i.e.*, 19 and 20. Genotype 19 scored medium for amylose content and grain yield per plant and for rest of the trait scored low

whereas genotype 20 scored high for 1000 grain weight, Amylose content, Protein content and remaining traits scored medium. Group III represented by high number of productive tillers per plant and low number of grains per panicle comprises only one genotypes which shows medium score for days to 50% flowering, days to maturity, Plant height and high score for Amylose content, Protein content, grain yield per plant and remaining traits scored medium. Group IV represented by low number of productive tillers per plant and medium number of grains per panicle, comprises of three genotypes 13, 16 and 17. Genotype 13 shows high score for days to maturity, panicle length and low score for grain yield per plant and other traits exhibits medium score while genotype 16 and 17 score medium for all traits except Amylose content,

Table-2 : Categorisation of genotypes into low, medium and high range of each character with their symbols and sign.

Sr. No.	Days to 50% flowering	Days to Maturity	Plant height (cm.)	Number of productive tillers per plant	Panicle length (cm)	Number of grains per panicle	1000-grain weight (g)	Amylose content (%)	Protein content (%)	Grain yield per plant (g)	Ray Length
Low	Range 78.67-87.11	112.67-121.78	95-102.44	5.33-7.22	25.23-26.76	133.67-155.45	21.70-24.58	22.23-23.82	6.86-7.70	8.87-12.26	-
Genotypes	8,9,11,18,19	8,9,11,18,19	8,9,11,14,18,19	6,7,8,9,12,13,16,17,18	8,9,15,18,19	8,9,11,12,18,19,20	7,8,9,12,14,16,17,18,19,23,25	1,2,7,8,9,12,14,16,17,21,22,23,24,25	3,4,8,9,12,14,18,19,23,24	6,7,8,9,12,13,16,17,18	
Medium	Range 87.11-95.56	121.78-130.89	102.44-109.89	7.22-9.11	26.76-28.30	155.45-177.22	24.58-27.45	23.82-25.31	7.70-8.53	12.26-15.64	—
Genotypes	10,13,16,17,20	10,16,17,20	10,12,13,15,16,17,20	1,14,15,19,20,23,24,25	1,2,10,11,14,16,17,20,21,22,23,24,25	1,3,4,5,10,13,14,15,16,17,21,25	11,12,13,15,2,24	3,4,5,6,13,15,18,19	1,5,6,7,13,15,16,17,25	14,15,19,20,23,24,25	
High	Range 95.56-104.00	130.89-140	109.89-117.33	9.11-11	28.30-29.83	177.22-199.00	27.45-30.33	25.31-26.80	8.53-9.37	15.64-19.03	—
Genotypes	1,2,3,4,5,6,7,12,14,15,21,22,23,24,25	1,2,3,4,5,6,7,12,13,14,15,21,22,23,24,25	1,2,3,4,5,6,7,21,22,23,24,25	2,3,4,5,10,11,21,22	3,4,5,6,7,12,13	2,6,7,22,23,24	1,2,3,4,5,6,10,20,21	10,11,20	2,10,11,20,21,22	1,2,3,4,5,10,11,21,22	
Ray Position				X		Y					

Protein content, grain yield per plant which represent low score. Group V represented by medium number of productive tillers per plant and number of grains per panicle, included four genotypes *i.e.*, 1, 14, 15 and 25. Genotype 1 score high for most of the traits except panicle length and protein content which score medium and amylose content which score low value. Genotype 14 score high for days to 50% flowering, days to maturity and medium for panicle length and grain yield per plant while rest of the traits score low. Genotype 15 score high for days to 50 % flowering, days to maturity and low for panicle length while most of the traits score medium value. Genotype 25 score high for days to 50% flowering, days to maturity, plant height and low for 1000 grain weight and amylose content. Group VI represented by high number of productive tillers per plant and medium number of grains per panicle comprises of maximum genotypes *i.e.*, 3, 4, 5, 10 and 21. Genotype 3 and 4 score high for most of the traits except amylose content which score medium and protein content with score low. Genotype 5 score high for most of the traits except amylose content and protein content which score low. Genotype 10 score medium for days to 50% flowering, days to maturity, plant height, panicle length while 1000-grain weight, amylose content, protein content and grain yield per plant score high. Genotype 21 score high for most of the traits except medium for panicle length and low for amylose content. Group VII represented by low number of productive tillers per plant and high number of grains per panicle, included two genotypes *i.e.*, 6 and 7. Genotype 6 score high for most of the traits except amylose content, protein content which score medium and grain yield per plant which score low. Genotype 7 score high for most of the traits except 1000 green weight, amylose content, grain yield per plant which score low and protein content which score medium. Group VIII represented by medium number of productive tillers per plant and high number of grains per panicle, included two genotypes *i.e.*, 23 and 24. Group IX represented by high number of productive tillers per plant and high number of grains per panicle, included two genotypes *i.e.*, 2 and 22. Genotype 22 score high value for most of the traits except panicle length and 1000-grain weight and low value for amylose content. Genotype 2 score high for most of the traits except panicle length with score medium and amylose content with score low.

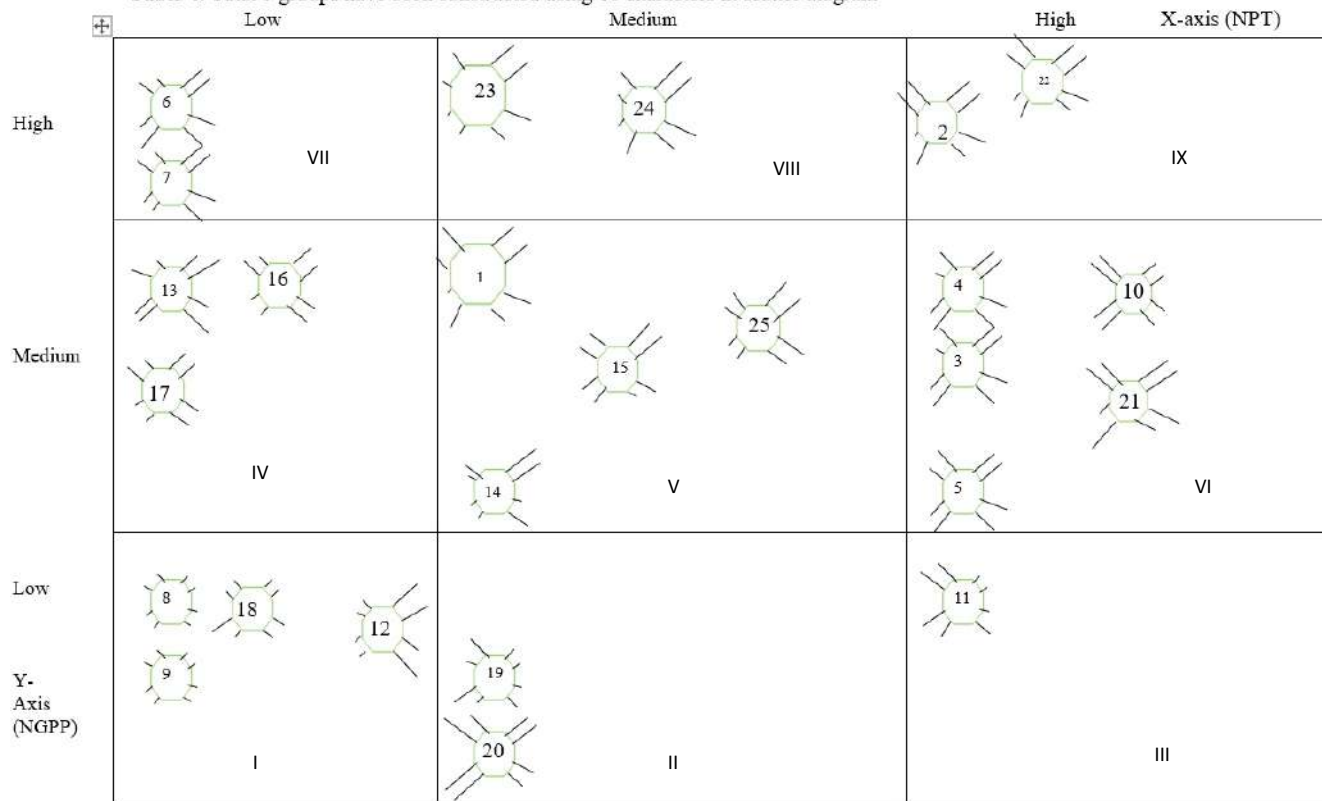
Similar study was conducted to assess genetic diversity by Gomathinayagan *et al.* (1981), Kotaiah *et al.* (1986), Ibrahim *et al.* (1990), Regina *et al.* (1992), Cheema *et al.* (2004) in rice, Rashid *et al.* (2007) in basmati rice mutants, Sravani *et al.* (2022).

The present study of rice genotypes reflected lots of variability among these genotypes for characters under study. This variability can be utilised in various breeding

Table-3 : Index score used for 10 characters.

S. No.	GENOTYPE	Days to 50% flowering	Days to Maturity	Plant height (cm.)	Number of productive tillers per plant	Panicle length (cm)	Number of grains per panicle	1000-grain weight (g)	Amylose content (%)	Protein content (%)	Grain yield per plant (g)	INDEX score
1.	RSK-1155-2-4-1	3	3	3	2	2	2	3	1	2	3	24
2.	RSK-1155-3-3-1	3	3	3	3	2	3	3	1	3	3	27
3.	RSK-1157-4-5-1	3	3	3	3	3	2	3	2	1	3	26
4.	RSK-1157-6-3-1	3	3	3	3	3	2	3	2	1	3	26
5.	RSK-1157-9-2-2	3	3	3	3	3	2	3	2	2	3	27
6.	RSK-1161-1-1	3	3	3	1	3	3	3	2	2	1	24
7.	RSK-1163-8-1	3	3	3	1	3	3	1	1	2	1	21
8.	RSK-1165-4-2	1	1	1	1	1	1	1	1	1	1	10
9.	RSK-1165-4-3	1	1	1	1	1	1	1	1	1	1	10
10.	RNSK-1167-11-1	2	2	2	3	2	2	3	3	3	3	25
11.	RNSK-1168-2-1	1	1	1	3	2	1	2	3	3	3	20
12.	RSK-1164-1-1	3	3	2	1	3	1	1	1	1	1	17
13.	RSK-1172-1-1	2	3	2	1	3	2	2	2	2	1	20
14.	RSK-1221-1-1	3	3	1	2	2	2	1	1	1	2	18
15.	RSK-1162-8-1	3	3	2	2	1	2	2	2	2	2	21
16.	RSK-1164-6-1	2	2	2	1	2	2	1	1	2	1	16
17.	RSK-1164-6-2	2	2	2	1	2	2	1	1	2	1	16
18.	RSK-1165-3-1	1	1	1	1	1	1	1	2	1	1	11
19.	RSK-1165-3-2	1	1	1	2	1	1	1	2	1	2	13
20.	RNSK-1167-5-1	2	2	2	2	2	1	3	3	3	2	22
21.	RSK-1155-6-1-2	3	3	3	3	2	2	3	1	3	3	26
22.	RSK-1155-6-3-1	3	3	3	3	2	3	2	1	3	3	26
23.	P-1121	3	3	3	2	2	3	1	1	1	2	21
24.	P-2511	3	3	3	2	2	3	2	1	1	2	22
25.	P-1460	3	3	3	2	2	2	1	1	2	2	21

Table 4. Total 9 groups have been constructed using 10 characters in scatter diagram



programme for crop improvement. On the basis of scatter diagram and index score, genotype RSK-1155-3-3-1 is found superior for among all the genotype under study.

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Genetic Variability in Chia (*Salvia hispanica* L.)

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Abstract

Genetic variability among 54 genotypes of chia was estimated in augmented design by Federer's (1956) standard statistical methodology during Rabi, 2022-23 at the Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur for eleven characters. The analysis of variance revealed highly significant mean sum of squares attributed to genotypes for all traits, indicating substantial variability observed in each trait. The traits like number of inflorescence per plant, harvest index and seed yield per plant exhibited high GCV and PCV values. The magnitude of heritability were high for all traits, with plant height exhibiting the highest heritability and seed protein content the lowest, indicating a strong genetic component for these traits. The genetic gain was highest for harvest index, followed by the number of inflorescences per plant, seed yield per plant, plant height, seed oil content, number of primary branches per plant, main inflorescence length, days to 50 per cent flowering, 1000 seed weight and days to maturity. Seed protein content had a lower genetic gain, suggesting a lesser scope for improvement through selection.

Key words : Analysis of variance, genetic variability, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic gain

Introduction

Chia (*Salvia hispanica* L.) is a herbaceous plant belonging to the mint family (Lamiaceae) and is native to Northern Guatemala and Southern Mexico (Ixtaina *et al.*, 2008). Chia is classified as a pseudo cereal and is cultivated for its edible seeds in several countries. Chia plants typically reach a height of 1 to 1.5 meters and have green, oval-shaped leaves with serrated edges and a pointed tip (Palma Rojas *et al.*, 2017). Chia seeds are small, oval-shaped and flat, ranging in color from black to white or greyish. These hydrophilic seeds can absorb up to twelve times of their weight in water when soaked and contain mucilaginous fiber, accounting for 27 per cent of the total grain weight. In terms of composition, chia seeds typically contain 42.14 per cent carbohydrates, 5.80 per cent water, 31 per cent fat, 16.54 per cent protein and 34 per cent dietary fiber (USDA, 2004). They are rich in various nutritious elements such as omega acids, vitamin B₁, vitamin B₃, iron, calcium, manganese, magnesium, zinc and phosphorus. The omega-3 fatty acids present in chia seeds play a significant role in preventing cardiovascular diseases. Chia seeds are consumed whole, ground into flour, used as seed mucilage or processed into oil. Due to its nutritional value, chia seeds have gained recognition as a "super food" and are increasingly popular in India. Crop development programs rely on genetic variability as a crucial foundation to achieve high-yielding and improved crop varieties. This

involves assessing various genetic traits such as variance components, coefficients of genotype and phenotype variability, inheritance patterns and genetic advancement. Therefore, the present study was carried out to estimate genetic variability present in a collection of 54 genotypes of chia.

Materials and Methods

The present investigation entitled "Character Interrelationship and Genetic Diversity in Chia (*Salvia hispanica* L.)" was laid out in Augmented design with five blocks during Rabi, 2022-23 at the Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. Single row per genotype were sown with inter and intra row spacing of 30 x 10 cm and 3 m row length.

Traits observed : Observations were made for all the characters viz., plant height, number of primary branches per plant, number of inflorescence per plant, main inflorescence length, 1000 seed weight, seed yield per plant, harvest index, seed oil content and seed protein content on five randomly selected plants for each treatment except days to 50 per cent flowering and days to maturity which were recorded on a plot-by-plot basis. The seed oil content was determined using the Soxhlet's Method. The average oil content percentage was calculated based on the results obtained. For determining the protein content, the nitrogen content of the seeds was measured using the standard Micro Kjeldahl method as

Table-1 : Analysis of variance for different characters in chia genotypes.

S. No.	Character	Block [4]	Treatment [53]	Check [3]	Germplasm [49]	C v/s G [1]	Error [12]
1.	Days to 50 per cent flowering	2.88	226.72**	221.38**	171.98**	2925.37**	2.68
2.	Days to maturity	1.77	280.21**	119.79**	222.07**	3610.25**	1.33
3.	Plant height	0.56	622.14**	359.66**	646.13**	234.10**	1.33
4.	Number of primary branches per plant	0.03	6.82**	36.96**	4.89**	11.22**	0.04
5.	Number of inflorescence per plant	0.37	26.69**	93.39**	20.03**	152.52**	0.56
6.	Main inflorescence length	0.03	5.89**	3.99**	5.40**	35.46**	0.11
7.	1000 seed weight	0.01**	0.03**	0.04**	0.03**	0.10**	0.00
8.	Seed yield per plant	0.01	0.21**	1.33**	0.12**	1.33**	0.01
9.	Harvest index	1.07	50.90**	136.54**	39.50**	352.53**	1.64
10.	Seed oil content	0.07	22.71**	88.11**	18.09**	52.94**	0.24
11.	Seed protein content	0.15	3.93**	3.41**	0.43**	176.97**	0.08

** Significant at 1 per cent

Table-2 : Mean, range, variability, heritability (broad sense), genetic advance and genetic gain of chia genotypes for seed yield and its contributing attributes.

Character	Mean	Range		Coefficient of variation (%)		Heritability (broad sense) (%)	Genetic advance (%)	Genetic gain (%)
		Min.	Max.	Genotypic	Phenotypic			
Days to 50 per cent flowering	91.97	72.00	116.00	13.55	13.65	98.44	26.59	27.69
Days to maturity	139.89	121.36	169.31	10.29	10.32	99.40	30.51	21.13
Plant height	128.45	90.66	169.23	19.59	19.61	99.79	52.26	40.32
Number of primary branches	13.69	10.00	19.33	16.38	16.45	99.08	4.51	33.58
Number of inflorescence per plant	20.85	11.66	27.46	22.16	22.47	97.20	8.96	45.00
Main Inflorescence length	15.41	11.33	19.33	15.36	15.53	97.88	4.69	31.31
1000 seed weight	1.35	1.06	1.83	12.38	13.01	90.55	0.33	24.26
Seed yield per plant	1.61	0.84	2.59	21.54	22.32	93.15	0.65	42.83
Harvest index	25.12	10.23	38.30	25.96	26.51	95.86	12.41	52.35
Seed oil content	25.68	15.40	35.21	16.81	16.93	98.65	8.64	34.40
Seed protein content	18.23	16.13	18.55	3.43	3.81	80.95	1.09	6.35

outlined by Lindner (1944). The nitrogen content was then converted to crude protein percentage by multiplying it with a factor of 6.25 and average protein percentage was calculated. Finally, statistical analysis was performed using the mean data of all the measured traits.

Statistical analysis : The quantitative character analysis was carried out in compliance with Federer's (1956) standard statistical methodology for augmented design. GCV and PCV were calculated using the formula suggested by Burton (1952). Heritability was computed using the formula stated by Burton and De vane (1953) and genetic gain was computed as per the formula of Johnson *et al.* (1955).

Results and Discussion

There was substantial variation among genotypes for several characteristics, including days to 50 per cent flowering (72 to 116 days), days to maturity (121.36 to 169.31 days), plant height (90.66cm to 168.23cm), number of primary branches per plant (10 to 19.33), number of inflorescences per plant (11.66 to 20.85), main inflorescence length (11.33cm to 19.33cm), 1000 seed weight (1.06g to 1.83g), seed yield per plant (0.84g to

2.59g), harvest index (10.23% to 38.30%), seed oil content (15.40% to 35.21%) and seed protein content (16.13% to 21.61%). The extent of GCV ranged from 3.43 per cent for seed protein content to 25.96 per cent for harvest index. Harvest index (25.96%), number of inflorescences per plant (22.16%) and seed yield per plant (21.54%) showed high estimates of GCV (>20%). GCV estimates were moderate (10-20%) for traits such as plant height (19.59%), seed oil content (16.81%), number of primary branches per plant (16.38%), main inflorescence length (15.36%), days to 50 per cent flowering (13.55%), 1000 seed weight (12.38%) and days to maturity (10.29%). On the other hand, seed protein content exhibited a low GCV of 3.43%. The extent of PCV varied from 3.81 per cent for seed protein content to 26.51 per cent for harvest index. Harvest index (26.51%), number of inflorescences per plant (22.47%) and seed yield per plant (22.32%) displayed high PCV estimates (>20%), while plant height (19.61%), seed oil content (16.93%), number of primary branches per plant (16.45%), main inflorescence length (15.53%), days to 50 per cent flowering (13.65%), 1000 seed weight (13.01%), days to maturity (10.32%) exhibited moderate estimates of PCV,

while seed protein content showed a low PCV (<10%) of 3.81%.

The high magnitude of heritability (>60%) were noticed in all the characters viz., plant height (99.79%), days to maturity (99.40%), number of primary branches per plant (99.08%), seed oil content (98.65%), days to 50 per cent flowering (98.44%), main inflorescence length (97.88%), number of inflorescence per plant (97.20%), harvest index (95.86%), seed yield per plant (93.15%), 1000 seed weight (90.55%) and seed protein content (80.95%). The genetic advance was found high (>20%) in the characters like plant height (52.26%), days to maturity (30.51%) and days to 50 per cent flowering (26.59%), while harvest index (12.41%) exhibited moderate (10-20%) genetic advance. However, lower genetic advance (<10%) was observed for 1000 seed weight (0.33%), seed yield per plant (0.65%), seed protein content (1.09%), number of primary branches per plant (4.51%), main inflorescence length (4.69%), seed oil content (8.64%) and number of inflorescence per plant (8.96). The harvest index (52.35%) exhibited the highest genetic gain followed by number of inflorescence per plant (45.0%), seed yield per plant (42.83%), plant height (40.32%), seed oil content (34.40%), number of primary branches per plant (33.58%), main inflorescence length (31.31%), days to 50 per cent flowering (27.69%), 1000 seed weight (24.26%) and days to maturity (21.13%). However, the genetic gain for seed protein content was low, being 6.35 per cent. These findings are in close agreement with previous researchers like Ibrahim *et al.* (2011), Patel *et al.* (2015), Grimes *et al.* (2018), Smita and Kishori (2018) and Thada *et al.* (2021).

Conclusions

The study revealed significant genetic variability for all the studied traits, as indicated by highly significant mean sum of squares attributed to genotypes. There was substantial variation among genotypes for all the characters. Traits like number of inflorescences per plant, harvest index, and seed yield per plant displayed high genetic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), indicating significant genetic diversity and potential for improvement through selection. All traits examined in the study exhibited high heritability. Traits like plant height, days to maturity, and days to 50 per cent flowering displayed both high heritability and high genetic advance, indicating that these traits are primarily governed by genetic factors and can be efficiently passed on to offspring through breeding. The study also identified the highest genetic gain in the harvest index, followed by the number of inflorescences per plant, seed yield per plant, plant height, seed oil content, number of primary branches per plant, main inflorescence length, days to 50 per cent

flowering, 1000 seed weight, and days to maturity. The research highlights the significant genetic diversity and heritability of the studied traits, providing valuable insights for targeted breeding programs aimed at improving key characters, ultimately enhancing crop productivity and performance.

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Comprehensive Study of Drying Methods on Quality Attributes of Red Cabbage Slices

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Abstract

The experiment comprised of six drying treatments viz., tray dryer (45°C), tray dryer (50°C), tray dryer (55°C), tray dryer (60°C), solar dryer (control) and shade drying with four replications under completely randomized design. Among different drying methods tray drying (55°C) effectively improved physio-chemical quality characteristics (moisture content, anthocyanin content, DPPH antioxidant capacity, water activity (a_w), TSS, proximate analysis, hunter colour value L^* , b^* and ascorbic acid) of dehydrated red cabbage slices.

Key Words : Drying, Red cabbage slices, DPPH antioxidant capacity and Proximate analysis

Introduction

Red cabbage (*Brassica oleracea* var. *capitata* f. *rubra* L.) is a cool-season vegetable. In India, nursery is prepared during October, and transplanted by November. Red cabbage is rich in antioxidants, proteins (0.35%), lipids (0.25%), minerals including calcium (3.56%), phosphorus (19.90%), potassium, sulfur, vitamins A, B₁, B₂, and C (Wojciechowska *et al.* 2007). It exhibits anti cancerous compound Indole-3 carbinol. It is consumed as salad, boiled vegetable, cooked in curries, and used in pickling, as well as dehydrated vegetables. Moreover, post-harvest losses can be reduced by taking care of the harvest (using proper, cooling storage container) and its processing (value addition, pickling, or dehydrating powders) Kamble *et al.*, 2022.

Drying is one of the most important methods in food processing, and the major aim is to decrease water activity, which in turn minimizes the chemical and physical modifications during storage (Chen *et al.*, 2017). Dehydrated vegetables are easy to use, have a longer shelf life than fresh vegetables, and have a higher nutritional value than fresh vegetables in addition to boosting menu diversity, decreasing losses, labor, and storage space (Chauhan and Sharma, 1993 and Ratti, 2005). To make vegetable more convenient for the consumer and to increase its availability all year long. Therefore, keeping in view "Comprehensive study of drying methods on quality attributes of Red Cabbage slices".

Materials and Methods

The present experiment was conducted at Department of

Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur, during February 2023 to June 2023. The experiment included six drying treatments viz., tray dryer (45°C), tray dryer (50°C), tray dryer (55°C), tray dryer (60°C), solar dryer (control) and shade drying with four replications under completely randomized design.

Sample Preparation : Fresh heads of red cabbage (*Brassica oleracea* var. *capitata* f. *rubra* L.) were procured from the farm of CTAE, MPUAT, Udaipur, Rajasthan. Following initial observation were taken for fresh heads samples (Table-1.1). The selected red cabbage heads were thoroughly washed with tap water to remove dirt and dust particles adhering to the surface of fruits and then again washed with chlorinated water and allowed to shade dry before slicing. The selected head was sliced to 5 mm thickness with a manual shredder. About 2 kg of the sliced sample was taken for drying.

Parameters	Content
Moisture (%)	91.54
Carbohydrate (mg/100g)	6.93
Ascorbic acid (mg/100g)	57.06
Total Sugar (%)	3.48
Reducing Sugar (%)	2.63
Protein (%)	1.42
Total fiber (%)	2.95

Drying techniques : The red cabbage heads were dried using different methods viz., Convective tray drying at different temperature 45°C, 50°C, 55°C and 60°C, solar drying and shade drying until the moisture level reached below 10 per cent.

Observation of dried sample : After drying of 2kg of sliced red cabbage following observation were studied.

Table-1 : Effect of different drying methods on quality of red cabbage slices.

Treatments	Convective tray dryer				Solar dryer	Shade dryer
	Tray Drying (45°C)	Tray Drying (50°C)	Tray Drying (55°C)	Tray Drying (60°C)		
Moisture content (%)	7.00 ± 0.06 C	6.75 ± 0.06 D	6.43 ± 0.06 E	6.03 ± 0.08 F	7.21 ± 0.08 B	7.65 ± 0.07 A
Anthocyanin content (mg/100g)	66.82 ± 0.61 B	67.38 ± 0.61 B	69.23 ± 0.63 A	62.19 ± 0.80 D	60.95 ± 0.66 D	64.82 ± 0.59 C
DPPH antioxidant capacity (%)	89.32 ± 0.81 B	91.43 ± 0.83 A	92.85 ± 0.85 A	0.83 ± 0.01 C	86.48 ± 0.93 C	88.15 ± 0.80 BC
Water activity (aw)	0.84 ± 0.01 BC	0.84 ± 0.01 BC	0.83 ± 0.01 C	0.83 ± 0.01 C	0.86 ± 0.01 AB	0.87 ± 0.01 A
TSS (°Brix)	6.74 ± 0.06 C	7.01 ± 0.07 B	7.23 ± 0.07 A	6.54 ± 0.09 D	6.49 ± 0.07 D	6.63 ± 0.06 CD
Proximate analysis	82.71 ± 0.16 B	82.80 ± 0.16 B	83.79 ± 0.21 A	82.71 ± 0.16 B	82.21 ± 0.16 C	82.71 ± 0.16 B
Colour	L*	19.851 ± 0.181 C	23.984 ± 0.22 B	26.382 ± 0.24 A	15.952 ± 0.21 D	11.866 ± 0.13 E
	a*	21.766 ± 0.198 C	20.876 ± 0.19 D	19.995 ± 0.18 E	24.154 ± 0.31 B	25.654 ± 0.28 A
	b*	7.187 ± 0.065 C	7.356 ± 0.07 B	7.877 ± 0.07 A	6.972 ± 0.09 D	6.186 ± 0.07 E
Ascorbic acid (mg 100g ⁻¹)	35.44 ± 0.321 B	37.73 ± 0.34 A	38.49 ± 0.35 A	33.60 ± 0.43 D	31.13 ± 0.34 E	34.51 ± 0.32 C

Moisture content (%) : of dried red cabbage slices was determined as per method suggested by AOAC (2005). The initial weight of the sample is determined using a digital scale. The sample was heated in the metal dish for 24 hours while being dried out in a hot air oven with a set temperature of 105°C. The sample was placed in the hot air oven for 24 hours and then cooled in a desiccator. The dried product's final weight was noted.

Anthocyanin content (mg/100g) : was measured by the pH-differential method (Liu, *et al.*, 2021). The red cabbage powder (1gm) mixed with 10 ml distilled water. It was further, diluted with 9 ml of two buffers (potassium chloride pH 1.0, 0.025 M and sodium acetate pH 4.5, 0.4 M) and the absorbance was measured at 520 nm (potassium chloride) and 700 nm (sodium acetate) using a UV-Vis spectrophotometer (Double beam by SL 210 UV Visible, colimeter, Ellico, Hyderabad, India). (c) Antioxidant capacity (%) was evaluated by 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging method (Blois, 1958). One gram of red cabbage powder sample (control and dried at different temp.) (0.2 g) was added into 50% ethanol at the ratio of 1:50 (g:ml). The sample was centrifuged (LEGEND XFR, Thermo scientific, Germany) for 15 min. at 1000 rpm, 4°C followed by addition of 0.5 ml DPPH (1mM solution) and incubated for 90 min in dark. Absorbance was estimated spectrophotometrically (Double beam by SL 210 UV Visible, colimeter, Ellico, Hyderabad, India) at 517 nm against methanol and DPPH mixture as control as blank. The DPPH antioxidant activity was evaluated using following formula

$$\text{Antioxidant activity (\%)} = \frac{\text{OD control} - \text{OD test}}{\text{OD control}} \times 100$$

Water activity (a_w) : Red cabbage slices a_w was measured using the digital activity meter (Novasnia Labtouch Smart Water Activity meter, DFT, Chennai, India) to estimate the unbound water vapour pressure, with an accuracy of ±0.03. It was precalibrated

with milli-Q-water at 25°C. 2.3.e. TSS (°Brix) of the dried red cabbage was determined with the help of a digital refractometer (QA Supplies, LLC) of range 0– 45 °Brix. According to Kamble *et al.* (2022) the powder was dissolved in distilled water at a ratio of 1:10 w/v. The refractometer was calibrated with distilled water at 20°C prior to conducting measurements. To test supernatant was kept on the refractometer prism and the TSS was expressed in %.

Proximate compositional analysis : of red cabbage flour was determined according to methodology described b in (Kamble, *et al.*, 2022). The fat content was estimated by the extraction of petroleum ether using the Soxhlet apparatus AOAC, 2005. The crude protein was estimated using the Kjeldhal method Oser, 1976, and the conversion factor used for protein estimation was nitrogen% x 6.25 AOAC, 2005. The total carbohydrate percentage was calculate using.

Color change (L, a and b) values : of dried red cabbage were determined using a digital colorimeter (Hunter Lab Color Flex, Hunter Associates Laboratory Inc., Reston, VA, USA). Prior to measurement, it was pre-calibrated using black and white tiles. The chromacity parameters a* (green [-] to red [+]), b* (blue [-] to yellow [+]), and the color parameters L* (L* = 0 for black and L* = 100 for white) were also assessed. (h) Ascorbic acid (mg 100g⁻¹) was estimated according to 2, 6-dichlorophenolindophenol dye using method optimized by Malik and Singh (2005).

Results and Discussion

Moisture content (%) and water activity (aw) : Data presented (table-1) revealed that the minimum moisture content (6.03%) and water activity (0.83) was observed in 60°C tray drying, as compared to shade drying (7.65%) and water activity (0.87) respectively. The variation in moisture content (%) and water activity by different drying methods may be due temperature of different drying process. It might have associated with control temperature

and constant flow of air as a cumulative mass transfer driving force facilitating migration of moisture at faster rate. It was observed that further drying methods of red cabbage slices during later phase of processing did not bring any considerable decrease in moisture content and water activity. Similar types of results were also reported by Cheman *et al.*, (1997) and Pawar *et al.*, (1988).

Quality attributes : Data in (table-1) reported that tray drying at 55°C maintained maximum anthocyanin content (69.23), DPPH antioxidant capacity (92.85), TSS (7.23 °Brix), ascorbic acid (38.49 mg), hunter colour value L^* (26.38), b^* (7.88) and proximate analysis (83.79%) recorded with tray drying (55°C). Although, maximum hunter colour value a^* (25.65) under solar drier. Whereas, minimum anthocyanin content (60.95), DPPH antioxidant capacity (86.48), TSS (6.49 °Brix), ascorbic acid (31.13 mg), hunter colour value L^* (11.86), b^* (6.18) and proximate analysis (82.21%) solar drier, while hunter colour value a^* (19.99) notice under tray drier (55°C). Red cabbage slices were dried in tray drier at (60, 55, 50 and 45°C) significantly affect quality; since at higher temperature, it is likely that loss of ascorbic acid, anthocyanin, antioxidant loss of volatile chemicals, dry matter. The exposure of the cabbage to direct sunlight resulted in highest vitamin C loss during sun drying as compared to tray and shade dryer. This is associated with higher sensitivity of vitamin C to most assessable atmosphere constituents like oxygen, light and temperature. Goyal and Mathew (1990) reported that maximum vitamin C, in tray dried in cabbage may be due to controlled drying condition and least exposure of vegetable to temperature and air. Moreover, at higher temperature, vitamin C of brussel sprouts oxidized Daniela *et al.*, (2007). Sakhale and Panwar (2007) reported that tray dried cabbage recorded maximum Vitamin C (42.9%) followed by lowest in sun drying (30.5%). Similarly results reported by Mondal *et al.*, (2019); However, at higher temperature quick dehydration of product resulted in burning phenomenon which decreased colour and sensory quality (Maray *et al.*, 2017). This significant variation in hunter colour value L^* and b^* of red cabbage slices might be due to the nonenzymatic and enzymatic reaction of polyphenols with the oxygen polyphenol-oxidase enzyme resulting from an increase in tray drying temperature (Kamble *et al.*, 2022). Sakhale *et al.*, (2020) reported that the tray drying method was found comparatively superior in retention of sensory quality parameters (color, texture, and overall acceptability) over the sun and at par with shade drying of green leafy vegetables. similar findings observed by Oduro *et al.*, (2008) that the tray-dried (60°C) starches had higher color L^* values. Proximate analysis higher with tray drying due to drying temperature, airflow rate and head dimension of

red cabbage, similar results reported by Kamble *et al.*, 2022.

Conclusions

In conclusion the experiment has conclusively brought out some vital information on the drying methods among different types of drying methods tray drying at 55°C effectively improved physio-chemical quality characteristics (moisture content, anthocyanin content, DPPH antioxidant capacity, TSS, carbohydrate, protein, fat, hunter colour value L^* , b^* and ascorbic acid,) of dehydrated red cabbage slices. However, producers may effectively and economically preserve their food and sell it in both domestic and foreign markets throughout the off-season.

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Effect of Doses and Time of Application of Panchagavya on Nutrient Content and Uptake in Soybean [*Glycine max* (L.) Merrill]

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Abstract

A field experiment was conducted during the *kharif* season of 2022 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan) to evaluate the Performance of Soybean [*Glycine max* (L.) Merrill] under Various Doses and Time of Application of Panchagavya. Result show that application of 10% panchagavya observed maximum nutrient content (seed and haulm) and uptake (seed, haulm and total by crop). A significant increase in nutrient (N, P, K, S, Zn and Fe) content in seed and haulm and uptake (N, P, K, S, Zn and Fe) by seed, haulm and total uptake by crop were recorded with application of panchagavya at 45 and 60 DAS.

Key words : Soybean, panchagavya, nutrient content, nutrient uptake.

Introduction

Soybean [*Glycine max* (L.) Merrill] is an important oilseed pulse crop in India and world belongs to family Leguminosae with sub family papilionaceae. The crop is also called as “Golden Bean” or “Miracle crop” of the 21st century because of its multiple uses. It has been an economical crop because of comparatively good economic returns unit⁻¹ area obtained by the from its cultivation. This brought a revolution in rural areas with regard to improvement in the living condition of farmers. It has highest protein (40-42%) and oil content (18-20%) with high nutritive value. It is primarily grown for food; however, the haulm is used for feeding to animals. It is also a rich source of vitamin A, B and D. It contains 38-43% minerals and 2% phospholipids (Patil and Udmale, 2016). Additionally, the haulms, senesced nodules, and decayed roots improve the fertility of the soil for subsequent crops. Soybean is a major source of vegetable oil and feed for the poultry industry.

The global area of soybean in 2022-23 is 134.79 million ha and production are 369.57 million tonnes (USDA 2023). In India, soybean was cultivated on 12.81 million ha area with the annual production of 12.90 million tonnes at an average productivity of 1007 kg ha⁻¹ during 2020-21 (Government of India, 2021).

The package and practices for cultivation of organic soybean have been developed in Rajasthan which includes application of FYM and vermicompost @ 4 and 2 t ha⁻¹ respectively, use of neem cake @ 2 q ha⁻¹ and seed treatment with *Rhizobium*, *Azotobacter* and *Tricoderma*

besides organic pest and disease management (Sharma *et al.*, 2015).

Panchagavya, an organic product has potential to play the role in promoting growth and providing immunity in plant system. The use of organic liquid such as panchagavya results in higher growth, yield, and quality of crops (Choudhary *et al.*, 2014). Role of foliar applied panchagavya in production of many plantation crops had been well documented in India (Sailaja *et al.*, 2014). Panchagavya is an organic product recommended for crop improvement in organic agriculture (Sangeetha and Thevanathan, 2010).

Panchagavya is also being sought to improve crop establishment and health (Choudhary *et al.*, 2017). Panchagavya possess the properties of fertilizers and bio pesticides (Sharma *et al.*, 2015). Panchagavya has resulted in positive effect on growth and productivity of crops. It is used as a foliar spray, soil application along with irrigation, as well as seed treatment. Farmers in South India practice panchagavya for sustainable agriculture. The pH of panchagavya was lowered to 4.52 at 30 days of fermentation and this might be due to *Lactobacillus* bacteria in panchagavya, which produced more organic acids during fermentation. Panchagavya is also known to contain biofertilizers such as *Azospirillum*, *Azotobacter*, *Phosphobacteria* and *Pseudomonas* besides *Lactobacillus* (Choudhary *et al.*, 2017). Besides these, growth regulatory substances such as Indole acetic acid, gibberellic acid, cytokinin and essential plant nutrients have also been reported in panchagavya (Patil *et al.*, 2012) which caused a tremendous influence on the growth rate in *Allium cepa* and panchagavya at 30 days of

Table-1 : Effect of doses of panchagavya and its time of application on nitrogen, phosphorus and potassium content in seed and haulm of soybean.

Treatments	Nutrient content (%)					
	Nitrogen		Phosphorus		Potassium	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Doses of panchagavya						
Control	5.986	0.970	0.490	0.122	0.660	1.180
5 %	6.135	1.605	0.576	0.180	0.725	1.236
7.5 %	6.344	1.626	0.674	0.270	0.800	1.336
10 %	6.442	1.666	0.699	0.294	0.824	1.372
S.Em.±	0.077	0.015	0.008	0.003	0.010	0.014
C.D.(P=0.05)	0.221	0.044	0.022	0.008	0.029	0.040
Time of panchagavya application						
30 DAS	5.944	1.369	0.563	0.175	0.708	1.238
45 DAS	6.226	1.464	0.608	0.213	0.755	1.273
60 DAS	6.069	1.404	0.593	0.200	0.738	1.258
30 and 45 DAS	6.404	1.536	0.633	0.240	0.773	1.310
45 and 60 DAS	6.491	1.561	0.653	0.255	0.788	1.328
S.Em.±	0.086	0.017	0.009	0.003	0.011	0.016
C.D.(P=0.05)	0.247	0.049	0.025	0.009	0.032	0.045

Table-2 : Effect of doses of panchagavya and its time of application on sulphur, zinc and iron content in seed and haulm of soybean.

Treatments	Nutrient content					
	Sulphur (%)		Zinc (mg kg ⁻¹)		Iron (mg kg ⁻¹)	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Doses of panchagavya						
Control	0.172	0.107	26.06	18.18	66.61	179.42
5 %	0.220	0.173	31.68	27.02	94.22	191.94
7.5 %	0.266	0.214	38.58	30.30	111.27	202.83
10 %	0.280	0.221	40.70	31.08	113.78	206.04
S.Em.±	0.003	0.002	0.49	0.34	1.22	1.88
C.D.(P=0.05)	0.008	0.007	1.41	0.97	3.48	5.38
Time of panchagavya application						
30 DAS	0.211	0.167	31.00	24.88	89.18	189.17
45 DAS	0.231	0.176	34.03	26.68	95.39	194.43
60 DAS	0.222	0.173	33.30	25.88	92.95	192.74
30 and 45 DAS	0.253	0.186	35.95	27.68	100.63	198.50
45 and 60 DAS	0.256	0.191	37.00	28.13	104.21	200.45
S.Em.±	0.003	0.003	0.55	0.38	1.36	2.10
C.D.(P=0.05)	0.009	0.008	1.58	1.09	3.89	6.02

age recorded better chemical and microbial composition favourable for utilization as a growth promoter and panchagavya did not have direct antibacterial activity. Effective microorganisms in panchagavya were the mixed culture of naturally occurring, beneficial microbes mostly lactic acid bacteria (*Lactobacillus*), yeast (*Saccharomyces*), actinomycetes (*Streptomyces*), photosynthetic bacteria (*Rhodo pseudomonas*) and certain fungi (*Aspergillus*) (Swaminathan *et al.*, 2007).

Materials and Methods

The experiment was conducted during the *kharif* season of 2022 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur. The soil of experimental

site was clay loam in texture with 276.8, 23.9 and 337.4 kg ha⁻¹ available nitrogen, phosphorus and potassium, respectively in 0-30 cm soil depth with pH 8.2. The experiment was laid out in factorial randomized design with three replications and 20 treatment combinations consisting of control and three doses of panchagavya (5% panchagavya, 7.5% panchagavya and 10% panchagavya) as growth promoter and five time of application of panchagavya (30 DAS, 45 DAS, 60 DAS, 30 & 45 DAS and 45 & 60 DAS). In the experiment, soybean (JS-335 variety) was sown. The nutrient content was determined by the following method nitrogen by nessler's reagent colorimeter method (Snell and Snell, 1949), phosphorus by ammonium vanadomolybdate yellow

Table-3 : Effect of doses of panchagavya and its time of application on nitrogen, phosphorus and potassium uptake by seed and haulm of soybean.

Treatments	Nutrient uptake (kg ha ⁻¹)								
	Nitrogen			Phosphorus			Potassium		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Doses of panchagavya									
Control	53.77	13.20	66.97	4.41	1.67	6.08	5.91	15.93	21.84
5 %	71.56	25.52	97.08	6.72	2.86	9.59	8.46	19.66	28.11
7.5 %	83.33	28.37	111.70	8.86	4.73	13.59	10.52	23.31	33.83
10 %	88.13	30.25	118.37	9.59	5.36	14.95	11.30	24.90	36.20
S.Em.±	2.28	0.56	2.68	0.24	0.07	0.28	0.29	0.54	0.74
C.D.(P=0.05)	6.52	1.61	7.66	0.68	0.20	0.79	0.83	1.54	2.12
Time of panchagavya application									
30 DAS	65.07	21.29	86.37	6.26	2.75	9.00	7.78	18.76	26.55
45 DAS	72.20	24.09	96.30	7.14	3.53	10.67	8.83	20.74	29.57
60 DAS	68.46	22.50	90.96	6.79	3.23	10.02	8.36	19.77	28.13
30 and 45 DAS	80.42	26.12	106.54	8.09	4.16	12.24	9.83	22.10	31.92
45 and 60 DAS	84.82	27.67	112.49	8.71	4.62	13.33	10.44	23.38	33.82
S.Em.±	2.55	0.63	2.99	0.27	0.08	0.31	0.32	0.60	0.83
C.D.(P=0.05)	7.29	1.79	8.57	0.77	0.23	0.88	0.93	1.72	2.37

Table-4 : Effect of doses of panchagavya and its time of application on sulphur, zinc and iron uptake by seed and haulm of soybean.

Treatments	Nutrient uptake								
	Sulphur (kg ha ⁻¹)			Zinc (g ha ⁻¹)			Iron (g ha ⁻¹)		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Doses of panchagavya									
Control	1.54	1.45	2.99	23.45	24.65	48.11	59.93	242.98	302.91
5 %	2.57	2.75	5.33	36.97	42.99	79.96	110.09	305.02	415.10
7.5 %	3.50	3.74	7.24	50.83	52.89	103.72	146.09	353.50	499.59
10 %	3.86	4.02	7.88	55.88	56.38	112.27	156.08	372.91	528.99
S.Em.±	0.09	0.08	0.17	1.44	1.10	2.36	3.79	7.05	9.12
C.D.(P=0.05)	0.27	0.24	0.47	4.11	3.14	6.76	10.86	20.19	26.12
Time of panchagavya application									
30 DAS	2.35	2.61	4.95	34.59	38.63	73.22	100.08	287.65	387.74
45 DAS	2.73	2.93	5.66	40.26	43.95	84.21	113.18	316.27	429.45
60 DAS	2.54	2.79	5.33	38.33	41.37	79.70	107.28	302.85	410.13
30 and 45 DAS	3.27	3.20	6.47	46.24	47.22	93.46	129.98	334.13	464.11
45 and 60 DAS	3.45	3.43	6.88	49.50	49.99	99.48	139.71	352.11	491.82
S.Em.±	0.11	0.09	0.18	1.61	1.23	2.64	4.24	7.88	10.20
C.D.(P=0.05)	0.30	0.26	0.53	4.60	3.51	7.56	12.15	22.57	29.20

colour method (Richards, 1968), potassium by flame photometer method (Jackson, 1973), sulphur by turbidimetric method (Tabatabai and Bremner, 1970) and zinc and iron estimation on AAS (Lindsay and Norvell, 1978). The uptake of N, P and K after harvest in seed and haulm was estimated by multiplying the nutrient concentration values with yield of crop. The data were statically analysed using standard procedure of ANOVA at 5% level of significance.

Results and Discussion

Nutrient content

Doses of panchagavya : The significantly higher nutrient (nitrogen, phosphorus, potassium, sulphur, iron and zinc)

content was found with application of 10% panchagavya as compared to application of 5% panchagavya and control (Table 1-2). Similar findings were made by Beulah (2002), who discovered that the poultry manure + neem cake + panchagavya treatments improved the secondary and micronutrient (Ca, S and Fe) and macronutrient (NPK) contents. Similar outcomes have also been mentioned by Aher *et al.* (2019) and Sutar *et al.* (2019).

Time of application of panchagavya : Results reveal that higher nitrogen, phosphorus, potassium, sulphur, iron and zinc content in the seed and haulm (Tables 1-2), which led to higher seed and haulm production with the application of panchagavya at 45 and 60 DAS. The results

of present investigation are in line with those of Choudhary *et al.* (2017).

Nutrient uptake

Doses of panchagavya : The significantly higher nutrient (nitrogen, phosphorus, potassium, sulphur, iron and zinc) uptake was found with application of 10% panchagavya as compared to application of 5% panchagavya and control. Highest nitrogen, phosphorus, potassium, sulphur, iron and zinc uptake by seed, haulm and total by crop (Table 3-4) was observed in application of 10% panchagavya. Similar outcomes have also been mentioned by Aher *et al.* (2019) and Sutar *et al.* (2019).

Time of application of panchagavya : Results reveal that higher nitrogen, phosphorus, potassium, sulphur, iron and zinc uptake by seed and haulm, which led to higher seed and haulm production (Table 3-4) with the application of panchagavya at 45 and 60 DAS. The beneficial bacteria contained in panchagavya created bioactive compounds that positively altered the control of stomata and improved the blackgram's ability to absorb nutrients. The results of present investigation are in line with those of Choudhary *et al.* (2017).

Conclusions

On the basis of results of one year experimentation, above findings could be concluded as under. Application of 10% panchagavya in soybean resulted into significantly higher N, P, K, S, Zn and Fe content and uptake in seed and haulm of soybean and panchagavya application twice at 45 and 60 DAS recorded the highest N, P, K, S, Zn and Fe content and uptake in seed and haulm of soybean over the application of panchagavya at 30 and 45 DAS alone.

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Isolation and Molecular Characterization of Calcite Solubilizing Bacteria (CSB) Isolated from Marble Slurry Dump Yards

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Abstract

Calcite solubilising bacteria (CSB) are known to promote plant growth by solubilising calcium from calcareous soils, but their molecular characterization and potential as plant growth promoting rhizobacteria (PGPR) remain underexplored. In this study, CSB strains were isolated and characterized from calcareous soils and investigated their potential as PGPR. The results indicate that CSB strains exhibited high calcium solubilization activity, besides this potential, they are potent PGPR, thus exhibit important plant growth-promoting traits. Molecular characterization using 16S rRNA sequencing revealed the presence of diverse bacterial taxa, with most strains belonging to the genera *Bacillus*, *Pseudomonas* and *Arthrobacter*. Different findings suggest that CSB strains have the potential to be used as PGPR for enhancing plant growth in calcareous soils. Further studies are needed to elucidate the mechanisms underlying their plant growth promotion effects and to evaluate their potential for agricultural applications.

Key words : Calcite solubilizing bacteria, Plant growth promoting rhizobacteria, sustainable, biofertilizer.

Introduction

Calcium is an essential nutrient for plants, contributing to cell wall development, root growth, and overall plant structure (White and Broadley, 2003). In earth calcium accounts for 3.6 % of crust, it occurs in different forms such as marble, dolomite, limestone, corals etc. (Anderson, 1977). Calcite is one of the most common form of calcium carbonate (CaCO_3) known to be stable (Mucci *et al.*, 1983). Calcium carbonate in soil participates in the long-term sequestration of atmospheric carbon dioxide (CO_2) through the process of mineral carbonation (Richter *et al.*, 2009). Calcite in soil act as source of calcium for plants nutrient requirement but higher concentration of calcium carbonate in soil can lead to development of problematic soil (Xu *et al.*, 2021). Soil degradation is a major concern for agriculture throughout the world (Tazeh *et al.*, 2013). This reduces agricultural production significantly in comparison to normal soil because of the higher pH, exchangeable sodium ions (Rengasamy, 2006).

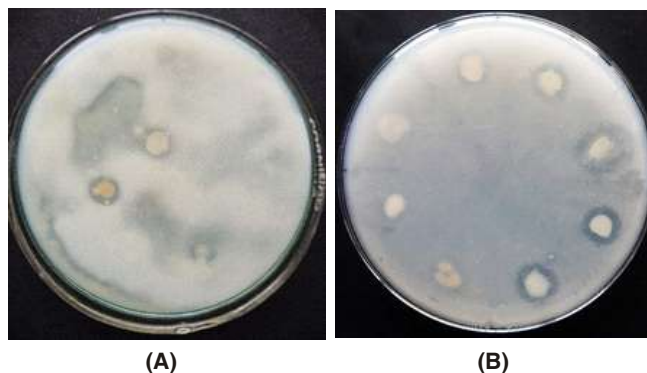
Marble processing is a growing industry in India particularly in the state of Rajasthan (Rana *et al.*, 2015). However a serious environment concern arises due to 70 % industrial loss of marble during extraction process, results in marble slurry and ultimately to larger dumping areas (Benjeddou *et al.*, 2021). Calcite solubilizing bacteria (CSB) have been recognised to have potential calcite dissolution activity which produces soluble Ca^{2+} ions. This leads to increase the availability of calcium for plants growth and metabolism (Tamilselvi *et al.*, 2016).

Their application in agriculture can significantly improve physical properties of soil and agricultural land when applied as Plant growth promoting rhizobacteria (Sulu-Gambari, 2012). Soil is a rich source of bacteria but only a few posses calcite solubilizing activity.

Calcite solubilizing bacteria (CSB) are a fascinating group of microorganisms that possess the unique ability to dissolve and mobilize calcium carbonate, a commonly occurring mineral in various geological and environmental settings (Hammes *et al.*, 2003). These bacteria produce specific enzymes, such as urease, that catalyze the hydrolysis of urea, including the role of exopolysaccharides and amino acids leadings to the production of ammonia and carbonate ions (Braissant *et al.*, 2003). The increase in carbonate ions triggers the solubilization of calcium carbonate, resulting in its dissolution and release of calcium and bicarbonate ions into the surrounding environment. Additionally, (Stocks-Fischer *et al.*, 1999) focused on the microbiological precipitation of calcium carbonate and its implications in soil biology and biochemistry. Moreover, discussed bacterial-induced mineral precipitation, with insights gained from the study of *Myxococcus*-induced mineralization (Rodriguez *et al.*, 2011).

Isolation of Calcite solubilizing bacteria : Various methodologies have been employed for the isolation of CSB from different environmental sources, including soils, sediments, and aquatic systems. Common approaches involve the enrichment of samples in selective media containing calcium carbonate as the sole carbon source, along with other nutrients. For isolation of the calcite

solubilizing bacteria by serial dilution and plating technique using DB agar medium method described by (Cacchio *et al.*, (2019) is generally used. In this study 10 potential CSB strains has been isolated from various marble slurry dump yards. Initially isolates were cultured by spreading on DB agar media and incubated for a week, resultants colonies were selected based on visual characterization after dot test as shown in figure bellow.



Cacchio *et al.* (2004) isolated 11 calcifying bacterial strains in their investigation from Cervo cave, a karst cave located near L'Aquila in Central Italy. Rana *et al.* (2015b) experimented by isolating 12 bacterial isolates from both fresh cow dung and stored cow dung showed the ability of calcite solubilization in availability and absence of urea.

Subrahmanyam *et al.* (2012) demonstrated that some bacteria represent two keystone culturable carbonate-dissolving heterotrophic bacterial phyla involved in *in vitro* carbonate dissolution and attendant miliolite weathering. Silveira *et al.* (2022) showed the potential strains of bacteria are able to solubilize Ca^{2+} from eggshells.

Plant Growth Promoting attributes : Plant Growth-Promoting Rhizobacteria (PGPR) are a group of beneficial microorganisms that colonize the rhizosphere, the region of soil surrounding plant roots. These bacteria form a symbiotic relationship with plants, providing various growth-promoting benefits (Bhardwaj *et al.*, 2014). PGPR can improve plant health and productivity through several mechanisms, including nutrient solubilization, production of plant growth hormones, and protection against pathogens (Glick, 2014; Lugtenberg and Kamilova, 2009). Additionally, PGPR can stimulate the plant's natural defence mechanisms and produce antimicrobial compounds, thus providing protection against soil-borne pathogens (Vessey, 2003). In the present investigation all CSB isolates shown potential results for plant growth promoting activities. The results are shown in the table given bellow.

S. No.	Strains	IAA $\mu\text{g/mL}$	Ammonia production	HCN production	P-solubilization index	K-solubilization index	Siderophore production index
1.	CS35	2.75	+	+	0.16	2.33	4.50
2.	CS29	5.55	+	+	0.49	1.4	3.04
3.	CS31	1.2	+	-	1.85	3.07	0.94
4.	CS43	1.6	-	+	-	1.22	2.12
5.	CS54	1.55	+	-	0.87	0.98	0.67
6.	CS62	2.3	+	-	-	0.55	1.77
7.	CS67	1.35	+	+	2.1	0.79	-
8.	CS88	0.65	-	-	2.06	1.25	0.75
9.	CS49	4.45	+	+	5.08	0.96	-
10.	CS40	1.55	+	-	0.93	2.88	3.01

IAA Production : Cassán *et al.* (2009) identified *Azospirillum brasilense* Sp7 from rhizosphere of maize plants capable of IAA production. Arshad and Frankenberger Jr (1998) evaluated that several species within the *Enterobacter* genus have been found to produce IAA. *Enterobacter spp.* have been isolated from different environmental sources, including rhizosphere soil and plant tissues.

Cassán *et al.* (2016) showed the ability of *Azospirillum brasilense* is a well-known plant growth-promoting rhizobacterium that can produce IAA, to synthesize IAA because of the presence of specific enzymes, such as tryptophan monooxygenase (*iaaM*) and indoleacetamide hydrolase (*iaaH*).

Chowdhury *et al.* (2015) demonstrated the ability of *Bacillus subtilis* and *Bacillus amyloliquefaciens* FZB42 to produce IAA. It possesses the enzyme indole-3-acetamide hydrolase, which converts tryptophan into IAA. Patten & Glick (2002) studied *Pseudomonas putida* for its IAA production and reported that it possesses the enzyme indole-3-pyruvate decarboxylase, which is involved in the synthesis of IAA from indole-3-pyruvic acid.

Siderophore production : Afzal *et al.* (2021) isolated and characterized siderophore-producing strains and found that their inoculation resulted in improved plant growth, increased photosynthetic pigment content, and enhanced oxidative stress tolerance in maize plants.

Gupta *et al.* (2020) focused on the siderophore production by *Pseudomonas sp.* DW1 and its potential to alleviate heavy metal stress in maize plants and demonstrated that the siderophore-producing strain effectively promoted plant growth.

Ammonia production : The ammonia produced by PGPR can enhance nitrogen availability, promote nutrient uptake, and contribute to overall plant growth and development (Bashan and de-Bashan, 2010).

Mishra *et al.*, (2018) experimented and showed that *Burkholderia phytofirmans* promotes plant growth and alleviates heavy metal stress through various mechanisms, including ammonia production (Dobbelaere *et al.*, 2002). The bacterium possesses enzymes involved in the degradation of organic nitrogen sources, such as amino acids, leading to the release of ammonia. This ammonia production enhances nutrient availability and aids in heavy metal detoxification. Xu *et al.*, (2020) *Rhizobium leguminosarum* is a nitrogen-fixing bacterium that forms a symbiotic relationship with leguminous plants. It produces ammonia through the process of nitrogen fixation, wherein atmospheric nitrogen is converted into ammonia by the enzyme nitrogenase.

Phosphate solubilizing activity : Organic acids, such as citric acid, gluconic acid, and oxalic acid, are excreted by PGPR and act as chelating agents, forming complexes with insoluble phosphates and facilitating their solubilization (Rodríguez and Fraga, 1999).

Glick (2012) reported that bacterial species related to many genera such as *Pseudomonas* spp., *Agrobacterium* spp. and *Bacillus* spp., can be used for soil inoculation in order to enhance phosphorus availability in soil by solubilization and mineralization abilities. Yu *et al.* (2022) isolated three PSB strains (identified as JP233, JP236, and J221) based on the development of a clear halo around the colonies after 7 days of incubation and identified as *P. putida*, *P. plecoglossicida* and *P. motellii*. The *Burkholderia gladioli*, *Bacillus megaterium*, *Enterobacter* spp., *Azospirillum brasilense*, *Pseudomonas fluorescens* are some of the phosphorus solubilizing bacterial sp. (Gaiero *et al.*, 2013).

Potassium mobilization : Singh *et al.* (2021) focused on mustard crops grown in potassium-deficient soil. They found that potassium-solubilizing bacteria enhanced plant growth, nutrient uptake, and yield in mustard plants, suggesting the potential of PGPR for mitigating potassium deficiency effects. Azarang *et al.* (2020) investigated the effects of biofertilizers containing potassium-solubilizing bacteria on maize plants. The study demonstrated that the application of these biofertilizers improved yield and nutrient uptake in maize plants, indicating the role of PGPR in enhancing potassium availability.

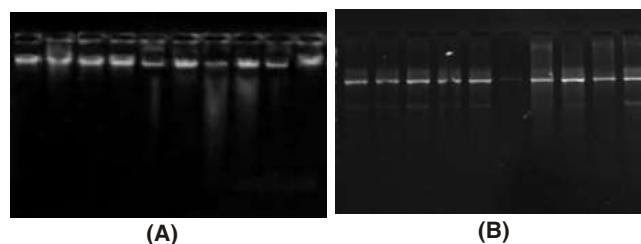
PGPR utilize the enzyme hydrogen cyanide synthase (HCN synthase) to catalyze the production of HCN from glycine and potassium cyanide (Bakker *et al.*, 1987).

Sinha *et al.*, (2019) identified several bacterial strains capable of HCN production and evaluated their plant growth-promoting potential. *Pseudomonas*

fluorescens, *Bacillus subtilis*, *Bacillus pumilus*, *Enterobacter cloacae* are some of the bacterial sp. responsible for HCN production in rhizosphere.

Singh *et al.*, (2020) conducted a study focused on the isolation and characterization of HCN-producing rhizobacteria from the rhizosphere of wheat plants in India and isolated several potential bacterial strains.

Molecular characterization : In recent years, molecular techniques have revolutionized microbial characterization, allowing for easy and rapid identification at various taxonomic levels, including genus, species, and even strain level (Gandhi *et al.*, 2014; Singh *et al.*, 2015; Ramanan *et al.*, 2016). These techniques utilize advanced molecular biology tools, such as DNA sequencing, polymerase chain reaction (PCR), and gene expression analysis, to analyze the genetic material of microorganisms. By targeting specific genes or regions in the microbial genome, researchers can obtain valuable information about the genetic diversity, phylogenetic relationships, and functional capabilities of microbial communities (Kumar *et al.*, 2017; Vaz-Moreira *et al.*, 2018). In the present investigation molecular characterization of 10 CSB isolates was carried out, initially DNA was isolated and 16S amplification was performed as shown in figure and characterization based on ARDRA technique.



Similarly, Velu *et al.* (2019) conducted the study by employing molecular techniques, including 16S rRNA gene sequencing, to identify and characterize the *Bacillus subtilis* and *Pseudomonas putida* strains involved in calcium carbonate precipitation. Devda *et al.* (2021) investigated the molecular characterization of CSB through 16S rRNA gene sequencing and universal primers, using PCR.

Jan *et al.* (2022) conducted studies and investigated the calcium carbonate (CaCO₃) precipitation potential of three bacterial strains: GSN-11, TFSN-14, and TFSN-15. These bacterial isolates were identified using 16S rRNA gene sequencing. The results of the sequencing revealed that strain GSN-11 belonged to the species *Bacillus toyonensis*, TFSN-14 was identified as *Paracoccus limosus*, and TFSN-15 was classified as *Brevundimonas diminuta*.

Conclusions

CSB strains isolated from various marble slurry dump yards have efficiency in calcite solubilizing activity, therefore can play a crucial role in bioremediation efforts leading to reclamation of calcareous soils. They also have potential PGPR activity. By improving nutrient availability, these bacteria can contribute to increased agricultural productivity and sustainable farming practices, also through harnessing CSB potential, it may be possible to enhance the dissolution of calcite in suitable geological formations, thus increasing CO₂ capture and storage capacity. CSB can also find applications in the concrete and construction industry. They can be used to produce self-healing concrete, where the bacteria are incorporated into the concrete mix. This biomineralization process can be useful for various applications, including the production of biodegradable materials, fabrication of novel biomaterials, and the development of biosensors and bioelectronics.

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Personal Socio-Economic Characteristics of the Turmeric Growers in Udaipur District of Rajasthan

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Abstract

Turmeric (*Curcuma longa* L), the ancient and sacred spice of India known as, "Indian saffron" is an important commercial spice crop grown in India. It is a native of India and is domesticated in Southern East Asia. Due to a larger area under turmeric in India, it is popularly known as 'Goldmine of India' and 'Indian Saffron'. The present study was designed to evaluate the personal socio-economic characteristics of the turmeric growers in Udaipur district of Rajasthan. The present study was conducted in Jhadol and Gogunda panchayat samities in Udaipur district of Rajasthan. For the purpose of study total 100 turmeric growers were included in the study sample. Data were collected through pre structured interview schedule. The findings of the study revealed that majority of respondents belonged to age group 33-64 years. 51.00 per cent respondents were having Pakka house. 52.00 per cent respondents belonged to nuclear families category. Maximum 77.00 per cent of respondents belonged to medium income group i.e., Rs. 29,624 to Rs. 1,55,205 per annum. 40.00 per cent respondents were belongs to ST caste. 44.00 per cent respondents were marginal farmers. 31.00 per cent of respondents were educated up to primary. Majority (74.00 %) of respondents reported to have medium level of sources of information.

Key words : Personal socio-economic characteristics, turmeric.

Introduction

India is known as 'Land of Spices'. India is the largest producer, consumer and exporter of spices in the world followed by China. The total area under these spices and condiments in India is over 45.28 lakh hectare and produce annually about 106.79 lakh tonnes (Ministry of Agriculture & Farmers Welfare 2021). The rapid stride in production has made available quality spices for export.

India utilizes 90.00 per cent of its production for domestic consumption. About 109 spices are notified all over world where India as single country grows 63 species among them. Share of spices in total agricultural export of India is about 6 per cent. India's share of world spice trade is about 45.00 to 50.00 per cent by volume and 25.00 to 30.00 per cent by value.

Turmeric (*Curcuma longa* L), the ancient and sacred spice of India known as, "Indian saffron" is an important commercial spice crop grown in India. The word "turmeric" is derived from a Latin word "terra merita" means "meritorious earth" referring to the colour of ground turmeric. Turmeric was grown and has been under cultivation in India from times immemorial. It is a native of India and is domesticated in Southern East Asia. Nearly about 80.00 per cent of world turmeric production comes

from India. Due to a larger area under turmeric in India, it is popularly known as 'Goldmine of India' and 'Indian Saffron'.

Udaipur district is second largest turmeric producing district in Rajasthan with an area of 55 hectares and production of 102 M.T. (Metric Tonnes) of turmeric in the state during the year 2020-21.

Research Methodology

The present study was conducted in Udaipur district of Rajasthan because Udaipur district have maximum area under turmeric cultivation in MPUAT service area during 2020-21 and the climatic condition of this district is most suitable for cultivation of turmeric. Two panchayat samities, namely Jhadol and Gogunda with maximum area under turmeric cultivation were selected for the study sample. Five villages from each panchayat samiti were identified on the basis of maximum area under turmeric cultivation. Thus, all ten villages were selected for the present investigation. Out of list, 10 farmers were selected from each village through random sampling technique. Thus, a total number of 100 turmeric growers were selected for the present investigation. The Ex-post-facto research design was used for the present study. Personal interview technique was used to collect data from the selected respondents thereafter; the data were then

Table-1 : Distribution of respondents on the basis of age.

Sr. No.	Age group	Jhadol Panchayat Samiti (n ₁ =50)		Gogunda Panchayat Samiti (n ₂ =50)		Total (n=100)	
		f	%	f	%	f	%
1.	Young (<33 years)	11	22.00	7	14.00	18	18.00
2.	Middle (33-64 years)	29	58.00	31	62.00	60	60.00
3.	Old (> 64 years)	10	20.00	12	24.00	22	22.00
	Total	50	100	50	100	100	100

f = frequency, % = per cent, Mean = 48.42, S.D. =15.58

Table-2 : Distribution of respondents according to their type of house.

Sr. No.	Type of house	Jhadol Panchayat Samiti (n ₁ =50)		Gogunda Panchayat Samiti (n ₂ =50)		Total (n=100)	
		f	%	f	%	f	%
1.	Kaccha	27	54.00	22	44.00	49	49.00
2.	Pakka	23	46.00	28	56.00	51	51.00
	Total	50	100	50	100	100	100

f = frequency, % = per cent

Table-3 : Distribution of respondents according to their Family type.

Sr. No.	Type of house	Jhadol Panchayat Samiti (n ₁ =50)		Gogunda Panchayat Samiti (n ₂ =50)		Total (n=100)	
		f	%	f	%	f	%
1.	Nuclear	28	56.00	24	48.00	52	52.00
2.	Joint	22	44.00	26	52.00	48	48.00
	Total	50	100	50	100	100	100

f = frequency, % = per cent

Table-4 : Distribution of respondents according to their annual income.

Sr. No.	Type of house	Jhadol Panchayat Samiti (n ₁ =50)		Gogunda Panchayat Samiti (n ₂ =50)		Total (n=100)	
		f	%	f	%	f	%
1.	Low income (< Rs.29,624)	2	04.00	4	08.00	6	06.00
2.	Medium income (Rs.29,624 to 1,55,205)	39	78.00	38	76.00	77	77.00
3.	High income (>Rs.1,55,205)	9	18.00	8	16.00	17	17.00
	Total	50	100	50	100	100	100

f = frequency, % = per cent, Mean =92415, S.D. = 62790

Table-5 : Distribution of respondents according to their caste.

Sr. No.	Caste	Jhadol Panchayat Samiti (n ₁ =50)		Gogunda Panchayat Samiti (n ₂ =50)		Total (n=100)	
		f	%	f	%	f	%
1.	ST	20	40.00	20	40.00	40	40.00
2.	SC	13	26.00	11	22.00	24	24.00
3.	OBC	10	20.00	9	18.00	19	19.00
4.	General	7	14.00	10	20.00	17	17.00
	Total	50	100	50	100	100	100

f = frequency, % = per cent

tabulated and analyzed with mean, standard deviation, were worked out for interpretation of results.

Results and Discussion

The findings on distribution of respondents according to

their selected personal socio-economic characteristics is presented in respective tables :

The data presented in table 1 depicts that out of total respondents, 60.00 per cent respondents belonged to middle age group of 33-64 years. While, 22.00 per cent respondents were found in old age group of above 64

Table-6 : Distribution of respondents on the basis of their size of land holding.

Sr. No.	Land Holding	Jhadol Panchayat Samiti (n ₁ =50)		Gogunda Panchayat Samiti (n ₂ =50)		Total (n=100)	
		f	%	f	%	f	%
1.	Marginal (below 1.00 ha)	26	52.00	18	36.00	44	44.00
2.	Small (1.01-2.00 ha)	18	36.00	19	38.00	37	37.00
3.	Semi-medium (2.01-4.00 ha)	6	12.00	13	26.00	19	19.00
	Total	50	100	50	100	100	100

f = frequency, % = per cent

Table-7 : Distribution of respondents on the basis of their education level.

Sr. No.	Education Level	Jhadol Panchayat Samiti (n ₁ =50)		Gogunda Panchayat Samiti (n ₂ =50)		Total (n=100)	
		f	%	f	%	f	%
1.	Illiterate	23	46.00	5	10.00	28	28.00
2.	Primary	12	24.00	19	38.00	31	31.00
3.	Secondary	8	16.00	11	22.00	19	19.00
4.	Senior Secondary	4	08.00	9	18.00	13	13.00
5.	Graduation & above	3	06.00	6	12.00	9	09.00
	Total	50	100	50	100	100	100

f = frequency, % = per cent

Table-8 : Distribution of respondents according to their sources of information.

Sr. No.	Sources of information	Jhadol Panchayat Samiti (n ₁ =50)		Gogunda Panchayat Samiti (n ₂ =50)		Total (n=100)	
		f	%	f	%	f	%
1.	Low (<8.44)	7	14.00	5	10.00	12	12.00
2.	Medium (8.44 to 12.39)	38	76.00	36	72.00	74	74.00
3.	High (>12.39)	5	10.00	9	18.00	14	14.00
	Total	50	100	50	100	100	100

f = frequency, % = per cent, Mean = 10.42, S.D. = 1.97

years and remaining 18.00 per cent respondents were found in young age group of less than 33 years. Findings are in line with findings of Karthiga *et al.* (2021) ^[2].

The data presented in the Table 2 indicates that out of 100 respondents, 51.00 per cent respondents were having Pakka house. While, 49.00 per cent respondents of study area were having Kaccha house.

The data presented in Table 3 indicates that 52.00 per cent respondents belonged to nuclear families and remaining 48.00 per cent respondents belonged to joint families. The findings are supported by the findings of Sahoo *et al.* (2017) ^[4].

Table 4 reveals that out of 100 respondents, Maximum 77.00 per cent of respondents belonged to medium income group *i.e.*, Rs. 29,624 to Rs. 1,55,205 per annum. While, 17.00 per cent respondents belonged to high income group *i.e.*, above Rs. 1,55,205 per annum. Only 06.00 per cent of respondents were belonging to low-income group *i.e.*, less than Rs. 29,624 per annum. The findings are supported by the findings of Jhansi and Kalal (2022) ^[1].

It is evident from the Table 5 that 40.00 per cent respondents were belongs to ST caste, 24.00 per cent respondents belonged to SC caste, 19.00 per cent respondents belonged to OBC caste and only 17.00 per cent were belongs to General caste. The findings are supported by the findings of Mugadur and Hiremath (2014) ^[3].

The table 6 indicates that out of 100 respondents, 44.00 per cent respondents were marginal farmers. While, 37.00 per cent respondents were small farmers. Whereas, only 19.00 per cent respondents were semi-medium farmers. None of the respondents were medium and large farmers. The findings are in line with findings of Singh (2020) ^[5].

The data presented in table 7 found that one third (31.00 %) of respondents were educated up to primary, 28.00 per cent of respondents were illiterate, 19.00 per cent respondents were educated up to secondary, 13.00 per cent respondents were educated up to senior secondary and rest 09.00 per cent respondents were educated up to graduation & above level. The findings are supported by the findings of Sravani *et al.* (2021) ^[6].

The data presented in table 8 that out of 100 respondents, majority (74.00 %) of respondents reported to have medium level of sources of information. Whereas, 14.00 per cent respondents reported of using high level of sources of information and remaining 12.00 per cent respondents were using low level of sources of information. Findings are in agreement with the findings of Thakur *et al.* (2020) ^[7].

Conclusions

It was revealed that turmeric growers have good socio-economic condition. The present study has been conducted under limited characteristics, so that, it will be better if more characteristics of turmeric growers are taken for further research in this area. As socio-economic status of the turmeric growers is a complex phenomenon and includes so many things as stated earlier, it may be possible that some important components might have skipped out which may be considered by other research workers in future.

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Personal Socio-Economic Profile of the Lime Growers in Udaipur District of Rajasthan

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Abstract

Growing fruit had been an essential and traditional practice since prehistoric times. Fruit crop cultivation was crucial to the general well-being of humanity and the country. The study was conducted purposely in one district, namely Udaipur, based on the maximum area in lime cultivation in Southern Rajasthan. This district was located in MPUAT service area. Udaipur district comprised of fifteen Tehsils, out of which Gogunda, Jhadol, Girwa, and Badgaon were selected based on the maximum number of lime farmers. A proportionate number of respondents, 26 from Gogunda, 28 from Badgaon, 23 from Jhadol, and 23 from Girwa, were selected randomly from each Tehsil. Thus, a total of 100 respondents were selected for the present investigation. Data were collected through a pre-structured interview schedule. The study examined personnel characteristics of the lime farmers, which revealed that the majority of respondents belonged to the age group of 32 to 52 years. This age group alone constituted 70.00 percent of the respondents. Additionally, 76.00 percent of the respondents belonged to a medium income level, i.e., Rs. 1,28,774 to Rs. 3,32,226 per annum. Furthermore, 82.00 percent of the respondents belonged to joint families. The majority (47.00 percent) of the respondents belonged to the ST category. About 49.00 percent of the respondents were primary educated, and 66.00 percent of the respondents were small farmers with land size below 1.01-2.00 hectares. Moreover, 82.00 percent of the respondents had a medium level of extension contacts, and 72.00 percent of them had a medium level of access to sources of information.

Key words : Socio- economic, lime growers, MPUAT service area.

Introduction

Growing fruit had been an essential and traditional practice since prehistoric times. Fruit crop cultivation was crucial to the general well-being of humanity and the country. The production and per capita consumption of fruits determined a nation's population's standard of living. India had been the second-largest producer of fruits (107.10 million tonnes) in the world after China (240.79 million tonnes), contributing about 12.00 % of the global fruit production. With a 3.0% CAGR, fruit production in India had reached from 97.97 million tonnes in 2018-19 to 107.10 million tonnes in 2021-22. Fruits were a great source of fiber as well as important vitamins and minerals. Fruits also included a variety of antioxidants that promoted health, such as flavonoids. Nutritionists advised consuming 400 grams of fruit per person per day, with as much variety as the season allowed. The citrus family of fruits was one of the primary fruit crops that were cultivated worldwide. Citrus was mostly a subtropical crop, but it could also thrive in certain tropical and temperate regions. With an output of 14,850 thousand MT and a yield of 13.4 MT/ha, citrus in India ranked second in terms of economic importance behind mango among the fruit crops (Anonymous 2021-22). These fruits were cultivated commercially in states like Maharashtra, Gujarat, Seemandhra, Telangana, Uttarakhand, Bihar, Assam,

Karnataka, and Madhya Pradesh, while they were farmed on a large scale throughout the country.

Research Methodology

The investigation was conducted in the Udaipur district of southern Rajasthan because Udaipur district had the maximum area under lime cultivation in the MPUAT service area. The Udaipur district had fifteen Tehsils, of which Gogunda, Jhadol, Girwa, and Badgaon were chosen because they had the maximum number of lime farmers. The following respondents were chosen by proportionate sampling from each chosen Tehsil: 26 (Gogunda), 28 (Badgaon), 23 (Jhadol), and 23 (Girwa). 100 respondents were thus chosen in total for the inquiry. An interview schedule was designed for the collection of desired information. Thereafter, the data were tabulated and analyzed with mean and standard deviation, which were worked out for the interpretation of results.

Results and Discussion

The findings on distribution of respondents according to their selected personal and socioeconomic characteristics is presented in respective tables.

Table-1 shows that out of 100 respondents, majority of respondents belonged to age group 32 to 52 years. This age group alone constituted 70.00 per cent of

respondents. While 19.00 per cent respondent were having less than 32 years and remaining 11.00 per cent respondents reported from above 52 years of age. This information was consistent with the findings of Kumar *et al.* (2012) revealed that majority of respondents belonged to middle age group (31-45 years).

Table-1 : Distribution of all the respondents as per age. n=100

Sr. No.	Age Groups	f	%
1.	Young (<32 years)	19	19.00
2.	Middle (32-52 years)	70	70.00
3.	Old (>52 years)	11	11.00
	Total	100	100.00

f = frequency, % = per cent, Mean = 41.77, S.D. = 10.25

Table-2 reveals that out of 100 respondents, maximum 76.00 per cent respondents belonged to medium income group i.e., Rs.1,28,774 to Rs.3,32,226 per annum where 13.00 per cent respondent belonged to high income group or above i.e., Rs. 3,32,226 per annum and rest 11.00 per cent respondents belonging to low income group i.e., less than Rs.1,28,774 per annum.

Table-2 : Distribution of respondents according to annual income. n=100

Sr. No.	Annual Income (Rs.)	f	%
1.	Low income (< Rs.1,28,774)	11	11.00
2.	Medium income (Rs.1,28,774 to 3,32,226)	76	76.00
3.	High income (>Rs.3,32,226)	13	13.00
	Total	100	100.00

f = frequency, % = per cent, Mean = 230500, S.D. = 101726.3

The details indicated in table 3 shows that majority 82.00 per cent respondents belonged to joint families. Whereas, 18.00 per cent respondents belonged to nuclear family.

Table-3: Distribution of respondents as per family type. n=100

Sr. No.	Family Type	f	%
1.	Nuclear	18	18.00
2.	Joint	82	82.00
	Total	100	100.00

f = frequency, % = per cent

The data presented in table 4 indicates that majority 47.00 per cent of respondents belonged to ST category. On the other hand, 42.00 per cent respondents were of General category, 06.00 per cent respondents were of OBC category and remaining 05.00 per cent of respondents belonged to SC category.

Table-4 : Distribution of respondents according to caste. n=100

Sr. No.	Caste	f	%
1.	SC	05	05.00
2.	ST	47	47.00
3.	OBC	06	06.00
4.	General	42	42.00
5.	Total	100	100.00

f = frequency, % = per cent

Data shown in table 5 presents that majority 49.00 per cent of respondents were primary education. On the other hand, 24.00 per cent respondents educated up to secondary, 21.00 per cent respondents educated up to senior secondary, 06.00 per cent respondents educated up to graduation and above level and rest not a single respondents was illiterate.

Table-5 : Distribution of respondents according to their education level. n=100

Sr. No.	Education	f	%
1.	Primary	49	49.00
2.	Secondary	24	24.00
3.	Senior Secondary	21	21.00
4.	Graduation and above	06	06.00
	Total	100	100.00

f = frequency, % = per cent

The table 6 indicates that out of 100 respondents, 66.00 per cent respondents were small farmers having land size of below 1.01-2.00 ha. About 29.00 per cent of respondents were marginal farmers having land size of below 1.00 ha, while 03.00 per cent respondents were semi-medium farmers having land size of 2.01 to 4.00 ha. 02.00 per cent respondents was medium farmer having land size of 4.01-10.00 ha and none of respondents had land size of 10.01 ha and above.

Table-6 : Distribution of respondents according to land holding. n=100

Sr. No.	Land holding	f	%
1.	Marginal (Less 1.00 hectare)	29	29.00
2.	Small (1.01-2.00 hectares)	66	66.00
3.	Semi-Medium (2.01-4.00 hectares)	03	03.00
4.	Medium (4.01-10.00 hectares)	02	02.00
	Total	100	100.00

f = frequency, % = per cent

Data given in table 7 reveals that out of 100 respondents, 82.00 per cent respondents had medium level of extension contacts, while 11.00 per cent respondents were having high level of extension contacts and remaining 07.00 per cent respondents were having low level of extension contacts.

Table-7: Distribution of respondents according to extension contacts. n=100

Sr. No.	Extension contacts	f	%
1.	Low (< 1.92)	07	07.00
2.	Medium (1.92 to 4.14)	82	82.00
3.	High (> 4.14)	11	11.00
	Total	100	100.00

f = frequency, % = per cent, Mean = 3.03, S.D. = 1.11

The data presented in table 8 that out of 100 respondents, majority 72.00 per cent of them had medium level of access to source of information where 18.00 per cent of them had low level access to source of information

and rest 10.00 per cent of them had high level access to source of information.

Table-8 : Distribution of respondents according to source of information. n=100

Sr. No.	Source of information	f	%
1.	Low (< 3.22)	18	18.00
2.	Medium (3.22 to 6.00)	72	72.00
3.	High (> 6.00)	10	10.00
	Total	100	100.00

f = frequency, % = per cent, Mean = 4.61, S.D. = 1.39

Conclusions

It was revealed that lime growers have good socio-economic condition. The study revealed that majority of respondents belong to middle age group, 76.00 per cent respondents were belong to medium income level i.e., Rs. 1,28,774 to Rs.3,32,226 per annum, majority of respondents belonged to joint family, majority (47.00%) of respondents belongs to ST category, (49.00 %) of respondents were primary, 66.00 per cent respondents

were small farmers having land size below 1.01- 2.00 ha, (82.00 %) respondents have medium level of extension contacts, (72.00 %) of them have medium level of access to source of information.

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Effect of Fertility Levels, Vermicompost and Biofertilizers on Nutrient Content and Uptake in Clusterbean {*Cyamopsis tetragonoloba* (L.) Taub}

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Abstract

A field experiment was conducted during the *kharif* season of 2022 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan) to evaluate the effect of Fertility Levels, Vermicompost and Biofertilizers on Productivity of Clusterbean. Result show that 100% RDF observed maximum nutrient content (seed and haulm) and uptake (seed, haulm and total by crop). A significant increase in nutrient (N and P) content in seed and haulm and uptake (N, P and K) by seed, haulm and total uptake by crop were recorded with application of 2.5 t vermicompost ha⁻¹. Highest N, P and K content (seed and haulm) and uptake (seed, haulm and total by crop) was recorded with NPK consortium + *Rhizobium*.

Key words : Biofertilizers, clusterbean, fertility levels, productivity and vermicompost.

Introduction

Clusterbean {*Cyamopsis tetragonoloba* (L.) Taub} popularly known by its indigenous name “Guar” belongs to the family *Fabaceae* (*Leguminosae*). It is an important cash crop, grown in semi-arid and arid regions of tropical India during *kharif* season. Among leguminous crops, it is comparatively more drought hardy crop due to its deep root system. Clusterbean is grown for various purpose since ancient time viz., vegetable, green fodder, production of seed and endospermic gum. It is also cultivated for hay, silage and green manure (Grestaa *et al.*, 2013). In the recent years, besides its conventional uses, it has emerged as an industrial crop due to presence of galactomannan (gum). The spherical shaped endosperm contains 28-33 % gum (Goldstein and Alter, 1959).

Mature clusterbean seed contain 23% protein, 1.7% fat, 6% carbohydrate and traces of vitamins and minerals. It is very good source of vitamin A, calcium, phosphorus, iron and ascorbic acid (Vijaylaxmi and Singh, 2011). Clusterbean enriches the soil by fixing atmospheric nitrogen almost 50-150 kg ha⁻¹, thus it helps in nitrogen economy (Lal, 1985). Sometimes it is used in reclamation of saline and alkaline soils (Kay, 1979).

A crop nutrient management plan is a tool that can increase the availability of all the nutrient. Among different plant nutrients, nitrogen plays an important role in synthesis of amino acid and chlorophyll, which contributes to the building units of protein and thus promotes the growth of plants. Insufficient nitrogen may deteriorate the

quality of produce and reduce yield drastically. The nitrogen application increased carbohydrates, crude fibre contents, crude protein, ash %, leaf area plant⁻¹, dry matter and green fodder yield of clusterbean cultivars (Mohammad *et al.*, 2011). Phosphorus increases the activity of rhizobia, formation of root nodules, stimulates early root development, help in more atmospheric nitrogen fixation and improve grain formation when applied to legumes. It also improves the crop quality and resistance to disease.

Organic manure (FYM and vermicompost) is the important component of the integrated nutrient management system. Manure supply plant nutrient in small quantities and provide organic matter in large quantities. When manure was applied in conjunction with chemical fertilizers for optimum growth of crop, the decline in organic carbon was arrested and the gap between actual yield and potential yield was bridged to a large extent (Singh *et al.*, 2007). According to Roy and Singh (2006), the use of vermicompost is being advocated for sustaining soil fertility in various field crops. Vermicompost is nutritionally rich organic fertilizer, which slowly release nutrients in the soil, to overcome the problem of leaching. Moreover, they also help in balancing the nutrient availability to growing as well as succeeding crop and boost up the quality and production of crop.

Biofertilizer is microbial inoculants of selective microorganisms which have the capacity to mobilize nutritionally important elements from non- available to available form through biological processes such as

atmospheric nitrogen fixation, phosphate solubilization, excretion of plant growth promoting substances or cellulose and lignin biodegradation in soil, compost and other environments. They are effective, renewable and low-cost source of plant nutrients to the supplement of chemical fertilizers (Boraste *et al.*, 2009). Biofertilizers help in the maintaining long term soil fertility and sustainability. It may increase yield of crops by 10-30 % (Khandelwal *et al.*, 2012). They play a significant role in improving availability of nutrient to the plants. They are recognised as a constituents of integrated plant nutrient supply system (Anonymous, 2020). Clusterbean being a legume crop which has the capacity to fix atmospheric nitrogen by its effective root nodules. Biofertilizer increases the number of such microorganism and effective root nodule. The major part of nitrogen is met through nitrogen fixation.

Materials and Methods

The experiment was conducted during the *kharif* season of 2022 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction (pH 8.3), medium in available nitrogen (284.19 kg ha⁻¹), organic carbon (0.68 %), available phosphorus (18.65 kg ha⁻¹) and high in available potassium (319.50 kg ha⁻¹). The experiment consisted of eighteen treatment combination of three fertility levels (50% RDF, 75% RDF and 100% RDF), two vermicompost level (control and 2.5 t vermicompost ha⁻¹) and three biofertilizer combination (*Rhizobium*, *Rhizobium* + PSB and NPK consortium + *Rhizobium*) were replicated three times in factorial randomized block design. RDF (Recommended dose of fertilizers)- 20 kg N+40 kg P₂O₅ was applied as per treatment. In the experiment, clusterbean (variety RGC- 1033) was sown. The nutrient content was determined by the following method Nitrogen by Nessler's reagent colorimeter method (Snell and Snell, 1949), Phosphorus by Ammonium vanado-molybdate yellow colour method (Richards, 1968), Potassium by Flame photometer method (Jackson, 1973). The uptake of N, P and K after harvest in seed and haulm was estimated by multiplying the nutrient concentration values with yield of crop. The data were statically analysed using standard procedure of ANOVA at 5% level of significance.

Results and Discussion

Nutrient content

Fertility levels : Increasing levels of fertility up to 100% RDF significantly increased N and P content in seed and haulm and K content in haulm also. However, application of 100% RDF increased the K content in seed which was

found at par with 75% RDF. The increased translocation of N, P and K in plant parts may be caused by an improved nutritional environment in the rhizosphere and in the plant system. The increase in the factors that contributed to the crop's ability to absorb nutrients under 100% RDF over 50% RDF and 75% RDF could be attributed. These outcomes closely matched the conclusions of Bahadur and Chaplot (2014), Kumawat *et al.* (2017) in clusterbean.

Vermicompost : A significant increase in N and P content in seed and haulm and K content in haulm were recorded with application of 2.5 t vermicompost ha⁻¹ (Table-1). This could be as a result of vermicompost, which increases the availability of nutrients during the early stages of development through chemical fertilisers and other means. Vermicompost not only delivers essential nutrients but also improves soil conditions close to the rhizosphere.

Biofertilizers : It was observed that seed treated with NPK consortium + *Rhizobium* significantly increased N and P content in seed, however, the aforesaid inoculation failed to increase in potassium content in seed and haulm. The application of biofertilizer might have enhanced the nutrient environment in the plant system and rhizosphere, resulting in increased uptake and translocation of nutrients in the reproductive structures, which in turn led to their larger content and intake.

Nutrient uptake

Fertility levels : N, P and K uptake by seed, haulm and crop of clusterbean significantly increased up to 100% RDF. Application of 100% RDF was superior over 50 and 75% RDF in this regard (Table 2). nutrient uptake depends on the amount of nutrients in crop plants, seed yield and haulm yield. These values may have increased as a result of enhanced N and P fertilisation, which increased nutrient uptake in the current study. The maximum nitrogen, phosphorus and potassium uptake was seen when fertilisers had higher levels of N, P₂O₅ and K₂O (Goud *et al.*, 2014).

Vermicompost : Significantly maximum N, P and K uptake by seed, haulm and crop of clusterbean were recorded with application of 2.5 t vermicompost ha⁻¹. Application of vermicompost enhances soil quality, provides nutrients to the crop, and directly affects yield traits, biomass, and dry matter, all of which increase nutrient uptake. The outcomes are quite similar to Khokhar and Nepalia (2010), Sheoran *et al.* (2015) and Banotra *et al.* (2021) findings.

Biofertilizers : Results of the investigation in Table 2 indicated that significantly highest N, P and K uptake by seed, haulm and total by clusterbean crop was recorded

Table-1 : Effect of fertility levels, vermicompost and biofertilizers on nutrient content of clusterbean.

Treatments	Nutrient content (%)					
	Nitrogen		Phosphorus		Potassium	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Fertility level (% RDF)						
F ₁ -50	3.998	0.806	0.592	0.149	0.426	0.966
F ₂ -75	4.239	0.815	0.624	0.156	0.440	0.982
F ₃ -100	4.452	0.826	0.662	0.175	0.454	1.099
S.Em.±	0.023	0.003	0.005	0.001	0.006	0.005
C.D.(P=0.05)	0.067	0.009	0.015	0.003	0.016	0.015
Vermicompost level (t ha⁻¹)						
V ₁ -0	4.190	0.809	0.616	0.158	0.440	0.994
V ₂ -2.5	4.270	0.823	0.636	0.163	0.455	1.038
S.Em.±	0.019	0.003	0.004	0.001	0.005	0.004
C.D.(P=0.05)	0.054	0.008	0.013	0.002	0.014	0.013
Biofertilizers						
B ₁ - <i>Rhizobium</i>	4.107	0.808	0.609	0.158	0.442	1.006
B ₂ - <i>Rhizobium</i> + PSB	4.230	0.816	0.626	0.161	0.435	1.022
B ₃ -NPK consortium + <i>Rhizobium</i>	4.352	0.823	0.642	0.162	0.443	1.019
S.Em. ±	0.023	0.003	0.005	0.001	0.006	0.005
C.D.(P=0.05)	0.067	0.009	0.015	0.003	NS	NS

Table-2 : Effect of fertility levels, vermicompost and biofertilizers on nutrient uptake by clusterbean.

Treatments	Nutrient uptake (kg ha ⁻¹)								
	Nitrogen			Phosphorus			Potassium		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Fertility level (% RDF)									
F ₁ -50	31.34	14.76	46.10	4.65	2.73	7.38	3.33	17.67	21.00
F ₂ -75	37.59	17.24	54.83	5.52	3.29	8.81	3.90	20.75	24.65
F ₃ -100	41.07	18.66	58.72	6.10	3.76	9.86	4.18	23.55	27.73
S.Em.±	0.86	0.38	0.99	0.13	0.07	0.15	0.10	0.43	0.45
C.D.(P=0.05)	2.48	1.09	2.83	0.38	0.19	0.43	0.28	1.24	1.30
Vermicompost level (t ha⁻¹)									
V ₁ -0	34.52	15.82	50.34	5.08	3.10	8.17	3.61	19.45	23.06
V ₂ -2.5	38.81	17.28	56.09	5.78	3.43	9.20	3.99	21.87	25.85
S.Em.±	0.70	0.31	0.81	0.11	0.05	0.12	0.08	0.35	0.37
C.D. (P=0.05)	2.02	0.89	2.31	0.31	0.16	0.35	0.23	1.01	1.06
Biofertilizers									
B ₁ - <i>Rhizobium</i>	33.00	15.26	48.26	4.91	2.98	7.90	3.54	19.05	22.60
B ₂ - <i>Rhizobium</i> + PSB	36.57	16.59	53.16	5.41	3.28	8.69	3.75	20.82	24.57
B ₃ -NPK consortium + <i>Rhizobium</i>	40.42	17.81	58.23	5.96	3.52	9.48	4.11	22.10	26.21
S.Em.±	0.86	0.38	0.99	0.13	0.07	0.15	0.10	0.43	0.45
C.D.(P=0.05)	2.48	1.09	2.83	0.38	0.19	0.43	0.28	1.24	1.30

with NPK consortium + *Rhizobium*. The total uptake of nitrogen, phosphorous and potassium increased significantly as a result of the increased concentration of nutrients as well as the higher seed and haulm yields because nutrient uptake is a function of seed and haulm yield and their nutrient content. These results are closely matched with those of Mahawar *et al.* (2014), Navsare *et al.* (2018) and Kumawat *et al.* (2020).

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Effect of Pelleted Vermicompost on Growth Characters of Organic Greengram

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Abstract

A field experiment entitled "Effect of Pelleted Vermicompost on growth characters of organic greengram" was conducted during *kharif*, 2022 at Organic Farming Unit, Instructional Agronomy Farm of Rajasthan College of Agriculture, MPUAT, Udaipur. The experiment was laid out in factorial randomized block design with three replications and assigning 15 treatment combinations consisting of control and four levels of doses of pelleted vermicompost (1 t ha^{-1} , 2 t ha^{-1} , 3 t ha^{-1} and 4 t ha^{-1}) and three levels of scheduling of pelleted vermicompost (100 % at sowing, 50 % at sowing + 50 % at 4 WAS, 50% at sowing + 25 at 4 WAS + 25 % at 6 WAS). The greengram variety GM-4 was sown on 24 July 2022 at 30 cm x 10 cm row to row and plant to plant spacing by using recommended seed rate of 15 kg ha^{-1} . Application of 4 t ha^{-1} pelleted vermicompost significantly increased the seed and haulm yield of organic greengram. The significantly higher seed yield (1190 kg ha^{-1}) and net return (73077 ha^{-1}) of organic greengram was obtained with the application of 4 t ha^{-1} pelleted vermicompost.

Key words : Pelleted vermicompost, scheduling, greengram.

Introduction

Organic farming is being practiced in 191 countries of the world. The non-beneficial effects of chemicals used in agriculture have changed the mindset of some consumers of different countries who are now buying organic produce with high premium for health. Policy makers are also promoting organic farming for restoration of soil health and generation of rural economy apart from making efforts for creating better environment. The global organic area is 76 million hectares of agricultural land are managed by at least 3.7 million farmers. The world organic market is now 125 billion US\$ (FiBL, 2021). In India, about 9.11 million ha area is under organic cultivation and total production of certified organic products is 3.41 million MT (APEDA, 2023). India is fast becoming a major base for production and supply of organically produced agricultural products to the world market. India has developed National Standards under NPOP programme. APEDA and the National Centre of Organic Farming under Ministry of Agriculture is promoting organic farming as facilitator across the country and providing various assistance to organic entrepreneurs and farmers in India.

The Greengram (*Vigna radiata* L.) is one of the important *kharif* pulse crop and also called mung, moong and mung bean in India. It is a leguminous pulse crop, which are high in protein, easily digestible, and consumed as food easily digested, and consumed as food. The pulses are the chief sources of protein in a balanced diet in Indian conditions and contribute about 15 per cent of diet (Kumar and Ali, 2004). In a symbiotic relationship with

specific soil rhizobia root nodules develop on mung beans in which atmospheric nitrogen is converted to forms available to the mung bean plant. It has the capacity to fix the 42 kg N ha^{-1} from atmospheric nitrogen. It also helps in preventing soil erosion being intensive crop rotation. Greengram can be used as feed for cattle after harvesting the pods, green plant is uprooted or cut from ground level and chapped into small pieces and feed to the cattle. The husk of the seed can be soaked in water and used as cattle feeds. It contains about 2.5% protein, 1.3% fat, 3.5 minerals, 4.1% fibers and 56.7% carbohydrates.

The efficiency of the nitrogen applied in satisfying the nitrogen demand of the crop depends on the type of manure, timing of manure application and seasonal trends and nitrogen is an effective material for improving the crop production. Crop response to manure is also influenced by soil type, crop sequence and the supply of residual and mineralized nitrogen. Therefore, numerous strategies such as use of nitrogen sources, slow-release fertilizer, placement techniques and nitrification inhibitors have been devised to reduce nitrogen losses and improve nutrient use efficiency (Hernandez *et al.*, 2006). An effective solution is to apply densification technology with molding of manure and compost into pellet (Alemi *et al.*, 2010). Pelleting is one such approach. In technological process in agriculture, pelleting is interaction between particles of material and applied forces, through a process of biomass densification, to increase its bulk density and decrease volume. Biomass densification is the use of some form of mechanical pressure to reduce the volume of grind material and conversion of this material to a solid

form (pellets), that is easier to handle and store than original material (Erickson and Prior, 1990; Hernandez *et al.*, 2006).

Materials and Methods

The organic farming unit, instructional farm at the Rajasthan College of Agriculture in Udaipur served as the site of the field experiment. It is located at 24°35'N latitude and 73°42'E longitude, in the southeast region of Rajasthan, at a height of 581.13 metre above mean sea level. It is located in Agro-climatic Zone IVa, which includes Rajasthan's Aravalli hills and the Sub-Humid Southern Plain. Maximum temperature is about 45°C during hot summer months of May and June, while during winter months of December and January the minimum temperature may be subzero. The actual mean weekly meteorological data during the crop seasons of *kharif* 2022-23, recorded at observatory located at, Instructional Farm, Rajasthan College of Agriculture, Udaipur, Rajasthan College of Agriculture, Udaipur are given in Table 3.1 and Fig. 3.1. The rainfall received during the *kharif* crop seasons of 2022-23 was 450.5 mm. The mean weekly maximum temperature in *kharif* 2022-23 ranged between 29.1 to 34.0°C.

Table : Treatment details.

S. No.	Treatments	Symbols
(A)	Doses of pelleted vermicompost	
	Control	D ₁
	1.0 t ha ⁻¹	D ₂
	2.0 t ha ⁻¹	D ₃
	3.0 t ha ⁻¹	D ₄
	4.0 t ha ⁻¹	D ₅
(B)	Scheduling	
	100% at the time of sowing	S ₁
	50% at the time of sowing + 50% at 4 WAS	S ₂
	50% at the time of sowing + 25% at 4 WAS + 25% at 6 WAS	S ₃

Experimental Details :

Preparation of vermicompost pellets : Well dried vermicompost is taken after proper sieving into a container and bentonite as binding agent, is thoroughly mixed and then taken into the pellet making machine which makes small cylindrical pellets. The cylindrical pellets are then placed in centrifugal machine which helps in transforming the cylindrical pellets into spherical pellets.

Growth Attributes

Plant height : Five plants were tagged randomly in each plot for recording the height at 30, 45 DAS and at harvest. The height was measured with the help of metre scale from the base of plant to the tip of the tallest leaf. Average plant height was computed and expressed in cm.

Dry matter of crop : Dry matter accumulation of plant at 30, 45 DAS and at harvest was recorded. For this purpose, five plants were taken from second row in each plot. Sample plants were cut close to ground level and sample were kept in dryer for 48 hours at 72°C. Therefore, dry weight of samples was recorded with the help of electronic balance. Mean dry matter accumulation in g plant⁻¹ was computed.

Results and Discussion

Plant height : The data on effect of the pelleted vermicompost and its scheduling on plant height at 30, 45 DAS and at harvest are given in Table-1.

At 30 DAS

Doses of pelleted vermicompost : The application of pelleted vermicompost ranging from control to 4 t ha⁻¹ brought about significant variation in plant height at 30 DAS. Higher plant height was recorded with the application of pelleted vermicompost 4 t ha⁻¹ at 30 DAS, as compared to 3, 2, 1 t ha⁻¹, and control (17.92, 29.38 and 46.50 %, respectively).

Doses of pelleted vermicompost : Dose of pelleted vermicompost 4 t ha⁻¹ significantly increased plant height over 3, 2, 1 t ha⁻¹ and control by 15.67, 25.34 and 37.17 percent, respectively. 3 t ha⁻¹ pelleted vermicompost was recorded significantly higher over 2, 1 t ha⁻¹ and control (7.79, 16.81 and 27.83 %). 2 t ha⁻¹ pelleted vermicompost was recorded significantly higher over 1 t ha⁻¹ and control (9.72 and 18.58 %). 1 t ha⁻¹ pelleted vermicompost was recorded significantly higher over control (9.43 %).

Doses of pelleted vermicompost : The data indicate that all the doses of pelleted vermicompost significantly increased plant height at harvest as compared to control. Maximum plant height was recorded under 4 t ha⁻¹ of pelleted vermicompost, while the minimum was recorded under control. Further data shows that the application of 3 t ha⁻¹ pelleted vermicompost significantly increased on plant height by 2, 1 t ha⁻¹ and control (7.81, 16.96 and 28.20 %). 2 t ha⁻¹ pelleted vermicompost significantly increased plant height over 1 t ha⁻¹ and control (8.47 and 18.91 %). 1 t ha⁻¹ pelleted vermicompost significantly increased plant height by control (9.62 %).

Dry matter accumulation

At 30 DAS

Doses of pelleted vermicompost : The data indicate that in Table-2, dose of pelleted vermicompost 4 t ha⁻¹ recorded significantly higher dry matter accumulation as compared to 3, 2, 1 t ha⁻¹ and control.

At 45 DAS

Doses of pelleted vermicompost : An appraisal of data

Table-1 : Effect of pelleted vermicompost on plant height at different growth stages of organic greengram.

Treatment	Plant height (cm)		
	30 DAS	45 DAS	At harvest
Doses of pelleted vermicompost			
Control	11.72	42.50	45.20
1 t ha ⁻¹	13.27	46.51	49.55
2 t ha ⁻¹	14.56	50.40	53.75
3 t ha ⁻¹	15.83	54.33	57.95
4 t ha ⁻¹	17.17	58.30	62.20
S.Em.±	0.425	1.336	1.436
C.D.(P=0.05)	1.233	3.869	4.159

Table-2 : Effect of pelleted vermicompost on dry matter accumulation by plant at different growth stages of organic greengram.

Treatment	Dry matter accumulation (g plant ⁻¹)		
	30 DAS	45 DAS	At Harvest
Doses of pelleted vermicompost			
Control	1.90	7.20	9.13
1 t ha ⁻¹	2.20	7.85	10.08
2 t ha ⁻¹	2.48	8.45	11.04
3 t ha ⁻¹	2.75	9.05	12.06
4 t ha ⁻¹	3.03	9.98	13.15
S.Em.±	0.088	0.202	0.323
C.D.(P=0.05)	0.256	0.585	0.934

indicates that with increasing level of pelleted vermicompost, the dry matter accumulation also increased. Maximum dry matter accumulation recorded by application of pelleted vermicompost 4 t ha⁻¹ followed by 3, 2, 1 t ha⁻¹ and control. Further data shows that application of 3 t ha⁻¹ pelleted vermicompost significantly increased on plant height by 2 t ha⁻¹, 1 t ha⁻¹ and control (7.10, 15.28 and 25.69 %). 2 t ha⁻¹ pelleted vermicompost significantly increased on plant height by 1 t ha⁻¹ and control 7.64 and 17.36 %). 1 t ha⁻¹ pelleted vermicompost significantly increased on plant height by control (10.40 %).

Doses of pelleted vermicompost : Data clearly indicate that the maximum plant dry matter accumulation at harvest was recorded under 4 t ha⁻¹ as compared to 3, 2, 1 t ha⁻¹ and control, respectively.

An appraisal of data indicates that all the doses of pelleted vermicompost tried in experiment caused significant increment in the growth parameters of organic greengram *i.e.*, plant height and crop dry matter accumulation compared to control. Among the doses pelleted vermicompost, application of 4 t ha⁻¹ recorded the maximum plant height (17.17, 58.30 and 62.20 cm) at 30, 45 and at harvest successive stages (Table 4.1). Higher accumulation of plant dry matter at 30, 45 and at harvest

successive stage *viz.*, 3.03, 9.98 and 13.15 (Table-2) was observed under application of 4 t ha⁻¹ of pelleted vermicompost as compared to control. Finding are in conformity with the work done by Ghanshyam *et al.* (2010) and Rekha *et al.* (2018)

The correlation studies showed positive inter-relation between plant height at harvest and dry matter accumulation at harvest. The correlation coefficient of plant height with dry matter accumulation shows $r=0.958^{**}$ this shows that as the dry matter increases the plant height also increases.

Conclusions

Significant increase in plant height at 30, 45 DAS and at harvest was observed with the application of 4 t ha⁻¹ pelleted vermicompost over control and other doses of pelleted vermicompost. Dry matter plant⁻¹ at 30, 45 DAS and at harvest was observed a significant increase with the application of 4 t ha⁻¹ pelleted vermicompost over control and other doses of pelleted vermicompost.

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Knowledge and Adoption Level of PKVY Beneficiary and Non-beneficiary Farmers

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Abstract

An Ex-post-facto research design was used in the present study. The present study was concluded in southern Rajasthan. At present southern Rajasthan comprise of seven districts namely Udaipur, Dungarpur, Banswara, Chittorgarh, Pratapgarh, Bhilwara and Rajsamand. Out of these, three districts viz., Udaipur, Dungarpur and Banswara were selected on the basis of maximum number of PKVY beneficiaries. Two panchayat samities from each identified district were selected for study on the basis of maximum number of farmers were benefited through Paramparagat Krishi Vikas Yojana. Therefore, a total of six panchayat samities were taken for the study. From each selected panchayat samiti two beneficiary villages and one non-beneficiary village was randomly selected. Thus, a total 12 beneficiary villages and 6 non-beneficiary villages were selected for the study. 15 farmers were selected randomly from each identified village. Thus, a total of 180 beneficiary farmers and 90 non-beneficiary farmers were selected for the present investigation. It was found from the study that 63.89 per cent beneficiary farmers have medium level of knowledge and 50.00 per cent of non-beneficiary farmers have low level of knowledge about recommended organic farming practices. Study also revealed that 60.00 per cent beneficiary farmers have medium level of adoption and 47.78 per cent of non-beneficiary farmers have low level of adoption regarding recommended organic farming practices through PKVY.

Key words : Knowledge, Attitude, PKVY and Organic farming

Introduction

The Paramparagat Krishi Vikas Yojana (PKVY), an initiative to promote organic farming in the country was launched in 2015. It is an extended component of Soil Health Management (SHM) under the Centrally Sponsored Scheme (CSS), National Mission on Sustainable Agriculture (NMSA). Paramparagat Krishi Vikas Yojana aims at supporting and promoting organic farming, in turn resulting in improvement of soil health. The scheme promotes Participatory Guarantee System (PGS) for India (PGS- India) which form of organic certification that is built on mutual trust, locally relevant and mandates the involvement of producers and consumers in the process of certification. PGS – India operates outside the framework of “Third Party Certification”. Funding pattern under the scheme is in the ratio of 60:40 by the Central and State Governments, respectively. In case of North Eastern and Himalayan States, Central Assistance is provided in the ratio of 90:10 (Centre: State) and for Union Territories, the assistance is 100 per cent. The Scheme was targeted to form 10,000 clusters of 20 ha each and bring nearly two lakh hectares of agricultural area under organic farming.

Research Methodology

The present study was conducted in southern Rajasthan during the year 2022-2023 with a total of 270 respondents selected from three districts namely, Udaipur, Dungarpur

and Banswara out of two panchayat samities and two villages selected from each district. 15 respondents were selected from each village. Likewise, 15 farmers who were not benefited under this scheme, selected randomly from each non-beneficiary village. Thus, total 90 non-beneficiary farmers were included in sample of study. To identify the constraints, a schedule was prepared with the help of agriculture experts. Data were collected with the help of interview schedule. Face to face interview technique was used for collection of information from respondents.

Results and Discussion

This part of the report deals with the level of knowledge and adoption of beneficiary and non-beneficiary the farmers about PKVY organic farming practices. The results were presented in below Tables.

Knowledge level of beneficiary and non-beneficiary farmers about organic farming practices of PKVY :

The knowledge level of beneficiary and non-beneficiary farmers with respect to organic farming practices of PKVY was studied through a structured interview schedule. Three categories *i.e.*, low (<30.07), medium (30.07 to 66.83) and high (>66.83) were made on the basis of S.D and mean of the total obtained score of the beneficiary and non-beneficiary farmers. The results have been presented in Table-1.

Table-1 show the level of knowledge among

beneficiaries and non-beneficiaries in three districts namely Udaipur, Dungarpur and Banswara. It was found that 63.89 per cent of beneficiary farmers had medium level of knowledge. Whereas, 23.89 and 12.22 per cent of beneficiary farmers had high and low level of knowledge, respectively. In case of non-beneficiary farmers, 50.00 per cent farmers had low level of knowledge. It was followed by the 25.56 and 24.44 per cent of farmers had medium and high level of knowledge, respectively.

Further analysis of Table shows that in Udaipur district 63.33 per cent beneficiary farmers had medium level of knowledge, while 21.67 and 15.00 per cent farmers had high and low level of knowledge, respectively. While in case of non-beneficiary 50.00 per cent farmers had low level of knowledge. It was followed by the 30.00 and 20.00 per cent farmers had medium and high level of knowledge, respectively.

In Dungarpur district 60.00 per cent beneficiary farmers were in medium knowledge category. Whereas, 31.67 and 8.33 per cent farmers possessed high and low level of knowledge, respectively. It was found in case of non-beneficiary 56.67 per cent farmers had low level of knowledge. Only 23.33 and 20.00 per cent farmers had high and medium level of knowledge about organic farming practices, respectively.

The level of knowledge in Banswara district 68.33 per cent beneficiary farmers possessed medium level of knowledge about organic farming practices. It was followed by the 18.33 and 13.33 per cent farmers had high and low level of knowledge, respectively. While in case of non-beneficiary farmers 43.33 per cent farmers had low level of knowledge. Likewise, 30.00 and 26.67 per cent farmers had high and medium level of knowledge, respectively.

It is concluded from the above-mentioned data that more than half of the beneficiary respondents had medium level of knowledge about the PKVY practices. This may be due to the fact that farmers having medium to high knowledge with the help of training, extension contact and their interest in organic farming. Reason behind low knowledge level of non-beneficiary farmers in comparison to beneficiary farmers was that they were not benefitted from this scheme.

A similar pattern of result was obtained by Vashistha *et al.* (2013) who revealed that the majority (57.50%) of beneficiary farmers had medium level of knowledge about organic farming production technology, followed by 24.17 and 18.00 per cent of them who had low and high level of knowledge about organic farming in rice cultivation, respectively. This study also supported by the Kumar *et al.* (2014) Choudhary and Yadav (2016) who indicated that the majority of non-beneficiary farmers (57.33%) had medium knowledge level, whereas 15 and 17 per cent

Table-1 : Knowledge level of beneficiary and non-beneficiary farmers about organic farming practices of PKVY. n=270

S. No.	Categories	Udaipur						Dungarpur						Banswara						Total	
		Beneficiary			Non-beneficiary			Beneficiary			Non-beneficiary			Beneficiary			Non-beneficiary			Beneficiary	Non-beneficiary
		f	%	F	f	%	F	f	%	F	f	%	F	f	%	F	f	%	f	f	%
1.	Low (Less than 30.07)	9	15.00		15	50.00	5	8.33	17	56.67	8	13.33	13	22	43.33	13	45	50.00	22	12.22	45
2.	Medium (30.07 to 66.83)	38	63.33	9	30.00	36	60.00	6	60.00	6	20.00	41	68.33	8	26.67	8	23	25.56	115	63.89	23
3.	High (Above 66.83)	13	21.67	6	20.00	19	31.67	7	23.33	7	23.33	11	18.33	9	30.00	9	22	24.44	43	23.89	22
Total		60	100	30	30	100	60	100	30	100	60	100	30	180	100	30	90	100	180	100	100

f = Frequency, % = Per cent

Table-2 : Adoption level of beneficiary and non-beneficiary farmers about organic farming practices of PKVY. n=270

S. No.	Level of adoption	Udaipur						Dungarpur						Banswara						Total	
		Beneficiary			Non-beneficiary			Beneficiary			Non-beneficiary			Beneficiary			Non-beneficiary			Beneficiary	Non-beneficiary
		f	%	F	f	%	F	f	%	F	f	%	F	f	%	F	f	%	f	f	%
1.	Low (Less than 16.15)	8	13.33	15	50.00	11	18.33	13	43.33	3	5.00	15	50.00	22	12.22	43	47.78		22	12.22	43
2.	Medium (16.15 to 50.74)	39	65.00	9	30.00	31	51.67	6	20.00	38	63.33	12	40.00	108	60.00	27	30.00		108	60.00	27
3.	High (Above 50.74)	13	21.67	6	20.00	18	30.00	11	36.67	19	31.67	3	10.00	50	27.78	20	22.22		50	27.78	20
Total		60	100	30	30	100	60	100	30	100	60	100	30	180	100	90	100		180	100	100

f = Frequency, % = Per cent

non-beneficiary farmers were having low and high knowledge level about organic farming practices.

Adoption level of beneficiary farmers about organic farming practices of PKVY : The adoption level of beneficiary and non-beneficiary farmers with respect to organic farming practices of PKVY was studied through a structured interview schedule. Three categories *i.e.*, low (<16.15), medium (16.15 to 50.74) and high (>50.74) were made on the basis of S.D and mean of the total obtained score of the beneficiary and non-beneficiary farmers. The results have been presented in Table-2.

Table-2 show the level of adoption among beneficiaries and non-beneficiaries in three districts namely Udaipur, Dungarpur and Banswara. It was found that 60.00 per cent of beneficiary farmers had medium level of adoption. Whereas, 27.78 and 12.22 per cent of beneficiary farmers had high and low level of adoption, respectively. In case of non-beneficiary farmers 47.78 per cent farmers had low level of adoption. It was followed by the 30.00 and 22.22 per cent of farmers had medium and high level of adoption, respectively.

Further analysis of Table shows that in Udaipur district 65.00 per cent beneficiary farmers had medium level of adoption, while 21.67 and 13.33 per cent farmers had high and low level of adoption, respectively. In case of non-beneficiary farmers, 50.00 per cent farmers had low level of adoption. It was followed by the 30.00 and 20.00 per cent farmers had medium and high level of adoption, respectively.

In Dungarpur district 51.67 per cent beneficiary farmers were in medium adoption category. Whereas, 30.00 and 18.33 per cent farmers possessed high and low level of adoption. It was found in case of non-beneficiary, 43.33 per cent farmers had low level of adoption. Only 36.67 and 20.00 per cent farmers had high and medium level of adoption about organic farming practices.

The level of adoption in Banswara district 63.33 per cent beneficiary farmers possessed medium level of adoption about organic farming practices. It was followed by the 31.67 and 5.00 per cent farmers had high and low level of adoption, respectively. While in case of non-beneficiary farmers 50.00 per cent farmers had low level of adoption. Likewise, 40.00 and 10.00 per cent farmers had high and medium level of adoption.

It may be concluded from the above discussion that majority of the PKVY farmers' level of adoption was medium to high in comparison to the non-beneficiary farmers might be due to the fact that beneficiary farmers are benefited by the department and provided different inputs used for organic farming. While, non-beneficiaries have limited knowledge about getting organic products and not adopting in much quantity of organic farming

practices. Beneficiary farmers also getting financial help from the agriculture department to buy organic products, labour for hand weeding, making of vermi-compost and other organic products for insect pest management, seed treatment etc. But non-beneficiary farmers have to pay on their own for the same, that's why their adoption level is lower than beneficiary farmers.

The present findings are similar with the findings of Mahadik *et al.* (2018) who reported that three fourth (75%) of the total respondents were in the 'medium' adoption group whereas, 12.00 per cent respondents were in 'high' adoption group and remaining 13.00 per cent mango growers observed in the 'low' level of adoption. These findings also supported by the findings of Sangeetha *et al.* (2018) who analyzed the adaptive capacity organic farmers, majority (52%) were 'moderately adaptable' and nearly half (48%) were 'highly adaptable'.

Conclusions

It was found that 63.89 per cent of beneficiary farmers had medium level of knowledge. Whereas, 23.89 and 12.22 per cent of beneficiary farmers had high and low level of knowledge, respectively. In case of non-beneficiary farmers 50.00 per cent farmers had low level of knowledge. It was followed by the 25.56 and 24.44 per cent of farmers had medium and high level of knowledge, respectively.

Whereas, 60.00 per cent of beneficiary farmers had medium level of adoption. It was followed by 27.78 and 12.22 per cent of beneficiary farmers had high and low level of adoption, respectively. In case of non-beneficiary farmers 47.78 per cent farmers had low level of adoption. It was followed by the 30.00 and 22.22 per cent of farmers had medium and high level of adoption, respectively.

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Genetic Architecture in Indian Mustard [*Brassica juncea* (L.) Czern & Coss] for Yield and Contributing Traits

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Abstract

The magnitude of relative heterosis (RH), heterobeltiosis (HB), economic heterosis (EH) for 27 F_1 's obtained by crossing 9 mustard lines with 3 tester using line x tester mating design. The 41 entries including 27 hybrids along with 12 parents and 2 checks viz., NRCHB-101 and RH-0749 were evaluated for 14 traits at Instructional farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during *Rabi* 2022-23 under in randomized block design with 3 replications. The cross between GM-3 and Pusa Jai Kisan depicted positive significant economic heterosis for seed yield per plant with the magnitude of 4.39 over the check NRCHB-101. Similarly maximum relative heterosis was also exhibited by the cross between GM-3 and Pusa Jai Kisan. The maximum heterobeltiosis for this trait was observed in GM-3 x Swarna Jyoti. Maximum positive significant economic heterosis for oil content trait was exhibited by the cross between Varuna and Pusa Jai Kisan and IC-597870 x Swarna Jyoti exhibited positive significant heterobeltiosis for this trait with the magnitude of 4.89 per cent. Majority of the crosses exhibited significant negative relative heterosis for maturity traits and plant height indicated that for these traits the genes with negative effects were dominant. The results revealed that the hybrid combinations GM-3 x Pusa Jai Kisan is found promising for exploitation of heterosis.

Key words : heterosis, heterobeltiosis, economic heterosis

Introduction

Brassica juncea (L.) commonly known as Indian mustard is globally used as vegetable, Oilseed and condiments. Mustard belongs to family Brassicaceae and genus Brassica. Indian mustard is a natural amphidiploid ($2n = 36$) of *B. rapa* ($2n = 20$) and *B. nigra* ($2n = 16$). Indian mustard is an agriculturally important oilseed crop with a long history of cultivation in India, China and increasingly in Australia. In India, it is predominantly cultivated in Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat, which contribute 81.5% area and 87.5% production. It originated in Asia with its major centre of diversity in China (Vaughan, 1977). It was introduced in India from China and from where it spread to Afghanistan and other countries. It is largely a self-pollinated crop (85-90 %). However, owing to insects, especially the honeybees, the extent of cross-pollination varies from 4.0 to 16.6 per cent (Ram bhajan *et al.*, 1991).

Mustard is a *Rabi* season crop of temperate region, which requires relatively cool temperature. Mustard seed is largely crushed for edible oil, which is perhaps the cheapest source of oil in our daily diet. Mustard seeds contain about 38-42 per cent oil, which is golden yellow, fragrant and considered among the healthiest and most nutritional cooking medium. It is also utilized as a condiment, for medicinal uses and has industrial applications. The seed is used as a condiment in the

preparation of pickles and for flavoring curries and vegetables. The green leaves of young plants are used as green vegetables as they supply enough sulphur and minerals in the diet.

In India, it covers an area of about 6.69 Mha. with 10.11 million Tonnes production and 1511 kg/ha productivity (Anonymous, 2022). Out of the four oleiferous *Brassica* species, viz., *Brassica juncea*, *B. napus*, *B. rapa* and *B. carinata*; *B. juncea* contributes more than 80% of the total rapeseed mustard production of the country. It is because of its wider adaptability and comparative tolerance to biotic and abiotic stresses as compared to other *Brassica* species grown as oilseeds.

Rajasthan is the largest producer of rapeseed-mustard as it is cultivated on about 2.72 Mha. area with 4.51MT production and with 1659 Kg/ha. productivity (Agriculture statistics of Rajasthan, 2021). It is mostly grown in districts of Alwar, Bharatpur, Shri Ganganagar, Kota and Jaipur. Exploitation of heterosis may play a very significant role to boost up the production and productivity of Indian mustard. Heterosis breeding can be one of the most viable options for breaking the present yield barrier. Further, for developing better genotypes through hybridization, the choice of suitable parents is of great concern. Keeping in view these points, the present study was undertaken to estimate the magnitude of relative heterosis (RH), heterobeltiosis (HB), economic heterosis (EH) of 27 F_1 's of mustard.

Table-1 : Extent of heterosis for number of siliquae per plant, length of siliqua and number of seeds per siliqua.

S. N.	Crosses	No of siliqua per plant			Length of siliqua			No of seeds per siliquae		
		Het	Hb	EH	Het	Hb	EH	Het	Hb	EH
1.	ALBELI X URVASHI	-16.10**	-	-	5.89	4.69	5.46	-1.99	-	4.44
2.	ROHINI X URVASHI	-8.02**	-	-	-9.85*	-	-	-13.85**	-	-
3.	VARUNA X URVASHI	10.56**	4.92*	-	21.84**	13.34*	11.59*	9.27**	-	3.15
4.	IC-597904 X URVASHI	9.23**	6.18**	-	-1.81	-	-	-6.58*	-	-
5.	RGN-229 X URVASHI	17.62**	13.77**	5.93**	3.50	2.02	0.44	3.22	-	4.76
6.	GM-3 X URVASHI	13.91**	12.78**	7.13**	-1.10	-	-	5.39	1.25	7.93*
7.	IC-597889 X URVASHI	-8.61**	-	-	19.68**	13.49*	11.73*	4.10	-	0.71
8.	EJ-20 X URVASHI	20.41**	13.72**	5.89**	15.41**	6.97	5.31	-9.59**	-	-
9.	IC-597870 X URVASHI	-12.58**	-	-	-13.54**	-	-	5.40	0.37	6.99*
10.	ALBELI X PUSA JAI KISAN	-2.70	-	-	17.27**	12.67*	13.51*	2.71	1.71	10.49**
11.	ROHINI X PUSA JAI KISAN	-6.10**	-	-	-6.68	-	-	-12.77**	-	-
12.	VARUNA X PUSA JAI KISAN	11.61**	6.83**	-	3.33	-	-	19.39**	4.87	13.91**
13.	IC-597904 XPUSA JAI KISAN	13.62**	11.43**	1.90	3.74	1.43	-	5.00	-	6.90*
14.	RGN-229 X PUSA JAI KISAN	5.59**	3.04	-	-0.16	-	-	1.66	-	4.21
15.	GM-3 X PUSA JAI KISAN	17.04**	14.86**	9.10**	7.57	5.09	-	-2.13	-	1.22
16.	IC-597889 X PUSA JAI KISAN	-2.35	-	-	4.32	1.75	-	8.22**	-	5.79
17.	EJ-20 X PUSA JAI KISAN	13.65**	8.26**	-	23.24**	17.41**	9.00	-2.51	-	4.30
18.	IC-597870 X PUSA JAI KISAN	2.91	1.90	-	-7.27	-	-	2.79	-	5.38
19.	ALBELI X SWARNA JYOTI	10.20**	3.51*	7.59**	-13.98**	-	-	-6.54*	-	-
20.	ROHINI X SWARNA JYOTI	-6.20**	-	-	-9.80	-	-	-10.13**	-	-
21.	VARUNA X SWARNA JYOTI	4.22*	-	-	1.25	-	-	15.23**	2.83	7.70*
22.	IC-597904 X SWARNA JYOTI	27.56**	25.18**	14.32**	11.36*	9.39	0.59	8.57**	3.51	8.42*
23.	RGN-229 X SWARNA JYOTI	14.15**	11.46**	1.78	-9.05	-	-	9.84**	5.47	10.46**
24.	GM-3 X SWARNA JYOTI	10.87**	8.73**	3.28	0.00	-	-	8.49**	5.12	10.09**
25.	IC-597889 X SWARNA JYOTI	-5.50**	-	-	22.19**	19.74**	10.11	3.12	-	-
26.	EJ-20 X SWARNA JYOTI	-6.82**	-	-	0.21	-	-	2.75	2.44	7.93*
27.	IC-597870 X SWARNA JYOTI	-14.51**	-	-	-9.96*	-	-	-3.54	-	-

*, ** Significant at 5% and 1%, respectively.

Materials and Methods

The experimental material comprised of 27 F₁ crosses, 12 parents and 2 checks viz., NRCHB-101 and RH-0749. The Crosses were developed during *Rabi* 2021-22 by making crosses between 9 mustard lines and 3 testers viz., Urvashi, Pusa Jai Kisan and Swarna Jyoti using line x tester mating design. The experimental material was evaluated in randomized block design with 3 replications at instructional farm, Rajasthan College of Agriculture. Each treatment was sown in single row plot of 4-meter length maintaining 30 cm x 10 cm row to row and plant to plant spacing, respectively. The other recommended package of practices of zone IV A of Rajasthan will be followed to raise a healthy crop.

Traits observed : Observations were recorded on plant basis, 5 individual plants were randomly selected for all the genotypes in each replication for all the characters viz. days to 50% flowering, days to maturity, plant height(cm), total number of primary branches per plant, total number of secondary branches per plant, length of main axis(cm), number of siliqua per plant, length of siliqua(cm), number of seed per siliqua, seed yield per plant(g), 1000 seed weight(g), biological yield per plant, harvest index(%) and oil content(%)

Statistical analysis : Estimation of heterosis, heterobeltiosis and economic heterosis was done by the method suggested by shull (1908), Fonesca and Patterson (1968) and Meredith and Bridge (1972).

Table-2 : Extent of heterosis for number of primary branches per plant, number of secondary branches per plant and length of main axis.

S. N.	Crosses	No. of primary branches			No. of secondary branches			Length of main axis		
		Het	Hb	EH	Het	Hb	EH	Het	Hb	EH
1.	ALBELI X URVASHI	-3.90	-	0.59	-0.81	-	-	-10.02**	-	1.47
2.	ROHINI X URVASHI	-19.78**	-	-	-0.59	-	-	-7.60*	-	2.42
3.	VARUNA X URVASHI	4.98	-	2.96	-4.20	-	-	3.60	-	15.53**
4.	IC-597904 X URVASHI	-2.59	-	0.00	-1.30	-	-	-7.74*	-	1.10
5.	RGN-229 X URVASHI	-26.04**	-	-	12.50**	10.12**	4.21	-6.34	-	2.64
6.	GM-3 X URVASHI	-9.84**	-	-	-4.95	-	-	3.19	1.15	7.87
7.	IC-597889 X URVASHI	-12.20**	-	-	-2.42	-	-	0.81	0.01	6.66
8.	EJ-20 X URVASHI	-3.32	-	-	6.49*	0.74	-	6.80	6.58	14.13**
9.	IC-597870 X URVASHI	6.59	-	5.33	4.31	-	-	4.20	2.72	9.55*
10.	ALBELI X PUSA JAI KISAN	5.62	-	1.78	-10.96**	-	-	-7.66*	-	0.71
11.	ROHINI X PUSA JAI KISAN	-9.34**	-	-	-8.68**	-	-	-6.00	-	0.70
12.	VARUNA X PUSA JAI KISAN	2.83	1.63	-	-5.18	-	-	-4.07	-	3.42
13.	IC-597904 X PUSA JAI KISAN	11.26**	4.97	4.97	-0.30	-	-	-1.32	-	4.48
14.	RGN-229 X PUSA JAI KISAN	-0.47	-	-	-3.83	-	-	-7.70	-	-
15.	GM-3 X PUSA JAI KISAN	-11.90**	-	-	0.00	-	-	3.80	2.19	4.66
16.	IC-597889 X PUSA JAI KISAN	-7.30*	-	-	2.97	-	-	6.53	3.63	8.75
17.	EJ-20 X PUSA JAI KISAN	33.72**	30.82**	21.30**	2.15	-	-	12.92**	8.78	16.49**
18.	IC-597870 X PUSA JAI KISAN	12.78**	10.58*	2.07	7.24*	0.00	-	13.90**	11.50*	15.53**
19.	ALBELI X SWARNA JYOTI	-2.52	-	-	0.46	-	-	-0.68	-	8.10
20.	ROHINI X SWARNA JYOTI	22.89**	2.76	10.06*	-1.06	-	-	4.47	-	11.69*
21.	VARUNA X SWARNA JYOTI	11.92**	0.33	-	-9.62**	-	-	3.13	-	10.94*
22.	IC-597904 X SWARNA JYOTI	-8.50*	-	-	-1.99	-	-	-6.90	-	-
23.	RGN-229 X SWARNA JYOTI	-4.60	-	-	3.29	0.64	-	-8.78*	-	-
24.	GM-3 X SWARNA JYOTI	7.97	-	-	-4.91	-	-	5.82	3.94	6.46
25.	IC-597889 X SWARNA JYOTI	25.36**	2.62	15.98**	-0.78	-	-	8.45*	5.27	10.47*
26.	EJ-20 X SWARNA JYOTI	21.05**	7.53	-	7.76**	1.49	-	8.80*	4.58	12.00*
27.	IC-597870 X SWARNA JYOTI	23.15**	9.62*	1.18	0.78	-	-	13.44**	10.80*	14.81**

Results and Discussion

The magnitude of relative heterosis (RH), heterobeltiosis (HB) and economic heterosis (EH) have been calculated and expressed as per cent increase or decrease of F_1 value over mid parent (relative heterosis), over better parent (heterobeltiosis) and over standard check (standard or economic heterosis). The character wise results of mid parent, better parent and economic heterosis are presented in table-1,2,3.

One cross depicted positive significant economic heterosis for seed yield per plant with the magnitude of 4.39 (GM-3 x Pusa Jai Kisan) and one cross also exhibited positive significant economic heterosis for oil content with the magnitude of 3.13 (Varuna x Pusa Jai Kisan)

6 crosses exhibited positive significant heterobeltiosis for seed yield per plant with the magnitude ranged from 3.75 (EJ-20 x Swarna Jyoti) and (GM-3 x Urvashi) to 7.68 (GM-3 x Swarna Jyoti) whereas for other yield contributing trait the number of crosses depicting positive significant heterobeltiosis ranged from 4 cross for biological yield, 13 crosses for number of siliqua per plant, 3 crosses for number of primary branches, 1 cross for oil content, 3 crosses for harvest index and 2 crosses for length of main axis.

Out of 27 crosses only one cross exhibited negative significant heterobeltiosis for 50% of flowering, 4 crosses showed negative significant heterobeltiosis for days to maturity and and 6 crosses for plant height. These results are in accordance with the Aher *et al.* (2009) Barupal *et al.* (2017), Bharti *et al.* (2018), Meena *et al.* (2014), Mohan *et*

Table-3 : Extent of heterosis for seed yield per plant, 1000-seed weight and biological yield per plant.

SN.	Crosses	Seed yield per plant (g)			Test weight (g)			Biological yield per plant (g)		
		Het	Hb	EH	Het	Hb	EH	Het	Hb	EH
1.	ALBELI X URVASHI	3.94**	3.77*	-	5.23	3.91	-	16.32**	7.50*	2.97
2.	ROHINI X URVASHI	0.04	-	-	8.63	2.32	1.46	-11.20**	-	-
3.	VARUNA X URVASHI	-6.19**	-	-	-7.03	-	-	-14.34**	-	-
4.	IC-597904 X URVASHI	0.06	-	-	14.45*	9.99	4.55	-8.57**	-	-
5.	RGN-229 X URVASHI	-0.21	-	-	8.51	8.27	-	6.73**	-	11.39**
6.	GM-3 X URVASHI	5.14**	3.75*	-	14.05*	6.92	-	5.93*	1.24	-
7.	IC-597889 X URVASHI	0.57	0.34	-	26.69**	12.88	-	-17.82**	-	-
8.	EJ-20 X URVASHI	2.85	2.61	-	-1.03	-	-	-1.73	-	-
9.	IC-597870 X URVASHI	-0.32	-	-	6.01	1.22	-	-10.16**	-	-
10.	ALBELI X PUSA JAI KISAN	2.65	1.26	-	7.41	5.72	-	26.85**	7.33**	26.00**
11.	ROHINI X PUSA JAI KISAN	2.47	1.52	-	13.65*	4.25	3.37	-20.84**	-	-
12.	VARUNA X PUSA JAI KISAN	0.57	-	-	15.94**	5.51	6.46	-17.07**	-	-
13.	IC-597904 XPUSA JAI KISAN	-1.01	-	-	4.83	-	-	-4.75*	-	8.07**
14.	RGN-229 X PUSA JAI KISAN	2.40	1.93	-	5.75	3.03	-	-23.52**	-	-
15.	GM-3 X PUSA JAI KISAN	10.54**	7.46**	4.39**	25.37**	20.77**	-	11.03**	-	13.64**
16.	IC-597889 X PUSA JAI KISAN	-0.60	-	-	52.17**	39.10**	15.11*	-39.43**	-	-
17.	EJ-20 X PUSA JAI KISAN	4.08**	2.74	-	3.41	-	-	-12.25**	-	-
18.	IC-597870 X PUSA JAI KISAN	0.34	-	-	26.14**	23.83**	2.47	-29.22**	-	-
19.	ALBELI X SWARNA JYOTI	4.24**	1.16	-	13.24*	11.37	-	0.37	-	-
20.	ROHINI X SWARNA JYOTI	4.70**	1.19	-	12.48*	3.12	2.25	-11.52**	-	-
21.	VARUNA X SWARNA JYOTI	4.47**	1.73	-	7.13	-	-	4.09	1.46	-
22.	IC-597904 X SWARNA JYOTI	6.09**	3.02	-	20.52**	12.65	7.08	12.56**	4.09	14.02**
23.	RGN-229 X SWARNA JYOTI	2.12	-	-	2.38	-	-	-19.13**	-	-
24.	GM-3 X SWARNA JYOTI	9.35**	7.68**	-	33.36**	28.55**	6.24	25.45**	21.58**	13.14**
25.	IC-597889 X SWARNA JYOTI	8.18**	4.92**	-	9.92	0.54	-	-22.85**	-	-
26.	EJ-20 X SWARNA JYOTI	6.98**	3.75*	-	25.66**	19.50**	9.49	10.40**	5.92*	7.27*
27.	IC-597870 X SWARNA JYOTI	4.62**	0.88	-	30.45**	28.14**	5.90	-15.28**	-	-

al. (2017), Rai et al. (2017), Patel et al. (2015), Kumar et al. (2019).

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Effect of Integrated Nutrient Management on Yield Attributes and Yield of Blackgram

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Abstract

A field experiment entitled "Effect of Integrated Nutrient Management on Soil Properties and Productivity of Blackgram (*Vigna mungo* L.) in Typic Haplustepts" was conducted at Agronomy Instructional Farm, Rajasthan College of Agriculture, Udaipur, during *kharif* 2022. The experiment included nine treatments of integrated nutrient management, including one common control in blackgram. Three replications of the experiment were set up in a randomised block design. Application of 25% RDF + 25% vermicompost + 25% enriched compost + 25% poultry manure + *Rhizobium* + foliar spray @ 0.5% Zn (T9) was recorded maximum number of pods plant⁻¹ (36.13), number of seeds pod⁻¹ (4.98) and test weight (45.00 g) and higher seed yield (909 kg ha⁻¹), haulm yield (1535 kg ha⁻¹) and biological yield (2444 kg ha⁻¹) followed by 75% RDF + 25% poultry manure + *Rhizobium* + foliar spray @ 0.5% Zn (T8).

Key words : Blackgram, yield, vermicompost, enriched compost, poultry manure

Introduction

Blackgram belongs to leguminosae family and subfamily papilionaceae. Blackgram, popularly known as "urad bean". Being a crop of tropical region, it requires "hot and humid" climate for the best growth (Chhatwani *et al.*, 2022). It contains about 26% protein, 1.2% fat and 56.6% carbohydrates on dry weight basis and it is rich source of calcium and iron. Apart from this, blackgram forms excellent forage and it gives a profuse vegetative growth and covers the ground so well that it checks the soil erosion. Being drought tolerant and warm weather crop, blackgram is well adopted to the drier regions of the tropics, where other food legumes do not perform well. It is one of the important legume crops, which like other pulse crops has unique capability of maintaining and restoring soil fertility through biological nitrogen (N) fixation, and its deep root system also maintains physical properties of soil (Kannan *et al.*, 2014). It has ability to fix about 22.10 kg of atmospheric nitrogen ha⁻¹ through its root nodules. In addition, it is shade tolerant and therefore compatible as an intercrop with maize, millet, sorghum, sugarcane and cotton (Divyavani *et al.*, 2020).

About 70% of the world's blackgram is produced in India, which is a major producer of the crop. With a production of 1.8 mt and an average yield of 515 kg ha⁻¹, blackgram takes up 3.6 mha of land in the nation (Anonymous, 2022). In Rajasthan, blackgram occupies 4.25 lakh ha area with a production of 1.56 lakh tones and productivity of 366 kg ha⁻¹ (Directorate of Economics & Statistics, Rajasthan, 2020-21). Blackgram is originated

from India and secondary origin was Central Asia extended from India to Myanmar which later spreads throughout the Asia during trading spreads to other parts of the world as staple food grain legumes (Vavilov, 1951).

The integrated nutrient management is the main technique where all the components are used and the effect of INM causes the productivity of the soil more. The basic concept of integrated nutrient management is the supply of the required plant nutrients for sustaining the desired crop productivity with minimum deleterious effect on soil health environment. INM, which entails the maintenance of soil fertility to an optimum level for crop productivity to obtain the maximum benefit from all possible sources of plant nutrients organic as well as inorganic in an integrated manner (Singh *et al.*, 2017). Integrated nutrient management approach is not only a reliable way of obtaining high productivity with substantial fertilizer economy, but also a concept of ecological soundness leading to sustainable agriculture by improving physio-chemical and biological properties of the soil. The basic concept of integrated plant nutrient system is maintenance and improvement of soil fertility for sustaining crop productivity on long term basis. Application of different organic-cum-inorganic sources of nutrients have been found very effective in realizing higher yield, better economy and improved fertility of the soil (Chhatwani *et al.*, 2022).

Vermicompost is the end-product of organic matter by earthworms (Haridha *et al.*, 2020). Vermicompost is a peat like material with excellent structure, porosity, aeration, drainage and moisture holding capacity

(Choudhary *et al.*, 2004). Vermicompost contain 0.6% nitrogen, 1.34% phosphorous, 0.4% potassium (Anasuyamma *et al.*, 2022). Enriched composts supply the plant nutrients and add a sufficient amount of organic matter to the soil, which helps in improving the physical, chemical and biological properties of the soil. It helps to maintain and sustain soil fertility for enhancing crop productivity and also acts as a recess for microbes and enriches the soil with a variety of the indigenous micro-flora and fauna (Purohit *et al.*, 2022). Poultry manure contains considerable amount of plant nutrients which has to be used as manure after composting (Khan *et al.*, 2022). Poultry manure is a rich source of nutrients as it contains 3.03% nitrogen, 2.63% phosphorus and 1.4% potassium. It improves soil fertility by adding both major and essential nutrients, as well as soil organic matter, which improves moisture and nutrient retention (Kannan *et al.*, 2015). Seed inoculation with appropriate *Rhizobium* strain is required to ensure adequate nodulation for maximum growth and yield of pulse crops (Kumar and Chandra, 2005). Zinc has been the micronutrient needed by crops especially pulses in sufficiently large quantity (Yashona *et al.*, 2018). The foliar spray of micro-nutrients was found to have beneficial effect on enhancing growth and increasing seed yield. In plants, zinc is key constituent of many enzymes and proteins (Soni *et al.*, 2020).

Materials and Methods

The experiment was laid out during *kharif* season of 2022 at the Instructional Farm (Agronomy), Rajasthan College of agriculture, Udaipur, which is situated at 24°34' latitude and 73°42' longitude with an average altitude of 579.5 m above mean sea level. The region falls under agro-climatic zone-IVa of Rajasthan *i.e.* Sub-humid Southern Plain and Aravalli Hills Zone. The experiment included nine treatments of integrated nutrient management, including one common control in blackgram. Three replications of the experiment were set up in a randomised block design. The soil at the experimental site was a clay loam with a slightly alkaline reaction (8.12 pH), medium in available nitrogen (284.43 kg ha⁻¹) and phosphorus (17.50 kg ha⁻¹) and high in potassium (352.17 kg ha⁻¹).

The experiment was comprised of nine treatments viz., T1 - control, T2 - 100% RDF, T3 - 50% RDF + 50% Vermicompost + *Rhizobium* + Foliar spray @ 0.5% Zn, T4 - 75% RDF + 25% Vermicompost + *Rhizobium* + Foliar spray @ 0.5% Zn, T5 - 50% RDF + 50% Enriched compost + *Rhizobium* + Foliar spray @ 0.5% Zn, T6 - 75% RDF + 25% Enriched compost + *Rhizobium* + Foliar spray @ 0.5% Zn, T7 - 50% RDF + 50% Poultry manure + *Rhizobium* + Foliar spray @ 0.5% Zn, T8 - 75% RDF + 25% Poultry manure + *Rhizobium* + Foliar spray @ 0.5% Zn, T9 - 25% RDF + 25% Vermicompost + 25% Enriched

compost + 25% Poultry manure + *Rhizobium* + Foliar spray @ 0.5% Zn.

After harvest of rabi crop, the field was ploughed with tractor drawn disc plough and fallow in summer season. After getting pre-monsoon rainfall, the experimental field was ploughed by tractor drawn disc plough followed by planking. The crop stubbles, grasses and weeds were removed from field manually. The fertilizer was applied into soil after last plough in field as per treatment. Nitrogen and Phosphorus were applied through urea and SSP. Vermicompost, enriched compost and poultry manures were applied into soil 5 days before of sowing as per treatment. Before sowing of seed, blackgram seed was treated with *Rhizobium* as per treatments. Foliar spray of 0.5% zinc was done as per treatment.

All observation related to crop yield attributes take on five tagged plant of each plot of blackgram crop of experimental site. Five seed samples of 1000 grains were drawn from net plot yield of each treatment and test weight was recorded and mean was expressed in grams. Seed yield obtained from each net plot including the tagged plants was sun dried and recorded treatment wise and expressed as kg ha⁻¹. Haulm yield was calculated by subtracting seed yield from respective biological yield of each plot and expressed as kg ha⁻¹. The unthreshed produce from net plot area including tagged plants after thorough sun drying was weighed for recording the biological yield and expressed as kg ha⁻¹. The ratio of economic yield (seed yield) to the biological yield was worked out and expressed in percentage as advocated by Donald and Hamblin (1976).

$$HI (\%) = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

Where,

Economical yield = Grain yield,

Biological yield = Grain yield + Haulm yield

The data presented in Table-1 indicate that integrated nutrient management in blackgram crop resulted in a significant effect on number of pods plant⁻¹, number of seeds pod⁻¹ and test weight. Maximum number of pods plant⁻¹, number of seeds pod⁻¹ and test weight observed under treatment T9 (25% RDF + 25% vermicompost + 25% enriched compost + 25% poultry manure + *Rhizobium* + foliar spray @ 0.5% Zn), increased significantly as compared to rest of the treatments, while control resulted in minimum number of pods plant⁻¹, number of seeds pod⁻¹ and test weight. The beneficial response of vermicompost to yield attributes and yield could also be attributed to the availability of sufficient amounts of plant nutrients throughout the growth period, particularly during critical growth periods of crop, resulting in better uptake, plant vigour, and superior yield attributes

Table-1 : Effect of integrated nutrient management on yield attributes of blackgram.

Treatment	Yield attributes		
	Number of pods plant ⁻¹	Number of seeds pod ⁻¹	Test weight (g)
T1 : Control	24.55	3.61	33.70
T2 : 100% RDF	30.10	4.11	39.30
T3 : 50% RDF + 50% Vermicompost + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	29.13	4.05	39.00
T4 : 75% RDF + 25% Vermicompost + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	33.00	4.56	42.20
T5 : 50% RDF + 50% Enriched compost + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	27.80	4.03	38.10
T6 : 75% RDF + 25% Enriched compost + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	32.80	4.54	42.00
T7 : 50% RDF + 50% Poultry manure + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	29.90	4.07	39.10
T8 : 75% RDF + 25% Poultry manure + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	33.10	4.57	42.30
T9 : 25% RDF + 25% Vermicompost + 25% Enriched compost + 25% Poultry manure + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	36.13	4.98	45.00
SEm±	0.90	0.13	0.84
CD (5%)	2.69	0.40	2.51

Table-2 : Effect of integrated nutrient management on yield and harvest index of blackgram.

Treatment	Yield (kg ha ⁻¹)			Harvest index (%)
	Seed	Haulm	Biological	
T1 : Control	538	1029	1568	34.07
T2 : 100% RDF	722	1252	1975	36.57
T3 : 50% RDF + 50% Vermicompost + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	679	1228	1908	35.62
T4 : 75% RDF + 25% Vermicompost + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	816	1399	2215	36.86
T5 : 50% RDF + 50% Enriched compost + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	665	1174	1840	36.31
T6 : 75% RDF + 25% Enriched compost + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	804	1379	2183	36.82
T7 : 50% RDF + 50% Poultry manure + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	693	1246	1939	35.73
T8 : 75% RDF + 25% Poultry manure + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	826	1400	2226	37.13
T9 : 25% RDF + 25% Vermicompost + 25% Enriched compost + 25% Poultry manure + <i>Rhizobium</i> + Foliar spray @ 0.5% Zn	909	1535	2444	37.20
SEm±	26.15	41.27	62.08	0.79
CD (5%)	78.41	123.74	186.11	NS

(Brar and Pasricha, 1998). Vermicompost provides vital plant nutrients, vitamins, growth hormones, and enzymes, which promotes higher yield attributes. These findings corroborate the findings of several other researchers by Kanwar *et al.* (2017), Gadi *et al.* (2017) and Meena *et al.* (2017).

A perusal of data (Table-2) showed that integrated nutrient management in blackgram crop resulted in a significant effect on seed yield, haulm yield and biological yield. Highest seed yield, haulm yield and biological yield observed under treatment T9 (25% RDF + 25% vermicompost + 25% enriched compost + 25% poultry manure + *Rhizobium* + foliar spray @ 0.5% Zn), increased significantly as compared to rest of the treatments, while control resulted in minimum yield. The higher rise in these yield attributes and yield has been linked to the release of macro and micronutrients during microbial decomposition (Singh and Ram 1992). As plants grew and developed, the steady supply of nutrients from poultry manure kept the production of metabolites and the efficiency of photosynthetic reactions at a higher level. Later, the

translocation of photosynthates to different sinks led to higher seed and haulm yields (Nagarajan and Balachandar, 2001). Bhadu *et al.* (2018), Shekhawat *et al.* (2018), Tyagi and Singh (2019), Todawat and Sharma (2021), Jakhar *et al.* (2022) and Meera *et al.* (2022) also found findings that were comparable.

It is revealed that harvest index of blackgram was not increased significantly due to integrated nutrient management practices during present investigation (Table-2).

Results presented in Table-1 and 2 revealed that maximum and significantly higher yield attributes viz., number of pods plant⁻¹, number of seeds pod⁻¹, test weight, seed yield, haulm yield and biological yield were observed in application of 25% RDF + 25% vermicompost + 25% enriched compost + 25% poultry manure + *Rhizobium* + foliar spray @ 0.5% Zn.

Conclusions

On the basis of experimental findings of one year experimentation we concluded that blackgram crop

fertilized with 25% RDF through fertilizer + 75% through organic manures (25% vermicompost + 25% enriched compost + 25% poultry manure) + seed treated with *Rhizobium* + foliar spray @ 0.5% Zn gave higher productivity and profitability in prevailing agro-climatic conditions of Zone IVa (Sub-humid Southern Plain and Aravali Hills) of Rajasthan. Therefore, it can be concluded that employing *Rhizobium* and foliar spray of 0.5% Zn to apply 75% RDF with poultry manure is a cheap and natural way to increase soil fertility and increase blackgram productivity.

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Effect of Organic Nutrient Management on the Growth Parameters of Colocasia (*Colocasia esculenta* L.)

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Abstract

A field experiment was conducted during *kharif*, June 2022 and November 2022 at Rajasthan college of Agriculture, MPUAT, Udaipur to study effect of organic nutrient management in colocasia (*Colocasia esculenta* L.). In the present investigation, eight treatments and three replications were taken and the results depicted that the treatment T₈ (1/3rd RDF through FYM + 1/3rd RDF through NADEP + 1/3rd RDF through vermicompost) have significantly maximum values for growth characters such as number of stolons (4.27), stolon length (21.07 cm), leaf lamina length (38.40 cm), leaf lamina width (28.62 cm). However, T₇ (½ RDF through NADEP + ½ RDF through vermicompost) have maximum values for plant height (59.46 cm) and T₁ have maximum number of leaves (3.77) as compared to T₈.

Key words : FYM, NADEP, Vermicompost

Introduction

Taro (*Colocasia esculenta* L.) is important tuber vegetables of the world and known as “Great leaved caladium” or “elephant ear” in English. Colocasia is an ancient and useful root crop from the monocotyledonous family, Araceae. The family consists of about 110 genera with over 2500 species. Colocasia is a perennial, herbaceous, subtropical or tropical plant usually grown for its starchy and sweet flavored corms. Colocasia roots also known as dasheen and eddoe are grown in many areas of the world. Plants are perennial but cultivated as annuals, lactiferous and very variable herb with 30-150 cm in height. Leaves are large or rather large, obliquely erect long petioled with varying colour and size. Petiole is sheathing at the base, uniformly light or dark green, green with dark streaks or violet, 40-150 cm long. It consist mainly leaves with long petiole which arises in a whorl from the apex of the underground corms. Corms are cylindrical with short internodes and few side tubers. Colocasia is also grown as an ornamental plant. It grows very quickly and new plants can be formed easily by the dispersal of seeds and corms which re-sprout easily. It is mainly cultivated for its fleshy corms and cormels, though all plant parts are consumed *i.e.*, the leaves, petioles, corms and cormels. The pressure-cooked taro corms after being passed through strainer are allowed to ferment giving an acid product called “poi”.

Colocasia contains good quality protein, digestible

starch, vitamin C, thiamine, riboflavin, niacin and essential amino acid. The crop is also very rich in dietary-fibre; thus, it could be employed in the treatment of diseases such as obesity, diabetes, cancer and gastrointestinal disorder (Mukharjee *et al.*, 2016).

Materials and Methods

The experiment was conducted during *kharif* season of the year 2022-23 at the Horticulture Farm, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur, which is situated at 74° 42' E longitude and 24° 35' N latitude with an altitude of 581.13 m above mean sea level. The experiment included eight treatment combinations *i.e.* T₁ (Control), T₂ (RDF through FYM), T₃ (RDF through Vermicompost), T₄ (RDF through NADEP compost), T₅ (½ RDF through FYM + ½ RDF through NADEP), T₆ (½ RDF through FYM + ½ RDF through Vermicompost), T₇ (½ RDF through NADEP + ½ RDF through Vermicompost), T₈ (1/3rd RDF through FYM + 1/3rd RDF through NADEP + 1/3rd RDF through Vermicompost). They were under taken in randomized block design with three replications. Observations were recorded at 120 days after planting (DAP) for various parameter like plant height (cm), number of leaves, number of stolens, stolon length (cm), leaf lamina length (cm) and leaf lamina width (cm).

For the experiment variety Muktakeshi was used and for organic nutrient management FYM, vermicompost and NADEP were used with nutrient composition of

Table-1 : Effect of organic nutrient management on growth characters colocasia.

Treatments	Plant height (cm)	Number of stolons	Stolon length (cm)	Number of leaves	Leaf lamina length (cm)	Leaf lamina width (cm)
T ₁ (Control)	45.73	2.33	13.27	3.77	32.33	23.60
T ₂ (RDF through FYM)	53.20	2.85	16.60	3.36	33.21	24.27
T ₃ (RDF through Vermicompost)	52.67	3.72	16.67	3.52	35.27	24.80
T ₄ (RDF through NADEP compost)	50.80	2.62	14.81	3.64	33.13	25.14
T ₅ (½ RDF through FYM + ½ RDF through NADEP)	53.60	2.45	15.47	3.34	33.93	23.84
T ₆ (½ RDF through FYM + ½ RDF through Vermicompost)	51.25	3.15	20.84	3.33	35.47	25.67
T ₇ (½ RDF through NADEP + ½ RDF through Vermicompost)	59.46	3.34	20.07	3.21	36.73	27.53
T ₈ (1/3 rd RDF through FYM + 1/3 rd RDF through NADEP +1/3 rd RDF through Vermicompost)	56.87	4.27	21.16	3.09	38.40	28.62
SE(m) ±	0.78	0.06	0.26	0.07	0.56	0.34
CD (P=0.05)	2.38	0.17	0.80	0.21	1.70	1.03

(0.5:0.25:0.50); (1.8:0.28:0.30) and (1.5:0.9:1.4), respectively. Field contains total 24 plots in number with plant spacing of 60 cm X 45 cm for R X P.

Results and Discussion

Effect of various levels of FYM, NADEP and Vermicompost on growth parameters : The effect of FYM, NADEP and vermicompost were observed significant on growth traits. The maximum plant height at 120 DAP (59.46 cm), number of stolons (4.27), stolon length (21.07 cm), leaf lamina length (38.40 cm), leaf lamina width (28.62 cm) and minimum number of leaves (3.09) were recorded under treatment T₈ (1/3rd RDF through FYM + 1/3rd RDF through NADEP +1/3rd RDF through vermicompost), whereas, minimum plant height at 120 DAP (45.73 cm), number of stolons (2.33), stolon length (13.27 cm), leaf lamina length (32.33 cm), leaf lamina width (23.60 cm) and maximum number of leaves (3.44) were recorded under T₁ (Control). It happened due to the use of combined application FYM, NADEP and vermicompost, which improved the soil physical, chemical, and biological properties, resulting in increased root growth, which could have resulted in increased nutrient absorption and efficient nutrient translocation to the plant system during vegetative growth. Plants may absorb nutrients according to their needs, resulting in improved growth and development. The reason behind the result might be due to significant positive effect of combination of particular organic manure and compost on growth characters of the plant and the contribution added by the combination of organic manure and compost to the level of fertility in the soils. When the manure and compost starts decomposition most of the macro as well as micro nutrient is enhanced in the soil which improves physical

and chemical properties of the soil and ultimate increase the vegetative parameter of the plants. These findings are confirmed with the work of Wakre *et al.*, (2022) in yam bean, Suja *et al.* (2009) tannia (*Xanthosoma sagittifolium* L.), Goel and Kaur (2012) in tomato, Bhattarai and Maharjan (2013) in carrot and Kumar and Dahiya (2013) in chilli.

Conclusions

The present investigation entitled “Effect of Organic Nutrient Management in Colocasia (*Colocasia esculenta* L.)” was carried out during *kharif* season 2022-23 with the principal purpose. It is concluded from the present investigation that combined application of FYM, NADEP and vermicompost as organic manures improved the performance of colocasia in term of growth, yield and quality and also soil properties as compared to control. Among the all treatment combination application of T₈ treatment (i.e. 1/3rd RDF through FYM + 1/3rd RDF through NADEP +1/3rd RDF through Vermicompost) can be recommended to colocasia growers for obtaining better growth, yield and quality as well as for improving the soil properties.

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Economical Weed Control in Lentil (*Lens culinaris* Medik. L.)

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Abstract

A field experiment entitled “Effect of Weed Management on Weed Density, growth, and Productivity of Lentil (*Lens culinaris* Medik. L.)” was conducted during *rabi* 2021-22 at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur. The experiment was laid out in Factorial Randomized Block Design consisting of 20 treatment combinations and three replications. Ten chemical weed management practices *i.e.*, pendimethalin 500 g ha⁻¹ PE, pendimethalin 750 g ha⁻¹ PE, pendimethalin 1000 g ha⁻¹ PE, imazethapyr 50 g ha⁻¹ PoE, imazethapyr 60 g ha⁻¹ PoE, imazethapyr 70 g ha⁻¹ PoE, pendimethalin + imazethapyr 500 g ha⁻¹ PE, pendimethalin + imazethapyr 750 g ha⁻¹ PE, pendimethalin + imazethapyr 1000 g ha⁻¹ PE and control (No herbicides) were taken as factor A and HW at 40 DAS and control treatment were taken as factor B. Lentil variety Kota Masoor-3 was used as test crop. All the weed management treatments resulted in significantly higher net return from lentil crop. The maximum net return was realized by applying HW at 40 DAS which was 29.26 per cent higher over control (₹ 47645 ha⁻¹). The economic analysis of treatments in terms of B : C ratio reveals the highest B : C ratio (1.91) was obtained by Pendimethalin + Imazethapyr 1000 g ha⁻¹ PE which was significantly superior over control (1.64).

Key words : Lentil, hand hoeing, herbicides, weed control, economics.

Introduction

Pulses are an important part of the human diet since they are high in protein (20-27%), fibre, vitamins, and amino acids. They contain 15 vital mineral components that are required for mankind's well-being, in addition to protein (Wang *et al.*, 2003). Pulse crops can be a good example of a sustainable cropping pattern because they can be grown in low-cost, low-fertility soils and marginal lands. Small and marginal farmers on the Indian subcontinent love them because of their low cultivation costs and hardness. They also increase the nitrogen condition of the soil by fixing nitrogen. India is the world's greatest producer and consumer of pulses, but yields are too low, with a large yield difference between India and other industrialised countries, as well as between research station yield and field yield within India. Pulse crops may overcome poor yields and deliver good profit to farmers in India by introducing improved varieties, promoting better management techniques and developing inclusive marketing channels. Chickpea (54.09 %), pigeon pea (24.14 %) and lentil are the three most important pulse crops farmed in India (7.02%).

Weeds are one of the most significant constraints to the lentil crop worldwide, with weed infestation reducing

yield by up to 80%. Weeds compete for nutrients, moisture, and space with lentils, as well as harbouring insects, pests, and pathogens that can harm the crop. Because of the crop's poor early development and short height, considerable care must be made to weed management up to 40-45 days after sowing (Yadav *et al.*, 2007). Lentil is extensively plagued with thin and broad-leaved weeds and sedges, which compete with the crop and reduce yields by up to 60% (Chandrakar *et al.*, 2016).

Herbicides have transformed agriculture throughout the world, and they've helped boost output. They are widely recognised as a key tool in weed management since they significantly minimise labour requirements and are simple and convenient to operate. Low lentil productivity can be attributed to poor weed management (Lhungdim *et al.*, 2013). Weeds compete heavily with lentils since they are a short-statured crop, reducing crop yields significantly. Various pre-emergence herbicides for controlling weeds in lentil, such as trifluralin and pendimethalin, are only effective for the first month or two, although lentil is a long duration crop (145 days) and weeds sprouting later compete with crop plants. There is a scarcity of information on the usage of post-emergence herbicides in this crop notably in India.

Table-1 : Effect of weed management on net return and B : C ratio of lentil.

Treatment	Economics	
	Net Return (₹ ha ⁻¹)	B : C ratio
Levels of manual weeding		
Control	47645	1.64
HW at 40 DAS	61588	1.76
S.Em. ±	862	0.03
CD (P=0.05)	2469	0.08
Chemical weed management		
Pendimethalin 500 g ha ⁻¹ PE	56488	1.75
Pendimethalin 750 g ha ⁻¹ PE	56767	1.77
Pendimethalin 1000 g ha ⁻¹ PE	55961	1.74
Imazethapyr 50 g ha ⁻¹ PoE	57771	1.81
Imazethapyr 60 g ha ⁻¹ PoE	57523	1.80
Imazethapyr 70 g ha ⁻¹ PoE	57187	1.79
Pendimethalin + Imazethapyr 500 g ha ⁻¹ PE	61702	1.92
Pendimethalin + Imazethapyr 750 g ha ⁻¹ PE	62165	1.92
Pendimethalin + Imazethapyr 1000 g ha ⁻¹ PE	62736	1.91
Control (No herbicides)	17866	0.57
S.Em. ±	1928	0.06
CD (P = 0.05)	5520	0.17

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 experiment field was clay loam in texture, slightly alkaline in reaction (PH 8.6), medium in available nitrogen (298.1 kg ha⁻¹) and phosphorus (22.12 kg ha⁻¹) while high in available potassium status (452.5 kg ha⁻¹). The experiment consisted of twenty treatments combinations *i.e.*, two levels of weeding (control, hoeing at 20 DAS and weeding at 40 DAS) and ten weed management chemicals *viz.*, Pendimethalin 500 g ha⁻¹, Pendimethalin 750 g ha⁻¹, Pendimethalin 1000 g ha⁻¹, Imazethapyr 50 g ha⁻¹, Imazethapyr 60 g ha⁻¹, Imazethapyr 70 g ha⁻¹, Pendimethalin + Imazethapyr 500 g ha⁻¹, Pendimethalin + Imazethapyr 750 g ha⁻¹, Pendimethalin + Imazethapyr 1000 g ha⁻¹, and Control. These were replicated thrice in Factorial randomized Block Design (FRBD). Lentil variety kota Masoor-3 was used as test crop. A uniform dose of 20 kg N + 40 kg P₂O₅ ha⁻¹ was applied. Urea and DAP were used as a source of nitrogen and phosphorus. The common weeds observed in lentil fields were *Avena fatua* L. (Wild oat), *Phalaris minor* Retiz. (Bird's seed grass), *Chenopodium album* L. (lamb's quarters/Goose foot), *Anagallis arvensis* L. (Blue pimpernel), *Convolvulus arvensis* L. (field bindweed), *Melilotus indica* (L.) All.

Result and Discussion

Economics : The data deferring the effect of the treatments on net return is given in Table-1. All the weed management treatments resulted in significantly higher net return from lentil crop. The maximum net return was realized by applying HW at 40 DAS which was 29.26 per cent higher over control (₹ 47645 ha⁻¹). Compared to control (₹ 17866 ha⁻¹), all the weed management treatments resulted in significantly higher net return from lentil crop. However, the magnitude of increase in net return varied from ₹ 38095 ha⁻¹ to ₹ 44870 ha⁻¹. The maximum net return (₹ 62736 ha⁻¹) was realized by pre-emergence application of pendimethalin + imazethapyr 1000 g ha⁻¹ which was 251.14 per cent higher over weedy check. Net return obtained through this treatment was higher over the rest of the treatments but was at par with pendimethalin + imazethapyr 500 g ha⁻¹ PE (₹ 61702 ha⁻¹) and pendimethalin + imazethapyr 750 g ha⁻¹ PE (₹ 62165 ha⁻¹).

The data deferring the effect of the treatments on B C ratio is given in Table-1. The economic analysis of treatments in terms of B C ratio reveals the highest B C ratio (1.76) was obtained by HW at 40 DAS which was significantly superior over control (1.64). It is evident from the data in Table-1 that the highest B C ratio (1.92) was obtained with pendimethalin 1000 g ha⁻¹ PE or with,

however, it remained at par with all the treatments except control.

The minimum net monetary return was fetched under control (No herbicide). However, pendimethalin + Imazethapyr 1000 g ha⁻¹ PE was found most remunerative, as it fetched the highest net return and B C ratio in chemical weed managements. The comparatively lower cost of treatment application coupled with a good economic yield might be the reason for higher net monetary return and B C ratio. weed control treatments were superior to weedy check in influencing net returns due to weed control. Similar results were reported by Kundra and Gill (1990), Rana (2002) and Angiras and Singh (2005) and they also obtained higher net returns with better control of weeds.

Conclusions

The results of the field experimentation concluded that pre-emergence application of pendimethalin + imazethapyr 1000 g ha⁻¹ reduced the infestation of dominant weed species and these practises could be suggested as an efficient, economically viable, ecologically desirable and practically feasible management system for controlling weed species in lentil crop grown in southern Rajasthan.

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Correlation and Path Coefficient Analysis for Yield and its Contributing Traits in Blackgram (*Vigna mungo* (L.) Hepper)

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Abstract

Current investigation comprised of sixty-three genotypes including three checks (Pratap Urd-1, MU-2, and MU-3) of blackgram. The experiment was conducted in augmented design with four blocks as such that there were 15 genotypes along with three checks planted in each block and checks were randomized in each block during *Kharif* 2022 at Instructional farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. Correlation estimates revealed that seed yield per plant showed significant positive correlation at both genotypic and phenotypic levels with number of seed per plant and only at phenotypic level with branches per plant. The path analysis showed that branches per plant, followed by pods per plant, number of seeds per plant, biological yield and seed protein content had a direct positive influence on dry pod yield per plant. Further, these genotypes belong to different clusters indicates that they are diverse too. Significant positive correlation between yield and its contributing characters would help in indirect selection. Existence of diversity between genotypes in different clusters furnished scope of attaining promising results on hybridization among them.

Introduction

Blackgram (*Vigna mungo* (L.) Hepper, $2n=22$), popularly known as urdbean or mash, is a self-pollinating grain legume domesticated from *V. mungo* var *Silvestris* (Chandel, 1984). It is an important short duration crop widely cultivated in India which give us an excellent source of easily digestible good quality protein and ability to restore the fertility of soil through symbiotic nitrogen fixation. (Roopa Lakshmi *et al.*, 2003). Blackgram is a good source of protein for human and animal nutrition. Multiple studies hypothesize that proteins are more satiating than carbohydrates or fats, thus limiting overall food intake and helps in maintaining regular body weight. In addition, plant proteins lead to a lower kidney workload as compared to animal proteins.

Blackgram is the most highly prized pulse crops of India and an economically important grain legume crop in Asia which is widely cultivated on marginal lands with low inputs during *Kharif*, *Rabi* and summer seasons. It is also an excellent green manure and soil conservation crop. Its Dehusked cotyledon is used for the preparation of fermented foods such as idli, dosa and non-fermented foods like cooked dal, hopper, papad and waries (spicy hollow balls) (Batra and Millner, 1974).

Black gram is the fourth main pulse crop in India. Total pulse production in India is estimated to 27.3 MT whereas total production of Urd bean is recorded as 2.84 MT (black gram outlook, 2022). In India, black gram is cultivated in 5.031 Mha with a total production of about

0.653 MT. It is mostly grown in Madhya Pradesh, Uttar Pradesh, Andra Pradesh, Rajasthan, Maharashtra, Odisha, Chhattisgarh and Telangana.

Correlation analysis help us to know the association prevailing between highly heritable characters and give a better understanding of the contribution of each trait in the genetic makeup of the crop. Further, the method of path coefficient analysis measures the direct influence of one variable upon the other and permits the separation of correlation coefficient into components of direct and indirect effects.

Correlation studies cannot solely give accurate results of cause and effect of relationship between yield traits and their degree of association. Path analysis was initially advocated by Wright (1921) and later by Dewey and Lu (1959) provides measure of direct and indirect effects of traits on yield, partitioning the correlation coefficients into direct and indirect effects.

Materials and Methods

Material used in the current investigation comprised of sixty-three genotypes including three checks (Pratap Urd-1, MU-2, and MU-3) of blackgram. The experiment was conducted in augmented design with four blocks as such that there were 15 genotypes along with three checks planted in each block and checks were randomized in each block during *Kharif* 2022 at Instructional farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur.

Table-1 : Phenotypic correlation (below diagonal) and genotypic correlation (above diagonal) among 12 characters in blackgram.

S.N.	Character	Days to 50% flowering	Days to maturity	Plant Height	Branches /plant	Pods/plant	Pod Length	Number of seeds per plants	Seed yield/plant	seed weight	Biological yield	Harvest index	Seed Protein Content
1.	Days to 50% flowering		9.00	-0.04	0.10	0.13	0.00	-0.18	-0.12	-0.34**	0.03	0.01	0.09
2.	Days to maturity	0.87**		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
3.	Plant Height	-0.04	-0.06		0.25	0.40**	0.06	-0.09	-0.04	0.07	0.04	-0.09	0.01
4.	Branches per plant	0.11	0.25	0.24		0.26*	0.10	0.01	0.32*	0.14	0.20	0.11	-0.15
5.	Pods per plant	0.12	0.13	0.39**	0.26*		-0.04	0.09	0.25	0.08	0.33**	0.12	0.06
6.	Pod Length	0.03	0.08	0.06	0.13	-0.04		0.11	-0.10	-0.22	-0.02	-0.11	0.02
7.	Number of seeds per plants	-0.15	-0.12	-0.10	-0.00	0.09	0.09		0.46**	0.26*	0.20	0.43**	-0.07
8.	Seed yield per plant	-0.12	-0.07	-0.03	0.29*	0.22	-0.03	0.39**		0.25	0.66**	0.50**	0.04
9.	seed weight	-0.19	-0.16	0.05	0.17	0.07	-0.12	0.26*	0.21		0.21	0.14	-0.25
10.	Biological yield per plant	0.02	0.10	0.05	0.19	0.33**	-0.03	0.20	0.60**	0.18		-0.15	-0.07
11.	Harvest index	-0.01	0.01	-0.08	0.13	0.12	-0.07	0.40**	0.50**	0.12	-0.14		0.08
12.	Seed Protein Content	0.15	0.08	0.01	-0.13	0.06	0.01	-0.05	-0.04	-0.17	-0.08	0.03	

* and ** Significant at 5% and 1% respectively.

Table-2 : Genotypic path analysis for Seed yield per plant.

S.N.	Character	Days to 50% flowering	Plant height	Branches per plant	Pods per plant	Pod length	Number of seeds per plants	seed weight	Biological yield per plant	Seed protein content	r
1.	Days to 50% flowering	-0.1408	0.0044	0.0295	0.0004	-0.0006	-0.0608	0.0149	0.0195	0.0125	-0.1209
2.	Plant height	0.0060	-0.1026	0.0719	0.0013	-0.0095	-0.0308	-0.0030	0.0227	0.0021	-0.0419
3.	Branches per plant	-0.0143	-0.0254	0.2898	0.0009	-0.0168	0.0024	-0.0062	0.1129	-0.0212	0.3219*
4.	Pods per plant	-0.0180	-0.0406	0.0766	0.0034	0.0062	0.0294	-0.0035	0.1868	0.0090	0.2493
5.	Pod length	-0.0005	-0.0060	0.0302	-0.0001	-0.1617	0.0394	0.0098	-0.0110	0.0026	-0.0974
6.	Number of seeds per plants	0.0249	0.0092	0.0020	0.0003	-0.0185	0.3443	-0.0115	0.1143	-0.0095	0.4554**
7.	100-seed weight	0.0479	-0.0070	0.0413	0.0003	0.0363	0.0905	-0.0438	0.1153	-0.0354	0.2454
8.	Biological yield per plant	-0.0049	-0.0042	0.0586	0.0011	0.0032	0.0705	-0.0090	0.5579	-0.0097	0.6635**
9.	Seed protein content	-0.0122	-0.0015	-0.0426	0.0002	-0.0030	-0.0227	0.0108	-0.0375	0.1442	0.0358

Residual = 0.5894, * , ** Significant at 5% and 1% respectively.

Traits observed : Observations were recorded on randomly selected five competitive plants for plant height, number of branches per plant, number of pods per plant, pod length, number of seeds per pod, seed yield per plant, seed-weight (g), biological yield per plant, harvest index and protein content while days to 50 per cent flowering and days to maturity were recorded on plot basis. Harvest index analysis was done by using formulas. The mean data for all characters were calculated for the statistical analysis.

Statistical analysis : The correlation analysis for 63 genotypes were (epic and phenotypic level), GCV and PCV was calculated. Path coefficients were analysed at genotypic and phenotypic levels for seed yield per plant. The path coefficient analysis was carried out as per the method suggested by Dewey and Lu (1959).

Results and Discussion

The genotypic and phenotypic correlation coefficients for twelve characters were calculated as per formula proposed by Burton (1952). The coefficient of variance at two (genotypic and phenotypic) levels are presented in table-1. The genotypic correlation coefficients (r) are comparatively higher than their corresponding phenotypic correlation coefficients (r_p) for 12 characters studied. Days to 50 per cent flowering exhibited significant positive correlation only at phenotypic level with days of maturity ($r_p = 0.87^{**}$). This trait exhibited significant positive correlation at phenotypic level with days to 50 per cent flowering ($r_p = 0.87^{**}$). Plant height exhibited significant and positive correlation at both genotypic and phenotypic levels with number of pods per plant ($r_g = 0.40^{**}$, $r_p = 0.39^{**}$). This trait exhibited significant positive correlation at both genotypic and phenotypic levels with number of pods per plant ($r_g = 0.26^{**}$ and $r_p = 0.26^{**}$), seed yield per plant ($r_g = 0.32^{**}$ and $r_p = 0.29^{**}$). Number of pods per plant exhibited significant positive correlation at genotypic levels ($r_g = 0.33^{**}$) and at phenotypic level ($r_p = 0.33^{**}$) with biological yield. Pod length exhibited significant positive and negative correlation with none of the characters. Pod length exhibited significant positive correlation at both genotypic as well as phenotypic level with seed yield per plant ($r_g = 0.46^{**}$ and $r_p = 0.39^{**}$), 100-seed weight ($r_g = 0.26^{**}$ and $r_p = 0.26^{**}$) and harvest index ($r_g = 0.43^{**}$ and $r_p = 0.40^{**}$). Seed yield per plant exhibited significant positive correlation at both genotypic and phenotypic levels with biological yield ($r_g = 0.66^{**}$ and $r_p = 0.60^{**}$) and harvest index ($r_g = 0.50^{**}$, $r_p = 0.50^{**}$). 100-seed weight exhibited significant positive correlation at both genotypic and phenotypic levels with number of seed per plant ($r_g = 0.26^{**}$ and $r_p = 0.26^{**}$). While, days to 50 per cent flowering ($r_g = -0.34^{**}$) exhibited significant negative correlation only at genotypic level. Harvest index trait exhibited significant positive correlation at both genotypic and phenotypic levels with pods per plant ($r_g = 0.33^{**}$ and $r_p = 0.33^{**}$), seed yield per plant ($r_g = 0.66^{**}$ and $r_p = 0.60^{**}$). Harvest index exhibited significant positive correlation at

both genotypic and phenotypic levels with number of seed per plant ($r_g = 0.43^{**}$ and $r_p = 0.40^{**}$) and seed yield per plant ($r_g = 0.50^{**}$ and $r_p = 0.50^{**}$).

The path analysis showed that branches per plant, followed by pods per plant, number of seeds per plant, biological yield and seed protein content had a direct positive influence on dry pod yield per plant. The highest positive direct effect between the biological yield and dry pod yield per plant was seen across all the parameters. Similar results for correlation and path coefficient analysis were found by Babu (2016), Gowsalya (2016), Hemlatha (2017).

Conclusions

From the present investigation it may be concluded that GPU-KPU-1143, AKU-12-3, AKU-14-02, KU-16-8 and KU-16-9 appeared promising for seed yield and other yield contributing traits. Correlation estimates revealed that seed yield per plant showed significant positive correlation at both genotypic and phenotypic levels with number of seed per plant and only at phenotypic level with branches per plant. The path analysis showed that branches per plant, followed by pods per plant, number of seeds per plant, biological yield and seed protein content had a direct positive influence on dry pod yield per plant. Further, these genotypes belong to different clusters indicates that they are diverse too. Significant positive correlation between yield and its contributing characters would help in indirect selection. Existence of diversity between genotypes in different clusters furnished scope of attaining promising results on hybridization among them.

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Symptomatology, Isolation and Pathogenicity of Post-Harvest Fruit Rot Pathogens of Papaya (*Carica papaya* L.)

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Abstract

Papaya (*Carica papaya* L.) is economically important and a popular fruit. It is consumed as fresh fruit, vegetable and used as a processed product. Papaya, a very wholesome fruit, is highly nutritious and medicinal. Owing to increasing demand for its delicious fruit taste and extraction of its digestive constituent papain. Due to its high return income, the area and production of papaya have increased next to banana during the last few decades. Among all fungal diseases *Colletotrichum truncatum*, *Fusarium pallidoseum* and *Aspergillus niger* are most destructive post-harvest diseases of papaya fruit. For the pathogenicity experiments, healthy mature fruits of papaya were selected from the papaya plants or procured from the local market and pathogenicity were performed through pin prick injury methods. The pure culture was also sent to Indian Type Culture Collection (I.T.C.C.), Division of Mycology and Plant Pathology, I.A.R.I., New Delhi – 110 012 for further confirmation of the identification.

Key words : Papaya, post-harvest fruit rot, symptomatology, isolation, identification and pathogenicity.

Introduction

Papaya (*Carica papaya* L.) “Wonder fruit of the tropics” belonging to family Caricaceae. The genus *Carica* contains 21 species, out of which 5 species, *C. papaya*, *C. chilensis*, *C. goudotiana*, *C. monoica* and *C. pubescens* produce edible fruits. Papaya, a very wholesome fruit, is highly nutritious and medicinal. Owing to increasing demand for its delicious fruit taste and extraction of its digestive constituent papain. Due to its high return's income, the area and production of papaya have increased next to banana during the last few decades. Global papaya production during 2021-22 was 13.89 MT. India was the largest producer of papaya, its share in the world market is 43.7 per cent in 2021-22. India rank first with production of 5.77 MT in a total area of 0.149 million ha followed by Brazil (11.8%) which rank second and Indonesia (7.0%) rank third respectively. According to Directorate of Horticulture, Rajasthan (2021-22). Rajasthan having 19th position with 7.52 thousand hectares area and 8920 tons production.

The crop is being infected by thirty-three fungal, twelve viral, eight bacterial, six nematode and two phytoplasma diseases. Common bacterial pathogens are *Erwinia* spp. causes cankers and black rot. *Pseudomonas* spp. causing bacterial leaf spot and wilt. Fungal diseases including anthracnose (*Colletotrichum gloeosporioides*),

chocolate spots (*Asperisporium caricae*), black spot (*Cercospora papaya*), damping off (*Phytophthora palmivora* or *P. nicotianae*), fruit spot (*Cercospora mamaonis*) fusarium fruit rot (*Fusarium* spp.), powdery mildew (*Erysiphe cichoracearum* and *Oidium caricae*), nematodes including reniform nematode (*Rotylenchulus reniformis*, *R. parvus*), root- knot nematode (*Meloidogyne incognita*, *M. javanica*, *M. arenaria* & *M. hapla.*) and viral diseases including leaf curl virus. papaya ring spot (Papaya ring spot virus) and spotted wilt (Tomato spotted wilt virus) (Luk *et al.*, 2005).

In papaya, post-harvest losses reported 10-40 per cent in sea shipments, 5-30 per cent in air shipments are usual and losses due to disease ranges 1 to 93 per cent, which depends upon post-harvest handling and packing procedure (Alvarez and Nishijima, 1987). In developing countries, post-harvest losses of papaya were reported 40-100% due to its high perishable nature thus reducing the per capita availability. (Adene *et al.*, 2013 and Machado *et al.*, 2014). The post-harvest diseases of papaya cause 45 per cent loss of their market value (Abeywickrama *et al.* 2012). Most of the post-harvest diseases are initiated due to injuries created during and following the harvest. The infection process, mainly during post-harvest, is greatly aided by mechanical injuries to the surface of the papaya fruit such as fingernail scratches, abrasions, pin punctures and cuts (Wills *et al.*, 1989).

Materials and Methods

Collection of disease sample : From each market 2-3 diseased fruit samples were collected during survey from mandi and local fruit markets of different districts and brought to the laboratory for symptomatology, isolation and identification of fruit rot pathogens associated with it. The associated pathogen was preliminarily identified based on microscopic characters and symptoms produced by it.

Isolation and maintenance of the associated pathogens : Associated pathogens were isolated from diseased fruits of papaya samples. The fruits showing typical rotting symptoms were washed properly. The infected portion was cut into pieces with the help of sterilized blade and treated with 0.1% sodium hypochlorite, mixed in 50ml of sterilized distilled water and shaken vigorously. The mixture was diluted serially up to 10^{-4} and plated on pre-poured PDA plates. The inoculated Petri plates were incubated at $28 \pm 2^\circ\text{C}$. The individual fungal colonies were picked from the agar plates after two days of inoculation and sub cultured on petri plates poured with PDA. These inoculated plates were again incubated at $28 \pm 2^\circ\text{C}$. Pure cultures of fungal pathogens thus obtained were further purified and maintained by using hyphal tip method on PDA slants under aseptic condition and stored in refrigerator at $4-5^\circ\text{C}$ for further studies.

Identification of associated pathogens : Identification of the pathogens associated with papaya fruit rots was carried out by studying the colony characters viz., colour, pattern of mycelial growth and morphological characters of spores. These were measured under high power (40X) magnification of the microscope from actively sporulating 10 to 18 days old culture of different fruit rotting fungal species were compared with those given in the literature. The pure culture was also sent to Indian Type Culture Collection (I.T.C.C.), Division of Mycology and Plant Pathology, I.A.R.I., New Delhi – 110 012 for further confirmation of the identification.

Pathogenicity of associated pathogens : For the pathogenicity experiments, healthy mature fruits of papaya were selected from the papaya plants or procured from the local market, washed thoroughly with tap water, swabbed with sodium hypochlorite (1 part sodium hypochlorite and 3 parts distilled water) for 30 seconds and washed with sterile distilled water to remove the traces of sodium hypochlorite.

Pin prick injury : The sterilized fruit surface was injured by pricking with the help of a sterilized needle. Sterilized cotton pad of about 5.0 sq. cm was dipped in spore suspension of test fungus and swabbed over the wounded surface of the fruits. The inoculated fruits were kept along with cotton plug dipped in water, to maintain the humidity

and incubated at room temperature ($28 \pm 2^\circ\text{C}$). Suitable control with sterilized fruits uninjured and un-inoculated were kept under the high moisture condition and incubated at room temperature in all the three artificial inoculation methods. Symptoms produced were recorded and compared with the earlier literature. The fungi were re-isolated from the inoculated diseased portion of the fruits and the morphological and cultural characters were compared with original cultures to prove the Koch's postulates. The fungus was sub-cultured on PDA slants and allowed to grow at $27 \pm 1^\circ\text{C}$ for one week. Such slants were preserved in the refrigerator at 5°C and sub cultured once in two months.

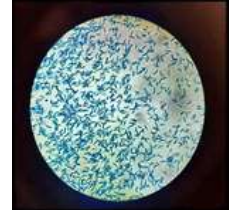
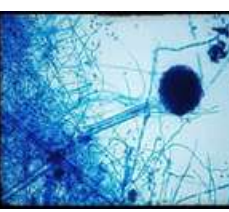
Purification and maintenance of fungal culture : The original culture was purified by following the hyphal tip method and the culture obtained was maintained on potato dextrose agar (PDA) medium slants by adopting subsequent sub-culturing at periodical and regular intervals. Seven days old culture was used for further studies.

Results and Discussion

Symptomatology : Symptoms of *C. truncatum* produced dark brown to black sunken lesions with black-coloured acervuli in concentric rings. On the other hand, *F. pallidoroseum* developed as sunken watery spots with white to yellowish or pinkish mycelial growth and *A. niger* produced soft rot bearing black mycelium with suppressed growth and green-coloured conidial mass. Similar symptoms of anthracnose in papaya have also been reported by Gautam *et al.* (2012), Singh *et al.* (2012) and Sharma and Kulshrestha (2015). However, *C. truncatum* produced dark brown to black sunken lesions with black coloured acervuli in concentric rings. Tapia-Tussell *et al.* (2008), TorresCalzada *et al.* (2013), Moraes *et al.* (2013) and Aktaruzzaman *et al.* (2018) also observed similar type of symptoms in anthracnose caused by *C. truncatum*.

Pathogens association and pathogenicity of post-harvest fruit rot pathogens of papaya : The associated pathogens were isolated from symptomatically differentiated rotten fruit showing post-harvest fruit rot through standard procedure as described in the materials and methods. A perusal indicates that all three fungal species viz., *Colletotrichum truncatum*, *Fusarium pallidoroseum* and *Aspergillus niger* were found to be predominantly associated with the post-harvest rots in papaya. However, in addition to these, *Rhizopus sp* and *Alternaria sp.* was also found associated to a limited extent, these species were initially identified on the bases of their mycelial and spore characters. All three *C. truncatum* *F. pallidoroseum* and *A. niger* was responsible for causing post-harvest rot throughout the year. These

Plate-1 : Symptomatology and Pathogenicity of post-harvest fruit rot causing pathogens.

Pathogens	Infected fruits	Symptoms	Culture Plates	Spores
<i>Colletotrichum truncatum</i>		Dark brown to black sunken water-soaked spots with black colored acervuli in concentric rings.		
<i>Fusarium pallidoroseum</i>		Slightly sunken lesions with whitish to pinkish mycelial growth on the fruit epidermis.		
<i>Aspergillus niger</i>		Water-soaked lesion with black coloured conidial mass.		

results are in conformity with the findings of various workers who have already reported the association of *C. fructicola* (Saini *et al.*, 2016 and Marquez – Zequera *et al.*, 2018), *C. truncatum* (dos Santos Viera *et al.*, 2019), *R. stolonifer* (Helal *et al.*, 2018 and Kadam *et al.*, 2019), *A. flavus* (Echerenwa and Umechuruba, 2004), *Fusarium* spp. (Akinro *et al.* 2015 and Sharma, 2015) and *A. alternata* (Pooja *et al.*, 2012) with anthracnose or different post-harvest rots of papaya. However, *C. fructicola* has been reported to be a member of *C. gloeosporioides* group (Weir *et al.*, 2012) while, *C. truncatum* is a synonym of *C. capsici* (Squizzato *et al.*, 2015).

Pathogenicity : Pathogenicity tests were conducted by inoculating the pure culture bits of each pathogen on young uninfected/healthy papaya fruits by Pin-prick injury method which showed in (Plate-1) and the incubation period of each pathogen was recorded as 3 days, *Colletotrichum truncatum* & *Fusarium pallidoroseum* while 1 day for *Aspergillus niger* respectively after inoculation. Louis *et al.* (2013) and Nicolice *et al.* (2016) who recorded an incubation period of 2 days in different plants inoculated with *Aspergillus* sp.

Identification of the pathogens : For primary identification of the pathogen microscopic observations were carried out based on that all three pathogens were identified primarily as *Colletotrichum* sp., *Fusarium* sp. and *Aspergillus* sp. The cultures were sent to the Indian Type Culture Collection, New Delhi for further

identification and identified as *Colletotrichum truncatum* (ITCC No.: 11.843.23), *Fusarium pallidoroseum*. (ITCC No.: 11.844.23) and *Aspergillus niger* (ITCC No.: 11.845.23).

Conclusions

Symptoms of *C. truncatum* produced dark brown to black sunken lesions with black-coloured acervuli in concentric rings. On the other hand, *F. pallidoroseum* developed as sunken watery spots with white to yellowish or pinkish mycelial growth and *A. niger* produced soft rot bearing black mycelium with suppressed growth and green-coloured conidial mass. During pathogenicity tests conducted on mature healthy papaya fruits by pin-prick method, an incubation period of each pathogen was recorded as 3 days, *C. truncatum* & *F. pallidoroseum* while 1 day for *A. niger* respectively after inoculation.

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Screening of Different Okra Varieties against Mite (*Tetranychus cinnabarinus* Boisduval)

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Abstract

Investigations on Screening of different Okra Varieties Against Mite (*Tetranychus cinnabarinus* Boisduval) conducted at Horticultural Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *kharif*, 2019. Out of ten varieties screened against the mite of okra, none of the variety was found completely free from the attack of mite. The peak population of sucking insect pest was categorized by using the formula. The varieties GOA-5, AOL-13-137 and GO-3 were rated as less susceptible against mite population. The varieties, AOL-13-90, AOL-13-136, GOH-2, Parbhani Kranti, AOL-12-55 were rated as moderately susceptible, whereas the varieties, GJO-3 and Pusa Sawani as highly susceptible to mite infestation.

Key words : Screening, mite, AOL-13-90, Parbhani Kranti, GOA-5, Pusa Sawani, Kharif.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] belongs to family Malvaceae is also known as lady finger, gumbo, or bhindi, is an important vegetable crop of the tropical and subtropical regions of the world. The crop can be grown throughout the year and commonly cultivated in *Kharif* and summer season. It is native of tropical Africa. India is the largest producer of okra. In India, Gujarat is leading state in production of okra with 921.72 thousand metric tonnes. In Rajasthan area and production of okra is 4.15 thousand ha and 21.39 thousand metric tonnes respectively (Anonymous, 2018). Okra is a multipurpose crop valued for its tender and delicious pods. In West Africa, leaves, buds, and flowers of okra are also consumed. Okra is a very good source of dietary fibre, magnesium, manganese, potassium, vitamin K, vitamin C (30mg/100g), B1, and B6, and folate (1.5mg/100g) (Aykroyd, 1963).

Insect pests are one of the most limiting factors for accelerating yield potential of okra. The crop is prone to damage by various insects, fungi, nematodes and viruses, although there is wide variability in their degree of infestation. Some of the important insect pests which are considered most important to limit the crop yield are aphid (*Aphis gossypii* Glover), whitefly (*Bemisia tabaci* Genn), leaf hopper (*Amrasca biguttula biguttula* Ishida), fruit borer (*Earias vitella* Boisd), *Earias insulana* (Boisd), *Helicoverpa armigera* Hubner and red spider mite (*Tetranychus cinnabarinus* Boisduval). Among the mite pests, *T. cinnabarinus* become abundant and causes

appreciable damage of 23 to 27 per cent to okra crop. Mites suck the cell sap from leaves and produce white spot which latter covers the entire leaf by thick webs. In case of severe attack these pests can cause 36-90 per cent loss in fruit yield of okra (Misra, 2002). The damage potential of *T. cinnabarinus* certainly proved this is undoubtedly the series pest of okra and they should be given prime importance in entomological research.

A little work has been done on Screening of different okra varieties against mite of okra under the agro-climatic conditions of zone IC and it is needed to sort out the precise nature or extent of relationship, which exists between sucking pests mite and weather factors to determine varieties susceptibility and to formulate effective pest control strategies for sustainable management of sucking pests.

Materials and Methods

The present investigations were conducted at Horticultural Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *kharif*, 2019. The experiment was laid out in a simple randomized block design with ten varieties (GO-3, GAO-5, GJO3, GOH-2, AOL-13-137, AOL-13-90, AOL-12-55, AOL-13-136, Pusa Sawani and Parbhani Kranti) and each replicated thrice. The plot size was 2.25 x 3.0 m² with row to row and plant to plant distance of 45 cm and 30 cm, respectively. The crop was shown on 1st August in *Kharif*, 2020.

Method of observations : The observations on major sucking insect pests of okra were recorded soon after the

appearance of the pests at weekly intervals till the harvesting of the crop. The crop was allowed for natural infestation. For recording mite population, three leaves representing top, middle and bottom canopy were plucked randomly from each of the five plants per plot and kept in separate polythene bags, which were properly labelled and brought to the laboratory for recording the mite population. 2.5 cm² frame was cut out from craft paper sheet and this open frame was kept on each spot selected randomly exclusively on the surface of each leaf. The absolute counting of mite was done under stereo-binocular microscope. The observations were recorded from infestation to continue till last picking of the crop. The whole experimental plot was kept free from spraying of any insecticides.

$$\bar{X}$$

Where

$\bar{X}$ = Mean of pest population at peak.

= standard deviation of pests population at peak.

So as categorized were made as :

1. Less susceptible
2. Moderately susceptible
3. Highly susceptible

Results and Discussion

The data presented in the table-1 and 2 depicted that none of the variety of okra was found completely free from the attack of mite infestation. The first observation recorded on 34th standard meteorological week (3rd week of August), showed that the mean mite population ranged from 0.12 to 4.26/2.5 cm² leaves. Minimum mite population was recorded on GAO-5 followed by AOL-13-137, GO-3, AOL-13-90, AOL-13-136, and Parbhani Kranti with 0.12, 0.22, 0.37, 0.56, 0.68 and 0.73/2.5 cm² leaf area respectively and these varieties were comparable with each other. GO-3 (1.85/2.5 cm² leaf area) and AOL-12-55 (2.33/2.5 cm² leaf area) stood in middle order of susceptibility and both were found statistically at par. The maximum population recorded on GOH-2 and Pusa Sawani ranged between 3.67 to 4.59 per cent mite per 2.5 cm² leaf area and both stood at par and significantly inferior among all the ten varieties. The ascending order of susceptibility of okra varieties against mite were: GAO-5 < AOL-13-137 < GO-3 < AOL-13-90 < AOL-13-136 < GOH-2 < Parbhani Kranti < AOL-12-55 < GJO-3 < Pusa Sawani. The infestation of mite increased gradually and reached to its peak in third week of September (38th SMW) and the mean mite population ranged from 4.13 to 26.73/2.5 cm² leaf area. The lowest infestation of mite was observed on variety GAO-5

followed by AOL-13-137 and GO-3 with 4.13, 5.45, 5.67 mite per 2.5 cm² leaf and these were found at par with each other and significantly superior over rest of the varieties. However, AOL-13-90 and AOL-13-136 were comparable to GOH-2. The population recorded on GOH-2 (13.17/2.5 cm² leaves), AOL-13-136 (16.40/2.5 cm² leaves) and AOL-13-90 (17.00/2.5 cm² leaves) were comparable to each other and were categorized in middle order of susceptibility against mite, *T. cinabarinus*. The maximum mite population was recorded on variety Pusa Sawani (25.60/2.5 cm² leaves) followed by GJO-3 (24.77/2.5 cm² leaves), AOL-12-55 (23.87/2.5 cm² leaves) and Parbhani Kranti (23.07/2.5 cm² leaves). These four varieties were observed statistically at par and significantly inferior among all the varieties.

The data recorded on mean mite population revealed that the significant difference existed among all the ten varieties screened. On the basis of formula the varieties having population less than 7.41 were rated as less susceptible, the varieties having population in between 7.41 to 24.40 were ranked as moderately susceptible, while the varieties having population above 24.40 were rated as highly susceptible.

According to this formula, the varieties GAO-5, AOL-13-137 and GO-3 were rated as less susceptible. The varieties, AOL-13-90, AOL-13-136, GOH-2, Parbhani Kranti and AOL-12-55 were rated as moderately susceptible, whereas the varieties, GJO-3 and Pusa Sawani as highly susceptible. The ascending order of susceptibility of okra varieties against mite were: GAO-5 < AOL-13-137 < GO-3 < AOL-13-90 < AOL-13-136 < GOH-2 < Parbhani Kranti < AOL-12-55 < GJO-3 < Pusa Sawani.

The data on screening of ten varieties of okra against mite indicated that none of the variety was found completely free from the attack of mite. In the present findings, the varieties GAO-5, AOL-13-137 and GO-3 were rated as less susceptible to mite population. These result corroborate with the results of Manual *et al.* (2007) and Siddhapara *et al.* (2018) who reported Arka Anamika and Arka Abhay as resistant against mite, however, Singh (2017) reported Kashi Pragati as a moderately resistant against mite, partially support the present findings. The varieties, Kashi Chaman, Pusa A4, Versha Uphar, Hisar Unnat and Pusa Bhindi 5 were rated as moderately susceptible. The present result doesnot agree with the observations of Gulati (2004) and Singh *et al.* (2017) who reported Varsha Uphar as susceptible variety against mite. In the present findings, the varieties Pusa Makhmali and Pusa Sawani were found as highly susceptible against mite. The present findings are in fully akin with observations of Gulati (2004), Manual *et al.* (2007) and Siddhapara *et al.* (2018) who reported Pusa Sawani as

Table-1 : Relative susceptibility of okra varieties against mite, Tetranychus cinnabarinus during Kharif, 2020.

Varieties	Mite population** / 2.5 cm ² leaves at weekly intervals														Overall Mean
	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
GO-3	0.12 (0.82)*	0.45 (0.95)	1.20 (1.28)	1.95 (1.48)	4.13 (2.12)	2.75 (1.77)	2.67 (1.77)	2.40 (1.54)	2.20 (1.62)	2.10 (1.53)	2.00 (1.56)	1.00 (1.21)	0.20 (0.84)	0.10 (0.77)	1.66 (1.37)
GAO-5	0.65 (1.07)	1.65 (1.45)	3.40 (1.92)	6.00 (2.52)	16.40 (4.09)	13.40 (3.70)	10.10 (3.25)	6.40 (2.59)	5.00 (2.26)	3.35 (1.89)	2.90 (1.78)	1.45 (1.36)	0.75 (1.11)	0.35 (0.92)	5.13 (2.14)
GJO-3	1.85 (1.67)	4.26 (2.11)	5.10 (2.29)	11.40 (3.43)	23.87 (4.93)	20.70 (4.59)	15.70 (4.00)	11.60 (3.46)	8.40 (2.96)	6.50 (2.55)	5.10 (2.29)	3.20 (1.86)	2.00 (1.56)	1.15 (1.29)	8.65 (2.79)
GOH-2	3.67 (1.09)	1.80 (1.49)	3.95 (2.10)	9.25 (3.10)	17.00 (4.18)	16.00 (4.02)	11.00 (3.38)	7.00 (2.73)	5.10 (2.29)	3.80 (2.07)	3.00 (1.86)	1.75 (1.48)	0.80 (1.12)	0.40 (0.94)	5.83 (2.28)
AOL-13-137	0.37 (0.92)	1.20 (1.29)	2.55 (1.68)	2.85 (1.79)	5.67 (2.47)	6.20 (2.57)	5.15 (2.36)	4.25 (2.14)	3.25 (1.90)	2.80 (1.77)	2.45 (1.65)	1.15 (1.27)	0.45 (0.96)	0.25 (0.86)	2.76 (1.69)
AOL-13-90	4.10 (2.11)	6.00 (2.41)	9.20 (3.10)	17.50 (4.23)	25.60 (5.10)	23.60 (4.90)	19.85 (4.50)	15.80 (4.03)	12.70 (3.59)	10.25 (3.26)	9.40 (3.13)	7.00 (2.56)	4.40 (2.18)	3.20 (1.88)	12.04 (3.36)
AOL-12-55	2.33 (2.03)	4.80 (2.26)	6.10 (2.54)	13.70 (3.75)	26.73 (5.02)	22.33 (4.78)	17.20 (4.20)	13.95 (3.79)	10.10 (3.20)	8.50 (2.98)	7.25 (2.78)	4.65 (2.24)	3.25 (1.92)	2.16 (1.56)	10.17 (3.07)
AOL-13-136	0.56 (0.99)	1.45 (1.39)	3.00 (1.82)	3.75 (2.05)	13.17 (3.69)	9.00 (3.04)	8.60 (2.99)	5.30 (2.37)	4.50 (2.21)	3.00 (1.82)	2.75 (1.76)	1.30 (1.34)	0.65 (1.06)	0.25 (0.87)	4.09 (1.96)
Pusa swami	4.59 (0.84)	0.85 (1.15)	1.65 (1.46)	2.65 (1.77)	5.45 (2.43)	5.00 (2.34)	4.20 (2.15)	4.00 (2.11)	3.10 (1.85)	2.55 (1.72)	2.10 (1.60)	1.00 (1.17)	0.30 (0.89)	0.15 (0.81)	2.37 (1.59)
Parbhani Kranti	1.80 (1.50)	2.40 (1.70)	4.75 (2.27)	10.33 (3.28)	23.07 (4.85)	18.20 (4.32)	13.20 (3.70)	9.33 (3.11)	6.20 (2.56)	4.33 (2.18)	3.35 (1.94)	2.15 (1.61)	1.95 (1.55)	1.00 (1.17)	7.29 (2.55)
S.Em.±	0.12	0.23	0.24	0.25	0.19	0.27	0.22	0.28	0.32	0.28	0.26	0.26	0.15	0.17	0.23
C.D.(p=0.05)	0.37	0.70	0.71	0.74	0.56	0.80	0.64	0.85	0.96	0.82	0.78	0.77	0.44	0.51	0.69
CV (%)	16.32	25.05	20.26	15.70	8.38	13.03	11.61	17.70	22.93	21.99	22.25	28.04	19.62	26.95	19.27

*Figures in Parentheses are $\sqrt{X}$ 0.5 values, **Mean of three replications.

Table-2 : Categorization of susceptibility of different okra varieties against mite during Kharif, 2020.

S. No.	Peak Mite Population	Categories	Name of Varieties
1.	Below < 7.41	Less Susceptible	GAO-5, AOL-13-137, GO-3
2.	7.41 TO 24.40	Moderately Susceptible	AOL-13-90, AOL-13-136, GOH-2, Parbhani Kranti, AOL-12-55
3.	Above >24.40	Highly Susceptible	GJO-3, Pusa Sawani.

Mean of Peak population ($\bar{X}$) = 15.91 Standard deviation (s) = 8.50.

highly susceptible variety of okra against mite while Singh *et al.* (2017) reported Pusa Sawani as moderately susceptible to mite infestation partially corroborate the present findings.

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Management of Phosphorus in Cowpea [*Vigna unguiculata* (L.) Walp] through PROM and Phosphatic Inoculants : A review

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Abstract

Cowpea [*Vigna unguiculata* (L.) Walp] is one of the important *kharif* pulse crops in India referred as *lobia* and developed for vegetable, grain, forage and green manuring. This crop has great significance due to its short duration, high yielding and rapid growing variety. The vegetable cowpea pods contain 84.6% moisture, 4.3% protein, 8.0% carbohydrate and 0.2% fat. Cowpea seeds contain about 21.2% to 30.6% protein, 60.3% carbohydrate, 1.85 fat and is also good source of calcium, phosphorus and iron. Phosphorus is the second most important nutrient next to nitrogen. Indian soils are poor to medium in available phosphorus. In conventional agriculture, to ameliorate its deficiency, expensive phosphatic fertilizers are applied in enormous amounts. Excessive application of these chemical fertilizers over long period has ruined natural properties of soils by killing soil micro flora and fauna leading to diminished agricultural production. In this way, chemical phosphatic fertilizers pose two fold issues, in that, on the one hand almost 85% of the applied P is lost perpetually which results in environmental pollution and second soil ill health. Sustainable agriculture based on utilization of organic and biological fertilizers is an effective solution for submounting these problems. Phosphate Rich Organic Manure (PROM) also referred as "green chemistry phosphatic fertilizer" is an effective source of P to replace the costly chemical phosphatic fertilizers and proves a better source for phosphorus application. PROM is a combination of well-composted organic manure and high-grade rock phosphate mineral. Inoculation of legume seeds with phosphate solubilizing bacteria (PSB) enhances nodulation, available phosphorus content of the soil and root and shoot biomass. PSB release the acidic substances and convert the unavailable phosphorus to available form for plants. Mycorrhiza association is a symbiotic non-pathogenic association between plant roots and fungal hyphae with a fungal relation between soil and the root. Vesicular Arbuscular Mycorrhizas (VAMs) can supply as high as 80% of P and 25% of N needed by its symbiotic partner. The joint inoculation of N₂-fixers, PSB, and mycorrhizal fungi could be more powerful than single organism for supplying a more balanced nutrition for legume plants under conditions of decreased nutrient inputs.

Key words: Phosphorus, Cowpea, PROM, VAM

Effect of PROM

Growth parameters : Meena (2005) at Udaipur carried out an experiment to study the response of soybean to PR (34/74) incubated with non-edible oil cakes, PSB and FYM. The treatments consisted of application of 60 kg P₂O₅/ha through DAP and PROM [an incubated product of PR (34/74) and non-edible oil cakes] along with PSB and FYM @ 2 and 4 t/ha and an absolute control. The results revealed that application of PROM (34/74) + castor cake + FYM @ 4 t/hain soybean significantly increased the plant height, number of primary and secondary branches/plant and dry matter accumulation of system over control and PR (34/74) alone and found at par with DAP equivalent to 60 kg P₂O₅/ha. Babu (2006) in his study conducted at ANGRAU, Andhra Pradesh observed that increase in the proportion of FYM in PROM made either with recommended (RD) and double recommended dose (DRD) from 1:2 to 1:4 ratio increased the plant height and dry matter accumulation during all the growth stages of soybean. The maximum numbers of nodules/plant at 30

DAS were observed with RD of P₂O₅ through SSP which was closely followed by the treatments of PROM with higher proportions of FYM. Nodule dry weight was maximum with the application of PROM made of DRD of P₂O₅ in 1:4 ratios. The growth parameters recorded by PROM made of DRD of P₂O₅ were superior over PROM made of RD of P₂O₅. The number of days taken to maturity was significantly reduced by phosphorus application through PROM and SSP over no phosphorus application. Singh *et al.* (2015) conducted a field experiment at Jobner to evaluate the response of different sources and levels of phosphorus on yield, nutrient uptake and net returns on mungbean under rainfed condition during *kharif*, 2008. They noticed that among the different sources, phosphorus rich organic manure (40 kg P₂O₅/ha) significantly increased the number of effective nodules/plant (32.27) by 13.02 and 10.89 per cent, respectively in comparison to diammonium phosphate (28.55) and single super phosphate (29.10). Application of PROM also significantly increased the number of total nodules/plant by 11.81 and 10.11 per cent over DAP and

SSP, respectively. However, SSP and DAP remained statistically at par with each other. Khangarot (2020) conducted an experiment at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during on loamy sand soil to evaluate the effect of phosphate rich organic manure (PROM) and microbial inoculants in mungbean. The combined application of PROM + PSB + VAM + PF resulted in the maximum value of most of the growth determining characters viz., plant height, number of branches/plant, dry matter accumulation at all the stages, number and weight of root nodules/plant, CGR, LAI and chlorophyll content.

Yield attributes and yield : Singh (2010) conducted a field experiment at Jobner to study the response of mungbean to different sources and levels of phosphorus under rainfed conditions and reported that application of phosphorus through PROM @ 40 and 60 kg P_2O_5 /ha recorded significantly higher number of pods/plant, seeds/pod, test weight and seed and straw yields of mungbean in comparison to SSP, DAP and control. While carrying out a field study at Jobner, Singh *et al.* (2015) reported that application of PROM at 40 kg P_2O_5 /ha in mungbean recorded significantly more number of pods/plant (31.97), number of seeds/pod (11.46), test weight (33.12 g), seed (8.36 q/ha) and straw (13.73 q/ha) yield as compared to control, DAP and SSP. They further explained that PROM was superior in increasing the seed yield by 17.7 and 12.2 per cent, respectively, as compared to DAP and SSP. Aechra *et al.* (2017) conducted a pot experiment at Jobner during *kharif* season on cowpea and reported that application of phosphorus through PROM recorded significantly higher total and effective nodules, nodule index, number of pods/plant, number of seeds/pod, seed yield, straw yield and root biomass of cowpea in comparison to SSP and DAP. Khangarot (2020) reported from Jobner that maximum grain, straw and total biological yield were noticed under the combined application of PROM + PSB + VAM + PF. The combined application of PROM + PSB + VAM + PF fetched the highest net returns of 50920/ha.

Nutrient concentration, uptake and quality : Khandelwal *et al.* (2004) conducted an experiment on clusterbean at ARS, Durgapura, Jaipur and reported that application of 40 kg P_2O_5 /ha through organic manure along with 50% RD of phosphatic fertilizer indicated an increase in protein content of clusterbean over the RD of 40 kg P_2O_5 /ha through DAP. Singh (2010) while studying the response of mungbean to different sources and levels of phosphorus at SKRAU, Bikaner reported significant increase in N, P, K and protein content in seed and straw as well as their uptake with application of PROM @ 40 kg P_2O_5 /ha in comparison to DAP and SSP. However, DAP and SSP were found statistically at par with each other.

Singh *et al.* (2015) at Jobner studied the influence of PROM application at 40 kg P_2O_5 /ha in mungbean and recorded significantly higher N (3.85 & 1.29%), P (0.46 & 0.211 %) and K (0.39 & 1.15%) contents in seed and straw and their uptake, protein content (24.06%) in seed and net returns as compared to control. In an experiment conducted at Jobner by Khangarot (2020) found that being at par with PROM + PSB + VAM application of PROM + PSB + VAM + PF witnessed significantly higher concentration of N and P in grain and straw, protein content in seed and uptake of N, P and K by crop.

Effect of Phosphatic inoculants

Growth parameters : Amit *et al.* (2010) conducted an experiment during *kharif* season to study the response of greengram to biofertilizers under different fertility levels. Inoculation of *Rhizobium* + PSB and application of 15 kg N + 20 kg P_2O_5 /ha significantly increased the number of branches and root nodules/plant as compared to control. Kumawat *et al.* (2010) conducted a field experiment at SKRAU, Bikaner and result revealed that inoculation of mungbean seed with *Rhizobium* + PSB significantly increased the plant height and number of branches/plant as compared to control, *Rhizobium* and PSB, alone. While investigating the effect of *Rhizobium* and vesicular arbuscular mycorrhizal fungi (VAM) on greengram under temperate condition, Bhat *et al.* (2011) found that combined inoculation of VAM fungi and *Rhizobium* significantly increased the dry weight of nodules/plant at flowering and at harvest stage, respectively. Inoculation with VAM alone yielded 42.40 and 30.26 mg dry weight of nodules/plant at these stages that were significantly higher than control. Das *et al.* (2011) while studying the effect of INM on cowpea demonstrated that number of leaves, plant height, number of pods, branches/plant, diameter and length of pods were significantly improved by the application of 75 per cent RDF + Vermicompost + *Rhizobium* + PSB as compared to only RDF which resulted in saving of 25 per cent chemical fertilizer. Saharan and Nehra (2011) reported that inoculation of plants with certain strains of plant growth promoting rhizobacteria (PGPR) like *Pseudomonas fluorescens* improved the biomass production through direct effects on root and shoots growth. They further stated that PGPR enhanced the seedling germination, stand health, plant height, chlorophyll content and nodulation in legumes as compared to control. Yaseen *et al.* (2011) while studying the effect of arbuscular mycorrhizal (AM) inoculation on nutrient uptake, growth and productivity of cowpea reported that AM inoculated plants out performed than non-inoculated plants in terms of growth parameters like plant height, number of nodules and flowers/plant. They reported gain in shoot and root dry weight of cowpea plants over AM- uninoculated. Prasad *et al.* (2012) while

studying the effect of different nitrogen sources and phosphate solubilizing bacteria on growth and yield of cowpea reported that inoculation of PSB+ *Rhizobium* along with 20 kg N/ha in cowpea considerably augmented the growth factors such as crop growth rate, plant height, plant dry weight, number of root nodules/plant. Patel *et al.* (2013) conducted a field experiment on *kharif* greengram at Sardarkrushinagar, Gujarat on loamy sand soil and observed that PSB inoculation significantly increased the number of branches/plant, plant spread, number of nodules/plant and dry matter accumulation over uninoculated control. Kumar *et al.* (2014) conducted a field experiment at Baghpat in U.P and observed that dual inoculation of blackgram seed with PSB + VAM significantly increased the number of branches/plant, dry matter production and root nodules/plant as compared to no inoculation and PSB alone. Satodiya *et al.* (2015) while studying the effect of planting density and INM on flowering and growth of cowpea reported that seed inoculation with PSB + *Rhizobium* along with spacing of 60 cm x 30 cm + 15:30:0 kg NPK/ha significantly enhanced the height of cowpea plant that is by 48.19 cm, which was greater than other treatments. Result of the field study conducted by Chauhan *et al.* (2016) on INM in cowpea revealed that by the use of biofertilizers *i.e.*, 2.4 kg/ha *Rhizobium* + 2.5 kg/ha PSB along with 2.64 t/ha neem cake + 0.66 t/ha vermicompost + 165 kg/ha mustard cake enhanced the height of plant by 57.73 cm. They opined that it may be due to seed treatment with PSB + *Rhizobium* which hastened the root development. Nadeem *et al.* (2017) conducted an experiment to study the influence of phosphorus and bio-fertilizers on growth and yield of cowpea and observed that combined inoculation of seed with *Rhizobium* + PSB along with 40 kg P/ha significantly increased the stem girth, total dry matter, green pod yield and soil nutrient status in acid soil (pH 6.2) over rest of the treatment combinations. A field experiment was conducted by Kumar and Yadav (2018) at Jobner during *kharif*, 2014. The experiment consisted of four levels of phosphorus and bio-organics (Control, PSB, VAM, vermicompost at 2 t/ha and VC at 2 t/ha + VAM). Results indicated that application of vermicompost at 2 t/ha + VAM recorded significantly the highest value of growth attributes *viz.*, plant height, number of branches/plant, dry matter accumulation, total and effective nodules/plant, fresh and dry weight of nodules and CGR of mungbean over control, PSB, VAM and vermicompost @ 2 t/ha, respectively. Singh *et al.* (2018) reported from Faizabad (UP) that integrated treatment of 80 kg P_2O_5 /ha + PSB significantly increased the plant height, LAI, dry matter accumulation and number of branches/plant in mungbean in comparison to 60 kg P_2O_5 /ha and absolute control. A pot experiment was

conducted by Bhabai *et al.* (2019) at Coochbehar, West Bengal to investigate the effect of biofertilizer on production potential of greengram. The plants were grown in pots containing soils amended with consortium of *Rhizobium* + VAM + PSB. They found that agronomic parameters like, plant height, shoot and root length, effective root nodules/plant, dry matter accumulation etc. were significantly increased by the addition of biofertilizer packages along with graded doses of phosphorus upto 60 kg/ha over uninoculated control.

Yield attributes and yield : Choudhary *et al.* (2010) conducted a field experiment at Anand in Gujarat and observed that inoculation of greengram seed with *Rhizobium* + VAM attained significantly higher number of pods/plant, pod length, test weight, number of seeds/pod, protein content and seed yield over control. Kumawat *et al.* (2010) studied the effect of biofertilizers under different fertility levels and reported that inoculation of mungbean seed with *Rhizobium* + PSB significantly improved the number of pods/plant, pod length, test weight and number of seeds/pod as compared to control and PSB alone. Rathore *et al.* (2010) investigated the effect of P application through different sources on yield of blackgram. They found that combined effect of FYM @ 5 t/ha + 40 kg P_2O_5 /ha + dual inoculation with PSB + VAM and 40 kg P_2O_5 /ha + dual inoculation with PSB + VAM produced significantly higher grain yield as well as number of pods/plant and seeds/pod. Bhat *et al.* (2011) in their experiment on greengram found that combined inoculation of VAM + *Rhizobium* recorded maximum grain and straw yields that were significant over control or single inoculation. They opined that it might be due to positive influence of VAM fungi and *Rhizobium* inoculation on yield attributing characters, better N-fixation, availability and solubilization of phosphorous. Khandelwal *et al.* (2012) in their study on cowpea observed that with the application of 30 kg P and 15 kg N/ha in addition to inoculation of seeds with PSB + *Rhizobium*, the yield and yield attributing traits were found superior *i.e.*, pod/plant, seeds/pod, straw yield and seed yield. It was also reported that the application of PSB + *Rhizobium* inoculation increased the pods/plant by 8.52, seed yield by 9.20 q/ha, straw yield by 20.12 q/ha and seeds/pod by 8.11. While studying the effect of integrated nutrient management on yield and economics of cowpea, Patel *et al.* (2012) reported that application of 20 kg N and 40 kg P_2O_5 /ha along with PSB and *Rhizobium* inoculation significantly increased the seed yield over 10 kg N + 20 kg P_2O_5 /ha but it was at par with 10 kg N + 20 kg P_2O_5 /ha alongwith PSB which indicated that PSB+ *Rhizobium* or PSB inoculation saved 50 percent nitrogen and phosphorus as chemical fertilizers. Senthilkumar and Sivagurunathan (2012) observed that inoculation of *Rhizobium* + phosphobacteria increased

number of nodules/plant, number of flower /plant and number of pods/plant in cowpea and mungbean than control and *Rhizobium* inoculation. Sivakumar *et al.* (2013) examined in a study that cowpea when inoculated with bacterial fertilizers *i.e.*, phosphobacteria + *Azospirillum* + *Rhizobium* reported significant effect on number of pods/plant by 4.2 which was greater than other treatments. Kumar *et al.* (2014) conducted a field experiment and observed that inoculation of blackgram seed with PSB + VAM had significantly higher pods/plant, number of seeds/pod, test weight, seed yield and biological yield over no inoculation. Khan *et al.* (2015) reported that the seed inoculation in cowpea with *Rhizobium*+PSB increased the microbial population and their activities in soil and increase the total and effective nodules/plant, number of pods/plant as well as number of seed/pods over no inoculation. Meena *et al.* (2015) reported that seed inoculation with *Rhizobium* + PSB in cowpea significantly increased the plant height and number of branches/plant, total and effective nodules/plant, number of pods/plant and number of seed/pods over control. Rani *et al.* (2016) reported from NDUAT, Kumarganj, Faizabad (U.P.) that inoculation of mungbean seed with PSB significantly increased the pods/plant and seeds/pod. An increase of 3.88% in seed and 3.99% in stover yield was also recorded with PSB inoculation than un-inoculation. Aechra *et al.* (2017) carried out a pot experiment at Jobner during *khari* season and reported that dual inoculation with PSB + VAM recorded significantly higher total and effective nodules, nodule index, number of pods/plant, number of seeds/pod, grain and straw yield and root mass of cowpea over rest of the treatments but in case of nodule index, it remained at par with PSB. Kumar and Yadav (2018) based on their studies at Jobner reported that application of vermicompost @ 2 t/ha + VAM registered significantly the highest number of pods/plant, grains/pod, test weight and grain, straw and biological yields of mungbean over vermicompost at 2 t/ha, PSB, VAM and control, respectively. Pargi *et al.* (2018) conducted an experiment in Gujarat and reported that *Rhizobium* + PSB + 100% RDF application induced 11.48 g of seed index in cowpea which was higher than other treatments, this was due to proper uptake of fertilizers by plants. Singh *et al.* (2018) conducted a field trial at Faizabad to know the effect of phosphorus and PSB on yield attributes of greengram. Results showed that the yield contributing characters *viz.*, number of pods/plant, seeds/pod, test weight, biological yield and seed as well as stover yield was maximum at 80 kg P₂O₅/ha + PSB followed by 60 kg P₂O₅/ha + PSB. Ajiboye *et al.* (2019) studied the effect of VAM on seedling growth and pod production of cowpea. Results revealed that fungal organisms greatly influenced the fresh and dry

shoot and root mass. The VAM was also found to greatly improve the seed and pod production of the cowpea when compared with the untreated seedlings.

Nutrient concentration, uptake and quality :

Choudhary *et al.* (2010) at AAU, Gujarat observed significantly higher protein content (23.42%) in *khari* greengram under *Rhizobium* + VAM over control which was at par with *Rhizobium* (22.83%) and *Rhizobium* + PSB (21.63%). Kumawat *et al.* (2010) at SKRAU Bikaner observed that inoculation of greengram seed with *Rhizobium* + PSB significantly improved the nitrogen and phosphorus uptake. The magnitude of increase in N uptake was 72.8, 33.7 and 39.64 per cent in seed and 66.3, 25.1 and 32.2 per cent in straw. The corresponding increase in phosphorus uptake was 83.1, 36.8 and 29 per cent in seed and 59.1, 22.5 and 17.9 per cent in straw over control, *Rhizobium* and PSB, respectively. Rathore *et al.* (2010) investigated the effect of P application through different sources on yield and nutrient uptake by urdbean. They found that FYM at 5 t/ha + 40 kg P₂O₅/ha, 5 t/ha of FYM + dual inoculation with PSB + VAM and 40 kg P₂O₅/ha + dual inoculation with PSB + VAM produced significantly higher yield and uptake of N, P and K by urdbean. Bhat *et al.* (2011) in their experiment on greengram reported that the interaction effect of VAM + *Rhizobium* exhibited significant increase of total N and P uptake over uninoculated control or single inoculation in greengram. Dekhane *et al.* (2011) conducted an experiment at Junagadh in Gujarat and observed that inoculation of cowpea seed with *Rhizobium* significantly increased the protein and N, P content as well as uptake of N and P by grain and stover as compared to PSB and control. Yaseen *et al.* (2011) from Pakistan reported that maximum uptake of nutrients (Ca, K, Mg, P, Fe, S and Si) in cowpea was attained in mycorrhizal plants over control. Khandelwal *et al.* (2012) conducted an experiment at Jobner on cowpea and reported that dual seed inoculation of *Rhizobium* + PSB recorded significantly enhanced N and P content in cowpea seed and straw and their total uptake by the crop as well as protein content in seed over control and PSB. However, inoculation with PSB was also found significantly superior over control in respect to increasing the quality parameters. Senthilkumar and Sivagurunathan (2012) observed that inoculation of seed with *Rhizobium* + Phosphobacteria significantly increased the chlorophyll content, protein content, carbohydrate, amino acids, inorganic phosphorus, nitrogen content of cowpea than control and *Rhizobium* alone treatment. Dhanya and Adeline (2014) found that mungbean plant treated with *Pseudomonas fluorescens* and other PGPRs showed higher protein content as compared to individual inoculation. Khan *et al.* (2015) observed that seed inoculation of cowpea with *Rhizobium* + PSB gave

significantly higher protein content in seed as compare to control. Meena *et al.* (2015) reported that application of nutrients through 75% RDF + 2.5 t/ha vermicompost + *Rhizobium* + PSB significantly improved the protein content, nutrient content and uptake by cowpea when compared with other combinations. Tripura *et al.* (2017) conducted an experiment at Jobner and reported that higher values of N, P and K content, their uptake and protein content in seeds of cowpea were obtained with the application of potassium humate @10 mg/kg soil + *Rhizobium* + VAM + PSB seed inoculation than other treatments. Birla *et al.* (2018) conducted an experiment and evaluated that under the treatment of 50 per cent nitrogen through FYM + PSB + 50 per cent nitrogen through vermicompost the higher protein content in seeds of cowpea was reported *i.e.*, 22.50 per cent. Results of a field experiment laid out by Kumar and Yadav (2018) showed that application of vermicompost @ 2 t/ha + VAM in mungbean recorded the significantly highest N, P and K content in grain and straw, their total uptake of nitrogen, phosphorus and potassium and protein content than vermicompost at 2 t/ha, PSB, VAM and control. Rekha *et al.* (2018) reported from Gujarat that application of phosphorus at 40 kg/ha+ PSB + FYM @ 10 t/ha recorded the maximum removal of nutrients by cowpea from the soil. The maximum N,P,K,S, Fe and Zn content and their uptake by crop was recorded due to application of phosphorus at 40 kg/ha+ PSB over rest of the treatments.

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Physiological Parameters of Cowpea [*Vigna unguiculata* (L.) Walp] as Influenced by Application of PROM and Phosphatic Inoculants

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Abstract

A field experiment was carried out at Agronomy farm, S.K.N. Agriculture University, Jobner during *kharif* season of 2020 on to study the "Response of cowpea [*Vigna unguiculata* (L.) Walp] to varying levels of PROM and phosphatic inoculants". The experiment consisted four levels of PROM (control, PROM equivalent to 20 kg, 40 kg and 60 kg P₂O₅/ha) and four phosphatic inoculants (control, PSB, VAM and PSB + VAM). The total 16 treatment combinations were tested in factorial randomized block design with three replications. Results revealed that the magnitude of most of physiological parameters was higher under application of PROM equivalent to 60 kg P₂O₅/ha as compared to other combinations and control, but it was at par with PROM equivalent to 40 kg P₂O₅/ha. In phosphatic inoculants PSB+VAM treatment recorded higher CGR, RGR and Leaf area index and remained at par with VAM.

Key words : LAI, CGR, PROM, VAM, Cowpea

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp] is one of the important *kharif* pulse crops in India referred as *lobia* and developed for vegetable, grain, forage and green manuring. This crop has great significance due to its short duration, high yielding and rapid growing variety. Green tender pods of cowpea are utilized as vegetable. Cowpea is rich in protein, minerals and vitamins, generally preferred for its tender pods and fresh seeds but in some parts of the country, dry seeds are also consumed. The vegetable cowpea pods contain 84.6% moisture, 4.3% protein, 8.0% carbohydrate and 0.2% fat. Cowpea crop can provide up to 88 kg nitrogen per hectare. The crop gives such enormous vegetative growth and cover to the ground that it checks the soil erosion and later it can be furrowed down for green manuring. It has significant guarantee as an alternative pulse crop in dry land farming. Being rich in protein and containing numerous other nutrients, it is sometimes also called as 'vegetable meat'. Cowpea seeds contain about 21.2% to 30.6% protein, 60.3% carbohydrate, 1.85 fat and is also good source of calcium, phosphorus and iron (Mann, 1975). Being a legume, phosphorus fertilization assumes a significant part in deciding the yield of cowpea. Phosphorus is imperative constituent of nucleic acid, phosphoric acid and several enzymes. Likewise, it is also required for the transfer of energy inside the plant system and has

advantageous impact on early root advancement, plant growth, yield and quality of produce. It is also fundamental constituent for majority of enzymes, which are vital in transformation of energy in carbohydrate and fat metabolism and furthermore respiration in plants (Yawalkaret *et al.*, 1996). Phosphate Rich Organic Manure (PROM) also referred as "green chemistry phosphatic fertilizer" is an effective source of P to replace the costly chemical phosphatic fertilizers and proves a better source for phosphorus application. PROM constituents are organic manure-55-60%, P₂O₅ -14-16%, C: N ratio-15:1 and pH 7-7.5. PROM is extremely successful even in the saline soils where other phosphatic fertilizers get totally fail. Inoculation of legume seeds with phosphate solubilizing bacteria (PSB) enhances nodulation, available phosphorus content of the soil and root and shoot biomass. PSB release the acidic substances and convert the unavailable phosphorus to available form for plants. PSB might add 30 Kg of Phosphorus per hectare in the soil and enhance the yield of crop by 10-30% viz., legumes and vegetables etc. Use of phosphorus influences symbiotic N-fixation, yield and quality of cowpea pods. Inoculation of seed with P-solubilizing microorganisms is a promising method which may rectify the deficiency of phosphorus. The bioavailability of soil inorganic phosphorus in the rhizosphere varies widely with plant species and nutritional status of soil. Mycorrhiza association is a symbiotic non-pathogenic association

Table-1 : Effect of varying levels of PROM and phosphatic inoculation on crop growth rate (CGR) of cowpea.

Treatments	CGR (g/m ² /day)		
	0-25 DAS	25-50 DAS	50 DAS-At harvest
Levels of PROM			
Control	0.54	2.54	0.62
PROM equivalent to 20 kg P ₂ O ₅ /ha	0.62	2.91	0.72
PROM equivalent to 40kg P ₂ O ₅ /ha	0.67	3.23	0.83
PROM equivalent to 60kg P ₂ O ₅ /ha	0.68	3.52	0.90
SEm±	0.02	0.09	0.02
CD (P=0.05)	0.05	0.25	0.05
Phosphatic inoculation			
Control	0.56	2.78	0.67
PSB	0.64	3.09	0.77
VAM	0.64	3.04	0.76
PSB + VAM	0.67	3.30	0.87
SEm±	0.02	0.09	0.02
CD (P=0.05)	0.05	0.25	0.05
CV (%)	9.94	9.75	8.40

between plant roots and fungal hyphae with a fungal relation between soil and the root. Vesicular Arbuscular Mycorrhizas (VAMs) can supply as high as 80% of P and 25% of N needed by its symbiotic partner. The significance of mycorrhiza association in both agricultural and ecological systems has been widely recognised. Since, VAM symbiosis can have beneficial effect on plant growth and health, there is a growing interest in their application and management, especially within the context of sustainable agriculture.

Materials and Methods

An attempt was made to study the response of cowpea to varying levels of PROM and phosphatic inoculants. Field experiment was conducted during kharif season of 2020 at agronomy Farm, SKN Agriculture University, Jobner (Rajasthan). The soil was loamy sand with pH 8.1, available N 124.8 kg/ha (Subbiah and Asija, 1956), P 16.56 kg/ha (Olsen et al., 1954), K 153.8 kg/ha (Jackson., 1967) and 0.18% organic carbon (Jackson, 1973). The field experiment comprised of four levels of PROM (Control, PROM equivalent to 20 kg/ha, PROM equivalent to 40 kg/ha and PROM equivalent to 60 kg/ha) control, and four phosphatic inoculants (Control, PSB, VAM and PSB + VAM) there by making 16 treatment combinations. The experiment was laid out in Factorial Randomized Block Design with three replications. PROM (10.4% P₂O₅) applied as basal equivalent to 20, 40 and 60 kg P₂O₅/ha and was incorporated well into the soil at the time of sowing as per treatments. Cowpea seed was inoculated with liquid PSB culture i.e. *Bacillus megatherium* @3 ml/kg seed. The soil based VAM (*Trichoderma viride*) containing

hyphae, spores and sporocarp was incorporated into soil in crop rows at the time of sowing @5 kg/ha VAM was mixed with 8-10 kg vermi-compost as per treatment and thoroughly mixed manually in the treated plots. Seeds of the cowpea variety, RC-19 were sown on 7th July, 2020 in rows spaced at 30 cm apart at the depth of 4-5 cm with the help of 'kera' method using a seed rate of 20 kg/ha. CGR is calculated on the basis of following formula $CGR = (1/P) \times (W_2 - W_1) / (t_2 - t_1)$ LAI is calculated on the basis of following formula $LAI = \text{leaf area} / \text{ground area}$ RGR is calculated on the basis of following formula $RGR = (1/W) (dW/dt)$. The experimental data recorded for CGR, RGR and LAI were subjected to statistical analysis in accordance with the "Analysis of Variance" technique suggested by (Fisher, 1950). Appropriate standard error for each of the factor was worked out. Significance of differences among treatment effects was tested by "F" test. Critical difference (CD) was worked out, wherever the difference was found significant at 5.0 or 1.0 per cent level of significance.

Results and Discussion

Crop growth rate

Levels of PROM : It can be seen from the table-1 that CGR in mungbean increased progressively with the advancement of crop age. The values of CGR were lower during 0 - 25 DAS stage; highest during 25 – 50 DAS and then moderate during 50 DAS - harvest stage. A critical examination of data revealed that Application of PROM equivalent to 60 kg P₂O₅/ha attained the highest CGR values of 0.68, 3.52 and 0.90 g/m²/day during 0-25

Table-2 : Effect of varying levels of PROM and phosphatic inoculation on relative growth rate (RGR) of cowpea.

Treatments	RGR (mg/g/day)	
	25-50 DAS	50 DAS at harvest
Levels of PROM		
Control	43.51	4.55
PROM equivalent to 20 kg P ₂ O ₅ /ha	43.55	4.64
PROM equivalent to 40 kg P ₂ O ₅ /ha	44.18	4.84
PROM equivalent to 60 kg P ₂ O ₅ /ha	45.62	4.87
SEm±	1.04	0.12
CD (P=0.05)	NS	NS
Phosphatic inoculation		
Control	44.67	4.58
PSB	43.55	4.68
VAM	43.81	4.70
PSB + VAM	44.51	4.95
SEm±	1.04	0.12
CD (P=0.05)	NS	NS
CV (%)	8.16	8.44

NS = Non Significant

Table-3 : Effect of varying levels of PROM and phosphatic inoculation on Leaf area index (LAI).

Treatments	LAI	
	25 DAS	50 DAS
Levels of PROM		
Control	2.35	5.21
PROM equivalent to 20 kg P ₂ O ₅ /ha	2.89	5.74
PROM equivalent to 40 kg P ₂ O ₅ /ha	3.21	6.15
PROM equivalent to 60 kg P ₂ O ₅ /ha	3.36	6.29
SEm±	0.07	0.13
CD (P=0.05)	0.20	0.37
Phosphatic inoculation		
Control	2.63	5.27
PSB	3.03	5.94
VAM	2.94	5.87
PSB + VAM	3.21	6.30
SEm±	0.07	0.13
CD (P=0.05)	0.20	0.37
CV (%)	8.01	7.69

DAS, 25-50 DAS and 50 DAS-at harvest stages, respectively among all the levels.

Phosphatic inoculation : Further comparison of the data revealed that all the phosphatic inoculations viz. PSB, VAM and PSB+VAM registered significantly higher CGR values than obtained under control (Table-1). The maximum CGR values during 0-25 DAS, 25-50 DAS and 50 DAS-harvest stages (0.67, 3.30 and 0.87 g/m²/day) were obtained under dual inoculation with PSB+VAM.

Relative growth rate

Levels of PROM : Analysis of data given in table-2 revealed that increasing levels of PROM could not bring variation in RGR of cowpea upto the level of significance during all the stages.

Phosphatic inoculation : Further examination of data (Table-2) showed the RGR in cowpea remained uninfluenced during all the stages due to different phosphatic inoculation treatments.

Leaf area index

Levels of PROM : Data pertaining to the effect of increasing levels of PROM on leaf area index at 25 DAS and at harvest in cowpea have been presented in table-3. Results showed that every increase in level of PROM upto PROM equivalent to 40 kg P₂O₅/ha resulted significant improvement in LAI at both the stages over preceding levels, remaining at par with PROM equivalent to 60 kg P₂O₅/ha

Phosphatic inoculation : A critical study of the data given in table-3 further showed that phosphatic inoculation with PSB, VAM and PSB+VAM significantly increased the LAI at 25 DAS and at 50 DAS over control. Inoculation with PSB+VAM registered the maximum LAI at these two stages (3.21 and 6.30) among all the treatments

Conclusions

Based on the results of one year experimentation, it may be inferred that application of PROM equivalent to 40 kg P₂O₅/ha combined with dual phosphatic inoculation of PSB + VAM (P₄₀IPV) was found the most superior treatment combination for obtaining higher values of CGR, RGR and Leaf area index in cowpea.

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Significance of Vermicompost and Vermiwash on Crop Productivity of Pulses : A Review

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Abstract

Pulses, being a rich source of protein and essential nutrients, play a crucial role in ensuring global food security and nutrition. However, the sustainable production of pulses faces challenges such as soil degradation, nutrient depletion and environmental concerns. In recent years, the utilization of organic amendments like vermicompost and vermiwash has gained attention as promising solutions to enhance crop productivity while maintaining soil health and sustainability. This review paper aims to explore and evaluate the significance of vermicompost and vermiwash in improving the productivity of pulse crops by enhancing soil fertility, nutrient availability and overall plant growth.

Key words : Nutrient management, soil health, sustainable agriculture, vermicompost and vermiwash

Introduction

Pulses are essential crops that contribute to balanced diets, especially in regions where animal protein consumption is limited. Sustainable pulse production is vital to meet the growing global demand for nutritious food. Traditional agricultural practices often lead to soil degradation and reduced crop yields due to the excessive use of synthetic fertilizers and inadequate organic matter incorporation. About 65% of the country's total gross cultivated land in India is made up of foodgrain crops, namely grains (50%) and pulses (15%). Pulses are grown with the least amount of resource utilisation in India. The importance of pulses for a food basket makes them a "Smart Food." Pulses may also thrive in drought-prone locations and assist to improve soil fertility by fixing atmospheric nitrogen in the soil. They are also very water-efficient crops. It is clear that there is significant potential for using both direct and residual soil fertility caused by legumes. For cost-effective and long-term production, it is necessary to replace nitrogen with the available resources, particularly farmyard manure, vermicompost and appropriate biofertilizer strains (Singh *et al.*, 2015). Vermicompost, a nutrient-rich organic material produced through the digestion of organic waste by earthworms and vermiwash, a liquid extract obtained from vermicomposting, have gained attention as effective alternatives for improving soil fertility and crop productivity. Vermicompost is characterized by a well-balanced nutrient composition, including higher levels of essential macronutrients (nitrogen, phosphorus and potassium) and micronutrients compared to traditional compost. The organic matter in vermicompost enhances soil structure, water-holding capacity and

nutrient retention. Vermicompost has been shown to improve soil's chemical, physical and biological properties and may be utilised successfully to promote sustainable agricultural development, according to Das *et al.* (2019). Because there are live creatures in the vermicompost, it has a favourable effect on the nutrients that are accessible for plants to absorb, promoting growth. Technology for vermicomposting can be applied to sustainable agricultural methods (Mayunchi *et al.*, 2014).

Additionally, vermiwash contains water-soluble nutrients, plant growth-promoting substances and beneficial microorganisms that contribute to improved plant health and vigor. Vermiwash is a coelomic fluid extraction that includes vitamins, macro and micronutrients, plant growth hormones and enzymes. Vermiwash is an organic liquid fertiliser that not only acts as a biopesticide for plants but also has outstanding growth-promoting properties (Jandaik *et al.*, 2015). Regarding its origin, cost-effectiveness, availability, reproductibility and dependability as well as its biopesticide and eco-friendly soil conditioner, which makes it more beneficial, vermiwash has potential applications in sustainable development in agriculture (Varghese and Prabha, 2014). Vermiwash continuously supplies plants with the biologically accessible nutrients throughout time and it also contains biochemical components that are absent from ordinary compost and chemical fertilisers. Vermiwash can help cut back on the usage of pesticides and artificial fertilisers (Bansod, 2020). The application of vermicompost and vermiwash has shown positive effects on soil health indicators such as soil structure, microbial diversity and nutrient cycling. These amendments contribute to increased microbial

activity, leading to nutrient mineralization and enhanced nutrient availability for plant uptake. Improved soil structure reduces soil compaction, enhances aeration and facilitates root penetration, resulting in better water and nutrient absorption by pulse crops. The utilization of vermicompost and vermiwash reduces the environmental impact associated with chemical fertilizers and pesticide use. These organic amendments promote nutrient cycling, minimize nutrient leaching and mitigate soil and water pollution. The recycling of organic waste through vermicomposting also aids in waste management and reduces landfill accumulation.

Effect of Vermicompost

Plant Growth : According to Chaudhari *et al.* (2013), summer greengram plants that received the recommended dose of N (20 kg/ha) through vermicompost along with foliar applications of panchagavya exhibited significantly higher values of all growth characteristics, including plant height (41.6 cm), number of branches/plant (7.8), dry matter accumulation/plant (38.7 g) and root nodules/plant (27.3), compared to plants that received the other treatments. Choudhary *et al.* (2013) observed higher plant height, leaves and branches per plant, leaf area index, effective nodules /plant, nodule index and total dry matter of cowpea with application of vermicompost 2.5 t/ha followed by poultry manure 1.5 t/ha over control in cowpea crop. According to Dhakal *et al.* (2013), adding nutrients to greengram using a mixture of 75% RDF, 2.5 t/ha vermicompost, rhizobium and phosphate-solubilizing bacteria (PSB) increased the number of nodules per plant and the dry weight of nodules. Sitaram *et al.* (2013) studied that the application of higher levels of vermicompost from 5 to 7.5 t/ha significantly enhanced the plant height at harvest, dry matter accumulation at 30, 45 and 60 DAS, dry weight of root nodules at 30 and 45 DAS, total chlorophyll content in fresh leaves at 30, 45 and 60 DAS, leaf area index at 30, 45 and 60 DAS, CGR during 30-45 and 45-60 DAS, RGR during 45-60 DAS in greengram crop. According to Srikanth *et al.* (2013), vermicompost treatment resulted in considerably greater dry matter accumulation in pigeonpea reproductive sections at harvest (53.7 g) than control (48.9 g). Vermicompost application of 2 t/ha resulted in significantly taller plants (54.70 cm), more total root nodules per plant (40.73), more effective root nodules per plant (36.05) and more dry matter accumulation per plant (18.61 g) in a field experiment conducted during the Rabi season of 2016–2017, according to Yadav *et al.* (2017). During the Kharif seasons of 2016 and 2017, Sharma *et al.* (2018) undertook a two-year field experiment at JNKVV, Jabalpur (M.P.) to investigate the effects of integrated nutrient management on soybean growth, yield and yield

characteristics in Madhya Pradesh's rainfed conditions. According to their research, the plant height at harvest stage varied between 43.3 cm in the control treatment and 63.4 cm in the combined application of vermicompost @ 1.5 t/ha enhanced with PSB & Rhizobium + remainder of RDF using chemical fertiliser. They also recorded the largest number of branches/plant. According to Yadav *et al.* (2019), the cowpea crop generated noticeably greater plant height (67.12 cm), number of branches/plant (13.99), number of leaves/plant (52.03) and LAI (4.02) when FYM 5 t/ha + vermicompost 2 t/ha + Rhizobium + PSB were applied.

Yield attributes and Yield : With the application of vermicompost together with foliar application of panchgavya above the other treatments in summer greengram crop, Chaudhari *et al.* (2013) reported substantially higher values of yield characteristics, namely number of pods/plant (32.3) and number of seed/pod (8.6). According to Dhakal *et al.* (2013), applying nutrients using a mixture of 75% RDF, 2.5 t/ha vermicompost, Rhizobium and phosphate-solubilizing bacteria (PSB) enhanced greengram yield parameters, including seed yield (12.34 q/ha) and harvest index. According to Maryam and Mohammad (2013), vermicompost and plant density had a substantial impact on the biological yield of greengram. By employing 10 t/ha of vermicompost, a significant increase in biological yield (7502 kg/ha) was seen. In their study, Tyagi and Upadhyay (2013) at Tikamgarh (M.P.) found that the application of 100% RDF + vermicompost 1 t/ha + Rhizobium in greengram crop produced significantly higher yield attributes than the other treatments, including pods/plant (13.5), seeds/pods (10.6), test weight (36.4 g), seed yield (1.18 t/ha), stover yield (3.12 t/ha) and biological yield (4.30 t/ha). In a research conducted at Jobner, Khan *et al.* (2015) found that applying vermicompost at a rate of 6.0 t/ha significantly boosted cowpea seed, straw and biological yield compared to other treatments, while remaining on par with vermicompost at a rate of 4.0 t/ha. In comparison to other treatment combinations, Kumar *et al.* (2016) found that applying RDF + vermicompost (50:50) to urdbean produced the highest yield attributes, including pod length (8.3 cm), number of seeds/pod (7.6), test weight (47.1 g), seed yield (10.7 q/ha), straw yield (15 q/ha) and biological yield (25.7 q/ha). In a field study on the impact of various organic manures on the development and yield of chickpea (*Cicer arietinum* L.) at Udaipur, Yadav *et al.* (2017) discovered that application of vermicompost at a rate of 2 t/ha resulted in significantly higher pods/plant (50.12), seed yield (1916 kg/ha) and haulm yield (2998 kg/ha) compared to other organic manures. Sharma *et al.* (2018) at Jabalpur (M.P.) found that maximum pods (41.0 /plant), seeds (2.83 /pod) and

test weight (10.33 g) were recorded in combined application of vermicompost 1.5 t/ha enriched with PSB & Rhizobium + remaining of RDF through chemical fertiliser in soybean as against pods (30.2 /plant), seeds (2.30 /pod) and test weight (9.61 g) in control treatment. In an experiment on how different organic manures alone and in combination with biofertilizers affected cowpea (*Vigna unguiculata* (L.) Walp.), Yadav *et al.* (2019) found that the combined application of FYM 5 t/ha + Vermicompost 2 t/ha + Rhizobium + PSB culture increased cowpea yield by 46% in comparison to control treatment. Harireddy and Dowson (2020) in Prayagraj (U.P.) discovered that the application of vermicompost 6 t/ha + Rhizobium + Azospirillum increased the number of pods/plant (33.72), number of seeds/pod (9.6) and straw production (2629.9 kg/ha) in the cowpea crop. The influence of integrated nutrient management on the development and production of pigeonpea [*Cajanus cajan* (L.) millsp.] under rainfed conditions was studied by Kirar *et al.*, 2020. They discovered that applying 50% RDF + 2.5 t/ha vermicompost outperformed the other treatments in terms of yield and yield parameters, such as number of pods per plant, number of seeds per pod, test weight (g), seed yield (kg/ha), straw yield (kg/ha) and harvest index (%).

Effect of Vermiwash

Plant Growth : According to Rajan and Murugesan's (2012) research, cowpea shoot length obtained at concentrations of 75% (20.53 cm) and 100% (20.63 cm) of vermiwash saw outstanding growth. According to Khairnar and Gunjal (2012), the application of 50 l/ha of vermiwash as a foliar spray resulted in 3.23 times as many branches as water spray in greengram. In a research on the gram crop, Nath and Singh (2015) discovered that several combinations of vermiwash (buffalo dung) + grae bran with neem oil and aqueous garlic extract are efficient for boosting gram growth, blooming early and production up to three times over control. According to Jaybhaye and Bhalerao (2015), greengram and blackgram crops saw better germination percentages (100%) with increased vermiwash concentration. Maheshwari *et al.* (2016) in Chennai (T.N.) investigated that application of vermiwash and panchagavya concentration of 10:3 in *Dolichus lablab* resulted in considerably increased plant growth features such as number of leaves, leaf surface area, chlorophyll content and shoot length. In comparison to other treatments, Verma *et al.* (2017) found that using the full recommended dose of fertiliser (RDF) with 100 l/ha of vermiwash significantly increased plant height (232.14 cm), the number of primary branches (19.07), the number of secondary branches (17.61), the leaf area index (2.3) and the amount of dry matter accumulated per plant (214 g). In a study conducted in Egypt by Hassan and Elbatran in 2020, it was discovered that the application of

vermiwash + rhizobium + PGPR produced the highest levels of root nodulations and plant development. Meyyappan and Sivakumar (2020) investigated the impact of foliar applications of vermiwash and NAA on cowpea and discovered that vermiwash 5% and NAA 40 ppm significantly increased plant height, the number of leaves per plant and the leaf area index compared to the control treatment. According to Selvarani *et al.* (2020), the application of 5% vermiwash to a cluster bean crop produced the greatest growth metrics, including plant height (44.2 cm), leaf area (45.12 cm²) and the number of leaves per plant (21.36).

Yield attributes and Yield : According to Yadav *et al.* (2013), foliar application of vermiwash 10% spray in summer mungbean resulted in considerably greater seed production (1383 kg/ha), seed weight/plant (6.92 g) and seed number/pod (11.53). In a field experiment, Jadhav *et al.* (2014) discovered that foliar spraying with 2% vermiwash at various crop stages resulted in considerably greater numbers of pods per plant (34.48), seed production (1161.3 kg/ha) and straw output (2833.73 kg/ha) in fenugreek than the control. Esakkiammal *et al.* (2015) reported that the combination of vermiwash and vermicompost had the greatest favourable impact on lablab bean production. According to Chongre *et al.* (2016) research, the application of cow urine with vermiwash plus FYM resulted in considerably greater yields of straw (2256.7 kg/ha), seeds (743.2 kg/ha) and pods (20.7) per plant than the control in greengram. In a field experiment done by Bhardwaj and Sharma (2016) in Kurukshetra, the researchers discovered that foliar application of 5 % vermiwash boosted pod length, pod weight and pod number/plant in addition to the average mungbean seed output being about 44.9 % higher than control. According to Deotale *et al.* (2017), foliar humic acid administration by vermicompost wash in combination with NAA produced noticeably superior yield characteristics in pigeonpea, including pods/plant, seeds/pod, test weight (g) and seed yield (kg/ha), with greater concentrations over control. Vermiwash 10% spray on chickpeas produced substantially more pods per plant, seed yield (1783 kg/ha) and straw yield (2645 kg/ha) compared to control treatment, according to Yadav *et al.* (2017). According to Rao *et al.* (2017), foliar application of panchagavya + vermiwash + NAA resulted in the best yields of straw (2172 kg/ha), seeds (941.11 kg/ha) and seeds/pod (8.42). In a field experiment, Sutar *et al.* (2018) discovered that the soybean crop produced straw yield (2546 kg/ha) and seed yield (1270 kg/ha) when RDF + 10% vermiwash spray was applied. The seed production of cowpea was considerably greater with the application of vermiwash spray 25% and vermiwash 5% + NAA 40 ppm (741 kg/ha and 770 kg/ha, respectively) compared to

control treatment (670 kg/ha), according to Meyyappan and Sivakumar (2020). In a field trial, Selvarani *et al.* (2020) found that the clusterbean crop produced the most pods per plant (82.6), the longest pods (14.0 cm) and the most pods per acre (8.4 q/acre) after applying 5% vermiwash.

Conclusions

Incorporating vermicompost and vermiwash into pulse crop production systems offers significant potential to improve crop productivity, enhance soil health and promote sustainable agriculture. The balanced nutrient composition, positive effects on soil structure and microbial diversity, as well as disease suppression capabilities, make these organic amendments valuable tools for addressing the challenges of modern agricultural practices. Further research is warranted to optimize application rates, methods and their integration with existing agricultural systems to maximize their benefits for pulse crop production.

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Effect of Nutrient Management on Nutrient Uptake and Quality of Mustard [*Brassica juncea* (L.) Czern and Coss] in Typic Haplustepts

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Abstract

A field experiment was conducted at the Instructional Farm (Agronomy) of Rajasthan College of Agriculture, Udaipur, Rajasthan during 2016-17 to evaluate the influence of different vermicompost, zinc and iron levels on productivity of rabi season mustard. The experiment was laid out in a randomized block design, comprising 9 treatments replicated three times. The increasing levels of vermicompost, zinc and iron increased the nutrient content, uptake and quality of mustard under Typic Haplustepts soil. The application of vermicompost, iron and zinc increased the nutrient content and uptake of nitrogen, phosphorus, potassium, sulphur, zinc and iron in seed and stover and oil content in seed over control. The maximum nutrient content and uptake in seed and stover and oil content in seed was obtained under the combined application of vermicompost 4 t ha⁻¹ + iron 5 kg ha⁻¹ + zinc 5 kg ha⁻¹ (T9), respectively.

Key words : mustard, content, uptake, quality, vermicompost, zinc and iron

Introduction

Mustard is the major oilseed crop (>80% of rapeseed-mustard), widely grown in *Rabi* season mostly in North and North-Western. Indian mustard predominantly cultivated in Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh and Gujarat. In Rajasthan, rapeseed and mustard occupies prime place amongst all the oilseed crops grown in the state. Although it is major oilseed crop but its productivity (1334 kg/ha) in the state is much lower than its realizable yield potential of 2200 to 2400 kg/ha. The application of vermi compost not only adds plant nutrients (macro and micro) and growth regulators to one but also increases soil water retention, microbial population, humic substances of the soil, mineralization and release of nutrients. Besides these, Vermi compost also improves soil aeration, reduction of soil erosion, reduces of evaporation losses of water, accelerates the process of humification, stimulates the microbial activity, deodourification of obnoxious smell, destruction of pathogens, detoxification of pollutant in soil etc. (Manna and Biswas, 1996).

Micronutrients are equally important in plant nutrition as the major nutrients; they simply occur in plants and soils in much smaller concentrations. Plants grown on micronutrients deficient soils can exhibit similar reductions in plant growth and yield as major nutrients (Tisdale *et al.*, 1993). Recently, Singh (2008) reported that 48, 12, 5, 4, 33, 13 and 41% soils of India are

deficient in Zn, Fe, Mn, Cu, B, Mo and S, respectively. Micronutrient Fe and Zn are essential for the process of atmospheric nitrogen fixation and required by several enzyme systems, auxin and in protein synthesis. Zinc is one of the first micronutrients recognized as essential for plants that transported to plant root surface through diffusion (Maqsood *et al.*, 2009). Iron plays a vital role in the formation of chlorophyll and takes part in oxidation-reduction reactions involved in ribonucleic acid (RNA) metabolism of the chloroplast. It is a constituent of the enzyme ferridoxin and cytochromes and is involved in symbiotic nitrogen (N)-fixation in the synthesis of several metallo enzymes, carbohydrate metabolism and protein synthesis.

The efficiency of native micronutrients is further improved when these are used in conjunction with organic manures especially when the soils are belonging to semi-arid areas having coarse textured, low in organic carbon with low moisture retention and microbial activity. Improvement in available nutrient status of the soil with the incorporation of vermi compost alone or integration with chemical fertilizer could be attributed to the slow decomposition of organic manure producing acids and enhancing soil biological activity. These in turn provides congenial physical condition, conserves soil nitrogen and increases the availability of other nutrients. The mineralization of nutrients in the rhizosphere improves crop growth and provides a better source-sink relationship by enhancing synthesis and allocation of metabolites to reproductive organs.

Table-1 : Effect of nutrient management on nitrogen and phosphorus content (%) in seed and stover of mustard.

Treatments	Nitrogen		Phosphorus	
	Seed	Stover	Seed	Stover
T ₁ : Control	3.011	0.598	0.401	0.201
T ₂ : Vermicompost 2 t ha ⁻¹	3.103	0.624	0.420	0.252
T ₃ : Vermicompost 4 t ha ⁻¹	3.174	0.635	0.429	0.263
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	3.241	0.647	0.437	0.277
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	3.263	0.657	0.448	0.289
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	3.252	0.649	0.439	0.280
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	3.272	0.660	0.452	0.292
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	3.315	0.671	0.463	0.305
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	3.333	0.687	0.475	0.318
S.Em±	0.024	0.005	0.004	0.004
CD (P=0.05)	0.072	0.015	0.011	0.012

Table-2 : Effect of nutrient management on potassium and sulphur content (%) in seed and stover of mustard.

Treatments	Potassium		Sulphur	
	Seed	Stover	Seed	Stover
T ₁ : Control	0.632	1.201	0.802	0.424
T ₂ : Vermicompost 2 t ha ⁻¹	0.660	1.244	0.833	0.444
T ₃ : Vermicompost 4 t ha ⁻¹	0.667	1.258	0.841	0.452
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	0.678	1.264	0.852	0.466
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	0.687	1.279	0.861	0.478
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	0.680	1.269	0.854	0.469
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	0.691	1.284	0.865	0.482
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	0.711	1.309	0.888	0.494
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	0.723	1.330	0.901	0.508
S.Em±	0.004	0.004	0.003	0.004
CD (P=0.05)	0.011	0.011	0.010	0.013

Table-3 : Effect of nutrient management on zinc and iron content (mg kg⁻¹) in seed and stover of mustard.

Treatments	Zinc		Iron	
	Seed	Stover	Seed	Stover
T ₁ : Control	33.68	13.02	149.05	150.25
T ₂ : Vermicompost 2 t ha ⁻¹	35.01	13.45	151.01	152.03
T ₃ : Vermicompost 4 t ha ⁻¹	35.65	13.68	151.49	152.41
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	36.01	13.84	152.07	153.09
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	36.49	13.98	152.47	153.49
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	36.15	13.87	152.00	153.06
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	36.57	14.01	152.17	153.17
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	37.25	14.37	153.14	154.10
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	38.55	14.78	154.50	154.97
S.Em±	0.40	0.11	0.43	0.28
CD (P=0.05)	1.20	0.34	1.30	0.83

Materials and Methods

A field experiment was conducted during *rabi* season of 2016-17 at Instructional Farm (Agronomy) of Rajasthan College of Agriculture, Udaipur (Rajasthan) (24.34° N, 73.42° E and 579.5 m above mean sea level). The experimental soil was clay loam in texture and alkaline in

reaction. There were 9 treatments viz. Control, Vermicompost 2 t ha⁻¹, Vermicompost 4 t ha⁻¹, Vermicompost 2 t ha⁻¹ + Iron 5 kg ha⁻¹, Vermicompost 4 t ha⁻¹ + Iron 5 kg ha⁻¹, Vermicompost 2 t ha⁻¹ + Zinc 5 kg ha⁻¹, Vermicompost 4 t ha⁻¹ + Zinc 5 kg ha⁻¹, Vermicompost 2 t ha⁻¹ + Iron 5 kg ha⁻¹ + Zinc 5 kg ha⁻¹, Vermicompost 4 t ha⁻¹ + Iron 5 kg ha⁻¹ + Zinc 5 kg ha⁻¹ respectively. The

Table-4 : Effect of nutrient management on nitrogen and phosphorus uptake (kg ha⁻¹) by seed and stover of mustard.

Treatments	Nitrogen		Phosphorus	
	Seed	Stover	Seed	Stover
T ₁ : Control	29.38	12.05	3.91	4.05
T ₂ : Vermicompost 2 t ha ⁻¹	34.76	14.83	4.70	5.99
T ₃ : Vermicompost 4 t ha ⁻¹	40.06	17.45	5.41	7.23
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	45.40	20.06	6.13	8.59
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	47.02	20.98	6.46	9.23
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	45.68	20.18	6.17	8.71
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	47.43	21.20	6.55	9.38
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	52.65	23.41	7.35	10.65
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	58.50	25.91	8.34	11.98
S.Em±	1.59	0.71	0.23	0.32
CD (P=0.05)	4.76	2.13	0.70	0.95

Table-5 : Effect of nutrient management on potassium and sulphur uptake (kg ha⁻¹) by seed and stover of mustard.

Treatments	Potassium		Sulphur	
	Seed	Stover	Seed	Stover
T ₁ : Control	6.16	24.21	7.82	8.55
T ₂ : Vermicompost 2 t ha ⁻¹	7.39	29.56	9.33	10.55
T ₃ : Vermicompost 4 t ha ⁻¹	8.41	34.46	10.60	12.38
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	9.50	39.19	11.94	14.45
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	9.91	40.83	12.41	15.26
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	9.55	39.46	12.00	14.58
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	10.02	41.23	12.54	15.48
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	11.30	45.70	14.11	17.26
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	12.69	50.18	15.82	19.17
S.Em±	0.33	1.17	0.41	0.46
CD (P=0.05)	1.00	3.51	1.22	1.37

Table-6 : Effect of nutrient management on zinc and iron uptake (g ha⁻¹) by seed and stover of mustard.

Treatments	Zinc		Iron	
	Seed	Stover	Seed	Stover
T ₁ : Control	328.68	262.52	1454.62	3029.49
T ₂ : Vermicompost 2 t ha ⁻¹	392.12	319.57	1691.33	3612.25
T ₃ : Vermicompost 4 t ha ⁻¹	449.34	374.77	1909.43	4178.99
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	504.95	429.16	2130.15	4747.06
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	526.37	446.32	2197.23	4900.24
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	507.84	431.33	2135.30	4759.81
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	530.16	449.86	2206.05	4918.26
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	591.57	501.72	2432.02	5380.32
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	676.69	557.48	2712.03	5846.64
S.Em±	19.59	13.15	69.39	147.54
CD (P=0.05)	58.75	39.43	208.02	442.32

mustard var. Bio-902 was taken as test crop and sown in lines 30 cm apart manually by 'Kera methods'. Whole amount of vermicompost as per treatment was broadcasted uniformly at the time of sowing and incorporated in the soil. The recommended dose of nitrogen (60 kg ha⁻¹) through urea, phosphorus (40 kg

ha⁻¹) through DAP, potassium (30 kg ha⁻¹) through MOP, zinc through ZnSO₄.7H₂O and iron through FeSO₄.7H₂O were applied as basal as per treatments. Yield from each plot was recorded as kg/ha. The N, P, K, S, Zn and Fe contents in seed and stover were estimated as per the procedures described by Prasad *et al.* (2006). The

Table-7 : Effect of nutrient management on oil content (%) in seed of mustard.

Treatments	Oil content (%)
T ₁ : Control	36.00
T ₂ : Vermicompost 2 t ha ⁻¹	37.13
T ₃ : Vermicompost 4 t ha ⁻¹	37.35
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	37.85
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	38.01
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	37.90
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	38.11
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	39.02
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	39.55
S.Em+	0.38
CD (P=0.05)	1.12

uptakes of these nutrients were calculated by multiplication of concentrations with the respective yield (seed & stover).

Results and Discussion

Nutrient content and uptake : The application of vermicompost, iron and zinc significantly increased nitrogen, phosphorous, potassium, sulphur, zinc and iron content and uptake in mustard seed and stover over control. The maximum content of nitrogen, phosphorous, potassium, sulphur, zinc and iron content in mustard seed (3.333%, 0.475%, 0.723%, 0.901%, 38.55% & 154.50%) and stover (0.687%, 0.318%, 1.330%, 0.508%, 14.78% & 154.97%) (Table 1, 2 & 3) and the maximum uptake of nitrogen, phosphorous, potassium, sulphur, zinc and iron by mustard seed (58.50 kg ha⁻¹, 8.34 kg ha⁻¹, 12.69 kg ha⁻¹, 15.82 kg ha⁻¹, 676.69 g ha⁻¹ & 2712.03 g ha⁻¹) and Stover (25.91 kg ha⁻¹, 11.98 kg ha⁻¹, 50.18 kg ha⁻¹, 19.17 kg ha⁻¹, 557.48 g ha⁻¹ & 5846.64 g ha⁻¹) was recorded highest under application of vermi compost 4 t ha⁻¹ + iron 5 kg ha⁻¹ + zinc 5 kg ha⁻¹ (T₉) (Table 4, 5 & 6) and the minimum under control (T₁), respectively. The positive influence of vermi compost was due to adequate supply of nutrients in root zone and plant system. The increased availability of these nutrients in the root zone coupled with increased metabolic activity at cellular levels might have synthesized more nutrients and their accumulation in various plant parts. Thus crop supplied with higher dose of vermicompost had utilized more nutrients as compared to lower doses resulting in increased nitrogen, phosphorus, potassium and sulphur content in seed and stover. The increased uptake of nitrogen, phosphorus, potassium and sulphur content in seed and stover seems to be due to the fact that uptake of nutrient is a product of biomass and nutrient content. The results obtained in the present investigation are in close conformity with those of Kumawat and Jat (2005) in barley and Kansotia et al. (2013) in mustard and the also

significantly increased zinc and iron content and uptake in mustard with application of vermicompost. The increase in content of Zn and Fe with application of vermicompost might be due to increased availability of native micronutrient cations. This is due to transformation of their solid phase form to soluble metalo-complexes and the application of micronutrients increased their contents (Samant, 2015).

The application of iron and zinc increased the content and uptake of N, P, K and S by seed and stover of mustard. This is clear from the fact that experimental soil was low in organic matter, nitrogen and phosphorus status. The application of iron and zinc supplied the nitrogen as well as other nutrients and increase their availability to the plants, resulting into higher absorption and uptake of nitrogen, phosphorus and potassium by plants. Similar, findings were also observed by Sharma (2015).

The applications of iron and zinc significantly increased the content and uptake of zinc and iron by seed and stover of mustard. The higher response of micronutrients (content) was because of inadequate availability of these micronutrients in the experimental soil. The increase in uptake may be attributed to increased seed and stover yields with the application of iron and zinc combinations (Meena *et al.*, 2006).

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Effect of Nutrient Management on Yield and Economics of Mustard [*Brassica juncea* (L.) Czern and Coss] in Typic Haplustepts

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Abstract

A field experiment was conducted at the Instructional Farm (Agronomy) of Rajasthan College of Agriculture, Udaipur, Rajasthan during 2016-17 to evaluate the influence of different vermicompost, zinc and iron levels on productivity of rabi season mustard. The experiment was laid out in a randomized block design, comprising 9 treatments replicated three times. The increasing levels of vermicompost, zinc and iron increased the yield and yield attributes of mustard under Typic Haplustepts soil. The combined application of vermicompost, iron and zinc was more beneficial for increasing yield attributes, yield and net returns of mustard as compared to control. The maximum seed yield and net returns (1755.36 kg ha⁻¹ and 37655.62 Rs ha⁻¹) was obtained under the combined application of vermicompost 4 t ha⁻¹ + iron 5 kg ha⁻¹ + zinc 5 kg ha⁻¹ (T9), respectively.

Key words : mustard, yield, economics, vermicompost, zinc and iron

Introduction

Rapeseed and mustard are important oilseed crops of the family *cruciferae* and occupy prominent place among oilseed crops being next to soybean. India is second in rapeseed and mustard production to China and first in area. It occupies 5.3 million ha area with 7.4 million tonnes of production (Anonymous, 2015-2016). In Rajasthan, rapeseed and mustard occupy prime place amongst all the oilseed crops grown in the state, occupying 2.63 million ha area, 3.51 million tonnes production and productivity 1334 kg ha⁻¹ (Anonymous, 2015-2016). Vermicompost is an eco-friendly and effective way to recycle agricultural and kitchen wastes. The material excreted through the anus of the earthworms in the form of manure is known as vermicompost. The earthworms act as natural bio ideal breeding home for aerobic bacteria which can multiply very fast and compete on aerobic bacteria and fungi. The biological recycling is process of transformation of organic waste into more elaborate products which are relatively richer in humic substances. The application of vermicompost not only adds plant nutrients (macro and micro) and growth regulators to one but also increases soil water retention, microbial population, humic substances of the soil, mineralization and release of nutrients (Manna and Biswas, 1996).

Zinc is one of the essential micronutrient and plays important role in various enzymatic and physiological activities of the plant. It is also essential for photosynthesis and N-metabolism and important for the stability of cytoplasmic ribosome's, cell division, dehydrogenase, proteinase, peptidase enzymes and in the synthesis of tryptophan, a component of some

proteins and a compound needed for production of growth hormones (auxin) such as indole acetic acid. Singh and Singh (1981) reported that most of the soils of Rajasthan were deficient in zinc and assigned low availability of zinc in coarse textured soils with low organic carbon content. Iron is a structural component of porphyrin molecules, cytochromes, heams, hematin, ferri chrome and leghaemoglobin. These substances are involved in oxidationreduction reactions in respiration and photosynthesis. Iron in chloroplasts reflects the presence of cytochromes for performing various photosynthetic reduction processes and ferredoxin as an electron acceptor. The ferredoxins are Fe-S proteins and are the first stable redox compound of the photosynthetic electron transport chain.

Materials and Methods

A field experiment was conducted during rabi season of 2016-17 at Instructional Farm (Agronomy) of Rajasthan College of Agriculture, Udaipur (Rajasthan) (24.340 N, 73.420 E and 579.5 m above mean sea level). The experimental soil was clay loam in texture and alkaline in reaction. There were 9 treatments viz. Control, Vermicompost 2 t ha⁻¹, Vermicompost 4 t ha⁻¹, Vermicompost 2 t ha⁻¹ + Iron 5 kg ha⁻¹, Vermicompost 4 t ha⁻¹ + Iron 5 kg ha⁻¹, Vermicompost 2 t ha⁻¹ + Zinc 5 kg ha⁻¹, Vermicompost 4 t ha⁻¹ + Zinc 5 kg ha⁻¹, Vermicompost 2 t ha⁻¹ + Iron 5 kg ha⁻¹ + Zinc 5 kg ha⁻¹, Vermicompost 4 t ha⁻¹ + Iron 5 kg ha⁻¹ + Zinc 5 kg ha⁻¹ respectively. The mustard var. Bio-902 was taken as test crop and sown in lines 30 cm apart manually by 'Kera methods'. Whole amount of vermicompost as per treatment was broadcasted uniformly at the time of sowing

Table-1 : Effect of nutrient management on number of siliquae per plant, number of seeds per siliqua and test weight of mustard.

Treatments	Number of siliquae per plant	Number of seeds per siliqua	Test weight (g)
T ₁ : Control	139.96	10.44	3.41
T ₂ : Vermicompost 2 t ha ⁻¹	153.02	11.35	3.66
T ₃ : Vermicompost 4 t ha ⁻¹	159.70	11.56	3.74
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	166.71	12.01	3.96
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	178.45	12.45	4.05
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	168.49	12.05	3.98
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	180.11	12.55	4.08
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	195.34	13.03	4.25
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	205.09	13.85	4.51
S.Em±	1.89	0.11	0.06
CD (P=0.05)	5.66	0.33	0.17

Table-2 : Effect of nutrient management on seed and stover yield (kg ha⁻¹) of mustard.

Treatments	Seed yield	Stover yield
T ₁ : Control	975.89	2016.22
T ₂ : Vermicompost 2 t ha ⁻¹	1120.01	2376.00
T ₃ : Vermicompost 4 t ha ⁻¹	1260.43	2739.54
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	1400.74	3100.90
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	1441.09	3192.55
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	1404.80	3109.77
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	1449.53	3210.98
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	1588.10	3491.45
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	1755.36	3772.71
S.Em±	44.88	91.70
CD (P=0.05)	134.54	274.92

Table-3 : Effect of nutrient management on net returns (Rs ha⁻¹) of mustard.

Treatments	Net returns
T ₁ : Control	18863.17
T ₂ : Vermicompost 2 t ha ⁻¹	19907.82
T ₃ : Vermicompost 4 t ha ⁻¹	19313.55
T ₄ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹	30536.96
T ₅ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹	26073.05
T ₆ : Vermicompost 2 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	30666.34
T ₇ : Vermicompost 4 t ha ⁻¹ + Zinc 5 kg ha ⁻¹	26368.53
T ₈ : Vermicompost 2 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	37421.96
T ₉ : Vermicompost 4 t ha ⁻¹ + Iron 5 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	37655.62
S.Em±	1605.17
CD (P=0.05)	4812.31

and incorporated in the soil. The recommended dose of nitrogen (60 kg ha⁻¹) through urea, phosphorus (40 kg ha⁻¹) through DAP, potassium (30 kg ha⁻¹) through MOP, zinc through ZnSO₄.7H₂O and iron through FeSO₄.7H₂O were applied as basal as per treatments.

Results and Discussion

Yield attributes : Application of vermicompost, iron and zinc significantly increased the number of siliquae per plant, number of seeds per siliqua and test weight of

mustard (Table-1). The application of vermicompost 4 t ha⁻¹ + iron 5 kg ha⁻¹ + zinc 5 kg ha⁻¹ recorded the maximum value of these parameters. It is an established fact that vermicompost improves the physical and biological properties of soil including supply of almost all the essential plant nutrients for the growth and development of plants. Thus balanced nutrition under favourable environment might have helped in production of new tissues and development of new shoots. The beneficial effect of vermicompost on these parameters might also be

due to its contribution in supplying additional plant nutrients and increasing the availability of native soil nutrients due to increased microbial activity. These results are in agreement with that of Kansotia *et al.* (2013) and Singh *et al.* (2014). Zinc plays an important role in auxin (IAA) synthesis and other enzyme system and has been recognized as an essential component in several dehydrogenase, proteinases and peptodases for normal plant growth. The iron as it helps in catalytic effect on most of the physiological and metabolic process of plant. Fe is also a constituent of large number of metabolically active compounds like cytochromes, haeme and non-haeme enzyme and other functional metallo proteins such as ferredoxin and haemoglobin. Fe plays an important role in Zn, Cu and Mg metabolism (Kumar *et al.*, 2014).

Yield : The application of vermicompost, iron and zinc also enhanced the seed and stover yield of mustard significantly (Table-2). The significant increase in seed and stover yield under the influence of vermicompost, iron and zinc was largely a function of improved growth and yield attributes like number of siliquae per plant, number of seeds per siliqua and test weight which consequently increased seed and stover yield. The interrelationship between various yields attributes of the crop and its seed and stover yield had also been observed by Premi *et al.* (2005) and Singh *et al.* (2011). The application of different nutrients fertilizer (Fe +Zn) alone or in combination increased the yield attributes and yield of mustard, but the response was more when more number of nutrients was applied through mineral mixture. This may be due to the fact that applications of fertilizer alone have supplied only one or two nutrients, but conjoint use of macro and micronutrient fertilizers have provided all the essential nutrients in proper amount, required by the plant for its growth and development. This might be due to the cumulative effect of all the nutrients and also due to low status of respective nutrients in experimental field. Physiological role of different nutrient enhance the yield attributes and ultimately increase the seed and stover

yield. Similar, results have also been reported in mustard (Ajay *et al.*, 2010).

Economics : The application of vermicompost 4 t hac + iron 5 kg ha⁻¹ + zinc 5 kg ha⁻¹ (T9) recorded highest net return (₹ 37655.62 ha⁻¹) and the minimum (₹18863.17 ha⁻¹) under control (T1) (Table-3). The application of vermicompost 4 t ha⁻¹ + iron 5 kg ha⁻¹ + zinc 5 kg ha⁻¹ to mustard crop significantly enhanced the net returns which was mainly due to increase in seed yield of mustard owing to enhanced nutritional environment of soil.

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Effect of Organic Manures and Vermiwash on Nutrient Content and Uptake in Cowpea [*Vigna unguiculata* (L.) Walp.] cv. Pusa Komal

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Abstract

The present investigation conducted during Kharif 2019 at Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan. It is determined that under prevailing agro-climatic conditions, cowpea crop for green pods fertilized with 50% RDN through FYM + 50% RDN through neem cake + Vermiwash 10% spray at 10% flowering stage revealed the maximum available nitrogen (221.28 kg ha⁻¹), maximum available phosphorus (24.72 kg ha⁻¹), highest concentration of available potassium (265.08 kg ha⁻¹), highest concentration of available sulphur (11.109 kg ha⁻¹), highest organic carbon 0.71 per cent, highest population of actinomycetes (34.25 × 10⁵ CFU g⁻¹), highest population of bacteria (29.33 × 10⁶ CFU g⁻¹), highest population of fungi (25.32 × 10⁵ CFU g⁻¹).

Key words : Cowpea, growth, vermiwash, compost, farm yard manure, neem cake.

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] commonly known as *Lobia*, southern pea, black eye pea, crowder pea and *chawla fali* belongs to family Leguminosae and having chromosome number 2n=22. Worldwide production of cowpea crop is 8 million tons, with an average yield of 1.4 tonne/ha. In India production of cowpea is 3 million tone. Cowpea seeds contain 54.5% carbohydrates, 24.1% protein and 0.1% fat. The green tender pod contains moisture (84.6%), protein (4.6%), carbohydrate (8.0%), fat (0.2%) and is a rich source of calcium, phosphorus, iron, etc. (Aykroyd, 1963). Organic manures viz., FYM, vermicompost, poultry manure and oilcakes help in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activity of microorganisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increases nutrient solubility, alters soil salinity, sodicity and pH. (Alabadian *et al.*, 2009). Vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B, the uptake of which has a positive effect on plant nutrition, photosynthesis, chlorophyll content of the leaves and improves the nutrient content of the different plant components (roots, shoots and the fruits). The high percentage of humic acids in vermicompost contributes to plant health, as it promotes the synthesis of phenolic compounds such as anthocyanins and flavonoids which may improve the plant quality and act as a deterrent to pests and diseases (Theunissen *et al.*, 2010). Neem seed cake acts as a nutrient reservoir providing favorable pH, aeration and improving other physical and chemical properties of the soil (Uma Singh and Pokhriyal, 1997).

Earthworms secrete body fluid through the dorsal pores to survive in the environment. The body fluid collected from the earthworm without harming them is called vermiwash. It contains enzymes which are secretions that stimulate the growth and yield of crops and even help to develop resistance in crops that receive this spray, such preparation would certainly have soluble plant nutrients apart from some organic acids and mucus of earthworms and microbes (Shivasubramanian and Ganesh Kumar, 2004). Therefore, the present investigation was planned for the effect of organic manures and vermiwash on growth, yield and quality of Cowpea. Use of organic manures to meet the nutrient requirement of crop would be an inevitable practice in the years to come for sustainable agriculture since, organic manures generally improve the soil physical, chemical and biological properties along with conserving the moisture holding capacity of soil and thus resulting in enhanced crop productivity along with maintaining the quality of crop produce although the organic manures contain plant nutrients in small quantities as compared to the fertilizers, the presence of growth promoting principles like enzymes and hormones, besides plant nutrients make them essential for improvement of soil fertility and productivity (Premsekhar and Rajashree, 2009).

Materials and Methods

The experiment was conducted during June 2019–November, at Horticulture farm, Rajasthan College of Agriculture, MPUAT, Udaipur. Geographically, Udaipur is located at 24° 34' N latitude and 73° 42' E longitude at an elevation of 582.17 meters above mean sea level. This

Table-1 : Nitrogen content of inputs

S. No.	Name of manure	N (%)
1.	FYM	0.50
2.	Vermicompost	1.5
3.	Compost	1.30
4.	Neem cake	5.2
5.	Vermiwash	0.40

Table-2 : Treatment details are following :

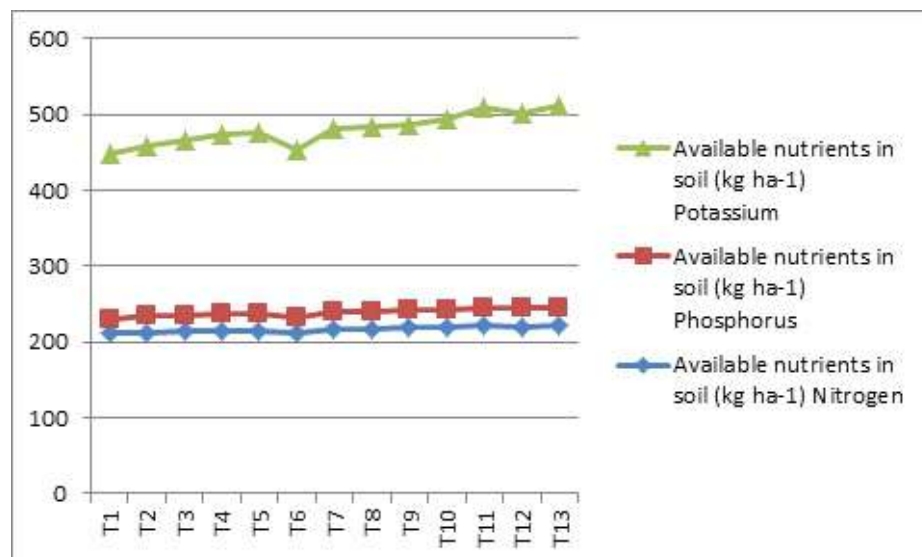
Treatments	
T1	Control
T2	100% RDN through FYM
T3	100% RDN through compost
T4	100% RDN through vermicompost
T5	100% RDN through neem cake
T6	Vermiwash 10% spray at 10% flowering stage
T7	100% RDN through FYM + Vermiwash 10% spray at 10% flowering stage
T8	100% RDN through compost + Vermiwash 10% spray at 10% flowering stage
T9	100% RDN through vermicompost + Vermiwash 10% spray at 10% flowering stage
T10	100% RDN through neem cake + Vermiwash 10% spray at 10% flowering stage
T11	50% RDN through FYM + 50% RDN through vermicompost + Vermiwash 10% spray at 10% flowering stage
T12	50% RDN through FYM + 50% RDN through compost + Vermiwash 10% spray at 10% flowering stage
T13	50% RDN through FYM + 50% RDN through neemcake + Vermiwash 10% spray at 10% flowering stage

particular part of India falls under agro-climatic zone IV A i.e. "Sub-Humid Southern Plain and Aravalli Hills" of Rajasthan state. This zone possesses typical sub-tropical climatic conditions characterized by mild winter and moderate summers associated with high relative humidity at the time of July to September. The mean annual rainfall of Udaipur is 630 mm with a range between 373-1140 mm, most of which is contributed by S-W monsoon from July to October.

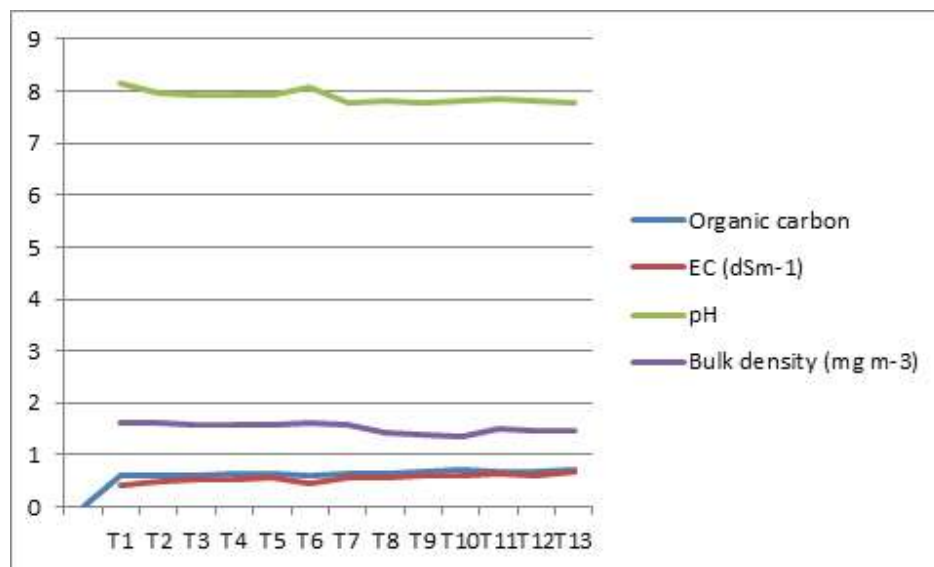
The allocation of treatment combinations in the layout was done with the help of a random number table (Fisher, 1950). The experiment was laid out Randomized Block Design with three replications 13th treatments combinations treatments using a seed rate of 15 kg ha⁻¹. Randomly selected ten plants were from each replication and each treatment to record observations. The organic carbon content was determined by Walkley and Black's rapid titration method (1947). Available nitrogen was estimated by alkaline potassium permanganate method as illustrated by Subbiah and Asija (1956). Available phosphorus was estimated by Olsen's method (Olsen *et al.* 1954). Extraction of soil with 0.5 M NaHCO₃ at pH 8.5 and colour was developed by SnCl₂ and colour intensity was measured by use of spectrophotometer. Available potassium was measured by extracting it with neutral 1 N ammonium acetate (Jackson, 1973) and determined on flame photometer. Microbial population was determined by using serial dilution plate method as described by Aneja (1996). Soil samples (10-15 & 15-30 cm) were

taken before start of the experiment which was analyzed for determining physical and chemical properties of the soil. It contained organic carbon (0.58%), available N (211.15 kg/ha) were low in status. Before 10 days of sowing FYM, vermicompost, compost and neem cake were applied as per treatment and vermiwash was applied at the time of flowering.

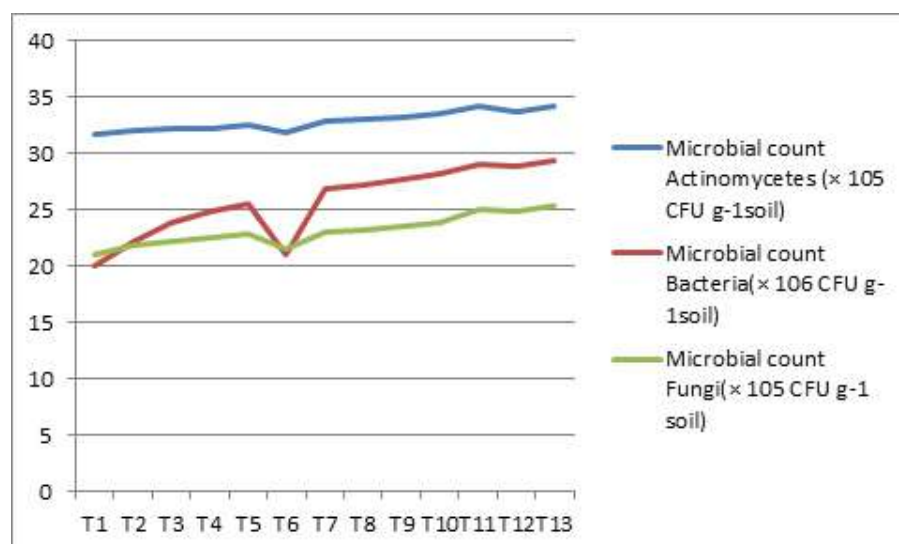
In this experiment, many soil nutrients like nitrogen, phosphorus, potassium, showed significant variances due to 10% spray of vermiwash with different doses of different organic manures. Available soil nutrient i.e. available soil nitrogen (221.28 kg ha⁻¹), available soil phosphorus (24.72 kg ha⁻¹) and available soil potassium (265.08 kg ha⁻¹) was maximum in treatment T₁₃ (50% RDN through FYM + 50% RDN through neem cake + Vermiwash 10% spray at 10% flowering stage) at par with treatment T₁₁ (50% RDN through FYM + 50% RDN through vermicompost + Vermiwash 10% spray at 10% flowering stage) and treatment T₁₂ (50% RDN through FYM + 50% RDN through compost + Vermiwash 10% spray at 10% flowering stage) minimum value was recorded under treatment T₁ (control) though in every treatment there is some amount of increase as compare to initial value. The application of organic manure might have increased the microbial population leading to mineralization of organically bound N into plant available form and also helped in the solubility of native insoluble phosphates, thus increasing the available phosphorous content in soil. The higher availability of K in soil may be



Graph-1 : Effect of organic manures and vermiwash on soil available nutrient after harvest of cowpea crop.



Graph-2 : Effect of organic manures and vermiwash on soil property after harvest of cowpea crop.



Graph-3 : Microbial count of soil.

due to beneficial effect of organic manures on the reduction of potassium fixation; added organic matter interacted with K clay to release K from non-exchangeable fraction to the available pool. The same results were also reported by Pandey *et al.* (2006). Organic manures such as vermicompost, FYM and neem cake are known to contain high concentrations of plant available nutrients such as nitrates, phosphates, exchangeable calcium and soluble potassium. Which, when added to the soil, improve the nutrient content of the soil by lowering the soil pH and electric conductivity and release the plant nutrients slow and steady rate. Significant increase in uptake of NPK by cowpea was also reported by Kadam (2000) and Bhikane (2002).

The soil samples were analyzed and results revealed that the application of various organic manures viz., farm yard manure, compost, vermicompost, neem cake etc. significantly improved the soil organic carbon. The highest organic carbon 0.71 per cent was analyzed under the application of T₁₃. The supplementation of cowpea crop with organic manures and vermiwash spray did not affect the soil electrical conductivity, soil Ph and soil bulk density. The increase in pH of acid soil due to addition of organic manures is attributed to the deactivation of Fe³⁺ and concomitant release of basic cations during their decomposition (Lal and Mathur, 1988). Organic manure increases soil tilth, infiltration rate and soil water holding capacity; contributes nutrients to the crop and is a significant source of raw or decaying plant organic matter (Bill, 2001). Similar results were also obtained by Singh *et al.* (2010) on sown chick pea and field pea, Chesti *et al.* (2012) on green gram and Negi *et al.* (2017) on broccoli.

The highest population of actinomycetes (34.25×10^5 CFU g⁻¹) in soil were recorded with the treatment T₁₃ followed by T₁₁. The highest population of bacteria (29.33×10^6 CFU g⁻¹) soil were noted with the treatment T₁₃ followed by T₁₁ and T₁₂. The highest population of fungi (25.32×10^5 CFU g⁻¹) soil was observed under the treatment T₁₃. The lowest was recorded with the treatment T₁. The supply of organic manures augmented the organic carbon content of the soil and thereby increasing the microbial population. However, Organic carbon has significant positive correlation with fungal and bacterial populations. Increasing organic carbon as a result of manure additions not only results in increased microbial biomass but has also been linked to changes in microbial community structure and increased functional diversity.

Conclusions

On the basis of results emanated from the present investigation conducted during Kharif 2019 it could be concluded from this study that under prevailing

agro-climatic conditions, in cowpea crop among different combination vermiwash with different doses of different manures application of treatment T₁₃ 50% RDN through FYM + 50% RDN through neem cake + Vermiwash 10% spray at 10% flowering stage showed significantly the highest Nitrogen (221.28 kg ha⁻¹), phosphorus (24.72 kg ha⁻¹) and potassium (265.08 kg ha⁻¹) content after harvesting the crop which was statistically at par with the T₁₁ and T₁₂. Application of treatment T₁₃ also increase soil organic matter (0.71%) and soil microbial count viz. actinomycetes (34.25×10^5 CFU g⁻¹), bacteria (29.33×10^6 CFU g⁻¹), fungi (25.32×10^5 CFU g⁻¹) which was statistically at par with the application of T₁₁ and T₁₂. Hence treatment T₁₃ i.e. 50% RDN through FYM + 50% RDN through neem cake + Vermiwash 10% spray at 10% flowering stage was found best combination of organic manure and vermiwash in Pusa komal variety of cowpea. The application of neem cake and vermiwash showed a better improvement in soil nutrient content, soil organic matter and microbial count of soil after harvesting.

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Quality of Cowpea [*Vigna unguiculata* (L.) Walp.] cv. Pusa Komal influence by Application of Organic Manure and Vermiwash Spray

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Abstract

The present investigation conducted during Kharif 2019 at Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan. It is determined that under prevailing agro-climatic conditions, cowpea crop for green pods fertilized with 1/2 recommended dose of nitrogen through farm yard manure + 1/2 recommended dose of nitrogen through neem cake + Vermiwash 10% spray at early flowering stage proved most efficient in enhancing quality of cowpea. In the treatment T13 maximum Total soluble solids of green seeds (4.85 brix) and green pod (2.80 brix), highest protein content (24.43 %), highest chlorophyll content of green leaves and green pod was 3.171 mg g⁻¹ and 2.467 mg g⁻¹ respectively, lowest percent loss of weight (31.46 %) and maximum days of keeping the pods fresh (2.50).

Key words : Cowpea, growth, vermiwash, compost, farm yard manure, neem cake.

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] commonly known as *Lobia*, southern pea, black eye pea, crowder pea and *chawla fali* belongs to family Leguminosae and having chromosome number 2n=22. Worldwide production of cowpea crop is 8 million tons, with an average yield of 1.4 tonne/ha. In India production of cowpea is 3 million tone. Cowpea seeds contain 54.5% carbohydrates, 24.1% protein and 0.1% fat. The green tender pod contain moisture (84.6%), protein (4.6%), carbohydrate (8.0%), fat (0.2%) and rich source of calcium, phosphorus, iron, etc. (Aykroyd, 1963). Organic manures viz., FYM, vermicompost, poultry manure and oilcakes help in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activity of microorganisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increases nutrient solubility, alter soil salinity, sodicity and pH. (Alabadian *et al.*, 2009). Vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B, the uptake of which has a positive effect on plant nutrition, photosynthesis, chlorophyll content of the leaves and improves the nutrient content of the different plant components (roots, shoots and the fruits). The high percentage of humic acids in vermicompost contributes to plant health, as it promotes the synthesis of phenolic compounds such as anthocyanins and flavonoids which may improve the plant quality and act as a deterrent to pests and diseases (Theunissen *et al.*, 2010). Neem seed cake acts as a nutrient reservoir providing favorable pH, aeration and improving other physical and chemical properties of the soil (Uma Singh and Pokhriyal, 1997).

FYM application to crop is being practiced since long. Well decomposed FYM in addition to supplying plant nutrients acts as a binding material and improves soil physical properties (Kale and Bane, 1988). Earthworm secrete body fluid through the dorsal pores to survive in the environment. The body fluid collected from the earthworm without harming them is called vermiwash. It contains enzymes which are secretions that stimulate the growth and yield of crops and even help to develop resistance in crops that receive this spray, such preparation would certainly have soluble plant nutrients apart from some organic acids and mucus of earthworms and microbes (Shivasubramanian and Ganesh Kumar, 2004). Therefore, the present investigation was planned for effect of organic manures and vermiwash on growth, yield and quality of Cowpea.

Materials and Methods

The experiment was conducted during June 2019–November, at Horticulture farm, Rajasthan College of Agriculture, MPUAT, Udaipur. Geographically, Udaipur is located at 24° 34' N latitude and 73° 42' E longitude at an elevation of 582.17 meters above mean sea level. This particular part of India falls under agro-climatic zone IV A i.e. "Sub-Humid Southern Plain and Aravalli Hills" of Rajasthan state. This zone possesses typical sub-tropical climatic conditions characterized by mild winter and moderate summers associated with high relative humidity at the time of July to September. The mean annual rainfall of Udaipur is 630 mm with a range between 373-1140 mm, most of which is contributed by S-W monsoon from July to October.

Table-1 : Nitrogen content of inputs

S. No.	Name of manure	N (%)
1.	FYM	0.50
2.	Vermicompost	1.5
3.	Compost	1.30
4.	Neem cake	5.2
5.	Vermiwash	0.40

Table-2 : Treatment details are following :

Treatments	
T1	Control
T2	100% RDN through FYM
T3	100% RDN through compost
T4	100% RDN through vermicompost
T5	100% RDN through neem cake
T6	Vermiwash 10% spray at 10% flowering stage
T7	100% RDN through FYM + Vermiwash 10% spray at early flowering stage
T8	100% RDN through compost + Vermiwash 10% spray at early flowering stage
T9	100% RDN through vermicompost + Vermiwash 10% spray at early flowering stage
T10	100% RDN through neem cake + Vermiwash 10% spray at early flowering stage
T11	1/2 RDN through FYM + 1/2 RDN through vermicompost + Vermiwash 10% spray at early flowering stage
T12	1/2 RDN through FYM + 1/2 RDN through compost + Vermiwash 10% spray at early flowering stage
T13	1/2 RDN through FYM + 1/2 RDN through neemcake + Vermiwash 10% spray at early flowering stage

The allocation of treatment combinations in the layout was done with the help of a random number table (Fisher, 1950). The experiment was laid out Randomized Block Design with three replications 13th treatments combinations treatments using a seed rate of 15 kg ha⁻¹. Randomly selected ten plants were from each replication and each treatment to record observations. TSS was recorded with the help of digital hand refractometer. Protein content (%) in cowpea green pod and green seed was worked out by multiplying the N content of green pod and green seed with a factor 6.25. the concentration of N was determined through a modified Kjeldel procedure (Jackson, 1973).

Green pods were kept for day until the color went green to yellow and physiological loss in weight were recorded by measuring weight of five cowpea pods for 5 days and calculated by following formula.

$$PLW (\%) = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}} \times 100$$

For estimation of chlorophyll content of fresh leaves at 50 % flowering by using colorimetric method (Arnon, 1949). Total chlorophyll content was determined by using formula :

$$\text{Total chlorophyll content (mg g}^{-1}\text{)} = \frac{20.2A_{645} + 8.02 A_{663}}{a \times 1000} \times \frac{V}{W}$$

Whereas = length of path in cell (generally 1 cm)

V = volume of extract (ml)

W = weight of leaf sample (g)

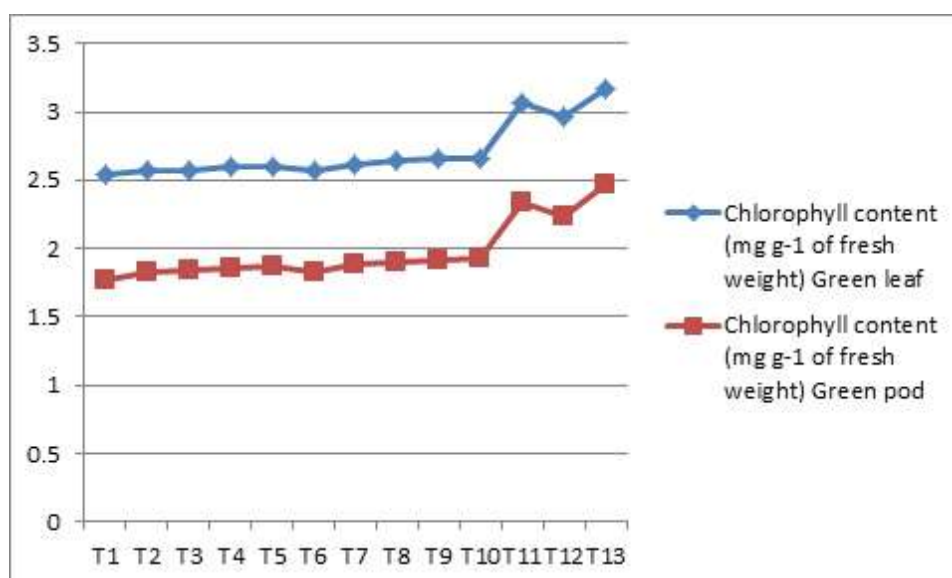
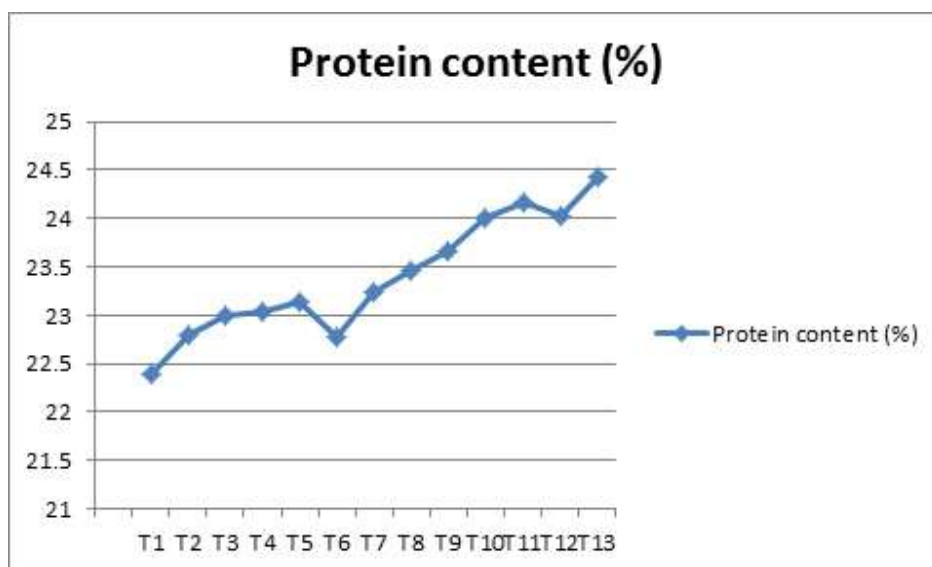
The same trend was observed under chlorophyll content of green pods (2.467) and green seeds (3.171), which might have stored high amount of photosynthates in the sinks which will be helpful for, maintain the succulence of pods during the storage time. Pods harvested from treatment T13 retained fresh for 2.5 days keeping time, which was statistically at par with the treatments T11. Minimum physiological loss was observed in treatment T13 (31.46). Organic liquid manures not only contain macronutrients, micro nutrients, vitamins, essential amino acids but also growth stimulating substances such as IAA, GA and beneficial microorganisms, which helps in improving the quality parameters of the crops. Similar results were also reported by Amit Kumar (2019) in onion, Senthilmurugan *et al.* (2018) in okra and Rosangpuii Pachuau (2019) in assam lemon.

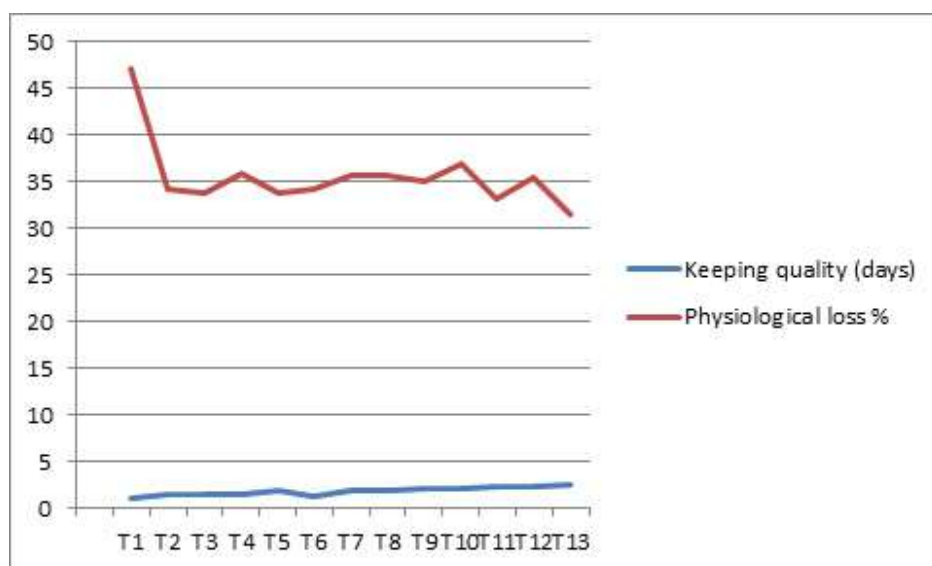
Conclusions

On the basis of results emanated from the present investigation conducted during *Kharif* 2019 it could be concluded from this study that under prevailing agro-climatic conditions, in cowpea crop among different combination vermiwash with different doses of different



Graph-1 : Effect of organic manures and vermiwash on TSS of cowpea crop.





manures application of treatment T13 showed significantly the highest quality parameter *i.e.* TSS of green pod (2.80) and seed (4.85), protein content (24.43), chlorophyll content of green leaf (3.171) and green pod (2.467) and keeping quality (2.50) followed by application of treatment T11 and treatment. The lowest physiological loss (31.46) was showed in T13. The lowest quality parameters were recorded in control. quality content of treatment under treatment under T13 1/2 RDN through FYM + 1/2 RDN through neem cake + Vermiwash 10% spray at 10% flowering stage was found best combination of organic manure and vermiwash in Pusa komal variety of cowpea. The application of neem cake and vermiwash showed a better improvement in quality of cowpea.

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Study the Biology of Maize Fall Armyworm *Spodoptera frugiperda* (J.E. Smith) in Ambient Conditions

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Abstract

The fall armyworm (FAW), *Spodoptera frugiperda* (JE Smith, 1797) (Lepidoptera: Noctuidae) is a highly polyphagous lepidopteran pest. The eggs took 2-4 days to hatch, with a mean time of 3.26 days. The mean total larval period of *S. frugiperda* on maize, in the laboratory, was recorded to be 16.97 days. The mean pupal length was 15.7 mm and the mean pupal period was recorded to be 8.96 days. The mean adult longevity of female and male moths was 40.11 days and 36.15 days, respectively. While, the mean body length (mm), wing length (mm) and wing span (mm) of male and female adults were 15.8, 13.7, 31.7 and 15.0, 13.1, 30.8, respectively. The observations also reveal that female moths lived more than the male moths.

Key words : Fall armyworm, life cycle, lepidoptera, moth, polyphagous, maize, pest, cannibalism, creamaster, ambient condition.

Introduction

The fall armyworm (FAW), *Spodoptera frugiperda* (JE Smith, 1797) (Lepidoptera: Noctuidae) is a highly polyphagous lepidopteran pest (Prasanna *et al.* 2021). It feeds and develops on the leaves, stems, and reproductive parts of over 350 plant species, primarily Poaceae, causing serious economic damage to key food crops (e.g., maize, sorghum, rice, soybean) and fibre crops (e.g., cotton) (Montezano *et al.* 2018; Overton *et al.* 2021). FAW originates from tropical and subtropical areas of the Americas. Its native year-round distribution includes much of South and Central America, the Caribbean, and southern parts of Texas and Florida. It is also a strong seasonal migrator, causing transient damage in temperate regions of North and South America (Kansiime *et al.*, 2019). Since its first observation in West Africa in 2016, this pest has invaded many territories worldwide, including most of sub-Saharan Africa, parts of West, East, and South Asia, and parts of Oceania, including southern Australia. FAW is also regularly intercepted on imported plant material in Europe (EPPO 2020). Current control strategies for the management of FAW are challenging due to its high fecundity and mobility, the rapid development of insecticide resistance in insecticide-exposed populations, and its high physiological and behavioural plasticity (Paredes-Sánchez *et al.* 2021).

Materials and Methods

The present study was carried out at Entomological

laboratory of Rajasthan College of Agriculture, Udaipur during 2022. In order to study the biology of FAW on maize, initially larvae were collected from field of Rajasthan College of Agriculture, Udaipur, brought into the insect culture chamber and were allowed to feed the plant. Larvae were supplied with a continuous amount of fresh plant until time of pupation. The development period (in days) from neonate to pupa, larval length, pupal length was recorded at pupation. After the adult emergence keep it in separate chambers. Both male and female moths were placed along with the 10 % honey- sugar solution. The screen was placed on the top of the cloth enclosing the moths and allow to mating and oviposition for further generation.

Result and Discussion

Egg : The eggs were generally laid in egg masses. The number of eggs per mass may be 25-330, which can either be laid in a single layer or stacked up in two to three layers. A gravid female can lay 4-11 egg masses. The eggs were pale white to creamish in colour covered with grayish white scales of the female abdomen. The colour of the eggs turned brown to black just before hatching. The eggs took 2-4 days to hatch, with a mean time of 3.26 days.

Larva : The fall armyworm has six larval instars. The characteristics and duration of each instar were observed and recorded.

First instar : The first larval instars were very tiny. They completely devoured the egg shells from which they

Table-1 : Biology of *S. frugiperda* on maize in laboratory.

S. No.	Life stages	Period of study								Mean
		Aug-Sept		Sept-Oct		Oct-Nov		Nov-Dec		
		Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	
1.	Incubation period (days)	3.0-4.0	3.40±0.49	3.0-4.0	3.33±0.47	3.0-4.0	3.46±0.50	3.0-4.0	3.36±0.49	3.38
2.	Larval period (days)	13.0-19.0	16.46±1.45	14.0-20.0	16.76±1.54	14.0-21.0	17.06±1.83	14.0-21.0	17.23±1.94	16.87
3.	Pupal period (days)	7.0-11.0	8.36±1.40	7.0-11.0	8.76±1.10	8.0-11.0	9.00±0.98	8.0-12.0	9.20±1.37	8.83
4.	Pre-oviposition period (days)	3.0-5.0	3.28±0.61	2.0-5.0	3.30±0.85	3.0-4.0	3.35±0.49	3.0-5.0	3.64±0.63	3.39
5.	Oviposition period (days)	2.0-4.0	2.92±0.68	3.0-4.0	3.15±0.37	2.0-4.0	2.50±0.75	2.0-4.0	3.14±0.66	2.92
6.	Post-oviposition period (days)	4.0-8.0	6.07±1.38	5.0-7.0	6.15±0.80	4.0-9.0	6.25±1.34	5.0-8.0	6.35±1.08	6.20
7.	Female adult longevity (days)	9.0-17.0	11.68±2.18	10.0-16.0	12.35±1.80	9.0-17.0	12.30±2.25	11.0-17.0	12.50±1.74	12.20
8.	Male adult longevity (days)	8.0-12.0	9.50±1.09	7.0-12.0	9.84±1.42	8.0-13.0	9.93±1.33	7.0-14.0	10.00±2.14	9.81
9.	Total life cycle (days)	35.0-43.0	38.80±2.32	33.0-49.0	40.66±3.61	33.0-50.0	40.40±4.47	35.0-51.0	41.10±3.67	40.24
	Female	36.0-43.0	39.68±2.49	37.0-49.0	41.70±3.31	36.0-50.0	41.50±4.89	36.0-51.0	42.13±4.22	41.25
	Male	35.0-40.0	37.78±1.67	33.0-46.0	38.26±3.66	33.0-46.0	39.30±3.84	35.0-44.0	39.69±2.30	38.75
10.	No. of eggs/female	995-2287	1740±153	750-2065	1629±109	915-2126	1638±185	850-1935	1241±129	1562

Table-2 : Duration (days) of larval instars of *S. frugiperda*.

Period	I instar		II instar		III instar		IV instar		V instar		VI instar	
	Range	Mean±S.D.	Range	Mean±S.D.	Range	Mean±S.D.	Range	Mean±S.D.	Range	Mean±S.D.	Range	Mean±S.D.
Aug-Sept	2.0-3.0	2.7±0.50	2.0-3.0	2.4±0.49	2.0-3.0	2.1±0.30	2	2.0	2.0-3.0	2.6±0.60	3.0-5.0	4.2±0.49
Sept-Oct	2.0-3.0	2.9±0.30	2.0-3.0	2.5±0.50	2.0	2.0	2.0-3.0	2.1±0.30	2.0-3.0	2.7±0.50	4.0-6.0	4.6±0.50
Oct-Nov	2.0-3.0	2.9±0.30	2.0-3.0	2.6±0.60	2.0	2.0	2.0	2.0	2.0-3.0	2.7±0.50	4.0-8.0	5.3±0.75
Nov-Dec	2.0-3.0	2.8±0.40	2.0-3.0	2.5±0.50	2.0-3.0	2.3±0.45	2.0	2.0	2.0-3.0	2.8±0.40	4.0-7.0	5.5±0.50
Mean	2.8		2.5		2.1		2.0		2.7		4.9	

Table-3 : Morphometric data of *S. frugiperda*.

S. No.	Life stages	Range (mm)	Mean $\pm$ SD (mm)
1.	Larval length	I instar	1.5-2.0
		II instar	3.0-4.0
		III instar	5.5-6.5
		IV instar	9.0-10.5
		V instar	15.0-18.0
		VI instar	32.0-36.0
2.	Pupal length		14.0-19.0
3.	Adult		
		Male	
		Body length	14.0-17.0
		Wing length	12.5-15.0
		Wing span	29.0-35.0
		Female	
		Body length	13.0-17.0
		Wing length	12.0-15.0
		Wing span	29.0-34.0

hatched. They had a comparatively large flattened circular black head and a whitish body covered with minute hairs. After feeding on leaves, their body colour changed to greenish white. The mean development time of the first larval instar was 2.8 days and the mean body length was recorded to be 1.8 mm.

Second instar : The second instar larvae had amber coloured head and a pale white to yellowish coloured body with a tinge of brown on the dorsum. The body also developed faint white dorsal and sub-dorsal lines at this stage. The mean development time of the second larval instar was 2.5 days and the mean body length was recorded to be 3.5 mm.

Third instar : The third instar larvae showed an immense change in body colour. The body colour changed from pale white to greenish brown. The larvae were light brown on the dorsum and greenish on the ventral side. The dorsal and sub-dorsal white lines were plainly visible and the black spots became prominent. The mean development time of this instar was 2.5 days and the mean body length was recorded to be 6.2 mm.

Fourth instar : The larvae showed a distinct difference from third to fourth instar in their appearance. Their body colour varied from olive brown to dark brown. The dorsal and sub-dorsal white lines also became conspicuous. The spiracles on prothorax and eighth abdominal segments were elliptical, while the rest were circular. The mean development time of the fourth larval instar was 2.0 days and the mean body length was recorded to be 9.7 mm.

Fifth instar : At this stage, the body attained a grayish brown colour on the dorsum and greenish colour on the ventral and sub-ventral sides. All the spiracles turned elliptical in shape. The mean development time of the fifth larval instar was 2.7 days and the mean body length was recorded to be 16.8 mm.

Sixth instar : The larvae during this stage were most stout and bulged with somewhat cylindrical in shape. Their body was smooth with clear and distinct segmentation. The head was black and slightly bilobed. The colour of the body was grayish brown on the dorsum, while the ventral and sub-ventral sides were greenish mottled with reddish brown colour. The mean development time of the sixth larval instar was 4.9 days and the mean body length was recorded to be 33.5 mm.

Total larval period : The mean total larval period of *S. frugiperda* on maize, in the laboratory, was recorded to be 16.97 days

Pupa : The freshly laid pupae of *S. frugiperda* were orange-brown in appearance and changed to dark reddish brown colour with time. They had a typical cremaster with two spines. The male and female pupae were also distinguishable based on the distance between their genital and anal opening slots. In females this distance was more and vice versa. The mean pupal length was 15.7 mm and the mean pupal period was recorded to be 8.96 days.

Adult : The adult of *S. frugiperda* is a small to medium sized moth. Sexual dimorphism was clearly evident; in males the forewings were generally shaded in gray and brown colour, with triangular white spots at the tip and near the center, while in females the forewings were less distinctly marked, ranging from a uniform grayish brown to a fine mottling of gray and brown. The hind wings were iridescent silver-white with a narrow dark border in both sexes.

Morphometric data of the adults reveal that the males were slightly larger than the females. The mean body length (mm), wing length (mm) and wing span (mm) of male and female adults were 15.8, 13.7, 31.7 and 15.0, 13.1, 30.8, respectively. The observations also reveal that

female moths lived more than the male moths. The mean adult longevity of female and male moths was 40.11 days and 36.15 days, respectively.

Pre-oviposition period/Oviposition period/ Post-oviposition period : The mean pre-oviposition period of *S. frugiperda* was 3.47 days. The oviposition took place during night hours. The mean oviposition time was recorded to be 2.96 days (table). Oviposition period was the shortest among the pre-oviposition, oviposition and post-oviposition periods. The mean post-oviposition period was 6.13 days.

Total life cycle : The mean duration in which *S. frugiperda* completes its entire life cycle was recorded to be 37.68 days.

Fecundity/ Sex ratio : The range of the eggs laid by the female moths varied considerably from 750-2287. However, the average number of eggs laid per female was 1662. The female: male ratio recorded during the four life cycles was 16: 14, 17: 13, 15: 15 and 16: 14, respectively. The number of female moths was higher every time. Earlier investigations have compared the development of FAW on maize. Dew (1913) reported that the eggs of *S. frugiperda* are laid in masses ranging in size from just a few to hundreds and will usually hatch within 4 days under optimum conditions. Similarly, Hardke *et al.* (2015) studied that the FAW late instar showing inverted 'Y' shape on head capsule and four typical dots in a square manner on eighth abdominal segment was also observed. Jason *et al.* (2001) also studied cannibalism in *Spodoptera frugiperda* larvae commonly even when food was not limiting, but occurred more frequently at low food availability or high rearing population.

Conclusion

Due to its powerful flight ability, polyphagous nature, lack of diapause, and rapid development of, FAW invaded Africa, Asia, and Oceania very quickly. This finding

summarizes several biological traits related to its lifecycle and will help to make IPM tactics, which offers some helpful data for the investigation of FAW in the future.

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Genetic Variability in Foxtail Millet [*Setaria Italica* (L.)]

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Abstract

Foxtail millet, a small millet serves a good source of protein, calcium and phosphorus. The protein in foxtail millet is relatively high with leucine and methionine. To study the genetic variability, genotypic and phenotypic coefficient of variation, broad sense heritability and genetic advance in foxtail millet, a field experiment was conducted during *Kharif*, 2022. The experiment, laid out in Augmented design comprised of 54 genotypes along with 4 checks and observations on 12 traits of foxtail millet were recorded. In this experiment, analysis of variance indicated that significant variation was present among the different genotypes of the foxtail millet for all the traits under study. The highest genotypic (GCV) and phenotypic coefficient of variation (PCV) were exhibited by the Seed yield per plant, weight of panicle, Biological yield per plant and number of effective tillers per plant. The PCV was found higher than GCV which indicates the important role of environment in the expression of the characters. High heritability and high genetic advance were observed in seed yield per plant, number of effective tillers per plant, weight of panicle, biological yield per plant and panicle length. The combination of the high heritability and high genetic advance provide the clear image of the trait in the selection process for crop improvement programme.

Introduction

Foxtail millet (*Setaria italica* L., $2n=2x=18$) a self-pollinated crop, belongs to family *Poaceae* and it is known as italian millet, german millet, korralu, kangu, kangani, koni and kaon in the different parts of india. It is one of the oldest and important small millets crops cultivated for various purposes like food, hay, pasture and grain. Millets share a set of characteristics which make them unique amongst cereals. It is a short day C4 crop with wider adaptability in diverse agro- ecological regions of the tropics. The protein in foxtail millet is relatively high with leucine and methionine. Some foxtail millet varieties contain 100% amylopectin. The starch contained in foxtail, proso and barnyard millets are more digestible than maize starch. It is largely a subsistence crop cultivated without supplementary irrigation by small-scale farmers and plays an important role in the dietary needs and economy of these farmers (Sapkota *et al.*, 2016).

Foxtail millet gene pool possess huge diversity for various quality and nutritional traits which can be exploited for various biotic and abiotic stresses besides improving resilience to climate change (Reddy *et al.*, 2015). Yield is quantitative and complex in nature due to its interaction with various component traits. Hence information on heritable variability and correlation among characters is important for assessing the joint selection of two or more traits and launching successful breeding programme. The actual dependence of grain yield on

correlated component characters towards dependent variable like yield. A knowledge of association between yield and yield contributing characters coupled with nutritional quality traits would be of immense aid in plant breeding programme where simultaneous improvement in two or more characters is highly desirable (Tyagi *et al.*, 2011).

Yield is a complex character, which is highly influenced by the environment, hence direct selection for yield alone limit the selection efficiency and ultimately results in limited success in yield improvement. Thus, effective improvement in yield may be brought about through selection of yield component characters. The variability in the population thus identified is further partitioned into heritable and non-heritable components and are estimated by various genetic parameters viz., genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance. These parameters assist the breeder towards the formulation of effective selection strategies in crop breeding.

Materials and Methods

The field study was conducted at Instructional Agronomy farm, Rajasthan College of Agriculture MPUAT, Udaipur (Rajasthan) to analyze the genetic variability, genotypic and phenotypic coefficient broad sense heritability and genetic advance during *Kharif*, 2022. Fifty-eight genotypes including four checks of foxtail millet were

procured from Agriculture research station, Buldana, Maharashtra and Sam Higginbottom university of agriculture, Prayagraj, UP. The field experiment was laid out in Augmented Design. Fifty-eight genotypes including four checks were planted with a spacing of 25 cm row to row and 10 cm plant to plant distance. All the recommended agronomical practices and plant protection measures were adopted to raise the healthy crop.

At maturity five competitive plants were randomly selected from each genotype for recorded observation, except for days to 50 per cent heading and days to maturity observation recorded on plot basis. The procedure adopted for recorded observations / data on different characters are as follow: Days to 50 per cent heading, days to maturity, plant height (cm), number of effective tillers per plant, panicle length (cm), peduncle length (cm), weight of panicle(g), test weight(g), biological yield per plant (g), seed yield per plant (g), harvest index (%), seed protein content.

The data were subjected for analysis of variance by Federer's (1956). The genotypic and phenotypic coefficient was calculated by Burton (1952) technique. Heritability was computed using the formula stated by

Burton and De vane (1953). The genetic advance in percentage of mean was calculated by using Johnson *et al.* (1955) formula.

Results and Discussion

58 foxtail millet genotypes including four checks with 12 traits have been selected to study the genetic variability, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV).

It is clear from Table-1 that significant variations were present between the genotypes for all the recorded traits. The variation present in genotypes is very important for the plant breeder and selection is effective when only magnitude of variability is enough in breeding population. Table 2 depicted that the observation between the genotypes was highly significant for all the recorded traits. Genotypic coefficient of variation, phenotypic coefficient of variation, broad sense heritability and response to selection for thirteen recorded traits were shown in Table-3.

There was substantial variation among genotypes for several characteristics, including days to 50 per cent flowering (45 to 59 days), days to maturity (76.50 to

Table-1 : Mean and Range performance of the traits among the foxtail millet [*Setaria italica* (L.)].

Traits	Minimum	Maximum	Average performance
Days to 50% heading	45.00	59.00	53.07
Days to maturity	76.50	104.20	89.49
Plant height (cm)	80.80	147.08	111.16
Number of effective tillers per plant	1.30	5.00	2.84
Panicle length (cm)	12.60	28.50	17.84
Peduncle length (cm)	17.80	35.30	26.07
Weight of panicle (g)	6.66	33.30	14.92
Test weight (g)	2.13	2.87	2.49
Biological yield per plant (g)	6.67	88.33	40.62
Seed yield per plant (g)	6.67	50.00	12.82
Harvest index (%)	24.65	46.89	33.76
Seed protein content (%)	10.29	12.13	11.42

Table-2 : Analysis of variance of the different characters among the genotypes of the foxtail millet [*Setaria italica* (L.)].

Character	Block [5]	Treatment [57]	Check [3]	Genotype [53]	C v/s G [1]	Error [15]
Days to Heading	1.27	12.33**	31.00**	10.56**	50.35**	5.60
Days to Maturity	5.52	47.57**	32.17**	46.78**	135.46**	8.26
Plant height	64.78	219.36**	145.20*	225.30**	127.00	42.00
Number of effective tillers per plant	0.02	1.24**	0.09*	0.93**	20.80**	0.02
Panicle length	0.14	7.64**	0.10	8.10**	5.78**	0.09
Peduncle length	12.90	20.59**	42.19*	19.56**	10.62	12.24
Weight of panicle	1.71	28.97**	8.81*	29.63**	54.43**	2.46
Test weight	0.03	0.06**	0.13**	0.04*	0.68**	0.03
Biological yield per plant	32.19	210.76**	76.64**	206.85**	820.65**	19.74
Seed yield per plant	0.40	44.45**	1.35**	47.32**	21.69**	0.32
Harvest index	19.07	43.09*	97.11*	37.28	189.06*	29.43
Seed protein content	0.07	0.45**	0.39**	0.28**	9.63**	0.08

**Highly Significant at 0.01% level *Significant at 0.05% level.

Table-3 : Genetic variability parameters for different characters in foxtail millet [*Setaria italica* (L.)].

S.No.	Characters	Range		Mean	GCV	CV	h ²	GA	GG
		Min.	Max.						
1.	Days to 50% heading	45.00	59.00	53.07	4.20	6.12	46.97	3.14	5.92
2.	Days to Maturity	76.50	104.20	89.49	6.94	7.64	82.35	11.60	12.97
3.	Plant height	80.80	147.08	111.16	12.18	13.50	81.36	25.16	22.63
4.	Number of effective tillers per plant	1.30	5.00	2.84	33.61	34.06	97.37	1.94	68.32
5.	Panicle length	12.60	28.50	17.84	15.87	15.95	98.95	5.80	32.51
6.	Peduncle length	17.80	35.30	26.07	10.38	16.96	37.43	3.41	13.08
7.	Weight of panicle	6.66	33.30	14.92	34.93	36.48	91.68	10.28	68.90
8.	Test weight	2.13	2.87	2.49	4.38	8.30	27.90	0.12	4.77
9.	Biological yield per plant	6.67	88.33	40.62	33.67	35.41	90.46	26.80	65.98
10.	Seed yield per plant	6.67	50.00	12.82	53.46	53.64	99.32	14.07	109.76
11.	Harvest index	24.65	46.89	33.76	8.30	18.09	21.04	2.65	7.84
12.	Seed protein content	10.29	12.13	11.42	3.90	4.64	70.63	0.77	6.74

104.20 days), plant height (80.80 cm to 147.08 cm), number of effective tillers per plant (1.30 to 5.00), panicle length (12.60 to 28.50), peduncle length (17.80 to 35.30 cm), weight of panicle(g) (6.66 to 33.30 g) test weight (2.13 to 2.87 g), biological yield per plant (6.67 to 88.33 g), seed yield per plant (6.67 to 50 g), harvest index (24.65 to 46.89%) and seed protein content (10.29 to 12.13%). The extent of GCV ranged from 3.90 per cent for seed protein content to 53.46 per cent for seed yield per plant. Seed yield per plant (53.46%), weight of panicle (34.93%), biological yield per plant (33.67%) and number of effective tillers per plant (33.61%) showed high estimates of GCV (>20%). GCV estimates were moderate (10-20%) for traits such as panicle length (15.87%), plant height (12.18%) and peduncle length (10.38%). On the other hand, seed protein content exhibited a low GCV of 3.90%. The extent of PCV varied from 4.64 per cent for seed protein content to 53.64 per cent for seed yield per plant. Seed yield per plant (53.64 %), weight of panicle (36.48%), biological yield per plant (35.41%) and number of effective tillers per plant (34.06%) displayed high PCV estimates (>20%), while harvest index (18.09%), peduncle length (16.96%), panicle length (15.95%) and plant height (13.50%) exhibited moderate estimates of PCV, while test weight (8.30%), days to maturity (7.64%), days to 50% heading (6.12%) and seed protein content (4.64%) showed a low PCV.

The high magnitude of heritability (>60%) were noticed in the characters viz., seed yield per plant (99.32%), panicle length (98.95%), number of effective tillers per plant (97.37%), weight of panicle (91.68%), biological yield per plant (90.46%), days to maturity (82.35%), plant height (81.36%) and seed protein content (70.63) The genetic advance was found high (>20%) in the characters like biological yield per plant (26.80%), plant height (25.16%), while seed yield per plant

(14.07%), days to maturity (11.60%) and weight of panicle (10.28%), exhibited moderate (10-20%) genetic advance. However, lower genetic advance (< 10%) was observed for test weight (0.12%), seed protein content (0.77%), number of effective tillers per plant (1.94%), harvest index (2.65%), days to 50% heading (3.14%), peduncle length (3.41%) and panicle length (5.80%). The seed yield per plant (109.76%) exhibited the highest genetic gain followed by Weight of panicle (68.90%), number of effective tillers per plant (68.32%), biological yield per plant (65.98%), panicle length (32.51%) and plant height (22.63%). However, the genetic gain for test weight was low, being 4.77 per cent. These findings are in close agreement with previous researchers like Banu *et al.* (2017), Devaliya *et al.* (2018), Yogeesh *et al.* (2015), Brunda *et al.* (2014), Nirmalakumari and Vetriventhan (2010).

Conclusions

The study revealed significant genetic variability for all the studied traits, as indicated by highly significant mean sum of squares attributed to genotypes. There was substantial variation among genotypes for all the characters. Traits like Seed yield per plant, weight of panicle, biological yield per plant and number of effective tillers per plant displayed high genetic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), indicating significant genetic diversity and potential for improvement through selection. All traits examined in the study exhibited high heritability. Traits like seed yield per plant, number of effective tillers per plant, weight of panicle, biological yield per plant and panicle length displayed both high heritability and high genetic advance, indicating that these traits are primarily governed by genetic factors and can be efficiently passed on to offspring through breeding. The study also identified the highest genetic gain in the seed yield per plant, weight

of panicle, number of effective tillers per plant and biological yield per plant. The research highlights the significant genetic diversity and heritability of the studied traits, providing valuable insights for targeted breeding programs aimed at improving key characters, ultimately enhancing crop productivity and performance.

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Effect of Different Weed Management Practices on Nutrient Content and Uptake of Dill

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Abstract

A field experiment was conducted at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur during *rabi* 2021-22 to assess the effect of weed management practices on nutrient content and uptake in dill. The experiment consisted of thirteen treatments *i.e.*, pendimethalin 1000 g ha⁻¹ PE, pendimethalin 750 g ha⁻¹ PE *fb* HW at 40 DAS, pendimethalin 750 g ha⁻¹ PE *fb* quizalofop ethyl 40 g ha⁻¹ PoE, oxadiargyl 100 g ha⁻¹ PE, oxadiargyl 75 g ha⁻¹ PE *fb* HW at 40 DAS, oxadiargyl 75 g ha⁻¹ PE *fb* quizalofop ethyl 40 g ha⁻¹ PoE, oxadiargyl 50 g ha⁻¹ PoE oxyfluorfen 100 g ha⁻¹ PE, oxyfluorfen 75 g ha⁻¹ PE *fb* HW at 40 DAS, oxyfluorfen 75 g ha⁻¹ PE *fb* quizalofop ethyl 40 g ha⁻¹ PoE, IC *fb* HW at 20 & 40 DAS, oxadiargyl 50 g ha⁻¹ + propaquizafop 50 g ha⁻¹ PoE and weedy check. The maximum total nitrogen (35.98 kg ha⁻¹), phosphorus (8.88 kg ha⁻¹) and potassium (38.93 kg ha⁻¹) uptake were registered with IC *fb* HW at 20 & 40 DAS. This study assessed the effect of weed management practices on nutrient uptake, nutrient content and protein content in dill.

Key words : Dill, nutrient uptake, nutrient content, weed management.

Introduction

Dill is a fragrant and therapeutic annual herb of the *Apiaceae* family. There are two species of dill in cultivation: European dill (*Anethum graveolens* L.) and Indian dill (*Anethum sowa* Roxb). Dill is grown in Canada, Denmark, Germany, the United Kingdom, Hungary, India, Netherlands, Pakistan and the United States. In India, Gujarat and Madhya Pradesh are the most important states for dill cultivation. It is grown in 36,000 hectares area with a production of approximately 35,000 metric tonnes (Kalikut, 2017). Dill seed and leaves are used as flavouring ingredients in sauces, vinegar, pastries and soups (Choudhary *et al.*, 2022). The seeds have medicinal value and act as a diuretic, stimulant and carminative. The active ingredient in dill seeds is its essential oil, which contains the primary ingredients carvone and limonene (Bailer *et al.*, 2001). The seed of Indian dill has more dillapiole (36.0%) and less carvone (19.5 %), whereas European dill contains more carvone (45.9%) and less dillapiole *i.e.*, 45.9 and 7 per cent, respectively (Malhotra and Vashishtha, 2007). In seed spices, if weed growth is minimized during the initial crop weed competition period, crop yield will be equivalent to that of a weed-free crop. Therefore, it is vital to control weeds by all means throughout the crop weed competition time (Patel *et al.*, 2019).

Materials and Methods

A field investigation was carried out during *rabi* 2021-22 at the Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and

Technology, Udaipur. The soil of the experimental site was sandy clay loam in texture, non-saline and slightly alkaline in reaction. The soil was medium in available nitrogen, organic carbon and phosphorus and high in available potassium. The experiment comprising 13 weed management treatments *i.e.*, pendimethalin 1000 g ha⁻¹ PE, pendimethalin 750 g ha⁻¹ PE *fb* HW at 40 DAS, pendimethalin 750 g ha⁻¹ PE *fb* quizalofop ethyl 40 g ha⁻¹ PoE, oxadiargyl 100 g ha⁻¹ PE, oxadiargyl 75 g ha⁻¹ PE *fb* HW at 40 DAS, oxadiargyl 75 g ha⁻¹ PE *fb* quizalofop ethyl 40 g ha⁻¹ PoE, oxadiargyl 50 g ha⁻¹ PoE oxyfluorfen 100 g ha⁻¹ PE, oxyfluorfen 75 g ha⁻¹ PE *fb* HW at 40 DAS, oxyfluorfen 75 g ha⁻¹ PE *fb* quizalofop ethyl 40 g ha⁻¹ PoE, IC *fb* HW at 20 & 40 DAS, oxadiargyl 50 g ha⁻¹ + propaquizafop 50 g ha⁻¹ PoE and weedy check were laid out in randomized complete block design (RCBD) with 3 replications. The crop was sown manually on 21st October in 2021. Fertilizers, *viz.*, 90 kg N, 40 kg P₂O₅ and 20 kg K₂O ha⁻¹ were applied as recommended for dill in the area. The N, P and K contents in dill (seed and straw) samples were estimated by micro-Kjeldhal, Vanadomolybdo-phosphoric yellow colour and flame photometer methods, respectively (Jackson 1973) after harvest. The percentage content was then multiplied by the total biomass produced for the estimation of nutrient uptake. Protein content in seed (%) was calculated from the per cent nitrogen in the grain multiplied by the factor of 6.25 (Simson *et al.*, 1965). All the parameters were subjected to statistical analysis and interpretation as per Gomez and Gomez (1984).

Results and Discussion

Table-1 : Effect of weed management on nutrient (nitrogen, phosphorus and potassium) and protein content in dill at harvest.

Sr. No.	Treatment	Dose (g ha ⁻¹)	Application stage (DAS)	Nutrient content (%)						Protein content (%) in seed
				Nitrogen		Phosphorus		Potassium		
				Seed	Straw	Seed	Straw	Seed	Straw	
1.	Pendimethalin	1000	PE	1.79	0.67	0.41	0.18	0.64	1.36	11.17
2.	Pendimethalin fb HW at 40 DAS	750	PE	1.79	0.67	0.41	0.18	0.64	1.37	11.19
3.	Pendimethalin fb quizalofop ethyl	750 fb 40	PE fb PoE (3-4 leaf stage)	1.77	0.66	0.41	0.18	0.63	1.35	11.05
4.	Oxadiargyl	100	PE	1.82	0.68	0.42	0.19	0.65	1.47	11.34
5.	Oxadiargyl fb HW at 40 DAS	75	PE	1.82	0.68	0.42	0.19	0.65	1.48	11.38
6.	Oxadiargyl fb quizalofop ethyl	75 fb 40	PE fb PoE (3-4 leaf stage)	1.81	0.68	0.42	0.18	0.64	1.43	11.31
7.	Oxadiargyl	50	PoE (3-4 leaf stage)	1.80	0.67	0.41	0.18	0.64	1.42	11.25
8.	Oxyfluorfen	100	PE	1.72	0.63	0.40	0.17	0.61	1.38	10.77
9.	Oxyfluorfen fb HW at 40 DAS	75	PE	1.75	0.64	0.40	0.17	0.62	1.39	10.92
10.	Oxyfluorfen fb quizalofop ethyl	75 fb 40	PE fb PoE (3-4 leaf stage)	1.73	0.64	0.40	0.17	0.62	1.39	10.82
11.	IC fb HW at 20 & 40 DAS			1.83	0.69	0.42	0.19	0.66	1.50	11.43
12.	Oxadiargyl + propaquizafop	50 + 50	PoE (3-4 leaf stage)	1.76	0.66	0.40	0.18	0.63	1.40	10.98
13.	Weedy check			1.72	0.63	0.39	0.17	0.61	1.38	10.75
	SEm±			0.03	0.02	0.01	0.004	0.02	0.04	0.19
	CD (P=0.05)			NS	NS	NS	NS	NS	NS	NS

Table-2 : Effect of weed management on nutrient uptake (nitrogen, phosphorus and potassium) in dill.

S. No.	Treatment	Dose (g ha ⁻¹)	Application stage (DAS)	Nutrient Uptake (kg ha ⁻¹)								
				Nitrogen			Phosphorus			Potassium		
				Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
1.	Pendimethalin	1000	PE	16.49	12.30	28.78	3.76	3.31	7.07	5.87	25.01	30.87
2.	Pendimethalin fb HW at 40 DAS	750	PE	16.65	12.46	29.11	3.84	3.35	7.19	5.96	25.33	31.29
3.	Pendimethalin fb quizalofop ethyl	750 fb 40	PE fb PoE (3-4 leaf stage)	16.20	12.13	28.33	3.71	3.26	6.98	5.77	24.78	30.55
4.	Oxadiargyl	100	PE	20.66	13.32	33.97	4.77	3.62	8.39	7.39	28.84	36.23
5.	Oxadiargyl fb HW at 40 DAS	75	PE	21.13	13.61	34.74	4.90	3.73	8.64	7.57	29.46	37.03
6.	Oxadiargyl fb quizalofop ethyl	75 fb 40	PE fb PoE (3-4 leaf stage)	17.92	12.76	30.68	4.14	3.48	7.62	6.36	27.10	33.46
7.	Oxadiargyl	50	PoE (3-4 leaf stage)	17.03	12.53	29.56	3.92	3.39	7.31	6.07	26.48	32.55
8.	Oxyfluorfen	100	PE	13.79	11.15	24.94	3.17	3.00	6.18	4.91	24.18	29.09
9.	Oxyfluorfen fb HW at 40 DAS	75	PE	15.31	11.73	27.04	3.51	3.17	6.68	5.47	25.49	30.96
10.	Oxyfluorfen fb quizalofop ethyl	75 fb 40	PE fb PoE (3-4 leaf stage)	14.91	11.63	26.54	3.42	3.13	6.55	5.36	25.26	30.62
11.	IC fb HW at 20 & 40 DAS			21.73	14.25	35.98	5.02	3.87	8.88	7.83	31.10	38.93
12.	Oxadiargyl + propaquizafop	50 + 50	PoE (3-4 leaf stage)	15.79	12.06	27.84	3.64	3.23	6.87	5.64	25.67	31.31
13.	Weedy check			8.20	5.95	14.15	1.88	1.58	3.47	2.92	12.98	15.90
	SEm±			0.64	0.76	1.00	0.16	0.16	0.21	0.29	1.43	1.38
	CD (P=0.05)			1.88	2.23	2.92	0.47	0.48	0.61	0.85	4.18	4.04

Nutrient content in dill crop : N, P and K content of dill seed and straw was unaffected by weed management practices. However highest N, P and K content from dill seed and straw were recorded from IC fb HW at 20 & 40 DAS (T_{11}) (Table-1). Weeds consume more nutrients than they need for their growth and may accumulate higher mineral nutrient concentrations than crop plants (Kaur *et al.*, 2018). Such results corroborate with the findings of Yadav *et al.* (2004), Mehriya *et al.* (2008) in cumin, Yadav *et al.* (2015) in coriander, Bagri *et al.* (2014) and Singh *et al.* (2014) in fenugreek.

Nutrient uptake by dill seed : The data presented in Table-2 show that in comparison to weedy check, all the weed control treatments tended to increase nitrogen uptake by seed significantly but with varying magnitudes. The highest uptake of nitrogen (21.73 kg ha^{-1}), phosphorus (5.02 kg ha^{-1}) and potassium (7.83 kg ha^{-1}) was found in IC fb HW at 20 & 40 DAS. Whereas, the least uptake of nitrogen (8.20 kg ha^{-1}), phosphorus (1.88 kg ha^{-1}) and potassium (2.92 kg ha^{-1}) by dill seed were recorded from weedy check. Such results corroborate with the findings of Yadav *et al.* (2004), Mehriya *et al.* (2008) in cumin, Yadav *et al.* (2015) in coriander, Bagri *et al.* (2014) and Singh *et al.* (2014) in fenugreek.

Nutrient uptake by dill straw : The data presented in Table-2 show that in comparison to weedy check, all the weed control treatments tended to increase nitrogen uptake by straw significantly but with varying magnitudes. The highest uptake of nitrogen (14.25 kg ha^{-1}), phosphorus (3.87 kg ha^{-1}) and potassium (31.10 kg ha^{-1}) was found in IC fb HW at 20 & 40 DAS. Whereas, the least uptake of nitrogen (5.95 kg ha^{-1}), phosphorus (1.58 kg ha^{-1}) and potassium (12.98 kg ha^{-1}) by dill straw were recorded from a weedy check. Such results corroborate with the findings of Yadav *et al.* (2004), Mehriya *et al.* (2008) in cumin, Yadav *et al.* (2015) in coriander, Bagri *et al.* (2014) and Singh *et al.* (2014) in fenugreek.

Nutrient uptake by dill crop (seed + straw) : The data presented in Table-2 show that the least uptake of total nitrogen (14.15 kg ha^{-1}), phosphorus (3.47 kg ha^{-1}) and potassium (15.90 kg ha^{-1}) by dill straw were recorded from weedy check. Whereas, the highest uptake of total nitrogen (35.98 kg ha^{-1}), phosphorus (8.88 kg ha^{-1}) and potassium (38.93 kg ha^{-1}) was found in IC fb HW at 20 & 40 DAS. Such results corroborate with the findings of Yadav *et al.* (2004), Mehriya *et al.* (2008) in cumin, Yadav *et al.* (2015) in coriander, Bagri *et al.* (2014) and Singh *et al.* (2014) in fenugreek.

Protein content : As mentioned above the nitrogen content in grain did not varied significantly and protein content was also calculated from the nitrogen per cent in

grain. So, protein content also had a similar response and didn't vary significantly by different weed management practices (Table-1). However, highest protein content (11.43 %) was recorded from IC fb HW at 20 & 40 DAS and the lowest protein content (10.75 %) from weedy check. Such results corroborate with the findings of Yadav *et al.* (2004), Mehriya *et al.* (2008) in cumin, Yadav *et al.* (2015) in coriander, Bagri *et al.* (2014) and Singh *et al.* (2014) in fenugreek.

Conclusions

Therefore, it can be inferred that effective weed management practices significantly increase the nutrient uptake by dill seed and straw. Contrary to this nutrient content and protein content were not significantly affected by different weed management practices. Consequently, it is essential to combine various weed management practices, including chemical and physical methods like interculture and hand weeding, to enhance dill's nutrient utilization efficiency and overall productivity.

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Variability and Path Coefficient Analysis for Yield and its Contributing Traits in Spanish Bunch Type Groundnut (*Arachis hypogaea* L.) Genotypes

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Abstract

The current study on Spanish bunch type groundnut was carried out in the Kharif, 2022 at Instructional farm, RCA, MPUAT, Udaipur. 35 different genotypes, including four checks (TG-37A, GG-7, JL-501, and PM-3), were grown in three replications in RBD. All observations for the thirteen characters were recorded. In the analysis of variance each genotype was highly significant for all the characters, indicating considerable amount of variability for all the characters and thereby good scope for precise phenotypic based selection. The moderate values (10-20%) for GCV and PCV was found for dry pod yield per plant (g) (15.67%) and harvest index (%) (13.79%) while highest value of heritability was found for harvest index (95.16). At both the genotypic and phenotypic levels, there was a positive and significant association between the dry pod yield per plant and the number of pods per plant and oil content. The sound mature kernel (0.9428) had the highest direct positive effect on dry pod yield per plant, followed by the 100-kernel weight (0.3861), biological yield per plant (0.3797) and protein content (0.0016), had a positive influence on dry pod yield per plant.

Introduction

Groundnut (*Arachis hypogaea* L.), is an important crop among oilseeds and it contribute 30% of the total domestic vegetable oil supply and is self-pollinated, annual, herbaceous legume that belong to Fabaceae family and having cleistogamous flower having chromosome number ($2n=4x=40$) ($x=10$ basic chromosome number) grown in tropical and sub-tropical regions of the world. It belongs to subfamily Papilionaceae (Faboideae) of the family Fabaceae.

Groundnut is the also known as “The king of oilseeds” because it contains poly unsaturated fatty acids (PUFA) (40-50%) and mono unsaturated fatty acids (MUFA) like linoleic acid (25-35%) in right proportion which makes groundnut oil stable and nutritive. Groundnut containson the average 12-15% carbohydrates, 25-30% protein and 45-50% oil. It is also a dietary source of vitamin E, niacin, falcin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium.

Assessment of variability is a first step in any breeding programme. The genetic variability along with the heritability gives a reliable picture of the genetic advance to be expected from selection (Burton, 1952) while the heritability coupled with genetic advance aids in predicting the valuable conclusion for effective selection based on phenotypic performance. Further the selection is more effective when it is practiced simultaneously for

the characters which have desired nature of association with the traits of ultimate interest.

Correlation studies provide an opportunity to study the magnitude and direction of association of yield with its components and also among various components. To exploit optimum combination of yield contributing characters in a single genotype, it is essential to entail the implication of the interrelationships of various characters along with path coefficients.

Materials and Methods

Thirty-five Spanish bunch type groundnut genotypes (including four checks) were used for this experiment which were obtained by AICRP on Groundnut, at Instructional Farm, College of Technology and Engineering (CTAE), Maharana Pratap University of Agriculture and Technology, Udaipur during Kharif, 2022 to evaluate the information on “Genetic divergence analysis in groundnut (*Arachis hypogaea* L.)” laid out in Randomized Block Design with three replications. Five rows per genotype were sown in a plot of 5.0m x 1.5m with inter and intra row spacing 30 x 10 cm and 5m row length.

Observations were taken regarding the number of branches per plant, plant height, pods per plant, shelling percentage (%), 100-kernels weight (g), sound mature kernel (%), dry pod yield per plant (g), biological yield per plant (g), harvest index (%), oil content (%) and protein content (%). While plot-based observations for days to 50 per cent flowering and days to maturity were taken.

Sr. No.	Characters	GCV	PCV	h^2	GA	GG
1.	Days to 50 per cent flowering	1.61	3.32	23.37	0.53	1.60
2.	Days to maturity	1.54	2.92	27.71	1.81	1.67
3.	No. of branches per plant	7.56	11.13	46.08	0.71	10.57
4.	Plant height	5.03	7.06	50.72	2.84	7.37
5.	Pods per plant	23.72	24.80	91.54	5.77	46.76
6.	Shelling per cent	2.28	3.06	55.45	2.48	3.49
7.	100-Kernels weight (g)	7.92	8.49	87.14	6.07	15.23
8.	Dry pod yield per plant(g)	15.67	16.64	88.61	3.73	30.38
9.	Sound mature kernel (%)	2.22	3.79	34.25	2.31	2.68
10.	Biological yield per plant(g)	9.44	10.96	74.18	5.27	16.74
11.	Harvest index (%)	13.79	14.10	95.76	11.77	27.81
12.	Oil content (%)	2.88	4.43	42.42	1.65	3.87
13.	Protein content (%)	4.46	6.26	50.69	1.44	6.54

Harvest index were calculated by using formulas. Oil content was determined by the Soxhlet's Method (A.O.A.C., 1965) and average oil content in per cent was worked out. The mean data for all characters were computed for the statistical analysis.

The correlation coefficients were calculated for determining the degree of association of various characters with yield and among the yield components. The genotypic and phenotypic components of variance and covariance were used to worked out genotypic and phenotypic correlation coefficient as described by Singh and Choudhary (1985) and as per formula given by Johnson *et al.* (1955).

As suggested by Wright (1921) and expanded upon by Dewey and Lu (1959), the percentage of direct and indirect contributions of various parameters to the overall correlation coefficient with seed yield was calculated by path coefficient analysis.

Results and Discussion

Genotypes under the study varied greatly for a number of characteristics, including days to 50 per cent flowering (31.61 to 34.67 days), days to maturity (104.73 to 113.11 days), number of branches per plant (5.81 to 9.34), plant height (36.19 cm to 44.43), pods per plant (7.95 to 20.44), shelling percentage (66.20% to 73.78%), 100-kernels weight (g) (32.78 to 45.27), sound mature kernel (81.98% to 90.98%), dry pod yield per plant (7.63 to 15.99), biological yield per plant (25.65 to 38.23), harvest index (32.90 % to 54.46 %), oil content (41.32% to 45.11%) and protein content (19.71% to 24.68 %).

In the current investigation, the moderate values (10-20%) for GCV and PCV was found for dry pod yield per plant(g) (15.67%) and harvest index (%) (13.79%). in the current investigation, indicating a significant role of environment on the character expression in groundnut.

The magnitude of PCV in the investigation was higher than the magnitude of GCV for all characters.

At both the genotypic and phenotypic levels, there was a positive and significant association between the dry pod yield per plant and the number of pods per plant and oil content. Typically, the genotypic correlation estimates were greater or at par with the corresponding phenotypic correlation coefficient.

The sound mature kernel (0.9428) had the highest direct positive effect on dry pod yield per plant, followed by the 100-kernel weight (0.3861), biological yield per plant (0.3797) and protein content (0.0016), had a positive influence on dry pod yield per plant.

Conclusions

In the analysis of variance each genotype was highly significant for all the characters, indicating considerable amount of variability for all the characters and thereby good scope for precise phenotypic based selection. Genotypes varied greatly for a number of characteristics, including days to 50 per cent flowering, days to maturity, number of branches per plant (5.81 to 9.34). moderate values (10-20%) for GCV and PCV was found for dry pod yield per plant(g) (15.67%) and harvest index (%) (13.79%). In the current investigation, indicating a significant role of environment on the character expression in groundnut. The magnitude of PCV in the investigation was higher than the magnitude of GCV for all characters. At both the genotypic and phenotypic levels, there was a positive and significant association between the dry pod yield per plant and the number of pods per plant and oil content. The sound mature kernel (0.9428) had the highest direct positive effect on dry pod yield per plant, followed by the 100-kernel weight (0.3861), biological yield per plant (0.3797) and protein content (0.0016).

[illegible]

S. No.	Character	Days to 50 per cent flowering	Days to maturity	Number of branches per plant	Plant height	Pods per plant	Shelling percentage	100 Kernels weight (g)	Sound mature kernel (%)	Biological yield per plant(g)	Oil content (%)	Protein content (%)	r
1.	Days to 50 per cent flowering	-0.9386	0.1217	0.0552	-1.3521	-0.9744	0.3518	0.0605	-0.7128	0.8820	-0.2436	-0.2812	0.1347
2.	Days to maturity	0.0133	-0.8577	-0.1838	0.2994	0.7274	0.1306	-0.0758	-0.7515	0.1331	0.3211	-0.2177	-0.2231
3.	Number of branches per plant	0.0067	-0.2025	-0.7783	0.7020	0.1446	0.7689	-0.4241	0.3095	-0.1382	-0.0997	0.1089	-0.2318
4.	Plant height (cm)	-0.1118	0.2262	0.4813	-0.9645	0.1793	0.8182	0.5870	0.7137	0.2855	0.9616	-0.0469	0.1112
5.	Pods per plant	-0.1942	0.1324	0.2389	0.4458	-0.4710	0.1591	0.2548	0.9137	0.3149	-0.5491	0.0538	0.4937**
6.	Shelling percentage	0.4790	0.6252	0.8680	0.3472	0.1087	-0.8943	0.2343	0.3969	-0.1728	0.3010	-0.1335	0.1597
7.	100-Kernels weight (g)	-0.0147	0.1684	0.8549	-0.7257	-0.3109	-0.2040	0.3861	-0.7054	0.4765	-0.6310	0.0668	-0.1639
8.	Sound mature kernel (%)	0.2274	0.2190	-0.8187	-0.7530	-0.6314	-0.9299	-0.9255	0.9428	-0.7189	0.3917	-0.2552	0.1671
9.	Biological yield per plant(g)	-0.2180	-0.3006	0.8346	-0.8536	-0.3906	0.3138	0.4846	-0.5572	0.3797	-0.2464	0.1855	0.1246
10.	Oil content (%)	-0.0302	0.6333	-0.1023	0.2937	-0.3412	0.1183	0.3213	-0.1316	0.2342	-0.7581	0.4731	0.4100*
11.	Protein content (%)	0.2635	0.8641	-0.8464	0.5315	-0.2531	0.9187	0.2575	-0.7498	0.7031	-0.3581	0.0016	0.1092

According to a broad analysis of the current experiment, the test genotypes UG-199, UG-202, UG-209, GG7, and PM-3 were superior in terms of yield and desired yield component characters like pods per plant and kernel yield per plant. As a result, these genotypes appear to be promising and might be employed in groundnut breeding programmes in the future.

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Studies on Fenugreek for Cultural and Morphological Variability of Different Isolates of *Fusarium* spp.

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Abstract

Fenugreek (*Trigonella foenum-graecum* L.) is an annual diploid species, popularly known by “methi”, belonging to the sub-family “Papilionaceae” of the family “Fabaceae”. In this observation such as growth rate, colony diameter (mm), colour of the colony, sporulation and pigmentation were evaluated by growing the culture of nine isolates on PDA medium and the average size of the spores like breadth, length and number of septa per spore and arrangement of the chlamydospores were recorded. Among the nine isolates, maximum mean colony diameter (90.00 mm) was recorded for the isolate FOS CTR-1 white with yellow margin and fast growth habit with excellent (++++) sporulation and 90.00 mm colony diameter white colour and fast growth habit with excellent (++++) sporulation in FOS CTR-2. Among the isolates maximum mean length and width of macro conidia was recorded in the isolates FOS CTR-1 which measured $34.42 (29.29-39.56) \times 6.34 (5.76-6.92) \mu\text{m}$ with both solitary, terminal and in chain of 2-4 types chlamydospore are present.

Introduction

Fenugreek (*Trigonella foenum-graecum* L.) is an annual diploid species, popularly known by “methi”, belonging to the sub-family “Papilionaceae” of the family “Fabaceae”. It is a self- pollinated crop with chromosome no. $2n=16$ (Meena *et al.*, 2017). India is a leading country in both production and productivity of fenugreek in the world (Sharma and Maloo, 2022). In India, fenugreek production was 2.03 MT and occupied area 1.21 Mha (Anonymous, 2021). Among different states Rajasthan is leading state in fenugreek production followed by Madhya Pradesh, Gujarat, Haryana and West Bengal. Rajasthan has first position in the production with more than 80 per cent area under fenugreek cultivation in India. It occupied 0.09 Mha area with 0.10 MT production. Major fenugreek growing district of Rajasthan are Bikaner, Nagour, Jodhpur, Churu, Sikar and Jhunjhunu (Anonymous, 2021).

The fungus can survive either as mycelium or as any of its three different spore type *i.e.*, microconidia, macroconidia and chlamydospores (Agrios, 2005). *Fusarium oxysporum* colonies were cottony white to dark pink coloured. Mycelium was septate hyaline and produced both macro and microconidia. Macroconidia were moderately curved, stout, sickle shaped, usually 1-3 septate. Wilt is caused by *F. oxysporum* which is an active saprophyte in soil and organic matter with some specific forms that are plant pathogenic (Smith *et al.*, 1988) and caused 20-70 per cent yield losses in India (Kumar, 2019). This disease was first reported by Shivpuri and Bansal (1987) from Rajasthan (Ghule *et al.*, 2021).

Materials and Methods

Present investigations on Laboratory experiments were carried out during 2021- 2023 in the Department of Plant Pathology, Rajasthan College of Agriculture, Udaipur.

Cultural variability of *Fusarium oxysporum* : Cultural characteristics, such as growth rate, colony diameter (mm), colour of the colony, sporulation and pigmentation were evaluated by growing the culture of nine isolates on PDA medium. Each isolate of *F. oxysporum* was extracted from the periphery of a seven-day old culture and aseptically placed in the middle of the PDA poured plate. These plates were incubated at $26 \pm 2^\circ\text{C}$ in a BOD incubator.

Morphological Study of *Fusarium oxysporum* : Culture of *Fusarium oxysporum* of all the collected isolates of infected host tissue and isolated in a pure culture form were mounted on a clean glass slide. Spores were mixed with lacto phenol thoroughly in order to obtain uniform spread, on which cover slip was placed. Spores (macro and micro conidia) were measured under high power objective using light microscope (400X). The average size of the spores like breadth, length and number of septa per spore and arrangement of the chlamydospores were recorded. Microphotographs were taken to show the typical spore morphology of the pathogen.

Results and Discussion

Cultural characteristics : Nine isolates of *Fusarium* spp. were cultured on PDA Petri plates and cultural characteristics of each isolate were observed and

Table-1 : Cultural characteristics of different isolates of *Fusarium oxysporum* Schlecht.

S. No.	Name of isolates	Colony diameter* (mm)	Colony colour and pigmentation	Growth habit	Sporulation
1.	FOS UDR-1	79.67	Creamish white with irregular margin patchy growth	Moderate	**
2.	FOS UDR-2	88.00	Greyish irregular growth	Fast	***
3.	FOS UDR-3	89.00	Pinkish cottony regular growth with white margin	Fast	***
4.	FOS CTR-1	90.00	Light grey regular cottony growth	Fast	****
5.	FOS CTR-2	90.00	Greyish and fluffy in center with white margin	Fast	****
6.	FOS CTR-3	85.67	Pure white cottony	Fast	***
7.	FOS RAJ-1	84.00	Cottony dull white with irregular margin	Moderate	***
8.	FOS RAJ-2	53.33	White with purple tinge irregular thread like growth	Slow	*
9.	FOS RAJ-3	59.67	Off white	Slow	*
CD at 5%		2.18			
SEm±		0.72			
CV %		1.57			

+ Poor, ++ Moderate, +++ Profuse, ++++Abundant, *Mean of four replications.

recorded after 7th day of incubation. The results revealed that all the nine isolates of *F. oxysporum* Schlecht differed in colony characters on 7th day of incubation under uniform medium and environmental conditions. Among the nine isolates, maximum mean colony diameter (90.00 mm) was recorded for the isolate FOS CTR-1 light grey regular cottony growth and fast growth habit with excellent (****) sporulation and 90.00 mm colony diameter greyish and fluffy in center with white margin and fast growth habit with excellent (****) sporulation in FOS CTR-2 which was followed by 89.00 mm colony diameter pinkish cottony regular growth with white margin and fast growth habit with showed good (***) sporulation in isolates FOS UDR-3, 88.00 mm colony diameter and greyish irregular growth, fast growth habit with showed good (***) sporulation in the isolates of FOS UDR-2, 85.67 mm colony diameter and pure white cottony colour, fast growth habit with good(***) sporulation in the isolates of FOS CTR-3 and 84.00 mm colony diameter and cottony dull white with irregular margin colour, fast growth habit with good (***) sporulation in the isolates of FOS RAJ-1 while the minimum mean colony diameter was recorded for the isolates FOS RAJ-2 in 53.33 mm and white with purple tinge irregular thread like growth, slow growth habit with poor (*) sporulation which was followed by 59.67 mm colony diameter and off white colour, slow growth habit with poor (*) sporulation in the isolates of FOS RAJ-3 and 79.67 mm colony diameter and creamish white with irregular margin patchy growth, moderate growth habit with showed moderate (**) sporulation in the isolates of FOS UDR-1 (table-1).

Morphological characteristics : The maximum number of mean septa in macro conidia are 4-5 found in isolates of FOS UDR- 3, FOS CTR-1 and FOS CTR-2 followed by 3-4 septa present in the isolates of FOS UDR-2, FOS CTR-3 and FOS RAJ-1 another minimum number of mean septa 2-3 are observed in the isolates of FOS UDR-1, FOS RAJ-2 and FOS RAJ-3.

All the nine isolates of *F. oxysporum* Schlecht showed significant variation in macro and micro conidia. The mean length and width of macro conidia in different isolates of *F. oxysporum* Schlecht were ranged from 10.27-34.42×3.98-6.34 µm, whereas the mean length and width of micro conidia in different isolates of *F. oxysporum* Schlecht ranged from 3.77-8.64×2.02-3.92 µm. Among the isolates maximum mean length and width of macro conidia was recorded in the isolates FOS CTR-1 which measured 34.42 (29.29-39.56) × 6.34 (5.76-6.92) µm which was followed by isolate FOS UDR-3 measured 33.12 (27.95-38.29) × 6.01 (5.25-6.78) µm, FOS CTR-2 measured 30.32 (25.68-34.96) × 5.98 (5.48-6.49) µm, FOS UDR-2 measured 28.61 (23.36-33.87) × 5.67 (5.15-6.20) µm, FOS CTR-3 measured 26.08 (20.48-31.69) × 4.91 (4.67-5.15) µm, FOS RAJ-1 measured 22.07 (20.88-23.26) × 4.52 (4.20-4.85) µm and FOS UDR-1 measured 18.25 (17.90-18.60) × 4.40 (4.15-4.66) µm, length and width of macro conidia. The minimum mean length and width of macro conidia was recorded in the isolate FOS RAJ-2 had 10.27 (8.95-11.66) × 3.98 (3.40-4.56) µm which was followed by isolates FOS RAJ-3 13.96 (10.68-17.25) × 4.10 (3.80-4.41) µm in size.

Table-2 : Variation in conidial morphology in different isolates of *Fusarium oxysporum* Schlecht.

S. No.	Pathogenic Isolates	Macro conidia 40 X						Micro Conidia 40 X						Arrangement of chlamydospore				
		Length (µm*)			Width (µm*)			Septa per spore			Length (µm*)				Width (µm*)			Septa per spore
		Mean	Range		Mean	Range		Mean	Range		Mean	Range			Mean	Range		
1.	FOS UDR-1	18.25±0.61	17.90-18.60		4.40±0.25	4.15-4.66	2-3	5.12±	4.35-5.90		2.33±	1.87-2.79	1	Solitary 2-3				
2.	FOS UDR-2	28.61±0.67	23.36-33.87		5.67±0.29	5.15-6.20	3-4	7.82±	7.15-8.50		3.22±	2.85-3.60	1	Solitary 1-2				
3.	FOS UDR-3	33.12±0.23	27.95-38.29		6.01±0.40	5.25-6.78	4-5	8.37±	7.90-8.85		3.52±	2.56-4.48	1	Solitary				
4.	FOS CTR-1	34.42±0.41	29.29-39.56		6.34±0.61	5.76-6.92	4-5	8.64±	8.10-9.18		3.92±	2.89-4.96	1	Both solitary, terminal and in chain of 2-4				
5.	FOS CTR-2	30.32±0.56	25.68-34.96		5.98±0.23	5.48-6.49	4-5	8.18±	7.59-8.78		3.25±	2.40-4.10	1	Solitary				
6.	FOS CTR-3	26.08±0.37	20.48-31.69		4.91±0.67	4.67-5.15	3-4	6.17±	5.25-7.10		3.10±	2.25-3.96	1	Solitary 3-4				
7.	FOS RAJ-1	22.07±0.29	20.88-23.26		4.52±0.37	4.20-4.85	3-4	5.44±	4.68-6.21		2.72±	2.19-3.26	1	Solitary and terminal 1-2				
8.	FOS RAJ-2	10.27±0.71	8.95-11.66		3.98±0.19	3.40-4.56	2-3	3.77±	3.25-4.30		2.02±	1.58-2.46	1	Solitary and terminal				
9.	FOS RAJ-3	13.96±0.44	10.68-17.25		4.10±0.56	3.80-4.41	2-3	4.02±	3.90-4.15		2.12±	1.65-2.6	1	Solitary 3-4				
	SEM±	0.729			0.157			0.181			0.098							
	CD (p=0.05)	2.210			0.541			0.610			0.307							

In case of micro conidia, the maximum mean length and width 8.64 (8.10-9.18) $\times$ 3.92 (2.89-4.96) μm was measured in the isolate FOS CTR-1 among all the isolates of *F. oxysporum* Schlecht which was followed by the FOS UDR-3 measured 8.37 (7.90-8.85) $\times$ 3.52 (2.56-4.48) μm , FOS CTR-2 measured 8.18 (7.59-8.78) $\times$ 3.25 (2.40-4.10), FOS UDR-2 measured 7.82 (7.15-8.50) $\times$ 3.22 (2.85-3.60) μm , FOS CTR-3 measured 6.17 (5.25-7.10) $\times$ 3.10 (2.25-3.96), FOS RAJ-1 measured 5.44 (4.68-6.21) $\times$ 2.72 (2.19-3.26) μm , FOS UDR-1 measured 5.12 (4.35-5.90) $\times$ 2.33 (1.87-2.79) μm while the minimum mean length and width of micro conidia was observed in the isolate FOS RAJ-2 that had 3.77 (3.25-4.30) $\times$ 2.02 (1.58-2.46) μm followed by isolates FOS RAJ-3 that had 4.02 (3.90-4.15) $\times$ 2.12 (1.65-2.6) μm in size.

In most of the cases chlamydospore arrangement was observed in chain of 1-2 solitary types. According to maximum mean length and width of micro and macro conidia in isolate FOS CTR-1 the chlamydospore arrangement are both solitary, terminal and in chain of 2-4 which was followed by isolate FOS UDR-3 in which chlamydospore arrangement are solitary type. In isolate FOS CTR-2 the arrangement of chlamydospore are solitary type, in isolate FOS UDR-2 arrangement of chlamydospore are solitary 1-2 type, in isolate FOS CTR-3 arrangement of chlamydospore are solitary 3-4 type, in isolates FOS RAJ-1 arrangement of chlamydospore are solitary and terminal 1-2 types. According to the minimum mean length and width of macro and micro conidia was recorded in the isolate FOS RAJ-2 in arrangement of chlamydospore are solitary and terminal types followed by isolates FOS RAJ -3 in arrangement of chlamydospore are solitary 3-4 types (table-2).

Conclusions

Fusarium oxysporum Schlecht isolates show significant variance in colony diameter, colony growth characteristics and its conidial morphology. Among the nine isolates, maximum mean colony diameter (90.00 mm) was recorded for the isolate FOS CTR-1 white with yellow margin and fast growth habit with excellent (++++) sporulation and 90.00 mm colony diameter white colour and fast growth habit with excellent (++++) sporulation in FOS CTR-2. Among the isolates maximum mean length and width of macro conidia was recorded in the isolates FOS CTR-1 which measured 34.42 (29.29-39.56) $\times$ 6.34 (5.76-6.92) μm with both solitary, terminal and in chain of 2-4 types chlamydospore are present and minimum mean length and width of macro conidia was recorded in the isolate FOS RAJ-2 had 10.27 (8.95-11.66) $\times$ 3.98

(3.40-4.56) μm in size with both solitary and terminal types chlamydospore are produced.

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Effect of Different Temperature and pH on the Radial Growth of *Helminthosporium oryzae* Causing Brown Leaf Spot Disease of Rice (*Oryza sativa* L.)

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Abstract

A laboratory studies for the growth of pathogen on different temperature and pH was studied during year 2018-19. The pathogen grow in culture with in a wide temperature range of 20°C-30°C. The maximum fungal growth as dry weight (mg.) was obtained at temperature 25°C (673.21 mg.) followed by 26°C and 27°C with dry weight 520.50 and 375.25 mg. respectively they consequently showed good sporulation, the fair sporulation was recorded at temperature 23°C, 24°C, 28°C with dry weight of 112.00, 320.50 and 190.57 mg. respectively, the poor sporulation was recorded at temperature 29°C and 30°C with dry weight of 110.00 mg. and 115.20 mg. The maximum fungal growth occurred at pH 7.0 recorded dry weight (725.33 mg.) followed by pH 6.5 (600.00mg.) both showed excellent sporulation. The optimum pH range for fungal growth was from 6.5 to 7.0. There was also significant reduction in growth at pH lower than 6.5 and higher than 7.0, lower fungal growth recorded at pH level of 7.5 to 8.0 as compared to pH level of 5.0 to 6.0. The lowest fungal growth was noticed at pH 8.0 with dry weight of (152.24 mg.). Generally, the sporulation correspondent well with the type of fungal growth at different pH level. Excellent was observed at pH level 6.5 to 7.0. Good sporulation was recorded at pH 6.0 (525.50 mg) of dry weight.

Key words : Rice, disease incidence, temperature, pH range.

Introduction

Rice (*Oryza sativa* L.) belongs to the family Gramineae or Poaceae (2n=24) and it is originated from Indo Burma region and is most important cereal crop worldwide rice is a major food staple and a mainstay for the rural population and their food security. In Northern and Western parts of the country, where rainfall is high and winter temperature is fairly low, only one crop of rice is grown during the month from May to November. There are three seasons for growing rice in India viz.- autumn, winter and summer. The main rice growing season in the country is the 'Kharif'. It is known as winter rice as per the harvesting time. The sowing time of winter (kharif) rice is June-July and it is harvested in November-December. Winter rice is known as 'Aman' in West Bengal, 'Sali' in Assam, 'Sarrad' in Orissa, 'Agahani' in Bihar and Uttar Pradesh, 'Sarava' in Andhra Pradesh, 'Mundakan' in Kerala and 'Samba/Thaladi' in Tamil Nadu. In cuisine, rice is an ingredient of many soups and dishes with fish, poultry, and other types of meat. It is used to stuff vegetables or is wrapped in grape leaves (dolma). When combined with milk, sugar, and honey, it is used to make desserts. In some regions, such as Tabaristan, bread is made using rice flour. Rice may be made into congee (also called rice porridge or rice gruel) by adding more water than usual, so that the cooked rice is saturated with water, usually to the point that it disintegrates. Rice porridge is commonly eaten as a breakfast food, and is a traditional food for the sick. Rice is infected by number of seed borne fungal pathogens

namely *Alternaria padwickii*, *Helminthosporium oryzae*, *Cercospora oryzae*, *Fusarium moniliforme*, *Phoma glumarum*, *Pyricularia oryzae* and *Ustilaginoidea virens* (Hau and Rush 1980). Among these, three most important pathogens are *Pyricularia oryzae*, (blast), *Helminthosporium oryzae*, (brown spot) and *Xanthomonas oryzae* pv. *oryzae*, (bacterial blight) (Gangopadhyay, 1983). In USA, the first two diseases account for 30 per cent losses in rice, which means about 2 per cent loss of total annual rice production.

Materials and Methods

Effect of temperature on the growth and sporulation of the pathogen : For the test against different temperature experiment was conducted during year 2018-19 on Potato Dextrose Agar Medium with Nine different temperature Viz. 20°C, 23°C, 24°C, 25°C, 26°C, 27°C, 28°C, 29°C and 30°C maintained in different incubators. Potato Dextrose Medium was used as the basal medium and the average dry weight of the mycelium mat and degree of sporulation and final data were recorded after incubation of 10 days. Each treatment was replicated three times.

Effects of hydrogen-ion concentration on the growth and sporulation of the pathogen : For study the effect of hydrogen-ion concentration on vegetative and reproductive growth of the fungus an experiment was conducted during year 2018-19. Richard's medium was used as basal medium. Different initial pH meter and

Table-1 : Average dry weight of *Helminthosporium oryzae* recorded after 10 days of incubation at various temperature (2018-19).

S.No.	Temperature (°C)	Average dry mycelial weight (mg.)	Sporulation
1.	20	000.00	No Sporulation
2.	23	112.00	Fair Sporulation
3.	24	320.50	Fair Sporulation
4.	25	673.21	Excellent Sporulation
5.	26	520.50	Good Sporulation
6.	27	375.25	Good Sporulation
7.	28	190.57	Fair Sporulation
8.	29	110.00	Poor Sporulation
9.	30	115.20	Poor Sporulation

C.D. at 5% level = 3.936

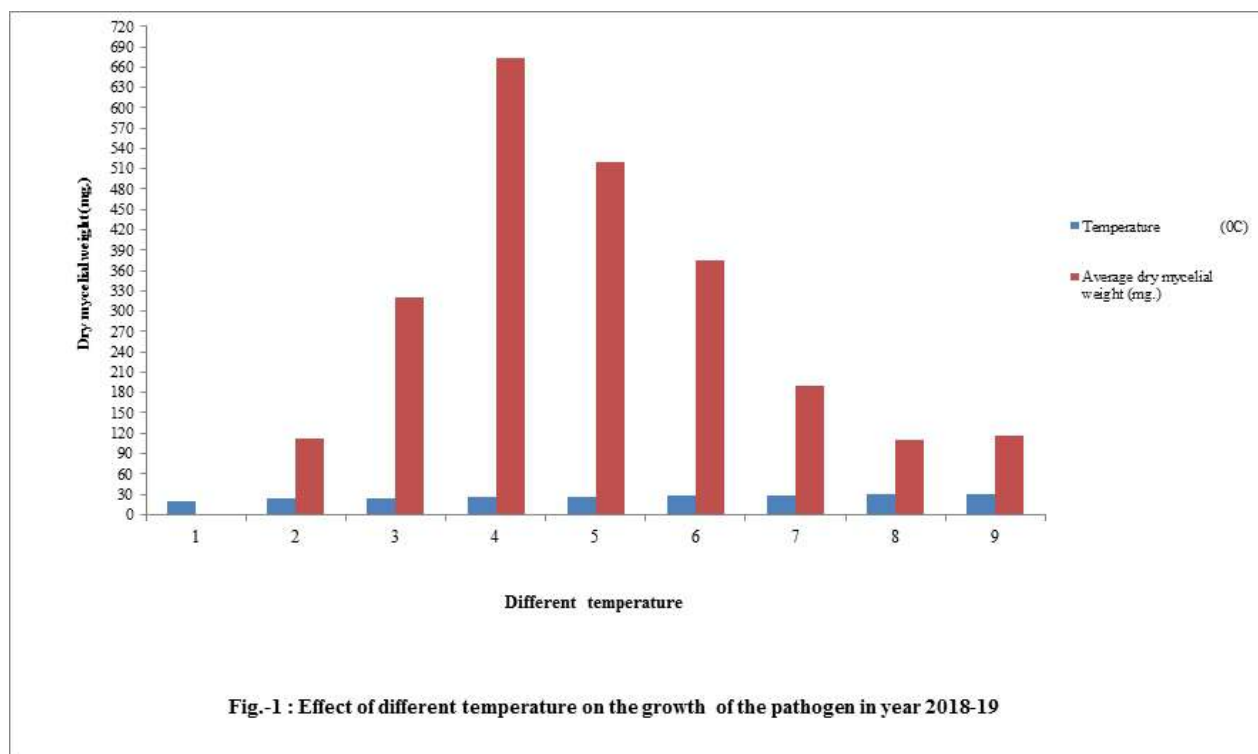


Fig-1 : Effect of different temperature on the growth of the pathogen in year 2018-19

buffered by using N/10 sodium hydroxide and N/10 hydrochloric acid before autoclaving. Seven level of pH Viz., 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, and 8.0 were used in the present studies. Each treatment was replicated three time. After autoclaving the final pH of the medium was maintained. Then the average dry weight of mycelium mat and degree of sporulation were recorded after 8 day of incubation $28 \pm 1^\circ\text{C}$.

Results and Discussion

Effect of temperature on the growth and sporulation of the pathogen : To find out the optimum as well as the range of the temperature for the growth and sporulation of the pathogen. It was grown on nine different temperature. These temperature studies were made on natural Potato Dextrose Medium, as it had definite known constituents and proved to be the best medium. After 10 days the result

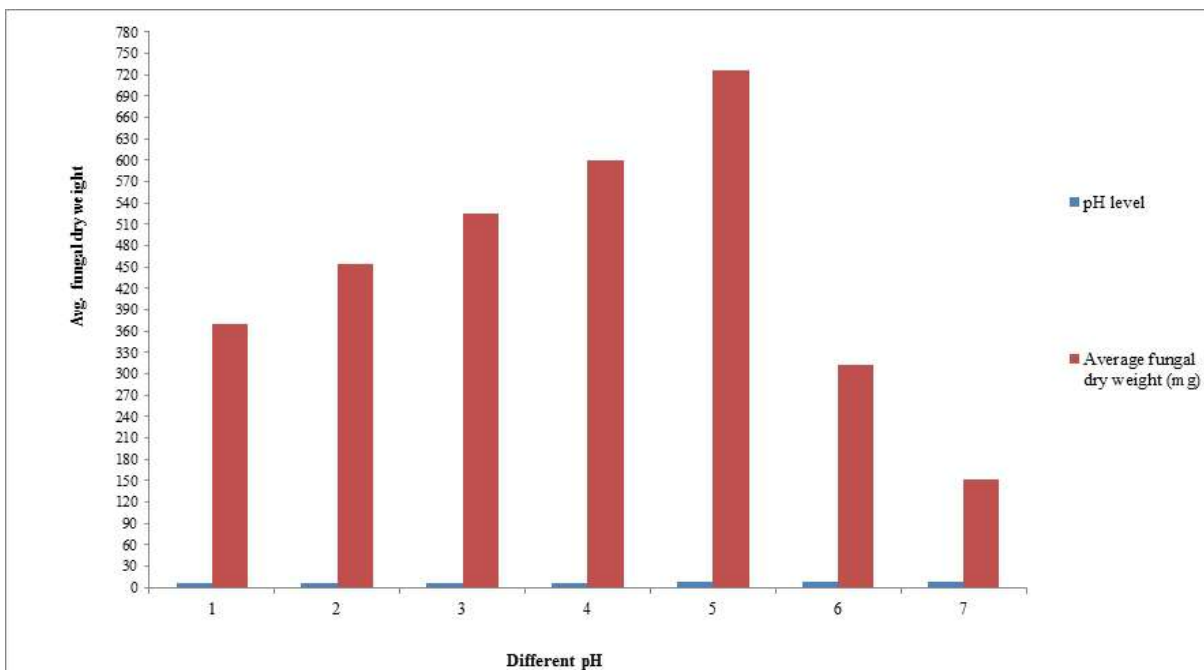
as average mycelial dry weight of the fungus were recorded and are given in Table-1 with corresponding histogram Fig-1.

The result indicate that the pathogen grow in culture with in a wide temperature range of 20°C - 30°C . The maximum fungal growth having dry weight (mg.) was obtained at temperature 25°C (673.21 mg.) followed by 26°C and 27°C with dry weight 520.50 and 375.25 mg. respectively. They consequently showed good sporulation, the fair sporulation was recorded at temperature 23°C , 24°C , 28°C with dry weight of 112.00, 320.50 and 190.57 mg. respectively, the poor sporulation was recorded at temperature 29°C and 30°C with dry weight of 110.00 mg. and 115.20 mg. The present finding coincides with the finding of (Arshad *et al.*, 2013) have recorded the behavior of *Bipolaris oryzae* at different temperatures, culture media, fungicides and rice.

Table-2 : Average fungal dry mycelial weight and sporulation of *Helminthosporium oryzae* on different pH level after 8 days of incubation 28+1°C (2018-19).

S.No.	pH level	Average fungal dry weight (mg)	Sporulation
1.	5.0	370.00	Poor Sporulation
2.	5.5	455.06	Fair Sporulation
3.	6.0	525.50	Good Sporulation
4.	6.5	600.00	Excellent Sporulation
5.	7.0	725.33	Excellent Sporulation
6.	7.5	312.00	Fair Sporulation
7.	8.0	152.24	Poor Sporulation

C.D. at 5% level = 3.573

**Fig.-2 Average fungal dry mycelial weight of *Helminthosporium oryzae* on different pH level (2018-19).**

Effects of hydrogen-ion (pH) concentration on the growth and sporulation of the pathogen : The experiment was conducted during year 2018-19 to find out the best pH as well as range of pH levels for the growth of *Helminthosporium oryzae*. This study was made on Richard's medium. The effect of seven different hydrogen-ion concentration in terms of dry mycelial weight and sporulation of the pathogen was recorded and data have been summarized in Table-2 with corresponding histogram Fig.-2. The maximum fungal growth occurred at pH 7.0 recorded dry weight (725.33 mg.) followed by pH 6.5 (600.00mg.) both showed excellent sporulation. The optimum pH range for fungal growth was from 6.5 to 7.0. There was also significant reduction in growth at pH lower than 6.5 and higher than 7.0, lower fungal growth recorded at pH level of 7.5 to 8.0 as compared to pH level of 5.0 to 6.0. The lowest fungal growth was noticed at pH 8.0 with dry weight of (152.24 mg.). Generally, the sporulation

correspondent well with the type of fungal growth at different pH level. There was poor spore formation at pH 5.0 and 8.0. Excellent was observed at pH level 6.5 to 7.0. Good sporulation was recorded at pH 6.0 (525.50 mg) of dry weight. It is interesting to note that the acidity of the medium increase the growth goes on increasing but as the alkalinity of the medium increase the growth goes on decreasing. It suggests that the pathogen like acidic medium in comparison to alkaline.

The result shows that the maximum fungal weight (mg.) occurred at pH 7.0 (725.33) followed by pH 6.5 (600.00), pH 6.0 (525.50), pH 5.5 (455.06), pH 5.0 (370.00), pH 7.5 (312.00) and minimum was found at pH 8.0 (152.24). The result coincides with the finding of (Channakeshava *et. al.*, 2018) and (Chattopadhy and Dasgupta 1965) have investigated the different pH on conidial production *Helminthosporium oryzae* in rice.

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Depiction of Physicochemical Properties of *Emblica officinalis*, and its Application for Development of Jam

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Abstract

Amla (*Emblica officinalis* G.) is well known for its medicinal and nutritional properties, since ancient times. It is a rich source of ascorbic acid, anti-oxidants, and other biochemical compounds, but still an under-utilized fruit because of its astringent taste. The physicochemical properties of amla had been studied during this research work. These fruits were utilized for the preparation of jam by taking 3 different proportions of fruit pulp and sugar. Jam was stored at room temperature for 45 days to study the chemical changes (total soluble solids, moisture loss, acidity, and pH), and organoleptic (on a 9-point Hedonic scale) properties. Jam prepared by taking an equal proportion of fruit pulp and sugar showed the best organoleptic properties during the storage period and other properties were also within the limit. Total soluble solids and pH tend to increase while the acidity was reduced during the storage period. The Overall acceptability (OAA) was also enhanced due to a reduction in astringency as compared to raw fruit.

Key words : *Emblica officinalis*, jam, physicochemical, organoleptic, storage.

Introduction

The Amla tree, also known as “Amalaki” or “Indian Gooseberry”, is a minor sub-tropical deciduous tree belonging to the family Euphorbiaceae. It is said to be native to tropical Asia and found growing wild in tropical forests of India as well as on the hill slopes up to an elevation of 1300 m from mean sea level. It is a multipurpose fruit, is extremely rich in vitamin C, helps cure gastro disorders, is said to encourage youth and liveliness, and is exported all over India and possibly over the world in the form of sweets and medicines (Khan 2009).

Amla fruit is rich in vitamin C (Singh *et al.* 2006). It contains 500-1500 mg of ascorbic acid in 100 gm of pulp and is a good source of polyphenols, pectin, tannins, and antioxidants. It also contains essential minerals like calcium, iron, and phosphorus (Chauhan *et al.* 2005). Its fruit is very nutritious and has good medicinal properties due to which, it is used to cure many health problems like diabetes, colic, asthma, leprosy, headache, depression, dyspepsia, cough, flatulence, skin problems, and bronchitis (Khan 2009).

The fruits are light green at first, but when they mature become dull greenish-yellow. Fruits have nearly spherical and globular shapes and smooth surfaces with six obscure vertical furrows. Amla gets ready for harvesting during November-December. The major harvesting period in Northern India is the second week of December to the third week of January (Chadha 2006).

Uniquely, it has a natural balance of tastes (sweet, sour, pungent, bitter, and astringent) except salt all in one fruit. Amla cultivation, production, processing, and consumption, especially in soils of high pH (alkaline) and low fertility have been emphatically recommended by scholars, nutritionists, dieticians, and pomologists.

India produced about 1046 million tons of Amla in 2018-19. The leading amla-producing states were Uttar Pradesh, Madhya Pradesh, and Tamil Nadu, which account for approximately 75% of total production. Other states like Andhra Pradesh, Gujarat, Chhattisgarh, Jharkhand, and Haryana also contribute in amla production (NHB 2020).

Jam is an intermediate moisture-sweetened food consumed daily by people of almost all age groups. In this research program, the main aim was to formulate preservative-free, economical products, provide less energy for production and storage, and provide equal benefits in terms of nutrition as other amla products available. Storage study would provide more information about the shelf-life and other changes.

Thus, amla processing will provide a strong impact on society, and also it will reduce wastage during harvesting season. Therefore, formulation, standardization, and storage study of amla value-added products could provide great importance in national and international markets, which might play a vital role in depleting malnutrition among rural populations in addition to benefits.

Materials and Methods

Procurement of raw materials : Freshly harvested amla fruits were purchased from the local market. It was cleaned in running tap water to remove any adhering dust particles or impurities. The cleaned amla fruits were kept for half an hour to remove the surface moisture and then stored at refrigerated temperature. Uniform shape and size fruits were taken for the physiochemical and further product preparation.

Physical properties of raw materials : Physical parameters like weight, size, shape, thickness and colour were studied. Weight was measured using electronic weighing scale having 0.01g accuracy and colour was observed visually.

Linear dimensions : The distance between tip and stalk was taken as a polar diameter. The largest width of the amla in a plane perpendicular to the polar diameter was taken as the equatorial diameter. A digital vernier calliper with a resolution of 0.01 mm was used to measure the equatorial diameter (D_e), polar diameter (D_p), and thickness (T) of 10 fruits separately. The geometric mean diameter (D_{GM}), arithmetic mean diameter (D_{AM}), surface (SA), and cross-sectional of areas (CSA) was calculated using eq. 1,2,3 and 4 respectively (Mohsenin 2020).

$$\text{Geometric mean diameter } (D_{GM}) = (D_e D_p T)^{0.333}, \text{ cm} \dots (1)$$

$$\text{Arithmetic mean diameter } (D_{AM}) = \frac{D_e + D_p + T}{3}, \text{ cm} \dots (2)$$

$$\text{Surface area } (SA) = \frac{4}{3} D_e D_p, \text{ cm}^2 \dots (3)$$

$$\text{Cross-sectional area } (CSA) = \frac{D_e D_p T}{3}, \text{ cm}^2 \dots (4)$$

Shape Index : Shape index was used for evaluation of the shape of amla fruits and it was calculated according to the eq. 5 (Abd-Alla 1993).

$$\text{Shape Index} = \frac{D_e}{\sqrt{D_p * T}} \dots (5)$$

The fruit was considered spherical if the shape index < 1.5, on the other hand, it was considered an oval if the shape index > 1.5.

Surface Area : The overall area of the amla fruit's exterior was referred to as its surface area. When measuring the surface area of a fruit, aluminium foil was wrapped around it and then cut into thin strips long enough to lay the foil flat. The area of the foil, which represents the surface area of the relevant fruit, was measured using a planimeter.

Volume and density : The water displacement method was used to calculate the density of the samples. Each fruit were weighed before being dropped, one at a time, into a 1000 ml measuring cylinder that had been up to its 500 ml mark with water. Rise in water level revealed the bulk capacity of the amla fruits. Bulk density was estimated using the mass and bulk volume of the fruits. The decision was made five times for each situation, and the mean was taken into account.

Gravimetric Characteristics

Friction angle : The test fruit was kept at the centre of the horizontal platform, in the most stable position (on their base) to keep it from falling over (top upwards), for measuring the friction angle. The platform was then tilted till the fruit started to roll by rotating the handle at the slowest possible speed. At this point, the handle's rotation was stopped, and a protractor was used to measure the platform's inclination angle. The average of three angles of friction for each fruit was calculated (Buyanov and Voronyuk 1985).

Coefficient of friction (CoF) : CoF was the ratio of the force required to slide the fruit over a surface divided by the normal force pressing the fruit against the surface. CoFs were determined for amla fruits on three surfaces: glass, galvanized steel and plywood. The material surface was fastened to tilting table. A frame made with square wooden bars was placed on the surface. The fruit was put on the frame. The table was tilted slowly manually until movement of the fruit. The CoF was the tangent of the slope angle of the table measured with a protractor (Oje and Ugbor 1991).

Chemical properties of raw materials

Chemical properties of fruit like Total Soluble Solids (TSS), Titrable Acidity, Ascorbic Acid, Reducing Sugars, Non-reducing Sugars, Total Sugars and Total Polyphenols was studied. TSS was measured using digital refractometer (range: 0-85°Brix, make: Hanna Instruments).

Estimation of titrable acidity : Titrable acidity was estimated using titration method given by (AOAC 2005). Titration was performed against 0.1N sodium hydroxide and phenolphthalein as indicator. Experiment was performed three times and the result was expressed in terms of citric acid.

Estimation of ascorbic acid : Ascorbic acid was estimated using AOAC (2005) method. Fresh amla juice was taken and titrated against meta-phosphoric acid and indo-phenol as indicator. Similarly, standard Ascorbic acid was taken as blank and titrated against meta-phosphoric acid and indo-phenol as indicator.

Estimation of sugars : The spectrophotometric method was used to estimate the total sugar content (Yemm and Willis 1954). A solution of 80% ethanol was used to extract the total sugar. 0.1 ml of the fresh amla juice extract was taken, and 10 ml of anthrone reagent was pipetted into the empty test tubes before they were submerged in an ice-cold water bath. The anthrone reagent was then mixed with early dilutions, and test tubes were placed in a boiling water bath for 10 minutes to develop the colour. After cooling, absorbance at 625 nm was observed. Standard curve was created using a glucose solution with graduated concentrations (25 to 250 ppm).

The spectrophotometric method was used to estimate reducing sugars (Grewal *et al.* 2001). In test tubes 1 ml of fresh amla juice extract was taken, and then Nelson's reagent was added. The mixture was mixed properly, and diluted to 25 ml with distilled water before being heated in a boiling water bath for 20 minutes. At 520 nm, a stable blue colour was observed against blank. The standard curve was created using glucose solution in a range of concentrations (20 to 100 ppm).

Non-reducing sugar was measured using difference method i.e. Total Sugar (%) – Reducing Sugar (%).

Estimation of total polyphenols : The amount of total polyphenol was calculated using the UV-spectrophotometer (Anesini *et al.* 2008). 1 ml of the fresh amla juice extract was placed in a test tube along with 0.5 ml of the Folin-Ciocalteu (FC) reagent. After 3 minutes, 1 ml of the saturated sodium carbonate solution was added, and the volume was increased to 10 ml with distilled water. After 30 minutes, absorbance was measured against a graded concentration of gallic acid standard (0-100 ppm) at 760 nm. The concentration of total polyphenols was calculated as mg GAE (gallic acid equivalents) per g.

Procedure for making amla jam : Fresh amla fruit was taken and washed thoroughly to remove any adhering dust or soil particle. Fruits were grated to get pulp and stone removal. Fruit pulp and sugar was taken in three different ratios (S1 - 40:60), (S2 - 45:55), and (S3 - 50:50) to check cooking and storage properties of prepared amla jam. Cooking temperature for jam was taken constant (100?). Equal amount of water (50 ml) was taken for making sugar syrup. Amla pulp was cooked in prepared sugar syrup at 100? till it become thick and passed plate test (plate test is used to determine optimum cooking). The prepared jam was poured into glass jar for further storage studies.

Storage study : During storage moisture loss, TSS, acidity and pH of prepared amla jam were observed at a regular interval of 15 days.

Moisture loss : Moisture loss was determined by taking weight of all the samples using calibrated weighing scale.

Acidity : Acidity was measured using same (AOAC 2005) method that was used for measuring acidity of fruit.

pH : pH was measured in solution, according to the (AOAC 1995). A total of 10 g of prepared jam were weighed and placed in an Erlenmeyer flask, added with 100 mL of distilled water at 25 °C. The content was mixed in an electronic agitator for 30 min after the water was added. The contents were placed in a beaker, left to rest for 10 min, and pH was measured.

Organoleptic properties : This is a scientific approach for evoking, measuring, analyzing, and interpreting those responses to products that are perceived by the senses of sight, smell, touch, taste, and hearing. During this study, 9-point Hedonic scale was used for testing the organoleptic properties of amla jam.

Statistical Analysis : The arithmetic mean and standard deviation (SD) of the collected data was analysed using MS-Excel.

Results and Discussion

Physicochemical properties of amla : Physicochemical properties of any fruit are considered while processing it into various products. Amla fruit utilized in preparation of jam is characterised for studying its various properties. Fruit weight ranged from 20.11 to 20.93 g. Polar diameter (Dp) and Equilateral diameter (De) of the fruit ranged from 27.60 to 28.30 mm and 34.20 to 35.00 mm. Thickness of the fruit ranged from 33.40 to 34.20 mm. Geometric mean diameter and Arithmetic mean diameter ranged from 31.66 to 32.36 mm and 31.80 to 32.50 mm respectively. Surface area and cross-sectional area ranged from 2976.16 to 3063.27 mm² and 2382.68 to 2488.73 mm² respectively. Shape index of the fruit ranged from 1.12 to 1.14. True density and bulk density of the fruit ranged from 1.00 to 1.08 and 0.454 to 0.478 g/ml. Porosity of the fruit ranged from 54.44 to 57.77. Frictional angle ranged from 53.80 to 59.89. CoF on wood, metal and glass surface ranged from 0.249 to 0.424, 0.306 to 0.404 and 0.231 to 0.404 respectively. Results observed were comparable to the results reported by Tewari *et al.* (2019).

TSS of the fruit ranged from 12.4 to 13.2°Brix. Acidity of the fruit ranged from 11.37 to 12.05%. Ascorbic acid of the fruit ranged from 1.98 to 2.55 mg/100g. Total sugars in the fruit ranged from 27.95 to 28.19 %. Reducing sugars in the fruit ranged from 17.67 to 17.87 %. Non-reducing sugars in the fruit ranged from 10.15 to 10.59 %. Total polyphenols ranged from 30.86 to TSS of the fruit ranged from 12.4 to 13.2°Brix. Acidity of the fruit ranged from 11.37 to 12.05%. Ascorbic acid of the fruit ranged from

1.98 to 2.55 mg/100g. Total sugars in the fruit ranged from 27.95 to 28.19 %. Reducing sugars in the fruit ranged from 17.67 to 17.87 %. Non-reducing sugars in the fruit ranged from 10.15 to 10.59 %. Total polyphenols ranged from 30.86 to 31.07 mg GAE/g. Result observed were comparable to the reported results observed by (Parveen and Khatkar 2015).

Table-1 : Physical and gravimetric properties of amla fruit.

Measured parameters	Mean $\pm$ SD
Fruit Weight (W) (g)	20.52 $\pm$ 0.25
Polar Diameter (D_p) (mm)	27.89 $\pm$ 0.21
Equilateral Diameter (D_e) (mm)	34.59 $\pm$ 0.25
Thickness (T) (mm)	33.64 $\pm$ 0.23
Geometric mean Diameter (mm)	31.89 $\pm$ 0.21
Arithmetic mean Diameter (mm)	32.04 $\pm$ 0.21
Surface Area (mm ²)	3030.85 $\pm$ 42.22
Cross-sectional Area (mm ²)	2418.87 $\pm$ 32.25
Shape Index	1.12 $\pm$ 0.05
True Density (g/ml)	1.05 $\pm$ 0.02
Bulk Density (g/ml)	0.46 $\pm$ 0.01
Porosity	55.77 $\pm$ 1.20
Gravimetric parameters	
Frictional angle	57.54 $\pm$ 2.01
CoF (Wood Surface)	0.36 $\pm$ 0.05
CoF (Metal Surface)	0.33 $\pm$ 0.05
CoF (Glass Surface)	0.35 $\pm$ 0.05

Values are mean $\pm$ SD of 10 replicates.

Table-2 : Chemical properties of amla fruit.

Measured parameters	Mean $\pm$ SD
TSS ($^{\circ}$ Brix)	12.81 $\pm$ 0.26
Acidity (%)	11.70 $\pm$ 0.20
Ascorbic Acid (mg/100g)	2.43 $\pm$ 0.17
Total Sugars (%)	28.07 $\pm$ 0.09
Reducing Sugars (%)	17.77 $\pm$ 0.06
Non-reducing Sugars (%)	10.30 $\pm$ 0.12
Total Polyphenols (mg GAE/g)	30.99 $\pm$ 0.07

Values are mean $\pm$ SD of 10 replicates.

Storage Studies

Properties of amla jam during storage : Moisture loss in prepared amla jam had been increased. This may be due to the crystallization of sugar used during preparation of amla jam. The total soluble solids content of amla jam had been slightly increased during the storage in all the samples. This may be due to the hydrolysis of polysaccharides like starch, cellulose, and pectin into

simpler molecules, which results in a rise in the amount of soluble solids and total soluble sugars. This suggests that the composition of cooked pulp in jam changed while it was being stored. The TSS values found in this work at different storage times were within the values (Girdhari *et al.* 1998). They mentioned that the TSS of Indian gooseberry jam will range from 71.5 Brix to 78 Brix if prepared. Similar outcomes were seen in muskmelon nectar, and jam (Katiyar *et al.* 1967) and papaya jam (Saravanan *et al.* 2004).

During the period of storage, amla jam's acidity showed a trend toward reduction. This may be caused by complex in the presence of metal ions or the hydrolysis of polysaccharides and non-reducing sugars where acid was used to transform them into hexose sugars (reducing sugars). The falling trend may also resulted from chemical reactions between juice's components of citrus fruits brought on by temperature-dependent enzymatic activity (Palaniswamy *et al.* 1974). According to (Bhatia *et al.*, 1956), the degree of acidity decrease depends on the sugar concentration and is a common occurrence when products are stored with sugars present.

During the storage period, prepared jam was stored for 45days, its pH showed an upward trend, a comparable drop in acidity brought on by chemical processes. Potential causes of pH shift include interactions between organic acids and pigments (Kannan and Thirumaran 2001). Similar findings were noted by (Thakur and Barwal 1998) in kiwi fruit squash and (Begum and Premakumar 2021) in amla based beverage preparation.

Organoleptic properties of amla jam : Overall acceptability of prepared Amla Jam with 50 percent fruit pulp and 50 percent sugar (S3) showed high consumer acceptance with 8 points and above whereas the jam prepared with 45 percent fruit pulp and 55 percent sugar showed 6.72 $\pm$ 0.67 to 7.16 $\pm$ 0.37 points and the jam prepared by 40 fruit pulp and 60 percent sugar showed lowest points 5.83 $\pm$ 0.56 to 6.08 $\pm$ 0.50 during storage.

Conclusions

Through this study, physiochemical properties of amla were studied which helps in equipment design and processing of the fruit. The prepared amla jam was optimized on the basis of its chemical properties and most importantly for its organoleptic properties during the storage period. Based on the observations, equal parts of pulp and sugar (S3), showed positive results in all the parameters. The other samples that were prepared had either dark end colour or separated sugar crystals were observed during storage period. S3 not only had overall market acceptability (= 8) on a 9-point hedonic scale but also had the best keeping qualities.

Table-3 : Properties of amla jam during storage.

Samples	Period	Moisture loss (%)	TSS (°Brix)	Acidity (%)	pH
S1	Control	17.03	80	1.00	2.84
	15th day	18.51	82	0.96	2.87
	30th day	19.25	86	0.95	2.92
	45th day	21.48	90	0.92	2.96
S2	Control	40.49	78	1.05	2.89
	15th day	42.15	80	1.04	2.91
	30th day	42.9	85	1.02	2.94
	45th day	44.63	88	0.99	2.98
S3	Control	40.00	72	1.06	2.92
	15th day	40.55	74	1.06	2.95
	30th day	40.72	75	1.04	2.99
	45th day	40.86	78	1.02	3.04

Table-4 : Organoleptic properties of prepared amla jam during storage (9-point Hedonic Scale).

Samples	Period	Texture	Colour	Flavour	Taste	Overall Acceptability
S1	Control	6.12 ± 0.33	6.04 ± 0.20	6.08 ± 0.28	6.08 ± 0.28	6.08 ± 0.50
	15th day	6.04 ± 0.20	5.91 ± 0.28	5.95 ± 0.20	5.87 ± 0.33	6.00 ± 0.29
	30th day	5.87 ± 0.33	5.83 ± 0.48	5.91 ± 0.28	5.75 ± 0.44	5.79 ± 0.41
	45th day	5.83 ± 0.38	5.75 ± 0.53	5.87 ± 0.44	5.54 ± 0.50	5.83 ± 0.56
S2	Control	7.12 ± 0.44	7.16 ± 0.47	7.20 ± 0.50	7.12 ± 0.33	7.16 ± 0.37
	15th day	7.08 ± 0.27	7.08 ± 0.40	7.04 ± 0.20	7.04 ± 0.20	6.96 ± 0.20
	30th day	6.96 ± 0.20	7.00 ± 0.28	6.96 ± 0.20	6.84 ± 0.37	6.88 ± 0.33
	45th day	6.80 ± 0.50	6.84 ± 0.47	6.92 ± 0.27	6.80 ± 0.57	6.72 ± 0.67
S3	Control	8.32 ± 0.47	8.20 ± 0.40	8.24 ± 0.43	8.20 ± 0.50	8.36 ± 0.49
	15th day	8.16 ± 0.37	8.12 ± 0.33	8.08 ± 0.40	8.08 ± 0.27	8.32 ± 0.47
	30th day	8.08 ± 0.27	8.04 ± 0.35	8.00 ± 0.28	8.00 ± 0.40	8.24 ± 0.52
	45th day	7.96 ± 0.20	7.92 ± 0.27	7.92 ± 0.40	7.84 ± 0.55	8.04 ± 0.35

Values are mean ± SD of the observations.

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Correlation Coefficient and Path Analysis of Yield Components and Fibre Quality Parameters in Upland Cotton (*Gossypium hirsutum* L.)

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Abstract

The experiment was carried out using twenty-five genotypes for sixteen traits of cotton with the objective to estimate the extent of correlation coefficient and path analysis. The material was evaluated in randomized complete block design with four replications during *kharif*, 2019. In this study, the positive and highly significant correlation was observed between seed cotton yield per plant and boll weight followed by ginning per cent and lint yield per plant at both genotypic and phenotypic levels. A highly significant and positive association exhibited by seed cotton yield with sympodia per plant, number of bolls per plant and micronaire at genotypic level. Path analysis based on genotypic correlation revealed that lint yield per plant and lint index exhibited high direct effect on seed cotton yield per plant in the positive direction which signifies their conclusive association with seed yield per plant. The residual effect was low in magnitude suggesting that the majority of the yield attributes have been included in the study of path analysis. It can be concluded that, the traits like number of sympodia per plant, number of bolls per plant, boll weight, ginning per cent, lint yield per plant, seed index and lint index could be used as selection criterion to recognize the suitable genotypes for future breeding programmes.

Key words : Correlation, path, association, direct effect, residual effect.

Introduction

Cotton (*Gossypium hirsutum* L.) is the most important economical crop grown in more than 70 countries of the world. It is also known as “White Gold”. It generates employment at various stages during cultivation, ginning, spinning and garment making. Cotton is grown for its lint, which is a major textile raw material, and for its seed cotton, which produces oil and protein (Meena *et al.*, 2022). Cotton is mainly grown for fibre, which is the economic component and plays a vital role for uplifting the country's economy. Cotton belongs to *Malvaceae* family and genus *Gossypium*, which consists of five allotetraploid and forty-five diploid species among them only four species are cultivated worldwide comprising of two diploids and two tetraploids also called old world and new world species (Ulloa *et al.*, 2006). The ultimate objective of breeding programmes is to develop high yielding varieties with superior qualitative traits. However, selection is the most effective strategy for taking a specific trait into account, which completely depends on how closely yield-related traits and seed yield are correlated. A statistical method called correlation can be used to determine if and how strongly two sets of traits are related to each another and determines the component characters on which selection can be based for genetic

improvement in seed cotton and lint yield (Salahuddin *et al.*, 2010). Breeders use genotypic and phenotypic correlations to assess the degree of association between yield and yield contributing traits. Correlation between yield and its contributing traits is a powerful method for selecting superior genotypes from diverse genetic backgrounds. However, it does not provide information about the direct and indirect effects of independent variables on the dependent variable, which requires path coefficient analysis (Erande *et al.*, 2014). Path analysis divides the correlation coefficient into direct and indirect effects. In order to investigate the direct and indirect effects of each component trait on the dependent variable, i.e., seed cotton yield per plant, path coefficient analysis is used. Studying path coefficients enables breeders to concentrate on the components that have a strong direct impact on seed cotton yield per plant. These factors were taken into consideration when conducting the current research, which analysed the correlation coefficient and estimated the direct and indirect effects on seed cotton yield.

Materials and Methods

The experiment was conducted at Agronomy Instructional Farm of C. P. College Agriculture, S.D. Agricultural University, Sardarkrushinagar. The experimental material

comprised of twenty-five different cotton genotypes sourced from the Cotton Research Station, S.D.A.U., Talod. These genotypes were subjected to evaluation using a Randomized Block Design (RBD) with four replications during the *Kharif* season of 2019-20. Each genotype was sown in 6 meter length rows, with a spacing of 90 cm between rows and 60 cm between individual plants. To raise a healthy crop, recommended agronomical and plant protection practises were followed throughout the crop season. Within each set of replications, five plants per genotype were randomly selected and marked for data collection purposes for sixteen different agro-morphological traits. The observations pertaining to the fibre quality traits were recorded using a cutting-edge High Volume Instrument (HVI) in ICC mode at CIRCOT, Mumbai.

Using the Al-Jibouri *et al.* (1958) formula, the correlation coefficients between all possible character combinations at the phenotypic and genotypic levels were calculated. Following the formula proposed by Wright (1921) and used by Dewey and Lu (1959), the path coefficient analysis was carried out. This analytical process was executed through the utilization of the INDOSTAT software version 9.2, which is a recognized tool for statistical computations in scientific research.

Results and Discussion

Correlation Coefficient Analysis : Understanding the relationship between various traits and seed cotton yield per plant is crucial for an efficient selection method. Correlation coefficient analysis was performed at both the genotypic and phenotypic levels to determine the type of association between different variables and seed yield per plant. The results are shown in Table-1.

Among all the component traits, days to flowering showed highly significant positive association with days to boll bursting ($r_g = 0.5941^{**}$), ginning per cent ($r_g = 0.6903^{**}$) and lint yield per plant ($r_g = 0.2116^*$) at only genotypic level and it is an important component in identifying and deciding the duration of the cotton crop indicated that increase in one character will lead to increase in second and *vice versa*. Similar results has been reported by Padmavathi *et al.* (2015). The number of sympodia per plant exhibited highly significant positive association with lint yield per plant ($r_g = 0.4021^{**}$) at genotypic level. A significant genotypic association was showed by number of bolls per plant ($r_g = 0.5482^{**}$), ginning per cent ($r_g = 0.3441^{**}$), boll weight ($r_g = 0.4048^{**}$), lint index ($r_g = 0.2935^{**}$) and highly significant positive correlation with seed cotton yield per plant ($r_g = 0.3997^{**}$) indicating that selection for high seed cotton yield per plant based on number of sympodia per plant is beneficial. Similar results were also reported by

Padmavathi *et al.* (2015) and Chaudhari *et al.* (2017). Number of bolls per plant showed significant positive association with lint yield per plant ($r_g = 0.2381^*$ and $r_p = 0.2571^{**}$) and seed index ($r_g = 0.6847^{**}$ and $r_p = 0.2821^{**}$) at both genotypic and phenotypic levels indicating that these traits can be improved simultaneously.

It showed positive and highly significant association with boll weight ($r_g = 0.5537^{**}$), lint index ($r_g = 0.6216^{**}$) and seed cotton yield per plant ($r_g = 0.2526^{**}$) at genotypic level. The selection for high seed cotton yield per plant based on number of bolls per plant is beneficial as their association is significantly positive at genotypic level. These results are in conformity with the results of Chaudhari *et al.* (2017) and Nawaz *et al.* (2019). A highly significant and positive correlation was observed for ginning per cent with lint yield per plant ($r_g = 0.3731^{**}$ and $r_p = 0.3630^{**}$), lint index ($r_g = 0.6855^{**}$ and $r_p = 0.39151^{**}$) and seed cotton yield per plant ($r_g = 0.2884^{**}$ and $r_p = 0.3806^{**}$) at both genotypic and phenotypic levels suggesting that the selection based on these traits may lead to improve the genetic architecture of genotypes. These results are in the agreement with the reports of Farooq *et al.* (2014) and Abbas *et al.* (2015). Boll weight exposed significant positive association with sympodia per plant ($r_g = 0.4084^{**}$), number of bolls per plant ($r_g = 0.5537^{**}$), ginning per cent ($r_g = 0.3645^{**}$), lint yield per plant ($r_g = 0.3781^{**}$), seed index ($r_g = 0.2637^{**}$), lint index ($r_g = 0.4186^{**}$) and 2.5% span length ($r_g = 0.2805^{**}$) at genotypic level. The selection for high seed cotton yield per plant based on boll weight is advantageous as their relationship is highly significant and positive ($r_g = 0.3721^{**}$ and $r_p = 0.6048^{**}$) at both genotypic and phenotypic levels, revealed higher phenotypic correlation indicated that the apparent association between these traits is not only due to genes, but also salutary influence of environment. Similar results were reported by Reddy *et al.* (2015) and Nawaz *et al.* (2019). A positive and significant association at both genotypic and phenotypic level was observed by lint yield per plant with bolls per plant ($r_g = 0.2381^*$ and $r_p = 0.2571^{**}$), ginning per cent ($r_g = 0.3731^{**}$ and $r_p = 0.3630^{**}$) and seed cotton yield per plant ($r_g = 0.9959^{**}$ and $r_p = 0.2614^{**}$) indicating the positive role of lint yield per plant towards enhancing the seed cotton yield per plant. Reddy *et al.* (2015) and Nawaz *et al.* (2019) also reported similar findings. The genotypically significant negative correlation between seed cotton yield per plant and seed index ($r_g = -0.2358^*$) and the phenotypically significant positive correlation between seed cotton yield and seed index (0.0442) clearly demonstrate the independent nature of these traits, making it unreliable to select for high seed cotton yield per plant based on seed index. According to Chaudhari *et al.* (2017), the seed index had a positive, statistically significant relationship

Table-1 : Genotypic and Phenotypic correlation coefficient among different characters in cotton.

	DF	DBB	PH	MP/P	SP/P	B/P/P	GP	BW	L/P	SI	LI	OIL	SL	MIC	FS	SCY
DF	G	1.00	0.5941**	0.0285	0.0716	0.1177	-0.1642	0.6903**	-0.0359	0.2116*	-0.2773**	0.1834	-0.0215	-0.1990*	0.1730	0.1360
	P	1.00	0.0997	0.0948	-0.1104	0.0215	-0.2682**	-0.1452	-0.0451	-0.1679	-0.1109	0.0739	-0.1112	0.0151	-0.0933	0.0326
DBB	G		1.00	0.0626	0.1312	0.0536	0.0343	0.5164**	0.0099	0.1920	-0.0806	0.2156*	0.0020	-0.0191	0.1554	0.3351**
	P		1.00	0.3237**	-0.0126	0.0382	0.0862	-0.1148	0.3325**	0.0090	0.0769	-0.2124 *	0.0467	-0.0527	0.0098	0.0052
PH	G			1.00	0.1959	0.4364**	0.5607**	0.2406*	0.1353	-0.0399	0.3671**	0.4363**	0.2195*	0.0780	0.1959	-0.3247**
	P			1.00	0.0183	0.0669	0.0700	-0.0390	0.1056	0.0058	-0.1755	-0.1220	-0.1883	-0.1128	-0.0187	-0.0429
MP/P	G				1.00	0.2412*	-0.0877	0.0667	-0.4837**	-0.1768	-0.0001	0.0527	-0.1925	-0.2517*	0.0011	-0.1873
	P				1.00	0.1189	0.2830**	0.4250**	0.1016	0.1079	0.0129	0.2763 **	0.0080	0.1750	-0.0457	0.2909**
SP/P	G					1.00	0.5482**	0.3041**	0.4084**	0.4021**	0.1219	0.2935**	0.1114	0.0403	0.0795	-0.4552**
	P					1.00	0.1555	-0.0816	0.0123	-0.3114**	-0.0849	-0.0238	-0.0850	-0.1494	-0.0972	-0.0086
BP/P	G						1.00	0.1822	0.5537**	0.2381*	0.6847**	0.6216**	0.1187	0.0231	0.1137	-0.1917
	P						1.00	0.4987**	0.1586	0.2571**	0.2821**	0.0693	0.2716**	0.1139	-0.0018	0.1514
GP	G							1.00	0.3645**	0.3731**	0.1608	0.6855**	-0.3139**	-0.2443*	-0.0261	-0.1992
	P							1.00	0.1181	0.3630**	0.3196**	0.3915**	0.3214**	0.1075	0.0006	0.3806**
BW	G								1.00	0.3781**	0.2637**	0.4186**	0.1681	0.2805**	-0.1289	-0.0765
	P							1.00	0.1865	1.00	0.1547	0.0920	0.0767	-0.2427*	0.0271	0.6048**
L/P	G								1.00	-0.2173*	0.0345	0.0345	-0.1357	-0.1016	0.4380**	-0.3771**
	P								1.00	0.1302	0.1930	0.1198	0.1198	0.1117	0.0339	-0.0051
SI	G									1.00	0.8251**	0.0874	0.2139*	0.2139*	-0.2945**	0.1670
	P									1.00	-0.0435	0.9959**	0.0753	0.0753	-0.1035	0.1017
LI	G										1.00	-0.1071	0.0444	-0.2436*	-0.0024	-0.0277
	P										1.00	-0.0502	0.1559	-0.0338	-0.0996	0.8464**
OIL	G											1.00	0.6358**	0.0033	0.1429	-0.1019
	P											1.00	0.0954	-0.1015	0.0992	-0.003
SL	G												1.00	0.0625	0.2579**	-0.0778
	P												1.00	0.1683	-0.0117	0.0003
MIC	G													1.00	-0.3672**	0.4600**
	P													1.00	0.0616	-0.082
FS	G														1.00	-0.3731**
	P															-0.0673

*-Significant at 5% level of significance, **-Significant at 1% level of significance.

with plant height and boll weight. At the phenotypic level, lint index revealed a strong positive correlation with seed cotton yield per plant ($r_p = 0.8464^{**}$). The correspondence result of lint index with seed cotton yield per plant was observed by Nawaz *et al.* (2019). Oil content exhibited positive and noteworthy correlation with the traits, plant height ($r_g = 0.2195^*$) and 2.5% span length ($r_g = 0.6358^{**}$) at genotypic level. Oil content showed negative non-significant association with days to flowering and positive significant correlation with plant height. Chaudhari *et al.* (2017) found positive significant correlation for plant height which is similar to the present study. Span length observed a non-significant and negative association with seed cotton yield per plant and micronaire, clearly indicating that the independent nature of these traits and selection for high seed cotton yield per plant based on 2.5% span length is not a reliable approach. The results are in correspondence with the findings of Kale *et al.* (2007) and Farooq *et al.* (2013). Micronaire showed significant positive association with seed cotton yield per plant ($r_g = 0.4600^{**}$) at genotypic level. The results are in agreement with the findings of Nawaz *et al.* (2019). At the genotypic level, there was a significant negative correlation between fibre strength and seed cotton yield per plant ($r_g = -0.3731^{**}$) and a

non-significant negative correlation ($r_p = -0.0673$) at phenotypic level, indicates the independent nature of these traits and selection for high seed cotton yield per plant based on fibre strength is unreliable. The experiment conducted by Handi *et al.* (2016) reported similar results.

The genetic elements accountable for a correlated response in traits are linkage and pleiotropy (a single gene affects multiple traits). If the association between two traits, whether positive or negative, remains consistent in both the original and separating populations, it suggests that this association is a result of pleiotropy. Conversely, if this relationship alters within the segregating population, it's likely due to linkage or gene recombination (Mallikarjun *et al.*, 2003). The pleiotropy or linkage may involve two desirable traits like seed cotton yield per plant with number of bolls per plant and boll weight or one desirable and one undesirable trait like seed cotton yield per plant with plant height and days to flowering hindering the progress. In light of above results, we can infer that genotypic correlation is more stable as it excludes environmental effects and is of paramount importance for a plant breeder to bring about genetic improvement in one character by selecting the other character of a pair that is genetically correlated.

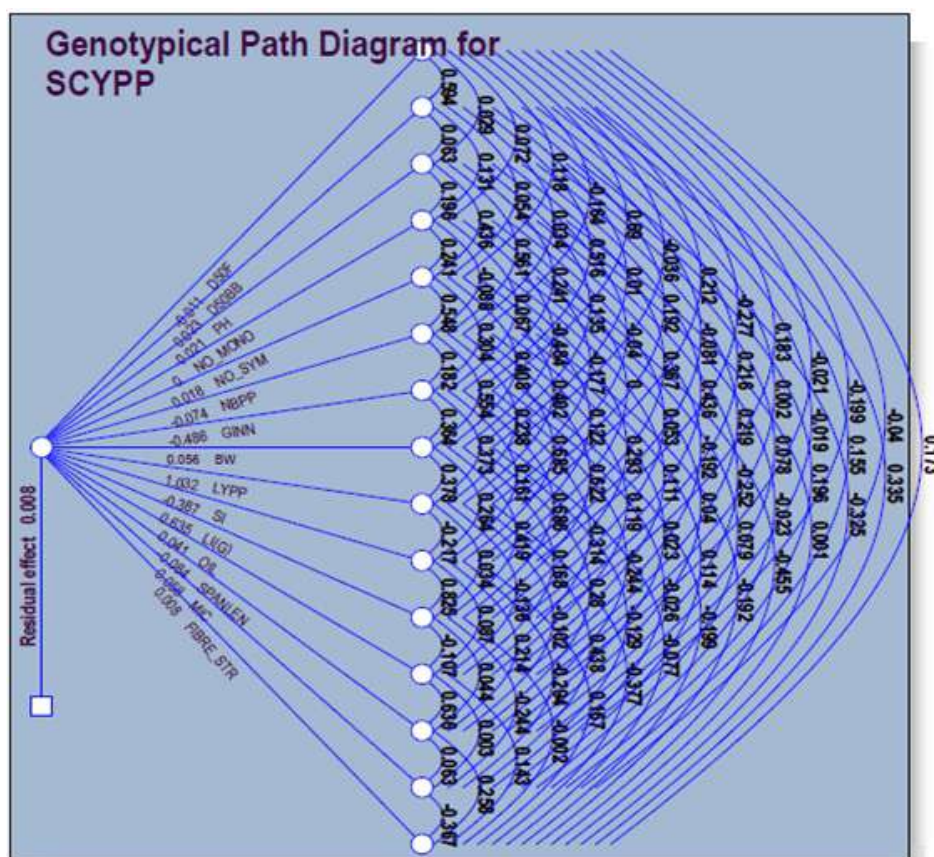


Fig-1 : Genotypic Path Diagram Illustrating the Causal Relationship and Effects of Yield Components on Seed Cotton Yield per Plant in Cotton (*Gossypium hirsutum* L.).

Table-2 : Path coefficient analysis showing direct and indirect effects of various traits on seed cotton yield in cotton on genotypic level.

	DF	DBB	PH	MP/P	SP/P	BP/P	GP	BW	LYP	SI	LI	OIL	SL	MIC	FS
DF	-0.0114	-0.0068	-0.0003	-0.0008	-0.0013	0.0019	-0.0079	0.0004	-0.0024	0.0032	-0.0021	0.0002	0.0023	0.0005	-0.0020
DBB	0.0139	0.0234	0.0015	0.0031	0.0013	0.0008	0.0121	0.0002	0.0045	-0.0019	0.0050	0.0000	-0.0004	0.0036	0.0078
PH	-0.0006	-0.0013	-0.0207	-0.0041	-0.0091	-0.0116	-0.0050	-0.0028	0.0008	-0.0076	-0.0091	-0.0046	-0.0016	-0.0041	0.0067
MP/P	0.0001	0.0001	0.0001	0.0004	0.0001	0.0000	0.0000	-0.0002	-0.0001	0.0000	0.0000	-0.0001	-0.0001	0.0000	0.0000
SP/P	0.0021	0.0010	0.0078	0.0043	0.0178	0.0097	0.0054	0.0073	0.0071	0.0022	0.0052	0.0020	0.0007	0.0014	-0.0081
BP/P	0.0121	-0.0025	-0.0414	0.0065	-0.0405	-0.0738	-0.0135	-0.0409	-0.0176	-0.0505	-0.0459	-0.0088	-0.0017	-0.0084	0.0142
GP	-0.3354	-0.2509	-0.1169	-0.0324	-0.1477	-0.0885	-0.4858	-0.1771	-0.1813	-0.0781	-0.3330	0.1525	0.1187	0.0127	0.0968
BW	-0.0020	0.0006	0.0075	-0.0269	0.0227	0.0308	0.0203	0.0557	0.0211	0.0147	0.0233	0.0094	0.0156	-0.0072	-0.0043
LYP	0.2184	0.1982	-0.0412	-0.1825	0.4152	0.2459	0.3852	0.3903	1.0325	-0.2243	0.0356	-0.1401	-0.1049	0.4522	-0.3893
SI	0.1075	0.0312	-0.1422	0.0001	-0.0472	-0.2653	-0.0623	-0.1022	0.0842	-0.3874	-0.3197	-0.0339	-0.0829	0.1141	-0.0647
LI	0.1165	0.1370	0.2771	0.0335	0.1864	0.3948	0.4354	0.2659	0.0219	0.5241	0.6352	-0.0681	0.0282	-0.1547	-0.0015
OIL	-0.0009	0.0001	0.0090	-0.0079	0.0046	0.0049	-0.0129	0.0069	-0.0056	0.0036	-0.0044	0.0412	0.0262	0.0001	0.0059
SL	0.0166	0.0016	-0.0065	0.0210	-0.0034	-0.0019	0.0204	-0.0234	0.0085	-0.0179	-0.0037	-0.0531	-0.0835	-0.0052	-0.0215
MIC	-0.0023	0.0090	0.0114	-0.0014	0.0046	0.0066	-0.0015	-0.0075	0.0254	-0.0171	-0.0141	0.0002	0.0036	0.0580	-0.0213
FS	0.0014	0.0028	-0.0027	0.0000	-0.0037	-0.0016	-0.0016	-0.0006	-0.0031	0.0014	0.0000	0.0012	0.0021	-0.0030	0.0082
SCY (rg)	0.1360	0.1433	-0.0576	-0.1873	0.3997**	0.2526*	0.2884**	0.3721**	0.9959**	-0.2358*	-0.0277	-0.1019	-0.0778	0.4600**	-0.3731**

Residual effect = 0.0082, *Significant at 5% level of significance, **Significant at 1% level of significance.

Path Coefficient Analysis : Studying the correlation coefficient and mutual relationship between different characters can help you understand how improving seed cotton yield, an economically significant attribute, would benefit from the direct and indirect contributions of various traits. Path analysis helps to measure the magnitude and nature of direct and indirect effect of each trait on the dependent trait i.e., yield. Utilising genotypic correlation coefficient, relationships between seed cotton yield per plant and the other fifteen parameters were evaluated. Additionally, residual effect is estimated to reflect the influence of unmeasured independent variables on the dependent trait. Path analysis helps in identifying the most promising genotypes from a diverse genetic population. Path analysis was conducted at the genotypic level to assess the impacts of various yield component traits on seed cotton yield per plant. The results of this analysis, along with the corresponding genotypic path diagrams shown in Figure-1, illustrate both the direct and indirect effects of these traits. These findings are summarized in Table-2.

The direct effect of days to flowering on seed cotton yield per plant was negative and negligible (-0.0114). However, there were slight positive indirect effects of this characteristic on seed cotton yield per plant through seed index (0.1075) and lint index (0.1165) observed low. On the other hand, the direct effect of the days to boll bursting had positive and negligible (0.0234) direct effect on seed cotton yield per plant. While the plant height had negative and negligible direct effect (-0.0207) on seed cotton yield per plant. Gulhane *et al.* (2017) observed negative direct effect on seed cotton yield per plant.

The number of sympodia per plant had a small yet positive direct impact on the seed cotton per plant (0.0178). However, there was a significant positive indirect effect through lint yield per plant (0.4152), which was substantial, and a lower positive indirect effect through lint index (0.1864). Positive direct effect of number of sympodia per plant on seed cotton yield per plant was also reported by Chaudhari *et al.* (2017) and Gulhane *et al.* (2017). The direct effect of number of bolls per plant on seed cotton yield per plant was observed negative and negligible (-0.0738). The positive moderate indirect effect of boll per plant on seed cotton yield per plant was observed *via* lint yield per plant (0.2459), although the positive indirect effect of this trait on seed cotton yield per plant *via* lint index (0.3948) was high. The ginning per cent showed negative and high direct effect (-0.4858) on seed cotton yield per plant, while high indirect effect was observed through lint yield per plant (0.3852) and lint index (0.4354). Similar results were reported by Chaudhari *et al.* (2017). Boll weight had

positive and negligible direct effect (0.0557) on seed cotton yield per plant, however the indirect effect through lint yield per plant (0.3903) was high and the lint index (0.2659) was moderate. Positive direct effect of boll weight on seed cotton yield per plant reported by Chaudhari *et al.* (2017). The direct effect of lint yield per plant on seed cotton yield per plant was positive and very high (1.0325). The positive indirect effect of this trait on seed cotton yield per plant via days to boll bursting (0.0045), plant height (0.0008), number of sympodia per plant (0.0071), boll weight (0.0211), seed index (0.0842), lint index (0.0219), 2.5% span length (0.0085) and micronaire (0.0254) was negligible. Positive direct effect of lint yield per plant on seed cotton yield per plant was also reported by Dahiphale *et al.* (2015). Seed index showed negative and high direct effect (-0.3874) on seed cotton yield per plant, while the indirect effect through lint index (0.5241) was high. The negative direct effect of seed index on seed cotton yield per plant observed by Chaudhari *et al.* (2017). The direct effect of lint index observed positive and high (0.6352) on seed cotton yield per plant, whereas the indirect effect through ginning per cent (-0.3330) and seed index (-0.3197) was observed negative and high. Similar results for positive direct effect on seed cotton yield were also reported by Vinodhana *et al.* (2013) and Pujer *et al.* (2014).

The residual effect determines how well the causative factors account for the dependent factor's variability. The residual effect (0.0082) in the current investigation is very small, indicating that the majority of the yield-attributing characters have been taken into account in the path analysis study and that the characters considered in the study contribute significantly to the high variability of the dependent variable, i.e. yield. The small number of few other characters which were left out from the current study are responsible for the low percentage of contribution.

Conclusions

The current study demonstrated a noteworthy and strong positive correlation between various important traits and seed cotton yield per plant. The results highlighted that boll weight, ginning percentage, and lint yield per plant were the most influential factors positively impacting seed cotton yield. This suggests that these traits could potentially serve as reliable indicators for predicting and improving seed cotton yield in future breeding programs. The path analysis provides valuable insights into the relationships between different traits and seed cotton yield per plant. Lint yield per plant and lint index are positively correlated with seed yield, making them most important traits for direct selection to enhance seed cotton yield. Conversely, traits such as ginning percentage, seed

index, 2.5% span length, bolls per plant, plant height, and flowering time are negatively correlated with seed yield, indicating that minimizing these traits could contribute to higher seed cotton yield. The small residual effect value indicates that most of the yield-attributing traits have been considered in the path analysis study. These findings offer guidance to the breeders for effective breeding strategies aimed at improving cotton genotypes for higher seed cotton yield.

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Conflict of Interests

The authors state that there are no possible conflicts of interest.

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Efficacy of Fungicides and Bioagents against *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) Snyder and Hansen Inciting Wilt on Tomato

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Abstract

Effect of fungicides and bioagents against tomato wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* under *in vitro* condition. The observations were recorded under that maximum growth inhibition in Carbendazim and Tebuconazole with complete inhibition at each concentration followed by propiconazole (87.72, 100, 100, 100 and 100 %), Difenoconazole and Hexaconazole at different concentration. Minimum mycelium growth inhibition in Copper oxychloride with (20.78, 26.28, 30.94, 35.85 and 42.08 %) at 25, 50, 75, 100 and 125 ppm. Among all the bioagents maximum growth inhibition was recorded in *T. harzianum* (76.82 %) and minimum growth inhibition was found in *P. flourescens* (47.23 %).

Key words : Tomato wilt, *Fusarium oxysporum* f. sp. *lycopersici*, Carbendazim, Tebuconazole, *Trichoderma harzianum* and per cent inhibition.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular and widely grown vegetable crop in the world belongs to the Solanaceae family and sub-family Solanoideae and genus *Lycopersicon*. The genus *Lycopersicon* belongs to the largest tribe, Solanaceae which includes 18 genera, the largest being *Solanum* and the smallest *Lycopersicon*, the closely related genera. The genus *Lycopersicon* is sub divided into 2 groups, *Eulycopersicon* - the coloured fruited species and *Eriopersicon* – the green fruited species (Swarup, 2014). In India tomato came by way of Portuguese explores during the early 16th century and today tomato is also known as 'Poor Man Apple' and became the major food crop in India (Mehta, 2017). Tomato is cooked alone as vegetable or in combination with potato and can be eaten raw when ripe. It possess a nutritional value as well as medicinal qualities apart from being a rich source of vitamins (vitamin C) and other minerals like calcium, phosphorus and iron. Extract of tomato contains carotenoids such as lycopene, beta carotene and vitamin E which are known as effective antioxidants to inactivate free radicals and slow the atherosclerosis (Bhowmik *et al.*, 2012). The tomato yield production is affected by various fungal, bacterial and viral diseases for e.g. early blight of tomato caused by *Alternaria solani*, buckeye rot of tomato caused by *Phytophthora nicotianae*, bacterial canker of tomato caused by *Clavibacter michiganensis* sub sp. *michiganensis* and tomato spotted wilt caused by tomato spotted wilt virus. Among fungal diseases, tomato wilt caused by *F. oxysporum* f. sp. *lycopersici* seriously damage the yield losses in tomato throughout the world

(Carmona *et al.*, 2020). It is a soil borne pathogen in the class Hyphomycetes that causes wilt of tomato as the only host of pathogen. The clearing of veinlets and drooping of the petioles are the earliest symptoms on young plant. Yellowing of the older lower leaves is the first symptom of *Fusarium* wilt. Lower leaves show yellowing and die (Maurya *et al.*, 2019). The young leaves may die in succession, and in the course of a few days the entire plant may wilt and die (Rangaswami and Mahadevan, 2014). The causal agents of tomato wilt cause root and basal stem deterioration and result in the wilting of vegetable plants. Browning of the vascular tissue is strong evidence of *Fusarium* wilt (Ghorbandi *et al.*, 2016). It causes serious loss in tomato production at all stages of plant growth by attacking plants through roots and considered as one of the main soil borne systemic disease with major limiting factor in the production of tomato both in green house and field grown (Mc Govern, 2015 and Khiareddine *et al.*, 2019). Manikandan *et al.* (2018) collected 20 isolates of *F. oxysporum* f. sp. *lycopersici* from different districts of Tamil Nadu and were grown on PDA to study their growth and variability in colony characters. Each isolates colony colour was significantly different from each other. The pathogen at the time of incubation produced different colony colors viz., light pink, pink, dark pink, creamy white, pale white with pink, creamy white with pink, milky white and pinkish white. The mycelial growth patterns showed adherent smooth and fluffy growths. Microscopic study revealed that microconidia are small, oval shaped, hyaline and single or bicelled whereas macroconidia were sickle shaped hyaline and multicelled with 3 to 5 septate. In addition,

chlamydospores were seen terminally and intercalary. Jha *et al.* (2018) reported that pathogenic fungi of genus *Fusarium* that is the causal agent of tomato wilt cause root and basal stem deterioration and results in wilting of vegetable plants. Browning of the vascular tissue is strong evidence of *Fusarium* wilt. It is highly destructive pathogen, causing 10 to 50% yield loss in many tomato production areas (Ghazalibiglar *et al.*, 2016).

In present investigation applied fungicides and bio-control agents in a compatible manner for effective management of tomato wilt caused by *Fusarium oxysporum* f. sp. *lycopersici*.

Materials and Methods

Isolation of pathogen the infected samples of tomato wilt symptoms and collected from Vegetable Research and Demonstration Block, Bharsar. To isolate pathogen, the following two methods: i) Moist chamber method, It helps to induce fungi to form external mycelium, to sporulate or to form sclerotia. Moist chambers were made by moistening round filter paper towels and placing in the Petri plates. Then infected area from the infected fruit were placed in the moist chamber at room temperature. ii) Petri plate method: The infected samples were washed in running tap water then placed in between blotting paper to remove excess moisture. Infected portions were cut from the leaves with the help of sharp sterilized blade along with some healthy portions. These pieces are surface sterilized in 0.1% mercuric chloride (HgCl_2) for 1 minute. After specimens were washed thoroughly in at least three changes of sterilized distilled water to remove the residue of mercuric chloride. Then aseptically transferred into plates containing potato dextrose agar (PDA) and incubated at $28 \pm 2^\circ\text{C}$ temperature and observed periodically for mycelial growth of fungus. Developed colonies from the pieces, were identified by microscopic observation by taking mycelial character as means for identifying the pathogen. All the isolates were cultured under sterilized conditions in a laminar air flow and incubated at $28 \pm 2^\circ\text{C}$ for 7 days till proper growth. Cultures purified from single colony appearing on PDA after observing under microscope and for further use they were then maintained on PDA slants at 4°C in a refrigerator. Stored cultures were sub cultured periodically. To confirm the identity of the isolated pathogens after making slides in glycerine and cotton blue stain, the fungal growth examined under compound microscope at 40 x magnification. The shape and size of acervuli, conidia/spore arrangement and sporulation have studied and photographed. Observations recorded i) Colony: Colour, shape and fragmentation. ii) Mycelium: Colour, shape, septation and branching. iii) Conidia : Colour and shape.

In vitro evaluation of different fungicides : Evaluation of Nine fungicides *i.e.* Captan, Carbendazim, Difenconazole, Mancozeb, Propiconazole, Chlorothalonil, Copper oxychloride, Tebuconazole and Hexaconazole using by poisoned food technique (Nene and Thapliyal, 2000). To get the desired concentration of active ingredient of each fungicide separately, the calculated quantities of fungicides were aseptically added to 100 mL of molten PDA in conical flasks. To ensure the proper mixing of chemicals in PDA the flasks were shaken gently, in each Petri plate 20 mL of molten and cooled PDA was poured. After solidification of media, mycelia discs (5 mm) were cut from the edges of 7 days old culture of test pathogen with the help of sterilized cork borer and placed into the middle of Petri plates and incubated at $28 \pm 2^\circ\text{C}$. The culture disks were grown under same conditions on PDA without fungicides were kept in suitable control. The mycelial colony growth measured after 7 days of incubation. Observation recorded, fungal colony diameter (in mm). Per cent mycelium inhibition in growth was calculated in relation to growth in control using the following formula suggested by Vincent (1947).

$$\text{PGI} = \frac{C - T}{C} \times 100$$

Where, PGI = Per cent growth inhibition

C = Mycelial growth in control

T = Mycelial growth in treatment

In vitro evaluation of different bioagents : Six bioagents *i.e.* *Trichoderma harzianum*, *Trichoderma viride*, *Trichoderma asperellum*, *Pseudomonas fluorescens*, *Bacillus subtilis* and *Bacillus cereus* were evaluated for their efficacy properties against *F. oxysporum* f. sp. *lycopersici* using by dual culture technique (Faheem *et al.*, 2010). In this method the bioagents and the test fungus were inoculated both side on a single Petri plate containing solidified PDA medium. Each treatment were replicated four times with one control by maintaining only pathogen and bioagents separately. The plates which were inoculated were incubated at $28 \pm 2^\circ\text{C}$ for 7 days. The diameter of colony of bioagents and the pathogen is measured in two direction with the help of the measuring scale and then the average radial growth were recorded. The efficacy of bioagents was expressed as per cent inhibition of mycelial growth over control, calculated by using following formula mentioned above. The data obtained and analyzed by using standard statistical procedure in the simple completely randomized design (CRD) with the help of OPSTAT.

Results and Discussion

Efficacy of fungicides : Nine different fungicides were evaluated at (25, 50, 75, 100 and 125 ppm) to find out their

Table-1 : Effect of fungicides on per cent mycelium growth inhibition of *F. oxysporum* f. sp. *lycopersici* at different concentrations.

Treatments	Average per cent mycelium growth inhibition				
	Concentrations (ppm)				
	25 ppm	50 ppm	75 ppm	100 ppm	125 ppm
Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Captan	56.22 (48.55)	62.01 (51.93)	67.11 (54.99)	71.97 (58.01)	77.91 (61.95)
Carbendazim	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
Difenoconazole	76.88 (61.25)	80.21 (63.58)	83.50 (66.01)	86.49 (68.41)	90.67 (72.19)
Mancozeb	25.59 (30.31)	34.23 (35.79)	41.10 (39.85)	49.44 (44.66)	58.72 (50.00)
Propiconazole	87.72 (69.46)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
Chlorothalonil	34.37 (35.88)	38.10 (38.10)	43.80 (41.42)	48.07 (43.87)	56.02 (48.43)
Copper oxychloride	20.78 (27.10)	26.28 (30.82)	30.94 (33.75)	35.85 (36.76)	42.08 (40.43)
Tebuconazole	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
Hexaconazole	62.15 (52.02)	72.42 (58.34)	78.84 (62.59)	84.97 (67.18)	92.46 (74.03)
SE (d)	1.57 (1.02)	1.49 (0.95)	1.45 (0.90)	1.26 (0.77)	0.69 (0.45)
C.D. _(p=0.05)	3.31 (2.15)	3.13 (2.01)	3.06 (1.89)	2.65 (1.61)	1.45 (0.96)

() = Values in parentheses are angular transformed.

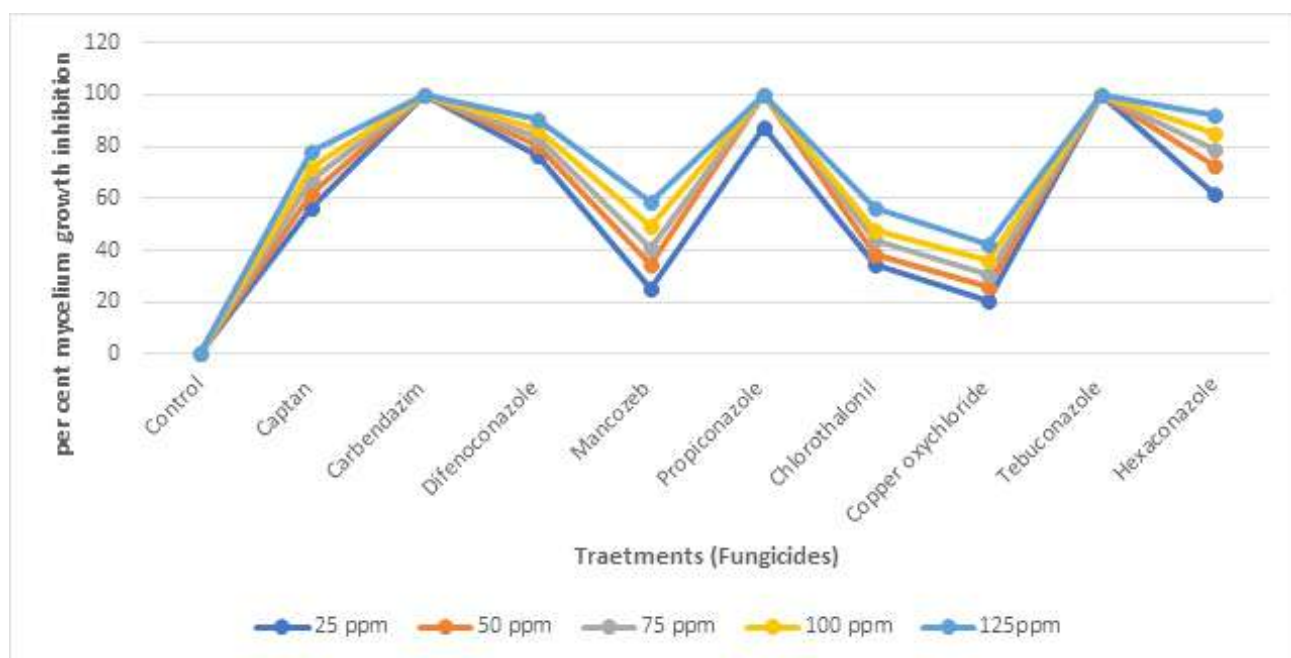
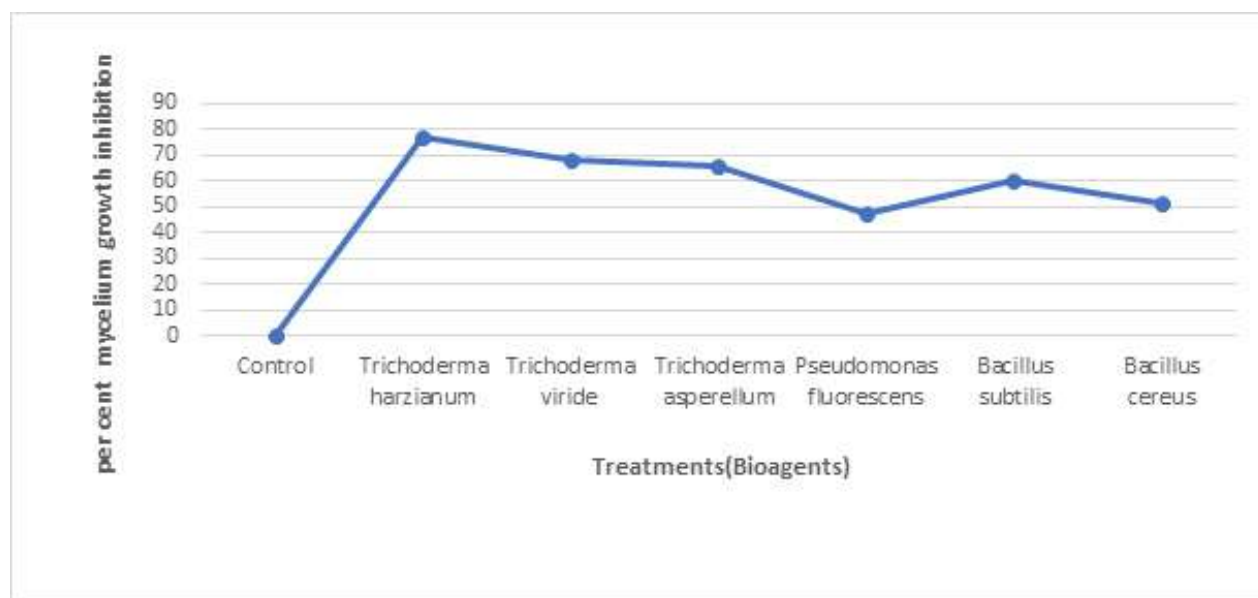
Fig.-1 : Effect of fungicides on per cent mycelium growth inhibition of *F. oxysporum* f. sp. *lycopersici* at different concentration.

Table-2 : Effect of different bioagents on per cent mycelium growth inhibition of *F. oxysporum* f. sp. *Lycopersici*.

Treatments	Average per cent mycelia growth inhibition
Control	0.00 (0.00)
<i>Trichoderma harzianum</i>	76.82 (61.20)
<i>Trichoderma viride</i>	68.28 (55.70)
<i>Trichoderma asperellum</i>	66.07 (54.35)
<i>Pseudomonas fluorescens</i>	47.23 (43.39)
<i>Bacillus subtilis</i>	60.15 (50.83)
<i>Bacillus cereus</i>	51.46 (45.82)
S.E. (d)	0.80 (0.48)
C.D. _(p=0.05)	1.74 (1.05)

() = Values in parentheses are angular transformed.

Fig-2 : Effect of bioagents on per cent mycelium growth inhibition of *F. oxysporum* f. sp. *Lycopersici*.

comparative efficacy on per cent mycelial growth inhibition of *F. oxysporum* f. sp. *lycopersici*. Data observed in (Table-1 and Figure-1) showed that all the fungicides inhibit the per cent mycelial inhibition of the test pathogen.

At 25 ppm : The significant variation as compared with control for per cent mycelial inhibition at 25 ppm concentration. It ranged from (0.00-100%). The maximum per cent mycelial inhibition was found in Carbendazim (100%) and Tebuconazole (100%) followed by Propiconazole (87.72%), Difenconazole (76.88%), Hexaconazole (62.15%), Captan (56.22%), Chlorothalonil (34.37%), Mancozeb (25.59%) and Copper oxychloride (20.78%) whereas, minimum per cent mycelial inhibition was observed in control.

At 50 ppm : It ranged from (0.00-100%). Maximum per cent mycelial inhibition was observed in Carbendazim (100%), Tebuconazole (100%) and Propiconazole (100%) which was followed by Difenconazole (80.21%), Hexaconazole (72.42%), Captan (62.01%), Chlorothalonil (38.10%), Mancozeb (34.23%) and Copper oxychloride

(26.28%) whereas, the minimum percent mycelial inhibition was observed in control.

At 75 ppm : The maximum per cent mycelial inhibition was recorded in Carbendazim (100%), Tebuconazole (100%) and Propiconazole (100%) followed by Difenconazole (83.50%), Hexaconazole (78.84%), Captan (67.11%), Chlorothalonil (43.80%), Mancozeb (41.10%) and Copper oxychloride (30.94%). Minimum per cent mycelial inhibition was observed in control.

At 100 ppm : Maximum per cent mycelial was found in Carbendazim (100%), Tebuconazole (100%) and Propiconazole (100%) followed by Difenconazole (86.49%), Hexaconazole (84.97%), Captan (71.97%), Mancozeb (49.44%), Chlorothalonil (48.07%) and Copper oxychloride (35.85%) whereas the minimum per cent mycelial inhibition was found in control.

At 125 ppm : The maximum per cent mycelial was found in Carbendazim (100%), Tebuconazole (100%) and Propiconazole (100%) followed by Hexaconazole (92.46%), Difenconazole (90.67%), Captan (77.91%),

Mancozeb (58.72%), Chlorothalonil (56.02%) and Copper oxychloride (42.08%) whereas the minimum per cent mycelial inhibition was found in control. All the treatments were tested against *F. oxysporum* f. sp. *lycopersici* under *in vitro* condition at 25, 50, 75, 100 and 125 ppm.

The experiment which showed that all the treatments were found statistically higher than control. Carbendazim and Tebuconazole was highly effective at all concentrations with maximum per cent mycelial inhibition *i.e.* 100% followed by Propiconazole with 100% mycelial inhibition @ 50, 75, 100 and 125 ppm, whereas control was found with minimum per cent mycelial inhibition *i.e.* (0.00%). Katyayani *et al.* (2019) found that under *in vitro* condition Carbendazim inhibited 100% mycelial growth of *F. oxysporum* f. sp. *lycopersici* at 10, 25, 50, 75 and 100 ppm. Similar findings were recorded by Chennakesavulu *et al.* (2013) under *in vitro* condition that Tebuconazole, Carbendazim and Propiconazole inhibited 100% mycelial growth of *Fusarium udum* at 50, 100, 250, 500 and 1000 ppm. Dahal and Shrestha (2018) also found that Carbendazim showing 100% mycelial growth inhibition of *F. oxysporum* f. sp. *lentis* under (*in vitro*) at 100, 150 and 200 ppm.

Efficacy of bioagents : The efficacy of bioagents on the growth of *F. oxysporum* f. sp. *lycopersici* were evaluated under *in vitro* condition and presented in (Table-2 and Figure-2). Among bioagents, after 7 days of incubation the average radial growth (mm) was recorded and it was evident that maximum growth inhibition of the test pathogen was in *T. harzianum* (76.82%) inhibition followed by *T. viride* (68.28%) inhibition, *T. asperellum* (66.07%), *B. subtilis* (60.15%) and *B. cereus* (51.46%) inhibition. The minimum growth inhibition of the test pathogen was recorded in *P. fluorescens* (47.23%) inhibition. All the treatments were found significant as compared with control. Singh *et al.* (2018) and Katyayani *et al.* (2019) under *in vitro* condition used bioagents against *F. oxysporum* f. sp. *lycopersici* by dual culture method and reported similar results that maximum growth inhibition was recorded in *T. harzianum* followed by *T. viride*. Basco *et al.* (2017) under *in vitro* also used bioagents against *F. oxysporum* f. sp. *lycopersici* and reported similar results that maximum growth inhibition was recorded in *T. harzianum* and minimum growth inhibition was recorded in *P. fluorescens*.

Conclusions

Effect of fungicides and bioagents against tomato wilt (*Fusarium oxysporum* f. sp. *lycopersici*). The observation were recorded that maximum mycelia growth inhibition was found in Carbendazim and Tebuconazole with complete inhibition at each concentration and minimum mycelia growth inhibition was found in Copper oxy

chloride at 25, 50, 75, 100 and 125 ppm. Among the bioagents maximum mycelia growth inhibition was recorded in *T. harzianum* and minimum was found in *P. fluorescens*.

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Assessment of Eco-Friendly impact of Organic and Chemical Fertilizers on Management of Brinjal Fruit and Shoot Borer, *Leucinodes orbonalis* Guenee

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Abstract

Brinjal fruit and shoot borer, (*Leucinodes orbonalis*) Guenee is a serious insect of brinjal. The present investigation, three organic manures, each having three different concentrations (25, 50 and 75%) were evaluated under field conditions. The effect of organic manures, 75% neem cake + 25% chemical fertilizers proved most effective for per cent shoot infestation, per cent fruit infestation (number and weight basis) and total yield (kg/plot and kg/ha basis) which was closely followed by 75% poultry manure + 25% chemical fertilizers. Minimum per cent shoot infestation (18.66%), per cent fruit infestation number basis (6.05%) and weight basis (16.31%). Maximum fruit yield on per plot basis (6.43 kg/plot) in 2019 and 6.12 kg/plot in 2020 and also maximum yield kg/ha was obtained by the treatment where 75% nitrogen given through the neem cake and remaining 25% through inorganic form.

Key words : Brinjal, fruit and shoot borer, *Leucinodes orbonalis*, organic manures, chemical fertilizers and efficacy.

Introduction

Brinjal (*Solanum melongena*) Linnaeus, commonly known as egg plant is an important vegetable crop cultivated since ages. It is cultivated worldwide for its immature tender fruits. South-East Asia, probably India, brinjal was first domesticated in India (Polunin, 1987). Brinjal is rich in certain nutritive elements like 4.0 per cent carbohydrate, 1.4 per cent protein, 0.3 per cent fat, 0.047 per cent phosphorus, 0.018 per cent calcium, 0.009 per cent iron and many other vitamins with 92.7 per cent moisture (Whitaker, 2003 and Bliss and Elstein, 2004). It is also used as a raw material in pickle making (Singh *et al.*, 1963) and as an excellent remedy for those suffering from liver complaints. Brinjal has many ayurvedic properties and is known for curing diabetes, good appetizer, aphrodisiac, cardi tonic, laxative and anti-inflammatory (Balkrishnan, 2017). Brinjal occupies third position amongst vegetable crops grown in India, it covers *i.e.* 680.0 thousand ha with a productivity of 18.70 t/ha and produces 12706.0 thousand tonnes in India in 2017-18. In Madhya Pradesh the annual production is 1154.0 thousand MT in an area of 46.12 thousand ha with a productivity of 25.02 t/ha in 2017-18 (Anonymous, 2018). One of the major constraints in increasing vegetable production is loss caused by vegetable pests. Insect pests are responsible for reducing 40% of the total yield of vegetables (Tewari, 2009).

Brinjal is attacked by several number of insect pests including mites, which result in significant loss in the yield

(Padwal *et al.*, 2016). Though brinjal is a summer crop, it is being grown throughout the year under irrigated condition. Hence, it is subjected to attack by number of insect pests right from nursery stage till harvesting (Regupathy *et al.*, 1997). The major insect pests of brinjal include fruit and shoot borer (BSFB), *Leucinodes orbonalis* (Guenee); White fly, *Bemisia tabaci* (Gennadius); Jassid, *Amrasca biguttula biguttula* (Ishida); Aphid, *Aphis gossypii* (Glover); Red spider mite, *Tetranychus telarius* (Linnaeus); Epilachna beetle, *Henosepilachna vigintioctopunctata* (Fabr.) (Anonymous, 2009). Among the major insect pests, brinjal shoot and fruit borer (BSFB) is the most destructive pest of brinjal in India (Tewari and Sandana, 1990; Rahman, 2006). It damages the crop throughout the year. It causes the serious yield losses ranging from (15 – 70%) in most of all brinjal producing areas of the world. The pest has been reported to inflict losses to the tune of 80 per cent (Jhala *et al.*, 2003).

Brinjal shoot and fruit borer is reported from all brinjal growing areas of the world including Germany, Burma, USA, Srilanka and India. It is known to damage shoot and fruit of brinjal in all stages of its growth. The yield loss due to the pest is to the extent of 70-92 per cent (Reddy and Srinivas, 2004). Shoot and fruit borer, *L. orbonalis* (Lepidoptera: Pyralidae) is the key pest throughout Asia (Allam *et al.*, 1982; Patial and Mehta, 2008). Fruit damage of about 70 per cent has been reported to be affected by larvae of this pest (Krishnaiah *et al.*, 1978). The yield loss due to the pest is to the extent of 70-92 % (Reddy and Srinivas, 2004).

Organic amendments which are easily available can be used as soil amendments to enhance the nutrient status and physical properties of the soil as well as for reducing the losses caused due to pests. The use of organic amendments in the pest management is considered an ecologically viable proposition which avoids environmental pollution and is economically feasible (Rajendran, 1993). Organic amendments and plant products are known to leave no toxic residues and non-phytotoxic. They have different insect controlling properties viz., antifeedant, repellent, attractant and reproduction retardant etc. (Urs, 1987; Hikal *et al.*, 2017.) and hence, chances of pest developing resistance to such substances are remote. Organic farming not only changes the host nutritional status but also reduces the pest incidence. Organic manures supply both macro and micro nutrients and build up resistance of plants to the pests.

Materials and Methods

Present investigations were carried out on eco-friendly management of brinjal shoot and fruit borer, (*Leucinodes orbonalis*) Guenee through organic manures and biopesticides at Plant Protection Laboratory and Vegetable Research and Demonstration Block, College of Horticulture, VCSG UHF Bharsar during two years 2019 and 2020. During the investigations, brinjal shoot and fruit borer, (*L. orbonalis*) was the major pest infesting the crop. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications and nine treatments. The seedlings of brinjal variety JBGR-1 was obtained from Junagarh Agriculture University to carry out the experiment. The plot size was $1.8 \times 1.35\text{m}^2$ and spacing was $60 \times 40\text{cm}$. The recommended interculture practices were undertaken as and when required.

These treatments were applied viz. Vermicompost (25, 50 and 75%), Neem cake (25, 50 and 75%) and Poultry manure (25, 50 and 75%). These treatments were applied 15 days before transplanting of brinjal crop for proper decomposition. The crop was not sprayed with any type of chemical or insecticides, but routine cultural practices and irrigation was made as and when required to grow the healthy crop. Uniform plant population was maintained in all the experimental plots. Calculation of the quantity of organic manures: The quantity of the organic manures required for the combination with recommended nitrogenous chemical fertilizer was calculated on the basis of the nitrogen requirement of the crop. The recommended dose of fertilizers for brinjal is 100: 37.5: 37.5 (NPK kg/ha). The composition of various organic manures is as under (Reddy and Reddy, 2004; Katyayan, 2006) :

S.N.	Organic manures	N kg/ha.	P kg/ha.	K kg/ha.
1.	Vermi-compost	3.00	1.00	1.50
2.	Neem cake	5.20	1.00	1.40
3.	Poultry manure	3.03	2.63	1.40

The formula to calculate the required quantity of organic manures is as follows :

$$\text{Quantity of organic manures required (kg/ha)} = \frac{100 \times \text{Quantity of Nitrogen to be given through organic manure}}{\text{Per cent Nitrogen content in the organic manures}}$$

The incidence of shoot and fruit borer, (*L. orbonalis*), five plants were randomly selected from net plot area of each plot and tagged. Observations on shoot infestation due to *L. orbonalis* was recorded from these five plants. The harvested fruits of each plot were carefully observed after each picking to ascertain fruit infestation and percentage fruit infested was worked out. The data on per cent shoot and fruit damage (Number and weight basis) was statistically analyzed after suitable transformation. The observations were recorded at weekly interval starting from the transplanting of the crop.

The formulae to calculate the percentage of shoot and fruit infestation of brinjal

$$\text{Percentage of shoot infestation} = \frac{\text{No. of damaged shoots}}{\text{Total no. of shoots}} \times 100$$

$$\text{Percentage of fruit infestation} = \frac{\text{No. of damaged Fruits}}{\text{Total no. of Fruits}} \times 100$$

$$\text{Total Yield (kg/ha)} = \frac{\text{Yield per plot}}{\text{Plot size}} \times 10000$$

Results and Discussion

Per cent shoot infestation during *rabi* season, 2019 :

The data presented in table-1 revealed the shoot infestation due to shoot and fruit borer in brinjal where the minimum shoot infestation observed 18.33% in the treatment T₇ (75% neem cake with 25% recommended dose of fertilizers). Which found statistically at par with the treatments T₉ (50% poultry manure + 50% recommended dose of fertilizers) 19.48% and treatment T₁₀ (75 % poultry manure + 25% recommended dose of fertilizers) of 19.18%. while the maximum shoot infestation observed in the treatment T₁ (Control) 30.11%. All the treatments found significant as compared with treatment T₁ (Control) except T₂ (25% vermicompost + 75% recommended dose of fertilizers) 29.21%.

Table-1 : Effect of organic manures on per cent shoot infestation during *rabi* season, 2019 and *kharif* season, 2020, their pooled effect due to brinjal shoot and fruit borer (*L. orbonalis*).

S.No.	Treatments	Per cent Shoot Infestation		
		2019	2020	Pooled Mean effect
T ₁	Control	30.11±1.21 (33.26)	30.38±0.75 (33.43)	30.25±0.14 (33.35)
T ₂	25% VC + 75% RDF	29.21±0.83 (32.70)	29.04±0.49 (32.59)	29.13±0.08 (32.65)
T ₃	50% VC + 50% RDF	25.68*±1.07 (30.42)	25.61*±0.51 (30.38)	25.64*±0.03 (30.41)
T ₄	75% VC + 25% RDF	20.57*±0.42 (26.95)	22.27*±0.69 (28.14)	21.42*±0.85 (27.55)
T ₅	25% NC + 75% RDF	27.28*±1.12 (31.46)	26.73*±0.50 (31.12)	27.00*±0.27 (31.29)
T ₆	50% NC + 50% RDF	21.22*±0.51 (27.41)	23.09*±0.79 (28.70)	22.16*±0.94 (28.06)
T ₇	75% NC + 25% RDF	18.33*±0.58 (25.33)	19.00*±0.89 (25.82)	18.66*±0.33 (25.58)
T ₈	25% PM + 75% RDF	27.67*±0.78 (31.72)	27.03*±0.58 (31.31)	27.35*±0.31 (31.52)
T ₉	50% PM + 50% RDF	19.48*±0.38 (26.18)	22.14*±0.47 (28.05)	20.81*±1.33 (27.11)
T ₁₀	75% PM + 25% RDF	19.18*±0.24 (25.96)	20.14*±0.73 (26.65)	19.67*±0.48 (26.31)
SE(d)		0.97 (0.64)	0.86 (0.57)	0.78 (0.54)
C.D.(0.05)		2.06 (1.35)	1.82 (1.22)	1.80 (1.25)

() = Parentheses are retransformed values, while outside are angular transformed values. Where, VC= Vermicompost, NC= Neem Cake, PM = Poultry Manure, RDF= Recommended dose of fertilizer.

Table-2 : Effect of organic manures on per cent fruit infestation (number basis) during *rabi* season, 2019 and *kharif* season, 2020, their pooled effect due to brinjal shoot and fruit borer.

S. No.	Treatments	Per cent fruit Infestation (number basis)		
		2019	2020	Pooled effect
T ₁	Control	20.50±0.80 (26.90)	21.57±0.63 (27.65)	21.03±0.53 (33.35)
T ₂	25%VC + 75%RDF	16.88*±0.34 (24.24)	17.07*±0.33 (24.39)	16.97*±0.09 (32.65)
T ₃	50%VC + 50%RDF	11.83*±0.23 (20.11)	11.12*±0.26 (19.46)	11.48*±0.36 (30.41)
T ₄	75%VC + 25%RDF	7.74*±0.26 (16.14)	7.07*±0.29 (15.41)	7.41*±0.33 (27.55)
T ₅	25%NC + 75%RDF	14.76*±0.38 (22.58)	14.84*±0.61 (22.64)	14.80*±0.35 (31.78)
T ₆	50%NC + 50%RDF	9.74*±0.34 (18.17)	9.10*±0.45 (17.54)	9.42*±0.32 (28.07)
T ₇	75%NC + 25%RDF	5.78*±0.82 (13.84)	6.31*±0.31 (14.53)	6.05*±0.26 (25.58)
T ₈	25%PM + 75%RDF	16.59*±0.90 (24.01)	16.18*±0.97 (23.69)	16.38*±0.20 (31.52)
T ₉	50%PM + 50%RDF	9.81*±0.13 (18.24)	10.56*±0.32 (18.95)	10.18*±0.37 (27.11)
T ₁₀	75%PM + 25%RDF	6.17*±0.31 (14.37)	6.44*±0.16 (14.69)	6.30*±0.13 (26.31)
C.V.		8.00 (4.53)	6.89 (3.48)	3.73 (2.24)
SE(d)		0.78 (0.73)	0.67 (0.56)	0.44 (0.65)
C.D.(0.05)		1.65 (1.55)	1.43 (1.19)	1.02 (1.51)

() = Parentheses are retransformed values, while outside are angular transformed values. Where, VC= Vermicompost, NC= Neem Cake, PM =Poultry Manure, RDF= Recommended dose of fertilizer.

Per cent shoot infestation during *kharif* season, 2020 :

The data had observed shoot infestation due to shoot and fruit borer in brinjal revealed that the minimum shoot infestation observed 19.00% in the treatment T₇ (75% neem cake with 25% recommended dose of fertilizers). Which found statistically at par with the treatment T₁₀ (75 % poultry manure + 25% recommended dose of fertilizers) of 20.14%. while the maximum shoot infestation observed in the treatment T₁ (Control) 30.38%. All the treatments found significant as compared with treatment T₁ (Control) except T₂ (25% vermicompost + 75% recommended dose of fertilizers) 29.04%.

Pooled effect of shoot infestation during *rabi* season, 2019 and *kharif* season, 2020 : The data pertained for shoot infestation due to shoot and fruit borer in brinjal

revealed that the minimum shoot infestation observed 18.66% in the treatment T₇ (75% neem cake with 25% recommended dose of fertilizers). Which found statistically at par with the treatment T₁₀ (75 % poultry manure + 25% recommended dose of fertilizers) of 19.66%. while the maximum shoot infestation observed in the treatment T₁ (Control) 30.25%. All the treatments found significant as compared with treatment T₁ (Control) except T₂ (25% vermicompost + 75% recommended dose of fertilizers) 29.13%. The results are more or less similar to Sudhakar *et al.* (1998), The lower dose of potash (30 kg/ha) resulted in higher shoot (14.4%) and fruit (44.3%) infestation. Krishnamoorthy *et al.* (2001) they have found organic amendments recorded higher yield compared to untreated check. Yields in FYM+ NC+BF+P+NO (6500 Kg/ha) and soil application of neem cake reduced the

Table-3 : Effect of organic manures on fruit infestation (on weight basis) during *rabi* season, 2019 and *kharif* season, 2020 and their pooled effect due to brinjal shoot and fruit borer.

S. No.	Treatments	Per cent fruit infestation (weight basis)		
		2019	2020	Pooled effect
T ₁	Control	25.80±0.10 (30.51)	26.61±0.30 (31.04)	26.21±0.4 (30.78)
T ₂	25% VC + 75% RDF	24.65±0.41 (29.75)	23.80*±0.36 (29.18)	24.22*±0.42 (29.47)
T ₃	50% VC + 50% RDF	19.22*±0.41 (25.99)	21.50*±0.38 (27.61)	20.36*±1.13 (26.80)
T ₄	75% VC + 25% RDF	17.66*±0.96 (24.82)	19.60*±0.29 (26.26)	18.63*±0.97 (25.55)
T ₅	25% NC + 75% RDF	20.72*±0.71 (27.06)	20.93*±0.48 (27.21)	20.82*±0.10 (27.14)
T ₆	50% NC + 50% RDF	19.67*±0.80 (26.30)	19.97*±0.16 (26.53)	19.82*±0.15 (26.42)
T ₇	75% NC + 25% RDF	16.50*±0.30 (23.95)	16.13*±0.57 (23.66)	16.31*±0.18 (23.81)
T ₈	25% PM + 75% RDF	21.64*±0.30 (27.71)	20.80*±0.39 (27.12)	21.22*±0.42 (27.42)
T ₉	50% PM + 50% RDF	19.00*±0.66 (25.82)	19.36*±0.99 (26.07)	19.18*±0.18 (25.96)
T ₁₀	75% PM + 50% RDF	17.03*±0.44 (24.36)	17.78*±0.38 (24.92)	17.40*±0.37 (24.64)
C.V.		4.61 (2.52)	4.09 (2.28)	3.63 (1.97)
SE(d)		0.76 (0.55)	0.69 (0.50)	0.74 (0.52)
C.D(0.05)		1.61 (1.16)	1.46 (1.06)	1.70 (1.21)

()=Parentheses are retransformed values, while outside are angular transformed values. Where, VC= Vermicompost, NC= Neem Cake, PM =Poultry Manure, RDF= Recommended dose of fertilizer.

Table-4 : Effect of organic manures on total fruit yield on plot basis during *rabi* season, 2019 and *kharif* season, 2020 and their pooled effect.

S.N.	Treatments	Total Fruit Yield (Kg/plot)		
		2019	2020	Pooled effect
1.	Control	3.80±0.08	3.69±0.02	3.74±0.05
2.	25% VC + 75% RDF	4.75*±0.07	4.67*±0.03	4.71*±0.04
3.	50% VC + 50% RDF	5.04*±0.09	4.97*±0.02	5.00*±0.03
4.	75% VC + 25% RDF	5.75*±0.17	5.51*±0.06	5.63*±0.12
5.	25% NC + 75% RDF	5.41*±0.13	5.32*±0.04	5.36*±0.04
6.	50% NC + 50% RDF	6.18*±0.12	6.05*±0.01	6.11*±0.06
7.	75% NC + 25% RDF	6.43*±0.10	6.12*±0.01	6.27*±0.15
8.	25% PM + 75% RDF	5.19*±0.11	5.09*±0.01	5.14*±0.05
9.	50% PM + 50% RDF	5.91*±0.15	5.62*±0.01	5.76*±0.14
10.	75% PM + 25% RDF	5.20*±0.09	5.10*±0.00	5.15*±0.05
SE(d)		0.06	0.04	0.14
C.D.(0.05)		0.14	0.09	0.06

()=Parentheses are retransformed values, while outside are angular transformed values. Where, VC= Vermicompost, NC= Neem Cake, PM =Poultry Manure, RDF= Recommended dose of fertilizer.

shoot and fruit borer incidence in brinjal. Similar observations were reported in brinjal by Venkatesh *et al.* (2004) and Kavitharaghavan *et al.* (2006) they have found minimum % shoot damage (4.47 %) in FYM+NC+BF.

Per cent fruit infestation (number basis) during *rabi* season, 2019 : Per cent fruit infestation on number basis due to shoot and fruit borer in brinjal revealed that the minimum shoot infestation observed 5.78% in the treatment T₇ (75% neem cake with 25% recommended dose of fertilizers). Which found statistically at par with the treatment T₁₀ (75 % poultry manure + 25% recommended dose of fertilizers) of 6.17%. while the maximum shoot infestation observed in the treatment T₁ (Control) 20.50%.

All the treatments found significant as compared with treatments T₁ (Control).

Per cent fruit infestation (number basis) during *kharif* season, 2020 : The data had observed per cent fruit infestation (number basis) due to shoot and fruit borer in brinjal revealed that the minimum shoot infestation observed 6.31% in the treatment T₇ (75% neem cake with 25% recommended dose of fertilizers). Which found statistically at par with the treatment T₄ (75% vermicompost + 25% recommended dose of fertilizers) 7.07% and T₁₀ (75 % poultry manure + 25% recommended dose of fertilizers) of 6.44%. while the maximum shoot infestation observed in the treatment T₁

Table-5 : Effect of organic manures on total fruit yield on hectare basis during *rabi* season, 2019 and *kharif* season, 2020 and their pooled effect.

S.N.	Treatments	Total Fruit Yield (Kg/ha)		
		2019	2020	Pooled effect
1.	Control	15664.67±350.16	15184.67±85.64	15424.67±240.00
2.	25% VC + 75% RDF	19561.00*±323.45	19231.33*±152.47	19396.16*±164.95
3.	50% VC + 50% RDF	20753.67*±409.02	20479.67*±117.48	20616.67*±137.00
4.	75% VC + 25% RDF	23168.33*±535.01	22702.00*±247.25	22935.16*±233.26
5.	25% NC + 75% RDF	22277.00*±536.77	21892.67*±164.71	22084.84*±192.05
6.	50% NC + 50% RDF	25445.33*±526.97	24896.67*±24.29	25171.00*±274.33
7.	75% NC + 25% RDF	26474.33*±422.44	25184.67*±47.80	25829.50*±644.83
8.	25% PM + 75% RDF	21358.67*±450.34	20946.00*±71.01	21152.34*±206.23
9.	50% PM + 50% RDF	24183.33*±629.62	23127.00*±23.67	23655.16*±528.20
10.	75% PM + 25% RDF	21439.67*±443.99	20987.00*±0.00	21213.34*±226.24
SE(d)		182.81	176.63	234.44
C.D.(0.05)		387.05	373.96	537.83

() = Parentheses are retransformed values, while outside are angular transformed values. Where, VC = Vermicompost, NC= Neem Cake, PM =Poultry Manure, RDF= Recommended dose of fertilizer.

(Control) 21.57%. All the treatments found significant as compared with treatment T₁ (Control).

Pooled effect of fruit infestation (number basis) during *rabi* season, 2019 and *kharif* season, 2020 : The data presented in table-2 where result show that fruit infestation (no. basis) due to shoot and fruit borer in brinjal recorded that the minimum shoot infestation observed 6.05% in the treatment T₇ (75% neem cake with 25% recommended dose of fertilizers). Which found statistically at par with the treatment T₁₀ (75 % poultry manure + 25% recommended dose of fertilizers) of 6.30%. while the maximum shoot infestation observed in the treatment T₁ (Control) 21.03%. All the treatments found significant as compared with treatment T₁ (Control). The present findings are in accordance with Godase and Patel (2003) recorded that the lowest incidence of fruit borer was observed in neem cake @ 1.700 Kg/ha (6.08%), Venkatesh *et al.* (2004) observed the influence of application of organic manures and neem cake was the most effective among all treatments tested (5.00%). The neem cake was effective against the fruit borer in okra reported by Tripathy *et al.* (2007) and Adilakshmi *et al.* (2008) found that the lowest fruits were damaged (7.32%) in the plots fertilized with 75% RDF from NC and remaining through inorganic fertilizers.

Per cent fruit infestation (weight basis) during *rabi* season, 2019 : The data was recorded on fruit infestation (weight basis) due to shoot and fruit borer in brinjal revealed that the minimum shoot infestation observed 16.50% in the treatment T₇ (75% neem cake with 25% recommended dose of fertilizers). Which found statistically at par with the treatment T₄ (75% vermicompost + 25% recommended dose of fertilizers) 17.66% and T₁₀ (75 % poultry manure + 25% recommended dose of fertilizers) 17.03%. while the

maximum shoot infestation observed in the treatment T₁ (Control) 25.80%. All the treatments found significant as compared with treatment T₁ (Control) except T₂ (25% vermicompost + 75% recommended dose of fertilizers) 24.65%.

Per cent fruit infestation (weight basis) during *kharif* season, 2020 : The data had observed on fruit infestation (weight basis) due to shoot and fruit borer in brinjal revealed that the minimum shoot infestation observed 16.13% in the treatment T₇ (75% neem cake with 25% recommended dose of fertilizers). Followed by T₁₀ (75 % poultry manure + 25% recommended dose of fertilizers) 17.78%. While the maximum shoot infestation observed in the treatment T₁ (Control) 26.61%. All the treatments found significant as compared with treatment T₁ (Control).

Pooled effect of fruit infestation (weight basis) during *rabi* season, 2019 and *kharif* season, 2020 : The data pertained on fruit infestation (weight basis) due to shoot and fruit borer in brinjal revealed that the minimum shoot infestation observed 16.31% in the treatment T₇ (75% neem cake with 25% recommended dose of fertilizers). Which found statistically at par with the treatment T₁₀ (75 % poultry manure + 25% recommended dose of fertilizers) of 17.40%. while the maximum shoot infestation observed in the treatment T₁ (Control) 26.21%. All the treatments found significant as compared with treatment T₁ (Control). These findings are similar to the neem cake against the shoot and fruit borer in brinjal is also reported by Krishnamoorthy *et al.* (2001) tested soil application of neem cake 250 Kg/ha reduced the borer incidence 13.21% as compared to 33.23% in untreated check. Godase and Patel (2003) recorded that the lowest incidence of fruit borer was observed in neem cake @ 1.700 Kg/ha (6.08%), Singh (2003), Venkatesh *et al.* (2004) found that the influence of application of five

organic manures and neem cake was the most effective among all treatments tested (9.79%)

Effect of organic manures on total fruit yield per plot basis during *rabi* season, year 2019 : The data revealed that the maximum yield of healthy brinjal fruits (6.43 kg/plot) observed in the treatment T₇ (75% neem cake + 25% recommended dose of fertilizers). Which is followed by the T₆ (50% neem cake + 50% recommended dose of fertilizers) (6.18 kg/plot) where the minimum yield (3.80 kg/plot) observed in the treatment T₁ (Control). All the treatments found significant as compared with control (T₁).

Effect of organic manures on total fruit yield per plot basis during *kharif* season, year 2020.

The data had observed maximum yield of healthy brinjal fruits (6.12 kg/plot) observed in the treatment T₇ (75% neem cake + 25% recommended dose of fertilizers). Which is statistically at par with T₆ (50% neem cake + 50% recommended dose of fertilizers) (6.05 kg/plot) where the minimum yield (3.69 kg/plot) observed in the treatment T₁ (Control). All the treatments found significant as compared with control (T₁).

Pooled effect of organic manures on total fruit yield per plot basis during year *rabi* season, 2019 and *kharif* season, 2020 : The data presented in (Table-4) revealed that the maximum yield of healthy brinjal fruits (6.27 kg/plot) observed in the treatment T₇ (75% neem cake + 25% recommended dose of fertilizers). Which is followed by T₆ (50% neem cake + 50% recommended dose of fertilizers) (6.11 kg/plot) where the minimum yield (3.74 kg/ha) observed in the treatment T₁ (Control). All the treatments found significant as compared with control (T₁).

Effect of organic manures on total fruit yield hectare basis during *rabi* season, year 2019 : The data revealed that the maximum yield of healthy brinjal fruits (26474.33 kg/ha) observed in the treatment T₇ (75% neem cake + 25% recommended dose of fertilizers). Which is followed by the T₆ (50% neem cake + 50% recommended dose of fertilizers) (25445.33 kg/ha) where the minimum yield (15664.67 kg/ha.) observed in the treatment T₁ (Control). All the treatments found significant as compared with control (T₁).

Effect of organic manures on total fruit yield hectare basis during *kharif* season, year 2020 : The data had observed maximum yield of healthy brinjal fruits (25184.67 kg/ha) observed in the treatment T₇ (75% neem cake + 25% recommended dose of fertilizers). Which statistically at par with T₆ (50% neem cake + 50% recommended dose of fertilizers) (24896.67 kg/ha) where the minimum yield (15184.67 kg/ha) observed in the treatment T₁ (Control). All the treatments found significant as compared with control (T₁).

Pooled effect of organic manures on total fruit yield hectare basis during year *rabi* season, 2019 and *kharif* season, 2020 :

The data presented in table-5 revealed that the maximum yield of healthy brinjal fruits (25829.50 kg/ha) observed in the treatment T₇ (75% neem cake + 25% recommended dose of fertilizers). Which is followed by T₆ (50% neem cake + 50% recommended dose of fertilizers) (25171.00 kg/ha) where the minimum yield (15424.67 kg/ha) observed in the treatment T₁ (Control). All the treatments found significant as compared with control (T₁). Chakraborti (1999) recorded that effect of organic manures reduced shoot and fruit infestation and increased the brinjal yield (28224.33 Kg/ha). Similar results were reported by Singh (2003), Venkatesh *et al.* (2004), Perumala and Vatsala (2005) and Suresh *et al.* (2007) recorded the per cent damage of shoot and fruit borer was less in the FYM (12.5 t/ha) + BF (2 Kg/ha) + neem cake (800 Kg/ha). Raj and Kumari, (2001) organic manures found the effective in the crop yield in okra FYM + neem cake giving the highest yield (158.48 q/ha). Mandal *et al.*, 2006 observed in the highest marketable okra fruit yield (123.14 q/ha). Tripathy *et al.*, 2007 recorded the highest yield of okra (10.39 t/ha).

Conclusions

Minimum brinjal fruit and shoot infestation (18.66%) due to fruit and shoot borer (*Leucinodes orbonalis*) was recorded in the treatment where maximum nitrogen requirement 75% was supplied through neem cake combined with remaining 25 % through chemical fertilizers. The fruit infestation in brinjal due to *L. orbonalis* on number basis was significantly minimum (6.05%) in the treatment where maximum nitrogen requirement 75% was supplied through neem cake combined with remaining 25 % through chemical fertilizers. The minimum per cent fruit infestation on weight basis *i.e.* (16.31%) due to *L. orbonalis* was recorded in the treatment where maximum nitrogen requirement 75% was supplied through neem cake combined with remaining 25 % through chemical fertilizers. The maximum yield of healthy brinjal fruits (6.27 kg/plot) and (25829.50 kg/ha) basis was recorded in the treatment where 75 % of the recommended dose of nitrogen was provided through neem cake and 25 % through chemical fertilizers.

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An Overview of Nutraceuticals and High Anthocyanin Containing Purple Tomato

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Abstract

In vegetable and fruit crops, numerous nutrients, pigments, secondary metabolites, and other elements are found, which are essential and helpful for human health. Due to their better nutritional qualities, consumption of coloured fruits and vegetables has substantially increased recently using conventional breeding and contemporary transgenic techniques. More precisely, purple tomatoes are currently becoming more significant due to their high anthocyanin content and nutraceutical value. More so, due to the excess amount of pigment, it has anti-inflammatory, anti-microbial, anti-cancerous, cardio-protective, hepato-protective, and neuro protective effects. Similarly, the regular consumption of purple tomatoes has also been discovered to help prevent several chronic human ailments. Purple tomatoes now have improved storability and a longer shelf life due to higher anthocyanin content. The availability and acceptance of purple tomatoes in India will eventually benefit farmers, the food industry, and public health.

Key words : Purple tomato, anthocyanins, shelf lives.

Introduction

Tomato (*Solanum lycopersicum*) is native to western South America and Central America. It was domesticated in Mexico and is believed to have been first cultivated by the Aztecs. It is diploid organisms with 24 chromosomes. They belong to the Solanaceae family, which also includes other economically important crops such as potatoes, peppers, and eggplants. There are thousands of tomato cultivars, which have been bred for various traits such as size, color, flavor, disease resistance, and shelf life.

Tomatoes are one of the most widely cultivated vegetables in the world, with a total production of over 182 million tonnes in 2020. The top tomato-producing countries in the world are China, India, the United States, Turkey, and Egypt. Tomatoes are grown in both open fields and greenhouses, with greenhouse production becoming increasingly popular due to its ability to provide year-round production and higher yields. The average yield of tomatoes in the world is around 40 tonnes per hectare, but this varies widely depending on the region and the cultivation practices. The highest yields are seen in greenhouse production systems, where yields can reach up to 100 tonnes per hectare. The highest-yielding countries for tomatoes are the Netherlands, Belgium, and Israel, where greenhouse production is highly advanced. India is the second-largest producer of tomatoes in the world, with a production of over 20 million tonnes in 2020. Tomatoes are grown in almost all states in India, with the major producing states being Maharashtra, Karnataka, Andhra Pradesh, Gujarat, and Madhya Pradesh. The

productivity of tomato in India varies widely depending on the region and the cultivation practices. However, on average, the yield of tomato in India is around 20 tonnes per hectare.

The term “purple tomato” refers to tomato fruits that include anthocyanin colouring. Purple tomatoes have recently drawn a lot of curiosity and attention. As was already mentioned, the anthocyanin pigments in purple tomatoes not only serve to protect the tomato fruit but also serve as a dietary component with numerous positive impacts on human health. Researchers from all over the world are working hard to increase the anthocyanin content of tomato fruits. A different anthocyanin rich fruits and vegetables of the solanaceous family include eggplant, pepper and potato.

A purple tomato is a variety of tomato that has a dark purple or blackish skin. These tomatoes are typically smaller than regular tomatoes and are often used for their unique color and flavor in salads, sandwiches, and other dishes. Purple tomatoes are not genetically modified; rather, they are the result of cross-breeding between different tomato varieties. The purple color comes from a pigment called anthocyanin, which is also found in blueberries, blackberries, and other dark-colored fruits and vegetables. Some studies suggest that purple tomatoes may have higher levels of antioxidants than regular tomatoes, which may offer health benefits such as reducing inflammation and protecting against certain diseases. However, more research is needed to confirm these potential benefits.

Tomatoes are a good source of vitamin C, potassium, and folate. They also contain small amounts of other vitamins and minerals such as vitamin K, vitamin A, iron, and calcium. It's worth noting that the nutritional content of tomatoes can vary depending on factors such as variety, ripeness, and growing conditions. Additionally, cooking and processing can affect the nutritional content of tomatoes. Overall, however, tomatoes are a healthy and delicious addition to any diet.

Tomatoes have several biochemical properties that make them an important and nutritious food like Rich in antioxidants: Tomatoes are rich in antioxidants such as vitamin C, carotenoids, and flavonoids, which help protect the body against cellular damage caused by free radicals. It contains lycopene: Lycopene is a carotenoid that gives tomatoes their red color . It is a potent antioxidant that has been linked to a reduced risk of certain cancers and cardiovascular disease. Source of vitamins and minerals: Tomatoes are a good source of several vitamins and minerals, including vitamin C, potassium, folate, and vitamin K. High water content: Tomatoes are composed mainly of water, which makes them a hydrating food that can help maintain the body's fluid balance. Low in calories: Tomatoes are low in calories and high in fiber, making them a good food choice for weight management. Overall, the biochemical properties of tomatoes make them an important and nutritious food that can provide several health benefits when consumed as part of a balanced diet.

Purple tomatoes can be developed using traditional breeding methods, which involve cross-pollinating two different tomato varieties with desirable traits, such as size, flavor, and color . To create a purple tomato, breeders would typically start by selecting a variety of tomato that has high levels of anthocyanin, the pigment that gives the tomato its purple color. They would then cross this variety with another tomato variety that has desirable traits such as disease resistance, high yield, or good flavor. The resulting offspring would then be screened for desirable traits, including color, size, and taste, and those with the most desirable traits would be selected for further breeding. Over several generations, breeders would continue to cross-breed these selected offspring with each other and with other varieties until they develop a stable line of purple tomatoes with consistent characteristics. This process can take several years and requires careful selection and testing of the offspring. However, traditional breeding methods can be effective in developing new varieties of tomatoes with unique traits, such as the purple tomato, without the need for genetic modification.

Purple tomatoes can also be developed through

genetic modification, which involves inserting or deleting specific genes in the tomato's DNA to create a desired trait. In the case of purple tomatoes, scientists may insert genes that promote the production of anthocyanin, the pigment responsible for the tomato's purple color . One approach to genetic modification is to use a technique called "gene editing," which involves making targeted changes to specific genes in the tomato's DNA using tools such as CRISPR-Cas9 . This technique allows scientists to precisely modify the tomato's DNA without introducing genes from other organisms. Another approach is to use genetic engineering to introduce genes from other plants or organisms that promote the production of anthocyanin. For example, scientists may insert a gene from a purple cauliflower or grape into the tomato's DNA to promote the production of anthocyanin. It's worth noting that genetically modified (GM) foods are controversial and are subject to regulatory oversight in many countries. While some people believe that GM foods can offer benefits such as increased yield, disease resistance, and nutritional content, others are concerned about the potential risks and unintended consequences of genetic modification . As such, the use of genetic modification in developing purple tomatoes is still a topic of debate and research.

It's interesting to note that wild genotypes of tomato fruits with a deep purple colour and a high anthocyanin content exist. *Solanum chilense*, *Solanum peruvianum* and *Solanum lycopersicoides* are examples of wild tomato species that naturally contain anthocyanins in their fruit. These species grow green tomatoes, but when exposed to favourable lighting conditions, they develop anthocyanins in the peel. The biofortification of tomato fruit with anthocyanins has already been attempted on several occasions, although with varying degrees of success. The flavonoid content of tomato fruits can be increased by overexpressing flavonoid biosynthetic genes. When this was tried, the number of flavonoids increased just slightly and the manufacture of anthocyanins in tomato fruits was not even started. Later both conventional and transgenic methods were used to generate the purple colour in tomato fruits.

Due to enhanced pigment levels demonstrating antioxidative and nutritional benefits, coloured fruits and vegetables have recently become extremely important. The UN General Assembly declared 2021 to be an "International Year of Fruits and Vegetables (IYFV)" due to its nutritional value and significant impact on humanity in terms of ensuring food and nutritional security. Also, the recent increase in fruit and vegetable intake shows that people are including them in their diets, whether they are consumed raw, processed or with added value . The benefits of coloured fruits and vegetables extend beyond

their nutritional value for humans; pigments also play a role in controlling fruit and vegetable ripening and senescence. Because the ripening and senescence of fruit are said to be accompanied by an increase in the level of oxidative stress (rapid increase in reactive oxygen species), this aspect becomes more crucial for fruits like tomatoes. The significance of the aforementioned can also be understood because excessive postharvest losses for tomatoes (reaching up to 25 to 40% or even more) are caused by the rapid rate of tomato fruit ripening and decay due to pathogens as well as a lack of proper logistical and ideal conditions of postharvest storage. All this stresses an increase in the quantities of various pigments in fruits and vegetables that have potent antioxidant effects. As a result, tomatoes and other fruits and vegetables will have a longer shelf life and be easier to store, as well as higher nutrition and health benefits for people leading to an improvement in postharvest management. Thus, scientists are currently concentrating on numerous strategies to raise the amounts of various health-promoting chemicals in widely consumed fruits and vegetables. Anthocyanins, which give tomatoes their purple or purplish colour, have received a lot of attention lately because they are missing from conventional tomato types. There are two strategies to include and enhance the anthocyanin content of tomato fruit: traditional breeding and contemporary transgenic techniques. This article aims to give readers an update on conventional tomatoes and anthocyanin-rich purple tomatoes, as well as information on the advantages of anthocyanins in food and plants, development strategies for purple tomatoes, improved postharvest storage for purple tomatoes, purple tomatoes in India, and the benefits of purple tomatoes for overall health extra antioxidants along with other nutrition/nutraceuticals in the human diet.

Research on purple tomatoes has been conducted in India, primarily focused on developing new varieties of tomatoes with enhanced nutritional content and disease resistance. Here are some examples of research on purple tomatoes in India; Scientists at the Indian Institute of Horticultural Research (IIHR) in Bangalore have developed several hybrid varieties of purple tomatoes using traditional breeding methods. These hybrids have high levels of antioxidants, including anthocyanin, and have shown promising results in terms of disease resistance and yield. More so, study on the antioxidant properties of purple tomatoes. Researchers at the Indian Institute of Technology (IIT) in Delhi have conducted a study on the antioxidant properties of purple tomatoes. The study found that purple tomatoes had higher levels of antioxidants than regular tomatoes, and that they could potentially be used to develop functional foods with health benefits. Similarly, development of tomato-based

functional foods: Researchers at the National Institute of Nutrition (NIN) in Hyderabad have developed several functional foods using tomatoes, including a tomato juice enriched with anthocyanin-rich purple tomatoes. These functional foods have potential health benefits, such as reducing oxidative stress and inflammation.

Significance of anthocyanin-rich purple tomato

The tomato fruit is one of the most significant vegetables consumed either raw or cooked worldwide. The obvious red colour of tomatoes is well-known. The buildup of the carotenoid pigment lycopene in the tomato fruit's flesh and peel is what gives it its red color.

The fruit of the tomato is an abundant source of energy, carotenoids (lycopene, beta-carotene, and xanthophylls), flavonoids, phenolics, minerals, vitamin C, vitamin E, dietary fibers and other phytochemicals that are beneficial to human health. Tomato fruits are favored and well-liked dietary and culinary ingredients all over the world since they are low in calories, fat and cholesterol while also being rich in vitamin A. The need for tomato fruits in the daily diet of the population, especially in poor and developing countries is further highlighted by their numerous health benefits. In this way, tomatoes are unique and interesting due to their nutritive and qualitative potentials as well as the fact that most people consume them as part of their regular diet. The genes responsible for producing the colour anthocyanins are present in the tomato genome, however, most commercial tomato varieties do not normally express these genes. Traditional red tomatoes lack anthocyanin colours because anthocyanin production is turned off in these plants. The leaves and stems of the tomato plant appear to be the only parts of the plant where anthocyanins are found. The red colour of the fruit along with appropriate flavour, texture and other quality-related values was chosen based on consumer choice during the domestication of the tomato crop and later over time. Hence, ordinary, and typically farmed tomatoes do not include anthocyanin pigment despite having a great deal of genetic variation in their colour and their pigments. Instead, they contain lycopene along with other carotenoids in addition to flavonoids and other phenolic substances.

The constructive implication of Fruit on human health

Secondary metabolites known as anthocyanins are formed in various plant sections. These compounds are glycosylated, polyhydroxy or polymethoxy molecules made up of two aromatic rings joined to a benzene ring by a C3 bridge. Anthocyanins are a subclass of flavonoids that are naturally occurring plant pigments that give flowers, leaves, fruits and some vegetables their red, blue, and

purple hues. These are water-soluble plant pigments that can be produced in response to environmental stimuli. They are kept in vacuoles where the acidic environment helps them to stay stable. They play a significant role in luring pollinators and seed dissemination agents. Particularly in response to biotic and abiotic stressors, their function in plants as antioxidants (being scavengers of reactive oxygen species) is well documented. They also have photoprotective properties against UV-B radiation.

Anthocyanins are antioxidants that have numerous health benefits for people in addition to protecting plants from environmental stress. Anthocyanins are becoming more common in foods and dietary supplements due to a growing body of research supporting their benefits as antioxidants, free radical scavengers, anti-inflammatory agents, anti-viral defences, anti-cancer agents and treatments for diseases like diabetes and obesity.

Various approaches for improvement of purple tomato

Traditional method of breeding : In the past, numerous interfertile wild species were crossed with *Solanum lycopersicum* to produce unique genetic combinations. The genotypes of atrovioleacea (atv) and anthocyanin fruit (Aft) that were homozygous for both alleles showed the greatest stability. Certain cultivated tomato species have been able to incorporate anthocyanin pigments as a result of interspecific crosses involving wild-type and conventional tomato species. By breeding programmes, the tomato accessions Aft, atv, and Abg (Aubergine), which can accumulate anthocyanins, have been developed. *Solanum lycopersicum* and *Solanum chilense* (wild-type) were crossed to produce the Aft, which produced fruits with anthocyanins visible as spots on the fruit's peel. Similar to Abgas, *Solanum lycopersicoides* has fruits with purple-coloured peels when it was crossed with the wild type. Fruits produced by a cross with *Solanum cheesemani* exhibited an accumulation of anthocyanins in both fruit and vegetative tissues.



Fig.-1 : Fruit of purple tomato variety Indigo Rose.

Breeders have added to the aforementioned aceAft/Aft atv/atv and Abg/- atv/atv progenies were produced by the crosses of Aft and atv, respectively. The fruit's skin contained more anthocyanins in both lines. Strong purple coloration was brought about by the activation of anthocyanin production genes in these lines, especially in the Aft/Aft atv/atv line. The two main anthocyanins (>75%) in these fruits were petanin and malvidin3-(4"-trans-p-coumaroyl)-Rut-5-Glc. The first conventionally bred purple tomato variety (Fig.-1) was called "Indigo Rose," and it was made available for planting in 2012.

Under various brand names, the Aft/Aft atv/atv lines have been marketed as non-genetically engineered foods." Sun black" is an Aft/Aft atv/atv derived line from the cross of Aft (accession number LA 1996) and atv (LA 0797) and it was also biochemically described. When purple-line fruits were compared to wild-type fruits, it was discovered that purple-line fruits had anthocyanins (1 mg/g dry weight), primarily petanin (56.6%) and negretein (21.4%), but wild-type fruits lacked any anthocyanins at all. In addition, purple fruits showed greater concentrations of total phenolics and total flavonoids, particularly rutin and chlorogenic acid. The number of total carotenoids was essentially identical, but purple fruits had larger proportions of lutein and carotene than wild-type fruits did. The amount of the lycopene pigment had changed significantly as well, being lower in purple tomato fruits. However, the ascorbic acid (vitamin C) level was higher than it was in fruits of the wild type, most likely because polyphenols did a better job of protecting vitamin C from oxidation. Overall, the biochemical profile showed that purple tomato fruits had improved nutritional status.

Transgenic approach : The first genetically modified tomato was created in 2008 by overexpressing the Delila and Rosea1 transcription factor genes under a fruit-specific E8 promoter in the Micro-Tom cultivar. This resulted in a fully developed Del/Ros1 purple tomato line. The anthocyanin content of these genetically modified tomato fruits is substantially higher, giving the fruit's peel and flesh a deep purple colour (Fig.-2). Later, a new tomato line called "Indigo" was created by crossing Del/Ros1 with a tomato line that was overexpressing the Arabidopsis thalianaMYB12 gene, a transcription factor (to activate the upstream reactions from primary metabolism to flavonoid biosynthesis). This tomato line had anthocyanin levels that were nearly twice as high. Phenylpropanoids such as chlorogenic acids, flavonoid and anthocyanins were expressed more strongly in this line. There was also produced a tomato variety known as the "Bronze tomato" expressed stilbene synthase from grapes with increased levels of polyphenols like flavonoid, anthocyanins and stilbene. Due to safety concerns, none

of the genetically modified purple tomato lines has been commercialised to date.

Overall, the expression of genes that govern the production of anthocyanins has been altered in both naturally bred varieties/lines and engineered varieties/lines. Traditional tomato cultivars have anthocyanins in the fruit's peel, but engineered lines have the pigment in both the fruit's flesh and its peel. New tomato varieties and lines that are high in anthocyanins have been created using both methods. Black Beauty, Blue Bayou, Blue Chocolate, Blue Gold, Dancing with Smurfs, Dark Galaxy, Fahrenheit Blues, Helsing Junction Blues, Indigo Blue Berries, Indigo Rose, Indigo Ruby, Sun Black and Purple Bumblebee are a few of the well-known purple tomato types and lines.

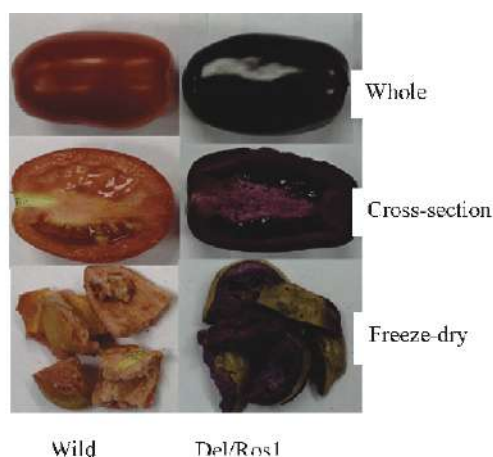


Fig.-2 : Whole, cross-section and freeze-drying of the ripe wild-type (left column) vs. the transgenic Del/Ros1 tomato fruit (right column).

Maligeppagol *et al.*, (2013) produced the transgenic purple tomato by transferring the transcription factors Ros1 and Del to the commercial cultivar Arka Vikas at the ICAR- Indian Institute of Horticultural Research (IIHR), Bangalore in the Indian state of Karnataka. The flesh and peel of the altered tomato fruits tended to accumulate significant quantities of anthocyanins, giving the fruits phenotypically dark chocolate to purple colour while remaining otherwise comparable to the wild-type. Also, it was discovered that these transgenic fruits had increased levels of chalcone isomerase (CHI) and flavonoid 3-hydroxylase (F3H) gene expression compared to wild-type fruits, which led to improved anthocyanin production. Later, created nine novel breeding lines of purple tomatoes at Bidhan Chandra Krishi Viswavidyalaya in Mohanpur, West Bengal, by conventionally breeding two specific genes—lycopene-enhancing “dg” present on chromosome 1 of the genotype BCT-115 and anthocyanin fruit gene “Aft” present on chromosome 10 of the genotype Alisa Craig.

Compared to traditional tomatoes, purple tomato fruits have higher nutraceutical value because they combine the health advantages of anthocyanins with those of other commonly used phytochemicals, particularly carotenoids. Because of this, purple tomato fruits have greater antioxidant capacity than tomato fruits without anthocyanin. In addition to their neuroprotective properties and capacity to lower the incidences of cardiovascular, metabolic and other degenerative or chronic diseases to have anti-inflammatory, anti-carcinogenic, antimicrobial and anti-obesity effects. The Del/Ros1 purple tomato line has anthocyanins that are comparable to those in blackberries and have anti-cancer properties. The tomato fruit from the transgenic “Bronze tomato” line, which contains more polyphenols including flavonoid, anthocyanins and stilbene, has also been claimed to have anti-inflammatory qualities (Scarano *et al.*, 2018). The primary factor underlying the aforementioned protective effects is the great antioxidant capacity of purple tomato fruits.

Storability and shelf life of purple tomatoes

Over the past few decades, efforts to increase the shelf-life of tomato fruits have advanced, and improvements have been made in terms of management through the regulation of storage temperature and air conditions in addition to breeding varieties with longer shelf lives.

The storability and shelf life of purple tomatoes are like those of other tomato varieties. Tomatoes are a perishable product, and their shelf life is affected by several factors, including temperature, humidity, and handling practices. For optimal storage, purple tomatoes should be kept in a cool, dry place, away from direct sunlight. Temperatures between 55-60°F (12-15°C) are considered ideal for tomato storage. At higher temperatures, the tomatoes may ripen and spoil faster. Humidity is also an important factor in tomato storage. Tomatoes should be stored in a dry environment to prevent the growth of mold and bacteria. Excessive humidity can also cause the tomatoes to soften and spoil more quickly. Proper handling practices can also help extend the shelf life of purple tomatoes. Tomatoes should be handled gently to prevent bruising and damage, which can lead to spoilage. It's also important to inspect the tomatoes regularly and remove any damaged or spoiled fruit to prevent the spread of mold and bacteria. In general, the shelf life of tomatoes varies depending on the variety, ripeness at the time of purchase, and storage conditions. However, properly stored and handled purple tomatoes can have a shelf life of up to two weeks.

The most popular and traditional method is to store fruits after they are harvested at the green mature or

breaker stage and let them ripen on their own. Cell wall enzymes and some metabolites have been targeted at the cellular level to extend the shelf life of tomato fruits. The enrichment of anthocyanins has shown encouraging effects in improving antioxidant capability while extending the shelf life of tomato fruits. This has been noted regarding transgenic Del/Ros1 tomatoes. In comparison to the wild-type, this line demonstrated a nearly two-fold increase in shelf life. Furthermore, postharvest diseases including *Botrytis cinerea* were discovered to be resistant to these tomatoes. The expression of genes like galactosidase and polygalacturonase, which are involved in the breakdown of cell walls, is lower in purple tomato fruits than it is in red tomato fruits. Due to the presence of anthocyanins and other bioactive substances, purple tomato fruits have a higher antioxidant capacity, which helps to successfully reduce oxidative damage throughout the ripening process. All of this contributes significantly to the purple tomato fruits' increased storability and shelf life.

A buildup of anthocyanins in the peel of tomato fruits of the Aft/Aft atv/atv line causes a delay in ripening as well as superior protection against postharvest infections. *Botrytis cinerea* resistance was also present in these fruits. When the fruits of the Aft/Aft atv/atv line were stored at a moderately low temperature (12°C), under suitable lighting conditions at the breaker stage, then the fruits showed an enhanced level of anthocyanins. This was done without affecting any other quality parameters, such as the carotenoid content, pH, titratable acidity, and total soluble solids. Research on the anthocyanin biosynthesis gene expression pattern during postharvest storage revealed that both structural and biosynthetic gene expression increased up to three weeks of storage under controlled storage settings. In contrast to red tomato fruits, there have also been reports of hormonal regulatory changes in purple tomato fruits. The overall delay in the process and development of ripening causes the climacteric peak of ethylene in purple tomato fruits to shift from the customary turning stage to the red stage.

It is already well established that traditional red tomatoes provide therapeutic and nutraceutical benefits. Traditional or genetic enhancements that further increase the anthocyanin content of conventional (red-coloured) tomatoes have changed not only their colour to purple but also their texture and other value-added qualities like nutritional value, firmness, flavour, resistance to tensile strength and susceptibility to various diseases. Due to all of this, purple tomato fruits now have a longer shelf life than traditional red tomato fruits (Gonzali and Perata 2020).

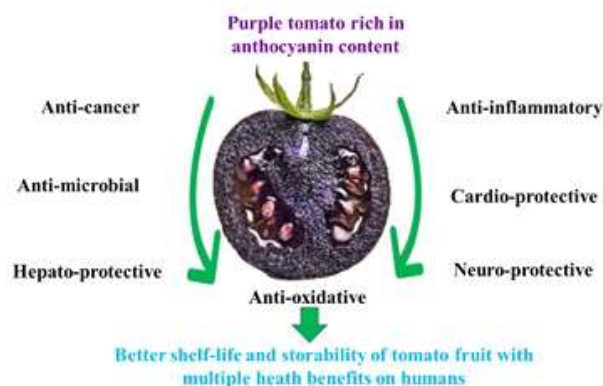


Fig.-3 : Benefits of anthocyanin-rich purple tomato fruits.

Conclusion and Future Perspectives

In conclusion, purple tomatoes are a unique and promising food crop that has gained attention for their high anthocyanin content and potential health benefits. The development of purple tomatoes through traditional breeding methods and genetic modification has shown promise in improving their nutritional content, disease resistance, and other desirable traits. Furthermore, research on the potential health benefits of purple tomatoes, such as reducing oxidative stress and inflammation, has also shown promising results.

In the future, further research on purple tomatoes could focus on improving their flavor and texture, as well as developing new varieties with higher levels of anthocyanin and other beneficial compounds. Additionally, more studies could be conducted to investigate the potential health benefits of purple tomatoes and their use in functional foods. Moreover, the commercialization of purple tomatoes could offer several benefits, such as diversifying the tomato market and providing a new source of income for farmers. However, the widespread adoption of purple tomatoes would require overcoming several challenges, including regulatory hurdles, consumer acceptance, and market demand.

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Assessment of Consumers Perception towards Street Food in Ranchi City of Jharkhand

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Abstract

Food sold on the streets is an integral part of a country's cuisine. These foods are highly demanded both by the sellers and consumers because of their tastes, easy availability, low cost, cultural & social heritage connection and being nutritional etc. Thus, the descriptive study aims to examine consumer's perception towards street food in Ranchi city, the capital of Jharkhand. Quantitative method was used for this study and 126 questionnaires were purposively distributed to the consumers of selected street food vendors. The data was analyzed using frequency and percentage and it was found that consumers perceive street food positively in the area of calories and energy, habitual consumption, attractiveness, social norms, public interest, parent's time & cost consideration and health consciousness. The results will be useful for people who are already in the street food business as well as for those who intend to embark on this business.

Key words : *Street food, consumer's perception, perceived value, Ranchi city.*

Introduction

The street food industry has an important role in the cities and towns of many developing countries in meeting the food demand of the urban dwellers. It feeds millions of people daily with a wide variety of foods that are relatively cheap and easily accessible. Consumer behaviors and informal economic activity within the urban lower middle-class demographics in urban areas are closely related. Street vendors tend to offer innovative product in major emerging markets, targeting consumers falling in the middle-class segment. The changes taking place in people's life styles have caused the habit of eating outside to evolve. Because the consumers do not have time for cooking at home, the changes in consumption habits of the society, cultural interactions, fast living and the contribution of women to work life are influencing and changing the nutrition style in crowded cities. In today's world, people prefer to buy food sold on the streets to meet their nutrition needs outside home.

Street foods are being prepared and sold at places with high traffic such as schools, parks, gardens, markets, avenues, office buildings, tourist areas, train stations, bus terminals, entertainment and festival areas where people are crowded. It allows vendors to implement a unique menu while using simplified techniques for preparing meals and provides an alternative to homemade food. Calloni (2013) have identified features of street food, including practicality, saving time in the preparation of dishes, convenience, seasonality, lack of restrictions and low costs of entering the market, as well as relatively low meal prices for consumers. Moreover, they are quick alternatives to restaurants, even during late hours after other food establishments are closed. Street food usually

represents local culture and traditions and the menu is distinguished in each country by its regional specificity. In the whole world cuisine culture, production and selling of street food has becoming a part of social life. As the people in developing countries spend an important amount of their budget for eating outside, street food has become an alternative eating trend (FAO, 2011; Badrie *et al.*, 2013). It has been historically popular especially in cities of third world and developing countries, for low and middle wage-earning classes of people (Tinker, 1999). This form of gastronomy, has been popular in countries for a long time. Because the consumers do not have time for cooking at home, the changes in consumption habits of the society, cultural interactions, fast living and the contribution of women to work life are influencing and changing the nutrition style in crowded cities. In today's world, people prefer to buy food sold on the streets to meet their nutrition needs outside the home (Steyn *et al.*, 2011).

Materials and Methods

A descriptive cross-sectional study was used for the acquisition of data. The study was conducted in the selected areas which are target street foods hub of Ranchi city. 126 consumers were selected purposively from different areas of Ranchi city to investigate the data. The results from the study (quantitative data) were analyzed using descriptive statistics such as frequencies and percentages. Self-administered questionnaire was used to collect the data for this study.

Population and Sample Size : The people living around Ranchi city were the population for this study whereas the consumers who eat out as the sample. As per provisional reports of Census India (2011), the population of Ranchi

city is around 1,073,427. Based on the population, the chosen number of sample size is determined. Hence, the sample size of this study was around 126.

Data Collection : The study targeted consumers in Ranchi city, Jharkhand who purchased street food before. Convenience sampling was adapted to collect data through self-administered questionnaire. Data collection took about a month time.

Data Analysis : Data was analyzed using MS- Excel to formulate graphs and table from the responses of participants. Frequency and percentage on respondents' perception, profile and demographics were tabulated and analyzed.

Results and Discussion

Street foods were found to be concentrated in areas where there were a lot of social activities such as road functions, motor parks, around universities, around churches, temples, gurudwara and mosques, shopping centers, markets and public buildings such as banks, courts etc. In fact, this activity offers to urban populations' ready-to-eat food with the popular taste at an acceptable cost, likewise the lack of adequate urban transportation and time, prevents many workers, students, school children, to go home for meals. Due to lack of effective system of catering such as canteens on the workplace, they buy street food at cheap price compared to what they would pay for a restaurant meal or even at home. Among all age groups, adolescents and young adults are found to be relatively more interested in street food consumption. The frequent consumption of street foods among people of all religion in their teens and in their twenties might be attributed to the specific qualities of such types of foods that are fast to prepare, convenient, and relatively inexpensive. In addition, during the transition from primary school to secondary school, high-school health adolescents become relatively more independent and have easy access to unhealthy dietary choices. The dietary habits of children, adolescents, and the youth are of significant importance because the dietary behaviors are likely to remain stable for their entire life span. Therefore, it seems necessary to study both the positive and the negative views of different consumers on street food consumption to determine its impact on people's life and consequently to establish effective policies and plans.

Gender of respondents : According to their gender, out of 126 consumers, 89 (71%) were male and 37 (29%) were female consumers.

Age of respondents : Up to 84 % of the consumers were between 15 to 40 years old with very few below 15 years and above 40 years (Figure-1). It was observed that majority (38.09 %) of the respondents were in the age

group of 15 - 20 years, about 27 % of them were in the age group of 20 - 25 years. It was evident that 13 consumers were fall 'under 15' category. About 9 % of the respondents were in the age group of 25-30 years. Only 18 respondents were belonging to the age group of 30-35 years (4.76 %). The percentage of consumers between 35-40 years (3.97%), 40-45 years (2.38%), 45-50 years (2.38%) and 50-55 years (0.79%) respectively, whereas, no one was found in the age group of above 55 years.

Religion of respondents : Again, it reveals from the figure-2 that most of the consumers were Hindu followed by Sarna (15.08%), Christian (14.28 %), Muslims (11.90 %) and Sikh (8.73%) religion respectively.

Distribution of respondents : Figure-3 illustrates the percent distribution of street food consumers according to their profession that most of the respondents were college students (70%) followed by school students (24%), private job holder (13%), unemployed person (8%), homemakers (6%), government job holders (3%), and labour (2%) respectively. Street foods provide variety to different ethnic groups and thus improve their popularity. The popularity of street foods could be attributed to the availability near the places they are consumed such as factories, schools and universities, transit points and market places. Street food is consumed in many countries as food, drinks, and snacks which reflect traditional cuisine culture in countries together with their content, preparation, sales methods, and consumption ways (Campbell, 2011).

Opinion of respondents : Further, it is revealed from figure 4 that, in case of full of calories and energy, majority of respondents (51.59%) were marked unsuitable for physically active person subcategory. However, around 48 % respondents answered in 'energetic.' Though convenient, time-saving and economical street food is perceived as a less healthy food choice. Many consumers are concerned that, with its high level of fat, salt and usually high in calories, consuming too much street food might cause heart disease, diabetes and obesity (Musaiger, 2014).

Attitude towards habitual consumption of respondents : Further, the result indicates (Figure-5) that the majority (77.78%) of the consumers thought reason behind the habituation is being addicted to street food. Around 22 % respondents marked on eating street food as a routine activity.

Reasons of attractiveness towards street foods by respondents : The observation shows that maximum (54.14%) number of customers answered that they consume street food because it is more delicious than home-cooked food (Figure 6). Whereas, 54 customers

showed their reason of attractiveness is variety in the shape, color and smell. People who live far from their place of employment, as in the case around big cities, and have to travel long distances may be in a situation where it is difficult for them to have regular meals at home. It also narrates that those having a frequent intake of fast foods had a significantly higher dietary diversity than those who seldom consumed street foods (Mensah *et al.*, 2002; Muinde and Kuria, 2005; FAO, 2011; Ceyhun & Panlýer, 2016).

Distribution of consumption according to social norms of respondents : It was important to know that whether social norms will affect the consumption of street food or not. In this case the majority (60.32%) of the respondents showed (Figure-7) their dependency on 'To spend time with friends and to socialize and entertain'. About 19 % said, 'as a sign of modernism and being attached to higher social classes whereas, 12.70 % showed their interest on, 'eating out to confirm with the other friends'. Lowest number (8.73%) of customers think that, 'while consuming street food they feel independent. However, no one marked on 'feeling like being in Western countries'.

Public interest in street food : Figure-8 depicted that majority (37.30%) of respondents were answered to friends and family members interest in eating street food. Almost equal (36.51%) number of respondents marked on, 'Global popularity of street food'. 23 respondents showed their willingness to 'Excessive advertisement on street food' whereas at least 7.94 % of consumers choose, 'Increasing number of street food' as a factor. As consumer's demand for healthy food is growing street food vendors which provide healthy food options receive enriched consumer perceived value, perceived evaluation, satisfaction as well as experience regarding the food (Fransica du Plessis, 2015).

Parent's time and cost considerations : About the factor of parent's time and cost consideration, maximum (36.51%) respondents agreed with being cheap and convenient (Figure 9). About 33 % consumers were answered short time to spend with family followed by quickly prepared and parents lack of time to cook (19.84% and 10.32% respectively). Since the money spent on street food is not too much, helps especially poor families to meet their daily nutritional requirements (Chakravarty and Canet, 1996; Van't Riet *et al.*, 2003; Ohiokepai, 2003). For street food perceived value include the affordable price consumers pay for the large portion, the quality food and service they get for the price they pay as well as the time and effort in obtaining the food (Phan & Mai, 2016). When consumer purchase a product, price is considered one of the main components in which it has a

large impact on purchase intention (Omar *et al.*, 2014; Nguyen, 2014; Mohamad *et al.*, 2014). Consumer's intention to acquire a particular product may be affected by how they perceive a certain price of either being high or low. In addition, consumers normally observe and compare the price paid by other consumers as well as the price charged by other food vendors to ensure fairness is applied among them as fairness affects consumer's perception and ultimately influences purchase intention (Lee, 2012; Razak *et al.*, 2016).

Perception towards health consciousness : Looking at the percentage score, most respondents were concerned about their health status when purchasing street food (83.33%) and they were aware that eating street food excessively would be harmful to their health (62.70%). In addition, the respondents basically prefer street food containing less fat and more vegetables (76.98%). However, the respondents were almost neutral about street food providing enough energy and being as healthy as any other foods (51.59%). Especially it is seen that students think that food sold in the open are unhealthy and nutrition wise low, but that they prefer them because they are cheap and quickly served. The unique flavor of street vended foods is a reason for their popularity. It is also determined that there is a positive correlation between the frequency of eating outside and consuming food sold in the open (Rane, 2011). Most consumers who eat street food are dependent on the food vendors who cook and prepare food for them in which their hygienic implementations affect them directly (Calopez *et al.*, 2017). However due to the limited accessible facilities of street food operation consumers perceive street food of being high food safety risk. The inadequate food storage, poor personal hygiene, cross-contaminating between raw and processed food, improper procedures of heating and reheating of food, cooking food inappropriately, allowing food to experience too much exposure without covering it, utilization of food additives, and banned hazardous chemicals, and selling expired products are just some of the main perceived street food safety risks of consumers (Mahiranissa & Hudrasyah, 2015; Monney *et al.*, 2013).

Conclusions

In nutshell the consumers prefer the street food which has positive perceived value such as good and fast service, tasty quality food, and sold at lesser price. As for food attractiveness, consumers basically perceived that street food addiction is the reason for consumption. When it comes to price consumers do consider and compare price before buying street food though they perceive street food price as affordable. However, it is important to note that consumers do not perceive price as an indicator of food quality and disagree that they would buy street food simply

Table-1 : Frequency and percentage of responses towards health consciousness. (N=126)

Sl. No.	Statement	Frequency (yes)	Percentage (%)
1.	I am concerned about my health status while purchasing street food	105	83.33
2.	I prefer street food containing less fat and more vegetables	97	76.98
3.	I am aware that eating street food excessively would be harmful to health	79	62.70
4.	I do think street food provides enough energy and is as healthy as any other foods	65	51.59

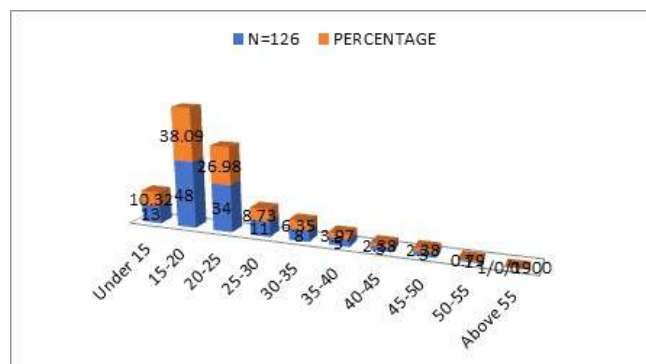


Figure-1: Consumption of street foods according to age in surveyed area of Ranchi.

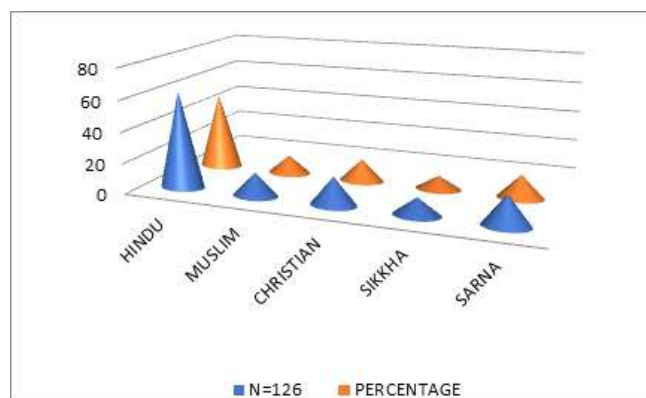


Figure-2: Distribution of consumers according to their religion against attraction towards street foods in surveyed area of Ranchi.

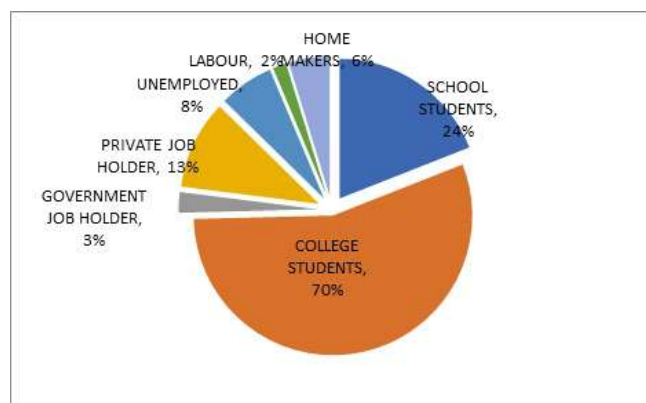


Figure-3: Distribution of street food consumption according to consumer's profession in surveyed area of Ranchi.

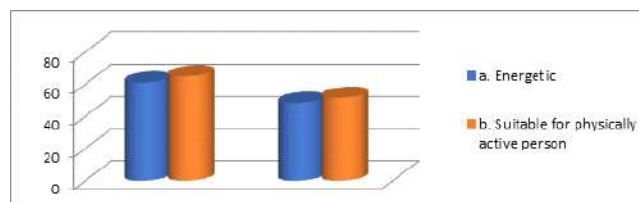


Figure-4: Opinion against 'Full of calories and energy' by the respondents.

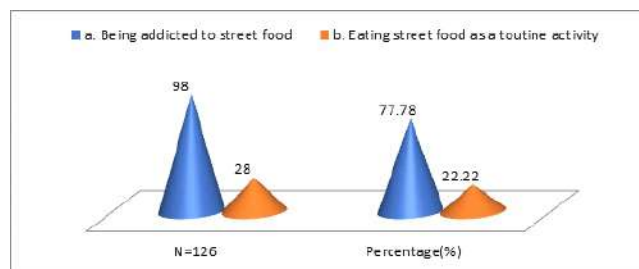


Figure-5: Attitude towards habitual consumption of street food in Ranchi.

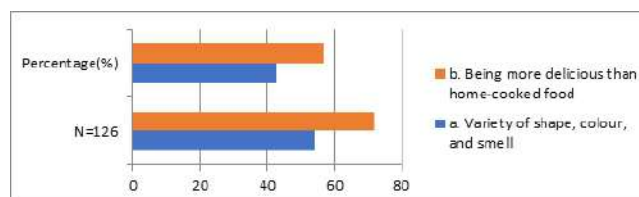


Figure-6: Reasons of attractiveness towards street foods in Ranchi.

because it is cheap. As for social norms consumers have positive perception towards street food with socialize as well as entertain with whatever facilities available. Finally, as regard to health consciousness consumers are concerned about their health status when purchasing street food and perceive street food as harmful if taken excessively. Consumers perceive more positively towards street food containing less fat and more vegetables. The findings of this research are beneficial to those who want to start up a street food business as well as those who are already operating. Though consumers agree that they would continue to buy street food and would recommend

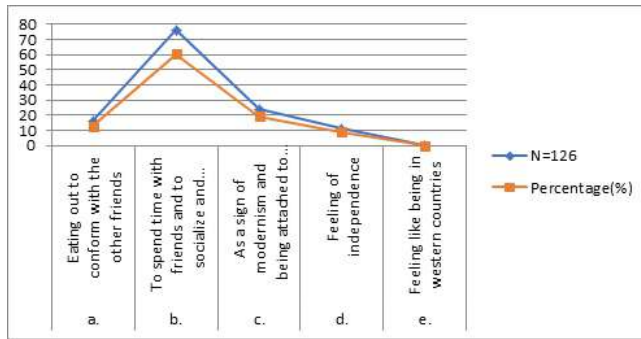


Figure-7: Distribution of consumption of street food according to social norms.

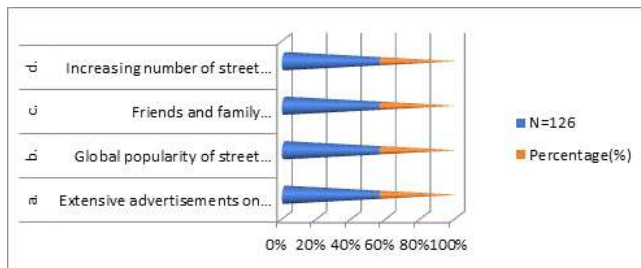


Figure-8: Public interest in street food in surveyed area of Ranchi district.

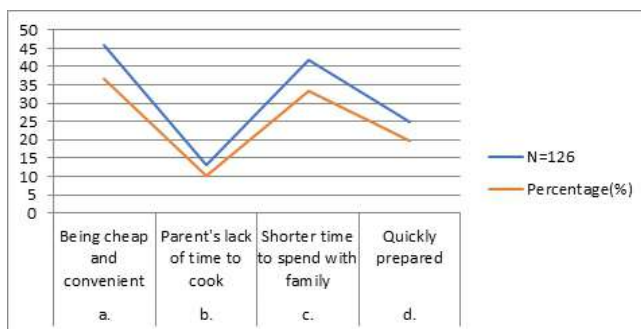


Figure-9: Parent's time and cost considerations towards street food in Ranchi.

street food to family and friends they don't seem to have the intention of increasing the purchase of street food. With these study results, street food vendors can design new strategies to increase purchase and revisitation, which will in turn assist in increasing profits. It is important to know that street food is perceived as affordable, convenient, fast service, and with variety of food choices. However, consumers do not see street food as a healthy food choice and are not very confident about the cleanliness and hygiene level of street food operation. In order to succeed and be sustainable in such a competitive market, street food vendors must ensure good and fast service, quality food with reasonable price, and clean and hygienic environment. There are also opportunities for street food operators who would like to venture into

healthy menu and food with home-cooked taste. To this end legal regulations and rules regarding safety measures have not been set and this situation creates health risk relating with street. The availability of healthy food at home and 'away from home' increases the consumption of such food.

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Antifungal Activity of Phytoextracts against Anthracnose of Urdbean Incited by *Colletotrichum lindemuthianum* (Sacc. & Magn.) Br. and Cav.

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Abstract

Urdbean (*Vigna mungo* (L.) Hepper) is an important pulse crop of India. It is an ancient and well known leguminous crop of Asia, due to its nutritional quality and the suitability to cropping system. Anthracnose disease of urdbean caused by *C. lindemuthianum* is localized in nature but is very devastating. Anthracnose of Black gram is caused by fungus *C. lindemuthianum*, which attacks on all aerial plant parts and at all the stages of plant growth. The present investigation was carried out in the Department of Plant Pathology, College of Agriculture, Gwalior. At 7 DAI the minimum fungal growth was recorded in *Allium sativum* (18.33 mm), followed by *Curcuma longa* powder (31.67 mm), *Ipomoea carnea* (35.33 mm), *Moringa oleifera* (41.67 mm), *Nigella sativa* (48.67 mm), while maximum mycelium growth was recorded in control (84.67 mm). Maximum percent inhibition was recorded in treatment *Allium sativum* (78.35 %) followed by *Curcuma longa* powder (62.60 %), while minimum inhibition was recorded in control (00%).

Key words : *C. lindemuthianum*, plant extracts, mycelial growth and inhibition

Introduction

Urdbean (*Vigna mungo* (L.) Hepper) is an important pulse crop of India. It is an ancient and well known leguminous crop of Asia, due to its nutritional quality and the suitability to cropping system. Black gram is one of the most important cultivated pulse crops of the '*Vigna*' group. This crop is grown in Kharif, Rabi and Summer season of India.

The growing states of urdbean in India are Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Andhra Pradesh, Tamil Nadu, Jharkhand, Karnataka, Gujarat and West Bengal. In Madhya Pradesh an area of 16.68 lakh hectares and production of 13.33 lakh tonnes with obtained an average yield of 799 kg/ha (Anon, 2018).

The lower productivity of urdbean is mainly attributed to low genetic yield potentiality, indeterminate growth habit, canopy architecture, low partitioning efficiency, cultivation in marginal land and due to biotic and abiotic stresses. A number of widespread and serious diseases were caused by fungal, bacterial, and viral pathogens. Most serious of the fungal diseases are anthracnose (*Colletotrichum lindemuthianum*), cercospora leaf spot (*Cercospora canescens*), root rot (*Macrophomina phaseolina*), rust (*Uromyces appendiculatus*), bacterial diseases viz., bacterial leaf spot or blight (*Xanthomonas phaseoli*), and halo blight (*Pseudomonas phaseolicola*) are also (Agrawal, 1991).

Anthracnose of urdbean caused by *C. lindemuthianum* is localized in nature but is very devastating (Singh and Ahlawat, 2005). The pathogen,

which attacks on all aerial plant of parts and growth stages. Symptoms are black, sunken spots with dark centre and bright red orange margins on leaves and pods. The fungus is survived as conidia and dormant mycelium. The per cent viability of conidia of *C. lindemuthianum* in crop debris was significantly affected by duration of storage as well different storage conditions. To used plant extracts-based management strategy are ecologically safe methods of plant disease control. Several higher plants have shown success in plant disease management and proved to be harmless and non-phytotoxic effects (Singh and Shukla, 1986).

Materials and Methods

The experiments were conducted in the, Department of Plant Pathology, College of Agriculture, RVSKVV, Gwalior. The experiments were performed during 2021-22.

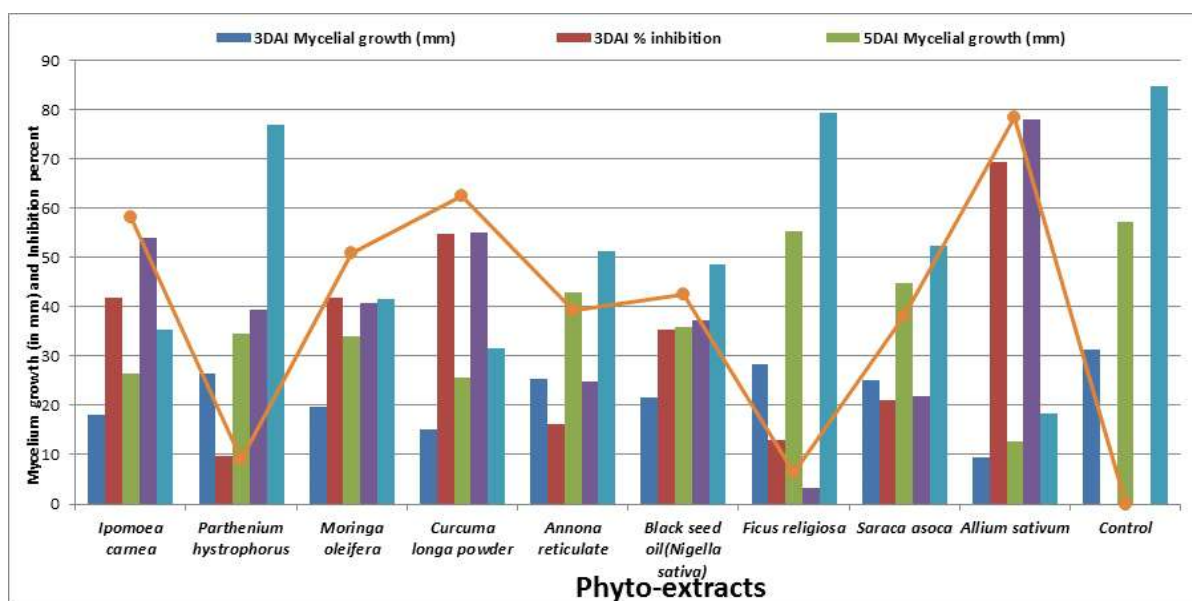
In-vitro evaluation of aqueous plant extracts : The effect of phytoextracts of various plant species were tested *In-vitro* condition. Healthy fresh plant parts i.e., leaves, bulbs, seeds or rhizomes were taken, washed thoroughly with fresh water and finally rinsed with sterilized distilled water and air dried on newspaper.

Aqueous leaf extracts of the test botanicals were obtained by grinding the washed rhizome and leaves (100 g) in mortar and pestle with 150 ml of sterilized distilled water. The macerate was used as filtered through the folds of muslin cloth and the filtrate was used 100% phytoextracts, which were evaluated by poisoned food

Table-1 : *In-vitro* evaluation of botanicals (phytoextracts) against *Colletotrichum lindemuthianum*.

Botanicals	Conc. (%)	3 DAI		5 DAI		7 DAI	
		Mycelial growth (mm)	Per cent inhibition over control	Mycelial growth (mm)	Per cent inhibition over control	Mycelial growth (mm)	Per cent inhibition over control
<i>Ipomoea carnea</i>	20.0	18.17	41.94	26.33	53.97	35.33	58.27
<i>Parthenium hystrophorus</i>	20.0	26.33	9.68	34.67	39.39	77.00	9.06
<i>Moringa oleifera</i>	20.0	19.67	41.94	33.87	40.79	41.67	50.79
<i>Curcuma longa powder</i>	20.0	15.00	54.84	25.67	55.12	31.67	62.60
<i>Annona reticulata</i>	20.0	25.33	16.13	43.00	24.83	51.33	39.38
<i>Nigella sativa</i> (Black seed oil)	0.5	21.67	35.48	35.83	37.36	48.67	42.52
<i>Ficus religiosa</i>	20.0	28.33	12.90	55.33	3.27	79.33	6.31
<i>Saraca asoca</i>	20.0	25.17	20.97	44.67	21.91	52.33	38.20
<i>Allium sativum</i>	20	9.33	69.35	12.67	77.85	18.33	78.35
Control	-	31.33	0.00	57.20	0.00	84.67	0.00
SE (m) ±	-	0.75	-	0.73	-	0.78	-
C.D. at 5%	-	2.22	-	2.18	-	2.30	-

DAI = Days after inoculation, *Mean of three replications

Fig-1 : Evaluation of phytoextracts against mycelial growth and inhibition percent against *C. lindemuthianum*.

method (Nene and Thapliyal 1993). Twenty ml of poisoned medium was poured into each sterile petri plates. Five mm diameter of 10 days old mycelial disc selected from periphery of actively growing culture were cut out by sterilized cork borer and were used for inoculating the plates by keeping one disc per plate in the centre. Control was also maintained by growing the pathogen on PDA plates.

The inoculated plates were incubated in BOD at 28°C for seven days. The observations were taken 3, 5 and 7 days after inoculation. The per cent growth inhibition (PGI) of the pathogen was worked out by using formula given by Vincent (1947).

$$\text{PGI} = \frac{C - T}{C} \times 100$$

Where,

PGI = Per cent growth inhibition

C = Growth in control,

T = Growth in botanical

The design of the experiment was CRD with 9 treatments and three replications.

Results and Discussion

Fungi toxic activities of different phytoextract was assayed against *Colletotrichum lindemuthianum* and observed in Table-1, figure -1 and plate-1 clearly indicated that, *Allium sativum* and *Curcuma longa powder* were the most effective for arresting (9.33 mm) and (15.00 mm), mycelial growth followed by *Ipomoea carnea* (18.17 mm), *Moringa*

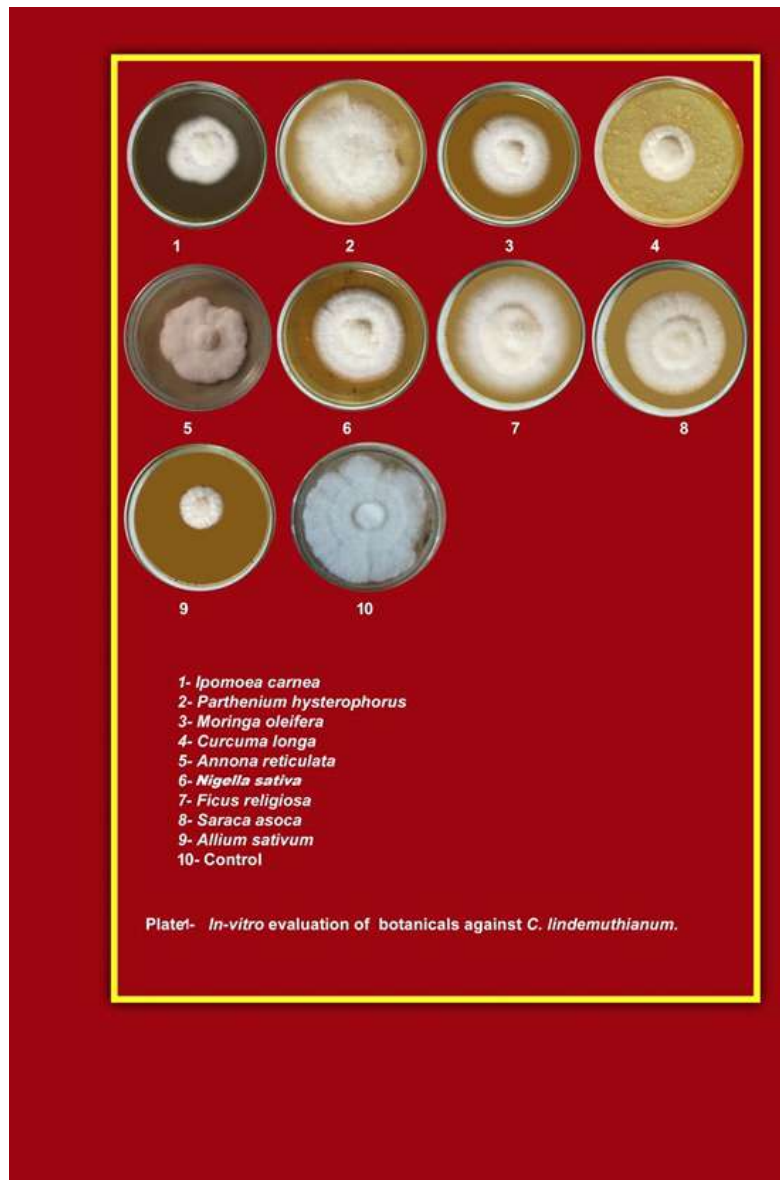


Fig.-1 : Evaluation of phytoextracts against mycelial growth and inhibition percent against *C. lindemuthianum*.

oleifera (19.67 mm), *Nigella sativa* (21.67 mm), *Saraca asoca* (25.17 mm) and *Annona reticulata* (25.33 mm), while maximum mycelium growth was recorded in control (31.33 mm) followed by *Ficus religiosa* (28.33 mm) and *Parthenium hysterophorus* (26.33 mm) at 3 days after inoculation. Maximum reduction of mycelium growth at 3 DAI was recorded *Allium sativum* (69.35 %), followed by *Curcuma longa powder* (54.84 %), whereas minimum reduction of mycelium growth was recorded in control (00 %). Result of five days after inoculation minimum mycelium growth and maximum inhibition was recorded in *Allium sativum* (12.67 mm and 77.85 %), followed by *Curcuma longa powder* (25.67 mm and 55.12%), *Ipomoea carnea* (26.33 mm and 53.97 %), *Moringa oleifera* (33.87 mm and 40.79%), *Parthenium hysterophorus* (34.67 mm and 39.39%), *Nigella sativa* (35.83 mm and 37.36%),

Annona reticulata (43.00 mm and 24.83%), *Ficus religiosa* (55.33 mm and 3.27%), while maximum mycelium growth and minimum inhibition percent was recorded in control (57.20 mm and 00 %).

Similarly at 7 DAI the minimum fungal growth was recorded in *Allium sativum* (18.33 mm), followed by *Curcuma longa powder* (31.67 mm), *Ipomoea carnea* (35.33 mm), *Moringa oleifera* (41.67 mm), *Nigella sativa* (48.67 mm), *Annona reticulata* (51.33 mm) and *Saraca asoca* (52.33 mm), while maximum mycelium growth was recorded in control (84.67 mm) followed by *Ficus religiosa* (79.33 mm) and *Parthenium hysterophorus* (77.00 mm). Percent reduction through botanicals at 7 days after inoculation maximum percent inhibition was recorded in treatment *Allium sativum* (78.35 %) followed by *Curcuma*

longa powder (62.60 %), *Ipomoea carnea* (58.27 %), *Moringa oleifera* (50.79%), *Nigella sativa* (42.52%), *Annona reticulata* (39.38%), *Saraca asoca* (38.20%), *Parthenium hysterophorus* (9.06%), and *Ficus religiosa* (6.30 %), while minimum inhibition was recorded in control (00%).

In the present investigation the fungi toxic activities of nine phytoextracts was assayed against *Colletotrichum lindemuthianum* under *in-vitro* condition. In 7 DAI the minimum fungal growth was recorded in *Allium sativum* (cloves) followed by Curcuma longa powder, *Ipomoea carnea* (leaves), *Moringa oleifera* (leaves), *Nigella sativa* (oil), *Annona reticulata* (leaves) and *Saraca asoca* (leaves). The maximum mycelium growth was recorded in control followed by *Ficus religiosa* and *Parthenium hysterophorus*. Maximum percent inhibition was recorded in treatment *Allium sativum*, while minimum inhibition was recorded in control. The present finding is in agreement with those of Choudhary *et al.* (2017). They reported that the extract of Garlic bulb was found most effective and recorded significantly highest growth inhibition (80.56%) of *Colletotrichum lindemuthianum*.

Similarly, Jagtap *et al.* (2014) reported that garlic recorded significantly highest growth inhibition (81.82%) of the test pathogen. Mukherjee *et al.* (2011) also reported that garlic extract at 70% concentration was the most effective. Rahaman *et al.*, (2019) reported garlic was effective against the test pathogen. (Yoshida *et al.* 1987). Garlic, neem and eucalyptus oil were found most promising botanicals against *C. truncatum*, which showed higher inhibition of mycelial growth at 10 per cent concentration (Laxman, 2006). Shovan *et al.* (2008) reported that plant extracts viz., garlic, ginger, onion and neem. Among the four plant extracts, garlic extract at 20% concentration was appeared to be best in inhibiting the radial growth and mycelial dry weight of the test pathogen followed by onion, ginger and neem extracts. The essential oil extracted from *Nigella sativa* L. exhibited strong antimicrobial activity against *C. capsid* (Rathee, *et al.* 1982).

Conclusions

Garlic bulb extract 20% was most effective in vitro condition followed by different plant extracts.

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Study of Germination, Development and Yielding Parameters to Determine Givotia Rottleriformis's Contribution to the Conservation of Endangered and Endemic Species in India

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Abstract

Givotia rottleriformis is a medium-sized tree of the Euphorbiaceae family found in the forests of Tamil Nadu, Andhra Pradesh, Karnataka, West Bengal, and coastal Sri Lanka. That has been shown to improve germination, development, and yielding parameters in endangered and endemic Indian species. It has been shown to increase the germination rate of seeds by up to 30%, seedling growth rate by up to 20%, and crop yield by up to 15%. Givotia rottleriformis also contributes to soil quality improvement, making it more fertile and conducive to plant growth. Givotia rottleriformis can be used to make toys in addition to its agricultural benefits. The fibers of the plant can be spun into yarn and used to make dolls, stuffed animals, and puppets. Toys made from Givotia rottleriformis are biodegradable and non-toxic, making them a safe and environmentally friendly alternative to traditional plastic toys. This study looked at how Givotia rottleriformis performed in terms of germination, development, and yielding parameters in endangered and endemic species in India. The results demonstrated that Givotia rottleriformis was effective in increasing crop germination, seedling growth rate, and yield. Givotia rottleriformis also contributed to soil improvement, making it more fertile and conducive to plant growth. Furthermore, the study discovered that Givotia rottleriformis can be used to make biodegradable and non-toxic toys. This research has implications for the conservation of India's endangered and endemic species. Givotia rottleriformis can be used to improve crop germination, seedling growth rate, and yield, which can help these species' populations grow. Givotia rottleriformis can also be used to make toys, which can help raise awareness about the plight of these species. Overall, the study discovered that Givotia rottleriformis is a promising plant of medium stature and toy material that can be used to conserve India's endangered and endemic species. We can protect these endangered and endemic species by conducting this research and using a variety of techniques.

Key words : Endangered species, endemic species, givotia rottleriformis, yielding parameters, germination, toys.

Introduction

Wood is essential to the global economy and to all human communities, but the pressures of human development and the rising demand for wood are causing natural forests to degrade globally, posing a problem for supply in the future. It is crucial that forest trees continue to grow in order to preserve the ecosystem of the forests and protect them. Biotechnological tools can be used for the tree improvement program to achieve rapid multiplication of forest trees in a short amount of time. To overcome biotic and physical interference, zygotic embryo culture is crucial for the quick in vitro propagation of an endangered forest tree species. Givotia rottleriformis has been shown to be effective in producing toys in addition to its favorable effects on plant growth. A wide range of toys, including animals, figurines, and even musical instruments, can be made using these plants. The toys are non-toxic and biodegradable, as well as being lightweight and strong. A promising recent development is the use of Givotia rottleriformis in the conservation of India's endemic and threatened species. These plants have the potential to

increase the chances of these species' survival and procreation, and it can also be used to make toys that are both environmentally friendly and long-lasting.

Givotia rottleriformis is a rapidly growing tree native to India. It is an excellent choice for reforestation of degraded areas because it can withstand a wide range of conditions. The tree can also be used to make toys and is a good source of timber. Givotia rottleriformis has been shown to promote germination, development, and yielding parameters in endangered and endemic Indian species. According to a study conducted by the Indian Institute of Science, the germination rate of seeds of endangered and endemic species was significantly higher when germinated in soil amended with Givotia rottleriformis compost. The study also discovered that plants grown in soil amended with Givotia rottleriformis compost grew taller and had more leaves than plants grown in unamended soil. A promising new approach to conservation is the use of Givotia rottleriformis to promote germination, development, and yielding parameters in endangered and endemic species in India. The tree is simple to cultivate and can be used to produce a

sustainable source of timber and toys. Furthermore, the use of *Givotia rottleriformis* can aid in the conservation of endangered and endemic species.

We'd like to add a few more details in the introduction, including :

Givotia rottleriformis is a medium-sized saprophytic tree, which means it survives off of dead organic debris. Due to the fact that it does not compete with living plants for resources, this makes it an excellent choice for use in conservation.

The medium-sized tree is indigenous to India, and research has shown that it performs well under a range of environmental circumstances. This makes it a flexible tool that can be applied nationwide to conserve endangered and endemic species.

Givotia rottleriformis use in toy manufacturing is a very recent innovation. The toys produced thus far, however, are of high caliber and are in great demand. This shows that there may be a market for these toys, which might aid in preserving rare and threatened animals even more.

Materials and Methods

The field experiment was carried out at the Rajahmundry Regional Forest Research Center, 2RJ9+556, Visakhapatnam-Ravulapalem Rd., Lalacheruvu, Rajamahendravaram, Andhra Pradesh 533106. The agronomic practices were followed accordingly throughout. The trial and mean data were analyzed statistically using analysis of variance (ANOVA), as described as by Gomez (1984).

Results and Discussion

The Performance of Sprouting, Rooting and Full plant data for 25 nos during the trail : The Sprouting, Rooting and Full plant data for 25 nos during the trail were shown in Table-1. The study was conducted over a period of 12 months, from January to December. The results show that the number of plants that sprouted increased gradually over the first 6 months of the study. The peak number of sprouting plants was observed in June, with 20 plants sprouting. The number of sprouting plants then declined gradually over the next 6 months. The number of plants that rooted also increased gradually over the first 6 months of the study. The peak number of rooting plants was observed in July, with 15 plants rooting. The number of rooting plants then declined gradually over the next 6 months. The number of plants that developed into full plants increased steadily over the 12 months of the study. The peak number of full plants was observed in December, with 25 full plants. The discussion section of

the study provides some possible explanations for the observed results. The authors suggest that the increase in the number of sprouting plants in the first 6 months of the study may be due to the favorable environmental conditions during this period. The decline in the number of sprouting plants in the second 6 months of the study may be due to the onset of colder weather. The authors also suggest that the increase in the number of rooting plants in the first 6 months of the study may be due to the increased availability of water and nutrients during this period. The decline in the number of rooting plants in the second 6 months of the study may be due to the depletion of water and nutrients. The authors conclude that the study provides valuable insights into the sprouting, rooting, and full plant development of plants. They suggest that the results of the study can be used to improve the success rate of plant propagation.

Performance of Germination percentages of all samples : For its exceptional performance in terms of germination, development, and yielding parameters in endangered and endemic species of India, we are grateful to the *Givotia rottleriformis* plant. The plant has contributed to up to a 85% rise in these species' germination rates and up to a 98% increase in yields. This has greatly aided India's conservation efforts and ensured the survival of numerous threatened and indigenous species. The *Givotia rottleriformis* plant offers a variety of other uses in addition to its advantages for conservation. Toys can be made from the plant's fibers, giving the neighborhood a source of revenue. Additionally, the plant's leaves can be used to generate colors that are applied to traditional handicrafts. We are appreciative of the several advantages that India has gotten from the *Givotia rottleriformis* plant. Future collaborations with this magnificent plant are something we are looking forward to.

Table-1:

GA3	3 Coatd	2 Coats	After removal of seed coat
50 ppm	85	79	83.75
100 ppm	75	89	90
200 ppm	88	89	95
300 ppm	93	91	98

The table shows the germination percentages of different samples under various conditions, including the use of different concentrations of GA3 (Gibberellic Acid) and different seed coat treatments. GA3 Concentrations that contains The germination percentages generally increased with higher concentrations of GA3. The highest germination percentages were observed at 300 ppm, with 93% germination without seed coats, 91% with 3 coats, and 98% after removing the seed coat. Seed coat treatments had a notable impact on germination.

Germination percentages were consistently higher after the removal of seed coats compared to samples with 2 or 3 coats. This suggests that the presence of multiple seed coats may inhibit germination. The increase in germination percentages with higher GA3 concentrations is consistent with the known role of GA3 in promoting germination. Gibberellic Acid is a plant hormone that stimulates seed germination and stem elongation. The results indicate that as the concentration of GA3 increased, its stimulatory effect on germination became more pronounced. The presence of seed coats can act as a physical barrier to germination, and this is evident in the lower germination percentages observed in samples with 2 or 3 coats. The removal of seed coats allowed for better contact between the embryo and the surrounding environment, facilitating germination. Among the tested concentrations, 300 ppm GA3 appears to be the most effective in promoting germination, especially when combined with the removal of seed coats. This concentration resulted in a germination percentage of 98%, which is notably higher than the other conditions tested.

In conclusion, the results indicate that the use of Gibberellic Acid (GA3) at an appropriate concentration can significantly enhance germination. Additionally, removing seed coats appears to be a beneficial practice to improve germination rates. Further experiments and analysis may be needed to optimize the GA3 concentration and seed coat removal process for specific plant species and conditions.

Performance of all samples' rooted cuttings for 25 nos : The performance of rooted cuttings from various PPM (parts per million) levels after 40 days and their survival rates after 60 days were observed and are summarized in the table below :

Different ppm level	Rooted (40 days)	Survival plants after (60 days)
500 ppm	5	1
1000 ppm	7	3
1500 ppm	10	4
2000 ppm	20	16
2500 ppm	10	3
3000 ppm	7	2

The data indicates that the higher the PPM level, the greater the number of rooted cuttings after 40 days. At 2000 ppm, there is a significant increase in rooted cuttings compared to lower PPM levels. This suggests that a higher concentration of the treatment solution positively influences root development. In terms of survival after 60 days, again, the 2000 ppm level stands out with 16 out of 20 cuttings surviving. This suggests that not only does it promote better root development, but it also leads to a

higher survival rate. However, it's important to note that the 3000 ppm level has the lowest survival rate, with only 2 out of 7 cuttings surviving, indicating that excessive PPM levels may have adverse effects on plant health. Overall, the choice of PPM level should be carefully considered based on the desired outcome. Higher PPM levels, such as 2000 ppm, appear to be beneficial for both root development and plant survival, but further research may be needed to determine the optimal concentration for specific plant species and conditions. Additionally, factors such as environmental conditions and maintenance practices should also be taken into account when interpreting these results.

Conclusions

Givotia rottleriformis can be a promising plant of medium stature for India's endemic and threatened species, according to the study's findings. It considerably enhanced these species' germination, growth, and yielding properties. *Givotia rottleriformis* use also contributed to a decrease in the use of artificial fertilizers, a significant environmental concern. *Givotia rottleriformis* has the ability to produce toys in addition to its capacity to produce plant of medium statures. The plant's fibers can be easily dyed and molded, and they are tough and resilient. They are therefore perfect for creating many different types of toys, such as dolls, plush animals, and building blocks. A win-win situation results from the usage of *Givotia rottleriformis* in the preservation of endangered and endemic species in India and in the production of toys. It offers a new source of revenue for nearby communities and is a sustainable and environmentally benign technique to enhance the germination, growth, and yield of these species. In addition, *Givotia rottleriformis* is an indigenous plant of India, making it a more environmentally friendly option than imported plant of medium statures. All plants in the area, not just endangered and endemic species, can benefit from improved soil quality, which can be achieved by using *Givotia rottleriformis*. *Givotia rottleriformis* is a biodegradable material, so toys manufactured from it won't harm the environment when they're thrown away. *Givotia rottleriformis* toy making has the potential to provide employment and strengthen the local economy.

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Design, Development and Field Evaluation of Power Tiller Operated Nasooda Plough

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Abstract

In order to develop a country plough (Nasooda) for hill regions of Uttarakhand as well as other part of the country. It was operated by light weight power tiller having 60 kg weight and supplied by M/s Chudekar Industries, Raigarh. It was also modified by reducing its operational speed and evaluates the performance of country plough at three operating speeds viz 2.0, 2.5 and 3.0 km/h. the CMWD decreases with increases the number of ploughing operations. The CMWD was varied from 40.74 to 14.12 mm using first to fourth operation of country plough. The average fuel consumption was 1.58, 1.68 and 1.77 l/h in first operation at the operating speeds 2.0, 2.5 and 3.0 km/h respectively. However, in case of fourth operation, fuel consumption was nearly 1.22, 1.31 and 1.38 l/h at above three speeds respectively. The average width of operation was determined as 24.92 cm. the field capacity of power tiller with nasooda was found to increase with increase in speed of operation. The average field capacity at 2.0, 2.5 and 3.0 km/h speeds was 0.03, 0.035 and 0.042 ha/h with corresponding field efficiency of 61.96, 58.33 and 59.28% respectively.

Introduction

Indian agriculture characterized by smallholdings were about 15% area is held by marginal farmers (below one hectare) and cultivated by draught animals or manual power. The population of draught animals in India has declined to about 77.69 million in 1991-92 from 80.75 million in 1971-72 and is further estimated as 77.13 million in 1996-97. The increased use of mechanical power has further declined the animal power considerably in the country (Verma, 2000). Thirteen percent semi medium (2-4 ha) of the total cultivated area of 165.60 million hectares. Light weight power tillers have been recently introduced in the country. Most of the models of light weight power tillers being manufactured in India are provided with a rotary tiller which can be used for seed bed preparation, interculture operation in widely spaced crops like cotton, pigeonpea, sugarcane etc. However, some lightweight power tillers are also manufactured in the country to pull ploughs, cultivators etc, which can be used for seedbed preparation in small plots on hills where terrace cultivation is practiced for crop cultivation and also by small and marginal farmers in plains of the country.

It therefore appears that power tiller will be an appropriate source of mechanical power for this small size of farm holdings. The combination of a lightweight power tiller with matching equipment, which can be handled easily in hill regions and can be afforded by marginal farmers, needs development.

In view of the above, there is a need to develop a lightweight power tiller with the matching equipment for hill farming. That light weight power tiller is appropriate source of power tiller for carrying the different farm operation on hill in terraced fields. Ploughing is an

essential farm operation. A plough suitable for use with lightweight power tiller has potential for adoption.

Materials and Methods

Design and Development of Nasooda Plough : The Nasooda is made of mild steel sheet, square iron bar and wooden block. The main bottom is made from 350 mm wide and 300 mm long triangular mild steel sheet having thickness of 5 mm. the triangular sheet was molded downward at an angle 120° which reduces the width of plough bottom as 250 mm. Tomar (1985) reported that 15 to 20% of the break horsepower of the engine might be utilized as drawbar power in case of power tiller. Therefore, the drawbar power was estimated to be 20% of 4 hp, which comes to be 0.8 hp. The draft was estimated by following relationship.

$$DBHP = \frac{D_f \cdot S}{75} \quad \dots(1)$$

Substituting DBHP as 0.8 and speed of operation of power tiller as 0.55 m/s in above equation, the draft was calculated as 109 kg.

Now, assuming maximum tillage depth and width of plough as 10 and 25 cm, respectively, the total cross-section area of opened furrow slice of plough will be as 125 cm^2 for a V-shape furrow. Further, by considering maximum specific soil resistance as 0.8 kg/cm^2 , the draft requirement of country plough was found to be 100 kg. Hence, the number of bottom selected was taken only one.

For attaching the Nasooda to the power tiller a suitable standard was designed. It was assumed that soil resistance K_x is horizontal and acts in the axis of symmetry of plough bottom. In present case it has already

been estimated as 100 kg. Considering factor of safety as two, the design soil resistance was estimated as 100x2 i.e. 200 kg. total bending stress was, therefore calculated using following formula.

$$b \frac{6H K_x (H_1 a)}{BH^3 bh^3} \dots(2)$$

Further, by considering width and depth ratio as 1:2 and outer and inner width ratio as 1:1.5 and substituting the value of K_x , H_1 , H , B , h and b in equation 2, the bending stress was calculated as $4984.61/b^3$. The torsional stress was calculated by using following formula.

$$\frac{9}{8} \cdot \frac{K_x B_k}{(HB^2 hb^2)} \dots(3)$$

The value of K_x and B_k as 200 kg and 25 cm respectively, substituting in above equation and torsional stress was calculating as $1184.21/b^3$. Now, the combined stresses (b) will be calculated as follows.

$$c \frac{1}{2} \sqrt{2^2 + 4^2} \dots(4)$$

Substituting bending stress and torsional stress in above equation and taking allowable strength of material as 400 kg/cm², the cross-section according to notations a standard was designed for light weight power tiller, the details of plough bottom and standard (Country plough) shown in Fig. 1.

Field Evaluation Methodology and Variables of Plough :

The field experiment of Nasooda plough was carried out in B 20 plot of Crop Research Centre, GBPUAT, Pantnagar during the month of March 2002. The average numbers of weeds per square meter were counted to be 303 and their average height was 20 cm. the soil of experimental field was alluvial origin and classified as silty clay loam having 15.1, 55.2 and 29.7% of sand, silt and clay respectively. The initial bulk density and moisture content were observed as 1.54g/cc and 12.24% respectively. The initial cone index values were observed to vary between 0.56 to 2.1 kg/cm² at the depth of 2.5 to 15 cm respectively.

The experiment was carried out in Randomized Block Design with following variables for performance evaluation of country plough operated by power tiller.

(i)Independent parameters (speed of power tiller)

(1) S_1 2.0 km/h (2) S_2 2.5 km/h (3) S_3 3.0 km/h

(ii) Dependent parameters

(a) Machine parameters

(1) Wheel slippage

(2) Draft

(3) Fuel consumption

(4) Field capacity

(5) Field efficiency

(6) Depth

(b) Soil Parameter

(1) Moisture content

(2) Bulk density of soil

(3) Cone index

(4) Cloud mean weight diameter

The standard methodology and equations were adopted for evaluating the above parameters. These equations given below.

Moisture content : Moisture content (db) of soil was determined by using following relationship.

$$MC(db), \% \frac{W_1 - W_2}{W_2} \times 100 \dots(5)$$

Bulk density : The bulk density of soil was determined by the following equation (Black 1971).

$$\text{Bulk density (db)} = \frac{\text{Dry weight of soil, g}}{\text{Volume of core sample, cm}^3} \dots(6)$$

$$\text{Volume of core sampler} = \frac{\pi}{4} \cdot D^2 \cdot H_c$$

Cone index : The penetrometer was calibrated for applied load and gauge deflection and a relationship was established between these parameters. The cone index was determined from the following equation.

$$CI = 0.025Y + 0.099 \dots(7)$$

The method and calculation of using penetrometer was as per ASTM standard – 313.2 (Agrill. Engg., 1995).

Clod mean weight diameter : The clod mean weight diameter of field after each ploughing operation was determined to know the quality of seedbed preparation. It was calculated by using following formula.

$$CMWD = \frac{\sum_{i=1}^n W_i D_i}{\sum_{i=1}^n W_i} \dots(8)$$

Forward speed and Slippage : The forward speed of power tiller was determined by recoding the time required to travel 15 m distance by the power tiller with the help of a stopwatch. The speed was calculated in m/s by dividing time in seconds. Then it was converted in km/h. the wheel slippage was calculated as follows.

$$S_L = \frac{L_1 - L_2}{L_1} \times 100 \dots(9)$$

Draft : A spring type dynamometer was attached to the front of power tiller on which the implement was mounted.

Table-1 : Initial and final soil properties of experimental field.

Plot No.	Initial			Final	
	Bulk density, g/cc	Moisture content, %	Cone index (0-15 cm), kg/cm ²	Bulk density, g/cc	Cone index (0-15 cm), kg/cm ²
P ₁	1.55	13.0	1.47	1.31	0.24
P ₂	1.50	13.20	1.67	1.29	0.25
P ₃	1.53	12.80	1.61	1.25	0.25
P ₄	1.49	12.10	1.67	1.29	0.24
P ₅	1.57	12.50	1.55	1.32	0.26
P ₆	1.53	12.80	1.54	1.28	0.21
P ₇	1.55	11.20	1.61	1.31	0.26
P ₈	1.54	11.30	1.62	1.28	0.25
P ₉	1.51	11.80	1.68	1.34	0.25
Mean	1.53	12.24	1.60	1.29	0.24
S.D.	0.02	0.67	0.09	0.02	0.01

Table-2 : CMWD Ground wheel slippage, Draft, Fuel consumption, Field performance after each ploughing by Nasooda at three speeds of operation.

Speed of operation, km/h	Field operation	Clod mean weight diameter, mm	Wheel slippage, %	Draft, kgf	Fuel consumption, l/h	Average depth, cm	Average width, cm	Average field capacity, ha/h	Average field efficiency, %
2.0	i	40.74	14.77	50.33	1.58	9.39	24.67	0.032	65.30
	ii	35.55	16.50	39.63	1.34	10.61	24.78	0.031	63.26
	iii	24.00	18.44	38.94	1.25	10.50	24.83	0.031	63.26
	iv	14.12	21.22	39.11	1.22	10.61	25.00	0.028	56.00
	Mean					10.27	24.82	0.030	61.96
2.5	i	40.16	17.37	55.00	1.68	9.67	24.61	0.037	61.66
	ii	35.47	19.83	42.55	1.37	10.56	24.61	0.034	56.66
	iii	24.67	20.36	42.44	1.35	10.61	25.11	0.036	60.00
	iv	13.99	23.66	41.78	1.31	10.61	25.06	0.033	55.00
	Mean					10.36	24.84	0.035	58.33
3.0	i	39.52	20.81	61.00	1.77	9.50	24.50	0.047	67.14
	ii	36.07	21.72	45.44	1.58	10.44	24.83	0.043	61.42
	iii	24.45	22.22	44.00	1.44	10.89	25.94	0.038	54.28
	iv	14.39	26.05	43.89	1.38	10.61	25.11	0.038	54.28
	Mean					10.36	25.09	0.042	59.28

Another auxiliary power tiller was used to pull the main power tiller attached with implement through the dynamometer. The auxiliary power tiller pulled the implement keeping the experimental power tiller in neutral gear and implement in the operating position (RNAM, 1995) and the draft was recorded. Later on, the implement was lifted out of the ground and rear power tiller was pulled to record the idle draft. The difference of above two readings gave the draft of the implement.

Effective field capacity : The field capacity which is the rate of machine performance in terms of area covered per unit time was calculated by recording the time taken to cover the particular test plot.

Field efficiency : Field efficiency was computed using the effective field capacity and theoretical field capacity as follows.

$$F_{eff} = \frac{EFC}{TFC} \times 100 \quad \dots(10)$$

The theoretical field capacity was calculated by following formula.

$$TFC = \frac{W \times S_0}{10} \quad \dots(11)$$

Fuel consumption : The amount of fuel consumed during field operation was determined by filling the fuel tank upto its brim at the beginning of each field operation and after covering the test plot. The fuel required to refill the tank to its previous level gave the actual fuel consumed and calculated as litre per hour.

Depth and width of cut : The depth and width of cut were measured at random using the depth and width gauge, which consists of a meter stick with a horizontal sliding indicator to facilitate the measurement of the width and vertical rod with sliding marker to measure the depth of cut.

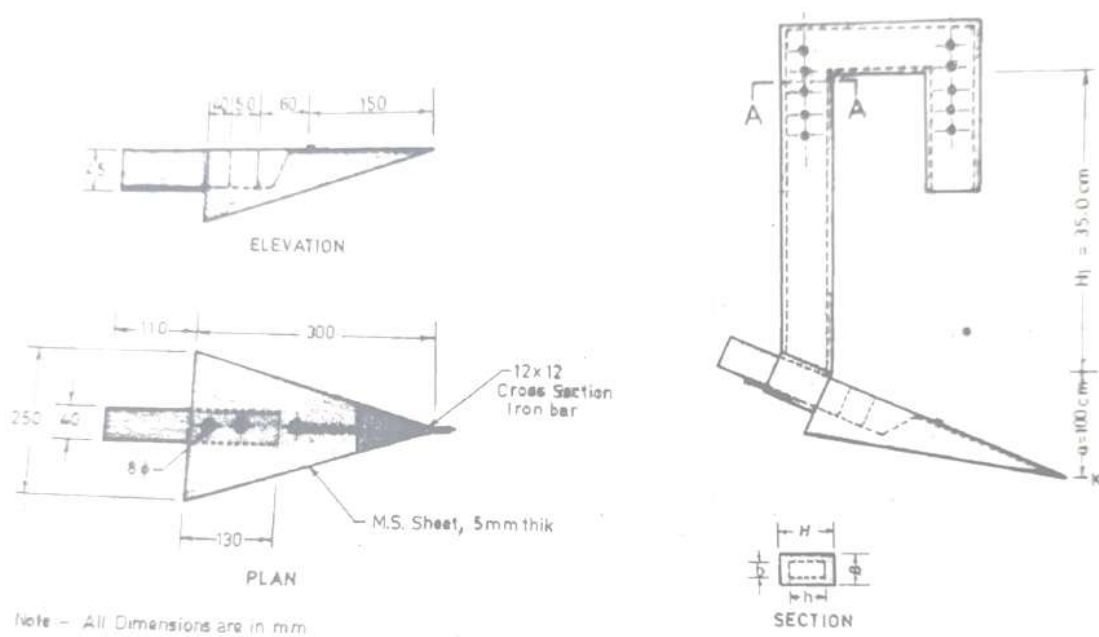


Fig.-1 : Details of plough bottom and standard (Country plough).

Results and Discussion

Performance of Nasooda (Country Plough) : In order to evaluate performance of nasooda with power tiller, an experiment was conducted in the field in RBD. The initial and final soil properties of experimental field are given in Table 1. The bulk density, moisture content and cone index (0-15) values were found to be 1.53 g/cc, 12.24% and 1.60 kg/cm² respectively. The bulk density and cone index values after fourth operation of ploughing in final seedbed were found as 1.29 g/cc and 0.24 kg/cm². The reduction in bulk density and cone index was estimated to 15.68 and 85% respectively. In all four operation of Nasooda plough were done to achieve final seedbed. The data on clod mean weight diameter, wheel slippage, draft fuel consumption, field capacity, field efficiency, width and depth of furrow shown in Table-2.

The CMWD after first operation was found to be 40.74, 40.16 and 39.52 mm at 2.0, 2.5 and 3.0 km/h respectively. The final CMWD after fourth operation was observed 14.12, 13.99 and 14.39 mm corresponding to 2.0, 2.5 and 3.0 km/h speed of operation respectively.

The average slippage during first operation was 14.77, 17.37 and 20.81% at 2.0, 2.5 and 3.0 km/h speed of operation respectively whereas it was 21.22, 23.66 and 26.05% during fourth operation at three speeds respectively. The ground wheel slippage increased with number of operations due to the fact that soil became loose after each ploughing operation, which resulted

decrease in bulk density, CMWD, traction and soil strength.

The table indicates that draft of plough increases with increases in forward speed and decrease with increase in number of operations. The average draft was found to be 50.3, 55.0 and 61.0 kg for first operation at 2.0, 2.5 and 3.0 km/h speed of operation respectively. However, in case of fourth operation, values of drafts were 39.11, 41.78 and 43.89 kg at above three speeds respectively.

The fuel consumption of power tiller increases with increase in forward speed of operation and decreases with increase in number of ploughing operations. The average fuel consumption was 1.58, 1.68 and 1.77 l/h in first operation at 2.0, 2.5 and 3.0 km/h speed of operation respectively. However, in case of fourth operation, fuel consumption was merely 1.22, 1.31 and 1.38 l/h at above three speeds respectively. The increase in fuel consumption with increase in speed of operation was due to higher draft. Similarly, the decrease in fuel consumption with increase in number of operation was due to decrease in draft because of loosening of soil in subsequent ploughing operations.

The average depth of operation during first operation was observed marginally lower than other subsequent operations for all three forward speeds. It was mainly due to compact soil during first operation, which resulted in lesser depth because of higher draft. The average depth was found to be 9.5 cm during first operation and 10.6 cm

in all subsequent operations. The average width of operation was determined as 24.92 cm. the field capacity of power tiller with nasooda was found to increase with increase in speed of operation. The average field capacity at 2.0, 2.5 and 3.0 km/h speeds was 0.03, 0.035 and 0.042 ha/h with corresponding field efficiency of 61.96, 58.33 and 59.28% respectively.

Conclusions

On the basis of field performance study, it may be concluded that the use of modified light weight power tiller operated country plough (Nasooda) for hill region gave satisfactory performance. No breakage any part of machine during test duration.

Acknowledgement

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Design, Development and Field Evaluation of Seed cum Fertilizer Drill

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Abstract

A two row seed cum fertilizer drill was developed as attachment of a light weight power tiller for sowing common crops are sorghum, wheat, Bengal gram etc. the field study was conducted in comparison to bullock drawn seed drill with power tiller operated seed cum fertilizer drill. The field capacity of the power tiller drawn seed cum fertilizer drill was about 44%, 19% for wheat and sorghum 27% height for Bengal gram than that of animal drawn seed drill. No appreciable difference was observed in the field efficiency of both the seed drills. The plant population was high in power tiller drawn seed drill for all the crops. The yield of all the crops was greater for the power tiller seed cum fertilizer drill as compared to bullock drawn seed drill.

Introduction

The power tillers were introduced in Indian Agriculture in 1960 through imports against ten credits from Japan. These were primarily conceived as a source of power for rotary tilling and to some extent for transport until recently; the only attachments provided with power tiller were rotter and pull (Trailer) and some cases, mould board plough and ridger etc. due to many numbers of implements, the power tiller owner had maintain a pair of bullocks also, and therefore, the power tiller could remain only as a supplementary source of power with very little impact on the mechanization of India farming. The limited annual use also adversely affected the operational economics of power tillers.

To increase the annual use of power tiller, it is essential to develop the matching implements. Further, the development of matching implements would lead to timeliness of operations and increase in the command area of the power tiller. Keeping these facts in view and the role of seed cum fertilizer drills in proper placement of seed and fertilizer and their subsequent effects on productivity, a power tiller drawn seed cum fertilizer drill was developed at Department of Farm Machinery and Power Engineering, college of technology, GB Pant University of Agricultural and Technology, Pantnagar, India.

Materials and Methods

Design considerations : Much of the areas in the same of Uttarakhand and Tarai belt of Uttarakhand falls under the sandy loam soil with high stone and humus content. The common crops grown in these soils are sorghum, mandua, wheat, Bengal gram, pea etc. therefore, the furrow openers of the seed drill should be such that they do not clog during operation and metering mechanism should be able to meter the seeds of the common crops accurately. Normally a 3-5 hp power tiller is able to

generate 40 to 60 kg draft in well prepared soils at a speed of 2-3 km/h. Therefore, the size of the power tiller is able to pull it without excessive slip. Furthermore, the height the unit should be such that it should cause any inconvenience to the operator in using control and seed cum fertilizer drill should be easily maneuverable.

Constructional Features : The unit mainly consists of the mainframe, seed and fertilizer box, fluted roller type metering mechanism, ground wheel, depth control assembly wooden beam for hitching mechanism etc. (Fig 1). The specifications of the main components of seed cum fertilizer drills are given Table-1.

Hitching Arrangement : Considering the factors like balancing and stability of the matching unit, maneuverability's especially at turns and locations of hitch point of the power tiller, a wooden beam and depth adjustment unit as shown in Figure 1. was developed. The hitching wooden beam made of season (*Delberzia shishoo* L.) wood and depth adjustment assembly consisting of an axle and two cast iron wheels for easing turning and adjustment.

Results and Discussion

Laboratory Testing : The seed cum fertilizer drill was tested under laboratory conditions by metering wheat, Bengal gram, sorghum, seeds and DAP and gomor fertilizer for uniformity of distribution in different rows, mechanical damage to seeds and capacity of the mechanism to achieve the desired seed and fertilizer application rates.

The test result (Table 2&3) shown that maximum deviation of seed and fertilizer delivery from both furrow openers was 5.0 to 5.5 of average seed and fertilizer delivery respectively, which is within the permissible limits specified by Bureau of Indian Standards. As seen from Table 4, the mechanical damage was observed only in Bengal gram seeds with visible damage of 4%. The

Table-1 : Specification of main components of seed cum fertilizer drill.

Sl. No.	Component	Specification
1.	Specification	
	Length	1035, mm
	Width	375, mm
	Height	750, mm
	Weight	25, mm
2.	Seed cum fertilizer box	Trapezoidal, length 375 mm, top width 260 mm, bottom width 210 mm, height 250 mm.
3.	Transport wheel assembly	2 wheel flat, 200 mm diameter attached on 360 mm long axle
4.	Ground wheel	Spiked 290 mm diameter
5.	Furrow openers	2, depending on row to row spacing of crop, inverted 'T' type, 120 mm long with provision for separate seed and fertilizer delivery
6.	Power transmission	Chain and sprocket type
7.	Depth control	Adjusting the position of holes on depth control system
8.	Seed and fertilizer metering	Fluted roller with adjustable opening

Table-2 : Data showing Uniformity of Distribution of seed and fertilizer for different furrow openers.

Seed/Fertilizer	Weight from different furrow openers			
	1	2	3	4
Wheat	169	172	170	170.0
Bengal Gram	54	56	58	55.0
Sorghum	172	174	173	173.0
DAP	270	271	270.5	270.5
Gromor	136	138	138.5	135.5

Table-3 : Capacity of seed cum fertilizer drill for metering different seeds and fertilizers.

Seed/Fertilizer	Row spacing, cm	Seed and fertilizer application rate, kg/ha	
		Zero setting of fluted roller	Full setting of fluted roller
Wheat	22.5	4.42	402
Bengal Gram	30.0	0	284
Sorghum	45.0	3.05	165
DAP	22.5	42.5	1205

Table-4 : Mechanical damage to seed from various furrow openers.

Seed	Mechanical damage from different furrow openers		Average
	1	2	
Wheat	0	0	0
Bengal Gram	0.5	0.8	0.65
Sorghum	0	0	0

Table-5 : Test results of power tiller seed cum fertilizer drill and animal drawn seed cum fertilizer drill.

Parameter	Power tiller seed drill			Animal drawn seed drill		
	Wheat	Bengal Gram	Sorghum	Wheat	Bengal Gram	Sorghum
Soil moisture, % (db)	17.3	17.0	18	17.2	17.5	18.5
Size of machine, cm	2x22.5	2x30	2x35	2x22.5	2x30	2x32.5
Speed of operation, km/h	2.5	2.4	2.5	2	2.3	2.4
Effective field capacity, ha/h	0.0839	0.105	0.105	0.047	0.077	0.099
Field efficiency, %	74.59	73	70	52	56	59
Depth of seed placement, cm	5	6	5	5	6.5	5.3
Depth of fertilizer placement, cm	5.5	6.5	5.4	5.5	6.7	5.4
Plant population, No./ha, (million)	1.89	0.69	0.59	1.84	0.64	0.56
Viability of seed, %	94	97	84	91	94	81
Average plant emergence, %	86	91.5	79.0	85	88	77
Yield, q/ha	40	22	13	37	19	11.5



Fig-1 : Schematic view of power tiller operated seed cum fertilizer drill.

capacity of seed drill was sufficient to accommodate the recommended seed and fertilizer application rates for the crops of the region.

Field Evaluation : The seed cum fertilizer drill was tested for the performance for sowing wheat, Bengal gram and sorghum crops and was compared with single row animal drawn seed cum fertilizer drill under statically designed experiments. The test results with regard to effective field capacity, plant emergence, yield etc. are shown in Table-5.

The data indicates that the field capacity of the power tiller drawn seed cum fertilizer drill was about 44%, 19% for wheat and sorghum 24% higher for Bengal gram than that of animal drawn seed drill. This was due to greater time loss in turning the bullocks and overlapping

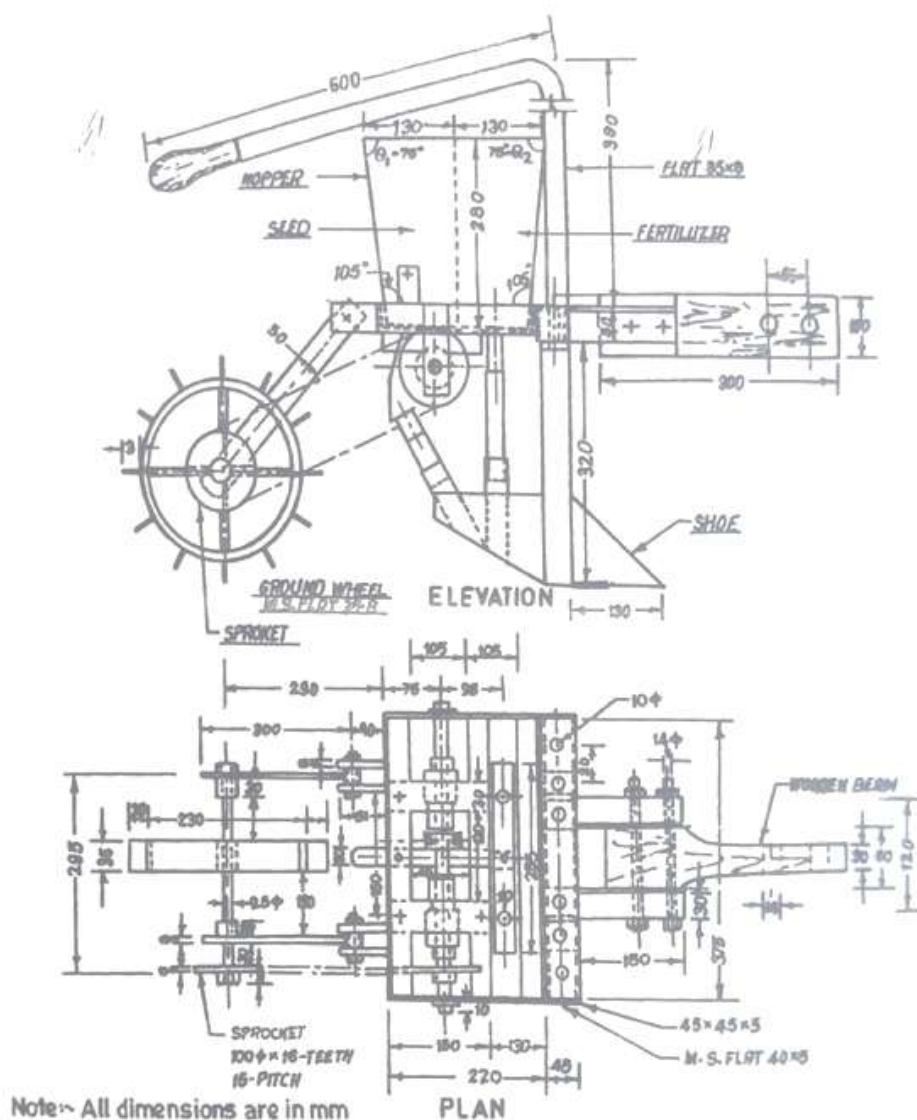


Fig-2 : Plan and elevation of two row power tiller drawn seed cum fertilizer drill.

of rows in bullock drawn seed cum fertilizer drill. The size of bullocks of hills was 150 to 250 kg so it cannot pull two rows seed drill easily. No appreciable difference was observed in field efficiency of both the seed drills. The plant population was high in power tiller drawn seed cum fertilizer drill for all the crops mainly due to skidding of the ground wheel of animal drawn seed drill, which affected the seed rate. Skidding of the ground wheel of animal drawn seed drill was caused by the choking of the fertilizer metering system, which restricted free movement of the ground wheel. This problem was not encountered in the power tiller drawn seed drill due to heavier ground wheel with greater number of spikes.

The yield of all the crops was greater for the case of power tiller seed cum fertilizer drill as compared to bullock drawn seed drill mainly due to higher plant population and proper drilling of fertilizer.

Conclusions

The field capacity of the power tiller drawn seed cum fertilizer drill was about 44% for wheat and 19% sorghum and 27% higher for Bengal gram in comparison to animal drawn seed drill.

The yield of all the crops was greater for the power tiller drawn seed cum fertilizer drill as compared to bullock drawn drill.

On the basis of these, the field performance of power tiller drawn seed cum fertilizer drill was satisfactory.

Acknowledgement

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Evaluation of Selected Insecticides against Sucking Pests of Okra (*Abelmoschus esculentus* L. Moench) under Field Conditions

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Abstract

The present experiment was done during *kharif* season of 2020-21, to evaluate the selected insecticides against sucking pests (whiteflies, jassids and aphids) of okra on the farmer field conditions in Satna district of MP. Seven treatments including control with three replications were taken up by using randomized block design (RBD). Three foliar sprays of insecticides on okra crop were applied at different day's interval. First spray was done at economic threshold level (ETL) of insects and second and third subsequently at 15th days interval for effectively control of sucking pests of okra. The data were recorded at one day before spraying and 3rd, 7th, and 15th days after the spray from each plot. Results revealed that all the treatments were found significantly superior over control. After data analysis it was found that among all the treatments, Beta-cyfluthrin 8.49 % + Imidacloprid 19.81 % OD @ 350 ml/ha (T₃) was found to be the most effective insecticide which showed the lowest number of whiteflies (1.32), jassids (1.27) and aphids (2.21) per 3 leaves respectively, followed by Diafenthiuron 47 % + Bifenthrin 9.4 % SC @ 625 ml/ha (T₁) which showed whitefly (1.44), jassids (1.45) and aphids (2.39) per 3 leaves respectively. In the control plot, the maximum number of whiteflies, jassids and aphids was observed per 3 leaves, which were 9.74, 9.51 and 12.10 respectively.

Key words : Evaluation, insecticides, *kharif*, sucking pests, *Abelmoschus esculentus*.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is most popular vegetable of the family Malvaceae. In India, it is grown both in *summer* and *rainy* seasons (Lal and Sinha, 2005). Tender fruits of okra are used as vegetable or in culinary preparations as sliced and dried pieces. It is also used for thickening gravies and soups, because of its high mucilage content. They are also good source, vitamins, proteins, carbohydrates, minerals, iron, calcium, potassium and acids *viz.*, rhamnose (22 %), galacturonic acid (27 %) and amino acid (11 %). It is an important vegetable crop cultivated all over India with a major share in state of Maharashtra, West Bengal, Uttar Pradesh, Karnataka, Gujarat and Madhya Pradesh (Shinde *et al.*, 2007). In Madhya Pradesh, area, production and productivity of okra is 40.12 thousand ha, 536.73 thousand MT, 13.38 MT/ha, individually (Anonymous, 2017). Insect pests are the principle bottleneck in development of this yield. One of the important limiting factors in the cultivation of okra is insect pests. As high as 72 species of insects have been recorded on okra (Srinivasa and Rajendran, 2003), of which, the sucking pests comprising of Aphids, *Aphis gossypii* (Glover), leafhopper, *Amrasca biguttula biguttula* (Ishida) and whitefly, *Bemisia tabaci* (Gennadius) causes significant damage to the crop. The sucking pest complex of okra consisting of aphids, jassids, whiteflies and mites causes 17.46 % yield loss and if failure to control them in initial

stages, damage was reported to cause 54.04 % yield loss (Anitha and Nandihalli, 2008).

Among different sucking insect pests; jassids, whiteflies and aphids are more serious and transmit certain viral diseases. In general, the overall damage due to insect pests accounts to 40-45 % crop yield losses (Subbireddy *et al.*, 2018) and ultimately increase the level of damage up to 60-70 % in optimal conditions. Jassids both nymphs and adults suck the cell sap usually from the lower surface of the leaves and while feeding inject toxic saliva into plant tissues, affected leaves turn yellowish and curl. Whitefly are the milky white minute flies; nymphs and adults suck the cell sap from the leaves. The affected leaves are curled and dried. The affected plants show a stunted growth. Whiteflies are also responsible for transmitting yellow vein mosaic virus (Singh *et al.*, 2008). Due to its rapid movement from one plant to another, high reproductive potential and its living habitat, management of this pest is very difficult (Fouly *et al.*, 2011). For this purpose the current investigation will be undertaken with the accompanying objectives to evaluate the selected insecticides against sucking pests of okra under field conditions.

Materials and Methods

The experiment was conducted during *kharif*, 2020-21 on the farmer field conditions in Satna district of Madhya Pradesh to evaluate the selected insecticides against sucking pests (whitefly, jassids and aphids) of okra. The

okra seeds of variety *Kashi pragati* were sown by dibbling method with spacing of 45 cm×30 cm by placing 2-3 seeds per hill on 25th June 2020. Gap filling and thinning was done to maintaining the optimum plant density and prevents competition among the plants. The crop was raised under standard agricultural practices with a fertilizer dose of 120:60:60 kg NPK/ha. The experiment was laid out in randomized block design with seven treatments including control and three replications. The treatments viz; Diafenthiuron 47 % + Bifenthrin 9.4 % SC (T₁), Pyriproxyfen 10 % + Bifenthrin 10 % EC (T₂), Beta-cyfluthrin 8.49 % + Imidacloprid 19.81 % OD (T₃), Flonicamid 50 % WG (T₄), Thiamethoxam 25 % WG (T₅), Acetamiprid 20 % SP (T₆). Three sprays of insecticides on okra crop were applied. First spray was done at economic threshold level (ETL) of insects and second and third subsequently at 15 days interval for effectively control of sucking pests of okra as against the farmers practice. The observations on the number of whiteflies (*Bemisia tabaci*, Gennadius), leafhoppers (*Amrasca biguttula biguttula*, Ishida) and aphids (*Aphis Gossypii*, Glover) were made, a day before spraying, followed by 3rd, 7th and 15th days after spray. The data were recorded from three leaves each from top, middle and bottom leaves from the five randomly selected and tagged plants from each plot without disturbing the plants to minimize the observational errors. Population of sucking pest was recorded from each net plot and the population was worked out per three leaves. The data were subjected to statistical analysis. The treatment details given in table-1.

Results and Discussion

The results of the study on the evaluation of selected insecticides against sucking pests of okra like whiteflies, jassids and aphids population are presented in Table-2, Table-3 and Table-4 respectively. On the basis of recorded data on whiteflies, jassids and aphids population result revealed that all the treatments were significantly superior over control and non-significant difference among the different treatments.

Whiteflies : The data on number of whiteflies/3 leaves of okra under field conditions is furnished in table-2. Results revealed that all the treatments were significantly superior over control. Among all the treatments Beta-cyfluthrin 8.49 % + Imidacloprid 19.81 % OD (1.32 whiteflies/3 leaves) is the most effective and recorded lowest population of whitefly, followed by Diafenthiuron 47 % + Bifenthrin 9.4 % SC (1.44 whiteflies/3 leaves), Pyriproxyfen 10 % + Bifenthrin 10 % EC (2.07 whiteflies/3 leaves) and Flonicamid 50 % WG (2.17 whiteflies/3 leaves) are at par with each other. Next effective treatment was Thiamethoxam 25 % WG (3.04 whiteflies/3 leaves), followed by Acetamiprid 20 % SP (3.51 whiteflies/3

leaves), while untreated control (9.74 whiteflies/3 leaves) is least effective among all the treatments. These findings are in accordance with the findings of Begum and patil (2016) reported that Imidacloprid was the most effective treatment indicating reduction in population of jassids and whiteflies. Similarly, Pawar *et al.*, (2016) reported that; mean population of jassids, aphids and whitefly after three sprays revealed that Imidacloprid was effective and superior insecticide for the control of whitefly, jassids and aphids. Preetha *et al.*, (2009) reported that Imidacloprid was found to be most effective neonicotinoids group insecticide against jassids, aphids and whiteflies. Sarkar *et al.*, (2016) explain that performance of insecticides against whitefly was recorded lowest mean population with imidacloprid treated plot.

Jassids : The data on number of jassids/3 leaves of okra under field conditions is furnished in table-3. Results revealed that all the treatments were significantly superior over control. Among all the treatments Beta-cyfluthrin 8.49 % + Imidacloprid 19.81 % OD (1.27 jassids/3 leaves) recorded lowest population, followed by Diafenthiuron 47 % + Bifenthrin 9.4 % SC (1.45 jassids/3 leaves). Next effective treatment was Pyriproxyfen 10 % + Bifenthrin 10 % EC (1.97 jassids/3 leaves) and Flonicamid 50 % WG (2.12 jassids/3 leaves), followed by Thiamethoxam 25 % WG (3.01 jassids/3 leaves) while Acetamiprid 20 % SP (3.52 jassids/3 leaves) is least effective among all the treatments. These findings are in accordance with the findings of Preetha *et al.*, (2009) reported that Imidacloprid was found effective against aphids, jassids and whiteflies, the other neonicotinoid, Thiamethoxam also provided similar levels of protection as that of Imidacloprid. Similarly, Begum and patil (2016) reported that Imidacloprid was the most effective insecticide indicating reduction in population of jassids and whitefly. Pawar *et al.*, (2016) reported that; mean population of jassids, aphids and whiteflies after three sprays revealed that Imidacloprid was effective and superior insecticide. Dabhi *et al.*, (2016) reported that Imidacloprid and Diafenthiuron were found to be most effective against jassids (81 %) infesting okra crop.

Aphids : The data on number of aphids/3 leaves of okra under field conditions is furnished in table-4. Results revealed that all the treatments were significantly superior over control. Among all the treatments Beta-cyfluthrin 8.49 % + Imidacloprid 19.81 % OD (2.21 aphids/3 leaves) recorded lowest population, followed by Diafenthiuron 47 % + Bifenthrin 9.4 % SC (2.39 aphids/3 leaves). Next effective treatment was Pyriproxyfen 10 % + Bifenthrin 10 % EC (2.78 aphids/3 leaves) and Flonicamid 50 % WG (3.07 aphids/3 leaves), followed by Thiamethoxam 25 % WG (3.86 aphids/3 leaves) while Acetamiprid 20 % SP

Table-1 : List of treatments to be used.

Sl. No.	Treatment Details	Dose/ha		Water (lit/ha)
		gm. a.i.	Formulation (ml)	
T ₁	Diafenthiuron 47 % + Bifenthrin 9.4 % (SC)	352	625	375
T ₂	Pyriproxyfen 10 % + Bifenthrin 10 % (EC)	125	625	375
T ₃	Beta-cyfluthrin 8.49 % + Imidacloprid 19.81 % (OD)	102	350	375
T ₄	Flonicamid 50 % (WG)	375	750	375
T ₅	Thiamethoxam 25 % (WG)	62.5	250	375
T ₆	Acetamiprid 20 % (SP)	75	375	375
T ₇	Untreated (Control)	-	-	-

Table-2 : Evaluation of selected insecticides against whiteflies of okra at different day's interval.

Sl. No.	Treatments	Number of whiteflies/3 leaves								Overall Mean
		First spray				Second spray				
		1 DBS	3 DAS	7 DAS	15 DAS	1 DBS	3 DAS	7 DAS	15 DAS	
01	Diafenthiuron 47 % + Bifenthrin 9.4 % (SC)	7.52 (2.74)	1.43 (1.23)	1.26 (1.12)	1.93 (1.39)	5.73 (2.36)	1.40 (1.17)	1.12 (1.06)	1.53 (1.23)	1.44 (1.21)
02	Pyriproxyfen 10 % + Bifenthrin 10 % (EC)	7.93 (2.81)	1.92 (1.39)	1.69 (1.29)	2.75 (1.65)	6.52 (2.52)	2.06 (1.43)	1.67 (1.29)	2.34 (1.52)	2.07 (1.43)
03	Beta-cyfluthrin 8.49 % + Imidacloprid 19.81 % (OD)	7.64 (2.76)	1.46 (1.21)	1.13 (1.06)	1.73 (1.31)	5.82 (2.40)	1.31 (1.15)	1.06 (1.03)	1.25 (1.12)	1.32 (1.15)
04	Flonicamid 50 % (WG)	7.74 (2.77)	2.15 (1.43)	1.76 (1.31)	2.64 (1.63)	6.93 (2.62)	2.11 (1.45)	1.86 (1.36)	2.52 (1.59)	2.17 (1.47)
05	Thiamethoxam 25 % (WG)	7.15 (2.66)	2.86 (1.59)	2.25 (1.43)	3.48 (1.77)	7.13 (2.65)	3.12 (1.77)	2.84 (1.68)	3.69 (1.88)	3.04 (1.60)
06	Acetamiprid 20 % (SP)	7.36 (2.70)	3.32 (1.80)	2.97 (1.71)	3.76 (1.93)	7.33 (2.67)	3.48 (1.86)	3.16 (1.76)	4.35 (2.08)	3.51 (1.86)
07	Untreated (Control)	6.95 (2.63)	7.29 (2.69)	7.96 (2.81)	8.57 (2.92)	9.94 (3.14)	10.42 (3.22)	11.63 (3.41)	12.58 (3.54)	9.74 (3.11)
	S. Ed. (±)	0.23	0.02	0.04	0.03	0.23	0.04	0.03	0.02	-
	C.D. (P = 0.05)	NS	0.06	0.14	0.08	NS	0.11	0.08	0.07	-

Table-3 : Evaluation of selected insecticides against jassids of okra at different day's interval.

Sl. No.	Treatments	Number of jassids/3 leaves								Overall Mean
		First spray				Second spray				
		1 DBS	3 DAS	7 DAS	15 DAS	1 DBS	3 DAS	7 DAS	15 DAS	
01	Diafenthiuron 47 % + Bifenthrin 9.4 % (SC)	6.96 (2.62)	1.47 (1.21)	1.28 (1.12)	1.86 (1.36)	5.14 (2.24)	1.27 (1.12)	1.16 (1.06)	1.69 (1.29)	1.45 (1.20)
02	Pyriproxyfen 10 % + Bifenthrin 10 % (EC)	6.88 (2.18)	1.75 (1.31)	1.28 (1.12)	3.34 (1.82)	6.26 (2.48)	1.75 (1.31)	1.48 (1.21)	2.25 (1.50)	1.97 (1.40)
03	Beta-cyfluthrin 8.49 % + Imidacloprid 19.81% (OD)	6.82 (2.60)	1.27 (1.12)	1.13 (1.06)	1.75 (1.31)	5.25 (2.25)	1.13 (1.06)	0.88 (0.93)	1.47 (1.21)	1.27 (1.12)
04	Flonicamid 50 % (WG)	6.92 (2.62)	1.84 (1.36)	1.35 (1.15)	3.82 (1.94)	6.29 (2.49)	1.96 (1.39)	1.53 (1.23)	2.24 (1.52)	2.12 (1.46)
05	Thiamethoxam 25 % (WG)	6.85 (2.61)	2.53 (1.59)	2.24 (1.50)	3.73 (1.93)	6.96 (2.59)	3.07 (1.75)	2.95 (1.71)	3.56 (1.88)	3.01 (1.72)
06	Acetamiprid 20 % (SP)	6.54 (2.55)	2.89 (1.69)	2.38 (1.52)	4.15 (2.03)	7.28 (2.65)	3.67 (1.91)	3.46 (1.86)	4.68 (2.16)	3.54 (1.87)
07	Untreated (Control)	6.87 (2.61)	7.48 (2.73)	7.95 (2.81)	8.63 (2.93)	10.12 (3.15)	10.66 (3.26)	11.48 (3.38)	10.89 (3.29)	9.51 (3.08)
	S. Ed. (±)	0.28	0.03	0.05	0.03	0.28	0.02	0.03	0.02	-
	C.D. (P = 0.05)	NS	0.09	0.10	0.09	NS	0.07	0.08	0.07	-

Table-4 : Evaluation of selected insecticides against aphids of okra at different day's interval.

Sl. No.	Treatments	Number of aphids/3 leaves								Overall Mean
		First spray				Second spray				
		1 DBS	3 DAS	7 DAS	15 DAS	1 DBS	3 DAS	7 DAS	15 DAS	
01	Diafenthiuron 47 % + Bifenthrin 9.4 % (SC)	10.97 (3.52)	2.34 (2.24)	2.18 (2.17)	2.84 (2.34)	7.26 (3.22)	2.23 (2.13)	2.16 (2.06)	2.59 (2.21)	2.39 (2.19)
02	Pyriproxyfen 10 % + Bifenthrin 10 % (EC)	8.76 (3.12)	2.63 (2.23)	2.25 (2.11)	3.42 (2.72)	7.33 (3.24)	2.84 (2.35)	2.38 (2.26)	3.17 (2.53)	2.78 (2.37)
03	Beta-cyfluthrin 8.49 % + Imidacloprid 19.81 % (OD)	7.84 (3.41)	2.21 (2.13)	2.16 (2.06)	2.63 (2.23)	6.41 (3.15)	2.27 (2.17)	1.68 (1.88)	2.32 (2.26)	2.21 (2.12)
04	Flonicamid 50 % (WG)	7.93 (3.54)	2.76 (2.26)	2.45 (2.13)	4.52 (2.82)	7.36 (3.48)	2.89 (2.39)	2.57 (2.17)	3.26 (2.42)	3.07 (2.36)
05	Thiamethoxam 25 % (WG)	7.95 (3.39)	3.42 (2.46)	3.11 (2.31)	4.64 (2.84)	7.86 (3.56)	4.05 (2.72)	3.74 (2.63)	4.23 (2.83)	3.86 (2.63)
06	Acetamiprid 20 % (SP)	7.66 (3.47)	3.79 (2.53)	3.26 (2.46)	5.18 (3.05)	8.27 (3.62)	4.45 (2.81)	4.32 (2.76)	5.48 (3.19)	4.41 (2.80)
07	Untreated (Control)	8.53 (3.56)	8.61 (3.73)	9.14 (4.12)	9.87 (4.97)	10.34 (4.25)	11.42 (4.62)	12.39 (5.17)	12.66 (5.84)	12.10 (4.74)
	S. Ed. (±)	0.34	0.07	0.09	0.07	0.34	0.06	0.07	0.06	-
	C. D. (P = 0.05)	NS	0.11	0.12	0.10	NS	0.09	0.10	0.09	-

(4.41 aphids/3 leaves) is least effective among all the treatments. These findings are in accordance with the findings of Preetha *et al.*, (2009) reported that Imidacloprid was found effective against aphids, jassids and whiteflies, the other neonicotinoid, Thiomethoxam also provided similar levels of protection as that of Imidacloprid. Similarly Pawar *et al.*, (2016) reported that; mean population of aphids, jassids and whiteflies after three sprays revealed that Imidacloprid was effective and superior insecticide.

Conclusions

Based on the findings of the present investigation, it can be concluded that combi insecticides like Beta-cyfluthrin 8.49 % + imidacloprid 19.81 % OD and Diafenthiuron 47 % + Bifenthrin 9.4 % SC are able to best control of whiteflies with (1.32 whiteflies/3 leaves), (1.44 whiteflies/3 leaves), followed by jassids (1.27 jassid/3 leaves), (1.45 jassids/3 leaves) while aphids (2.21 aphids/3 leaves), (2.39 aphids/3 leaves), of okra respectively. These insecticides are the most effective insecticides among other group of insecticides can be suitably incorporated in pest management against sucking pests like whiteflies, jassids and aphids of different crops.

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A Study on Perception and Adoption of Soil Health Cards (SHCs) by the farmers in Coastal Districts of Andhra Pradesh

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Abstract

The paper has analyzed the Perception and adoption of Soil Health Cards (SHC) by the farmer in Coastal districts of Andhra Pradesh. Soil Health Card (SHC) is a Government of India's scheme promoted by the Department of Agriculture & Co-operation under the Ministry of Agriculture and Farmers' Welfare. Soil Health Card scheme was launched by the Prime Minister of India. Shri Narendra Modi on 19 February 2015 at Suratgarh in Rajasthan. Soil Health Card Scheme is a very beneficial scheme for farmers. The results indicate that majority (45.00%) of the farmers had medium level of perception about soil health cards, majority (68.34%) expressed that lack of awareness about soil health card recommendation was major constraint, Conduct more number of pre seasonal awareness programmes on soil health management was the major suggestion elicited by farmers (65.00%) and Lack of awareness about site specific nutrient management among farmers (73.33%) was the major constraint expressed by DOA officials.

Key words : soil health cards, soil health, perception.

Introduction

Soil health can be defined as capacity of the soil to function as one of the vital living systems, by recognizing that it contains biological elements that are key to the functioning of the ecosystems within certain land-boundaries (Karlen *et al.*, 2001). Soil Health Card (SHC) is a Government of India's scheme promoted by the Department of Agriculture & Co-operation under the Ministry of Agriculture and Farmers' Welfare. Soil Health Card scheme was launched by the Prime Minister of India. Shri Narendra Modi on 19 February 2015 at Suratgarh in Rajasthan. It is being implemented through the Department of Agriculture of all the State and Union Territory Governments. Soil Health Card Scheme is a very beneficial scheme for farmers. There are many farmers in India and they do not know which types of crops they should grow to get maximum yield. Basically, they do not know the quality and the type of their soil. Excess application of fertilizers leads to wide range of nutrient deficiency symptoms in soils. Fertilizers are the main factors responsible for providing adequate food for the world's current population of over 7 billion people, fertilizers will be even more important in sustaining the over 9 billion people projected for 2050. While the primary impact of mineral fertilizers is on crop yields, they also have an indirect effect on the soil in terms of its health and quality. The soil health card (SHC) is a complete evaluation of the quality of soil right from its functional characteristics to water and nutrients content and other biological properties. It contains corrective measures that a farmer should adopt to obtain a better yield. The SHC helps the farmers as the farmers get a well monitored

report about the soil and they are guided by the experts to improve soil health. It also helps the farmers to get crop-wise recommendations of nutrients and fertilizers required in each type of soil. This can help in increasing the crop yield. Considering the importance of this scheme an attempt has been made to study the Perception and adoption of Soil Health Cards (SHC) by the farmer in coastal districts of Andhra Pradesh with the following objectives :

1. To study the perception and adoption of soil health cards
2. To find out the deviations in adoption of SHC recommendations
3. To find out the constraints and suggestions as perceived by the farmers.
4. To find out the constraints and suggestions as perceived by the department officials

Research Methodology

Ex post facto research design was followed for this study. The study was conducted in West Godavari, Visakhapatnam and Vizianagaram districts in which the SHC scheme was implemented since its inception year 2015-16. Out of 122 mandals, three mandals Yelamanchili, Seethanagaram & Akiveedu were selected purposively. From each mandal, 4 villages were selected making a total of 12 villages. From each village, 5 farmers were selected randomly for studying the perception and adoption of Soil health cards.

Table-1 : Distribution of Respondents according to level of Perception about Soil Health Cards (SHCs). (n=60)

S. No.		Frequency	Percentage
1.	Low level of perception	21	35
2.	Medium level of perception	27	45
3.	High level of perception	12	20
	Total	60	100

Table-2 : Distribution of Respondents according to adoption of soil health card recommendations for Paddy crop. Kharif :

S.No.	Nutrients	Less than Recommended		Recommended		Excess		Total freq.	Total %
		F	%	F	%	F	%		
1.	Nitrogen	11	18.33	29	48.33	20	33.33	60	100.00
2.	Phosphorus	42	70.00	12	20.00	6	10.00	60	100.00
3.	Potash	49	81.67	11	18.33	0	0.00	60	100.00
4.	Organic Manures	52	86.67	8	13.33	0	0.00	60	100.00
5.	Micro nutrients	36	60.00	20	33.33	4	6.67	60	100.00

Rabi:

S.No.	Nutrients	Less than Recommended		Recommended		Excess		Total freq.	Total %
		F	%	F	%	F	%		
1.	Nitrogen	21	35.00	7	11.67	32	53.33	60	100.00
2.	Phosphorus	18	30.00	6	10.00	36	60.00	60	100.00
3.	Potash	46	76.67	6	10.00	8	13.33	60	100.00
4.	Organic Manures	52	86.67	8	13.33	0	0.00	60	100.00
5.	Micro nutrients	36	60.00	20	33.33	4	6.67	60	100.00

Table-3 : Constraints/Reasons for Non adoption of SHC recommendations. (n=60)

S. No.	Constraints	F	%	Rank
1.	Lack of awareness about soil health card recommendations	41	68.34	I
2.	Lack of awareness about soil sampling procedure	35	58.32	II
3.	Lack of faith on SHC recommendations	32	53.33	III
4.	Non-availability of Organic manures in the village	24	40.00	IV
5.	Delay in issue of Soil Health Cards	17	28.33	V
6.	Lack of guidance from ground level extension personnel	12	20.00	VI

Table-4 : Suggestions for overcoming constraints in adoption of SHC recommendations. (n=60)

S. No.	Suggestions	F	%	Rank
1.	Conduct more number of pre seasonal awareness programmes on soil health management	39	65	I
2.	Conduct more number of skill trainings for taking soil samples in a more scientific way	32	53.33	II
3.	Timely supply of soil health cards	26	43.33	III
4.	Conduct more number of demonstrations for increasing trust on site specific nutrient management	19	31.67	IV
5.	Ground level extension staff need to be trained	13	21.67	V

Results and Discussion

From table-1, it clearly shows that majority (45.00%) of the farmers had medium level of perception about soil health cards followed by low (35.00%) and high (20.00%) level of perception about SHCs.

From table 3, it shows that majority (68.34%) expressed that lack of awareness about soil health card recommendation was major constraint followed by Lack of

awareness about soil sampling procedure (58.32%), Lack of faith on SHC recommendations (53.33%), Non-availability of organic manures in the village (40.00%), Delay in issue of Soil Health Cards (28.33%) and Lack of guidance from ground level extension personnel (20.00%).

From table-4, it shows that Conduct more number of pre seasonal awareness programmes on soil health management was the major suggestion elicited by

Table-5 : Reasons for non-adoption of Soil Health Cards recommendations as perceived by the DOA officials. (n=30)

S. No.	Reasons for non adoption of SHCs	F	%	Rank
1.	Lack of awareness about site specific nutrient management among farmers	22	73.33	I
2.	Lack of knowledge on calculation of nutrients present in different fertilizers for usage as per recommendations	18	60.00	II
3.	Unhealthy competition among farmers for getting higher yields	17	56.67	III
4.	Majority of the farmers are tenant farmers and their main concentration is only on yields	14	46.67	IV
5.	Lack of awareness about method of taking soil samples among farmers	12	40.00	V
6.	Lack of trust on fertilizer recommendations among farmers	10	33.33	VI
7.	Majority of the farmers depending on fellow farmers for advises	7	23.33	VII
8.	Lack of knowledge on scientific rationality about balanced fertilization among farmers	6	20.00	VIII
9.	Delay in issue of soil health cards	5	16.67	IX

farmers (65.00%) followed by Conduct more number of skill trainings for taking soil samples in a more scientific way (53.33%), Timely supply of soil health cards (43.33%), Conduct more number of demonstrations for increasing trust on site specific nutrient management (31.67%) and Ground level extension staff need to be trained (21.67%).

From table 5, it shows that Lack of awareness about site specific nutrient management among farmers (73.33%) was the major constraint expressed by DOA, followed by Lack of knowledge on calculation of nutrients present in different fertilizers for usage as per recommendations (60.00%), Un healthy competition among farmers for getting higher yields (56.67%), Majority of the farmers are tenant farmers and their main concentration is only on yields (46.67%), Lack of awareness about method of taking soil samples among farmers (40.00%), Lack of trust on fertilizer recommendations among farmers (33.33%), Majority of

the farmers depending on fellow farmers for advises (23.33%), Lack of knowledge on scientific rationality about balanced fertilization among farmers (20.00%), Delay in issue of soil health cards (16.67%).

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Correlation and Path Analysis in Maize (*Zea mays* L.) for Grain Yield and Its Attributes

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Abstract

An investigation was undertaken to study the character association and path analysis in 80 hybrids, 42 parents and 2 checks of maize for grain yield per plant at the Regional Research Station, CCSHAU, Uchani, Karnal during the *kharif* season of 2021 in Randomized Block Design with three replications. Correlation and path analysis in 80 hybrids along with its 42 parents for seventeen morphological as well as biochemical traits were studied in relation to checks viz. HM8 and HM11. Analysis of correlation revealed that the magnitude of genotypic and phenotypic correlation had positive and significant association for the trait grain yield per plant with number of grains per cob followed by number of kernels per row, test weight, shelling percentage, cob diameter, cob length, number of cobs per plant, plant height, physiological maturity, number of rows per cob, days to tasseling, days to silking and ear height whereas negative and non significant association was exhibited in lysine content and protein content while in tryptophan percentage positive and non significant association was exhibited. The positive direct effect on grain yield at genotypic level was exerted by number of grains per cob followed by 100 grains weight, days to tasseling, days to silking, number of cobs per plant, plant height, ear height, physiological maturity and tryptophan content whereas cob length, cob diameter, number of rows per cob, number of kernels per row, shelling percentage and lysine percentage exhibited negative direct effect on grain yield per plant indicated that selection for high grain yield can be done by indirect selection through yield components.

Key words : Maize, correlation, path, genotypic, phenotypic.

Introduction

Maize, scientifically known as *Zea mays* L., holds significant position among the cereal crops and is the third most important cereal crop in the world after rice and wheat considering growing area, production and productivity. It belongs to the family Poaceae and tribe Maydeae. Due to its wider adaptability, it is widely cultivated cereal worldwide and a staple food in many developing countries (Murdia *et al.*, 2016). It is known as the “Queen of cereals,” because of its exceptional higher yield potential among the cereals (Kannan *et al.*, 2013). Maize has earned a well-deserved reputation as “Poor man’s nutri cereal” due to its high nutritional value, being rich in carbohydrates, fats, proteins and some of the most essential vitamins and minerals. Its diverse applications are a testament to its versatility in meeting various needs. Approximately, 25% of maize is utilized for direct human consumption, while 12% is used as animal feed, 49% goes in poultry feed, 12% in starch, 1% in beer and 1% seeds (Elayaraja *et al.*, 2016).

The major states producing maize during *kharif* season are Karnataka, Andhra Pradesh, Maharashtra, MP, UP, Punjab and Haryana. It is also grown in Bihar, Punjab, Haryana, UP, Karnataka and coastal of Andhra Pradesh *etc.* during *Rabi* season as well. Maize is highly cross pollinated crop therefore, there are many

opportunities to take advantage of hybrid vigour, depending on the direction, strength and type of gene action. Maize is most productive in terms of food nutrients produced per unit of water transpired and per unit of time under the conditions for C₄ plants (David and Poehlman, 2007). It is a one-of-a-kind crop that can be used at any stage of development as food and fodder in addition to hundreds of industrial applications. About 50 to 60 percent of maize production in India is consumed as food for humans and feed for cattle, while 30 to 35 percent goes to poultry, piggery, and fish meal and 10 to 12 percent in wet milling for starch and oil extraction. Around 3 percent is used in dry milling for traditional food requirements like Dalia, Sattu and other food products such as corn bread and corn chips. Moreover, maize is one of the major fodder crops in northwest India during the summer season (Singh *et al.*, 2017). As a commodity for trade, maize holds a dominant position in the global economy. Its popularity is increasing in India, especially in the poultry feed industry, due to its high demand.

The correlation of different yield components with yield is considered to be highly significant based on indirect selection. Simple phenotypic correlation reveals the type of association between distinct features but is not a reliable basis for selection. As a result, a genotypic correlation based on the inheritance of the observed variation allows for the assessment of the pattern of underlying association that exists among the various

features. Path coefficient analysis is used to distinguish the interaction between characters into direct and indirect effects and to determine the relative importance of the causal factors involved. It is just a standardized partial regression coefficient that evaluates the direct influence of one variable on another. Plant breeders can utilize associated characteristics as selection criteria to identify traits that are useful as selection criteria to improve grain yield.

Materials and Methods

The 40 inbred lines and 2 testers were crossed in line x tester mating design during *khari* 2020 at RRS Uchani, CCS HAU, Karnal. The resultant 80 hybrids along with 42 parents and 2 checks were evaluated during *khari* 2021 at RRS Uchani, CCS HAU, Karnal. Correlation coefficient was determined as described by Singh and Choudhary (1979). The correlation coefficients were partitioned into direct and indirect effects using the path coefficient analysis according to Dewey and Lu (1959).

Results and Discussion

Genotypic correlations demonstrate the existence of significant associations, whereas phenotypic correlations can happen by coincidence. Significant phenotypic correlations are worthless without the presence of significant genotypic relationships. If the genotypic association is significant but the phenotypic correlation is not, it indicates that the existing real association is being masked by the impact of the environment.

From the table-1 and table-2, it is evident that all the traits had positive genotypic and phenotypic effect on grain yield per plant. Highest genotypic correlation was exhibited by the character number of grains per cob (0.949**) followed by number of kernels per row (0.943**), test weight (0.926**), shelling percentage (0.861**), cob diameter (0.836**), cob length (0.705**), number of cobs per plant (0.621**), plant height (0.512**), physiological maturity (0.425**), number of rows per cob (0.376**), days to tasseling (0.366**), days to silking (0.365**) and ear height (0.107*) whereas negative and non significant association was exhibited in lysine content (-0.102) and protein content (-0.053) while in tryptophan positive and non significant association percentage was

Table-1 : Genotypic correlation coefficient of the various traits of maize inbred lines on the grain yield per plant.

Traits	DT	DS	PM	PH	EH	CL	CD	NRC	NKR	NGC	TW	NCP	SH	P	LYS	TRY
DT	1.000															
DS	1.000**	1.000														
PM	0.924**	0.927**	1.000													
PH	0.164**	0.158**	0.286**	1.000												
EH	-0.018	-0.018	0.074	0.669**	1.000											
CL	0.248**	0.239**	0.322**	0.432**	0.235**	1.000										
CD	0.268**	0.279**	0.388**	0.540**	0.124*	0.619**	1.000									
NRC	0.175**	0.175**	0.189**	0.016	0.004	0.276**	0.300**	1.000								
NKR	0.364**	0.361**	0.421**	0.491**	0.073	0.667**	0.796**	0.223**	1.000							
NGC	0.380**	0.377**	0.436**	0.442**	0.072	0.681**	0.787**	0.524**	0.944**	1.000						
TW	0.328**	0.330**	0.386**	0.481**	0.070	0.628**	0.835**	0.178**	0.836**	0.783**	1.000					
NCP	0.106**	0.096	0.127*	0.396**	0.199**	0.521**	0.450**	0.161**	0.591**	0.582**	0.462**	1.000				
SH	0.334**	0.335**	0.398**	0.494**	0.040	0.596**	0.834**	0.258**	0.831**	0.811**	0.865**	0.404**	1.000			
P	-0.241**	-0.244**	-0.226**	-0.094	-0.037	-0.021	0.133*	-0.082	-0.076	-0.108*	0.105*	-0.371**	0.141**	1.000		
LYS	0.116*	0.102*	0.080	-0.013	-0.059	-0.062	-0.308**	-0.070	-0.133*	-0.124*	-0.139**	0.063	-0.159**	-0.516**	1.000	
TRY	0.064	0.062	0.101*	0.147**	-0.007	0.075*	0.007	-0.036	0.037	0.037	0.093*	0.115**	0.097	-0.305**	0.765**	1.000
GYP	0.366**	0.365**	0.425**	0.512**	0.107*	0.705**	0.836**	0.376**	0.943**	0.949**	0.926**	0.621**	0.861**	-0.053	-0.102	0.097

DT- Days to tasseling, DS- Days to silking, PM- Physiological maturity, PH- Plant height (cm), EH- Ear height (cm), CL- Cob length (cm), CD- Cob diameter (cm), NRC- Number of rows per cob, NK- Number of kernels per row, NGC- Number of grains per cob, TW- Test weight (g), NCP- Number of cobs per plant, SH- Shelling percentage (%), P- Protein content, LYS- Lysine percentage (%), TRY- Tryptophan percentage (%), GYP- Grain yield per plant (g)

Table-2 : Phenotypic correlation coefficient of the various traits of maize inbred lines on the grain yield per plant.

Traits	DT	DS	PM	PH	EH	CL	CD	NRC	NKR	NGC	TW	NCP	SH	P	LYS	TRY
DT	1.000															
DS	0.992**	1.000														
PM	0.858**	0.866**	1.000													
PH	0.151**	0.147**	0.223**	1.000												
EH	-0.008	-0.006	0.066	0.651**	1.000											
CL	0.231**	0.225**	0.291**	0.379**	0.217**	1.000										
CD	0.244**	0.258**	0.349**	0.460**	0.117	0.609**	1.000									
NRC	0.158**	0.163**	0.169**	0.028NS	0.001	0.254**	0.268**	1.000								
NKR	0.336**	0.334**	0.374**	0.431**	0.072	0.658**	0.769**	0.227**	1.000							
NGC	0.349**	0.350**	0.387**	0.388**	0.069	0.667**	0.755**	0.532**	0.941**	1.000						
TW	0.295**	0.300**	0.333**	0.410**	0.070	0.608**	0.794**	0.185**	0.805**	0.755**	1.000					
NCP	0.082	0.075	0.079NS	0.294**	0.162**	0.467**	0.387**	0.156**	0.524**	0.518**	0.411**	1.000				
SH	0.308**	0.310**	0.365**	0.417**	0.035	0.582**	0.804	0.231**	0.806**	0.780**	0.822**	0.356**	1.000			
P	-0.151**	-0.151**	-0.137*	-0.073	-0.075	-0.017	0.085	-0.079	-0.077	-0.105**	0.003	-0.260**	0.085NS	1.000		
LYS	0.106*	0.094	0.069	-0.002	-0.034	-0.058	-0.288**	-0.054	-0.120*	-0.108*	-0.103*	0.061	-0.148**	-0.499**	1.000	
TRY	0.057	0.056	0.097*	0.120*	0.009	0.072	0.011	-0.024	0.037	0.039	0.102*	0.104*	0.060	-0.328**	0.760**	1.000
GYP	0.332**	0.334**	0.370**	0.440**	0.102*	0.691**	0.801**	0.373**	0.926**	0.932**	0.922**	0.567**	0.827**	-0.101	-0.074	0.102

DT- Days to tasselling, DS- Days to silking, PM- Physiological maturity, PH- Plant height (cm), EH- Ear height (cm), CL- Cob length (cm), CD- Cob diameter (cm), NRC- Number of rows per cob, NK- Number of kernels per row, NGC- Number of grains per cob, TW- Test weight (g), NCP- Number of cobs per plant, SH- Shelling percentage (%), P- Protein content, LYS- Lysine percentage (%), TRY- Tryptophan percentage (%), GYP- Grain yield per plant (g)

Table-3 : Direct (diagonal) and indirect (off-diagonal) effects of various traits of maize on grain yield per plant.

Traits	DT	DS	PM	PH	EH	CL	CD	NRC	NKR	NGC	TW	NCP	SH	P	LYS	TRY
DT	0.104	0.105	0.092	0.054	-0.007	0.081	0.088	0.057	0.119	0.124	0.107	0.035	0.109	-0.078	0.039	0.024
DS	0.104	0.102	0.090	-0.050	0.006	-0.076	-0.089	-0.056	-0.115	-0.120	-0.105	-0.031	-0.107	0.076	-0.033	-0.017
PM	0.008	0.008	0.009	-0.003	-0.001	-0.003	-0.003	-0.002	-0.004	-0.004	-0.003	-0.001	-0.004	0.002	-0.001	-0.001
PH	0.003	0.003	0.005	0.018	0.012	0.008	0.010	0.000	0.009	0.008	0.009	0.007	0.009	-0.002	0.000	0.003
EH	0.000	0.000	0.001	0.007	0.010	0.002	0.001	0.000	0.001	0.001	0.001	0.002	0.000	0.000	-0.001	0.000
CL	-0.002	-0.002	-0.002	-0.003	-0.002	-0.006	-0.004	-0.002	-0.004	-0.004	-0.004	-0.003	-0.004	0.000	0.000	-0.001
CD	-0.018	-0.015	-0.012	-0.016	-0.004	-0.018	-0.030	-0.009	-0.024	-0.023	-0.025	-0.013	-0.025	-0.004	0.009	-0.001
NRC	-0.010	-0.010	-0.010	-0.001	0.000	-0.017	-0.016	-0.055	-0.012	-0.029	-0.010	-0.009	-0.014	0.004	0.004	0.001
NKR	-0.065	-0.070	-0.095	-0.080	-0.012	-0.109	-0.130	-0.036	-0.163	-0.154	-0.136	-0.096	-0.136	0.013	0.023	-0.016
NGC	0.150	0.147	0.260	0.325	0.053	0.500	0.578	0.385	0.693	0.733	0.575	0.426	0.598	-0.083	-0.092	0.048
TW	0.100	0.100	0.120	0.251	0.037	0.328	0.435	0.093	0.436	0.408	0.521	0.241	0.451	0.054	-0.074	0.055
NCP	0.009	0.008	0.010	0.032	0.016	0.042	0.036	0.015	0.048	0.047	0.036	0.081	0.033	-0.030	0.005	0.014
SH	-0.018	-0.012	-0.045	-0.025	-0.002	-0.032	-0.045	-0.014	-0.045	-0.043	-0.046	-0.022	-0.054	-0.007	0.009	-0.006
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LYS	-0.001	-0.001	-0.001	0.000	0.001	0.001	0.004	0.001	0.002	0.002	0.002	-0.001	0.002	0.006	-0.012	-0.009
TRY	0.002	0.002	0.003	0.005	0.000	0.004	0.001	-0.001	0.003	0.003	0.004	0.005	0.003	-0.009	0.021	0.003
GYP	0.366	0.365	0.425	0.512	0.107	0.705	0.836	0.376	0.944	0.949	0.926	0.621	0.861	-0.058	-0.103	0.097

DT- Days to tasselling, DS- Days to silking, PM- Physiological maturity, PH- Plant height (cm), EH- Ear height (cm), CL- Cob length (cm), CD- Cob diameter (cm), NRC- Number of rows per cob, NK- Number of kernels per row, NGC- Number of grains per cob, TW- Test weight (g), NCP- Number of cobs per plant, SH- Shelling percentage (%), P- Protein content, LYS- Lysine percentage (%), TRY- Tryptophan percentage (%), GYP- Grain yield per plant (g)

exhibited *i.e.* (0.097). The negative correlation will hinder the improvement in quality traits such situations some economic comprises have to be made. On the other hand, highest phenotypic correlation was exhibited by the character number of grains per cob (0.932**) followed by number of kernels per row (0.926**), test weight (0.922**), shelling percentage (0.827**), cob diameter (0.801**), cob length (0.691**), number of cobs per plant (0.567**), plant height (0.440**), number of rows per cob (0.373**), physiological maturity (0.370**), days to silking (0.334**), days to tasseling (0.332**) and ear height (0.102*) similar results were also reported by Ahmad *et al.* (2020), Chaurasia *et al.* (2022), Pavan *et al.* (2011), Kumer *et al.* (2014), Hailegebrial *et al.* (2015), Pandey *et al.* (2017), Jilo *et al.* (2019), Kamal *et al.* (2020), Jagadev *et al.* (2021) and Pranay *et al.* (2022). The significant correlation between the two variables and grain yield per plant indicates that these variables have a high degree of association. Therefore, selecting these characters leads to in better yield. However, it had negative and non significant association in lysine content (-0.102) and protein content (-0.053) while positive and non significant association was found in tryptophan percentage (0.102) (Table-2).

Mathew 2015 and Prasad and Shivani 2017 reported the plant height and ear height had positive and significant association with ear height, cob length, cob diameter and number of kernels per row as per present investigation as shown in Table 1&2 which indicates that plant and ear height would simultaneously increase these traits.

The correlation values only indicate the type and extent of association that exists between two characters. A dependent character, such as grain yield per plant, is influenced by several component characters that are interconnected with each other. Each component has two paths of action: direct effects on grain yield per plant and indirect effects *via* components that correlation studies do not reveal. The direct influence of one variable on another is measured by path coefficient analysis. Seventeen correlated characters were subjected to path analysis in order to partition the correlation values into direct and indirect effects of different component characters on grain yield per plant at the genotypic level, which are tabulated in Table 3. Present investigation indicated that positive direct effect on grain yield at genotypic level was exerted by number of grains per cob (0.733) followed by 100 grains weight (0.521), days to tasseling (0.104), days to silking (0.102), number of cobs per plant (0.081), plant height (0.018), ear height (0.010), physiological maturity (0.009) and tryptophan content (0.003). Similar results were found by Pranay *et al.* (2022), Munawar *et al.*

(2013), Raju K (2023) In order to improving grain yield, effective selection can be practiced for the characters having high direct effects and for the characters through which indirect effects are mainly exerted on grain yield per plant. Cob length, cob diameter, number of rows per cob, number of kernels per row, shelling percentage and lysine percentage exhibited negative direct effect on grain yield per plant indicated that selection for high grain yield can be done by indirect selection through yield components. Reddy *et al.* (2012) found that ear height (0.132), plant height (0.065), days to maturity (0.055), ear length (0.079), number of kernels per row (0.393) and 100-kernel weight (0.365) all had a positive direct effect on grain yield per plant, whereas days to 50% silking (-0.010) had a negative direct effect. Chaurasia *et al.* (2020) found that the number of kernel rows per ear (0.339) had a positive direct influence on grain yield per plant, whereas days to 50% tasseling (-0.031) and anthesis-silking interval (-0.121) had a negative direct effect. Hussain *et al.* (2020) reported that the number of ears per plant (0.058) had a positive direct effect on grain yield per plant, whereas ear girth (-0.081) had a negative direct effect. According to Mahesh *et al.* (2014) protein content (0.133) and oil content (-0.049) have a negative direct effect on grain output per plant.

Conclusions

The present investigation revealed that, the traits *i.e.* number of grains per cob, numbers of kernels per row and test weight were the most important for improvement of grain yield per plant. These three characters had highly significant positive correlation with each other and with grain yield per plant. Selection based on these characters can increase the grain yield per plant. Path analysis revealed that the traits, number of grains per cob followed by test weight, days to tasseling, days to silking, number of cobs per plant, plant height, ear height, physiological maturity and tryptophan content had positive direct effect on grain yield per plant at genotypic level. On the basis of these traits selection can be done for improvement of grain yield per plant.

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Competing Interests

Authors have declared that no competing interests exist.

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Effect of Nutrients and Thiourea on Yield and Quality of Chickpea (*Cicer arietinum* L.)

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Abstract

An experiment was conducted at Vivekananda Global University, Jaipur during *Rabi* season of 2022-23 to find out the. The experiment consists 9 treatment and laid out in Randomized Block Design and replicated thrice. Results revealed that application of foliar spray of T₉: NPK (19:19:19) @ 1.0% + DAP @ 2% + Thiourea @ 500 ppm was observed significantly higher seed yield (2387 kg ha⁻¹), N, P and K content in seed and haulm and their uptake by seed and haulm, protein content (20%), protein yield and return {(gross (? 134776 ha⁻¹), net return (? 96528 ha⁻¹) and B-C ratio (2.51)} of chickpea.

Key words : Economics, thiourea, quality, yield.

Introduction

India has become independent in cereal production but trails behind in pulse output. The ever-increasing population pressure, which results in protein deficiency, is a severe challenge that necessitates an immediate increase in pulse productivity. The importance of pulses in human diets and diverse farming methods is widely understood. Pulses are a significant source of dietary protein and have the unique capacity to maintain and restore soil fertility through biological nitrogen fixation as well as the addition of a large number of residues to the soil. Chickpea, pigeon pea, mungbean, urdbean, lentil, field pea, lathyrus, cowpea, common bean, mothbean and rice bean are among the pulse crops grown under various agro-ecological circumstances.

Chickpea (*Cicer arietinum* L.), often known as gramme, Bengal gramme, or Spanish pea, is a high-protein food in the human diet. Chickpeas are in high demand due to their nutritional content, with seeds comprising 20-22% protein, 60-62% carbohydrate, 5% fat, and being high in calcium and iron (Hirdyani *et al.*, 2014). The reason could be due to decreased soil fertility, particularly macro and micro nutrients, imbalanced fertiliser use, and a shortage of nutrients throughout critical stages of crop growth, which results in nutrient stress, poor chickpea growth, and productivity. Despite the fact that chickpeas continue to grow in low fertility soil, crop quality and quantity have been impacted, which can be addressed by providing the plant with sufficient nutrition, particularly through an ideal nutrient combination (Yengkokpam *et al.*, 2022).

Crop output is below potential yield, and this is primarily due to the cultivation of conventional types without or with little fertilisation, as well as a lack of other advanced agronomic practises. Because of nutrient

losses owing to leaching, denitrification, or volatilization, nutrients provided by soil application are difficult to absorb. Nitrate leaching contributes significantly to soil acidification. Foliar application, also known as foliar nutrition, is a method of feeding plants that involves administering liquid fertiliser directly to their leaves. Nutrient treatment by foliar sprays, in addition to soil application, provides various advantages in augmenting crop nutritional requirements. Water soluble fertilisers have recently been introduced solely for foliar feeding and fertilisation. For foliar application, water soluble fertilisers are preferable. Foliar use of water-soluble fertilisers at appropriate phases of growth may also help to alleviate nutrient deficit and heat stress (Patil and Chetan, 2018).

Materials and Methods

An experiment was conducted at Vivekananda Global University, Jaipur during *rabi* 2022-23. The field's soil was loamy sand, with low organic carbon (0.21%), an alkaline pH (pH 8.2), low available nitrogen (132.87 kg ha⁻¹), medium available phosphorus (20.64 kg ha⁻¹) and medium available potassium (238.10 kg ha⁻¹). The experiment consists 9 treatments (T₁: Control, T₂: Water spray, T₃: NPK spray (19:19:19) @ 1.0%, T₄: DAP spray @ 2%, T₅: Thiourea spray @ 500 ppm, T₆: NPK spray (19:19:19) @ 1.0% + DAP spray @ 2%, T₇: NPK spray (19:19:19) @ 1.0% + Thiourea spray @ 500 ppm, T₈: DAP spray @ 2% + Thiourea spray @ 500 ppm, T₉: NPK spray (19:19:19) @ 1.0% + DAP spray @ 2% + Thiourea spray @ 500 ppm) was laid out in Randomized Block Design and replicated three time. Plot size was 2.0 m × 2.0 m. Crop variety CSJ – 515 with 80 kg seed rate ha⁻¹ was taken for experiment.

For evaluation of the experiment observations procedure following: the grains harvested from each net

plot were sun dried for 2-3 days to attain 10 per cent moisture and then the weight of grains net plot⁻¹ area was recorded and expressed in kg ha⁻¹. Nitrogen content in seed and stover was estimated by digesting the samples with sulphuric acid using hydrogen peroxide to remove black colour. Estimation of nitrogen was done by colorimetric method using Nessler's reagent to develop colour (Snell and Snell, 1949). Nitrogen content was calculated and expressed in percentage. Phosphorus and potassium content in seed and stover was determined by digesting the samples with tri-acid mixture. Phosphorus content determination by vanadomolybdo phosphoric acid, yellow colour method by Spectrophotometer (Jackson, 1973) and potassium content by using Flame photometer (Jackson, 1973). The uptake of N, P and K by seed and straw was estimated by using the following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Per cent nutrient (NPK) content in seed or straw} \times \text{Seed or straw yield (kg ha}^{-1}\text{)}}{100}$$

The crude protein content in seed was calculated by multiplying the nitrogen per cent in seed with a factor 6.25 (A.O.A.C., 1960). Protein yield was estimated by using the following formula.

$$\text{Protein yield (kg ha}^{-1}\text{)} = \frac{\text{Per cent protein content in seed} \times \text{Seed yield (kg ha}^{-1}\text{)}}{100}$$

The net returns and B: C ratio on the basis of prevailing market price for inputs and produce of the experimentation was calculated as under: The gross returns (? ha⁻¹) occurred due to different treatments in the present study were worked out by considering market prices of economic product and by product during the experimental year. Net returns were calculated by subtracting the total cost of cultivation from gross returns and expressed as ₹ ha⁻¹. Treatment wise benefit-cost (B-C) ratio was also calculated to ascertain economic viability of the treatments by using the following formula :

$$\text{Benefit - Cost ratio} = \frac{\text{Gross return (ha}^{-1}\text{)}}{\text{Total cost (ha}^{-1}\text{)}}$$

Experimental data recorded in various parameters were statistically analyzed with the help of Fisher's analysis of variance technique (Fisher, 1950). The critical difference (CD) for the treatment comparisons was worked out wherever the variance ratio (F test) was found significant at 5% level of significance. To elucidate the nature and magnitude of treatments, summary tables along with S.Em. ± and CD (P=0.05).

Results and Discussion

Seed yield : An investigation at the data in Table-3 reveals that significantly higher seed yield was recorded under foliar spray of NPK (19:19:19) @ 1.0% + DAP @ 2% + Thiourea @ 500 ppm as compared to rest of treatments except NPK spray (19:19:19) @ 1.0% + DAP spray @ 2%, NPK spray (19:19:19) @ 1.0% + Thiourea spray @ 500 ppm and DAP spray @ 2% + Thiourea spray @ 500 ppm. The explanation for the overall improvement in chickpea production characteristics and output is appropriate availability of nitrogen, phosphate, and potassium through foliar treatment in the early stage of a plant's life, which is regarded vital in fostering rapid vegetative growth, branching, and enhanced seed setting. Nutrients and thiourea have a varied influence on physiological processes, increasing some and suppressing others depending on concentration, plant species, developmental stages, and ambient conditions. These findings are consistent with those of Mudalagiriappa *et al.* (2016), Meena *et al.* (2016), Takankhar *et al.* (2017), Waghmare *et al.* (2019), Choudhary *et al.* (2020), Singh *et al.* (2021), Banjara and Porte (2021) and Kanwar *et al.* (2022).

Nutrient content and uptake : Data (Table-1) indicate that N, P and K content in seed and haulm and their uptake of chickpea were increased significantly with foliar spray of NPK (19:19:19) @ 1.0% + DAP @ 2% + Thiourea @ 500 ppm as compared to rest of treatments, remained at par with NPK spray (19:19:19) @ 1.0% + DAP spray @ 2%, NPK spray (19:19:19) @ 1.0% + Thiourea spray @ 500 ppm and DAP spray @ 2% + Thiourea spray @ 500 ppm. The beneficial effect of foliar N: P: K application in conjunction with thiourea and DAP on nutrient content in chickpea appears to be attributable to enhanced nutritional levels in both the root zone and the plant system. Increased food availability in the root zone, combined with increased metabolic activity at the cellular level, may have enhanced nutrient uptake and accumulation in vegetative plant parts. Thiourea treatment may have aided in the improvement of plant metabolic processes and better growth and development due to increased nutrient absorption from the rhizosphere; this may be due to the metabolic involvement of the SH- group in root physiology and biochemistry. Thiourea improves the soil's microbial population, which is in charge of mobilising critical nutrients. All of these good effects of foliar spray of nutrients and thiourea, increased accumulation of nutrients in vegetative plant parts with improved metabolism, resulted in greater translocation of nutrients to crop reproductive organs and, as a result, raised the contents of seed and haulm. The enhanced content and production of chickpea with the foliar spray of

Table-1 : Effect of foliar application of nutrients and thiourea on nutrient content in seed and haulm of chickpea.

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Control	2.65	0.460	0.514	0.251	0.427	1.32
Water spray	2.70	0.466	0.523	0.254	0.436	1.34
NPK spray (19:19:19) @ 1.0%	2.94	0.516	0.577	0.276	0.468	1.47
DAP spray @ 2%	2.91	0.511	0.571	0.273	0.464	1.46
Thiourea spray @ 500 ppm	2.89	0.503	0.564	0.269	0.461	1.44
NPK spray (19:19:19) @ 1.0% + DAP spray @ 2%	3.17	0.563	0.627	0.297	0.503	1.61
NPK spray (19:19:19) @ 1.0% + Thiourea spray @ 500 ppm	3.16	0.559	0.623	0.293	0.498	1.59
DAP spray @ 2% + Thiourea spray @500 ppm	3.14	0.554	0.619	0.291	0.494	1.57
NPK spray (19:19:19) @ 1.0% + DAP spray @ 2% + Thiourea spray @ 500 ppm	3.20	0.567	0.632	0.299	0.507	1.62
SEm+	0.06	0.011	0.013	0.004	0.008	0.03
CD (P = 0.05)	0.18	0.034	0.039	0.013	0.023	0.09

Table-2 : Effect of foliar application of nutrients and thiourea on nutrient uptake by seed and haulm of chickpea.

Treatments	Nitrogen uptake (kg ha ⁻¹)		Phosphorus uptake (kg ha ⁻¹)		Potassium uptake (kg ha ⁻¹)	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Control	43.6	12.4	8.5	6.8	18.6	35.7
Water spray	45.8	13.2	8.9	7.2	19.7	37.9
NPK spray (19:19:19) @ 1.0%	57.7	16.7	11.3	8.9	24.3	47.5
DAP spray @ 2%	58.7	15.9	11.6	8.5	23.9	45.6
Thiourea spray @ 500 ppm	57.3	16.4	11.2	8.8	24.2	47.0
NPK spray (19:19:19) @ 1.0% + DAP spray @ 2%	72.2	20.0	14.3	10.5	29.3	57.1
NPK spray (19:19:19) @ 1.0% + Thiourea spray @ 500 ppm	72.8	20.3	14.3	10.6	29.5	57.5
DAP spray @ 2% + Thiourea spray @500 ppm	73.8	20.3	14.6	10.7	29.7	57.6
NPK spray (19:19:19) @ 1.0% + DAP spray @ 2% + Thiourea spray @ 500 ppm	76.3	21.1	15.1	11.1	30.9	60.3
SEm+	2.3	0.8	0.5	0.4	0.7	2.3
CD (P = 0.05)	6.9	2.5	1.6	1.2	2.2	6.8

Table-3 : Effect of foliar application of nutrients and thiourea on quality and economics of chickpea.

Treatments	Protein content in seed (%)	Protein yield (kg ha ⁻¹)	Seed yield (kg ha ⁻¹)	Economics			B-C ratio
				Gross return (₹ ha ⁻¹)	Cost of cultivation (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	
Control	16.6	272.5	1647	93293	36160	57133	1.58
Water spray	16.9	286.4	1699	96270	37060	59210	1.60
NPK spray (19:19:19) @ 1.0%	18.4	360.7	1961	111083	37498	73585	1.96
DAP spray @ 2%	18.2	367.0	2021	114068	37310	76758	2.06
Thiourea spray @ 500 ppm	18.1	358.1	1982	112274	37560	74714	1.99
NPK spray (19:19:19) @ 1.0% + DAP spray @ 2%	19.8	451.4	2278	128625	37748	90877	2.41
NPK spray (19:19:19) @ 1.0% + Thiourea spray @ 500 ppm	19.8	455.3	2301	129996	37998	91998	2.42
DAP spray @ 2% + Thiourea spray @500 ppm	19.6	461.4	2349	132657	37810	94847	2.51
NPK spray (19:19:19) @ 1.0% + DAP spray @ 2% + Thiourea spray @ 500 ppm	20.0	476.7	2387	134776	38248	96528	2.52
SEm+	0.4	14.4	80	-	-	4324	0.12
CD (P = 0.05)	1.1	43.1	240	-	-	12962	0.35

nutrients and thiourea may have increased N, P, and K absorption. Similar finding also reported by Takankhar *et al.* (2017), Premaradhya *et al.* (2018) and Waghmare *et al.* (2019).

Further data revealed that protein content in seed and protein yield of chickpea was increased significantly with foliar spray of NPK (19:19:19) @ 1.0% + DAP @ 2% + Thiourea @ 500 ppm as compared to rest of treatments except NPK spray (19:19:19) @ 1.0% + DAP spray @ 2%, NPK spray (19:19:19) @ 1.0% + Thiourea spray @ 500 ppm and DAP spray @ 2% + Thiourea spray @ 500 ppm. This increase in protein content could be attributed to increased N concentrations in seed caused by foliar spray of fertilizers that promote protein synthesis. Protein yield appears to have improved due to the fact that protein yield is a product of seed yield and protein content. Similar finding also reported by Takankhar *et al.* (2017), Premaradhya *et al.* (2018) and Waghmare *et al.* (2019).

Economics : The foliar spray of fertilizers and thiourea had a substantial impact on the economic evaluation of chickpea output in terms of gross returns, net returns and B-C ratio. Chickpea foliar spray with NPK (19:19:19) @ 1.0% + DAP @ 2% + Thiourea @ 500 ppm was found significantly highest gross, net returns and B-C ratio, remained at par with NPK spray (19:19:19) @ 1.0% + DAP spray @ 2%, NPK spray (19:19:19) @ 1.0% + Thiourea spray @ 500 ppm and DAP spray @ 2% + Thiourea spray @ 500 ppm. This could be because treatments produce much higher yields than other treatments. Similar findings have also been reported by Mudalagiriappa *et al.* (2016), Sruthi *et al.* (2020) and Banjara and Porte (2021) in chickpea.

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Impact of Seaweed Extract on Wheat Growth, Yield, Quality and Economics under Sandy Loam Soils of Rajasthan

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Abstract

The indiscriminate use of agrochemicals and high population growth rate causing deteriorating the land day by day so the use of organic sources can be an optimistic source for sustainability of land. The present field experiment was conducted at Research Farm, VGU, Jaipur, Rajasthan during *rabi* season of 2022-23 aimed to evaluate the "Effects of Seaweed Extract on Growth, Yield and Quality of Wheat [*Triticum aestivum* (L.)]". The experiment was laid out in randomized block design with three replications and eight treatments i.e., Water spray (T_1), Foliar application of seaweed extract @ 5mL/L water at tillering stage (T_2), Foliar application of seaweed extract @ 5mL/L water at heading stage (T_3), Foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage (T_4), Seed treatments with seaweed extract @ 3mL/kg seed (T_5), Seed treatments with seaweed extract @ 3mL/kg seed + Foliar application of seaweed extract @ 5mL/L water at tillering stage (T_6), Seed treatments with seaweed extract @ 3mL/kg seed + Foliar application of seaweed extract @ 5mL/L water at heading stage (T_7), Seed treatments with seaweed extract @ 3mL/kg seed + Foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage (T_8). The result revealed that the growth parameters viz., maximum plant height (32.60, 73.20 and 101.50 cm), maximum dry matter accumulation (147.70, 570.60 and 901.30 cm) at 40, 90 DAS and at harvest was recorded under T_8 . Whereas, the highest grain, straw yield, harvest index, protein, carbohydrate was also obtained under application of T_8 . The maximum gross return (115366 ?/ha), maximum net return (? 81134 ha⁻¹) and B:C ratio (2.37) was also found highest under T_8 .

Key words : Wheat, sea weed extract, growth, yield and quality.

Introduction

Wheat is the most important staple food crop of India and occupies a notable position among the food grain crops not only in terms of area and production, but also in its versatility in adaptation to a wide range of agro climatic conditions. Wheat (*Triticum aestivum* L.) is a major cereal crop being cultivated in India and belong to family poaceae (Kumari *et al.*, 2020). It is the first important and strategic cereal crop for majority of world's population. It ranks first in the world cereal production and is a staple food of about one third of the world population (Ghose, 2014). Common wheat, best known and most widely cultivated for the grain, used for chapatti, it is the source of flour for the world breadmaking (Payne, 1987). The mature wheat grain comprises three groups of major components, starch, proteins, and cell wall polysaccharides, which together account for about 90% of the dry weight, and minor components that include lipids, terpenoids, phenolics, minerals, and vitamins. Wheat is mainly composed of carbs but also has moderate amounts of protein (Shewry *et al.*, 2013; Shewry and Hey, 2015). Here are the nutrition facts for 3.5 ounces (100 grams) of whole-grain wheat flour calories (340), water (11%), protein (13.2g), carbs (72g), sugar (0.4g), fiber (10.7g) and fat (2.5 g) Shewry *et al.*, 2013.

Seaweed extracts are made from storm-cast or freshly cut seaweeds. The predominant species in the North Atlantic Ocean used for making extracts is *Ascophyllum nodosum*, belonging to the brown algae (*Phaeophyceae*). Other species used, all belonging to the *Phaeophyceae* are *Laminaria hyperborea* and *L. digitata*, and *Fucus vesiculosus* and *F. serratus* (Pereira *et al.*, 2020). In the Southern hemisphere the brown algae *Ecklonia maxima* and *Durvillea potatorum* are employed for making extracts. Surprisingly little attention has been given to the quality of the seaweed forming the basis of the extracts. It looks obvious in the preparation of seaweed extracts to start from freshly cut instead of storm-cast seaweeds, but it is unclear how far producers of seaweed extracts acknowledge the significance of this aspect (Verkleij, 1992). Likewise, information is scarce about which seaweed species are the most suited for making extracts, at which growth stage the seaweed should be harvested, which parts of the seaweed should be used, and when the seaweed should be harvested in the growing season. As will be discussed below, trace nutrients and plant hormones, in particular cytokinins, are the active constituents in seaweed extracts. Since young growing fronds ('leaves') of seaweeds probably contain the highest amounts of cytokinins and trace nutrients, they can best be harvested in the spring (Verkleij, 1992).

However, in autumn the fronds are rich in polyphenols with anti-fungal activities (Kirkham & Flood, 1956), so the value of extracts from seaweed harvested in the autumn must also be considered.

Foliar application of mineral nutrients offers a quicker method of supplying nutrients to higher plants than methods involving soil application. Recently, some authors pointed out the possibility of an active uptake through stomata pores instead of cuticular uptake (Eichert *et al.*, 1998; Burkhardt and Eichert, 2001). The application of seaweed concentrates has been reported many beneficial effects on wheat (Nelson and van Staden, 1984; Mooney and van Staden, 1985; Beckett and van Staden, 1990). Hence, in the present investigation possibilities were explored to study the effect of foliar applications of *Kappaphycus alvarezii* and *Gracilaria edulis* on growth, yield, and nutrient uptake of wheat.

Materials and Methods

The present experiment was conducted during *Rabi*, 2022-23 at Agricultural Research Farm, Vivekananda Global University, Jaipur. It having a very luxurious weather for the growth and development of wheat crop. The initial physico-chemical properties were analysed before and after the crop harvest. The soil was slightly alkaline in reaction (pH, 7.8), low in organic carbon, nitrogen and phosphorus and high in available potassium. The existing experiment was laid out in randomized block design with three replications. The treatment combinations of the existing experiment were given as Water spray (T_1), Foliar application of seaweed extract @ 5mL/L water at tillering stage (T_2), Foliar application of seaweed extract @ 5mL/L water at heading stage (T_3), Foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage (T_4), Seed treatments with seaweed extract @ 3mL/kg seed (T_5), Seed treatments with seaweed extract @ 3mL/kg seed + Foliar application of seaweed extract @ 5mL/L water at tillering stage (T_6), Seed treatments with seaweed extract @ 3mL/kg seed + Foliar application of seaweed extract @ 5mL/L water at heading stage (T_7), Seed treatments with seaweed extract @ 3mL/kg seed + Foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage (T_8).

Results and Discussion

Plant height (cm) : Plant height is an important growth parameter of the plant. In general plant height increase with advancement of the crop age to till harvest. The data presented in 1 revealed that effect of seed treatment and foliar application of seaweed extract found significant to control on plant height of wheat across all the growth stages (40, 90 days after sowing and at harvest). Among all the treatments of foliar application of seaweed extract

with and without seed treatments at 40 DAS and 90 DAS in seed treatment with seaweed extract higher value recorded under T_8 (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) (32.6 and 73.2) in 2022-23 and lower recorded in T_1 (foliar water sprayed with without seed treatment (32.0 and 70.3) at all growth stages during year of the cultivation. At harvest higher plant height was recorded with T_8 (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) (101.5) and lowest in T_1 foliar water sprayed with without seed treatment (97.1) in 2022-23, the same trend followed up to harvest during year of the experimentation.

Dry matter accumulation (g/m^2) : The dry matter accumulation is an important index indicating the photosynthetic efficiency of the crop which ultimately influences the crop yield. The data existing in 1 revealed that seed treatments had significant impact on dry matter accumulation of wheat at all the growing stage but seed treatment and foliar application of seaweed extract had significant effect on dry matter accumulation of plant at all stages 40, 90 days after sowing (DAS) and at harvest. Among the all of treatments foliar application of seaweed extract with and without seed treatments at 40 DAS and 90 DAS in seed treatment with seaweed extract numerically higher value of dry matter accumulation recorded under T_8 (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) (147.7 and 570.6) and lower dry matter accumulation recorded in T_1 (foliar water sprayed with without seed treatment (145.6 and 560.9) at all growth stages during year of the cultivation.

Grain yield : The presented in table-1 shows that the maximum grain yield ($q\ ha^{-1}$) was recorded with T_8 (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) ($54.29\ q\ ha^{-1}$) and minimum grain yield ($q\ ha^{-1}$) in T_1 (foliar water sprayed with without seed treatment ($49.50\ q\ ha^{-1}$) year of the experimentation. The grain yield ($q\ ha^{-1}$) was affected significantly by different treatments all the treatments were at par with each other.

Straw yield : Data pertaining to wheat straw yield as influenced by different treatments are presented in Table-1. It is evident from the data that highest straw yield of wheat was recorded in T_1 (foliar water sprayed with without seed treatment ($72.67\ q\ ha^{-1}$) the treatment and minimum straw yield ($q\ ha^{-1}$) in T_8 (foliar application of seaweed extract @ 5mL/L water at tillering & heading stage with seed treatments with seaweed extract @

Table-1 : Effect of seed weed extract on growth, biomass and yield of wheat.

Treatments	Plant height (cm)			Dry matter accumulation (g/m ²)			Grain yield (q/ha)	Straw yield (q/ha)
	40 DAS	90 DAS	At Harvest	40 DAS	90 DAS	At Harvest		
T ₁	32.0	70.3	97.1	145.6	560.9	867.8	49.50	72.67
T ₂	32.1	71.7	98.5	145.8	562.6	877.9	51.00	72.27
T ₃	32.1	71.8	99.0	146.1	566.0	882.9	51.25	72.30
T ₄	32.2	72.8	100.6	147.0	569.5	897.4	52.64	71.95
T ₅	32.3	70.7	98.0	146.3	562.0	871.7	50.85	72.07
T ₆	32.4	72.1	99.4	146.5	563.7	881.8	52.55	71.67
T ₇	32.5	72.2	99.9	146.8	567.1	886.8	52.90	71.70
T ₈	32.6	73.2	101.5	147.7	570.6	901.3	54.29	71.35
S. Em. (±)	0.09	0.20	0.28	0.41	1.57	2.45	0.18	0.22
CD (p 0.0.5)	0.27	0.60	0.84	1.24	4.76	7.46	0.56	0.68

Table-2 : Impact of seed weed extract on quality parameters of wheat.

Treatments	Harvest index (%)	Protein content	Carbohydrate content	Chlorophyll content	Gross return (₹/ha)	Net return (₹/ha)	B:C Ratio
T ₁	40.5	10.99	66.55	2.43	105188	73246	3.29
T ₂	41.4	11.04	66.65	2.47	108375	75683	3.32
T ₃	41.5	11.10	66.90	2.50	108906	76214	3.33
T ₄	42.3	11.13	67.70	2.53	111860	78418	3.34
T ₅	41.4	11.05	66.35	2.46	108056	75324	3.30
T ₆	42.3	11.10	66.45	2.50	111669	78187	3.34
T ₇	42.5	11.16	66.70	2.53	112413	78931	3.36
T ₈	43.2	11.19	67.50	2.56	115366	81134	3.37
S. Em. (±)	0.03	0.03	0.007	0.20	-	-	-
CD (p 0.0.5)	0.08	0.09	0.022	0.61	-	-	-

3mL/kg seed) (71.35 q ha⁻¹). All these three treatments were statistically at par with each other.

Harvest index (%) : Data pertaining to wheat yield as influenced by different treatments along with harvest index are presented in Table-1. It is evident from the data that the highest harvest index of wheat was recorded in T₈ (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) (43.2 %) the treatment and minimum harvest index (q ha⁻¹) in T₁ (foliar water sprayed with without seed treatment (40.5 %).

Protein content (%) : The data presented in Table-2 showed that percent protein content in seeds was recorded maximum in treatment T₈ (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) (11.19 %) and lowest protein content (%) in T₁ (foliar water sprayed with without seed treatment (10.99 %) year of the experimentation.

Carbohydrate content : To evaluate the effect of different treatments on carbohydrate content in seeds on wheat measured at harvest and data are presented in

Table-2. The carbohydrate content in seeds was recorded higher in treatment T₈ (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) (67.50 %) and lowest carbohydrate content in seeds in T₁ (foliar water sprayed with without seed treatment (66.55 %) year of the experimentation. The carbohydrate content in seeds were affected significantly by different treatments all the treatments were at par with each other.

Chlorophyll content : The data presented in 2 states that the chlorophyll content was recorded higher in treatment T₈ (foliar application of seaweed extract @ 5mL/L water at tillering & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) (2.56) and lowest chlorophyll content in T₁ (foliar water sprayed with without seed treatment (2.43) year of the experimentation. The chlorophyll content was affected significantly by different treatments all the treatments were at par with each other.

Economics : The economics of different treatments was calculated and data are presented in Table-2. It is evident from the data that the cost of cultivation was maximum in case of T₆, T₇ followed by T₄ and minimum in case of T₁. The gross return was slightly higher in case of T₈ as

compared to T_7 . The net return was found highest in case of T_8 (? 81134 ha⁻¹) followed by T_7 (? 78931 ha⁻¹) and lowest in case of T_1 (? 73246 ha⁻¹). Similarly, the B:C ratio was the highest in T_8 (3.37), which was closely followed by T_7 (3.36) and minimum in case of T_1 (3.29). From this study it is concluded that application of Seed treatments with seaweed extract @ 3mL/kg seed with Foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage higher economic return as compared to RDF applied through chemical fertilizers.

The highest plant height (32.60, 73.2 and 101.50 cm) and dry matter accumulation were recorded under T_8 (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) and lowest recorded in control at all growth stages. The similar findings were reported by Rathore *et al.*, 2009; Sunarpi *et al.* 2010. This might be due the presence of active compounds in seaweed extract like micro and macro elements as well as plant growth regulators that stimulate plant growth promoting substances increase capacity of plants to trap solar energy for photosynthesis as a result of increase protein synthesis cell division and mobilization of nutrients necessary for growth also promote germination and linear growth of the seedling. In control availability of necessary elements induced height. These results confirming with results of Bahrani *et al.* (2010), Kumar and Sahoo (2011). Seaweed extracts are known to enhance the growth of crops as they are reported to contain growth regulators such as auxins (IAA and IBA), gibberellins, cytokinins, betaines, and major macro- and micronutrients Blunden *et al.* 1991. This study showed that the application of seaweed liquid extract enhances the germination, growth, and yield of wheat plants.

The result exhibited in number of grain yield and straw yield were significantly influenced by T_8 (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) and lowest recorded in control without treatment with seaweed extract, respectively. It might be due to presence of growth promoting substances, development of healthy foliage more activities of meristematic tissues, cell differentiation, more meristematic division and more translocation of food materials in plants, increase chlorophyll content, leaf area and senescence retardation are philological effect of seaweed extract, it also Increases effective tillers, 1000 grain weight, increases, This would enhance the supply of photosynthesis available for grain filling, thus resulting increase sources and sink ratio, increased grain and straw yield. Similar result reported by Kavitha *et al.* (2008), and Pirani *et al.* (2020).

The foliar application of seaweed extract showed significant effect on Protein content, Carbohydrate content and Chlorophyll content and T_8 (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) recorded significantly higher quality of wheat and lowest in control, respectively. It is due to presence of some organic constituents in the seaweed extract, which chelates the trace elements and improves the efficiency of nutrient uptake our result supported by Strik and Van Staden (2006); Zhang *et al.* (2003); Rathore *et al.* (2009) and Zodape *et al.* (2009). This result increase in leaf content of chlorophyll, the elements in the extract have a role in activity of many important enzymes, especially responsible enzymes for the formation and construction of chlorophyll molecule, which contributed to the increase in content in the leaves and this result agreed with wheat reached Kasim *et al.*, 2015.

Among foliar application of seaweed extract effect on relative economic result exhibited that highest cost of cultivation, gross return, net return and B:C ratio were recorded under, T_8 (foliar application of seaweed extract @ 5mL/L water at tillering stage & heading stage with seed treatments with seaweed extract @ 3mL/kg seed) and lowest noted on (control) water sprayed, respectively. This is because of the fact that the increase in economic yield due to foliar application of seaweed extract and due to the relatively higher yield obtained from this treatment. The results calibrated with the findings of Satapathy *et al.*, 2014; Pramanick *et al.*, 2014; Singh *et al.*, 2016 and Gomathi *et al.*, 2017.

Conclusions

It can be concluded that the foliar application of seaweed extract @ 5mL/L water at tillering & heading stage with seed treatments with seaweed extract @ 3mL/kg seed significantly increased the growth parameters *i.e.*, plant height, dry matter accumulation, enhanced yield attribute and yield (seed and straw) with higher net return and B:C ratio as compared to control. However, the increment of net return is 9.72% over the control treatment. The higher quality parameters *i.e.*, chlorophyll, protein, carbohydrate was also found under T_8 (foliar application of seaweed extract @ 5mL/L water at tillering & heading stage with seed treatments with seaweed extract @ 3mL/kg seed).

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Conflict of interest

The authors declare that they have no conflicts of interest to disclose. All co-authors have seen and agree with the

contents of the manuscript and there is no financial interest to report. We certify that the submission is original work and is not under review at any other publication.

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Effect of Foliar Application of Urea and KCl Fertilizer on Growth, Yield Attributes and Yield of Barley (*Hordeum vulgare* L.) Varieties

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Abstract

An experiment in the field was carried out during *rabi* 2022-23 at the Research Farm, Vivekananda Global University, Jaipur to evaluate the effect of irrigation levels on growth, yield attributes and yield of barley. The eight treatment combinations {two varieties of barley *i.e.*, RD 2907 and RD 2897 and four fertilizer levels *i.e.*, control (no urea and KCl, 2.0% urea, 1.0% KCl and 2.0% urea + 1.0% KCl)} was laid out in factorial randomized block design and replicated thrice. Among varieties of barley, RD 2877 was recorded significantly higher growth parameters *viz.*, plant height and dry matter accumulation at 30, 60, 90 DAS and at harvest, yield attributes *viz.*, total number of effective tillers, length of spike, number of grains spike⁻¹, weight of grains spike⁻¹ and test weight, yield *viz.*, grain, straw and biological yield of barley over RD 2907. Application of 2.0% urea + 1.0% KCl increased significantly growth parameters, yield attributes and yield of barley as compared to 2.0% urea, 1.0% KCl and control.

Key words : Barley, varieties, fertilizer, yield.

Introduction

Barley (*Hordeum vulgare* L.) is a crucial crop since it is raised for both human and animal consumption. One of the first cereals to be farmed, it is a grass that grows well in temperate climates all over the world. Its grain is highly valued for its ability to cover and cool the body, which helps with digestion and is a source of vitamin B complex. It is a significant industrial crop that is used as a raw material in the beer, whisky, and brewing industries in addition to these historical purposes. Barley grain includes 10.6 g of protein, 2.1 g of fat, 64.0 g of carbohydrates, 50.0 mg of calcium, 6.0 mg of iron, and 31.0 mg of vitamin B in every 100 g. B2 vitamin 0.1 mg and folate 50.0 g. Its B-glucanase may aid in lowering the chance of developing cardiovascular disease (Vaughan *et al.*, 2006). In 2021-22, the crop was grown on over 49.00 million hectares of land, yielding 145.47 million tonnes with a productivity of 2805 kg ha⁻¹. During the same time period in India, the crop occupied nearly 0.68 lakh hectares of land, yielding nearly 1.67 million tonnes of grain at a productivity of 2641 kg ha⁻¹ (FAO, 2002). In Rajasthan, the crop was cultivated on 2.81 lakh hectares in 2020-21, yielding 8.56 lakh tonnes at a productivity of 3046 kg ha⁻¹ (Directorate of Economics and Statistics, 2021-22).

Adequate mineral fertilisation is thought to be one of the most important pre-requisites in this regard. Among nutrients, nitrogen plays an important role in the synthesis of chlorophyll, amino acids, and other organic compounds of physiological significance in plant system. Barley is a well-established fact that grain yield potentials of the barley genotypes are realised to the fullest extent when

they are grown under the best agro-climatic environment (Singh *et al.*, 2009).

The two main nutrients that crops need are nitrogen and potassium. Nitrogen affects the vegetative and reproductive growth of plants since it is a crucial component of protein, chlorophyll, and enzymes involved in numerous metabolic processes (Awasthi and Bhan, 1993). Due to the medium status of potassium in our soil, its application may occasionally be forgone. Fertilisers can be used wisely and frequently to increase crop yields that are both sustainable and good, as well as to assist farmers consistently make more money. To ensure appropriate crop development and yield, diet must be balanced. In addition to significantly increasing agricultural output on lands, fertilisers have frequently been shown to be crucial to the success or failure of crops. Barley has benefited greatly from fertiliser application on soils with nitrogen deficiencies, according to Bhan *et al.*, (1995).

The practise of foliar fertilisation is perhaps the oldest crop production technique used in agriculture. Nutrients applied to leaves are more efficient than those supplied to soil. Foliar delivery of nutrients can boost photosynthetic efficiency by preventing the beginning of leaf senescence due to improved absorption efficiency. Research on the fundamental and practical aspects of foliar absorption, translocation, and utilisation has been substantially influenced by the introduction of radioisotopes and the development of methods for plant analysis. The increased awareness of soil water pollution brought on by indiscriminate or excessive soil fertilisation as well as unfavourable soil conditions that encourage

nutrient fixation in the soil have also contributed to the recent interest in foliar nutrition. A foliar spray of 2% urea significantly increased the grain production (Yadav, 2006). The above facts, this research study was conducted during *rabi* season of 2022-23 at Research Farm, Vivekananda Global University, Jaipur with the objective to find out the effect of various levels of fertilizer on growth, yield attributes and yield of barley varieties.

Materials and Methods

An experiment was conducted during *rabi* 2022-23 at the Research Farm, Vivekananda Global University, Jaipur which is situated in South-Eastern part of Rajasthan at an altitude of 581.13 metre above mean sea level with 24°35' N latitude and 74°42' E longitude. The climate of this region is typically semi-arid, characterized by extremes of temperature during both summers and winters. During summers, the temperature may go as high as 48 °C, while in winters, it may fall as low as 1.0 °C. Frost is not uncommon during winter. The soil of the experimental field was loamy sand in texture, slightly alkaline in reaction (pH-7.9), low in available nitrogen (283.42 kg ha⁻¹), medium in available phosphorus (22.23 kg ha⁻¹) and organic carbon (0.73%), high in available potassium (288.31 kg ha⁻¹).

The experiment was laid out in factorial randomized block design with three replications. The eight treatment combinations {two varieties of barley *i.e.*, RD 2907 and RD 2897 and four fertilizer levels *i.e.*, control (no urea and KCl, 2.0% urea, 1.0% KCl and 2.0% urea + 1.0% KCl) were analyzed during experimentation. Irrigation was given in crop just after sowing for satisfactory germination of crop. Thereafter, irrigation schedule four irrigations.

The recommended fertilizer dose (60 kg nitrogen + 30 kg P₂O₅ per hectare) was used. Half of the N and full dose of P₂O₅ were applied as a basal dose at the time of sowing, and the remaining half was applied as a top dressing at the time of the first irrigation (as per treatment). The barley variety RD-2907 and RD 2897 was seeded at a rate of 100 kg ha⁻¹. On November 11, 2022, the seeds were manually sown in opened furrows at a depth of 5 cm in rows spaced 22.5 cm apart, and after depositing the seed in furrows, it was covered with earth to provide uniform germination and protection from bird damage. Each plot's crop was collected separately. The harvested plants were tied in bundles, tagged and kept for sun drying on threshing floor. After complete drying these bundles were weighed just before threshing to record biological yield. Threshing of the harvested produce from individual plot was done with the help of mini power operated thresher.

The plant height was measured from the ground to the tip of the main shoot on five randomly selected plants from each plot at 45, 90 DAS and at harvest to the tip of the upper spikelet of main ear (excluding awns). The average plant height was calculated and expressed in cm. Plants of 0.5 m row length from the sample rows of each gross plot were uprooted at 45, 90, DAS, and harvest. The root portion was removed, and the plants were separated into little pieces before being placed in a perforated labelled brown paper bag and dried in the sunlight first, then in the thermostatically controlled oven at 60 °C ± 2 °C. The drying process was repeated until a steady weight was reached, and the mean dry matter accumulation g 0.5 m⁻¹ row length was calculated. At harvest, the number of effective tillers was counted from one-metre row length in three locations over the net plot area. The average of the three values is given as the number of effective tillers per m⁻¹ row length. Five randomly selected spikes were taken from each plot and manually counted. The number of spikelets was counted and averaged for ear⁻¹ spikelets. Five ears were randomly selected from net plot, threshed and the total number grain was counted and average was taken as number of grain ear⁻¹. The length of spike was measured from five randomly selected ears at the time of crop harvest, and averaged to express in cm. Five ear heads were randomly selected from net plot, threshed and weighed. The average was taken as grain weight ear⁻¹ in g. A composite sample of grains was taken from the final produce in each plot at the time of threshing, thereafter 1000-grains were counted and weighed and expressed as g. The net plot crop was harvested, threshed and winnowed.

The grains harvested from each net plot were sun dried for 2-3 days to attain 10 per cent moisture and then the weight of grains net plot⁻¹ area was recorded and expressed in kg ha⁻¹. The straw yield from each net plot was sun dried for 4 to 6 days and weighed. Straw yield kg ha⁻¹ was computed from straw yield of each net plot. The unthreshed produce from net plot area, after sun drying was weighed for recording the biological yield and expressed in terms of yield in kg ha⁻¹. It is the ratio of economic yield (grain yield) to biological yield, and worked out by following formula (Donald and Hamblin, 1976) expressed in percentage. The results were statistically examined in accordance with Panse and Sukhatme's (1985) instructions in order to determine the significance of variance in experimental data collected for different treatment effects. Where the 'f' test was significant at the 5% level of probability, the crucial differences were calculated to evaluate the significance of treatment means. Summary tables and SEm± and CD at 5% were used, together with summary tables, to clarify the kind and scope of treatment effects.

Table-1 : Effect of foliar application of urea and KCl on plant population, plant height and dry matter accumulation at different growth stages of barley varieties.

Treatments	Plant population	Plant height			Dry matter accumulation				
		At 30 DAS	At 60 DAS	At 90 DAS	At harvest	At 30 DAS	At 60 DAS	At 90 DAS	At harvest
Varieties									
RD-2907	32.19	20.58	62.01	75.46	75.27	18.27	138.77	185.69	213.20
RD-2897	32.62	21.69	63.45	86.13	91.62	19.18	150.62	193.76	257.27
SEm+	0.26	0.33	0.47	0.64	1.02	0.45	3.61	4.66	6.10
CD (P=0.05)	NS	0.95	1.34	1.85	2.94	1.30	10.43	13.45	17.60
Foliar application of fertilizers									
Control	31.98	20.68	55.29	72.65	74.26	18.25	132.25	175.62	210.54
2.0% Urea	32.25	21.10	66.82	85.60	87.36	18.65	149.25	194.99	229.32
1.0 % KCl	32.33	21.15	60.64	77.36	82.35	18.71	145.20	190.00	248.11
2.0% urea + 1.0% KCl	33.06	21.61	68.17	87.56	89.81	19.29	152.09	198.30	252.96
SEm+	0.23	0.29	0.40	0.56	0.88	0.39	3.13	4.03	5.28
CD (P=0.05)	NS	0.83	1.16	1.61	2.54	1.13	9.03	11.65	15.24

Table-2 : Effect of foliar application of urea and KCl on yield attributes at harvest of barley varieties.

Treatments	Yield attributes				
	Total number of effective tillers per meter row length	Length of Spike (cm)	Number of grains spike ⁻¹	Grain weight spike ⁻¹ (g)	Test weight (g)
Varieties					
RD-2907	60.36	7.10	35.66	0.57	43.21
RD-2897	73.27	7.78	42.87	0.69	45.56
SEm+	1.33	0.15	0.79	0.01	0.87
CD (P=0.05)	3.85	0.44	2.29	0.04	2.51
Foliar application of fertilizers					
Control	61.62	6.50	34.16	0.48	43.35
2.0% Urea	66.14	7.30	39.40	0.63	44.21
1.0 % KCl	66.30	7.50	40.00	0.66	44.55
2.0% urea + 1.0% KCl	73.21	8.45	43.50	0.75	45.43
SEm+	1.16	0.13	0.69	0.01	0.75
CD (P=0.05)	3.34	0.38	1.98	0.03	2.17

Table-3 : Effect of foliar application of urea and KCl on yield of barley varieties.

Treatments	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest index (%)
Varieties				
RD-2907	3821	5673	9495	40.23
RD-2897	4273	6368	10642	40.14
SEm+	81	119	200	0.79
CD (P=0.05)	234	345	579	NS
Foliar application of fertilizers				
Control	3779	5770	9550	39.58
2.0% Urea	4045	6029	10074	40.16
1.0 % KCl	3982	5908	9890	40.27
2.0% urea + 1.0% KCl	4381	6378	10759	40.73
SEm+	70	103	173	0.68
CD (P=0.05)	202	299	501	NS

Results and Discussion

Effect of varieties of barley

Growth : The examination of Table-1 data indicates that RD-2897 variety of barley was recorded significantly higher

plant height and dry matter accumulation at 30, 60, 90 DAS and at harvest as compared to RD-2907 variety of barley. However, plant population was remained unchanged with varieties of barley. This might have resulted in higher uptake of nutrient and consequently better growth of plant as compared to var. RD 2907

(Tefera *et al.*, 2022). It is widely recognised that genotypes' development and production potential are an interacting result of their genetic potential, the environment they live in, and the agronomic support they receive throughout their life cycles. Given that both types were cultivated in the same agronomic and climatic conditions, the noticeable growth variation could be attributed to their genetic capacity to take advantage of the resources that are available for their growth and development. The findings of the current experiment closely align with those of Choudhary (2001) and Narolia (2009).

Yield attributes : In this study, data (Table-2) shows that yield attributes *viz.*, total number of effective tillers, length of spike, number of grains spike⁻¹, weight of grains spike⁻¹ and test weight of barley increased significantly with RD-2897 variety over RD-2907 variety. The significant improvement in yield attributes in the var. RD 2897 appears to be attributable to an overall improvement in growth as demonstrated by higher dry matter production as well as N and P uptake at harvest, supporting the idea that there were more growth inputs available to match the formation and development of yield components. It is a well-known fact that a crop's complementary interactions between vegetative and reproductive growth determine the amount and increase of yield components. These findings were in accordance with Tefera *et al.* (2022).

Yield : An analysis of the data in Table-3 reveals that RD-2897 variety of barley was observed significantly maximum yield *viz.*, grain, straw and biological yield of barley increased significantly with as compared to RD-2907 variety. However, harvest index was remained unchanged with varieties of barley. This might be due to increases the growth parameters, thus ultimately improved yield attributes then increased yield of barley. These results are in conformity with the findings of Tefera *et al.* (2022).

Effect of foliar application of fertilizers

Growth : The data in Table-1 show that foliar application of urea (2.0%) + KCl (1.0%) was increased significantly plant height and dry matter accumulation at 30, 60, 90 DAS and at harvest over control and remained at par with foliar application of urea (2.0%) and foliar application of KCl (1.0%). However, plant population was remained unchanged with foliar application of urea and KCl. The 2% urea foliar spray treatment produced the highest growth parameter values among foliar spray treatments. Fertilisers used topically may have a positive impact because of increased photosynthetic efficiency. The plant's total growth rose in terms of plant height and leaf area, which helped to improve the output of dry matter. At a crucial point in its life, fertilisers applied as foliar sprays

gave plants nutrients and water through their leaves, resulting in greater plant growth and development. This finding is supported by Srinivasan and Ramasamy (1992), Bhowmick (2006), Motwani and Sajfy (2006), Dixit and Elamathi (2007) and Elayaraja and Angayarkanni (2007).

Yield attributes : A perusal of data from Table-2 shows that yield attributes *viz.*, total number of effective tillers, length of spike, number of grains spike⁻¹, weight of grains spike⁻¹ and test weight of barley increased significantly with foliar application of urea (2.0%) + KCl (1.0%) as compared to control and which was at par with foliar application of urea (2.0%) and foliar application of KCl (1.0%). As previously mentioned, fertilisers applied by foliar spray play a critical role in the growth and development of plants due to their stimulatory influence on plant nutrients, chlorophyll content, and photosynthetic capacity (Ganapathy *et al.*, 2008). In general, crops need an optimal nutrient balance during the reproductive stage for the beneficial development of pods and grains, however soil-applied nutrients do not satisfy this need. The positive effects of optimal nutrition and the resulting improvement in yield characteristics may have boosted the yield of barley's grains and straw. Similar results were also noticed by Mahobia *et al.*, (2006) and Ghosh and Joseph (2008).

Yield : Data from Table-3 indicate that foliar application of urea (2.0%) + KCl (1.0%) was found significantly superior in yield *viz.*, grain, straw and biological yield of barley as compared to control and at par with foliar application of urea (2.0%) and foliar application of KCl (1.0%). Increases in growth parameters may have led to higher yield qualities and an increase in barley grain and straw yield. These findings closely align with those of Mahobia *et al.*, (2006) and Ghosh and Joseph (2008).

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Effect of Inorganic Fertilizers and Agro Chemicals Spray on yield and Nutrient Uptake of Pearl millet (*Pennisetum glaucum* (L.) under Rainfed Conditions

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Abstract

A field experiment was conducted at College Farm, Department of Agriculture, Vivekananda Global University, Jaipur during the *kharif* season of 2022. The study found that the maximum drymatter plant⁻¹ was produced by 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹ at harvest. The application of 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹ significantly improved grain yield and straw yield of pearl millet. The application also improved nitrogen, phosphorus, and potassium content in grain and straw of pearl millet. Among the agrochemicals spray at different stages of pearl millet, 500 ppm thiourea spray at tillering and booting stage proved to be superior in terms of plant height, dry matter accumulation, and productivity. The application of 500 ppm thiourea spray at tillering and booting stage was significantly superior over 100 ppm cycocel spray at tillering and booting stage and water spray in grain yield, straw yield, and nitrogen, phosphorus, and potassium content in straw of pearl millet.

Key words : Cycocel, dry matter accumulation, thiourea, water spray and yield.

Introduction

Pearlmillet (*Pennisetum glaucum* (L.) is one of the significant millet crops grown in India. In terms of output and area among the millets, it comes in second place after sorghum. Rajasthan, Uttar Pradesh, Maharashtra, Haryana, and Gujarat account for more than 90% of the total acreage and output. Rajasthan leads in terms of output and area for pearlmillet. It is a substantial fodder crop in addition to being a staple diet for 10% of the population in our country. It is the only cereal crop capable of responding to both intense management demands and difficult environmental conditions to provide a constant yield. A vital component of the human diet is its nutrient-rich grain, and during the dry season, stover is the main source of food for ruminant cattle. Furthermore, pearl millet grain is widely used as cow and poultry feed. It is more nutritious than many cereals since it has a considerable quantity of iron (2.8%), fat (5%) and protein (12.6%). Pearlmillet is considered to be a crop that is frequently grown in deserts since it is drought-tolerant and uses sun radiation well. The land used to cultivate pearl millet is rainfed, or without irrigation, to a little over 89.5%. Up until now, cultivars with large yields have been the major emphasis, mostly to feed the world's rising population. The sustainable development goals of the United Nations compel all nations to attain food security in connection to nutritional security. India has the highest proportion of malnutrition people in the world (194.6 million), with 38.4% of children under 5 years old being stunted and 35.7% of children underweight. Vitamin and/or mineral deficiencies cost India's economy more than \$12 billion year (Yadav *et al.*, 2022). In dry and

semi-arid areas of the country, pearlmillet covers more than 80% of the land. Rajasthan has the biggest acreage covered in pearl millet plantings and the highest production in the country. The State has an area of 46 lakh hectares and produces around 28 lakh tonnes annually at a productivity of 400 kg per hectare. Major pearlmillet-growing regions in the state include Barmer, Jodhpur, Nagaur, Churu, Jalore, Sikar, Jaipur, Jhunjhunu, Alwar, and Bikaner. Rajasthan's climate and soil composition offer the best conditions for cultivating pearlmillet (Yadav *et al.*, 2021). NPK fertilizers can help farmers cultivate healthy crops sustainably and increase income. Balanced diet is crucial for crop development and productivity (Chaudhary *et al.*, 2021). Nitrogen, phosphorus, and potassium are important plant nutrients. Bio-regulators manage plant efficiency and play a vital role in biotic and abiotic stress responses and tolerance. These molecules help overcome yield restrictions (Asgher *et al.*, 2015; Jangir *et al.*, 2021).

According to Chakrabarti and Mukherjee (2003), Plant growth regulators like thiourea can boost seed and stover productivity in pearlmillet, wheat, and mustard crops. These bio-regulators can help plants cope with environmental issues like climate change and global warming. Salicylic acid, a natural hormone, plays a crucial role in plant growth and development, including thermogenesis (Hayat *et al.*, 2010). Thiourea, a sulphhydryl molecule, is essential for plant physiology and controlling membrane protein redox status. Its application on foliage enhances CO₂ absorption and reduces membrane damage caused by oxidized sulphhydryl groups under heat stress, thereby reducing oxidative stress.

Thiourea and cycocel foliar sprays enhance plant photosynthetic efficiency and canopy photosynthesis, promoting antioxidant activity and slowing down senescence, benefiting reproductive and vegetative organs (Halmann, 1980). Thiourea is also known to improve the photosynthetically active leaf surface throughout the phase of grain filling in cereals (Sahu *et al.*, 2007). Furthermore, a lab test utilizing these thiol bio-regulators (seed soaking and foliar spray) at BARC, Mumbai has shown a positive impact on the translocation of 14-C sucrose from source to sink as well as multi-stress tolerance in mustard (Srivastava *et al.*, 2008). It has been demonstrated that thiourea foliar spray improves plant development and growth as well as dry matter partitioning for increased grain output (Arora, 2004). Study on agrochemicals' relevance and fertility levels in pearl millet plant processes was necessary under limited water and soil low fertile soils.

Materials and Methods

A field experiment under rainfed conditions was conducted at College Farm, Department of Agriculture, Vivekananda Global University, Jaipur during *kharif* season of 2022. The experiment was laid out in randomized block design were replicated three times. The treatments include the three levels of inorganic fertilizer; control (CF0), 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ (CF1) and 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹ (CF2) and three levels agrochemical spray; water spray (S1), 100 ppm cycocel spray at tillering and booting stage (S2) and 500 ppm thiourea spray at tillering and booting stage (S3). The statistical analysis of yield and nutrient uptake data were performed using R-software Agricole package.

Results and Discussion

Effect on growth attributes : The study found that pearl millet plant height and other growth attributes increased with crop stage advancement (table 1). The lowest increment was observed from 60 days after sowing to harvest, regardless of fertility levels or agrochemical spray treatments. Significantly the highest plant height was observed at 60 days and harvest with 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹, while the lowest was found with control treatments. The significantly higher dry matter accumulation (27.48 and 52.15 g) plant⁻¹ was observed with the application of CF1 followed by CF2 at different growth stages. The significantly higher leaf area (2848 cm²) and LAI (4.10) were also found with the application of CF2 than rest of the treatments. Significantly the highest plant height, DMA leaf area and LAI were observed with 500 ppm thiourea spray at tillering and booting stage.

The soils of the experimental field was low levels of

available nitrogen and medium levels of available phosphorus, which may have contributed to the rise in plant height due to an adequate supply of nitrogen and phosphorus through chemical fertilization. Elevated fertility levels also led to a significant increase in dry matter accumulation, which is produced as a result of plant growth, photosynthetic activity, and the ability to utilize available nutrients (Bhagchand and Gautam, 2000). The results showed that applying different fertility levels had no negative effects on pearl millet plant populations (Mukhtar *et al.*, 2011). Nutrients promote plant development and increase plant height, which may boost the production of dry matter. However, harvest fertility levels had a substantial impact on pearl millet plant growth at a later stage (Hernandez-Nistel *et al.*, 2023; Solanki *et al.*, 2007). The size and coverage of the canopy play a significant role in the solar energy intercepted, affecting net photosynthesis and plant photosynthetic activity (Garg *et al.*, 2006). The increase in leaf area/plant and LAI was caused by the rise in fertility levels up to 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹, which may have improved photosynthesis and increased the availability of photosynthates to plant parts, leading to higher dry matter accumulation/plant (Dhikwal *et al.*, 2013; Kumawat *et al.*, 2013).

The results show that foliar application of bioregulators (thiourea and cycocel) significantly boosted growth parameters plant height, dry matter accumulation, total number of tillers per plant, and leaf area per plant over control (Mathur and Vyas, 2007). Cycocel and thiourea promoted plant growth and development and controlled various hormonal processes, including seed germination, vegetative growth, photosynthesis, respiration, thermogenesis, flower formation, seed generation, and senescence (Vaiyapuri *et al.*, 2012; Choudhary and Gautam, 2006).

Effect on yield attributes : The number of tillers per plant varying results across treatments, with values such as 3.10 (CF0), 3.12 (CF1), and 3.20 (CF2) recorded at 30 DAS which was found statistically non-significant (table 2). The effective tillers per plant follow a similar trend, with slightly higher effective tillers per plant in CF2.

Earhead length significantly higher (27.4 cm) with application of CF2 and statistically at par (26.7 cm) with CF1. The significantly higher grains per ear (1486) was obtained with the application of CF2 followed by CF1 (1407) and the lowest was found with the control (1350). Among the different treatments of agrochemical spray, the significantly higher gains per ear (1459) was observed with the application of S2 followed by (1404) S1 and the lowest grains per ear (1351) was obtained with the application of water spray treatment (S0). The application

Table-1 : Effect of fertility levels and agrochemical spray on plant height, dry matter accumulation and leaf area of pearl millet.

Treatments	Plant height (cm)			DMA (g plant ⁻¹)			Leaf area (cm ² plant ⁻¹)	LAI
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS		
CF0	34.4	125.5	146.2	13.2	23.5	46.7	2578	3.80
CF1	35.2	130.6	155.1	13.4	25.45	49.19	2632	3.98
CF2	38.1	139.4	160.8	14.1	27.48	52.15	2848	4.10
LSD (P = 0.05)	NS	9.40	10.1	NS	1.69	3.50	185.4	0.30
S1	35.1	115.4	136.6	12.6	22.54	43.16	2541	3.74
S2	37.2	134.8	157.4	13.5	24.96	48.41	2634	3.82
S3	38.0	143.4	168.0	14.4	28.79	55.42	2846	3.94
LSD (P = 0.05)	NS	9.18	9.45	NS	1.54	3.42	168.7	0.27

CF0: Control, CF1: 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹, CF2: 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹. S1: Water spray, S2: 100 ppm cycocel spray at tillering and booting stage, S3: 500 ppm thiourea spray at tillering and booting stage, DAS: Days after sowing, LAI: Leaf area index, NS: Non-significant

Table-2 : Effect of fertility levels and agrochemical spray on yield attributes of pearl millet.

Treatments	Number of tillers (plant ⁻¹)			Effective tillers (plant ⁻¹)	Earhead length (cm)	Number of grains (plant ⁻¹)	Test weight (g)
	30 DAS	60 DAS	90 DAS				
CF0	3.10	3.50	3.60	2.46	25.9	1350	6.40
CF1	3.12	3.80	3.84	2.66	26.7	1407	6.43
CF2	3.20	3.86	3.92	2.85	27.4	1486	6.49
LSD (P = 0.05)	NS	0.21	0.27	NS	1.18	50.8	NS
S1	2.86	3.20	3.26	2.38	24.7	1351	6.45
S2	3.08	3.46	3.56	2.49	25.8	1404	6.47
S3	3.24	3.80	3.90	2.74	27.1	1459	6.48
LSD (P = 0.05)	NS	0.18	0.24	0.32	1.10	50.10	NS

CF0: Control, CF1: 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹, CF2: 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹. S1: Water spray, S2: 100 ppm cycocel spray at tillering and booting stage, S3: 500 ppm thiourea spray at tillering and booting stage, DAS: Days after sowing, NS: Non-significant

Table-3 : Effect of fertility levels and agrochemical spray on yield and nutrient uptake of pearl millet.

Treatments	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index (%)	N uptake (kg ha ⁻¹)		P uptake (kg ha ⁻¹)		K uptake (kg ha ⁻¹)	
				Grain	Straw	Grain	Straw	Grain	Straw
CF0	1685	4350	27.9	30.16	17.36	3.89	4.22	9.86	82.65
CF1	1855	4875	27.6	36.54	20.23	4.66	5.27	11.56	94.58
CF2	2115	5349	28.3	43.99	22.63	5.54	5.88	13.32	106.45
LSD (P = 0.05)	155.1	362.4	NS	6.88	3.95	0.93	0.99	2.91	6.12
S1	1662	4285	27.9	29.25	16.33	3.82	4.24	9.66	80.99
S2	1834	4576	28.6	35.76	18.67	4.44	4.80	11.19	87.86
S3	2096	5014	29.5	42.97	21.06	5.45	5.47	13.02	98.27
LSD (P = 0.05)	152.4	358.1	NS	6.59	3.45	0.81	0.87	2.65	6.03

CF0: Control, CF1: 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹, CF2: 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹. S1: Water spray, S2: 100 ppm cycocel spray at tillering and booting stage, S3: 500 ppm thiourea spray at tillering and booting stage, NS: Non-significant

of inorganic fertilizer and agrochemical spray does not any significant effect on test weight of pearl millet.

Fertility levels up to 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹ resulted in a significant increase in effective tillers/plant and increased quantity of grains/ear in pearl millet plants (Sahu *et al.*, 2007; Hooda *et al.*, 2004). This increase may be due to increased growth hormones and nutrient availability. In an intercropping system with legumes, yield characteristics improved with increases in nitrogen and phosphorus dosages. Treatment CF2 had more total and productive tillers per

plant. Bioregulators (thiourea and cycocel) significantly enhanced yield characteristics, including effective tillers per plant, grains per ear, and ear length (Lakhana *et al.*, 2005; Sahu *et al.*, 2005 and 2007). Thiourea foliar spray improved crop photosynthesis, while cycocel foliar spray postponed senescence, extending photosynthetically active sites and preventing premature crop maturity (Rathore *et al.*, 2007; Ghosh *et al.*, 2009; Kumar *et al.*, 2023).

Effect on yield and nutrient uptake : The significantly higher grain yield was obtained with the application of CF2

(2115 kg ha⁻¹) followed by CF1(1855 kg ha⁻¹) and lowest was observed under control (1685 kg ha⁻¹) treatment (table 3). Among the different treatments of agrochemical spray, the significantly higher grain yield (5014 kg/ha) was obtained under S2 followed by S1 and the lowest was obtained with only water spray (S0).

The similar trend was reported for straw yield also. The harvest index of pearl millet was increased with fertility levels and agrochemical spray but not reached up to level of significance. The nitrogen uptake in the grain of pearl millet was varied from 30.1 kg/ha to 43.9 kg/ha under different fertility levels. The application of CF2 (43.9 kg/ha) was significantly higher over CF1 (36.1 kg/ha) and control (30.1) in nitrogen uptake in grain of pearl millet. The application of S2 (42.9 kg/ha) was significantly increased over S1 (35.7 kg/ha) and water spray (29.2 kg/ha) in N uptake in grain of pearl millet. Similarly, the N uptake in straw of pearl millet followed the same trend as in nitrogen uptake in grain. The similar trends as in nitrogen uptake was followed in case of phosphorus and potassium uptake of pearl millet.

The application of fertilizers at a rate of 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹ significantly increased the concentration, uptake, and total uptake of phosphorus and nitrogen by grain and stover, as well as the protein content of pearl millet grain. However, up to 60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹, the nitrogen concentration and absorption by stover were dramatically enhanced (Leila et al., 2014; Kumawat et al., 2021). The increase in nitrogen content in the grain was the cause of the increase in protein content. Foliar spraying of bio-regulators (thiourea and cycocel) significantly raised the N and P content in grain and stover, as well as the total nitrogen, phosphorous, and potassium absorption by pearl millet (Singh et al., 2006; Muhal et al., 2014; Yadav et al., 2021). Thiourea treatment may have improved plant metabolic processes and growth and development due to higher absorption of nutrients from the rhizosphere. Cycocel treatment also boosted nutrient absorption and protein content in pearl millet grains (Abdelkader et al., 2010; Yadava 2017).

Conclusions

Among the fertility levels to pearl millet, application of CF2 (60 kg N ha⁻¹ + 30 kg P₂O₅ ha⁻¹ + 30 kg K₂O ha⁻¹) proved to be superior in the terms of dry matter production, yield and quality of *kharif* pearl millet. Among the agrochemicals spray at different stages of pearl millet, spraying of 500 ppm thiourea spray at tillering and booting stage (S2) proved to be superior in the terms of plant height, dry matter accumulation and productivity of pearl millet.

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Effect of Mulching and Nitrogen Levels on Growth, Yield and Quality of Wheat (*Triticum aestivum* L.)

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Abstract

The field experiment conducted at Research Farm, VGU, Jaipur, Rajasthan during the *rabi* season of 2022-23 to evaluate the effect of pearl millet husk mulch and nitrogen levels on the growth, yield, and quality parameters of wheat (*Triticum aestivum* L.). The treatment comprised of three levels of pearl millet husk mulch (0 t per ha, 3 t per ha and 6 t per ha) and three levels of nitrogen (75% RDN, 100% RDN and 125% RDN). The results showed that the use of pearl millet husk as mulch (6 t per ha) increased plant height and dry matter accumulation at all growth stages compared to the control or no mulch. The highest yield was obtained at the pearl millet husk mulch level (6 t per ha) with a grain yield of 34.8 and straw yield of 49.1. However, the harvest index decreased as the mulch level increased. The results showed that the use of pearl millet husk as mulch increased both grain and straw phosphorus content compared to the control treatment with no mulch. The highest phosphorus content was obtained at the highest mulch level (6 t per ha). However, there was no significant difference between the nitrogen content of wheat grain and straw treated with different mulch levels. The highest plant height, number of tillers/m² and dry matter accumulation were observed at the highest nitrogen level (125% RDN). The grain and straw yield increased with increasing nitrogen application. The highest yield was obtained at the highest nitrogen level (125% RDN) with a grain yield of 34.6q/ha and straw yield of 49.0q/ha.

Key words : Economics, pearl millet, husk, quality, yield.

Introduction

Wheat (*Triticum aestivum* L.) a member of Poaceae family, is the second most important crop grown on a large scale in world and the most consumed food crop after rice and plays a significant role in the global economy. It contains approximately 13% protein, 70% carbohydrates, 2.7 percent minerals, 1.7 percent fats, 2% fiber and 13% moisture (Sharma and Jain, 2014). Wheat was sown on approximately 29.31 million ha in India during 2018-19, yielding 103.57 million tones with an average productivity of 3533 kg/ha. In India, the state with the largest area (9.54 million ha) and production (32.74 million tons) was Uttar Pradesh, while Punjab had the highest productivity (5188 kg/ha) (Anonymous, 2022a). By 2050, demand for wheat in developing countries such as India will climb by 60%. (CIMMYT, 2013). Thus, in order to ensure sustainable food supply and to feed an ever-growing population, wheat yields must be increased. Wheat yields can be increased by the use of appropriate agronomic measures and high yielding varieties. However, in Haryana due to limited land resources and high population density horizontal expansion of wheat area is not possible. Therefore, increasing production of wheat by vertical ways i.e. agronomic management practices may be most suitable, viable and practical approach under such circumstances (Mandal *et al.*, 2013). By 2050, it is anticipated that a sustainable increase in global food

supply of 70-100 percent will be required to feed 9 billion people. As a result, to identify economically viable, ecologically sustainable and technologically feasible methods for boosting wheat grain production. Suitability of cultivars to a specific agro-climate is critical for maximizing their yield potential as plant production efficiency is governed by genotype-environment (G x E) interaction. One of the most effective agronomic practices for water-scarce areas is the use of crop residues as a soil cover (mulch) in conservation agriculture (CA). Mulches put on the surface have various benefits for crop development including enhancing soil nutrient and water status, decreasing loss of soil and water, preventing soil salinity from rising to the top profile and suppressing weeds. Mulching wheat increases grain output as compared to unmatched wheat because it conserves soil and water. Additionally, it enhances the soil's physical, chemical and biological properties. This has the effect of decreasing soil water evaporation and increasing plant transpiration rates. Mulching boosts wheat yield, water use efficiency and soil organic carbon fixation when irrigation is constrained (Ram *et al.*, 2013). Straw mulch greatly enhanced the productivity of winter wheat (Mrabet *et al.*, 2012). Thus, mulching enhanced soil moisture content, resulting in an improvement in yield of winter wheat and water use efficiency (Chen *et al.*, 2015). Mulching increases the soil's water retention capacity (Stagnari *et al.*, 2014).

Not only has that, but the addition of mulch resulted in an increase in beneficial microbial activity in the soil. Soil's microorganisms have vital role in regulating carbon and nitrogen dynamics (Zhao *et al.*, 2014) and contribute significantly to nutrient supplementation and sustainability of the agro-ecosystem. Straw mulch can boost soil microorganism activity and population (Dong *et al.*, 2017), whereas plastic film mulch can only boost the activity of microbes, hence, stimulating carbon and nitrogen mineralization (Chen *et al.*, 2014). Management by growth stage is critical to optimize returns from inputs such as nitrogen, plant growth regulator, fungicides & water.

Materials and Methods

An experiment was carried out during *rabi* 2022-23 at the Research Farm, Vivekananda Global University, Jaipur which is situated in South-Eastern part of Rajasthan at an altitude of 581.13 meter above mean sea level with 24°35' N latitude and 74°42' E longitude. The climate of this region is typically semi-arid, characterized by extremes of temperature during both summers and winters. During summers, the temperature may go as high as 48 °C, while in winters, it may fall as low as -1.0°C. Frost is not uncommon during winter. The soil in the experimental field was loamy sand in texture, somewhat alkaline in reactivity (pH-7.7), low in available nitrogen (273.52 kg ha⁻¹), medium in phosphorus (21.24 kg ha⁻¹) and organic carbon (0.71%), and high in accessible potassium (282.38 kg ha⁻¹).

During the experiment, the nine treatment combinations (three mulch levels, namely no mulch (control) M₁, Pearl Millet husk @ 3 t ha⁻¹ M₂ and Mulch @ 6 t per ha (M₃) in main plot, and three Nitrogen levels (N), namely 75% RDN N₁, 100% RDN N₂ and 125% RDN N₃ in sub plot) were laid out in Factor Randomized Block Design (FRBD) with three replications. Mulch was applied to all treatments after sowing (on December 14, 2022) to ensure crop germination on November 14, 2022. Following that, the irrigation plan will be followed according to treatments, with the first irrigation on 4 December 2022 and the second irrigation on 28 December 2022. At the time of seeding, a basal dose of fertilizer was applied according to the standard procedure.

The required fertilizer dose (120 kg N + 40 kg P₂O₅ + 40 kg K₂O per hectare) was used. Half of the N and full dose of P₂O₅ were applied as a basal dose at the time of sowing, and the remaining half was applied as a top dressing at the time of the first and second irrigation. The Wheat variety RJ-3077 was seeded at a rate of 100 kg ha⁻¹. On November 11, 2022, the seeds were manually sown in opened furrows at a depth of 5 cm in rows spaced

22.5 cm apart, and after depositing the seed in furrows, it was covered with earth to provide uniform germination and protection from bird damage. Each plot's crop was collected separately. The collected plants were tied into bundles, labelled, and sun dried on the threshing floor. These bundles were weighed right before threshing after thorough drying to determine biological yield. Threshing of gathered crops from individual plots was accomplished using a tiny power operated thresher.

The grains harvested from each net plot were sun dried for 2-3 days to attain 10 per cent moisture and then the weight of grains net plot⁻¹ area was recorded and expressed in kg ha⁻¹. The straw yield from each net plot was sun dried for 4 to 6 days and weighed. Straw yield kg ha⁻¹ was computed from straw yield of each net plot. The threshed produce from net plot area, after sun drying was weighed for recoding the biological yield and expressed in terms of yield in kg ha⁻¹. It is the ratio of economic yield (grain yield) to biological yield, and worked out by following formula (Donald and Hamblin, 1976) expressed in percentage.

Protein content in grain was estimated by multiplying nitrogen content in grain by 6.25 using the Lowry *et al.* (1951) technique. The chlorophyll concentration of barley was determined using a portable leaf chlorophyll meter (Minolta, Japan) and expressed as a SPAD 502 value. The economics of various treatments were calculated in terms of net return (Rs ha⁻¹) and B-C ratio using current market prices for inputs and outputs. To determine the more profitable therapy, the economics of various treatments were calculated in terms of net return (Rs ha⁻¹) using the current market rate, so that the most remunerative treatment could be recommended. Treatment wise benefit-cost (B-C) ratio was also calculated to ascertain economic viability of the treatments by using the following formula :

$$\text{Benefit - Cost ratio} = \frac{\text{Gross return (₹ ha}^{-1}\text{)}}{\text{Total cost (₹ ha}^{-1}\text{)}}$$

All data were statistically analysed using an acceptable method of analysis of variance to determine the significance of variation in experimental results. Wherever the F value was found to be significant at the 5% level of significance, the crucial difference (CD) value was calculated to compare the treatment means. In order to establish a cause and effect link, regression equations and coefficients of correlation were generated between specified characters. All of these calculations were carried out using the conventional statistical approach proposed by Panse and Sukhatme (1989).

Results and Discussion

Plant population : Data of Table-1 revealed that pearl

millet husk and nitrogen levels had no significant effect on plant stand/metre row length. Therefore, the application of nitrogen and pearl millet husk can increase the biomass, height, root length, and shoot dry weight of wheat plants (Babar *et al.*, 2015).

Table-1 : Effect of pearl millet husk and nitrogen on plant population per meter row length at 20 DAS of wheat.

Treatments	Plant population (per m row length)
Mulch levels	
Control	24.8
Pearl Millet husk @ 3 t/ha	25.1
Pearl Millet husk @ 6 t/ha	25.6
S.Em ±	0.5
C.D. (P = 0.05)	NS
Nitrogen levels	
75% RDN	24.3
100% RDN	25.4
125% RDN	25.5
S.Em ±	0.5
C.D. (P = 0.05)	NS
CV (%)	3.78

Plant height (cm) : The table-2 showed that both mulch levels and nitrogen levels had a significant effect on plant height at all growth stages. The mulching with pearl millet husk at 6 t per ha increased plant height significantly at all the stages of growth than the treatment mulching with 3 t per ha which in turn had taller plants than no mulch. The result further revealed that increasing levels of nitrogen significantly increased the plant height. The highest plant height (12.13, 30.67 and 57.60 cm) was observed in the treatment with 125% RDN at the CRI, Tillering and harvest stage, respectively. One study conducted in India found that the application of nitrogen and pearl millet husk significantly increased the biomass and height of wheat plants (Kumar *et al.*, 2019).

Table-2 : Effect of pearl millet husk and nitrogen on plant height of wheat at different stages.

Treatments	Plant height (cm)		
	CRI Stage	Tillering Stage	At harvest Stage
Mulch levels			
Control	9.2	23.9	55.6
Pearl millet husk @ 3 t/ha	11.4	30.7	62.8
Pearl millet husk @ 6 t/ha	13.6	34.3	64.4
S.Em ±	0.27	1.07	0.52
C.D. (P = 0.05)	0.83	3.19	1.54
Nitrogen levels			
75% RDN	8.22	21.35	49.78
100% RDN	10.17	27.45	56.23
125% RDN	12.13	30.67	57.60
S.Em ±	0.27	1.05	0.51
C.D. (P = 0.05)	0.80	3.09	1.49
CV (%)	6.15	7.81	8.82

The results indicate that both mulch levels and nitrogen levels had a significant effect on number of tillers at all growth stages. At the CRI stage, the treatment with 6 t/ha of pearl millet husk had significantly the highest number of tiller density (174.8 tillers/m²). At the tillering and harvest stage, the treatment mulching with 6 t/ha of pearl millet husk had significantly the highest tiller density (288.4 and 240.4 tillers/m², respectively) over mulching with 3 t/ha of pearl millet husk and no mulch treatment had the lowest tiller density (183.5 tillers/m²).

As regard to the table 2 on nitrogen levels, the highest number of tillers/m² was observed under application of 125% RDN which was significantly superior over no mulch at all the stages of growth while at tillering and at harvest stage, application of 125% RDN registered

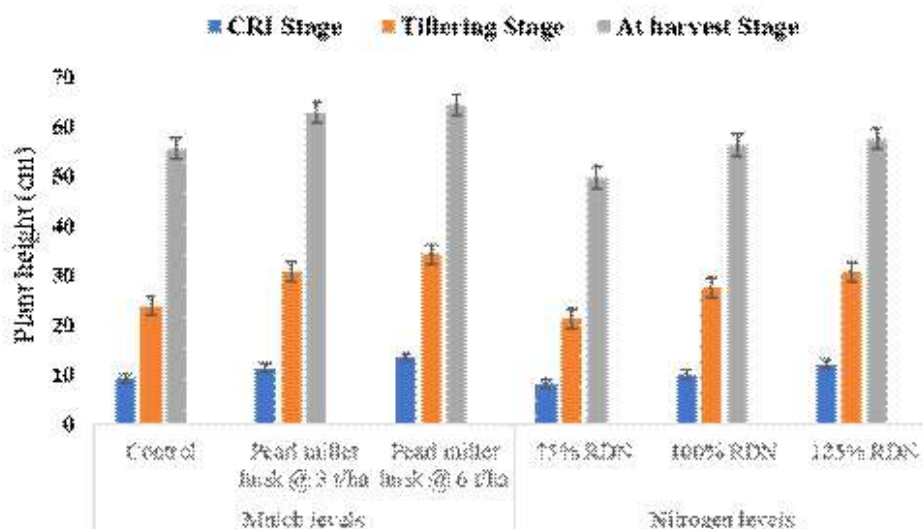


Fig-1 : Effect mulch and nitrogen on plant height of wheat.

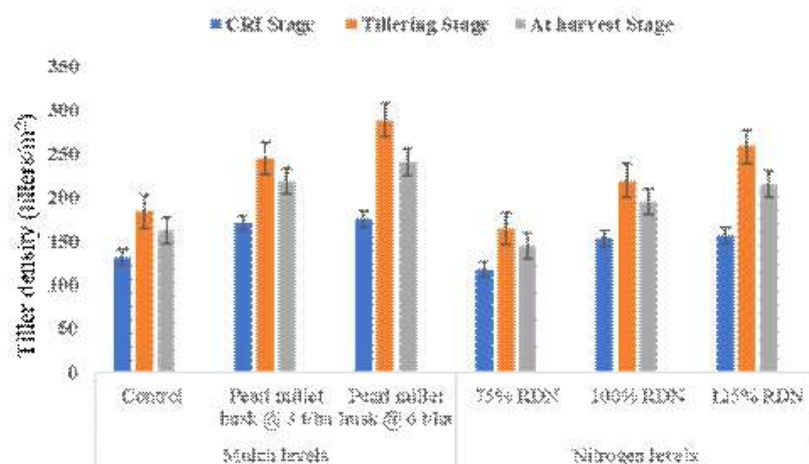


Fig-2 : Effect mulch and nitrogen on tiller density of wheat.

significantly higher number of tillers/m² over preceding levels of nitrogen. The study conducted in Pakistan found that the application of nitrogen and pearl millet husk increased the root length and shoot dry weight of wheat plants (Akhtar *et al.*, 2017).

Table-3 : Effect of pearl millet husk and nitrogen on total number of tillers of wheat at different stages.

Treatments	Tiller density (tillers/m ²)		
	CRI Stage	Tillering Stage	At harvest Stage
Mulch levels			
Control	131.1	183.5	161.7
Pearl millet husk @ 3 t/ha	170.4	244.7	218.5
Pearl millet husk @ 6 t/ha	174.8	288.4	240.4
S.Em ±	2.02	3.33	2.17
C.D. (P = 0.05)	6.00	9.90	6.48
Nitrogen levels			
75% RDN	117.30	164.22	144.67
100% RDN	152.49	218.96	195.50
125% RDN	156.40	258.06	215.05
S.Em ±	1.98	3.26	2.13
C.D. (P = 0.05)	5.81	9.59	6.27
CV (%)	6.70	6.35	8.90

Dry matter accumulation : The table-4 suggested that the application of pearl millet husk @ 3 t/ha and 6 t/ha resulted in higher dry matter accumulation compared to the control treatment at all three stages. However, the applications of pearl millet husk 6 t/ha showed statistically the highest dry matter accumulation compared to the control treatment at all the stages. The application of pearl millet husk at 3 t/ha exhibited a percent increment ranging from 20.4% to 22.6% across the different stages, while the treatment with pearl millet husk at 6 t/ha showed a percent increment ranging from 27.6% to 36.6%.

The increasing the nitrogen level from 75% RDN to

125% RDN led to higher dry matter accumulation at all stages. The application of 125% RDN reported significantly the highest dry matter accumulation of 17.8 g, 67.5 g and 223.5 g respectively at CRI, tillering and at harvest of wheat crop. The application of 100% RDN demonstrated percent increments ranging from 13.8% to 20.1%, while the treatment with 125% RDN showed percent increments ranging from 22.1% to 34.8% across the different stages. Therefore, the application of nitrogen and pearl millet husk can increase the biomass, height, root length, and shoot dry weight of wheat plants (Babar *et al.*, 2015).

Table-4 : Effect of pearl millet husk and nitrogen on dry matter accumulation per m row length (g) of wheat at different stages.

Treatments	Dry matter accumulation per m row length (g)		
	CRI Stage	Tillering Stage	At harvest
Mulch levels			
Control	14.5	50.1	174.5
Pearl millet husk @ 3 t/ha	17.6	61.4	210.4
Pearl millet husk @ 6 t/ha	18.5	68.4	224.2
S.Em ±	0.20	1.1	3.4
C.D. (P = 0.05)	0.61	3.28	10.1
Nitrogen levels			
75% RDN	13.2	48.4	171.1
100% RDN	16.5	60.2	207.0
125% RDN	17.8	67.5	223.5
S.Em ±	0.19	1.0	3.3
C.D. (P = 0.05)	0.58	3.01	9.9
CV (%)	7.44	6.28	7.05

Spike length, Number of spikelet spike⁻¹ and Number of grains spike⁻¹ : A perusal in table 5 on spike length, number of spikelet spike⁻¹, and number of grains spike⁻¹ indicated that the effect of mulching, the application of

pearl millet husk at 3 t/ha and 6 t/ha significantly increased spike length, number of spikelet spike⁻¹, and number of grains spike⁻¹ compared to the control (no mulch). Specifically, spike length increased by 2.1 cm (33.3%) and 2.2 cm (34.9%), number of spikelet spike⁻¹ increased by 3.5 (22.3%) and 5.3 (20.9%), and number of grains spike⁻¹ increased by 3.5 (13.8%) and 5.3 (18.9%) at 3 t/ha and 6 t/ha of pearl millet husk, respectively.

The effect of nitrogen levels, the application of nitrogen at 100% RDN and 125% RDN significantly increased spike length, number of spikelet spike⁻¹, and number of grains spike⁻¹ compared to 75% RDN. Specifically, spike length increased by 1.88 cm (33.3%) and 1.96 cm (34.8%), number of spikelet spike⁻¹ increased by 3.12 (22.2%) and 5.47 (24.5%), and number of grains spike⁻¹ increased by 3.13 (13.8%) and 5.29 (19.0%) at 100% RDN and 125% RDN, respectively.

Yields and harvest index : The result on the effect of pearl millet husk and nitrogen levels on grain yield, straw yield, and harvest index of wheat are presented in table 4.6. Among the different rate of mulching, the application of pearl millet husk @ 6 t/ha and 3 t/ha resulted in significantly higher grain of 45.5 q/ha and 44.2 q/ha and straw yield 60.5 and 57.0 q/ha, respectively over control or no mulch which produced the lowest grain yield (31.4 q/ha). The application of pearl millet husk at 3 t/ha and 6 t/ha was at par and did not differ significantly to each other.

The grain and straw yields increased significantly with the application of 125% recommended dose of nitrogen and increased by 43.88 and 38.89 per cent over 75% RDN. The difference in grain yield with the application of 100% RDN and 125% RDN was statistically non-significant, indicating that these treatments were remained at par while in case of straw yield increasing level of nitrogen treatments increased significantly.

The harvest index did not reach to the level of significance with pearl millet husk mulching and various levels of nitrogen. The positive effect of pearl millet husk and nitrogen on wheat yield can be attributed to several factors. First, pearl millet husk is a good source of organic matter, which can improve soil fertility and nutrient availability, leading to better plant growth and development (Anjum *et al.*, 2019). Second, nitrogen is an essential macronutrient that plays a crucial role in increasing crop yield by improving crop growth and increasing the number and weight of grains per spike (Zhang *et al.*, 2020). Therefore, the combined application of pearl millet husk and nitrogen can increase the yield of wheat by improving soil fertility and plant nutrition (Karimi *et al.*, 2020).

Table-5 : Effect of pearl millet husk and nitrogen on spike length, number of spikelet spike-1 and number of grains spike-1.

Treatments	Spike length (cm)	Number of spikelet spike ⁻¹	Number of grains spike ⁻¹
Mulch levels			
Control	6.3	15.7	25.3
Pearl millet husk @ 3 t/ha	8.4	19.2	28.8
Pearl Millet husk @ 6 t/ha	8.5	21.9	30.6
S.Em ±	0.05	0.71	0.46
C.D. (P = 0.05)	0.13	2.09	1.37
Nitrogen levels			
75% RDN	5.63	14.08	22.68
100% RDN	7.51	17.20	25.81
125% RDN	7.59	19.55	27.37
S.Em ±	0.05	0.69	0.45
C.D. (P = 0.05)	0.15	2.10	1.33
CV (%)	6.56	7.45	9.30

Table-6 : Effect of pearl millet husk and nitrogen on grain yield, straw yield and harvest index of wheat.

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Mulch levels			
Control	31.4	42.9	42.2
Pearl Millet husk @ 3 t/ha	44.5	57.0	43.8
Pearl Millet husk @ 6 t/ha	45.2	60.5	42.7
S.Em ±	0.81	1.42	0.86
C.D. (P = 0.05)	2.44	4.23	NS
Nitrogen levels			
75% RDN	29.4	39.6	42.6
100% RDN	41.1	52.8	43.7
125% RDN	42.3	55.0	43.4
S.Em ±	0.70	1.35	0.84
C.D. (P = 0.05)	2.10	4.04	NS
CV (%)	8.81	8.14	4.75

Biological yield and test weight : The table-7 showed the effect of pearl millet husk and nitrogen levels on biological yield (q/ha) and test weight (g) of wheat. The results indicated that the application of pearl millet husk and nitrogen levels significantly increased the biological yield and test weight compared to the control treatment. In terms of pearl millet husk, the biological yield increased from 74.3 q/ha in the control treatment to 101.5 and 105.7 q/ha in the treatments with 3 t/ha and 6 t/ha of pearl millet husk, respectively. The test weight also increased from 35.9 g in the control treatment to 39.5 and 42.1 g in the treatments with 3 t/ha and 6 t/ha of pearl millet husk, respectively. In case of biological yield of wheat application of pearl millet husk @ 6 t/ha (105.7 q/ha) remained at par with @ 3 t/ha (101.5 q/ha) whereas in case of test weight application of pearl millet husk @ 6 t/ha reported significantly height test weight. Nitrogen is a critical nutrient for wheat growth and development, and it

is often limiting in many agricultural soils (Chaudhary *et al.*, 2020). Therefore, the application of nitrogen and pearl millet husk can increase wheat yield by providing essential nutrients for plant growth.

Table-7 : Effect of pearl millet husk and nitrogen on biological yield and test weight of wheat.

Treatments	Biological yield (q ha ⁻¹)	Test weight (g)
Mulch levels		
Control	74.3	35.9
Pearl Millet husk @ 3 t/ha	101.5	39.5
Pearl Millet husk @ 6 t/ha	105.7	42.1
S.Em ±	1.90	0.28
C.D. (P = 0.05)	5.71	0.84
Nitrogen levels		
75% RDN	69.0	33.6
100% RDN	93.9	35.8
125% RDN	97.3	38.2
S.Em ±	1.81	0.27
C.D. (P = 0.05)	5.42	0.81
CV (%)	7.47	6.5

Conclusions

The use of pearl millet husk as mulch and increasing nitrogen levels had a positive effect on wheat growth, yield, and quality. The study recommends the use of pearl millet husk as mulch at a level of 6 t per ha and nitrogen application at a rate of 125% RDN for improving wheat productivity in similar agro-climatic conditions.

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Effect of Silicon on Quality, Productivity and Profitability of Barley (*Hordeum vulgare* L.) under Varying Irrigation Levels

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Abstract

A field experiment was carried out during *rabi* 2022-23 at the Research Farm, Vivekananda Global University, Jaipur to evaluate the effect of irrigation levels on growth, yield attributes and yield of barley. The nine treatment combinations (three irrigation levels *i.e.*, no irrigation (control), one irrigation at 30-35 DAS and two irrigations at 30-35 and 80-85 DAS in main plot and three silicon levels *i.e.*, control (no silicon, silicon 100 kg ha⁻¹ and silicon 150 kg ha⁻¹ in sub plot) was laid out in split plot design with three replications. Among irrigation levels, application of two irrigation at 30-35 and 80-85 DAS was recorded significantly higher quality *viz.*, protein, carbohydrates content, chlorophyll content and nitrogen content in grain, yield *viz.*, grain and straw yield of barley, net return and B-C ratio over application of one irrigation at 30-35 DAS and no irrigation (control). Application of 150 kg ha⁻¹ silicon increased significantly quality *viz.*, protein, carbohydrates content, chlorophyll content and nitrogen content in grain, yield *viz.*, grain and straw yield of barley, net return and B-C ratio as compared to application of 100 kg ha⁻¹ silicon and control.

Key words : Barley, irrigation levels, productivity, profitability, quality, silicon levels.

Introduction

Barley (*Hordeum vulgare* L.) is an important crop since it is farmed for a variety of purposes, including human food and feed for cattle and poultry. It is one of the world's first cultivated cereals, a member of the grass family that grows in temperate areas around the world. Its grain is also prized for its covering and cooling impact on the body, making digestion easier, as well as being a source of vitamin B complex. Aside from these traditional applications, it is a key industrial crop used as a raw material in the beer, whisky, and brewing industries. Each 100 g of barley grain contains 10.6 g protein, 2.1 g fat, 64.0 g carbohydrate, 50.0 mg calcium, 6.0 mg iron, 31.0 mg vitamin B. 0.1 mg vitamin B2 and 50.0 µg folate. Its B-glucanase can help reduce the risk of cardiovascular disease (Vaughan *et al.*, 2006).

As a result, this crop is frequently described as the most cosmopolitan of crops, as well as a poor man's crop due to its low input requirements and improved adaptation to drought, salt, alkalinity, and marginal terrain. During 2021-22, the crop was grown on almost 49.00 million hectares of land, yielding 145.47 million tonnes with a productivity of 2805 kg ha⁻¹. During the same reference time in India, the crop occupied nearly 0.68 lakh hectares of land, yielding nearly 1.67 million tonnes of grain at a productivity of 2641 kg ha⁻¹ (FAO, 2002). In Rajasthan, the crop was grown on 2.81 lakh hectares in 2020-21, yielding 8.56 lakh tonnes with a productivity of 3046 kg ha⁻¹ (Directorate of Economics and Statistics, 2021-22).

One of the most significant criteria for increasing output is adequate mineral fertilisation. Despite using recommended amounts of main nutrients, the production increase is not encouraging. Because of unpredictable imbalances in the status of different soil nutrients, the continuous use of chemical fertilizers has hit a production plateau. This scenario is exacerbated further by rigorous cultivation with exhausting high yielding crop cultivars. The overall result is a decrease in factor production. Among the 17 essential plant nutrients, N and P are the most vital in increasing agricultural productivity since they are required in the greatest quantity of all mineral nutrients absorbed by plant roots.

Silicon (Si) has been shown to reduce aluminium (Al) toxicity in various plant species. These include reduced oxidative damage and greater structural strength due to increased generation of secondary metabolites such as phenols. The goal of this study was to see how Si affected phenol synthesis and composition in two barley cultivars under Al stress. Silicon boosted antioxidant activity and soluble phenol concentration while decreasing lipid per oxidation regardless of Al dosage. In Si and Al treatments, both barley cultivars showed variations in culm creep rate, flavonoids and flavones content, lignin accumulation, and lignin composition. However, the yield increase may be attributable not only to the beneficial effects of Si, such as growth promotion, lodging resistance, and biotic and abiotic stress resistance, but also to some indirect effects, such as pH adjustment and acquisition of macro- and micronutrients contained in silicate fertilisers, particularly

when slags or Si-containing mineral ores are used as silicate fertiliser sources (Grewal, 2010).

Because of the excellent nutritional content of its grains, which provide complex carbohydrates, proteins, minerals, fibre, and antioxidants, including phenols, barley is one of the most farmed cereals in the world. The main phenolic compounds in barley grains are flavonoids (cyanidin-3-glucoside, petunidin-3-glucoside, delphinidin-3-glucoside) and phenolic acids (ferulic acid, p-coumaric acid, vanillic acid, sinapic acid), which benefit human health by lowering the risk of various diseases such as cancer and coronary heart disease (Musyimi *et al.*, 2007).

Nonetheless, just a few papers, to the best of our knowledge, have characterised the effects of Si on the phenolic metabolism of barley subjected to Al stress. Furthermore, the effect of Si on the phenolic metabolism of barley cultivars with varying Al tolerance has received little attention. As a result, the overall goal of this study was to assess the influence of Si on phenol synthesis and composition in tolerant and sensitive barley cultivars under Al stress. To achieve this goal, we conducted a hydroponic experiment with both types of cultivars grown under Al toxicity with and without Si addition, and we studied barley growth, antioxidant activity, and structural phenol content.

The above facts, this research study was conducted during *rabi* season of 2022-23 at Research Farm, Vivekananda Global University, Jaipur with the objective of to assess the effect of various levels of irrigation and silicon on yield and quality of barley and economic feasibility of the treatment.

Materials and Methods

An experiment was carried out during *rabi* 2022-23 at the Research Farm, Vivekananda Global University, Jaipur which is situated in South-Eastern part of Rajasthan at an altitude of 581.13 metre above mean sea level with 24°35' N latitude and 74°42' E longitude. The climate of this region is typically semi-arid, characterized by extremes of temperature during both summers and winters. During summers, the temperature may go as high as 48 °C, while in winters, it may fall as low as -1.0°C. Frost is not uncommon during winter. The soil in the experimental field was loamy sand in texture, somewhat alkaline in reactivity (pH-7.9), low in available nitrogen (283.42 kg ha⁻¹), medium in phosphorus (22.23 kg ha⁻¹) and organic carbon (0.73%), and high in accessible potassium (288.31 kg ha⁻¹).

During the experiment, the nine treatment combinations (three irrigation levels, namely no irrigation (control), one irrigation at 30-35 DAS, and two irrigations at 30-35 and 80-85 DAS in main plot, and three silicon

levels, namely control (no silicon, silicon 100 kg ha⁻¹, and silicon 150 kg ha⁻¹ in sub plot) were laid out in split plot design with three replications. Irrigation was applied to all treatments immediately after sowing (on November 7, 2022) to ensure crop germination on November 8, 2022. Following that, the irrigation plan will be followed according to treatments, with the first irrigation on 9 December 2022 and the second irrigation on 30 January 2023. At the time of seeding, a basal dose of silicon was applied according to the standard procedure.

The required fertiliser dose (60 kg N + 30 kg P₂O₅ per hectare) was used. Half of the N and full dose of P₂O₅ were applied as a basal dose at the time of sowing, and the remaining half was applied as a top dressing at the time of the first irrigation. The barley variety RD-2907 was seeded at a rate of 100 kg ha⁻¹. On November 7, 2022, the seeds were manually sown in opened furrows at a depth of 5 cm in rows spaced 22.5 cm apart, and after depositing the seed in furrows, it was covered with earth to provide uniform germination and protection from bird damage. Each plot's crop was collected separately. The collected plants were tied into bundles, labelled, and sun dried on the threshing floor. These bundles were weighed right before threshing after thorough drying to determine biological yield. Threshing of gathered crops from individual plots was accomplished using a tiny power operated thresher.

The grains harvested from each net plot were sun dried for 2-3 days to attain 10 per cent moisture and then the weight of grains net plot⁻¹ area was recorded and expressed in kg ha⁻¹. The straw yield from each net plot was sun dried for 4 to 6 days and weighed. Straw yield kg ha⁻¹ was computed from straw yield of each net plot. The unthreshed produce from net plot area, after sun drying was weighed for recoding the biological yield and expressed in terms of yield in kg ha⁻¹. It is the ratio of economic yield (grain yield) to biological yield, and worked out by following formula (Donald and Hamblin, 1976) expressed in percentage.

Protein content in grain was estimated by multiplying nitrogen content in grain by 6.25 using the Lowry *et al.* (1951) technique. The chlorophyll concentration of barley was determined using a portable leaf chlorophyll metre (Minolta, Japan) and expressed as a SPAD 502 value. The economics of various treatments were calculated in terms of net return (Rs ha⁻¹) and B-C ratio using current market prices for inputs and outputs. To determine the more profitable therapy, the economics of various treatments were calculated in terms of net return (Rs ha⁻¹) using the current market rate, so that the most remunerative treatment could be recommended. Treatment wise benefit-cost (B-C) ratio was also

calculated to ascertain economic viability of the treatments by using the following formula :

$$\text{Benefit - Cost ratio} = \frac{\text{Gross return (₹ ha}^{-1}\text{)}}{\text{Total cost (₹ ha}^{-1}\text{)}}$$

All data were statistically analysed using an acceptable method of analysis of variance to determine the significance of variation in experimental results. Wherever the F value was found to be significant at the 5% level of significance, the crucial difference (CD) value was calculated to compare the treatment means. In order to establish a cause and effect link, regression equations and coefficients of correlation were generated between specified characters. All of these calculations were carried out using the conventional statistical approach proposed by Panse and Sukhatme (1989).

Results and Discussion

Effect of irrigation levels

Quality : A review of the data in Table-1 reveals that significantly higher nitrogen content and quality parameter viz., protein content in grain, carbohydrate content in grain and chlorophyll content of barley was recorded significantly higher with application of two irrigations at 30-35 and 80-85 DAS over one irrigation at 30-35 DAS and control. This might be due to increased the availability of macro nutrients as well as micro nutrient. Therefore, treatments having higher and continuous water availability resulted in higher uptake of nutrients as expressed in nutrient content in grains, thus improve the other quality parameters of barley grain. These results are in conformity with the findings of Hingonia *et al.* (2018).

Yield : An investigation at the data in Table-1 reveals that application of two irrigations at 30-35 and 80-85 DAS was observed significantly maximum yield viz., grain, straw and biological yield of barley increased significantly with as compared to one irrigation at 30-35 DAS and control. However, harvest index remained unchanged with irrigation level, this might be increased the grain and straw yield almost equal proportion. The higher yield of barley with two irrigations attributed can be to advance photosynthetic activity of plants owing to optimum soil moisture for all the metabolic activities which leads to greater cell division, elongation resulted improve plant growth and development. Further, availability of most advantageous soil moisture with three irrigations might improve the source-sink relationship which facilitates higher translocation of photosynthetic substances from leaves to grain that leads to higher crop productivity. Whereas, moisture stress in crop due to shortage of water may cause a decrease in translocation of carbohydrates and growth substances disturb nitrogen metabolism, force loss of turgor and consequently cause a reduction in sink

size and its growth. These results are in conformity with the findings of Yadav *et al.* (2010) and Rahim *et al.* (2010).

Economics : A data present in Table-2 reveals that among the irrigation regimes, the significantly highest net return (Rs 121456 ha⁻¹) and B-C ratio (4.13) were obtained with application of two irrigations at 30-35 and 80-85 DAS. The higher crop productivity might be the principal reason for higher net returns with application of two irrigations compared to other treatments. Similar results of higher farm profitability were also reported by Parihar and Tiwari (2003).

Effect of silicon levels

Quality : Data in Table-1 indicate that among levels of application of silicon, application of silicon @ 150 kg ha⁻¹ was observed significantly higher nitrogen content and quality parameter viz., protein content in grain, carbohydrate content in grain and chlorophyll content of barley as compared to application of silicon @ 100 kg ha⁻¹ and control. This might be due to availability of macro nutrient (nitrogen) increased, so improved the quality of barley grain. Although not considered an essential element for plant growth, Si has been recently recognized as a “beneficial substance” or “quasi-essential” due to its important role in plant nutrition, especially notable under stressed conditions (Walsh *et al.*, 2018). Similar results of higher farm profitability were also reported by Akhter *et al.* (2022).

Yield : Table-1 data demonstrates that application of silicon @ 150 kg ha⁻¹ was observed significantly maximum yield viz., grain, straw and biological yield of barley increased significantly with as compared to application of silicon @ 100 kg ha⁻¹ and control. However, harvest index remained unchanged with irrigation level, this might be increased the grain and straw yield almost equal proportion. Silicon had many positive effects on the plant physiology and metabolism of the crop. Increase in yield attributes of barley due to silicon application might be due to higher photosynthetic activity of plant, much more uptake of nutrients resulted enhance carbohydrate. The increase in grain, straw & biological yield and harvest index of wheat might be attributed to the increase in growth and yield characteristics of barley and also to the stimulating effect of silicon in reducing biotic and abiotic stress. Silicon application may enhance crop yield by several indirect action such as decreased shading due to greater leaf erectness. Erectness of leaves as a result of silicon fertilization could account for about 10 per cent in the photosynthesis, thereby indirectly increasing yield. Similar results were also noticed by Marschner (1988), Ma and Takahashi (1993), Osuna *et al.* (1991), Buck *et al.*

Table-1 : Effect of irrigation and silicon levels on nitrogen content in grain and quality of barley.

Treatments	Nitrogen content in grain (%)	Protein content in grain (%)	Chlorophyll content	Carbohydrate content
Irrigation levels				
Control	1.62	10.12	1.13	63.46
One irrigation at 30-35 DAS	1.74	10.85	1.32	68.05
Two irrigations at 30-35 and 80-85 DAS	1.88	11.72	1.44	73.47
SEm $\pm$	0.01	0.13	0.01	0.81
CD (p=0.05)	0.03	0.54	0.07	3.21
Silicon levels				
Control	1.70	10.64	1.26	66.71
Silicon 100 kg ha ⁻¹	1.75	10.93	1.30	68.55
Silicon 150 kg ha ⁻¹	1.78	11.12	1.33	69.72
SEm $\pm$	0.01	0.09	0.01	0.54
CD (p=0.05)	0.02	0.28	0.03	1.66

Table-2 : Effect of irrigation and silicon levels on yield, quality and economics of barley.

Treatments	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Net return (Rs ha ⁻¹)	B-C ratio
Irrigation levels				
Control	37.06	71.14	94584	3.42
One irrigation at 30-35 DAS	40.22	79.50	104939	3.64
Two irrigations at 30-35 and 80-85 DAS	45.64	88.43	121456	4.13
SEm $\pm$	1.08	2.26	3342	0.12
CD (p=0.05)	4.25	8.87	13122	0.47
Silicon levels				
Control	37.07	72.71	95058	3.40
Silicon 100 kg ha ⁻¹	39.66	80.63	104172	3.62
Silicon 150 kg ha ⁻¹	46.20	85.81	121748	4.17
SEm $\pm$	1.01	1.61	2857	0.09
CD (p=0.05)	3.12	4.96	8809	0.29

(2008), Gholami and Falah (2013), Wattanapayapkul *et al.* (2011), Prakash *et al.* (2011) and Sorrato *et al.* (2012).

Economics : Data (Table-2) shows that application of silicon 150 kg ha⁻¹ was recorded maximum net return (Rs 121748 ha⁻¹) and B-C ratio (4.13) fetched statistically higher over silicon 100 kg ha⁻¹ and control. Silicon might be improve crop growth and yield characters along with make active photosynthetic activities and source- sink relationship which directly govern yield of crop. Similar findings were observed by Sorrato *et al.* (2012).

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Resource Use Efficiency of Major Farming Systems in Vizianagaram District of Andhra Pradesh

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Abstract

This research has been taken up to estimate the resource use efficiency in major farming systems of Vizianagaram district of Andhra Pradesh. A sample of 120 farmers from the existing six farming situations in Vizianagaram were interviewed for getting primary data on resource use efficiency and extent of diversification. Based on adoption, five farming systems were found to be major out of nine existing farming systems and this study conducted for major farming systems only. Data Envelopment Analysis (DEA) used to examine the resource use efficiency in major farming systems. DEA revealed that 41.44 per cent of farms in all major farming systems were operated at sub-optimal region of production followed by optimal region (29.73 %). The R^2 value ranged between 0.64 (FS-I) to 0.79 (FS-V). The input PPCs (Plant Protection Chemicals) was most significant and positively influencing determinant of RUE (Resource Use Efficiency) in FS-III and FS-I at 1% and 5% level respectively. The diversification index of farming systems ranged between 0.73 (FS-IV) to 0.88 (FS-II) which indicating high diversification in Vizianagaram district. The Pearson's coefficient of correlation between diversification and profitability was negative.

Key words : Farming Systems, RUE, DEA, Decomposition analysis, SID.

Introduction

Agriculture constitutes one of the important sectors of Indian economy which contributes nearly 14 per cent of national income. During last five decades, we witnessed several HVYs, cost saving technologies, high yielding animal breeds, farm machinery and implements etc. However, resources like land and water were heavily exploited at the same time. As there is no scope for horizontal expansion of land, the emphasis should be made on vertical expansion of land by increasing the productivity by proper selection of components in a farm. With Gol (Government of India) announcement on doubling the farmer's income by the year 2022, the focus shift on Farming System Approach (FSA). Farming system defined as complex inter-related set of elements containing crops and non-crop enterprises which interact among themselves. The output of one component of the farming system may be served as an input for the other component. Thus, the farming system is the result of a complex interaction among the number of interdependent components (Rao et al., 2017). Increase in farm income could be achieved either by increasing resource use efficiency or by better marketing of produce or by both. Hence, Farming System Approach (FSA) provides an opportunity to minimize the cost of production by efficient utilization of inputs which are generated within the system (Rao et al., 2017). Present study helps to find profitable farming system, in which efficient utilization of inputs takes place and conducted with following objectives.

to identify major farming systems existing in Vizianagaram.

to estimate the resource use efficiency in major farming systems of Vizianagaram.

to observe the extent of diversification in major farming systems of Vizianagaram

Research Methodology

The primary data was collected for the year 2019 from the farmers of Vizianagaram district. Vizianagaram has six farming situations and the farming situations are classified based on soil types and irrigation facilities by DAATT centre. All the mandals in each farming situations were listed out and the mandal with highest area was selected. Later, from each mandal, two villages with highest cultivable land were selected. A sample of 10 farmers from each village were randomly selected. Thus, 120 farmers were selected from 12 villages for identification of existing and profitable farming systems. The data was further analysed with DEA methodology for calculating resource use efficiency.

Data Envelopment Analysis (DEA) : Various methods to estimate economic efficiency have been developed and classified as parametric and non-parametric approaches. Data Envelopment Analysis (DEA), a non-parametric approach, was first introduced by Charnes *et al.* (1978). DEA has several advantages: it can handle multiple outputs and inputs, it does not require a prior specific functional form for the production frontier, it does not require the distributional assumptions of the inefficiency

term, and it is also possible to identify the best practice for every farm.

The DEA method is a frontier method that does not require specification of a functional or distributional form, and can accommodate scale issues. This approach was first used by Farrell (1957) as a piecewise linear convex hull approach to frontier estimation and later by Boles (1966) and Afriat (1972). This approach did not receive wide attention till the publication of the paper by Charnes *et al.* (1978), which coined the term data envelope analysis. A large number of papers have extended and applied the DEA technology in the western world. Very few studies have used this approach in India, especially in agriculture or horticulture for measuring resource use efficiency. DEA method has the disadvantage that it does not explicitly accommodate the effects of data noise. Charnes, Cooper and Rhodes (1978) proposed a model which had input orientation and assumed Constant Returns to Scale (CRS). Later, in the subsequent papers, Banker, Charnes and Cooper (1984) who proposed Variable Returns to Scale (VRS) model. In the present case, the DEA method was preferred because data noise was less of an issue as most of the variables in farming systems were included and because of its ability to readily produce rich information on technical efficiency, scale efficiency and peers.

The DEA was applied by using both classic models CRS (constant returns to scale) and VRS (variable returns to scale) with input orientation, in which one seeks input minimization to obtain a particular product level. Under the assumption of constant returns to scale, the linear programming model for measuring the efficiency of farming systems are (Coelli *et al.*, 1998):

$$\begin{aligned} \text{Min } & \theta \\ \text{Subject to } & -y_i + Y \theta \leq 0 \\ & x_i - X \theta \leq 0 \\ & \theta \geq 0 \end{aligned} \quad \dots(1)$$

where,

y_i is a vector ($m \times 1$) of gross output of the i^{th} farm,

x_i is a vector ($k \times 1$) of inputs of the i^{th} farm unit,

Y is a gross output matrix ($n \times m$) for n farms,

X is a farm input matrix ($n \times k$) for n farms,

θ is the efficiency score, a scalar whose value will be the efficiency measure for the i^{th} farm. If $\theta = 1$, farm will be efficient; otherwise, it will be inefficient, and

λ is a vector ($n \times 1$) whose values are calculated to obtain the optimum solution. For an inefficient farm, the values will be the weights used in the linear combination

of other, efficient, farms, which influence the projection of the inefficient farm on the calculated frontier.

The specification of constant returns is only suitable when the firms work at the optimum scale. Otherwise, the measures of technical efficiency can be mistaken for scale efficiency, which considers all the types of returns to production, *i.e.*, increasing, constant and decreasing. Therefore, the CRS model was reformulated by imposing a convexity constraint. The measure of technical efficiency obtained in the model with variable returns is also named as 'pure technical efficiency', as it is free of scale effects. The following linear programming model estimated it :

$$\begin{aligned} \text{Min } & \theta \\ \text{Subject to } & -y_i + Y \theta \leq 0 \\ & x_i - X \theta \leq 0 \\ & N_1 \theta \leq 1 \\ & \theta \geq 0 \end{aligned} \quad \dots(2)$$

where, N_1 is a vector ($n \times 1$) of ones. When there are differences between the values of efficiency scores in the models CRS and VRS, scale inefficiency is confirmed, indicating that the return to scale is variable, *i.e.*, it can be increasing or decreasing (Färe and Grosskopf, 1994). The scale efficiency values for each analyzed unit can be obtained by the ratio between the scores for technical efficiency with constant and variable returns as follows :

$$s = \theta_{\text{CRS}}(X_K, Y_K) / \theta_{\text{VRS}}(X_K, Y_K) \quad \dots(3)$$

where,

$\theta_{\text{CRS}}(X_K, Y_K)$ = Technical efficiency for the model with constant returns,

$\theta_{\text{VRS}}(X_K, Y_K)$ = Technical efficiency for the model with variable returns, and

s = Scale efficiency.

It was pointed out that model (2) makes no distinction as to whether farm is operating in the range of increasing or decreasing returns (Coelli *et al.*, 1998). The only information one has is that if the value obtained by calculating the scale efficiency in Equation (3) is equal to one, the farm will be operating with constant returns to scale. However, when s is smaller than one, increasing or decreasing returns can occur. Therefore, to understand the nature of scale inefficiency, it is necessary to consider another problem of linear programming, *i.e.*, the convexity constraint of model (2), $N_1 \theta \leq 1$, is replaced by $N_1 \theta \leq 1$ for the case of non-increasing returns, or by $N_1 \theta \geq 1$ for the model with non-decreasing returns. Therefore, in this work, the following models were also used for measuring the nature of efficiency. Non-increasing returns:

$$\begin{aligned}
 &\text{Min } \quad \quad \quad \\
 &\text{Subject to } - y_i + Y \quad 0 \\
 &\quad x_i - X \quad 0 \\
 &N_1 \quad 1 \\
 &\quad 0 \quad \quad \quad \dots(4) \\
 &\text{Non-decreasing returns :} \\
 &\text{Min } \quad \quad \quad \\
 &\text{Subject to } - y_i + Y \quad 0 \\
 &\quad x_i - X \quad 0 \\
 &N_1 \quad 1 \\
 &\quad 0 \quad \quad \quad \dots(5)
 \end{aligned}$$

It is to be stated here that all the above models should be solved n times, *i.e.*, the model is solved for each farm in the sample.

Farming system gross income (Rs.) was used as an output (Y) in the present case and total human labour (man-days), total machine labour (hr), seed (kg), farm yard manure (t), total fertilizers (kg) and plant protection chemicals (l) as inputs (X) in case of cropping alone. Farming systems having dairy, poultry and sheep & goat were additionally included with inputs like fodder (q), feed (kg) and veterinary medicines (Rs.). The models were solved using the DEAP version 2.1 taking an input orientation to obtain the efficiency levels.

Determinants of technical efficiency : Ray (1991) and Worthington and Dollery (1999), used traditional DEA in the first stage to estimate the technical efficiency and in the second stage estimated the determinants of technical efficiency from the factors contributing to this technical efficiency by using econometric procedure. In the present study, the technical efficiency values obtained from the DEA model considering the CRS input-oriented model were used for examining the relationship between the technical efficiency and factors influencing it. The technical efficiency score from CRS model was chosen as the dependent variable for its high accuracy in discriminating efficiency as compared to variable returns to scale (Gonclaves *et al.*, 2008). The above inputs are considered as explanatory variables. The traditional method of regression was used for this purpose and OLS analysis was carried out to estimate the regression equation. The regression model specified for the present study is given in the following equation:

$$Y = a X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} X_7^{b_7} X_8^{b_8} X_9^{b_9} \mu$$

where,

Y = Technical efficiency scores (CRS),

X_1 - Human labour (MD)

X_2 - Machine labour (hr)

X_3 - Seed (kg)

X_4 - FYM (t)

X_5 - Fertilizer quantity (kg)

X_6 - Plant protection chemicals (l)

X_7 - Fodder (q) (In case of dairy and sheep & goat)

X_8 - Feed (kg) (In case of dairy, poultry and sheep & goat)

X_9 - Veterinary expenses (Rs.) (In case of dairy, poultry and sheep & goat)

a and b_i are the constant and the coefficients respectively, which were estimated through the OLS analysis.

Simpsons Index of Diversification (SID) : To identify the extent of diversification in cropping activities and farming systems, the most widely used method is Simpsons Index of Diversification.

Diversification index for farming systems : Mathematically SID is formulated as :

$$D_i = 1 - \frac{S_i^2}{S}$$

Where D_i = Simpsons Diversification Index for diversification

S_i = Share of net income of i^{th} enterprise in per farm net income

S = Per farm net income of whole farming system

The Simpson's index value ranges between 0 and 1. If the index value is zero, there exists complete specialization and if it is 1, there exists complete diversification. The movement of index value from 0 to 1 indicates diversification and *vice-versa*.

Pearson's correlation coefficient is used to find the relation between diversification index and profitability of the farming systems.

The Pearson's correlation coefficient is a very important statistical tool which measures the strength between two variables. This is often referred as the Pearson R test.

$$r = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}}$$

Where

N = Number of pairs of scores

$\sum xy$ = sum of the products of paired scores

x = sum of the x scores

y = sum of the y scores

x^2 = sum of the squared x scores

y^2 = sum of the squared y scores

Results and Discussion

The results pertaining to the identification of major farming systems, resource use efficiency and extent of diversification are discussed in this section.

It could be seen from Table 1, a total of nine farming systems were practiced by the sample respondents of Vizianagaram district. A sample of more than 10 respondents practicing any of the nine farming systems were considered as major farming systems for further analysis *i.e.*, farming systems practicing by less than 10 respondents were considered as minor farming systems. Thus, the major farming systems identified in Vizianagaram district were Crops + Dairy (FS-II: 39 No.), followed by Crops alone (FS-I: 26 No.), Crops + Dairy + Poultry (FS-V: 19 No.), Crops + Poultry (FS-III: 14 No.) and Crops + Sheep & goat (FS-IV: 13 No.).

Table-1 : Farming systems practiced by the sample respondents in Vizianagaram.

S.No	Farming systems (FS)	Srikakulam (N=120)	
		No.	% to total
I	C	26	21.67
II	C+D	39	32.50
III	C+P	14	11.67
IV	C+S&G	13	10.83
V	C+D+P	19	15.83
VI	C+D+S&G	3	2.50
VII	C+P+S&G	2	1.67
VIII	C+D+P+S&G	2	1.67
IX	C+F	2	1.67
	Total	120	100

Note: C= Crops, D= Dairy, P= Poultry, S&G= Sheep & Goat, F=Floriculture

Resource use efficiency of major farming systems in Vizianagaram District : The efficiency measures (both CRS and VRS) and descriptive statistics of each farming system are presented in Table 2. The farms operated at 0.90 or more scores were considered as 'efficient farms' (Ferreira, 2005).

Farming system-I (Crops alone) : Fourteen farms out of 26 (53.85%) were efficient with scores of 0.90 or above in FS-I of Vizianagaram under CRS (Constant return to scale) assumption. The technical efficiency value ranged from 0.426 to 1 with an average of 0.856. When technical efficiency under VRS (Variable returns to scale) was calculated, the mean technical efficiency score increased

to 0.938 by increasing the number of efficient farms to 21. Regarding scale efficiency, 65.38 per cent farms were performed efficiently with average technical efficiency value of 0.912.

Farming system-II (Crops + Dairy) : From Table-2, results showed that 47.37 per cent of farms were efficient under CRS. The mean technical efficiency value (0.858) clarified that non efficient farms could reduce their input usage by 14.23 per cent to get equal income of efficient farms. The mean technical efficiency value increased to 0.922 when the VRS assumption was introduced by relaxing CRS. As regards to the scale efficiency, 60.53 per cent (23 farms out of 39) were operated at optimum level of efficiency with mean technical efficiency score of 0.920.

Farming system-III (Crops + Poultry) : Under CRS, 50 per cent of farms were non efficient as there was an excess usage of inputs by 11.64 per cent as indicated by mean technical efficiency value of 0.884. However, the number of efficient farms increased to 71.43 per cent under VRS assumption led to an increase in mean technical efficiency value to 0.949. Regarding scale efficiency, nearly 64.29 per cent farms were efficient with mean technical efficiency of 0.930.

Farming system-IV (Crops + Sheep & goat) : The mean technical efficiency value (0.605) under CRS assumption confirmed that there was a scope to reduce the input level by 39.51 per cent. Nearly 59.23 per cent of farms in FS-IV, which didn't operate at efficiency level, could reduce input usage by 15.20 per cent to get same level of income which was being received by 30.77 per cent of efficient farms. Under VRS, the mean technical value increased to 0.8490 and the number of farms performed at maximum efficiency level was increased to 53.85 per cent. Regarding scale efficiency, 61.54 per cent farms were operated at optimum level of efficiency *i.e.*, =0.90. The technical efficiency values ranged from 0.225 to 1 with an average of 0.718 under assumption of scale efficiency.

Farming system-V (Crops + Dairy + Poultry) : The results from Table 2, concluded that 52.63 per cent of farms were efficient under CRS. When VRS was calculated, the scenario of efficient farms changed to 73.68 per cent with a change in mean technical efficiency from 0.859 (CRS) to 0.920 (VRS). Nearly 57.89 per cent (11 out of 19) of farms were efficient regarding scale efficiency was considered.

From the above analysis, the percentage of farms efficient under CRS were more in FS-V, followed by FS-I, FS-III, FS-II and FS-IV of Vizianagaram. Under VRS, FS-I has the more number of efficient farms followed by FS-V, FS-III, FS-II and FS-IV. With reference to scale efficiency, FS-III has more number of efficient farms.

Table-2 : Efficiency measures and descriptive statistics across major farming systems in Vizianagaram district according to scale of operations.

Scale of operations	No. of respondents	Efficient farms (O = 90)		Efficiency measures			
		No.	%	Mean	SD	Max.	Min
FS-I							
Technical efficiency (Constant returns)	26	14	53.85	0.858	0.156	1	0.426
Technical efficiency (Variable returns)		21	80.76	0.938	0.105	1	0.571
Scale efficiency		17	65.38	0.912	0.116	1	0.517
FS-II							
Technical efficiency (Constant returns)	39	18	46.15	0.858	0.156	1	0.497
Technical efficiency (Variable returns)		27	69.23	0.922	0.133	1	0.537
Scale efficiency		23	58.97	0.930	0.094	1	0.576
FS-III							
Technical efficiency (Constant returns)	14	7	50.00	0.884	0.127	1	0.627
Technical efficiency (Variable returns)		10	71.43	0.949	0.070	1	0.809
Scale efficiency		9	64.29	0.930	0.996	1	0.641
FS-IV							
Technical efficiency (Constant returns)	13	4	30.77	0.605	0.302	1	0.204
Technical efficiency (Variable returns)		7	53.85	0.849	0.237	1	0.304
Scale efficiency		8	61.54	0.718	0.268	1	0.225
FS-V							
Technical efficiency (Constant returns)	19	10	52.63	0.859	0.190	1	0.324
Technical efficiency (Variable returns)		14	73.68	0.920	0.144	1	0.488
Scale efficiency		11	57.89	0.922	0.098	1	0.663

Table-3 : Distribution of respondents in major farming systems of Vizianagaram district according to type of returns.

Type of returns to scale	FS-I	FS-II	FS-III	FS-IV	FS-V	Total
Increasing (IRS)	10 (37.04)	16 (41.03)	4 (28.57)	8 (61.54)	8 (42.11)	46 (41.44)
Constant (CRS)	8 (29.63)	7 (17.95)	6 (42.86)	4 (30.77)	8 (42.11)	33 (29.73)
Decreasing (DRS)	9 (33.33)	15 (38.46)	4 (28.57)	1 (7.69)	3 (15.78)	32 (28.83)
Total	27 (100)	39 (100)	14 (100)	13 (100)	19 (100)	111 (100)

Note : Figures in parentheses indicate percentage to the respective FS total.

Regions of Operation in The Production Frontier :

After calculating the technical efficiency of farms, extent of inefficiency and optimum scale of operation, it is also important to know the distribution of farms on three zones of production frontier *i.e.*, number of farms under decreasing, increasing and constant returns to scale. These are estimated through the convexity constraint of LP as given in methodology.

Nearly 41.44 per cent (46 out of 111) of farms in all major farming systems of Vizianagaram district were operated in sub-optimal region of production frontier (Table 3). Thirty three out of 111 farms (29.73%) were operating at constant returns to scale. The percentage of farms operating at DRS was less in FS-IV (7.69%) followed by FS-V (15.78%), FS-III (28.57%), FS-I (33.33%) and FS-II (38.46%). Similarly, the percentage of farms operating at IRS was more in FS-IV (61.54%) and FS-V (42.11%).

Determinants of resource use efficiency in major farming systems of Vizianagaram district : Log linear regression model was used to analyze the determinants of

RUE of major farming systems of north coastal Andhra Pradesh. The inputs considered for DEA analysis were again used as influential factors for CRS obtained for major farming systems.

The results presented in Table-4 reported that the variable human labour and fertilizer costs were negatively significant at 5% level in FS-II. PPCs was positively significant at 1% and 5% level in FS-III and FS-I of Vizianagaram district. Singh (2018) also found positive impact of PPCs on gross income. Human labour, fodder and veterinary medicine components were positively significant at 1% level and FYM at 5% level in FS-IV. Both seed and feed variables in FS-V were significant at 5 per cent level. Singh et al. (2013) results also proved seed had significant positive impact on gross income. Fertilizer component was negatively significant in FS-I and FS-II at 1% and 5% level respectively. The R^2 value ranged from 0.64 (FS-I) to 0.79 (FS-V) in major farming systems of Vizianagaram district.

Extent of diversification in major farming systems of Vizianagaram district : From the Table 5., the

Table-4 : Determinants of resource use efficiency (CRS) in major farming systems of Vizianagaram district.

Variables	FS-I	FS-II	FS-III	FS-IV	FS-V
Intercept	0.932472	0.938453	0.727493	0.825419	0.997446
Human labour (Man-days)	-0.0058 (0.078)	-0.0092* (0.004)	-0.0049 (0.771)	0.7790** (0.008)	-0.0005 (0.001)
Machine labour (hrs)	0.1156 (0.944)	0.2788* (0.129)	-0.0015 (0.254)	-0.1756 (0.191)	0.0021 (0.477)
Seed (kgs)	-0.7117 (0.669)	-1.9337 (1.108)	0.9228** (0.118)	0.4419 (0.877)	0.0211* (0.011)
FYM (t)	0.01606** (0.005)	0.0066 (0.117)	0.0737 (0.221)	0.0922* (0.049)	0.0234 (0.119)
Fertilizers (kgs)	-1.0924** (0.0911)	-0.8837* (0.415)	-0.0307 (0.119)	-0.0072 (0.113)	-0.7014 (0.663)
PPCs (lts)	1.2176* (0.591)	0.0978 (0.557)	0.7725** (0.055)	0.0031 (0.002)	0.0881 (0.112)
Fodder		0.3378 (1.337)		0.2993** (0.033)	0.0144 (0.515)
Feed		1.7558** (0.611)	1.6183 (0.639)	-0.4042 (1.088)	0.9010* (0.411)
Veterinary medicine		-0.1183 (0.744)	0.9477 (1.271)	0.0316** (0.007)	0.5549** (0.098)
R ² value	0.64	0.69	0.73	0.67	0.79

Note : Figures in parentheses indicate standard errors of respective variables,
(*,** significance at 5 and 1 per cent levels respectively)

Table-5 : Diversification of farming systems in Vizianagaram district.

S.No.	Components of FS	FS-I		FS-II		FS-III		FS-IV		FS-V	
		Area (ha)	GR (Rs)	Area (ha)	GR (Rs)	Area (ha)	GR (Rs)	Area (ha)	GR (Rs)	Area (ha)	GR (Rs)
1.	CROPS										
2.	Paddy	0.86	63424	0.85	65454	0.85	61850	0.78	61884	1.14	87128
3.	Maize	0.24	26262	0.21	23423	0.13	14601			0.19	20050
4.	Blackgram	0.29	7760	0.29	8273	0.26	7365	0.28	7869	0.45	13157
5.	Greengram	0.26	7701	0.23	6881	0.30	8867	0.31	8912	0.36	10803
6.	Groundnut	0.09	7781	0.09	7844	0.11	9654			0.14	12038
7.	Sesame	0.13	5258	0.15	6272	0.17	6813	0.11	4278	0.16	6542
8.	Cotton	0.08	8145	0.07	7782	0.26	26593				
9.	Ragi	0.10	4553	0.14	6317	0.12	5519			0.20	9243
10.	Sugarcane	0.22	42839	0.22	41669	0.26	52741	0.21	41822	0.23	44023
11.	Banana	0.07	14473	0.05	10242					0.07	14156
12.	Coconut	0.14	20401	0.14	24047	0.18	31179	0.09	15847	0.25	44802
13.	Cashewnut	0.09	14429	0.08	12505	0.11	15341			0.11	14697
14.	Mango	0.09	13483	0.09	11555	0.11	19667			0.11	14497
15.	Teak	0.06	11740	0.04	9826						
16.	Casuarina			0.06	10168	0.08	13744	0.16	26246		
	Eucalyptus			0.03	5084			0.13	21325	0.08	14477
	Gross area	2.72		2.74		2.94		2.07		3.49	
	Dairy				73702						74386
	Poultry						23404 5				30800 3
	Sheep & Goat								15969 8		
	Total returns		24824 9		33104 4		50797 9		34788 1		68800 2
	SID for FS		0.87		0.88		0.75		0.73		0.76
	Pearson's Coefficient						-0.84				

diversification index of farming systems ranged from 0.73 (FS-IV) to 0.88 (FS-II). The major income contribution from sheep & goat component reduced the SID value in FS-IV. The SID values indicated more diversification in major farming systems of Vizianagaram district. The Pearson's correlation coefficient was negative (-0.84) when found the relationship between diversification index values of farming systems and corresponding profitability.

Conclusions

Technical and scale efficiencies were calculated for farms in major farming systems of Vizianagaram district by using DEA approach and the factors which influence the resource use efficiency also estimated by regression analysis. The resource use efficiency was highest in FS-III and FS-I under VRS assumption with mean technical efficiency scores of 0.95 and 0.94 respectively. About 28.83 per cent of farms (32) were found to be operated in decreasing returns or in supra-optimal region. The variables like PPCs, human labour, fodder and veterinary medicines have significant positive impact on technical efficiency scores (CRS). The farming systems with allied activities were found to be good in resource utilization. Hence, it is suggested to have allied activities like dairy or poultry in farming system for better input utilization. The extent of diversification also very high in Vizianagaram district, however, there was negative correlation between profitability and diversification. This indicating improper management of inputs and there is lot of scope to improve the input efficiency which eventually led to better income to farmers.

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The Effect of Phosphorous, Biochar and Biofertilizers on Growth Parameters of Black Gram

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Abstract

A field experiment was conducted at Instructional Farm of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan) during *kharif*, 2022 to assess the effect of phosphorous, biochar and biofertilizers on growth parameters of blackgram. The experiment has comprised a combination of 3 Phosphorous levels (0, 20, 40 kg ha⁻¹), 2 biochar levels (1, 2 t ha⁻¹) and 3 levels biofertilizers (Control, Rhizobium, Rhizobium + PSB) thereby making 18 treatment combinations replicated thrice in FRBD. Results concluded that the maximum plant height, dry matter accumulation, number of nodules and weight of effective nodules of blackgram was recorded with the 40 kg ha⁻¹, Biochar 2 t ha⁻¹ and *Rhizobium* + PSB.

Key words : Biochar, biofertilizer, rhizobium, blackgram, phosphorous.

Introduction

Blackgram is scientifically known as *Vigna mungo* L. and commonly called Urad in India. India is its primary center of origin and mainly cultivated in Asian countries including Pakistan, Myanmar and parts of Southern Asia. About 70 per cent of the world's blackgram production comes from India. Blackgram is a perfect combination of all nutrients, which includes proteins (25-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins (Tyagi *et al.*, 2019). The imbalanced nutrient supply adversely affects the seed yield of black gram, soil health, and even the profit of the farmers (Laddha *et al.*, 2006).

Phosphorus serves as “energy currency” within the plants and helps in root development and grain formation. Application of phosphorus to legumes not only benefits the targeted crop but also raises the soil nitrogen content, which benefits succeeding non-legume crops that need to use less nitrogen.

Biochar is a combination of two words one is “Bio” that means biomass and another one is “Char” that means charcoal (Nartey *et al.*, 2014). It is made by Pyrolysis. Biochar addition to agricultural soils has the potential to enhance soil fertility, improve water holding capacity and improve crop productivity (Sukartono *et al.*, 2011)

The imbalance application of chemical leads to poor yield of crop production and it leads to more cost of production, the use of biofertilizers.

Materials and Methods

The experiment was conducted at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur, Rajasthan. The experiment has comprised a combination of 3 Phosphorous levels (0, 20, 40 kg ha⁻¹), 2 biochar levels (1, 2 t ha⁻¹) and 3 levels of biofertilizers (Control, Rhizobium, Rhizobium + PSB) thereby making 18 treatment combinations in 54 plots and replicated thrice in FRBD. The plot size was 3.6 x 5.0 m² and the soil was clay-loam in texture, slightly alkaline in reaction and calcareous in nature, and medium in available nitrogen and phosphorus. Data on parameters were taken from five selected plants and an average was done for the result.

Results and Discussion

It was clear from the data (Table-1 to 3) the application of 40 kg P₂O₅ ha⁻¹ significantly improved plant height and dry matter accumulation over the control at 30, 60 DAS and at harvest by 6.60, 11.79, 13.4 and 37.71, 14.57, 10.74 per cent. Application of 40 kg P₂O₅ ha⁻¹ recorded significantly increases the number of root nodules (44.25) and weight of nodules (79.32).

The increasing levels of phosphorus significantly influenced all the growth parameters plant height, number of nodules plant⁻¹, dry matter and crop growth rate. Increased plant growth might be due to a better nutritional environment in the root zone. Phosphorus is a vital component of ADP and ATP and it plays an important role in the conservation and transfer of energy in metabolic reactions. It also stimulates cell division resulting in

Table-1 : Effect of phosphorous, biochar and biofertilizer on plant height of blackgram.

Treatments	Plant height (cm)		
	30 DAS	60 DAS	At harvest
Phosphorous levels (kg ha⁻¹)			
0	19.22	30.90	42.63
20	20.39	33.31	45.22
40	20.49	34.43	48.36
SEm±	0.39	0.53	0.83
CD(P=0.05)	1.12	1.54	2.40
Biochar levels (t ha⁻¹)			
1	19.57	30.97	43.06
2	20.50	34.78	47.75
SEm±	0.32	0.43	0.68
CD(P=0.05)	0.91	1.26	1.96
Biofertilizers			
Control	19.24	31.09	42.82
<i>Rhizobium</i>	19.93	33.51	46.35
<i>Rhizobium</i> + PSB	20.93	34.03	47.04
SEm±	0.39	0.53	0.83
CD(P=0.05)	1.12	1.54	2.40

Table-2 : Effect of phosphorous, biochar and biofertilizer on dry matter of blackgram.

Treatments	Dry matter accumulation (g plant ⁻¹)		
	30 DAS	60 DAS	At harvest
Phosphorous levels (kg ha⁻¹)			
0	4.11	14.61	25.78
20	5.33	15.58	26.62
40	5.66	16.74	28.55
SEm±	0.12	0.30	0.52
CD(P=0.05)	0.36	0.86	1.51
Biochar levels (t ha⁻¹)			
1	4.87	15.19	26.28
2	5.20	16.10	27.69
SEm±	0.10	0.24	0.43
CD(P=0.05)	0.29	0.70	1.23
Biofertilizers			
Control	4.84	14.64	25.55
<i>Rhizobium</i>	4.98	15.68	27.45
<i>Rhizobium</i> + PSB	5.29	16.61	27.95
SEm±	0.12	0.30	0.52
CD(P=0.05)	0.36	0.86	1.51

increased growth of plants and also improves nodulation and N fixation by roots. Increased growth of plants leads to higher plant dry weight (Singh *et al.*, 2020; Parashar *et al.*, 2020).

The application of biochar 2 t ha⁻¹ significantly increased the plant height and dry matter accumulation over biochar 1t ha⁻¹ at 30 DAS & 60 DAS and at harvest.

The application of biochar 2 t ha⁻¹ compared to biochar 1t ha⁻¹ significantly increased the number of

effective nodules and weight of effective nodules at 45 DAS by 6.69 and 5.54 per cent, respectively.

The study demonstrates that the application of biochar has a positive impact on both plants and soil. Plant and soil analysis at harvest revealed that biochar enriched the nutritional status of plant parts (seeds and haulm) and increased the organic carbon content of the soil. These improvements led to greater metabolic activities and activated the growth processes in plants. Morphological parameters such as plant height (Table

Table-3 : Effect of phosphorous, biochar and biofertilizer on primary branches, number of nodules plant⁻¹ and weight of nodules at 45 DAS of blackgram.

Treatments	Growth parameters	
	Number of nodules plant ⁻¹	Weight of nodules plant ⁻¹
Phosphorous levels (kg ha⁻¹)		
0	35.97	65.53
20	40.18	72.47
40	44.25	79.32
SEm±	0.516	0.391
CD(P=0.05)	1.483	1.123
Biochar levels (t ha⁻¹)		
1	38.83	70.48
2	41.43	74.39
SEm±	0.421	0.319
CD(P=0.05)	1.211	0.917
Biofertilizers		
Control	38.58	71.11
<i>Rhizobium</i>	40.72	72.42
<i>Rhizobium</i> + PSB	41.09	73.77
SEm±	0.516	0.391
CD(P=0.05)	1.483	1.123

4.1) and dry matter (Table-2), as well as total chlorophyll in leaves (Table 4.7), significantly increased with biochar application at each stage. Additionally, the number and dry weight of effective nodules in blackgram (Table-3) increased notably with the addition of biochar 2 t ha⁻¹. (Mollindo *et al.*, 2016)

The plant height increased significantly when the seed was inoculated with *Rhizobium* + PSB at 30 DAS, 60 DAS and at harvest by 8.78, 9.45 and 9.85 per cent over control. And it was at par with *Rhizobium* at 30, 60 DAS and at harvest.

Seed treatment with the *Rhizobium* + PSB significantly increased dry matter accumulation over the control at 30, 60 DAS and at harvest, while at 30 DAS and harvest, *Rhizobium* was statistically at par with *Rhizobium* + PSB.

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The *Rhizobium* + PSB inoculation increased the synthesis of more photosynthates and their translocation to the seed. The yield attributes viz. pod per plant, seeds per pod and seed yield showed very little improvement with *Rhizobium* + PSB inoculation than inoculating them separately. Higher dry matter accumulation due to inoculation may have contributed to the increased number

of pods plant⁻¹ and seeds pod⁻¹. Vijla and Jebaraj (2008) and Hussain *et al.* (2011) reported similar results.

Conclusions

This study concluded that the black gram crop treated 40 kg P₂O₅ ha⁻¹, biochar 2 t ha⁻¹ and *Rhizobium* + PSB before sowing to get higher plant growth parameters like plant height, Dry matter accumulation, number of nodules⁻¹ and weight of effective nodules.

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The Influence of Spacing on Growth and Yield of Broccoli (*Brassica oleracea* var. *italica* Plenck.)

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Abstract

The present study titled "The Influence of Spacing on Growth and yield of Broccoli (*Brassica oleracea* var. *italica* Plenck.)" was conducted during 2022-23 at Hi-tech unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. The experiment comprised twelve combined treatments involving different spacing, which were replicated three times and randomly applied to 36 plots using a Factorial Randomized Block Design. The results of the study revealed that among the various treatment of spacing S₃ (45 × 45 cm) exhibited significantly higher values Plant height 30 DAT (19.42 cm) , 60 DAT (35.24 cm) and at final harvest (48.77 cm), Leaf length 30 DAT (16.72 cm), 60 DAT (33.38 cm) and at final harvest (39.84 cm), Leaf width 30 DAT (15.56 cm), 60 DAT (26.40 cm) and at final harvest (31.59 cm), Days taken to head initiation (57.37 DAT), Number of leaves per plant 30 DAT (6.73), 60 DAT (10.33) and at final harvest (13.46) etc.

Key Words : Black mulch, spacing and sprouting broccoli.

Introduction

Broccoli (*Brassica oleracea* var. *italica*) is an important fancy and highly nutritive exotic vegetable. It is also known as winter broccoli or Heading broccoli or Italian broccoli in the USA or Italian Calabrese in Italy and is a member of cruciferae family. It is considered to be originated from wild cabbage, *Brassica oleracea* var. *oleracea* (*Sylvestris*), which is found growing wild along the Mediterranean Sea. In India, its cultivation is negligible but now gaining popularity with Indian growers for the last couple of years due to its high nutritive value and increased tourist influx. It is mostly cultivated in the hilly areas of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills and Northern plains of India. In India, cauliflower and broccoli is cultivated in an area of 4.58 lakh ha with an annual production of 88.40 MT and productivity of 19.30 t ha⁻¹ (FAO, 2020).

The word broccoli, derived from the Italian plural of broccoli, refers to the flowering top of a cabbage. Broccoli is classified in the *italica* cultivar group of the species *Brassica oleracea*. Broccoli has large flower heads, usually green in colour, arranged in a tree like structure on branches sprouting from a thick, edible stalk. The mass of flower heads is surrounded by leaves. Broccoli mostly resembles cauliflower, which is a different cultivar group of the same species. Broccoli is a rich source of folic acid, vitamin-C, vitamin-A and a compound, sulphoraphane which is associated with reducing the risk of cancer (Guo et al., 2001). The primary inflorescence was characterized by higher levels of dry matter, total nitrogen, vitamin-C,

chlorophyll, beta-carotene, carotenoids and by lower levels of nitrates. Nutritionally, it is rich in vitamin – A (2500 IU), vitamin – C (113 mg), protein (3.6 g), carbohydrates (5.9 g) and minerals like calcium (103 mg), iron (1.1 mg), phosphorous (78 mg), potassium (382 mg) and sodium (15 mg) per 100 g of edible portion (Rana, 2008).

Plant spacing is considered as an essential element that can manipulate plant population in a unit of plant that influences the growth and development of plant. The main impact of plant density on production is due to difference in distribution of solar energy and increasing light which leads increasing yield. Broccoli is a vegetable crop that responds to plant density, where the planting distance directly affects the quantity of the crop and the size, diameter and weight of the main curds and it affects the number of subcurds formed by the plants and the formation date of the curds and completing their growth, where the density affects the prolong the flowering period. The planting distances between plants and between the cultivation lines have a great influence on the vegetative growth for plants and the quantitative and qualitative yield for the produced curds. (Azam et al., 2020)

Materials and Methods

The experiment was conducted during *Rabi* 2022-2023 at the Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur which is located at 24° 34' N latitude and 73° 42' E longitude at an elevation of 582.17 meters above mean sea level. The experiment consisted

of then 12 treatment combinations including three spacing viz., S₁- 45 × 15 cm, S₂- 45 × 30 cm, S₃- 45 × 45 cm. The observations on various traits like Plant height (cm) (30, 60 DAT and at final harvest), Leaf length (cm), Leaf width (cm), Days taken to head initiation (DAT), Number of leaves per plant, Days taken to head harvest, Fresh weight of head (g), Diameter of head (cm), Compactness of head (scale), Yield per plot (kg), Yield (q/ha), Total soluble solid (°Brix), Vitamin A (µg/100g), Ascorbic acid (mg/100g), Moisture content (%) were recorded as per standard method.

Factor-I Spacing

- (i) S₁-45 × 15 cm
- (ii) S₂-45 × 30 cm
- (iii) S₃-45 × 45 cm

Observations Recorded : All the characteristics were periodically recorded according to the objectives of the experiment.

Plant height (cm) (30, 60 DAT and at final harvest) : Plant height (at 30, 60 DAT and at final harvest) of five randomly selected plants from each treatment in each replication was measured from the ground level to top of the selected plant with the help of meter scale and the average height worked out and presented in centimeter.

Leaf length (cm) : Leaf length (at 30 DAT, 60 DAT and at final harvest) of five randomly selected plants from each treatment in each replication was measured from length of longest leaf with the help of meter scale and the average height worked out and presented in centimeter.

Leaf width (cm) : Leaf width (at 30 DAT, 60 DAT and at final harvest) of five randomly selected plants from each treatment in each replication was measured in cm and data was taken from the same leaves taken for measuring leaf length and averaged.

Days taken to head initiation (DAT) : This observation was recorded by observing the experimental field daily and numbers of days were counted when the head become visible in the plant, right from the date of transplanting of seedlings to the date of head initiation.

Number of leaves per plant : Numbers of fully opened leaves per plant of five randomly selected plants from each treatment in each replication were counted and the results were expressed as mean number of leaves per plant.

Days taken to head harvest : The number of days from the date of transplanting to the date of marketable head maturity in observational plants was taken as days to head maturity.

Fresh weight of head (g) : Fresh weight of head of five randomly selected plants from each treatment in each replication were recorded and the average value was expressed in gram.

Diameter of head (cm) : Diameter of harvested head of five randomly selected plants from each treatment in each replication were measured in centimeters with the help of digital vernier calipers and averaged.

Compactness of head (out of 10) : Panels made to testing compactness of head, rank, marks were given out of ten. The compactness of head may be determined by pressing the head with fingers. The basis of above system heads were sorted into three group categories most compact (7.5 to 10), medium compact (5 to 7.5) and poor head (<5) (Pushendra Kumar, 2022).

Yield per plot (kg) : The head of five randomly selected plants from each treatment in each replication were harvested separately and weighed by digital balance and yield was expressed in kg per plot.

Yield (q/ha) : The yield per hectare was calculated by multiplying the net yield per plot with number of plots per hectare. It was measured in quintals per hectare.

Quality parameters

Total soluble solid (°Brix) : TSS of the head of broccoli was determined by using a pocket Refractometer of 0-53 °Brix range where in one drop of grinded broccoli juice extract were placed on the prism of refractometer and TSS was recorded directly. The value was corrected at room temperature expressed as TSS of the head (A.O.A.C., 2007).

Vitamin A (µg/100g) : One gram of sample was crushed and mixed thoroughly with 10 ml acetone: hexane (4:6) solution. This sample was centrifuged and optical density of the supernatant was measured by spectrophotometer (Model no. 200-20, Hitachi, Japan) at 663 µm, 645 µm, 505 µm and 453 µm. Calculation was done by the following formula (Nagata *et al.*, 1992).

$$\text{-Carotene (mg/100g)} = 0.216 (\text{OD}_{663}) + 0.452 (\text{OD}_{453}) - 1.22 (\text{OD}_{645}) - 0.304 (\text{OD}_{505})$$

Where, bold figure indicates optical density. The vitamin A content of the head was calculated by dividing the beta carotene content by 0.6 to get the vitamin A content of the head. (Ranganna, 1986).

Ascorbic acid (mg/100g) : Ascorbic content of broccoli head was estimated using 2, 6 dichlorophenol indophenols dye (DCPIP) visual titration method given in A.O.A.C. (1960).

Reagents :

A. Metaphosphoric acid solution (3%)

Table-1 : Main effects of plant spacing on plant height (cm) and leaf length (cm) of broccoli.

Treatment	Plant height (30 DAT)	Plant height (60 DAT)	Plant height (at final harvest)	Leaf length (30 DAT)	Leaf length (60 DAT)	Leaf length (at final harvest)
Factor-I						
S ₁ (45×15 cm)	15.98	32.24	40.95	13.65	27.39	31.45
S ₂ (45×30 cm)	16.92	33.58	44.35	15.48	29.60	34.84
S ₃ (45×45 cm)	19.42	35.24	48.77	16.72	33.38	39.84
SE(m)±	0.11	0.19	0.20	0.08	0.17	0.20
C.D.	0.32	0.55	0.56	0.24	0.49	0.56

Table-2 : Main effects of plant spacing on leaf width (cm) and number of leaves of broccoli.

Treatment	Leaf width (30 DAT)	Leaf width (60 DAT)	Leaf width (at final harvest)	Number of leaves (30 DAT)	Number of leaves (60 DAT)	Number of leaves (at final harvest)
Factor-I						
S ₁ (45×15 cm)	12.83	23.27	26.93	5.44	8.56	12.01
S ₂ (45×30 cm)	14.00	24.78	28.40	6.05	9.37	12.53
S ₃ (45×45 cm)	15.56	26.40	31.59	6.73	10.33	13.46
SE(m)±	0.08	0.14	0.17	0.04	0.06	0.08
C.D.	0.23	0.40	0.49	0.12	0.18	0.23

Table-3 : Main effects of plant spacing on days taken to head initiation, days taken to head harvest, diameter of head (cm), compactness of head and fresh weight (g) of broccoli.

Treatment	Days taken to head initiation	Days taken to head harvest	Diameter of head (cm)	Compactness of head (out of 10)	Fresh weight of head (g)
Factor-I					
S ₁ (45×15 cm)	56.93	76.89	10.57	5.39	127.77
S ₂ (45×30 cm)	53.39	74.78	12.06	6.46	292.57
S ₃ (45×45 cm)	57.37	76.95	14.27	7.01	411.93
SE(m)±	0.30	0.55	0.07	0.03	1.49
C.D.	0.84	1.56	0.19	0.09	4.23

Table-4 : Main effects of plant spacing on yield plot⁻¹ (kg), yield (q ha⁻¹), TSS (°Brix), vitamin A (µg/100g), ascorbic acid (mg/100g) and moisture content (%) of broccoli.

Treatment	Yield plot ⁻¹ (kg)	Yield (q ha ⁻¹)	TSS (°Brix)	Vitamin A (µg/100g)	Ascorbic acid (mg/100g)	Moisture content (%)
Factor-I						
S ₁ (45×15 cm)	7.03	175.68	6.16	99.36	109.96	81.22
S ₂ (45×30 cm)	8.48	212.11	6.21	103.27	110.92	82.59
S ₃ (45×45 cm)	7.83	195.67	6.30	104.21	111.45	81.71
SE(m)±	0.04	1.05	0.06	1.26	1.36	0.64
C.D.	0.12	2.99	NS	NS	NS	NS

Metaphosphoric acid (HPO₃) : 15 g Glacial acetic acid: 40 ml, Volume : 500 ml

B. 2, 6 dichlorophenol indophenol dye :

2, 6 dichlorophenol indophenol dye : 50 mg, Sodium bicarbonate : 42 mg

Volume : 200 ml

Ascorbic acid content of broccoli was determined by diluting the known volume of broccoli juice filtered through muslin cloth and with 3 per cent appropriate volume

metaphosphoric acid. 10 ml of aliquot was titrated against 2, 6- dichlorophenol indophenol dye solution till a stable light pink colour appeared. The results were expressed as mg ascorbic acid per 100 g.

The ascorbic acid content in broccoli was calculated using following formula :

Ascorbic acid mg per 100 g

$$= \frac{\text{Titer} \times \text{Dye factor} \times \text{Volume made up}}{\text{Volume of aliquot for estimation} \times \text{Volume of sample taken}}$$

Results and Discussion

Plant height (cm) : Results showed that effect of spacing significantly influenced plant height of broccoli at all the three stages, treatment S_3 (45×45 cm) registered maximum plant height of 19.42 cm, 35.24 cm and 48.77 cm at 30 DAT, 60 DAT and at final harvest, respectively, followed by treatment S_2 (45×30 cm) with values of 16.92 cm, 33.58 cm and 44.35 cm, respectively, whereas minimum plant height of 15.98 cm, 32.24 cm and 40.95 cm, respectively, were recorded for the treatment S_1 (45×15 cm).

Leaf length (cm) : The results indicated that the effect of spacing on leaf length was significantly influenced at all the three observed stages in broccoli, treatment S_3 (45×45 cm) registered maximum leaf length of 16.72 cm, 33.38 cm and 39.84 cm at 30 DAT, 60 DAT and at final harvest, respectively, followed by treatment S_2 (45×30 cm) with values of 15.48, 29.60 and 34.84 cm, respectively, whereas minimum leaf length was shown by treatment S_1 (45×15 cm) with values of 13.65 cm, 27.39 cm and 31.45 cm, respectively.

Leaf width (cm) : Results showed that effect of spacing significantly influenced leaf width of broccoli, at all the three stages, treatment S_3 (45×45 cm) recorded maximum leaf width at 30 DAT, 60 DAT and at final harvest with values of 15.56 cm, 26.40 cm and 31.59 cm, respectively, followed by treatment S_2 (45×30 cm) having leaf width of 14.00 cm, 24.78 cm and 28.40 cm, respectively, whereas minimum leaf width of 12.83 cm, 23.27 cm and 26.93 cm, respectively were recorded for S_1 (45×15 cm).

Days taken to head initiation : Results clearly showed that effect of spacing was found significant on days taken to head initiation of broccoli. The treatment S_2 (45×30 cm) taken minimum days to head initiation (53.39) followed by S_1 (45×15 cm) with value of 56.93, whereas the maximum (57.37 DAT) days taken to head initiation was observed for treatment S_3 (45×45 cm).

Number of leaves per plant : Data showed that the number of leaves per plant of broccoli was significantly influenced by plant spacing at all three stages studied, results revealed that the treatment S_3 (45×45 cm) recorded maximum number of leaves per plant of 6.73, 10.33 and 13.46, at 30 DAT, 60 DAT and at final harvest, respectively, followed by treatment S_2 (45×30 cm) with values of 6.05, 9.37 and 12.53, respectively, whereas treatment S_1 (45×15 cm) showed minimum number of leaves per plant of 5.44, 8.56 and 12.01, respectively.

Days taken to head harvest : The result showed that the effect of spacing significantly influenced days taken to head harvest, treatment S_2 (45×30 cm) registered

minimum (74.78 DAT) days taken to head harvest, followed by treatment S_1 (45×15 cm) with value of 76.89 DAT, whereas the maximum (76.95 DAT) days taken to head harvest was observed in treatment S_3 (45×45 cm).

Fresh weight of head (g) : The results data showed that the effect of spacing had significantly influenced fresh weight of head of broccoli. The treatment S_3 (45×45 cm) recorded maximum fresh weight of head (411.93 g), followed by treatment S_2 (45×30 cm) with value of 292.57 g, whereas the minimum fresh weight of head (127.77 g) was observed in treatment S_1 (45×15 cm).

Diameter of head (cm) : Result showed that the diameter of head was significantly influenced by spacing, results indicated that the treatment S_3 (45×45 cm) showed maximum diameter of head (14.27 cm), followed by treatment S_2 (45×30 cm) with value of 12.06 cm, whereas minimum diameter of head (10.57 cm) was recorded for treatment S_1 (45×15 cm).

Compactness of head (out of 10) : Results showed that compactness of head was significantly influenced by spacing, the treatment S_3 (45×45 cm) recorded maximum compactness of head (7.01), followed by treatment S_2 (45×30 cm) with value of 6.46, whereas minimum compactness of head (5.39) was observed for treatment S_1 (45×15 cm).

Yield per plot (kg) : The analyzed data showed that the yield per plot was significantly influenced by spacing, treatment S_2 (45×30 cm) produced maximum yield per plot (8.48 kg), followed by treatment S_3 (45×45 cm) with value of 7.83 kg per plot, whereas the minimum yield per plot (7.03 kg) was observed for treatment S_1 (45×15 cm).

Yield ($q\ ha^{-1}$) : The result showed that the effect of spacing had significantly influence on yield ($q\ ha^{-1}$). The treatment S_2 (45×30 cm) recorded maximum yield (212.11 $q\ ha^{-1}$), followed by S_3 (45×45 cm) with value of 195.67 $q\ ha^{-1}$, whereas the minimum yield (175.68 $q\ ha^{-1}$) was observed in treatment S_1 (45×15 cm).

Effect of spacing on quality parameters : Results showed that TSS ($^{\circ}Brix$), vitamin A ($\mu g/100g$), ascorbic acid ($mg/100g$), moisture content (%) were not influenced significantly by spacing. Results revealed that the spacing were found non-significant, however maximum value were observed for treatment S_3 .

Conclusions

On the basis of present investigation concluded that among all treatment, application of treatment combination S_3 (45 × 45 cm) established significant results for better growth, while treatment combination S_2 (45 × 30 cm) showed higher yield as compared to other treatment combinations.

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Bio-Efficiency of Novel Insecticides against Stem Fly *Melanagromyza sojae* Infesting Soybean

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Abstract

An experiment was conducted on “Bio-efficacy of Novel Insecticides against Stem fly *Melanagromyza sojae* Infesting Soybean” during Kharif, 2022-23. The results revealed that the mean stem fly infestation of two sprays ranged from 4.17% to 10.16% against control (19.92%) and in the treatment, Chlorantraniliprole 18.5 SC recorded the lowest infestation with 4.17% stem tunneling which was followed by Enamectin benzoate 5SG (5.25%). The highest stem fly infestation was recorded in Neem oil 2% (10.16%) followed by Profenofos 50 EC (8.47%).

Key words : Bio-efficacy, stem fly, chlorantraniliprole, neem oil 2%, soybean, and novel insecticides.

Introduction

The soybean (*Glycine max* (L.) family Leguminaceae, sub-family Papilionaceae) is a major oilseed crop of Madhya Pradesh. It is also known as the “Miracle crop”. Stem fly is the key pest of soybean whose damaging stage is maggot (white maggot) that feeds inside the stem. The maximum percent of stem fly infestation (36.34- 40.69%) and stem tunneling (20.99 to 28.99%) during early vegetative and grand growth stages of the crop Nayak *et al.*, (2012).

For successful management of these insect pests, various chemical control measures have been attempted earlier, which were found effective but were temporary. However, indiscriminate use of conventional insecticides led to problems like pest outbreaks, development of resistance by pests to insecticides, elimination of natural enemies, and risk to human and animal health besides environmental pollution. The novel insecticide molecules presently available have several advantages over conventional insecticides such as high selectivity to target pests, excellent efficacy at low rates or dosage and less harmful effects on the environment (Kodandaram *et al.*, 2010). Hence, some new insecticides and commonly recommended insecticides were evaluated against the stem fly of soybean for their better management

Materials and Methods

The field experiment to evaluate Bio - efficacy of novel insecticides against stem fly *Melanagromyza Sojae* (stem tunneling) infesting Soybean in the Instructional farm of Rajasthan College of Agriculture, Udaipur during *kharif* 2022. The insecticides were applied when the insect pest reached the economic threshold level. The observation for

the percent stem tunneling of stem fly of soybean was recorded 24 hours before the spray (pre-treatment population) and at 3, 7 and 10 days after each spray from randomly selected 5 plants in each plot. The second spray was done after rebuilding up to the pest population and again the observation was recorded just as in the manner after the first spraying.

Treatment Details :

S. No.	Treatments	Dose (ai/ha)
1.	Chlorantraniliprole 18.5 SC	150g
2.	Flubendiamide 39.35 SC	100g
3.	Spinetoram 11.7 SC	450ml
4.	Neem Oil 2%	1liter
5.	Profenofos 50 EC	650ml
6.	Enamectin benzoate 5 SG	200g
7.	Control	-

Statistical analysis : The management using novel insecticides involves the application of ANOVA using RBD design before necessary transformations of the observations are done (Gomez and Gomez, 1984).

Skeleton of Analysis of Variance (ANOVA):

Sources of variation	Df	SS	MSS	F cal.	F table
Replication	r-1	SSr	$MSSr = \frac{SSr}{r-1}$	$\frac{MSSr}{MSSe}$	
Treatments	t-1	SSt	$\frac{MSSt}{SSt / t-1}$	$\frac{MSSt}{MSSe}$	F at 5% (t-1, (r-1)(t-1))
Error	(r-1)(t-1)	SSe	$\frac{MSSe}{SSe / (r-1)(t-1)}$	-	-
Total	(r.t-1)	-	-	-	-

r = Number of replications

t = Number of treatments

Results and Discussion

First spray : A perusal of the data presented in Table-1 shows that all the treatments were found significantly superior to the control. The data presented in Table-1 reveals that the lowest stem fly infestation was recorded in the treatment of Chlorantraniliprole 18.5 SC which caused 4.69%, 4.12% and 5.25% stem tunneling after 3, 7 and 10 days of spray, respectively. The second most effective treatment after Chlorantraniliprole 18.5 SC was Emamectin benzoate 5 SG which caused 5.61%, 5.21% and 6.59% stem tunneling after 3, 7 and 10 days of spray, respectively. Following the Emamectin benzoate 5 SG next, Flubendiamide 39.35 SC which caused 6.37%, 6.19% and 7.08% stem tunneling after 3, 7 and 10 days of spray, respectively. Treatment application of Spinetoram 11.7 SC causes 7.12%, 6.69% and 7.59% stem tunneling after 3, 7 and 10 days of spray, respectively. The highest stem fly infestation was recorded in Neem oil 2% which caused 10.69%, 10.25% and 11.19% stem tunneling which was followed by Profenofos 50 EC caused 9.25%, 8.57% and 8.57 % stem tunneling after 3, 7 and 10 days of spray, respectively.

Second spray : The observations recorded on the decline in percent stem tunneling of stem fly after the second application of different treatment reveals that the treatment application of Chlorantraniliprole 18.5 SC proved to be most effective in recorded the percent stem tunneling of stem fly. The data presented in Table 1 reveals that the lowest stem fly infestation was recorded in the treatment Chlorantraniliprole 18.5 SC which caused 4.15%, 3.29% and 3.15% stem tunneling after 3, 7 and 10 days of second spray, respectively. The second most effective treatment after Chlorantraniliprole 18.5 SC was Emamectin benzoate 5 SG which caused 5.09%, 4.25% and 4.75% stem tunneling after 3, 7 and 10 days of second spray, respectively. Following the Emamectin benzoate 5 SG next, Flubendiamide 39.35 SC which caused 6.04%, 4.85% and 5.29% stem tunneling after 3, 7 and 10 days of the second spray, respectively. Treatment application of Spinetoram 11.7 SC causes 5.25%, 6.05% and 6.56% stem tunneling after 3, 7 and 10 days of second spray, respectively. The highest stem fly infestation was recorded in Neem oil 2% which caused 10.02%, 9.15% and 9.65% stem tunneling which was followed by Profenofos 50 EC caused 8.69%, 7.19% and 7.31 % stem tunneling after 3, 7 and 10 days of second spray, respectively.

Pooled Mean : The mean stem fly infestation of two sprays showed that Chlorantraniliprole 18.5 SC recorded the lowest infestation with 4.17% stem tunneling which was followed by Emamectin benzoate 5SG (5.25%). The

highest stem fly infestation was recorded in Neem oil 2% (10.16%) followed by Profenofos 50 EC (8.47%).

Two sprays are conducted in the experiment. The observations were recorded at 3, 7 and 10 days after spraying and the second spray was done 15 days after 1st spraying. The results revealed that at the end of the first spraying, the stem fly infestation ranged from 5.25% to 11.19% stem tunneling against control (19.24%). The lowest stem fly infestation was recorded in the treatment Chlorantraniliprole 18.5 SC (5.25% stem tunneling). The highest stem fly infestation was recorded in Neem oil (11.19%). At the end of the second spraying, the stem fly infestation ranged from 3.51% to 9.65% stem tunneling against control (24.00%). The lowest stem fly infestation was recorded in the treatment Chlorantraniliprole 18.5 SC (3.51% stem tunneling) which was followed by Emamectin Benzoate 5 SG (4.75%). The highest stem fly infestation was recorded in Neem oil (10.16%).

The mean stem fly infestation of the two sprays showed that Chlorantraniliprole 18.5 SC recorded the lowest infestation with 4.17% stem tunneling which was followed by Emamectin Benzoate 5 SG (5.25%). The highest stem fly infestation was recorded in Neem Oil (10.16%). Salunke *et al.* (2004) and Dahiphale *et al.* (2007a) reported that percent stem tunneled was lowest in phorate 10 G @ 10 kg/ha, whereas the lowest infestation of girdle beetle was recorded in carbofuran 3 G @ 30 kg/ha and Dahiphale *et al.* (2007b) reported reduction in tunneled stem length due to stem fly (*Melanagromyza sojae*) and girdle beetle (*Obereopsis brevis*) was maximum with the soil application of phorate 10 G. Khandwe *et al.* (2011) reports that Spinosad was effective in managing the stem fly. Balaji *et al.* (2012) reported that Diafenthiuron was effective in managing stem fly whereas the findings of Totanadak *et al.* (2012) and Raju *et al.* (2013) were contradictory to the experimental findings of the present investigation.

Conclusions

Among the treatments, Chlorantraniliprole 18.5 SC was found most effective in reducing the stem fly population on soybean followed by Emamectin benzoate 5 SG and Flubendiamide 39.35 SC. Whereas, Neem oil at 2% and Profenofos 50 EC were found least effective against stem fly (*Melanagromyza sojae*).

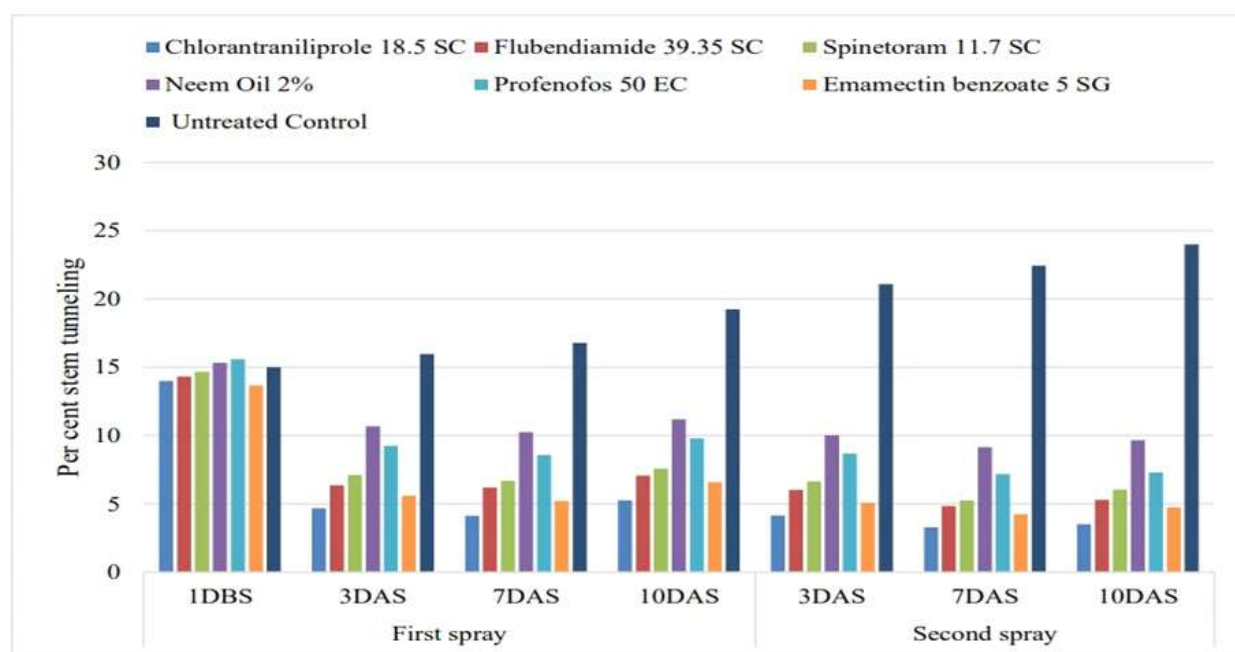
Acknowledgment

I would be more thankful to the Department of Entomology, Rajasthan College of Agriculture, Udaipur for all necessary requirements throughout the course of the investigation.

Table-1: Bio-efficacy of novel insecticides against stem fly, *Melanagromyza sojae* (Percent stem tunnelling) infesting Soybean during Kharif, 2022.

Treatments	First Spray				Second Spray			Pooled Mean
	1DBS	3DAS	7DAS	10DAS	3DAS	7DAS	10DAS	
Chlorantraniliprole 18.5 SC	14.00 (21.97)	4.69 (12.51)	4.12 (11.71)	5.25 (13.25)	4.15 (11.75)	3.29 (10.45)	3.51 (10.80)	4.17 (11.78)
Flubendiamide 39.35 SC	14.33 (22.24)	6.37 (14.62)	6.19 (14.41)	7.08 (15.43)	6.04 (14.23)	4.85 (12.72)	5.29 (13.30)	5.97 (14.14)
Spinetoram 11.7 SC	14.67 (22.52)	7.12 (15.48)	6.69 (14.99)	7.59 (15.99)	6.65 (14.94)	5.25 (13.25)	6.05 (14.24)	6.56 (14.84)
Neem Oil 2%	15.33 (23.05)	10.69 (19.08)	10.25 (18.67)	11.19 (19.54)	10.02 (18.45)	9.15 (17.61)	9.65 (18.10)	10.16 (18.59)
Profenofos 50 EC	15.59 (23.26)	9.25 (17.71)	8.57 (17.02)	9.80 (18.24)	8.69 (17.14)	7.19 (15.55)	7.31 (15.69)	8.47 (16.92)
Emamectin benzoate 5 SG	13.67 (21.70)	5.61 (13.70)	5.21 (13.19)	6.59 (14.87)	5.09 (13.04)	4.25 (11.90)	4.75 (12.59)	5.25 (13.25)
Untreated Control	15.00 (22.79)	15.97 (23.55)	16.79 (24.19)	19.24 (26.02)	21.09 (27.34)	22.44 (28.28)	24.00 (29.33)	19.92 (26.51)
SEM	0.20	0.14	0.12	0.25	0.12	0.15	0.12	0.14
CD at + 5%	NS	0.43	0.37	0.77	0.36	0.45	0.36	0.44

* Figures in parenthesis () are arcsine transformation values, DBS = Days before spraying, DAS = Days after spraying

**Fig.-1 : Bio-efficacy of novel insecticides against stem fly, *Melanagromyza sojae* (Percent stem tunneling) infesting Soybean during Kharif, 2022.**

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Nutrient Uptake as Influenced by Pre Mix Post Emergence Herbicides in Rabi Groundnut (*Arachis hypogaea* L.)

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Abstract

A field experiment was conducted during *rabi*, 2022-23 at S.V. Agricultural College Farm, Tirupati. The experiment was laid out in Randomized block design and replicated thrice. The treatments consisted of pre emergence (PE) application of pendimethalin 1.0 kg ha⁻¹ fb hand weeding at 30 DAS, post emergence (PoE) application of quizalofop-p-ethyl + imazethapyr (Pre mix) 98.43 g ha⁻¹, PoE application of fomesafen + quizalofop-p-ethyl (Pre mix) 225 g ha⁻¹, PoE application of oxyfluorfen + quizalofop-p-ethyl (Pre mix) 100 g ha⁻¹, PoE application of propaquizafop + imazethapyr (Pre mix) 125 g ha⁻¹, PoE application of sodium acifluorfen + clodinafop propargyl (Pre mix) 245 g ha⁻¹, PoE application of fomesafen + fluazifop-p-butyl (Pre mix) 222 g ha⁻¹, PoE application of imazethapyr + imazamox (Pre mix) 70 g ha⁻¹, hand weeding twice at 20 and 40 DAS and weedy check. Among Pre mix post-emergence herbicides viz., imazethapyr + imazamox 70 g ha⁻¹ or propaquizafop + imazethapyr 125 g ha⁻¹ and quizalofop-p-ethyl + imazethapyr 98.43 g ha⁻¹ were comparable among themselves and statistically at par with hand weeding twice at 20 and 40 DAS and Pre emergence application of pendimethalin 1.0 kg ha⁻¹ fb by one hand weeding at 30 DAS with respect to higher nutrient uptake i.e., N, P, K by groundnut crop and lower nutrient uptake by weeds. Lowest nutrient uptake of N, P, K by groundnut and highest uptake by weeds was recorded in weedy check.

Key words : Groundnut, herbicides, pre emergence, post emergence, pre mix and nutrient uptake.

Introduction

Groundnut (*Arachis hypogaea* L.) is known as king of vegetable oilseed crops and plays an important role in meeting the demand of edible oil across the world, which belongs to the family Fabaceae. Among the oilseed crops, groundnut is the 4th most predominant oilseed crop and 13th crucial food crop of the world. The groundnut seed contains 47-53% oil and 26% protein and 11.5% starch. As a legume, it fixes atmospheric nitrogen in the root nodules to the tune of 200 kg nitrogen per hectare (1). It is grown in almost all the tropical and sub-tropical countries. China and India are the huge producers of groundnut, accounting for over 41 % and 18 % of total world's production, respectively as per (2). India is one of the leading groundnut producing countries since it accounts for 39.31% of world's groundnut area and approximately 27.3% of production. In India, it is cultivated over an area of 4.9 m ha with a production of 9.25 m t and an average productivity of 1893 kg ha⁻¹. Andhra Pradesh occupies an area of 0.87 m ha producing 0.78 m t with a productivity of 894 kg ha⁻¹ (3). Among different constraints associated in groundnut cultivation, weed menace is one of the serious bottlenecks (4) which pose a severe competition for all the growth factors such as nutrients, light, moisture and space when they are limited. They can remove about 30-40 % of applied nutrients (5). Due to short stature and initial slow growth, groundnut is highly prone to weed preponderance

(6). Weeds impede with pegging, pod development and harvesting of groundnut besides competing for vital resources. Yield losses in peanut due to weeds have been estimated as high as 24 to 70%. Hence, weed management should be given utmost priority to increase groundnut yield and productivity. As a part of weed management, weeds are generally controlled through hand weeding and hand hoeing which are common methods adopted for the control of weeds in groundnut crop. Due to escalating labour wages, timely availability of labour, hand weeding is not economically viable, so pre emergence and post emergence herbicides are the alternative source for effective weed control, even though pre emergence application of pendimethalin controls weeds at initial stages, later emerged weeds are not controlled. Post emergence application of single group of herbicides with similar mode of action year after year and season after season, leads to shift in weed flora. To overcome this problem new generation Pre mix herbicides available in the market with combination of different group of herbicides having different mode of action need to be evaluated for attaining wide spectrum of weed control in Groundnut crop.

Material and Methods

The field experiment was conducted at S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh during *rabi*,

Table-1 : Nutrient uptake (kg ha⁻¹) by weeds at harvest of *rabi* groundnut as influenced by weed management practices.

	Treatments	Nitrogen	Phosphorus	Potassium
T ₁ :	Pre-emergence application of pendimethalin 1.0 kg ha ⁻¹ fb by one hand weeding at 30 DAS	8.53	3.07	4.77
T ₂ :	Post-emergence application of quizalofop-p-ethyl + imazethapyr (Pre mix) 98.43 g ha ⁻¹	10.67	5.20	6.81
T ₃ :	Post-emergence application of fomesafen + quizalofop-p-ethyl (Pre mix) 225 g ha ⁻¹	16.91	7.90	11.40
T ₄ :	Post-emergence application of oxyfluorfen + quizalofop-p-ethyl (Pre mix) 100 g ha ⁻¹	21.00	13.11	14.56
T ₅ :	Post-emergence application of propaquizafop + imazethapyr (Pre mix) 125 g ha ⁻¹	10.33	5.13	6.03
T ₆ :	Post-emergence application of sodium acifluorfen + clodinafop propargyl (Pre mix) 245 g ha ⁻¹	14.20	8.03	9.67
T ₇ :	Post-emergence application of fomesafen + fluazifop-p-butyl (Pre mix) 222 g ha ⁻¹	15.21	8.82	11.00
T ₈ :	Post-emergence application of imazethapyr + imazamox (Pre mix) 70 g ha ⁻¹	9.07	4.66	5.00
T ₉ :	Hand weeding twice at 20 and 40 DAS	8.47	2.93	4.63
T ₁₀ :	Weedy check	33.11	16.53	21.67
	SEm ±	1.081	0.788	0.827
	CD (P = 0.05)	3.21	2.34	2.46

Table-2 : Yield and nutrient uptake (kg ha⁻¹) of *rabi* Groundnut crop at harvest as influenced by weed management practices.

	Treatments	Nitrogen	Phosphorus	Potassium	Pod yield	Haulm yield
T ₁ :	Pre-emergence application of pendimethalin 1.0 kg ha ⁻¹ fb by one hand weeding at 30 DAS	88.19	23.67	88.70	3584	5351
T ₂ :	Post-emergence application of quizalofop-p-ethyl + imazethapyr (Pre mix) 98.43 g ha ⁻¹	86.62	22.89	86.34	3411	5185
T ₃ :	Post-emergence application of fomesafen + quizalofop-p-ethyl (Pre mix) 225 g ha ⁻¹	77.00	18.33	79.00	2678	4510
T ₄ :	Post-emergence application of oxyfluorfen + quizalofop-p-ethyl (Pre mix) 100 g ha ⁻¹	69.77	16.32	72.33	2135	4004
T ₅ :	Post-emergence application of propaquizafop + imazethapyr (Pre mix) 125 g ha ⁻¹	87.17	22.97	87.00	3460	5193
T ₆ :	Post-emergence application of sodium acifluorfen + clodinafop propargyl (Pre mix) 245 g ha ⁻¹	78.59	19.52	80.33	2754	4667
T ₇ :	Post-emergence application of fomesafen + fluazifop-p-butyl (Pre mix) 222 g ha ⁻¹	77.70	18.71	80.20	2718	4659
T ₈ :	Post-emergence application of imazethapyr + imazamox (Pre mix) 70 g ha ⁻¹	87.54	23.13	87.33	3570	5273
T ₉ :	Hand weeding twice at 20 and 40 DAS	89.62	24.61	88.37	3696	5549
T ₁₀ :	Weedy check	39.13	11.67	56.15	1580	3497
	SEm ±	2.270	0.591	1.926	167.9	168.6
	CD (P = 0.05)	6.81	1.77	5.76	501	504

2022-23. The soil of experimental field was sandy loam in texture, neutral in reaction, low in organic carbon (0.21%) available nitrogen (224 kg ha⁻¹), low in available phosphorus (23.4 kg ha⁻¹) and medium in available potassium (289 kg ha⁻¹). The experiment was laid out in RBD and replicated thrice. The treatments consisted of pre emergence (PE) application of pendimethalin fb hand weeding at 30 DAS, post emergence (PoE) application of quizalofop-p-ethyl + imazethapyr (Pre mix) 98.43 g ha⁻¹, PoE application of fomesafen + quizalofop-p-ethyl (Pre mix) 225 g ha⁻¹, PoE application of oxyfluorfen + quizalofop-p-ethyl (Pre mix) 100 g ha⁻¹ (T₄), PoE application of propaquizafop + imazethapyr (Pre mix) 125 g ha⁻¹, PoE application of sodium acifluorfen + clodinafop

propargyl (Pre mix) 245 g ha⁻¹, PoE application of fomesafen + fluazifop-p-butyl (Pre mix) 222 g ha⁻¹, PoE application of imazethapyr + imazamox (Pre mix) 70 g ha⁻¹, hand weeding twice at 20 and 40 DAS and weedy check. The variety Dheeraj was sown on 28-11-2022 and recommended dose of the fertilizer (30-40-50 N-P-K kg ha⁻¹) were applied. Composite plant samples of crop as well as weeds from all the plots were collected at harvest and these samples were dried and grounded into fine powder and used for estimation of N, P and K by using standard procedures outlined by (7). The uptake of nitrogen, phosphorus and potassium at harvest by the crop and its associated weeds were calculated by multiplying the respective nutrient content with

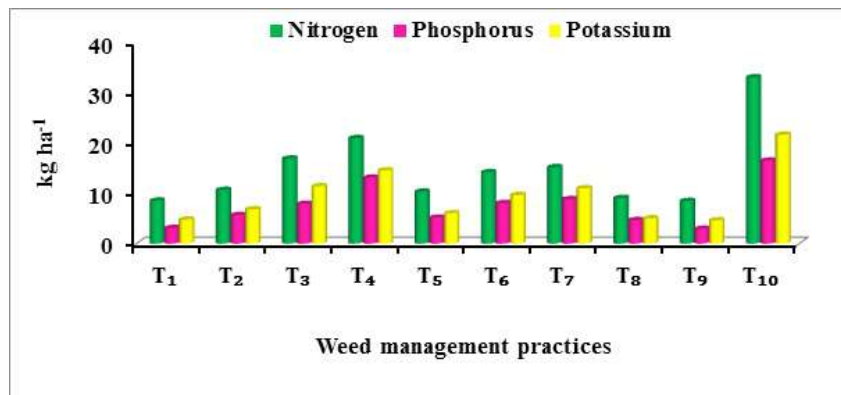


Fig.-1 : Nutrient uptake (kg ha⁻¹) by weeds at harvest as influenced by weed management practices in *rabi* groundnut crop.

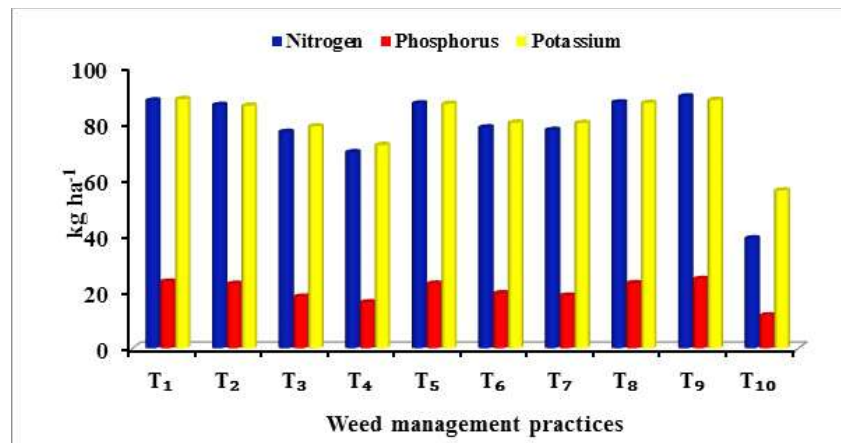


Fig.-2 : Nutrient uptake (kg ha⁻¹) by *rabi* groundnut crop at harvest as influenced by weed management practices.

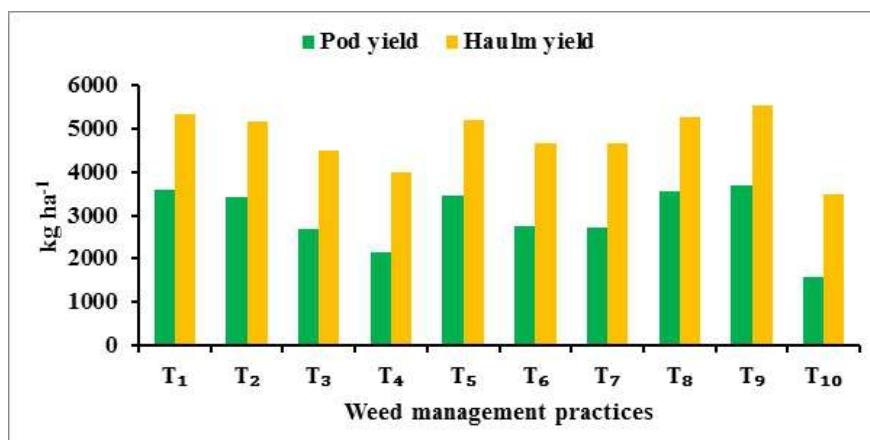


Fig.-3 : Yield (kg ha⁻¹) of *rabi* groundnut as influenced by weed management practices.

corresponding dry weights and expressed as kg ha⁻¹. All the other recommended practices were also adopted as per the crop requirement.

Results and Discussion

The weed flora of the *rabi* groundnut experimental field consisted of nine taxonomic families, of which two species were grasses, nine species were broad leaved weeds and only one species of sedge, *Cyperus rotundus*. *Digitaria sanguinalis*, *Cyperus rotundus*, *Boerhavia erecta*, *Borreria*

hispida (L.), *Dactyloctenium aegyptium*, *Celosia argentea*, *Euphorbia hirta* L., *Trichodesma indicum*, *Tridax procumbens* and other weeds.

Nutrient Uptake by Weeds at Harvest : Different weed management practices in groundnut significantly influenced the uptake of nitrogen, phosphorus and potassium by weeds at harvest in table-1 and fig.-1.

Higher uptake of nitrogen, phosphorous and potassium by weeds at harvest was recorded with Weedy

check, as no control measures are taken in weedy check and severe competition exists between the crop and weeds, which have taken more amount of nutrient sources and reduced the availability of nutrients to groundnut crop. These results are in conformity with (8). Post-emergence application of oxyfluorfen + quizalofop-p-ethyl (Pre mix) 100 g ha⁻¹ recorded significantly higher uptake of nutrients *i.e.*, N, P, and K by weeds, due to ineffective control of weeds present in the field so, that competition is increased and weeds might have taken more amount of nutrients compared to crop.

Significantly lower uptake of N, P and K by weeds was with hand weeding twice at 20 and 40 DAS, which was on par with PE application of pendimethalin 1.0 kg ha⁻¹ *fb* by one hand weeding at 30 DAS or post-emergence application of imazethapyr + imazamox (Pre mix) 70 g ha⁻¹ or propaquizafop + imazethapyr (Pre mix) 125 g ha⁻¹ and quizalofop-p-ethyl + imazethapyr (Pre mix) 98.43 g ha⁻¹. This might be due to effective control of weeds by herbicides and effective removal of weeds by manual method reduced the weed competition and crop has taken more amount of nutrients and recorded higher pod and haulm yield.

Nutrient Uptake by Groundnut at harvest : Nutrient uptake by groundnut at harvest significantly influenced by different weed management practices in table-2.0 and fig.-2.

The highest uptake of nitrogen, phosphorus and potassium by groundnut was recorded with two hand weeding twice at 20 and 40 DAS due to weed free environment created during crop growth resulted in recording of lower density of weeds, which led to lower uptake of nutrients by weeds. The hand weeding twice at 20 and 40 DAS, was in parity with pre-emergence application of pendimethalin 1.0 kg ha⁻¹ *fb* by one hand weeding at 30 DAS and post-emergence application of imazethapyr + imazamox (Pre mix) 70 g ha⁻¹, propaquizafop + imazethapyr (Pre mix) 125 g ha⁻¹ and quizalofop-p-ethyl + imazethapyr (Pre mix) 98.43 g ha⁻¹. This might be due to effective control of weeds leads to higher dry matter accumulation and increased the nutrient uptake by groundnut crop. (9) found that highest uptake of nutrients was with hand weeding twice at 20 and 40 DAS. As the nutrient uptake by groundnut was highest in above mentioned treatments, thereby photosynthates are translocated effectively from source to sink, which leads to increase in the pod and haulm yield in table-2 and fig.-3).

The lowest uptake of N, P and K by groundnut crop was recorded with weedy check, which was significantly

lower than the rest of the weed management practices. This could occur as a result of intense weed competition, which reduces the groundnut crop's ability to absorb nutrients and reduces the buildup of dry matter. These results are corroborative with findings of (10).

Conclusions

The results indicated that, among pre mix post-emergence herbicides higher uptake of nutrients and higher yield in groundnut was recorded with application of imazethapyr + imazamox 70 g ha⁻¹ or propaquizafop + imazethapyr 125 g ha⁻¹ and quizalofop-p-ethyl + imazethapyr 98.43 g ha⁻¹ which were comparable with each other and the above mentioned treatments are statistically on par with hand weeding twice at 20 and 40 DAS and pendimethalin 1.0 kg ha⁻¹ *fb* by one hand weeding at 30 DAS.

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Constraints Perceived Beneficiary Farmers in the Adoption of Onion Production Technology

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Abstract

The present research study was conducted in Sikar districts of Rajasthan to find out the constraints perceived by the beneficiary farmers of Front Line Demonstrations in adoption of Onion production technology. 4 panchayat samities were selected from Sikar district for the study purpose. 50 beneficiary farmer were selected who had participated in FLDs on Onion production technology in the year 2018-19, 2019-20 and 2020-21. The data from these farmers was collected using a well-structured and pre tested interview schedule during the year 2022-23. The findings showed that the overall constraints perceived by the beneficiary farmers were financial constraints (85.75 MPS) as most important Constraint followed by Marketing Constraint (79.33 MPS) and Input Constraint (60.89 MPS). Further, Technical Constraint (56.81 MPS) was perceived as least important constraint in adoption of Onion production technology by the beneficiary farmers. Further, it can be concluded that "High cost of weedicides", "Minimum support price is not fixed by the Govt.", "Lack of knowledge about grading and standardization" and "Supply of inferior quality seeds" were the major constraints perceived by the beneficiary farmers. There is a need to provide more FLDs, trainings and organizing demonstrations to raise the knowledge and hence increase the extent of adoption of onion production technology by the farmers.

Introduction

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops cultivated extensively in India and it belongs to the family Alliaceae. The primary centre of origin of the Onion is central Asia. Onion is one of the few versatile vegetable crops that can be kept for a fairly long time and can safely withstand the hazards of rough handling including long distance transport. It is liked for its flavour and pungency, which is due to the presence of a volatile oil "Allyl-prophyl-disulphide". It is dietary essential for human beings because of its nutritional and medicinal values, which commands extensive markets. It can also be used in innumerable ways. The immature and mature bulbs are eaten raw or they may be cooked and eaten as vegetable and commonly used as condiments and spices for flavouring and enriching various cuisines. It is also used in the form of dehydrated (form of flakes, rings, kibbles and powder), freezing, canning and pickling (in vinegar or brine).

Sikar region stands first rank in area of Onion in the state. In this region the Onion crop is grown in an area of 20827 ha with an annual production of over 442010 tonnes. (Anonymous 2019-20).

Sikar district is having maximum area of 10684 ha and production 300579 tonnes of Onion as compared to other district of Sikar region. (Anonymous 2019-20).

The main objective of the FLD is to demonstrate newly released crop production and protection technology

and its management practices on the farmer's field by the scientists themselves before taking it into main extension system of State Department of Agriculture under different agro-climatic regions and on field of farmers.

Research Methodology

The present study was conducted in sikar districts of Rajasthan. Sikar district was selected purposively due to the reason that sikar district has the highest area (10684 ha) and production (300579 t) of onion crop among all districts of Rajasthan (Anonymous 2019-20). Sikar district comprises of 13 Panchayat Samitis Out of which Laxmangarh, Fatehpur, Khandela and Piprali Panchayat Samities were selected purposively because Front Line Demonstrations on Onion were conducted by the KVK, Fatehpur (Sikar) in these Panchayat Samities. 16, 24 and 10 farmer's fields where FLDs were conducted in the year 2018-19, 2019-20 and 2020-21, respectively were included in the study as FLDs beneficiaries. Thus, the total sample size of 50 beneficiary farmers was selected. A separate interview schedule was prepared and data were collected using personal interview method. Appropriate statistical tools were applied to interpret the results. The responses obtained from respondents were recorded on a three -point continuum namely high, medium and low extent. Mean Percent Score (MPS) was calculated to find out the priority areas of various package of practices of onion production technology.

Mean Percent Score was obtained by dividing the

Table-1 : Input constraints perceived by the Beneficiary farmers in adoption of Onion production technology.

S. No.	Input Constraints	MPS	Rank
1.	Unavailability of good quality seeds at the time of sowing	72.00	II
2.	Supply of inferior quality seeds	74.67	I
3.	Unavailability of fertilizer at the peak seasons	45.33	VI
4.	Unavailability of recommended chemical for plant protection measures	47.33	V
5.	Lack of irrigation facility	58.67	IV
6.	Unavailability of short duration varieties	67.33	III

Table-2 : Technical constraints perceived by the Beneficiary farmers in adoption of Onion production technology.

S. No.	Technical Constraints	MPS	Rank
1.	Lack of knowledge about seed treatment	61.33	III
2.	Lack of knowledge about cultivation of HYV	64.67	II
3.	Lack of knowledge about grading and standardization	73.33	I
4.	Lack of knowledge about recommended seed rate	46.00	VIII
5.	Poor knowledge about doses of chemical fertilizers	44.00	IX
6.	Lack of knowledge about plant protection chemicals	55.33	VI
7.	Poor knowledge about irrigation management	52.67	VII
8.	Lack of knowledge about chemical weed control	57.33	IV
9.	Lack of knowledge about plant protection	56.67	V

Table-3 : Marketing constraints perceived by the Beneficiary farmers in adoption of Onion production technology.

S. No.	Marketing Constraints	MPS	Rank
1.	Lack of storage facilities	81.33	VI
2.	Transportation facilities are very costly	83.33	III
3.	Lack of knowledge about market rates	66.67	VIII
4.	Low prices of good quality produce in market	69.33	VII
5.	Mal practices by local businessmen	63.33	IX
6.	Minimum support price is not fixed by the Govt.	99.33	I
7.	Very high fluctuation in prices	83.33	III
8.	Lack of latest market information	84.67	II
9.	Lack of market for the commodity	82.67	V

Table-4 Financial constraints perceived by the Beneficiary farmers in adoption of Onion production technology.

S. No.	Financial Constraints	MPS	Rank
1.	Lack of credit facilities	63.33	IX
2.	High cost of labour	67.33	VI
3.	High cost of inputs	65.33	VII
4.	High cost of equipments	64.00	VIII
5.	High cost of HYV seeds	84.67	II
6.	High cost of weedicides	93.33	I
7.	High cost of plant protection chemicals	82.67	IV
8.	High cost of fertilizers	84.00	III
9.	Lack of facility for crop insurance	81.33	V

Table-5 : Overall constraints perceived by the Beneficiary farmers in adoption of Onion production technology.

S. No.	Constraints	MPS	Rank
1.	Input Constraints	60.89	III
2.	Technical Constraints	56.81	IV
3.	Marketing Constraints	85.75	I
4.	Financial Constraints	79.33	II
	Overall	70.70	

total score of each practice statement by maximum score obtained under each practice and multiplying it by hundred. The formula for calculation MPS is given below :

Results and Discussion

In this study the term constraint was used to denote the problems and obstacles which the farmers perceived in adoption of Onion production technology.

1. Category wise constraints perceived by the Beneficiary farmers in adoption of Onion production technology : For the analysis of constraints perceived by the Beneficiary farmers in adoption of Onion production technology, all major constraints were categorized into four different categories as technical, input, financial and marketing constraints. Each statement was assigned a rank according to the MPS obtained.

1.1 Input constraints perceived by the Beneficiary farmers in adoption of Onion production technology : The data presented in Table-1 showed that Beneficiary farmers reported the major constraints like "Supply of inferior quality seeds" as most perceived input constraint by the Beneficiary farmers having highest MPS of 74.67. "Unavailability of good quality seeds at the time of sowing" was second most important input constraint, which was having MPS of 72.00 "Unavailability of short duration varieties" (67.33 MPS), "Lack of irrigation facility" (58.67 MPS), "Unavailability of recommended chemical for plant protection measures" (47.33 MPS) and "Unavailability of fertilizer at the peak seasons" (45.33 MPS) were found as comparatively less important constraints and were ranked third, fourth, fifth and six, respectively.

The reason for facing these constraints might be lack of knowledge, socio-economic factors and poor availability of quality seeds and plant protection measures. These findings are in the line of finding of Meena (2010) and Yadav (2021).

1.2 Technical constraints perceived by the Beneficiary farmers in adoption of Onion production technology : The data in Table- 2 indicated that the Beneficiary farmers reported that major constraints like "Lack of knowledge about grading and standardization" was most perceived technical constraint by the Beneficiary farmers having highest MPS of 73.33, "Lack of knowledge about cultivation of HYV" was second most important technical constraint, which was having MPS of 64.67, "Lack of knowledge about seed treatment" (61.33 MPS), "Lack of knowledge about chemical weed control" (57.33 MPS), "Lack of knowledge about plant protection chemicals" (56.67 MPS), "Lack of knowledge about plant protection chemicals" (55.33 MPS), "Poor knowledge about irrigation management" (52.67 MPS), "Lack of knowledge about recommended seed rate" (46.00 MPS) and "Poor

knowledge about doses of chemical fertilizers" (44.00 MPS) were found as comparatively less important constraints and were ranked third, fourth, fifth, six, seven, eight and nine, respectively.

The analysis of table clearly indicated that poor technical knowledge lead to various technical constraints hindering the adoption of Onion production technology. Similar findings are reported by Jat (2011) and Patodiya (2015).

1.3 Marketing constraints perceived by the Beneficiary farmers in adoption of Onion production technology : The data in Table-3 also revealed that the constraints like "Minimum support price is not fixed by the Govt." was most perceived marketing constraint by the Onion growers having highest MPS of 99.33, "Lack of latest market information" was second most important marketing constraint which was having MPS of 84.67 "Transportation facilities are very costly" (83.33 MPS), "Very high fluctuation in prices" (83.33 MPS), "Lack of market for the commodity" (82.67 MPS), "Lack of storage facilities" (81.33 MPS), "Low prices of good quality produce in market" (69.33 MPS) and "Lack of knowledge about market rates" (66.67 MPS) and "Mal practices by local businessmen (63.33 MSP) were found as comparatively less important constraints and were ranked third, third, fifth, six, seven, eight, and nine respectively. Similar findings are reported by Meena (2010) and Yadav (2021).

1.4 Financial constraints perceived by the Beneficiary farmers in adoption of Onion production technology : The analysis of Table-4 revealed that the Beneficiary farmers reported that major constraint regarding financial aspects perceived were "High cost of weedicides" (93.33 MPS) was most perceived financial constraint "High cost of HYV seed" was second most important financial constraint, with 84.67 MPS "High cost of HYV fertilizers" (84.00 MPS), high cost of plant protection chemicals (81.33 MPS) "Lack of facility for crop insurance", "High cost of labour" (67.33 MPS) "High cost of inputs" (65.33 MPS), "High cost of equipments" (64.00 MPS), "Lack of credit facilities" (63.33 MPS) and were found to be comparatively less important constraints and were ranked third, fourth, fifth, six, seven and eight nine, respectively. Similar finding are reported by Yadav (2021).

2. Overall constraints perceived by the Beneficiary farmers in adoption of Onion production technology : The data in Table-5 reveals that overall constraints which could be responsible for adoption of improved Onion production technology. The data given in Table 4.5.5 depicts that the constraints like "Financial Constraints" was most perceived constraint by the Onion growers having highest MPS of 85.75 "Marketing Constraints" was

second most important constraint which was having MPS of 79.33 “Input Constraints” (60.89 MPS) and “technical constraints” (56.81 MPS) were found as comparatively less important constraints and were ranked third and fourth, respectively. Similar finding are reported by Yadav (2021), Jaitawat (2007), Asiwal (2006) and Nagar (2006).

Conclusions

It can be concluded that financial constraints (57.12 MPS) was perceived as the most important Constraint followed by Input Constraint (49.91MPS) and Marketing Constraint (46.21 MPS). Further, Technical Constraint (43.46 MPS) was perceived as least important constraint in adoption of Onion production technology by Beneficiary farmers of Sikar district of Rajasthan.

Aspect wise constraints was found that “High cost of weedicides”, “Minimum support price is not fixed by the Govt.”, “Lack of knowledge about grading and standardization” and “Supply of inferior quality seeds” were major constraints perceived by the Beneficiary farmers. There is a need to provide trainings and organizing demonstrations to raise the knowledge and awareness among the farmers.

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Growth and Yield of Mungbean [*Vigna radiata* (L.) Wilczek] as Influenced by Phosphorus and Growth Regulators

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Abstract

A field study was conducted during the *kharif* seasons of 2021-22 and 2022-23 at Agricultural Research Station, Fatehpur, Sikar, Rajasthan, to assess the response of Mungbean [*Vigna radiata* (L.) Wilczek] to phosphorus levels and growth regulators. Five phosphorus levels [0, 15, 30, 45 and 60 kg ha⁻¹] in main-plots and four concentrations of growth regulators viz. number of spray, salicylic acid 50 ppm, salicylic acid 75 ppm and salicylic acid 100 ppm, in sub plots were studied in split-plot design with 3 replications. Application of 45 kg phosphorus produced significantly taller plants with higher number of branches and more DMA plant⁻¹ at 50 DAS and harvest over lower doses of phosphorus and remained at par with 60 kg phosphorus. Significantly higher number of nodules plant⁻¹ (39.61) and nodule dry weight (84.3 mg), yield attributes viz., number of pods (19.81), seeds pod⁻¹ (8.63), test weight (32.53) and seed (1822 kg ha⁻¹) and straw yield (3145 kg ha⁻¹) were recorded with 45 kg phosphorus over preceding graded lower levels and found at par with next higher level. Foliar spray of salicylic acid 75 ppm resulted in significantly higher plant height, branches plant⁻¹ at 50 DAS and harvest and, yield attributes, seed (1789 kg ha⁻¹) and straw yield (3100 kg ha⁻¹).

Key words : Mungbean, growth regulators, salicylic acid, phosphorus levels.

Introduction

Pulses are the main source of dietary protein particularly for vegetarians and contribute about 14 per cent of the total protein of average Indian diet. Pulses account 31.03 Mha areas with production of 27.69 million tonnes in the country with a productivity of 892 kg ha⁻¹ (Anonymous, 2022 a). Mungbean [*Vigna radiata* (L.) Wilczek] is a major pulse crop of arid and semi-arid regions of country due to its drought tolerance. It occupies 4.03 Mha areas and contributes 3.15 Million tonnes in pulse production in the country (Anonymous, 2022 a), Rajasthan is chief contributor having 23.32 lakh hectares acreage with the production of 11.75 lakh tonnes and productivity of 504 kg ha⁻¹ (Anonymous, 2022 b). Its low productivity is a matter of serious concern and efforts are to be diverted towards removal of constraints which are responsible for its poor productivity. Inadequate and imbalanced plant nutrients and growth regulators are of grave significance for dry matter partitioning and retention of flower and pods on pulses.

Among macro nutrients phosphorus is critical for mungbean yield because it is reported to stimulate growth, initiate nodule formation as well as influence the efficiency of the rhizobium-legume symbiosis. It is required in large quantities in young cells such as shoot and root tips where metabolism is high and cell division is rapid. It also aids in flower initiation, seed and fruit

development (Ndakemi and Dakora, 2007). Growth regulator, salicylic acid (SA), also participates in the signaling of abiotic stresses. Application of exogenous SA could provide against several type stresses such as high or low temp, heavy metals, and so on preliminary treatment to plants with low concentrations of SA might have an acclimation-like effect, causing enhanced tolerance toward most kinds of abiotic stresses due to primarily to enhance anti oxidative capacity. Since, growth regulators are strong antioxidant and also supply reactive sulfhydryl group for the functioning of sucrose transport protein, they can more effectively improve assimilate partitioning and yield of mungbean under arid environmental condition. Considering these aspects, a study was carried out to assess the impact of phosphorus levels, and growth regulators in enhancing the productivity of mungbean.

Materials and Methods

A field experiment was carried out during the *Kharif* seasons of 2021 and 2022 in sandy-loam soil at Agricultural Research Station, Fatehpur, Sikar, Rajasthan under Jagannath University, Jaipur. Geographically this place is situated in Sikar district of Rajasthan. This region falls under Agro-climatic zone IIa (Internal drainage dry zone) of Rajasthan.

The location of the experiment is 324 m above mean

Table-1 : Effect of phosphorus and growth regulator on growth parameters of mungbean (pooled of two years).

Treatments	Plant height (cm)			Branches plant ⁻¹			DMA plant ⁻¹ (g)			No. of Nodules plant ⁻¹	Dry weight of nodules plant ⁻¹ (mg plant ⁻¹)
	25 DAS	50 DAS	Harvest	25 DAS	50 DAS	Harvest	25 DAS	50 DAS	Harvest		
Phosphorus											
P0-Control	18.29	36.62	56.75	4.10	6.12	6.45	15.11	49.29	59.71	36.24	67.09
P1-15 kg/ha	18.82	40.62	62.36	4.27	6.46	6.88	16.35	54.02	67.12	37.42	73.17
P2-30 kg/ha	19.05	44.94	68.17	4.39	6.87	7.24	17.42	59.48	71.86	38.54	79.22
P3-45 kg/ha	19.51	48.89	73.68	4.50	7.27	7.49	18.51	64.91	76.57	39.61	84.29
P4-60 kg/ha	19.83	49.51	74.45	4.53	7.35	7.54	18.66	67.57	76.92	39.74	85.47
SEm+	0.29	0.69	1.04	0.06	0.11	0.12	0.31	0.94	0.96	0.53	1.32
CD (P=0.05)	0.85	2.04	3.08	0.19	0.31	0.34	0.91	2.76	2.83	1.56	3.90
Growth regulators											
G0-No spray (control)	18.19	38.82	59.72	4.15	6.42	6.90	15.69	52.89	62.83	36.53	69.91
G1-Salicylic acid 50 ppm	19.13	42.91	65.61	4.35	6.71	7.10	16.81	57.83	68.88	37.95	76.08
G2-Salicylic acid 75 ppm	19.49	47.13	70.55	4.46	6.98	7.22	18.00	61.78	74.92	39.28	82.35
G3-Salicylic acid 100 ppm	19.59	47.61	72.45	4.49	7.16	7.26	18.35	63.73	75.12	39.49	83.06
SEm+	0.26	0.69	0.97	0.05	0.08	0.09	0.23	0.78	0.78	0.45	1.04
CD (P=0.05)	0.72	1.95	2.72	0.15	0.23	0.24	0.64	2.17	2.17	1.27	2.92

Table-2 : Effect of phosphorus and growth regulator on yield attributes and yield of mungbean (pooled of two years).

Treatments	No. of pods plant ⁻¹	No. of seeds pod ⁻¹	Pod length (cm)	Pod weight (g/plant)	Test weight (g)	seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Phosphorus									
P0-Control	16.29	7.00	6.01	29.39	27.30	1343	2523	2523	34.55
P1-15 kg/ha	17.40	7.71	6.84	34.80	29.19	1581	2839	2839	35.73
P2-30 kg/ha	18.44	8.22	7.32	38.39	30.91	1709	2984	2984	36.39
P3-45 kg/ha	19.61	8.63	7.90	44.18	32.53	1822	3145	3145	36.67
P4-60 kg/ha	19.80	8.73	8.12	44.86	32.93	1886	3228	3228	36.82
SEm+	0.24	0.11	0.10	0.56	0.51	21.51	33.50	33.50	0.53
CD (P=0.05)	0.69	0.33	0.29	1.65	1.52	63.44	98.82	98.82	NS
Growth regulators									
G0-No spray (control)	16.61	7.18	6.29	30.49	27.80	1440	2633	2633	35.15
G1-Salicylic acid 50 ppm	18.07	7.91	6.95	36.66	29.98	1603	2874	2874	35.73
G2-Salicylic acid 75 ppm	19.20	8.54	7.79	42.85	31.92	1789	3100	3100	36.55
G3-Salicylic acid 100 ppm	19.35	8.62	7.94	43.30	32.60	1841	3169	3169	36.70
SEm+	0.18	0.10	0.09	0.45	0.40	17.46	28.43	28.43	0.41
CD (P=0.05)	0.51	0.28	0.24	1.25	1.11	48.90	79.62	79.62	NS

sea-level on latitude 27° 98' North latitude and longitude 74° 95' East longitudes and is characterized by hot semi-arid climate. The annual rainfall is mainly confined to 3 months (July–September) and means precipitation is about 375mm. The soil was sandy loam with a pH 8.1, having low organic carbon (0.21%), low available nitrogen (144kg/ha), low available phosphorus (24kg/ha) and medium available potassium (130 kg/ha). The experiment was laid out in split plot design, comprising 5 levels of phosphorus i.e. 0, 15, 30, 45 and 60 kg P₂O₅ ha⁻¹ as main-plot and 4 concentrations of growth regulators, i.e. no spray, 50 ppm salicylic acid, 75 ppm salicylic acid and 100 ppm salicylic acid as sub plot treatment replicated thrice. Sowing of mungbean variety 'IPM-02-3' using 16 kg seed/ha was done at 30 cm line-to-line spacing and plant-to-plant distance of 10 cm was maintained. The phosphorus was supplied through single super phosphate. Salicylic acid was sprayed at flower

initiation stage. Five plants were selected randomly from each plot for taking biometric observations. Observation of growth and yield were recorded to evaluate the effect of treatments. The data were subjected to homogeneity test and upon finding the data homogenous pooling was done and the statistical analysis was done as per procedure suggested by Panse and Sukhatme (1985).

Results and Discussion

Growth : Addition of graded dose of phosphorus resulted in significant increase in plant height and branches plant⁻¹, dry matter accumulation (DMA) and nodules plant⁻¹. Application of 45 kg phosphorus ha⁻¹ recorded the significantly higher plant height (48.9 & 73.7 cm), and branches/plant (7.3 & 7.5) at 50 DAS and harvest, respectively and also fetched significantly higher number of nodules plant⁻¹ (39.6) and nodule weight (84.3 mg) at 40 DAS. Further increase, beyond 45 kg phosphorus failed to

achieve perceivable improvement in these growth parameters (Table1). Phosphorus not only plays an important role in root development and proliferation but also improves nodulation and nitrogen fixation by supplying assimilates to the roots. The energy obtained from photosynthesis and metabolism of carbohydrates stored in storage compounds (ATP and ADP) for subsequent use in growth which in turn resulted in vigorous growth of plants. These results are in agreement with those of Sharma *et al.* (2002), Yadav (2004) in green gram, Luikham *et al.* (2005) in green gram, Sepat (2005) and Kumawat (2006) also reported significantly higher plant height, dry matter accumulation due to phosphorus fertilization in mothbean.

Foliar spray of graded concentration of salicylic acid resulted in significant increase in plant height, DMA, branches plant⁻¹ and nodules number and their dry weight. Spray of 75 ppm salicylic acid recorded the significantly higher plant height, DMA and branches plant⁻¹ at 50 DAS over no spray and 50 ppm salicylic acid. The highest number of nodules plant⁻¹ (39.5) were observed at 100 ppm salicylic acid spray which was significantly superior over no spray and 50 ppm salicylic acid and remained at par with 75 ppm salicylic acid. The application of SA @ 100 ppm on plants gave the highest values for these growth parameters. Salicylic acid treated plants induce salt tolerance in plant by reducing ionic and osmotic stress and inducing plant growth. Similar findings have been recorded by Tufail *et al.*, (2013) and Akhtar *et al.*, (2013).

Yield attributes and yield : A significant improvement in pods plant⁻¹, seeds pod⁻¹, seed weight pod⁻¹, pod length and 1,000-seed weight, seed yield and straw yield of mungbean were recorded with each increment in phosphorus level. All these yield attributes and yields were the maximum at 60 kg phosphorus ha⁻¹, however, found at par with 45 kg phosphorus (Table-2). Favourable effects of yield attributes resulted in significant yield increase at each higher level of phosphorus. The maximum seed (1886 kg ha⁻¹) and haulm yield (3228 kg ha⁻¹) were recorded at 60 kg phosphorus, however, remained at par with 45 kg phosphorus. The increment in seed yield was 543,305, 177 and 64 kg ha⁻¹ over 0, 15, 30 and 45 kg phosphorus, respectively, the corresponding increase in haulm yield was 705,389,244 and 83 kg/ha. Physiological role of phosphorus in enhancing growth parameters might have led to increased yield attributes and thereby yield of crop at higher levels of phosphorus *vis-to-vis* application of phosphorus might have resulted in increased carbohydrate accumulation and their remobilization to reproductive parts of the plants, being the closest sink and hence, resulted in increased flowering, fruiting and seed

formation (Nadeem *et al.*, 2004), Sepat (2005) and Kumawat (2006).

Based on the results of study it was concluded that application of 45 kg phosphorus supplemented with foliar sprays of salicylic acid 75 ppm appeared to be the best intervention for getting higher yield in mungbean crop.

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Standardization of Fertigation Scheduling in Tomato under Poly-House

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Abstract

A experiment was laid out during two successive years 2016-17 and 2017-18 to evaluate the effect of vermicompost, various fertilizer doses and levels of irrigation on growth characters, of tomato under naturally ventilated polyhouse conditions. It found that the treatment F₆ (150% of RDF through WSF) found superior in terms of growth of tomato. In different irrigation levels treatment I₃ (IW/ETc ratio of 1.00) was found to be better as compared to control. Among different combinations of irrigation and fertilizers levels treatment F₆I₂ (150% of RDF through WSF + IW/ETc ratio of 0.90) found superior in terms of growth then the rest of treatments.

Introduction

World's second largest producer of vegetables is India with area of 10.25 Million hectare and annual production around 184.40 Million tonnes (Anonymous, 2018). This quantity is not sufficient to fulfill recommended requirements of 300 g per day for balance diet and we intake only 230 g per day.

Although, India has various diverse agro-climatic conditions, but cultivation of vegetables have generally been restricted to meet out seasonal and regional needs. Generally, protected structures are used to minimize the low temperature in temperate regions or high temperature under tropical climate. There is lot of potential for increasing the area under low cost green houses in peri-urban areas for production of high value low volume vegetables during off season to take benefit of the high price of the produce and to setup the vegetable production and improve its quality (Sanwal *et al.*, 2004)

Naturally ventilated polyhouse is the most popular protected structure among various protected structures due to its suitability and less costing. Naturally ventilated polyhouses are also known as zero energy polyhouse as no any provision of energy consumption is given in these structures. In recent years, undoubtedly chemical fertilizers have played a critic role in providing nutrients for intensive crop production which heralded green revolution in the country and have changed India from a region of food scarcity to food sufficiency. But increased use of chemical fertilizers in an unbalanced manner has created problem of nutrient deficiencies, diminishing soil fertility and unsustainable crop yields. These problems can be overcome by the use of optimum dose of fertilizers or by combinations of chemical fertilizers with organic manures

and also to improve the nutrient use efficiency of different crops. The use of chemical fertilizers in combinations with organic manures is helpful for improving soil health and sustaining crop production and soil fertility (Ahamd *et al.*, 2015). In polyhouses water requirement usually less over the open field conditions. But in some context there will be a scope to increase the water use efficiency to enhance the quality and yield with optimistic use of water (Sharma *et al.* 2011).

Tomato (*Solanum esculentum* Mill.) is one of the most important vegetable crop in the world. It belongs to family Solanaceae have diploid chromosome number 24 and a self pollinated crop.

It is a warm season vegetable, grown throughout the world under tropical and subtropical conditions. It is said to be the native of northern India (Pursglove, 1969).

Production of tomato in India is mainly restricted to open field cultivation. Nevertheless, biotic and abiotic stresses are the main factors responsible for low yield and poor quality under open field cultivation particularly during rainy season crop, resulting in poor productivity and quality of fruits. Green house production technology of cucumber and tomato emphasizes the need for proper density in order to boost up the production per unit area by utilizing the available space and nutrients. However, considering the recent concept of eco-friendly production under green house, the use of cost effective and optimum dose of fertilizers with suitable irrigation levels to restores the soil health while keeping the soil productive and sustainable with quality produce under protected conditions.

Thus, there is a prime need to increase the production and productivity of tomato in the state and country. It is challenge to the vegetable production

technology and utilization of natural resources to produce vegetables several times more to meet the needs of expected vegetable requirement of the country. Under such condition polyhouse (protected cultivation) along with proper fertigation schedule offers a unique opportunity of providing longer duration to the indeterminate tomato and cucumber varieties/hybrids. Hence there is urgent need to standardized packages which is most productive.

Materials and Methods

Location site and Climate : The experiment was carried out in naturally ventilated polyhouse at Hi-Tech Unit, Deptt. of Horticulture, Rajasthan College of Agriculture, Udaipur. The polyhouse size was 28m × 32m (896 sq. meters) covered with UV rays stabilized low density two hundred micron thickness polyethylene sheet with aluminate sheet, insect proof net and foldable side covers. The experimental site comes under IVa agro climate Zone (Sub-humid Southern Plain and Aravali Hills) of Rajasthan (subtropical and semi-arid). Average rainfall of area is 760-900 mm.

Fertility status of soil prior experiment.

S. N.	Properties of soil	Avg. content	Analysis methods
1.	Organic carbon %	0.54	Rapid titration method
2.	Available nitrogen (kg ha ⁻¹)	219	Alkaline KMnO4 method
3.	Available phosphorus (kg ha ⁻¹)	26	Olsen's method
4.	Available potassium (kg ha ⁻¹)	295	Flame photometer method
5.	pH	7.5	Electronic glass electrode method
6.	EC (dsm)	1.6	EC meter

Treatment Combinations

Notations	Treatment Combinations
F ₁ I ₁	50% of RDF through vermicompost + 50% of RDF through WSF + IW/ETc ratio of 0.80
F ₁ I ₂	50% of RDF through vermicompost + 50% of RDF through WSF + IW/ETc ratio of 0.90
F ₁ I ₃	50% of RDF through vermicompost + 50% of RDF through WSF + IW/ETc ratio of 1.00
F ₂ I ₁	100% of RDF through vermicompost + IW/ETc ratio of 0.80
F ₂ I ₂	100% of RDF through vermicompost + IW/ETc ratio of 0.90
F ₂ I ₃	100% of RDF through vermicompost + IW/ETc ratio of 1.0
F ₃ I ₁	75% of RDF through WSF + IW/ETc ratio of 0.80
F ₃ I ₂	75% of RDF through WSF + IW/ETc ratio of 0.90
F ₃ I ₃	75% of RDF through WSF + IW/ETc ratio of 1.00
F ₄ I ₁	100% of RDF through WSF + IW/ETc ratio of 0.80
F ₄ I ₂	100% of RDF through WSF + IW/ETc ratio of 0.90
F ₄ I ₃	100% of RDF through WSF + IW/ETc ratio of 1.00
F ₅ I ₁	125% of RDF through WSF + IW/ETc ratio of 0.80
F ₅ I ₂	125% of RDF through WSF + IW/ETc ratio of 0.90
F ₅ I ₃	125% of RDF through WSF + IW/ETc ratio of 1.00
F ₆ I ₁	150% of RDF through WSF + IW/ETc ratio of 0.80
F ₆ I ₂	150% of RDF through WSF + IW/ETc ratio of 0.90
F ₆ I ₃	150% of RDF through WSF + IW/ETc ratio of 1.00

Observations were recorded on various parameters for growth of polyhouse grown tomato at different stages of crop on five randomly selected and labeled plants in each replication as under :

Methodology used for recording observations of tomato:

Plant height at 150, 180 days and final stage of harvest (cm) : The plant height of five randomly selected and labeled plants was recorded at various stages of transplanting and at final stage of harvesting with the help of meter scale from ground level to its growing tip. Average height of selected plants was calculated and expressed in cm.

Number of branches per plant : The total number of branches per plant was taken at full maturity stage of crop in five labeled/selected plants in each plot and mean was calculated.

Stem diameter (cm) : The stem diameters of five randomly selected plants were taken by vernier calipers at 2 cm above the ground level in each replication at final stage of harvesting and average value was expressed in centimeters.

Statistical analysis : The data recorded for evaluation of different treatments in tomato and cucumber was statistically analyzed using standard procedure as suggested by Panse and Sukhatme (1985) for analysis of variance of F (RBD) in order to test the significance.

Results and Discussion

Plant height at 150 days after transplanting (cm) : The effect of vermicompost, fertilizer levels, irrigation levels and their combinations under polyhouse condition on plant height at 150 and 180 days after transplanting presented in Table-1.

The highest (141.29 cm) pooled value was recorded with the treatment F₆ (150% of RDF through WSF), while minimum plant height at 150 days after transplanting (130.47 cm) was observed in treatment F₃ (75% of RDF through WSF) followed by (131.95 cm) in treatment F₂ (100% of RDF through vermicompost).

Among various irrigation levels plant height at 150 days after transplanting had no significant difference. However, maximum pooled value (135.87 cm) was observed with the treatment I₂ (IW/ETc ratio of 0.90) while minimum plant height at 150 days after transplanting (134.25 cm) reported in treatment I₁ (IW/ETc ratio of 0.80).

Various combinations of fertilizer treatments and irrigation levels non-significantly affected the plant height at 150 days after transplanting during both the years of

experimentation. Though, maximum pooled value (142.54 cm) was recorded with the treatment F_6I_2 (150% of RDF through WSF + IW/ETc ratio of 0.90), while minimum plant height at 60 days after transplanting (130.31 cm) was observed in treatment F_3I_2 (75% of RDF through WSF + IW/ETc ratio of 0.90).

Plant height at 180 days after transplanting (cm) : Data maximum plant height at 180 days after transplanting (169.95 cm) was noticed with the treatment F_6 (150% of RDF through WSF), which was at par with treatment F_5 (125% of RDF through WSF) (168.16 cm), whereas minimum (158.70 cm) was recorded with the treatment F_3 (75% of RDF through WSF).

Different irrigation levels non-significantly influenced the plant height at 180 days after transplanting. The maximum value (164.65 cm) was recorded for treatment I_2 (IW/ETc ratio of 0.90), whereas minimum value (162.86 cm) was observed in I_1 (IW/ETc ratio of 0.80).

The pooled data indicated that all the treatment combinations had no significant difference for plant height at 180 days after transplanting. However, maximum plant height at 180 days after transplanting (171.38 cm) was recorded for treatment F_6I_2 (150% of RDF through WSF + IW/ETc ratio of 0.90), while minimum plant height at 180 DAT (157.77 cm) was observed in F_3I_1 (75% of RDF through WSF + IW/ETc ratio of 0.80).

Plant height at final stage of harvesting (cm) : Data regarding to plant height at final stage of harvesting in tomato under polyhouse conditions presented in Table 2. Highest pooled value (279.91 cm) was observed with the treatment F_6 (150% of RDF through WSF) which was at par (276.87 cm) with treatment F_5 (125% of RDF through WSF), while minimum plant height at final stage of harvesting in tomato (254.32 cm) was noticed in treatment F_3 (75% of RDF through WSF) followed (258.96 cm) by treatment F_2 (100% of RDF through vermicompost).

Plant height at final stage of harvesting had no significant difference among various irrigation levels. Though, maximum pooled value for plant height at final stage of harvesting (268.45 cm) was observed with the treatment I_2 (IW/ETc ratio of 0.90) while minimum pooled value (266.65 cm) was observed with treatment I_1 (IW/ETc ratio of 0.80).

Various combinations of vermicompost, fertilizers and irrigation levels non-significantly affected the plant height at final stage of harvesting during both the year of experimentation. However, maximum pooled value for plant height at final stage of harvesting (280.68 cm) between different treatment combinations was observed with treatment F_6I_2 (150% of RDF through WSF + IW/ETc ratio of 0.90), while minimum value (253.59 cm) was

noticed in treatment F_3I_2 (75% of RDF through WSF + IW/ETc ratio of 0.90) followed by (254.34 cm) treatment F_2I_3 (100% of RDF through vermicompost + IW/ETc ratio of 1.0).

Number of branches per plant : The higher numbers of branches per plant (8.51) with various fertilizer treatments were observed with the treatment F_6 (150% of RDF through WSF) followed by (8.38) treatment F_5 (125% of RDF through WSF), as compared to minimum numbers of branches per plant (7.32) with the application of 100 per cent of RDF through vermicompost in F_2 followed (7.41) by treatment F_3 (75% of RDF through WSF).

Higher numbers of branches per plant (7.99) with various levels of irrigation were observed with the treatment I_3 (IW/ETc ratio of 1.00), as compared to minimum numbers of branches per plant (7.82) with treatment I_1 (IW/ETc ratio of 0.80).

It is clear from data presented in Table-2. That higher numbers of branches per plant (8.62) were observed with the treatment F_6I_2 (150% of RDF through WSF + IW/ETc ratio of 0.90), as compared to minimum number of branches per plant (7.17) with treatment F_2I_1 (100% of RDF through vermicompost + IW/ETc ratio of 0.80).

Stem diameter (cm) : Data pertaining to stem diameter presented in Table-2. It is clear from pooled data that maximum value (1.33 cm) was noticed with the treatment F_6 (150% of RDF through WSF), which was at par (1.31 cm) with the treatment F_5 (125% of RDF through WSF), as compared to minimum value for stem diameter with treatments F_3 (75% of RDF through WSF) and F_2 (100% of RDF through vermicompost) having values 1.10 cm and 1.10 cm, respectively. Among various irrigation levels pooled data revealed that highest stem diameter 1.21 cm was observed with the treatment I_3 (IW/ETc ratio of 1.00) and I_2 (IW/ETc ratio of 0.90), whereas lowest stem diameter (1.17 cm) was recorded in treatment I_1 (IW/ETc ratio of 0.80). In pooled data maximum stem diameter (1.35 cm) was recorded with the treatments F_6I_2 (150% of RDF through WSF + IW/ETc ratio of 0.90) and F_5I_2 (125% of RDF through WSF + IW/ETc ratio of 0.90), at par with F_6I_3 (150% of RDF through WSF + IW/ETc ratio of 1.00) and F_5I_3 (125% of RDF through WSF + IW/ETc ratio of 1.00) with values of 1.34 cm and 1.31 cm, respectively. Whereas, minimum values for stem diameter noticed with the treatments F_3I_1 (75% of RDF through WSF + IW/ETc ratio of 0.80).

This might be due to the more and easily availability of nutrients to plant due to higher dose which perhaps resulted in more plant height than other treatment and may also due to microclimate conditions inside the

Table-1 : Main effects and interaction effects of vermicompost, recommended doses of fertilizer, irrigation levels and their combinations on plant height at 120 DAT, 150 DAT and 180 DAT of tomato.

Treatment Fertilizer	Plant height at 150 DAT (cm)			Plant height at 180 DAT (cm)		
	2016	2017	Pooled	2016	2017	Pooled
F ₁	131.55	134.47	133.01	159.01	161.40	160.21
F ₂	131.74	132.16	131.95	159.97	160.20	160.09
F ₃	129.33	131.60	130.47	156.70	160.71	158.70
F ₄	135.93	135.88	135.91	163.15	165.22	164.18
F ₅	136.52	139.57	138.05	165.73	170.60	168.16
F ₆	140.28	142.31	141.29	167.71	172.19	169.95
SEm±	1.41	1.01	0.87	1.83	1.76	1.27
CD at 5%	4.03	2.90	2.44	5.26	5.05	3.58
Irrigation						
I ₁	133.40	135.10	134.25	161.48	164.25	162.86
I ₂	134.38	137.36	135.87	162.49	166.82	164.65
I ₃	134.90	135.54	135.22	162.17	164.09	163.13
SEm±	0.99	0.72	0.61	1.30	1.25	0.90
CD at 5%	NS	NS	NS	NS	NS	NS
F×I						
F ₁ I ₁	131.56	135.16	133.36	158.02	161.24	159.63
F ₁ I ₂	133.33	136.97	135.15	160.78	162.18	161.48
F ₁ I ₃	129.75	131.30	130.53	158.24	160.79	159.51
F ₂ I ₁	130.45	130.96	130.71	159.50	158.27	158.88
F ₂ I ₂	131.40	133.36	132.38	159.46	163.06	161.26
F ₂ I ₃	133.38	132.16	132.77	160.95	159.28	160.12
F ₃ I ₁	129.08	130.87	129.98	154.87	160.67	157.77
F ₃ I ₂	127.73	132.89	130.31	158.50	162.14	160.32
F ₃ I ₃	131.18	131.03	131.11	156.74	159.31	158.03
F ₄ I ₁	135.08	134.41	134.75	164.13	166.31	165.22
F ₄ I ₂	135.38	136.23	135.81	160.71	165.80	163.25
F ₄ I ₃	137.33	137.00	137.17	164.61	163.55	164.08
F ₅ I ₁	135.36	138.23	136.79	165.41	169.30	167.36
F ₅ I ₂	137.08	141.00	139.04	167.03	173.41	170.22
F ₅ I ₃	137.13	139.49	138.31	164.75	169.08	166.92
F ₆ I ₁	138.86	140.95	139.91	166.94	169.70	168.32
F ₆ I ₂	141.37	143.71	142.54	168.43	174.33	171.38
F ₆ I ₃	140.60	142.26	141.43	167.74	172.54	170.14
SEm±	2.43	1.75	1.50	3.18	3.05	2.20
CD at 5%	NS	NS	NS	NS	NS	NS

polyhouse. Higher dose perhaps increased the availability of nutrients considerably resulting positive effect on plant height. These findings are also in agreement with the findings of Natarajan *et al.* (2005) for tomato under polyhouse condition. Shukla *et al.* (2020) also reported higher recommended doses resulted in maximum plant height in tomato. In different irrigation levels plant height at various stages found non-significant difference. However, maximum plant height at 30, 150, 180 and final stage was reported with treatment I₂ (IW/ETc ratio of 0.90), while at 60, 90 and 120 days after transplanting was reported with treatment I₃ (IW/ETc ratio of 1.00) in tomato under polyhouse. It might be due to the sufficient availability of moisture content in the root zone. Wang and

Xing (2016) also reported that application of irrigation at IW/ETc ratio of 1.0 gives higher plant height in greenhouse tomato. These results may be due to the more cell elongation and enlargement at growing tips with adequate moisture and more nutrient availability in soil. These findings are in accordance with Ankush *et al.* (2018) in open field conditions and Wankhede *et al.* (2018) in tomato.

Higher number of branches per plant in tomato might be due to reduced apical dominance, more cell elongation and rapid cell division in growing portion. Findings of Vasanthi *et al.* (2017) also reported that number of primary branches was significantly enhanced by increased RDFs and irrigation levels. Different treatment

Table-2 : Main effects and interaction effects of vermicompost, recommended doses of fertilizer, irrigation levels and their combinations on plant height at harvesting, number of branches per plant and stem diameter of tomato.

Treatment	Plant height at harvesting (cm)			Number of branches per plant			Stem diameter (cm)		
Fertilizer	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
F ₁	259.11	267.47	263.29	7.74	7.88	7.81	1.16	1.16	1.16
F ₂	255.88	262.03	258.96	7.29	7.36	7.32	1.11	1.09	1.10
F ₃	248.92	259.72	254.32	7.40	7.41	7.41	1.11	1.10	1.10
F ₄	264.95	277.39	271.17	8.16	8.02	8.09	1.18	1.20	1.19
F ₅	270.20	283.54	276.87	8.38	8.39	8.38	1.30	1.32	1.31
F ₆	274.82	285.00	279.91	8.46	8.57	8.51	1.32	1.34	1.33
SEm±	2.53	2.34	1.73	0.10	0.10	0.07	0.01	0.02	0.01
CD at 5%	7.27	6.72	4.87	0.28	0.28	0.19	0.04	0.05	0.03
Irrigation									
I ₁	261.79	271.52	266.65	7.88	7.76	7.82	1.16	1.19	1.17
I ₂	263.74	273.16	268.45	7.91	7.99	7.95	1.22	1.21	1.21
I ₃	261.42	272.89	267.16	7.92	8.06	7.99	1.20	1.21	1.21
SEm±	1.79	1.65	1.22	0.06	0.06	0.04	0.009	0.01	0.007
CD at 5%	NS	NS	NS	NS	0.19	0.12	0.02	NS	0.02
F×I									
F ₁ I ₁	256.41	266.87	261.64	7.50	7.70	7.60	1.13	1.15	1.14
F ₁ I ₂	261.00	264.31	262.65	8.03	7.73	7.97	1.19	1.17	1.18
F ₁ I ₃	259.93	271.22	265.57	7.70	7.50	7.87	1.15	1.15	1.15
F ₂ I ₁	254.28	260.57	257.43	7.40	7.33	7.37	1.07	1.09	1.08
F ₂ I ₂	258.88	263.52	261.20	7.27	7.07	7.17	1.15	1.10	1.13
F ₂ I ₃	254.47	262.01	258.24	7.20	7.67	7.43	1.09	1.07	1.08
F ₃ I ₁	248.20	260.48	254.34	7.47	6.97	7.22	1.08	1.08	1.08
F ₃ I ₂	249.47	260.59	255.03	7.17	7.40	7.28	1.15	1.09	1.12
F ₃ I ₃	249.10	258.09	253.59	7.57	7.87	7.72	1.09	1.12	1.11
F ₄ I ₁	268.10	276.15	272.13	8.30	7.63	8.02	1.15	1.21	1.18
F ₄ I ₂	265.06	279.15	272.11	7.93	8.30	8.12	1.15	1.14	1.14
F ₄ I ₃	261.69	276.87	269.28	8.23	8.03	8.13	1.23	1.26	1.24
F ₅ I ₁	269.85	280.81	275.33	8.27	8.33	8.30	1.25	1.29	1.27
F ₅ I ₂	272.22	285.83	279.03	8.47	8.63	8.55	1.33	1.36	1.35
F ₅ I ₃	268.54	283.97	276.26	8.40	8.20	8.30	1.30	1.32	1.31
F ₆ I ₁	273.86	284.23	279.05	8.37	8.53	8.42	1.28	1.29	1.29
F ₆ I ₂	275.79	285.56	280.68	8.57	8.73	8.62	1.34	1.37	1.35
F ₆ I ₃	274.80	285.19	280.00	8.43	8.60	8.50	1.33	1.36	1.34
SEm±	4.38	4.06	2.98	0.16	0.16	0.11	0.02	0.02	0.01
CD at 5%	NS	NS	NS	NS	0.48	NS	NS	NS	0.05

combinations had no significant difference on number of branches per plant. However, maximum number of branches (8.62) was found with treatment F6I2 (150% of RDF through WSF + IW/ETc ratio of 0.90), while minimum number of branches (7.17) reported in treatment combination F2I2 (100% of RDF through vermicompost + IW/ETc ratio of 0.90). Increased number of branches may be due the higher nutrient uptake by plants at optimum moisture level leads to maximum absorption and translocation of nutrients resulted in increased cell multiplication and enhanced the net assimilation rate and hence more plant height and number of branches per plant were observed. These findings were in accordance with Brahma *et al.* (2009) and Ughade *et al.* (2016) in

tomato. Similar results were also reported by Shelke *et al.* (2019) in okra.

Results revealed that maximum stem diameter might be due to the application of major nutrients through drip irrigation results in overall growth and biological efficiency of plant. Similar results were also reported by Gupta *et al.* (2009) while, working with capsicum and Singh *et al.* (2006) in chilli. The fertilizer treatment very significantly influenced the tomato stem diameter revealed by Wang and Xing (2016). In interaction effect maximum stem diameter was reported in treatments F6I2 (150% of RDF through WSF + IW/ETc ratio of 0.90) and F5I2 (125% of RDF through WSF + IW/ETc ratio of 0.90) with values of 1.35 cm and 1.35 cm, respectively while, minimum pooled

value for stem diameter (1.08 cm) in treatments F3I1 (75% of RDF through WSF + IW/ETc ratio of 0.80), F2I3 (100% of RDF through vermicompost + IW/ETc ratio of 1.0) and F2I1 (100% of RDF through vermicompost + IW/ETc ratio of 0.80). It may be due to the higher level of fertigation with optimum quantity of water attributed to maintenance favorable nutrient-water interaction in root zone leads to increased photosynthetic activities and respiration and proper translocation of photosynthates resulted to increase these traits. These results are in agreement with Wankhede *et al.* (2018) and Ayas (2015). Wang and Xing (2016) also reported that irrigation and fertilizers levels significantly influenced the stem diameter. Analyzed data showed that different combinations of fertilizer treatments and irrigation levels non-significantly influenced the leaf area of tomato.

Conclusions

On the basis of result it found that the treatment F₆ (150% of RDF through WSF) and irrigation levels treatment I₃ (IW/ETc ratio of 1.00) found superior in terms of growth of tomato. Among different combinations of irrigation and fertilizers levels treatment F₆I₂ (150% of RDF through WSF + IW/ETc ratio of 0.90) found superior in terms of growth then the rest of treatments.

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Impact of Provided Intervention through Developed Mobile Application on Coping Strategies of Early Adolescent Boys Regarding Selected Developmental Changes During Early Adolescent Stage

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Abstract

Adolescence is the word derived from Latin word *Adolescere* meaning to grow up to maturity. It is a transitional stage of physical and psychological development that usually occurs during the period starting from puberty to legal adulthood i.e. age of maturity. Adolescence is associated with 10 yrs. to 19 yrs. of age (World Health Organization, 2017); During these years, males grow muscle much faster than female, Early adolescence is a critical period for studying coping strategies including pubertal development, the development of autonomy, identity formation, increases in cognitive behavioural and emotional changes Coping can be defined as a set of cognitive and affective actions that arise in response to a particular concern. Generally noted, early adolescents use more avoidance strategies than approach strategies when coping with family stressors and more approach strategies than adolescent strategies when coping with school and peer stressors. In the present research study, Researcher found that the usages of mobile apps. strongly correlates with user context and depends on user's location and time of the day. Mobile apps are playing an ever-increasing role within healthcare and when designed and integrated correctly can yield many benefits. So after developing need based mobile app. on selected developmental changes during early adolescent stage , intervention was provided through developed need based mobile app. for a month to the respondents of experimental group only , it can be concluded that the provided intervention through developed mobile app., regarding selected developmental changes has significantly positive impact on coping strategies levels of early adolescent boys of experimental group only , where as very slight and negligible changes were found in the coping strategies of control group respondents , which indicates the emergency of intervention to early adolescent boys.

Key words : Early adolescent boys, selected developmental changes, impact, intervention, mobile application, coping strategies.

Introduction

Adolescence is the word derived from Latin word *Adolescere* meaning to grow up to maturity. It is a transitional stage of physical and psychological development that usually occurs during the period starting from puberty to legal adulthood i.e. age of maturity. Adolescence is associated with 10 yrs. to 19 yrs. of ages of human life. (World Health Organization, 2017); but it's physical and psychological and cultural expressions may starts very early and end later. As approximately 1.2 billion adolescents make up for 18% of the world's population where majority of total adolescents reside within Asia itself (United nations children's emergency funds, 2002). In case of India, India is called as a young country whose 19.6 % of the total population is between the age of 10 years to 15 years, and has the largest adolescent population in the world. (Sources: progress for children: A progress card on adolescents UNICEF). Early adolescence is a period which start from 12 yrs upto 14 yrs., when children should have a safe and clear space to come to terms with this physical , cognitive, emotional, social , sexual and psychological transformation unencumbered by engagements in adult roles and with

the full support of nurturing adults at home, at school and in the community.

During these years, males grow muscle much faster than female, an adolescent's heart and lungs increase in both size and capacity. The body begins to grow, shoulders will broaden and his muscles will develop. Hormones will produce more oil on his skin and may result in acne breakouts. Testicles will begin to grow, penis begins by growing in length, followed by width. Early adolescence is a critical period for studying coping strategies including pubertal development, the development of autonomy, identity formation, increases in cognitive behavioural and emotional changes. Coping can be defined as a set of cognitive and affective actions that arise in response to a particular concern. Coping skills are the ability to handle life's challenges in the most effective ways, maximizing the changes of success or survival and minimizing the damages and other negative consequences. There are positive coping strategies and negative coping strategies. Many people use their coping strategies to benefit them in a positive way. However, are not always able to cope with the difficulties that we face. If we are able to handle our emotions positively, our behavior will likely be positive. boys are more likely to rely

on avoidance strategies, girls are more likely to seek social support and engage in problem solving to boys. Generally noted, early adolescents use more avoidance strategies than approach strategies when coping with family stressors and more approach strategies than adolescent strategies when coping with school and peer stressors. Now a days, Mobile phone penetration rate has increased drastically over the last decade. Mobile phones usage is increasing as the cost of mobile technology development has reduced substantially and people find it more affordable irrespective of whether they fall in low and middle-income families. Smartphone technologies are now in the hands of a large number of students even from low- and middle-income families. More advanced mobile phone technologies are enabling the potential for education. Which is referred as mEducation.

The motivation behind the development in the mEducation field arises mainly from two factors. These are the myriad constraints felt by educational system of developing nations. These constraints include high population growth, a rate of ignorance and literacy inhabitants, limited financial resources to support educational infrastructure and educational information system and the recent rapid rise in mobile phone penetration in developing countries. With greater access to mobile phones from all segments of the country including rural areas, the potential of lowering information to deliver education improves. A mobile application (mobile app) is a computer program or software application designed to run on a mobile device such as a phone, tablet or watch. Mobile apps. are generally downloaded from application distribution platforms which are operated by the owner of the mobile operating system such as the App Store (IOS) or Google Play Store. With a growing number of mobile applications available in app. stores and the improved capabilities of smart phones, people are downloading more applications to their devices. Usages of mobile apps. has become increasingly prevalent across mobile phone users. In this present research study, Researchers found that usage of mobile apps. strongly correlates with user context and depends on user's location and time of the day. Mobile apps. are playing an ever-increasing role within healthcare and when designed and integrated correctly can yield many benefits.

Materials and Methods

To conduct present research study, Experimental research design was followed to find out the impacts of intervention imparted by developed need based mobile phone application only to experimental group respondents, to enhance awareness of early adolescent

boys regarding selected developmental changes. Experimental Research Design is a research method used to investigate the interaction between independent and dependent variables, which can be used to determine a cause and effect relationship. Experimental research is generally used within the framework of the scientific method in which two groups such as experimental and control were selected for comparison and for assessing impact of provided intervention to experimental sample.

The present research study was conducted in the four Government secondary schools located within the municipal limits of Beed city of Maharashtra to ensure optimum personal contacts for data collection.

Sample and it's Selection : For sample selection, the investigator first obtained a list of government schools from District Education Office, Beed, Maharashtra.

The researcher selected four schools within the municipal limits of Beed city, having the similar infrastructural facilities keeping the delimitations of the study in mind i.e. only early adolescent boys of age range between 12-14 years, those studying in Govt. Secondary schools of Beed city of Maharashtra and who can access android /smart mobile phone.

These schools were ready to cooperate with the investigator and were interested in contributing towards the research study. To obtain a sample of 200 early adolescent boys, a preliminary survey was conducted and 320 proformas were distributed (80 proformas in each school) among the desired age groups in the four selected schools. From the preliminary survey, an eligible sample of 260 subjects were obtained (60-65 eligible subjects from each of the schools) and the final sample of 200 adolescents boys (50 eligible subjects from each selected school) were drawn purposively as per the delimitations of the study. Remaining subjects were discarded as they were not fulfilling the criteria for sample selection. From the entire process, the final sample comprised of 200 early adolescents boys i.e. 100 early adolescent boys from two government schools for experimental group and 100 early adolescent boys from two government schools for control group between 12-14 years of age were selected.

Tools and Their description : Selection and development of tools to achieve the objectives of a research study is an important step in every research. Keeping in mind the purpose of the present research study and its inherent research variables, the investigator used the following research tools for data collection: Preliminary Information Proforma, Background Information Proforma, Scale for measuring coping strategies of early adolescent boys.

(a) Preliminary proforma : A preliminary proforma was prepared to get necessary details regarding subjects. The proforma was comprised of general information like name, age, address, occupation/profession of parents , etc. and accessibility for android / smart mobile phone

(b) Background information proforma : The proforma was developed by the investigator to get the general information about the personal and familial details of selected samples which have direct or indirect bearings on major research variables of the study such as name, age, address, family size and types, educational qualifications of the parents, monthly income etc.

(c) Scale for Assessment coping strategiesof regarding selected developmental changes : In order to measure the coping strategiesof early adolescent boys regarding selected developmental changes, a scale was constructed, developed and standardized by calculating its validity and reliability by the investigator . The different steps were followed for developing the scale as follows :

Step I : Generating Statements : First of all, the investigator referred different literature sources such as books, Journals and Standardized Scales and decided upon the various aspects under which regarding coping strategies selected developmental changes of early adolescents boys were assessed. Then, the final aspects of developmental changes i.e. Physical and Psychosocial-emotional ,social ,sexual, moral and changes in family relationships were selected. For assessing coping strategies regarding each aspect ,statements of specific aspect related to the age were formulated.

Step II : Scoring Pattern of “Scale for assessing Coping Strategies of early adolescent boys regarding selected developmental changes”

For measuring coping strategies of early adolescent boys regarding selected developmental changes ,scale has been developed which consists of four response options indicating .A ‘Highly appropriate ’, Appropriate’ and for ‘Not appropriate ’and ‘Neutral’ were given to each response to find the level of coping strategies among the early adolescent boys . The maximum and minimum scores were obtained by multiplying the total number of statements with “4” and “1” respectively.

(C) Standardization of developed Research scales

The standardization process is presented under the following heads :

Validity of scale and Reliability of scale Validation of Research Tool : The act of officially or legally certifying or approving something is called as Validity. Content Validity pertains to the degree to which the instrument fully

assesses or measures the construct of interest. The developed research tool i.e. Scale on coping strategies regarding developmental changes were assessed by the panelists consisting of experts from Human Development and Family Studies, Doctor, Psychologist and Sociologist for content validity. A pilot study on one third of selected respondents was carried out to validate the tool. Very valuable and useful feedback were received and incorporated in the content of the scales. The validation of scales was based on five point rating scale, which comprise 1 score for not at all suitable, 2 for Not Suitable, 3 for Suitable, 4 for Somewhat suitable and 5 score was for Highly suitable. The calculated mean scores obtained 5 indicated that the scale was ‘Highly Suitable’, 4 means ‘Somewhat Suitable’, 3 means ‘Suitable’, 2 means ‘Less Suitable’ and 1 means ‘Not at all Suitable’ to assess the aspects namely awareness and coping strategies.

Reliability of Scales : Reliability is the degree to which research method produces stable and consistent results. A specific measure is considered to be reliable if it's application on the same object of measurement number of times produces the same results. To establish reliability of the research scale, a pilot testing was done and the scale was administered on a sample of 40 early adolescent boys , which were not included in the final sample. The data collected was coded and reliability of Coping strategies scale was calculated by using split half technique. In split half technique, the test was divided into two equal halves and correlation of the whole scale was estimated by calculating the co-efficient of correlation between the variables. The reliability coefficient of the developed tool obtained is given in Table-1.

Table-1 : Reliability Coefficients of the Scale.

Scale	Coping strategies Scale
Reliability Coefficient	0.85

Designing, Development and Validation of mobile phone application : Mobile phone application on selected developmental changes in boys during early adolescence stage was developed based on the pre assessment results of coping strategies of respondents about the selected developmental changes during this period. The investigator did in-depth study of books, journals and research publications to gather information regarding developmental changes for developing and designing of the need based mobile app. The investigator provided all the information in a systematic, scientific and very simple way to a registered and certified mobile phone application developer to develop a mobile application in Hindi as well as in Marathi languages for imparting intervention for a month to only experimental group respondents. The content of mobile app. consist of sections such as-Early adolescence period, Physical

Table-1 : Background Information of early adolescent boys of experimental and control groups. n-200

Background variables	Percentages of the respondents	
	Control Group (100)	Experimental Group(100)
Age group		
12-14 yrs.	100 (100)	100 (100)
Sizes of families		
Small (1-4)	70 (70)	69 (69)
Medium (5-8)	21(21)	23 (23)
Large (>9)	9 (9)	8 (8)
Ordinal Position		
First	44 (44)	49 (49)
Second	54 (54)	50 (50)
Third	2 (2)	1 (1)
No. of Siblings		
1	89 (89)	86 (86)
2	10 (10))	10 (10)
3	01 (01)	04 (04)
Types of Family		
Joint	26 (26)	21 (21)
Nuclear	74 (74)	79 (79)
Fathers Education		
College + Under graduate	—	—
Middle School + High School	04 (04)	06 (06)
Primary School	25 (25)	35 (35)
Illiterate	71(71)	69(69)
Fathers Occupation		
Small business/Shop/Agriculture	37 (33)	33(33)
Skilled worker	09 (13)	13 (13)
Unskilled worker	64 (64)	54 (54)
Mothers Education		
College + Under graduate	—	—
Middle School + High School	02 (02)	07 (07)
Primary School	62 (62)	68 (68)
Illiterate	36 (36)	25 (25)
Mothers Occupation		
Small business/Shop/Agriculture	02 (02)	12 (12)
Skilled worker	02(02)	10 (10)
Unskilled worker	96 (96)	78 (78)
Monthly Income		
Low (Between Rs. 2500-5000)	69 (69)	77 (77)
Medium (Between Rs. 5001-7000)	31 (31)	33 (33)
High (Between Rs. 7001-Above)	—	—

Figure in the parentheses indicates the frequencies.

changes, Psycho-social changes. Emotional changes, Social changes, Sexual Changes, changes in morality Family Relationship,vi Coping strategies to be adopted.

Validation of developed Mobile Phone Application on “Awareness of early adolescent boys regarding developmental Changes during early adolescence stage : The developed Mobile Phone Application was provided to the subject matter experts for language, content analysis and methodology adopted. The subject matter experts were from the faculties of Human

Development and Family Studies, Psychology and Sociology. Field testing of developed mobile application was done on one third of selected respondents for validation of developed mobile phone app..Very valuable and useful feedback were received and incorporated in the content of the mobile app. The validation of the mobile app .was based on five point rating scale. The details of the rating are score1for poor, 2 for average,3 for good,4 for very good and 5 for excellent. Score obtained for developed mobile app.was 5,which indicates that it is excellent for providing intervention.

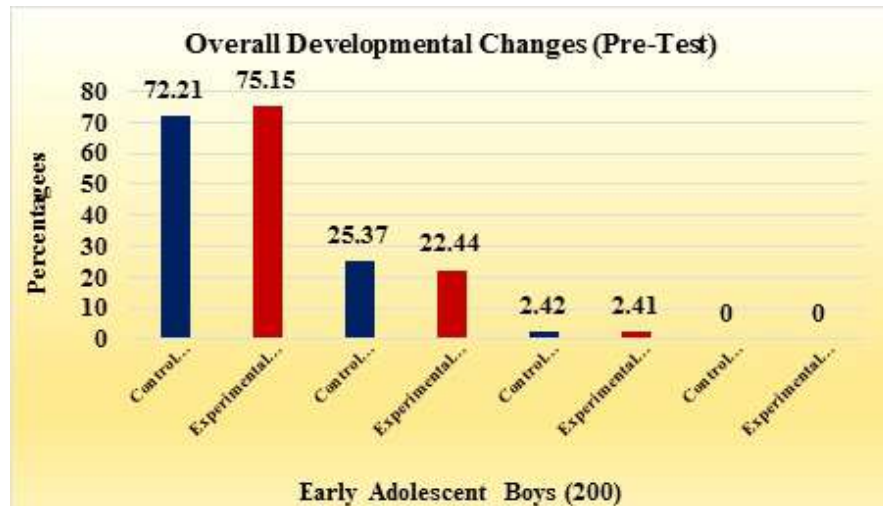


Fig.-1 : Percentage distribution for the levels of overall coping strategies regarding developmental changes during early adolescent stage before providing intervention in both groups respondents.

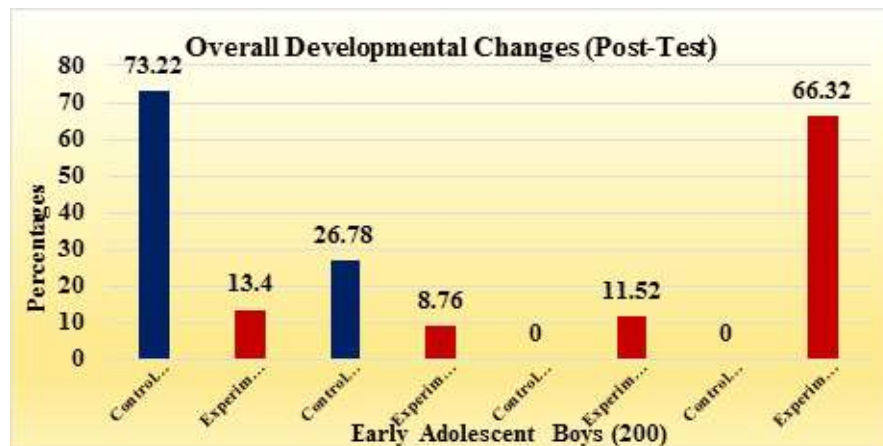


Fig.-2 : Percentage distribution for the levels of coping strategies regarding overall developmental changes of early adolescent stage after providing intervention.

Execution of intervention : Intervention was executed only to the respondents of experimental group through need based developed Mobile phone Application on coping strategies regarding selected developmental changes. Before providing intervention through developed mobile phone app. to early adolescent boys of experimental group, investigator personally provided training to the respondents on how to download ,browse /use the developed mobile app. The respondents were allowed to use it for a month as per their convenience though they were instructed to go through all the information sequentially given chapter wise. It was a highly interactive study which was profoundly engaged the user on daily basis and was keep them in constant contact with research scholar through emails, what's app and mobile phone calls for any queries. Therefore, this mobile app. based regime was not only facilitated the user but also effectively analyzed the impact of the developed need based mobile application on coping strategies of experimental groups' respondents.

Procedure for data collection : After the selection of the appropriate sample of 200 respondents (i.e.100 early adolescent boys for experimental groups and 100 early adolescent boys for control group from four government schools) through the preliminary survey, the scale to assess coping strategies regarding selected developments was developed by the investigator and administered on the respondents of both the groups . The investigator personally collected the data from the selected respondents of experimental and control groups from four selected government schools after the purpose of the study was made clear to the respondents. They were requested to give their responses and were assured that their identity would be kept confidential and information provided by them would be used exclusively for the purpose of research work. When the respondents were satisfied with the assurance given to them, the scales was administered on them to procure data regarding the research study from the experimental and control groups. Data collection on awareness regarding

selected developmental changes during early adolescent period was done by administering developed scale on "Coping strategies regarding selected developmental changes during early adolescent period". The respondents took around 35-45 minutes to fill the complete information. Pre assessment was conducted on the experimental and control groups' respondents. After administering the scale on the entire sample, the responses were coded for all the subjects and the results were obtained.

Coding, categorization and analysis of Coping strategies Scale :

To accomplish the first objective of the study, the data was coded on the basis of response options provided for each item of the scale on coping strategies of early adolescent boys and the 'Frequencies' and 'Percentages' were calculated for all the selected aspects. On the basis of scores obtained, the early adolescents boys were categorized into four main categories i.e. On the basis of scores obtained, the early adolescent boys were categorized into four main categories i.e. respondents having highly appropriate, appropriate, not appropriate and neutral coping strategies levels regarding selected developmental changes taking place during early adolescence years.

Analysis of data : For analysis of data, collected information was coded, categorized and put under statistical measures as mentioned above and statistical results were described in a very systematic and scientific way table wise in result and discussion chapter.

Results and Discussion

The information regarding the selected background variables and distribution of respondents of experimental and control groups for each variable is given in Table No1.

1. Age Group of the respondents : All the respondents i.e. (early adolescent boys) of experimental group (100) and control group (100) were in the age range of 12 yrs.to 14 yrs. as this age group comes under early adolescence stage of life.

2. Size of Families : Size of the families was decided on the basis of number of family members, and it was divided into three sub-categories . They are- Families having 1-4 members was small families , five to eight members was medium size and more than 9 members in the families was called as large families. The data for early adolescents boys of control group revealed that 70 per cent of the early adolescent boys were under small family size category, 21 per cent boys were under medium size family and remaining i.e. only 9 per cent early adolescent boys come under large family size.

On evaluating the data for experimental group early adolescents boys ,similar trend was found in both the

groups respondents i.e. majority of the boys (69.3%) were having small size family. 13 per cent were living in medium size family and only 8 per cent early adolescent boys were in the category of large size family

3. Ordinal Position of the respondents : In this section, ordinal position of the respondents of control and experimental groups were discussed ,this category was further divided into three sub categories i.e. First Born, Second Born and Third Born. Among early adolescents boys of control group, 44 per cent of the boys were first born, 54 per cent boys were second born and 2 per cent boys were third born. Among early adolescents boys of experimental group, 49 per cent of the boys were first born, 50 per cent boys were second born and only one per cent was third born.

4. Number of Siblings : This category was further divided into three sub-categories i.e. respondents having One, Two and three siblings. The data for early adolescents respondents of control group indicates that, 89 per cent of the boys were having one sibling, 10 per cent boys were having two siblings and only one per cent respondent was having three siblings. For the early adolescents boys of experimental group , majority of the boys (86 %) were having one sibling. 10 per cent boys were having two siblings and 4 per cent boys were having more than two i.e. three siblings.

5. Type of Families : This category was further divided into two sub-categories i.e. belonging to Joint family or Nuclear family . 26 per cent early adolescent boys of control group were belonging from joint family type where as majority i.e. 74 per cent of the respondents were from nuclear families. Similar trend was found in case of experimental group respondents i.e. 21 per cent respondents were belonging to joint families whereas, on the other hand majority (79 %) of them were belonging to nuclear family type

6. Educational Qualifications of Parents : The table-1, further throws light on the data related to educational qualifications of the parents. The four sub-categories are -College +Under graduate , Middle School + High school ,Primary School and Illiterate. For, the fathers of early adolescent boys of control group, majority (71%) were Illiterate (25%), were completed primary schooling, while rest (4%) were under Middle School + High school. Among the fathers of early adolescent boys of experimental group, majority were Illiterate (69%), 35 per cent were completed primary schooling , while remaining (6 %) were Middle School + High school .Among the mothers of early adolescent boys of control group, majority i.e. 62 per cent were completed primary schooling. 36 per cent mothers were Illiterate , while very less i.e. 2 per cent were completed their middle school + high school.

7. Occupation of the Parents : This category was further divided into three sub-categories for the fathers i.e. fathers engaged in Small business/Shop/ Agriculture, Skilled worker and Unskilled worker. Data related to father's occupation of early adolescent boys of control group revealed that majority (64%) were involved in unskilled work, 37 per cent were involved in Small business/Shop/ Agriculture while only 9 per cent father were skilled workers. For the fathers of early adolescent boys of experimental group 54 per cent were unskilled workers and remaining i.e. (13 %) were skilled workers. For the mothers, this category was further divided into three sub-categories i.e. Small business/Shop/Agriculture, Skilled worker and Unskilled worker. Data for mothers of early adolescents boys of control group, indicates that majority (96 %) of the mothers were unskilled workers while 2 per cent each were involved in Small business/Shop/ Agriculture and skilled workers respectively, on the other hand similar trend were found in mothers of experimental group respondents 78 per cent were unskilled workers, while 12 per cent mothers were involved in Small business/Shop/Agriculture, rest (10%) were skilled workers.

8. Monthly Income : This category was further divided into three sub-categories i.e monthly income between Rs. 2500-5001 as low income group, between Rs. 5001-7000 as medium income group and between Rs. 7001-Above as high income group families, Majority (69%) of the families of control group respondents were between Rs., 2500-5000/- while 31 per cent families were between Rs. 5001 - 7000 /-monthly income range . 77 per cent families of experimental group respondents were between Rs. 2500-5000, remaining i.e. 33 per cent were having Rs. 5001-7000 monthly income

Assessment of overall coping strategies of early adolescent boys of experimental and control groups before and after imparting intervention through developed mobile app., regarding selected developmental changes during early adolescent stage

From the Fig-1, it can be seen that among early adolescents boys of control and experimental group, majority i.e. 72.21 per cent and 75.15 per cent of respondents of both the groups were following neutral coping strategies respectively , followed by 25.37 per cent and 22.44 per cent reported to be following , not appropriate coping strategies while almost equal i.e. 2.42 per cent respondents of both the groups were under appropriate level of coping strategies prior to initiation of the intervention.

It can be clearly conclude that after imparting

intervention through developed need based mobile app. on coping strategies regarding selected developmental changes which takes place during early adolescent stage ,had positive impact on coping strategies of early adolescent boys as majority (66.23%) respondents of experimental group respondents showed highly appropriate coping strategies followed by 11.52 per cent were following appropriate coping strategies , whereas 8.76 per cent come under not appropriate coping strategies level and 13.4 per cent were neutral level of coping strategies. No change were reported by control group respondents.

The overall results of provided intervention through mobile app. clearly indicates, the need of intervention to early adolescent boys for enhancing their coping strategies in a positive directions.

Conclusions

It can be concluded that the provided intervention through developed mobile app., regarding selected developmental changes has significantly positive impact on enhancing coping strategies levels of early adolescent boys of experimental group, which indicates the emergency of intervention to early adolescent boys.

Future Scope

The developed need based mobile app., in dual language (Marathi and Hindi) is recommended for the use by the department of Women and Child welfare for providing intervention to early adolescent boys .Also it can be used by educators, scientists, psychologists, Human developmentalist, government and non government agencies for providing intervention to early adolescent boys.

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Importance of Microbial Assessment of Street Vended Fruit Juices

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Abstract

People now a days are very health conscious. They prefer a healthy and nutritious diet. So as, due to the stunning nutritive value, taste and flavour the street vended fresh fruit juices are on high demand. It is well known that fruit juices are rich in proteins, fibre, vitamins, water, sugar and phytochemicals that are of great importance to mankind. The regular intake of fresh fruits and vegetables has been associated with low incidence of diseases such as cardiovascular diseases, osteoporosis, chronic obstructive pulmonary diseases and cancer etc. It also helpful in detoxification of human body along with play effective role in improvement of blood lipid profile in persons suffering from hypercholesterolemia. As the life style is changing the demand and consumption of fresh juices is also increasing day by day as being preferred throughout the world. But the concern on food safety is very important issue to be taken care of as in street vended fruit juices due to unhygienic water use during preparation, improper handling practices of raw materials, preparation process, unclean utensils and hands, environment in which the juices are sold, swarming of flies on place of preparation and poor hygienic knowledge among the juice sellers that actually promotes the contamination of juices. From scientific studies done by various researcher's it was noticed that fruit juices sold on road side were found to be contaminated with faecal coliforms like *Escherichia coli*, *Shigella spp.*, *Staphylococcus aureus*, *Streptococcus spp.*, *Micrococcus spp.*, *Salmonella spp.*, *Pseudomonas spp.*, *Enterobacter aerogenes* and *Bacillus spp.* Fungi isolated from the street vended fruit juices included *Aspergillus spp.*, *Rhizopus*, *Penicillium spp.*, *Rhizopus spp.*, *Saccharomyces spp.*, *Fusarium spp.* and *Neurospora spp.* Some parasite species noticed were *Ascaris lumbricoides*, *Trichuris trichiura*, *Schistosoma spp.*, hookworms, *Giardia lamblia* and *Entamoeba hartmani*. Therefore, it is very important for the prevention and cure regarding the street vended fresh fruit juice intake to avoid any health-related issues.

Introduction

Fruits are recommended in our daily diet chart due to their immense health promoting attributes. They are very essential part of food we consume since they contain high levels of minerals especially electrolytes, vitamin C, fibres and few phytochemicals which act as antioxidants (Slavin and Lloyd, 2012). During harvest or post-harvest processing, they come in contact with water, soil, dust and handling. As a result of, they harbour a number of microorganisms including pathogens (Ogofure *et al.*, 2017). Consumption of these vended ready-to-eat fruits and their juices has become a trend all over the world due to their importance. It is so because of their accessibility, convenience and cheaper prices in comparison to whole fruits (Nwachukwu *et al.*, 2008). But the increase in consumption of such type of vended fruits and the juices made from them has been reported to pose a great risk to consumer health because it is difficult to follow the hygienic processes the fruits are subjected to after harvesting, during processing and before packaging (Nielsen, 2006). Moreover, these fruits are being sold by local hawkers or uneducated vendors who have little or no knowledge about food hygiene, nutrition and pathogens

(Muinde and Kuria, 2005). Generally, fruits are known to carry a natural but non-pathogenic microflora. They also possess an epidermal layer of cells that resist the penetration of microorganisms (Ogofure *et al.*, 2017).

Millions of people in developing countries, widely consume fruit and vegetable juices sold by street vendors. These juices act as readily available and affordable source of nutrients to many sectors of the population including the urban poor. Fresh flavour attributes make juices to be much preferred by the consumers and hence, their demand has increased been increasing day by day. Fruit juices are generally prepared by extracting the liquid, pulp of mature fruit and vegetables usually by mechanical means. The final product is clouded, unfermented, untreated juice, ready for consumption. From various reports, it was noticed that in countries, where street food vending is common, there is information gap on the incidence of food borne diseases pertaining to the street vended foods. Microbial studies on such foods in American, Asian and African countries have revealed a number of bacterial pathogens in the food. The chances outbreaks of illnesses in humans associated with the consumption of unpasteurized fruit, vegetable juices and fresh produce are more. For example, during an

incidence that occurred in 1995, unpasteurized fresh orange juice contaminated with *Salmonella* was linked to an outbreak in a Florida Theme Park, USA and more than 60 visitors were affected (Schmidt *et al.*, 1997). After drinking unpasteurized orange juice in Australia, 427 confirmed cases of salmonellosis were reported in 1999 (Victorian Government Department of Human Services). In Pune city a cholera epidemic occurred, that was related to street vended sugarcane juice containing ice that was contaminated with *Vibrio cholerae* (Mosupye *et al.*, 1999).

This review, may seeks to explore some of the microbial assessments of some vended fruit juices sold in local markets in India and some developing countries to create awareness about its effect on public health, medical practitioners, sensitize the concerned government health stakeholders, officers, consumers to promulgate and enforce laws that will stimulate the control of microbial contamination in these vended fruits.

Importance of improving the quality of the vended fruits and fruit juices : To tackle the threat of microbial contamination occurring in vended fruits, enforcement of intense training on good manufacturing practices before, during and after processing of fruits should be maintained by vendors to maintain a high standard of personal and environmental hygiene. The fresh fruit produce and its vended form should be with clean water before consumption, routine washing of hands, and accurate application of hazard analysis critical control point should be implemented. Fruits are on demand whole year but during summer season means in months of March to August) large population of all income and age groups consumes fresh fruits, pressed and squeezed juices and sherbets (Ahmed *et al.*, 2009). Commonly, unpasteurized juices are preferred by the consumers because of the taste, fresh flavour and low-cost type attributes. Such drinks are nutritious for consumption by a person for good health. They are simply prepared by mechanically squeezing fresh fruits or may be extracted with water. The final product is a ready for consumption, unfermented, clouded and untreated drink. The vended fruits are very good substrate for the growth of many microorganisms but a few of which may be pathogenic to man. Such pathogenic organism can cause various food borne diseases. According to the increasing popularity in consumption patterns, fresh fruits and vegetables have also become increasingly important vehicles in food borne disease statistics (Sivapalasingam *et al.*, 2004). Health benefits of consumption of fresh fruits and their juice to the general population cannot be ignored (Alothman *et al.*, 2009).

Juices are nutrient dense, fat-free beverages that are rich in minerals, vitamins and naturally occurring

phytonutrients that play part to good health. But it is good for health only when it is free from pathogenic microorganisms. As it is well known that contamination of food products can result in many health problems such as mild bloating and gas to serious incidents of food poisoning as well as dehydration. Non-hygienic fruits consumption is unsafe to health and it can cause serious outbreaks of food borne illness (Sivapalasingam *et al.*, 2004). There have been some notable outbreaks of illness in recent years that demonstrate the increasingly important role of fresh fruits and vegetables in food borne disease (Parish, 1997; Sandeep *et al.*, 2001). There are several reports showing the illnesses arises due to the food borne diseases associated with the consumption of vended fruit juices at several places around the globe (Mosupye and Holy, 2000; Muinde and Kuria, 2005; Chumber *et al.*, 2007; Igiehon *et al.*, 2020). To improve the quality of vended fruit juices and to prevent the post consumption effects of such juices the raw materials, containers, equipment's and hand of the handlers etc. are to be kept contamination free. If not taken care of then the contaminants from the raw materials as well as equipment's, additional processing conditions, improper handling will lead to the entry of bacterial pathogens in juices prepared from the contaminated fruits or vegetables (Oliveira *et al.*, 2006; Nicolas *et al.*, 2007). Moreover, one major source of juice spoilage is water used for juice preparation. Microbial contaminants such as total coliforms, fecal coliforms, fecal streptococci etc. are added through the contaminated water which causes some dreadful diseases so very important that vendors and the consumers must have the knowledge of such small but important things that cannot be ignored (Tasnim *et al.*, 2010).

Microbial contamination of some vended fruits and fruits juices : A number of experiments have been carried out to ascertain the safety in consumption of the locally available vended fruits and the juices prepared from such fruits as considering the immense importance of microbial assessment of vended ready-to-eat fruits and the fruit juices to consumer health. Some isolated organisms in few reports were *E. coli*, *Shigella sp.*, *Salmonella sp.*, *Pseudomonas sp.*, *Staphylococcus aureus* and one fungal isolate, *Mucor sp.* from the tested vended fruits (Igiehon *et al.*, 2020). The main cause of contamination could be poor hygiene, faecal contamination, and environmental factors such as contaminated air (Orji *et al.*, 2016). For instance, Mahale *et al.* (2008) reported the microbiological analysis of street vended fruit juices from Mumbai city, India. They subjected about thirty samples of fresh-squeezed juices of carrot, lime and sugarcane obtained from vendors in Mumbai city to microbial count. The total viable counts of the samples found in their study

were approximately log 6.5 CFU/100 ml with a major load of coliforms, *Vibrio*, faecal coliforms and staphylococcal counts.

Another study by Mahfuza *et al.* (2016) reported the microbial status of vended fruits such as guava, hog plum, plum and pineapple fruits that were obtained from vendors in Dhaka city in Bangladesh. Total bacterial count (TBC), total *Salmonella*–*Shigella* (TSS) count and total coliform count (TCC) in fresh-cut hog plum (*Spondias mombin* L.) were 3.5×10^3 CFU/g, 3.6×10^2 CFU/g and 4.8×10^2 CFU/g respectively. Whereas in guava (*Psidium guajava*), TBC, TCC and TSS count were 1.5×10^4 CFU/g, 4.9×10^2 CFU/g, and 2.3×10^2 CFU/g, respectively. TBC and TCC were 4.6×10^4 CFU/g and 3.9×10^2 CFU/g, respectively, in plum (*Ziziphus mauritiana* L.). *E. coli* (36%), *Bacillus* (25%), *Klebsiella* (9%), *Staphylococcus* (24%) and *Proteus* (6%) organisms mainly identified from the tested samples. Hence, it was concluded that the vended fruits were risky for the human consumption. Mahale *et al.* (2008) showed the presence of coagulase positive *S. aureus* in qualitative counts of five samples of sugarcane and two samples of carrot juice. Almost 70% of the ice samples collected from street vendors showed high microbial load ranging from log 5–8.5. The results demonstrate the unhygienic quality of the most popular types of street vended ice and fruit juices used for cooling of juices suggesting the urgent need for government participation in developing suitable intervention measures to improve microbial quality of juices.

Further, Khan *et al.* (2015) in their study taken as samples the papaya juice, sugarcane juice, lemon sherbet, tukmaria sherbet and wood apple sherbet. Their results showed a high microbial load in the drinks. The range of average total coliforms and total viable count (microbial load) were 210–1100 cfu/100 ml and 7.7×10^3 – 9×10^8 cfu/ml, indicated the heavy presence of microorganisms in all the drinks analyzed in the study. Moreover, it was revealed that tukmaria sherbet was most contaminated with a count of 9×10^8 cfu/ml. Whereas, least contamination was observed in lemon sherbet. A count of 1.98×10^6 cfu/ml was observed in papaya juice and 3.4×10^5 cfu/ml was in wood apple sherbet. Total coliforms were present in all samples and average count for total coliforms was high in tukmaria sherbets than others. In various other reports, various pathogenic species of bacteria such as *Proteus sp.*, *Enterobacter sp.*, *E. coli*, *Shigella sp.*, *Citrobacter sp.*, *Vibrio sp.*, *Yersinia sp.* and *Hafnia sp.* were isolated from the street vended juices and sherbets. Unhygienic water for dilution, dressing with ice, prolonged use without refrigeration, insanitary surroundings, raw materials, equipment, chemical properties, fruit flies and airborne dust are the

risk factors of contamination. Among all, the pathogens of main concern found to be *Salmonella spp.* and *Escherichia coli*. These organisms are highly pathogenic and may cause serious diseases in human beings. Beside these, causal organism for urinary tract infections, middle ear and infections in gall bladder etc found to be *Citrobacter*. *Escherichia coli* observed to cause mainly diarrhoea, septicaemia, urinary infections and pyogenic infections etc. Moreover, *Shigella* results in the destruction of the epithelial cells of the intestinal mucosa in the rectum and cecum. It may also result in dysentery.

Food born diseases related to fruit juices : In the past, the association of fruit juices with foodborne disease outbreaks rarely occurred, mainly due to the hygienic conditions maintained and the low pH values. According to knowledge available to the vendors at that time, under the acidic pH values, pathogen growth would not be observed or if it occurs then is very low, while survival, although possible. However, since the 1980s the foodborne disease outbreaks occurrence, mainly, resulted in more attention being given to acidic fruit juices. Such foodborne disease outbreaks have not only revealed the association of well-recognized foodborne pathogens such as *Salmonella*, *E. coli*, *C. cayetanensis* and *C. parvum* with fruits and vegetables but also of others such as protozoa, which have been shown to be potential and emergent associates. For example, in the Brazilian Amazon region, the appearance of the Chagas disease caused by *Trypanosoma cruzi* has been associated with the ingestion of triatomine vectors or their excrements during acai palm juice preparation for which the vectors can be crushed together with the fruit (Valente *et al.*, 1999). A large number of studies have been carried out showing the occurrence of patulin and/or its fate in apple juice processing in recent years (Baert *et al.*, 2006, 2007; Katerere *et al.*, 2007; Morales *et al.*, 2007; Spadaro *et al.*, 2007; Iha and Sabino, 2008; Sant'Ana *et al.*, 2008; Welke *et al.*, 2009 a,b). On the other hand, reports on the occurrence of ochratoxin A and its final fate during grape juice processing are scarce (Bellí *et al.*, 2004; Ng *et al.*, 2004; Rosa *et al.*, 2004; Bejaoui *et al.*, 2005; Bejaoui *et al.*, 2004, 2006; Shundo *et al.*, 2006).

Conclusions

Fruits are very important for healthy life style. They are consumed in raw form as well as in extracted juice form. Fruit juice are available in fresh form as well as cheaper form in local markets by street vendors. But most of the vendors practiced to sell their fruits and fruit juices without wearing gloves. Even most of them did not cover their head and 76.8% (approximately) did not wear an apron. It leads to the fruit juice contamination and increase in chances of spread of food related pathogen. Therefore,

there is an immense need to provide education on the food safety knowledge and practices before vendors are allowed to trade. Government should apply some food safety related standards in the light of recommendations of WHO and monitor the sanitary as well as hygienic conditions on a regular basis. To made a progress some Food safety training programs should be initiated on ground level to mass level. Moreover, to prevent such contamination in fruit juice drinks a Good Hygienic Practice (GHP) as defined in the Codex document on "General Principles of Food Hygiene" is initiated (Codex Alimentarius, 1997). Government Health Agencies must adopt measures to educate the vendors about safety and hygienic practices of food and to develop a regular monitoring system. Surveillance systems for the detection of food-borne pathogens, food products and on outbreaks needs an upgradation so that comparable data must be available from a wider range of countries. Overall, due to the low price and easy availability make the street vended juices and sherbets highly popular to general people. But these drinks will be beneficial if these are free from contamination. The compiled study revealed that all the studied fruit juices and sherbets had a higher microbial load than the specification set for fruit juices in some parts around the world. Regular monitoring of the quality of fruit juices for human consumption is recommended to avoid any future microbial pathogen outbreak. As well as in future, more advanced methods and techniques should be opted which are much more convenient, fast and accurate one.

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Evaluation of Organic Composts on *Cercospora* spp. of Okra (*Abelmoschus esculentus* L.)

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Abstract

Okra [*Abelmoschus esculentus* L., Moench] a native of South Africa and commonly known as 'Bhindi' is an annual malvaceous vegetable crop, especially grown in tropical and subtropical climates. It is also called a "perfect villager vegetable". *Cercospora* leaf spot is considered major disease among all the diseases. Among all disease, *Cercospora* leaf spot cause severe damage to okra. Spent mushroom compost, Vermicompost and Neem cake were tested under field conditions during Kharif 2021- 2022 for their efficacy against the *Cercospora* spp. Among the treatments the maximum plant height (cm) at 90 DAS was recorded in T₆ Vermicompost + spent mushroom compost + neem cake + FYM (95.3) followed by T₅ – Vermicompost + neem cake + FYM (92.4) as compared to untreated check control T₀ – (79.33 cm). The maximum Root length was recorded in T₆ Vermicompost+ spent mushroom compost+ Neem cake + FYM (20.36 gm) followed by T₅ – Vermicompost+ Neem cake + FYM (17.01 gm) as compared to untreated check control T₀ Control + FYM (10.46). The minimum *Cercospora* disease intensity (%) at 90 DAS was recorded in T₆ - Vermicompost+ spent mushroom compost + Neem cake + FYM (23.30), followed by T₅ - Vermicompost + Neem cake + FYM (24.41) as compared to untreated check control T₀ – control + FYM (27.47)

Key words : *Cercospora* spp, FYM, neem cake, spent mushroom compost, Vermicompost.

Introduction

Okra [*Abelmoschus esculentus* (L.), Moench], also known as lady's finger, bhindi and gumbo; is a flowering plant valued for its edible fruits and belongs to the family of *malvaceae*. The production in 2004 was more than 4.5 million of tons is more than 33 countries with India in top, producing 3.5 million tons (FAOSTAT). okra is of African origin where it has been cultivated for more than 4000 years but now is also grown in different tropical and warm temperature regions of the world, like Greece, Iran., Egypt, India, Japan, Southern united states and Turkey, Philippines. (Arapitsas., 2008). okra is a nutritious and delicious annual vegetable crop grown in the tropical and sub- tropical regions. There are about eight *Abelmoschus* species available in India. Out of these, *A. esculentus* is the only known cultivated species.

Okra is a nutritious vegetable which plays important role to meet the demand of vegetable are scanty in the market. Mature okra seeds are good sources of protein and oil (Priya singh *et al.*, 2018). Tender fruits are used as vegetables or in culinary preparations as sliced or dried pieces. Mature fruits and stems containing crude fibre and are used in paper industry. Its fruits have high nutritive, medicinal and industrial value and export potential. Its fruits are rich in vitamins, calcium, potassium and other mineral matters. okra contains highest amount of iodine which prevents from goiter disease and often

recommended by nutritionists because it control cholesterol level and weight reduction programmes. okra is very effective is frightening against ulcers, physiological conditions and depressions. The antioxidant activity of this crop is due to presence of vitamin A, B and C that prevents the oxidant damages by free radicals also helps in lowering down the aging process (Rajesh *et al.*, 2018). which is essential for human nutrition It has good nutritional value, especially high in vitamin C (30 mg/100 g), Ca (90 mg/100 g), Fe (1.5 mg/100 g) and other minerals such as magnesium and potassium, vitamin A and B, fat and carbohydrates (Aykroud., 1963).

Okra production in tropical regions is constrained by several abiotic and biotic factors and yield losses due to biotic factors are quite substantial. Fungal diseases constitute a major limiting factor to the growth and yield of okra. These include *Cercospora* leaf spot, damping off, powdery mildew, leaf blight and fruit rot. Leaf spot is an important disease of okra. It limits the photosynthetic potential of the leaves, there-by reducing the overall yield performance of the crop. Infection of the host by the parasite is usually brought about, after the germination of the conidia, by infecting hyphae which gain entrance through the stomata. It is prevalent in West Africa and areas where okra is cultivated in the tropics, especially during the rainy season with high relative humidity. Symptoms of the disease on infected okra usually begin

with the appearance of small brown irregular spots surrounded by pink colouration (Dania *et al.*, 2020). Usually, symptoms first appear on the lower, older leaves while lesion appears on the younger leaves, which become necrotic at an advanced stage of development.

Materials and Methods

The present study was carried out at the experimentation field of the Court yard of department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences. during *Kharif* season 2021. Plants showing typical symptoms, in field of standing crop, that is the infected plant part of okra. These disease plant materials were brought to the lab for further investigation. Examination of the fungal colony characteristics was done through microscopic examination. Appliances used: Disease sample, glass slide, cover slip, lactophenol, cotton blue, needle, Forceps, Compound microscope. Using a sterile needle, a small portion of the infected plant part was taken and placed on a sterile glass slide. It was stained using lactophenol and cotton blue and covered with the coverslip. Then, the microscope was used for the examination of morphological characteristics of fungal structures.

The soil of the plot was sandy loam in texture having good fertility, properly levelled and well drained. Row -to- Row and Plant -to- Plant 60 cm and 30 cm respectively. Cultural and agronomic practices were followed as per the standard recommendations and need based plant protection measures were taken up to maintain healthy crop stand. Observations were recorded on five competitive plants excluding border plants in each replication in each hybrid for days to 50% germination, plant height (cm) (30, 60 and 90 DAS), Root length (cm) (60,75,90 DAS), Disease Intensity (%) (60,75,90 DAS).

The experiment was analysed by using RBD (Randomized Block Design) with three replications having plot size 2 x 1.5 m². Seven treatments T₁-spent mushroom compost 10gm/kg seed, T₂- vermicompost 10gm/kg seed, T₃-neem cake 2kg/plot, T₄-spent mushroom compost + vermicompost 10gm/kg T₅-vermicompost + neem cake, T₆-spent mushroom compost+ vermicompost+ neem cake along with the control were taken.

Disease intensity : Disease intensity (%) formula was given by Wheeler (1969). It is calculated by using the following formula :

Disease Intensity (%) =

$$\frac{\text{Sum of all disease ratings}}{\text{Total number of rating}} \times \frac{\text{Disease intensity}}{\text{Maximum disease grade}} \quad 100$$

Disease severity scale for *Cercospora* leaf spot of okra: (Datta et al., 2015)

Disease rating/grade	Description
0	No disease
1	Light spotting in the lower plant canopy
2	Light spotting in the lower and upper plant canopy
3	Some spotting with light defoliation (<10%)
4	Noticeable spotting with some defoliation (<25%)
5	Spotting heavy with significant defoliation (<50%)

Results and Discussion

Plant height (cm) of okra : The maximum plant height (cm) at 30 DAS (52.13), 60 DAS (79.66) and 90 DAS (95.3) was recorded in treatment T₆-Spent mushroom compost + vermicompost + neem cake + FYM. Followed by 30 DAS (52.13), 60 DAS (79.66) and 90 DAS (95.3) was recorded in treatment T₅ - vermicompost + neem cake + FYM. However other varieties were affected by *cercospora* spp. and thus the plant parameters such as plant height was affected.

Root length (cm) of okra : The maximum root length (cm) at 60 DAS (18.70), 75 DAS (20.15) and 90 DAS (20.36) was recorded in treatment T₆ - Spent mushroom compost + vermicompost + neem cake+ FYM. Followed by 60 DAS (16.77), 75 DAS (16.42) and 90 DAS (17.01) was recorded in treatment T₅ – vermicompost + neem cake + FYM. However other were affected by *cercospora* spp. and thus the plant parameters such as root length was affected.

Disease intensity (%) of okra at 60 DAS : The minimum disease intensity at 60 DAS (5.66), 75DAS (14.04) and 90 DAS (25.30) was recorded in treatment T₆ - Spent mushroom compost + vermicompost + neem cake+ FYM. Followed by 60 DAS (6.17), 75 DAS (14.8) and 90 DAS (24.41) was recorded in treatment T₅ - vermicompost + neem cake + FYM. However other were affected by *cercospora* spp. and thus the plant parameters such as disease intensity was affected.

Conclusions

From the present study, It is concluded that among treatments, the maximum plant height, Root length and disease intensity was found in spent mushroom compost + vermicompost + neem cake + FYM. Use of organic compost neem cake, Vermicompost and Spent mushroom in the field would be considered as beneficial and eco-friendly *Cercospora* leaf spot of okra. However, the present study was limited to one crop season is. *Kharif season* under Prayagraj conditions, therefore, to substantiate the present result more trials are needed for 2-3 seasons for further research.

Table-1: Effect of organic compost on plant height of okra at 30, 60 and 90 DAS.

Tr. No.	Treatment details	30 DAS	60 DAS	90 DAS
T ₀	Control + FYM	42.93	66.46	79.33
T ₁	Spent mushroom compost + FYM	44.4	69.13	89.2
T ₂	Vermicompost + FYM	43.93	67.66	84.53
T ₃	Neem cake + FYM	46.73	74.2	85.86
T ₄	Vermicompost + SMC + FYM	44.93	72.4	90.86
T ₅	Vermicompost + neemcake + FYM	49.13	77.46	92.4
T ₆	Vermicompost + SMC + neemcake + FYM	52.13	79.66	95.3
	F test	S	S	S
	S.E(d)±	1.28	0.93	1.75
	C.D(0.05)	2.80	2.03	3.23

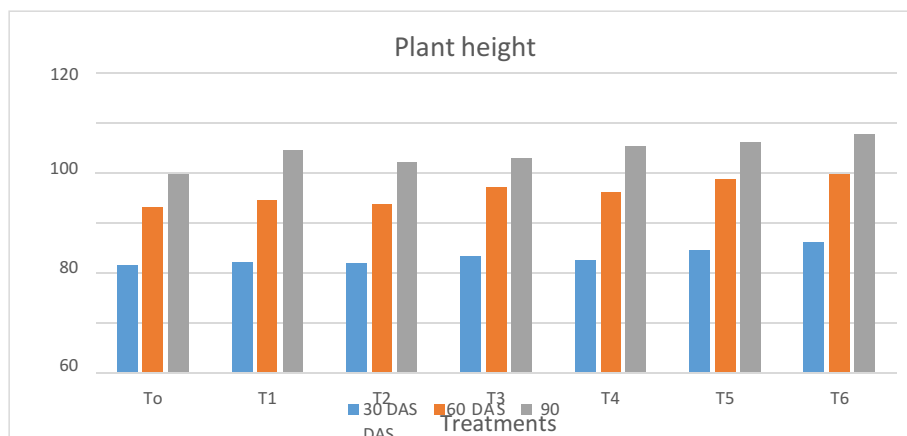


Fig.-1 : Effect of organic compost on plant height of okra at 30, 60 and 90 DAS.

Table-2 : Effect of organic compost along on Root length of okra at 60, 75 and 90 DAS.

Tr. No	Treatment details	60 DAS	75 DAS	90 DAS
T ₀	Control + FYM	9.12	10.13	10.46
T ₁	Spent mushroom compost + FYM	14.78	12.99	14.10
T ₂	Vermicompost + FYM	13.77	11.42	12.74
T ₃	Neem cake + FYM	14.44	15.99	15.01
T ₄	Vermicompost + SMC + FYM	12.90	14.98	14.88
T ₅	Vermicompost + Neem cake + FYM	16.77	16.42	17.01
T ₆	Vermicompost + SMC + Neem cake + FYM	18.70	20.15	20.36
	F-test	S	S	S
	S.E(d)±	0.68	0.67	0.72
	C.D (0.05)	1.43	1.42	1.36

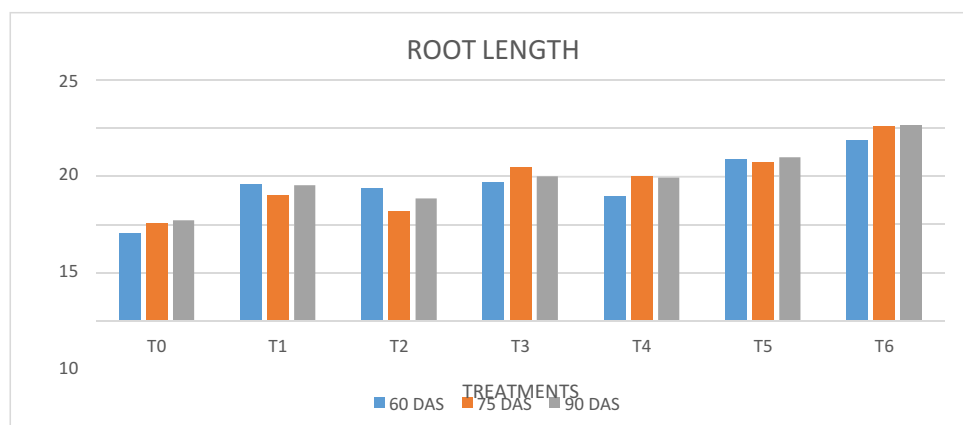
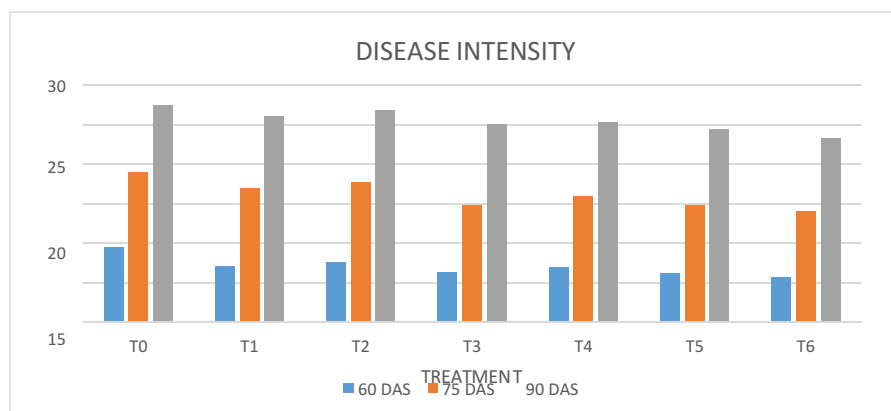
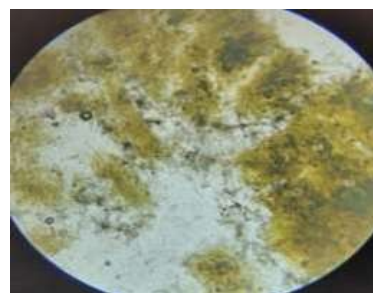


Figure-2 : Effect of organic compost on plant Root length of okra at 60, 75 and 90 DAS.

Table-3 : Effect of organic compost on the disease intensity of *Cercospora* of okra at 60, 75 and 90 DAS.

Tr. No	Treatment details	60 DAS	75 DAS	90 DAS
T ₀	Control + FYM	9.39	18.89	27.47
T ₁	Spent mushroom compost + FYM	7.1	16.89	26.04
T ₂	Vermicompost + FYM	7.62	17.7	26.75
T ₃	Neem cake + FYM	6.35	14.8	24.98
T ₄	Vermicompost + SMC + FYM	6.89	15.9	25.32
T ₅	Vermicompost + Neem cake + FYM	6.17	14.8	24.41
T ₆	Vermicompost + SMC + Neem cake + FYM	5.66	14.04	23.30
	F-test	S	S	S
	S.E(d)±	0.56	0.31	0.30
	C.D(0.05)	1.17	0.68	0.66

Figure-3 : Effect of organic compost on the disease intensity of *Cercospora* of okra at 60, 75 and 90 DAS.Fig. : *Cercospora* disease samples.Fig. : Microscopic view of *Cercospora*.

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A Mini Review on Medicinal Properties of *Pyracantha crenulata* (Ghingharu)

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Abstract

Pyracantha crenulata it's commonly known as Ghingharu, Chota shaeb, Nepalese firethorn, Nepal firethorn and its English name is Himalayan firethorn and it is found in the Himalayas from Sutlej to Bhutan and it is widely spread in the Nainital, Chamoli, Uttarkashi, Tehri, Almora, Pithoragarh district and the endemic of Himalayan hills ranging altitude is 900 to 2400m and it is dense bushy shrub grows widely in abundance in Barren, rocky and dry grassland. This drought and the frost tolerant species can withstand temperature fluctuations from subzero to 35 degrees. These brushes are 5 to 15ft high profusely branched with dark red colored puppy barriers during the month of Aug-sept. This perennial, deciduous and thorny shrub is commonly known as Indian Hawthorn. The food substances of the plant used as nutraceuticals, contain antioxidants, minerals, vitamins, prebiotics, probiotics, polyunsaturated 18 fatty acids certain phytochemical and dietary fibre. Through the review the medicinal importance of this valuable medicinal plant will be concluded. Ghingharu is on high demand for its curative characteristics.

Introduction

Pyracantha crenulata is commonly known as Ghingharu, Nepalese firethorn, Nepal firethorn and it's English name is Himalayan firethorn. *Pyracantha crenulata* in the Kumaon region of Uttarakhand commonly known as Ghingharoo [Chauhan, 1999, Osmaston, 1926]. In the Garhwal Himalaya it is also known for its rich bioresources and ethanocultural values [Saklani, 2012]. Pioneer basins of natural or herbal medicines are procured by the medicinal plants. The structural diversity of their phytoconstituents accomplishes them as an esteemed source of novel lead compounds for the quest of drugs to treat acute and chronic diseases. *Pyracantha* flowers are hermaphrodite (bisexual) having one ovary with 20 stamens. This perennial deciduous and thorny shrub is typically called Indian Hawthorn or Ghingharu [Brandis, 1921]. *Pyracantha* is used for a good soil binder for stabilizing degraded area that is a slope. That is prone to landslide [Gamble, 1972]. The fruit of this plant has been used in Garhwal folk and traditional medicine in the treatment of serious health condition like blood pressure, diabetes, hypertension, heart disorder, circulation system especially in case of angina [Spectrum 2010]. The fruit is antispasmodic, appetizers, cardiogenic, diuretic, vasodilator, sedative used to treat burns, cardiac failure, myocardial debility and Buerger's disease. The fruit is consumed by aged people for rejuvenation and to reduce joint pain and body pain.

The fruit powder combined with yoghurt is given to

cure bloody dysentery [Chauhan, 1999, Khare, 2004, Khare, 2007, Pande *et al.*, 2007, Saklani *et al.*, 2011, Saklani *et al.*, 2014]. The leaves possess antioxidant, immunomodulatory and anti-inflammatory activities that are used to prepare herbal teas, sunburn, creams and facial Cream [Simoons, 1990]. The origin of drugs to the greatest extent depends on these natural products from plant, animal, microorganism and minerals, which are pre-owned in the therapy of human and animal disease. The plant makes an excellent hedge and is grown as an ornamental plant [Dimitri, 1972]. Ghingharu fruit decreases blood pressure, does not increase cholesterol and also useful in diabetes. In Ghingharu vitamin C, vitamin A, vitamin B, vitamin B2, vitamin B12, vitamin E, protein, carbohydrates, fats, and calcium, potassium, fibres are found mainly [Negi *et al.*, 2009]. The bioflavonoids in most *Pyracantha* species are quite useful in the treatment of malfunctioning of the heart and blood circulatory system [Peschel *et al.*, 2008]. The antioxidant presents in the plant reduce damage from free radicals. The medicinal homes of this plant for the treatment of circulatory system ailment and respiration contamination already hooked up through the 18th century. In ayurvedic medication, it is taken into consideration to growth blood waft to coronary heart muscle and to repair ordinary coronary heartbeat. The antioxidant property of fruit supports the blood vessels. In other medicinal system, the flowers and fruit of plant considered acting as a mild heart tonic [Osmaston, 1926]. Also, in Ayurvedic medicine, it is reported to be useful in the treatment of a number of

ailments, including hepatic, stomach and skin diseases due to its diuretic, depurative, tonic, antirheumatic, cardiogenic, hypoglycaemic, hypotensive, anti-inflammatory and lithontripic properties [Otsuka, 1981, Himalaya, 1999, Fern, 2008]. Growing bacterial resistance is exhorting restoration in research of the antimicrobial aspect of herbs in contrast to resistant strains. Medicinal plants are significant to medical system [Ayaz et al., 2022].

Distribution and Occurrence : *Pyracantha crenulata* is widely distributed in Himalayan and in China as a perennial shrub [Saklani et al., 2014]. It grown in the range is between 1000- 2600nm in Uttarakhand. It is widely distributed in the Nainital, Chamoli, Uttarkashi, tehri, Almora, Bageshwar, Champawat and Pithoragarh district [Saklani et al., 2012]. It is an important plant in the foothills of the Himalayas and is found in Uttarakhand in Himachal Pradesh and northern eastern state of India and Nepal at elevation off 1600- 2500m. [Brandis, 1921]. Flowering season begins from March- May and its fruit is grown in season June to September. Its habitat is shrubberies, open slopes, cultivated areas, slopes roadsides, streamside among shrubs and its ripened fruits are eaten directly by the local communities in Uttarakhand [Kala, 2007]. *Pyracantha crenulata* is a thorny, woody shrub of 2-5m in peak it's far determined with inside the foothills in the Himalayas. It is found along streams on the banks of tributaries and in pine and queues forests. The white-colored inflorescence is a compound corymb with many flowers in it. The flowers are hermaphrodite (bisexual) having 20 stamen and one ovary within the centre. Every flower additionally incorporates five sepals and five petals. The fruit is a pome type and consisting of pulpy berries. Fruiting happens at some point of the month of July to September in Uttarakhand condition. The berries are small and each berry weighs 250 mg. The pome fruit is orange and red and it provides food for various birds [Weber, 2003].

Medicinal properties : The fruits are edible and rich in sugar and the leaves are used to make herbal tea [Kunkel, 1984]. The fruits contained proteins, vitamins, sugars, flavonoids, oligomeric proanthocyanidins, tannins, polyphenols, -sitosterol, esculetin and quercetin [Walker, 2006, Bahuguna and Chakraborty, 2014, Singh et al., 2015]. The flowers yielded phenyl ethylamine, Omethoxyphenyl ethylamine and tyamine. The plant possessed 2- phenylchromones and chlorogenic acid. Pyracenic acid was isolated from the bark. The major fatty acids of seed oil were linoleic, oleic and palmitic acids [Otsuka et al., 1981, Quiroga et al., 2003]. Therapeutic and pharmaceutical role played by the plants in protecting human beings from the effects of diseases and other complications, are contemplated as to have a cogent role

in the healthcare system. Leaves used in the preparation of herbal tea, sunburn and creams. Wood is used for making walking sticks, low-cost household items and agriculture tools. Bark is used in heavy bleeding during menstrual cycle. The stem bark is useful in fever exceptionally malaria. Antioxidant present in berries of Hawthorne reduced damage from free radicals. A root decoction is used in baths to alleviate body pain [Pal et al., 2013, Quattrocchi, 2012, Polunin and Stainton, 1984, Shah et al., 2006]. Extract of its bark applied topically protects skin from sunburn and all body organs from frostbite. The juice of hawthorn fruit has a hypoglycaemic effect in the treatment of diabetes [Andrade-Cetto et al., 2005].

A tonic from Ghingharu culmination named 'Hridayamrit' actually meaning 'Nectar for heart' organized through DRDO. Since the beginning of human culture, plants have been used by man for various purposes, especially for his survival and specifically, medicine. The application of medicinal plants all over the world precedes the introduction of antibiotics and other modern drugs. Fruits possess cardiogenic, coronary vasodilator and hypotensive properties use for cardiac failure, myocardial weakness, paroxysmal tachycardia, hypertension arteriosclerosis and burgers disease. The antioxidant present in fruits is helpful in reducing the ill effects of free radicals in our body maintaining blood pressure and reduce cholesterol. The plant possesses antihypertensive activity, antioxidant property, memory enhancer, antibacterial and antifungal activity, antiurolithogenic activity. Medicinal plants constitute a useful source of both traditional and modern medicines with herbal medicine having genuine utility upon which about 80% of the rural population depends as primary health care [Chauhan, 1999]. It is well adapted to wide range of soil types besides being drought and frost tolerant. The globose pome fruits turn orange-red on maturity and are eaten raw by the locals. An ethanolic fruit extract of Ghingaru pulp is reported to have antimicrobial activity against food poisoning bacteria. Importantly, the fruits are rich in crude protein, crude fibre, carbohydrates and antioxidants [Osmaston, 1926]. Ghingaru plant being hardy, no major insect pests and diseases are reported to cause economic damage/losses till recently. However, during the month of July in 2016 and in subsequent years, heavy infestation by larvae of an insect pest was observed in the area of around 5 km radius in the border district of Pithoragarh in Uttarakhand state. About 30-110 numbers of the insect larvae were observed feeding on each mature plant. After complete loss of the fruits and foliage of Ghingaru plants, the insect larvae were observed feeding on leaves of other local plants from Rosaceae family including Wild Himalayan Pear (*Pyrus pashia*), Padam (*Prunus cerasoides*), etc.

Medicinal plants to be screened for activity can be sampled randomly over a given area and identification of the plants is done before the commencement of the screening either at the time of collection or shortly after collection (Ayaz *et al.*, 2022). *Pyracantha* has been reported as an invasive in Cuba, the United States, Argentina, and Japan, whereas in Australia, this plant is considered a potentially high-risk weed (Csurhes *et al.*, 2016). In 1600–1650, *Pyracantha* was popular in Central Europe and was brought to Austria in 1623 (Lesel, 1994). A member of the genus was reportedly bred in Australia in 1867 (Csurhes and Markula, 2016) and the migration of birds caused the species to spread to Argentina (Vergara-Tabares *et al.*, 2016). fruit is about 5-7 mm spherical. Mature pericarp has varying yellow, orange, or red degrees depending on the variety. *Pyracantha* tolerates dry environment but is intolerant of shade. This plant prefers to grow in acidic and alkaline humid environments, but it is prone to iron chlorosis. However, if they are grown in nutrient-rich soil, or with excessive fertilizer and moisture, they will be more susceptible to disease. However, it may form dense, spiny and impenetrable thickets, compete with local vegetation, and hinder the activities of animals (Chari *et al.*, 2020). *P. coccinea* is an evergreen ornamental shrub that usually grows up to 6-18 feet tall and equally as wide. Secondary metabolites are also known to show curative activity against many ailments in humans and therefore could explain the rationale for the traditional use of medicinal plants in the treatment of human illnesses. They are chemical compounds with complex structures and are more restricted in distribution than the primary metabolites. The leaves of *P. coccinea* are elliptic to lance-tip with serrated edges, and the leaf blades are 4-8 mm wide, with the lower surface being densely and persistently tawny puberulent to puberulent-villous, whereas the margins are entire. The stems have sharp spines, and the flowers have a scent most people find unpleasant. When the fruit is ripe, bright orange to red berries can be seen. It is quite tasty but the unripe fruit will give it a bitter taste. *P. fortuneana* is an evergreen shrub reaching a height of 3 m. The perianth is integrated into a compound corymb, with pedicels 3-4 cm in diameter and common pedicels nearly glabrous. Its petals are white and round. Its fruit is nearly spherical and is orange–red or dark red. The flowering period is from March to May, and the fruit will slowly grow from August to November. The fruit of *P. fortuneana* has a strong sweet and sour aroma.

Biochemical properties : According to epidemiological studies, having foods rich in natural antioxidants strengthens the antioxidant capacity of organisms and eliminates the risk of chronic diseases (Prior and Cao, 2000). Because of this, antioxidant-rich *Pyracantha* also

has tonic, cardiogenic, and diuretic properties (Fico *et al.*, 2000; Keser, 2014; Sarikurkcü and Tepe, 2015). Previous studies have shown that *Pyracantha* is rich in bioactive compounds, such as polyphenols, fatty acids, vitamins, and minerals (Keser, 2014; Sarikurkcü and Tepe, 2015). Phenolic compounds are the most encountered secondary metabolites in the plant kingdom. Their structures can be as simple as phenolic acids or complex as tannins. Phenolic compounds include simple phenols (catechol, resorcinol etc), phenolic acids, stilbene (resveratrol etc), flavonoids (quercetin, cyanidin etc), biflavonoids (ormocarpine etc), proanthocyanidins (epicatechin), tannins, coumarins and anthraquinones. In particular, it has been demonstrated that flavonoids and phenolic acids show significant metal-chelating and free radical-scavenging capacities (Keser, 2014). It serves as a natural antioxidant in the food, cosmetics, and pharmaceutical sectors and may be used as a biomonitor to track the presence of heavy metals in the environment (Akguc *et al.*, 2010). *P. coccinea* is rich in nutrients, and its main nutrients include dietary fiber, carbohydrates, lipids, carboxylic acids, phenolic compounds, volatile compounds, protein and amino acids, vitamins, and minerals. Some secondary metabolites have been screened and characterized from the *P. coccinea*. Among them, flavonoids, tannins, saponins, and carotenoids are the primary components (Keser, 2014; Sarikurkcü and Tepe, 2015).

There are few studies on carotenoids of *Pyracantha* berries. It has been found that *P. angustifolia* was measured to contain 28 mg/kg dw pro- -carotene and polycopene, as well as 7 mg/kg polycopene stereoisomer (Popoviciu *et al.*, 2020). In that research, *P. crenulata* contained 17 mg/kg lycopene and 5 mg/kg -carotene. Popoviciu and Negreanu-Pirjol (2021) illustrated that *P. angustifolia* fruits contain over 65 mg/kg of carotenoids. Previous studies have reported that different rowanberry species included between 39 and 2659 mg/kg total carotenoids (23-1262 mg/kg -carotene), with variations associated with cultivar, soil types, and geographical location. These contents are by those previously found in *P. coccinea* fruits. The carotenoids content is affected by temperature and processing. The carotenoid decrease resulted from heat-drying fluctuated, ranging from 40% to 76%. Heat drying has also been proved as an unsuitable processing method, which led to a 53.22%–78.94% decrease in the concentrations of bioactive compounds in fruits such as rowanberry (*Sorbus* sp.) and firethorns (*Pyracantha* sp.) (Popoviciu, 2021).

Moreover, after being frozen, fresh fruit tissues can maintain pigment levels close to the initial, but drying and freeze-drying may cause further reductions in different

species and pigments (Shofian *et al.*, 2011). *F. palmata* (7.91 ± 0.51 mg GAE/g fw) followed by *P. crenulata* (6.59 ± 0.05 mg GAE/g fw) and *P. pashia* (4.92 ± 0.02 mg GAE/g fw) are the main types of secondary metabolites. The highest level of total phenolic content was found in *F. palmata* (7.91 ± 0.51 mg GAE/g fw) followed by *P. crenulata* (6.59 ± 0.05 mg GAE/g fw) and *P. pashia* (4.92 ± 0.02 mg GAE/g fw). Apart from three new components: norwogonin 5-glucoside, pinostrobin 5-glucoside and aromadendrin 5-methyl ether, ten new flavonoids were identified in the roots of *P. coccinea* (Bilia *et al.*, 1993). A total of 13 flavonoids have also been detected in the study of Sharifi-Rad *et al.* (2021), including catechin, galocatechin, procyanidin, apigenin, myricetin, quercetin and kaempferol. Previously, catechin and galocatechin were found with high concentration in green tea, banana peels and apple pomace and leaves (Keating *et al.*, 2018; Toh *et al.*, 2016; Wolfe and Liu, 2003), whereas kaempferol in *P. coccinea* was quantified as 14.67 ± 2.17 mg/g dw, followed by quercetin (11.59 ± 2.34 mg/g dw) and catechin (6.37 ± 1.98 mg/g dw) (Sharifi-Rad *et al.*, 2021). Besides, it has been also assessed various flavonoid content during the stage of ontogeny for *P. coccinea* (Fico *et al.*, 2000). As scientists and clinicians attach more importance to medicinal plants, the demand for tannins in the world is increasing because of their wide application in cosmeceuticals and food. They are primarily applied in leather coating to take the place of phenol in rubber products (Khanbabaee and Van Ree, 2001; Mgbemene *et al.*, 2014; Sousa and de Brito, 2015). In addition, they are considered to be natural antioxidants and vital agents in pharmaceutical industries (Min *et al.*, 2008; Sultana *et al.*, 2007).

Nutritional components

Macronutrients : Previously, plant polysaccharides, isolated and extracted from *P. fortuneana*, have been reported by several studies to have biological activity (Huang *et al.*, 2007; Yuan *et al.*, 2010), including solid resistance to free radical activity and the ability to influence the growth, apoptosis and senescence of cancer cells (Yao *et al.*, 2019). The fatty acid profiles of *Pyracantha* extracts have been summarized by Keser (2014). Specifically, linolenic and palmitic acids were the primary fatty acids in the target extract. Tocopherols are crucial in protecting polyunsaturated fatty acids to overcome peroxidation in the organism (Kamal-Eldin and Andersson, 1997). Phytosterols contain various cholesterol-like molecules; the dominating examples are ergosterol, 4-desmethyl sterols, stigmasterol, and -sitosterol (Quilez *et al.*, 2003).

Micronutrients : Vitamins are considered an essential organic substance to prevent health problems. The

composition can be a crucial feature for identifying medicinal or edible plants. Vitamin C works as an antioxidant in the body and interacts directly with oxidants, protecting other substances against oxidative damage. Furthermore, Vitamin C reduces the risk of gastric cancer and prevents cardiovascular diseases. As stated by Saklani *et al.* (2011), ascorbic acid content varied significantly among different species. For example, the highest amount of vitamin C was identified in the fruits of *P. crenulata* (5.30 ± 0.54 mg/100 g fw), followed by *Pyrus pashia* (4.59 ± 0.25 mg/100 g fw), whereas the lowest was found in *Ficus palmata* (2.93 ± 0.18 mg/100 g fw). Moreover, 47.10 ± 0.25 and 45.36 ± 0.28 mg/100 g dw Vitamin C were detected in *P. angustifolia* and *P. fortuneana* by Wang *et al.* (2018). In Australia, the recommended daily intake (RDI) of Vitamin C is 45 mg a day, that is, 100 g of extract of these two species could provide the RDI of Vitamin C for an adult.

Antibacterial and antifungal activity : The mechanism of herbal medicine in killing or inhibiting the growth of bacteria can be divided into three categories. The first one is the destruction of the microbial cell wall and cell membrane. After that, active substances permeate the cytoplasmic membranes or enter the cells and inhibit the normal synthesis of DNA and proteins (Liu *et al.*, 2017). The second is to change the microbial structure through the influence of genes and proteins. Finally, it interferes with the energy metabolic activity in bacterial cells to inhibit the production of a free radical (Arora and Kaur, 2007; Rios and Recio, 2005). *Pyracantha* genus has been shown to evaluate the antimicrobial activities of some microbial strains. Turker *et al.* (2012) reported that ethanolic extract of *P. coccinea* fruits showed remarkable antioxidant effects against Gram-positive bacteria, such as *Bacillus cereus*, *Enterococcus faecium*, *Staphylococcus hominis* and *Staphylococcus aureus*. Through the research on the antibacterial activity of the extract of *Pyracantha*, it was found that the 1% hydrochloric acid ethanol extract of *Pyracantha* has an antibacterial effect on *S. aureus*, *Escherichia coli* and an unknown bacterium, among which *E. coli* has an obvious inhibitory effect on the fungus *Penicillium*. However, Yotova and Medhat (2012) also found that antimicrobial activities were not present in fruit extracts of *P. coccinea*. This is because of differences in extract concentration, target microorganisms and composition of samples. The evaluation of *in vitro* antimicrobial activities, nutritional value, antinutritional value and phytochemical screening of wild edible fruit of *Pyracantha crenulata* investigated by disc diffusion method against ten bacterial stains and three fungal stains by Saklani and Chandra (2014). In another work, the antimicrobial activities of hexane, chloroform, acetone, ethanol, methanol and aqueous

extracts from roots and leaves of bushy lippia (*Lippia alba*) at the concentration of 2 mg/disc were evaluated against *S. aureus*, *B. subtilis*, *E. faecalis*, *Micrococcus luteus*, *E. coli*, *P. aeruginosa*, *Serratia marcescens*, *Mycobacterium smegmatis*, *Monilia sitophila* and *C. albicans*. The results indicated that chloroform, acetone and ethanol extracts from roots prevented the growth of *S. aureus*, *M. luteus*, *B. subtilis*, *M. smegmatis*, *C. albicans* and *M. sitophila*, while hexane, ethanol and methanol extracts from leaves inhibited *S. aureus*, *M. luteus*, *B. subtilis*, *M. smegmatis* and *M. sitophila*.

Conclusions

Medicinal plants are everywhere and are easily accessible. Their antimicrobial activity can be optimized and reproduced by collecting the correct species of the medicinal plant, using the correct method of extraction and complying with the provisions of correct microbiological screening principles. Ghingharu is one of the important medicinal plants possessing high medicinal importance. The fruits contained potent value of nutrients and antimicrobials as compared to the cultivated fruits with berry and 500gm fruits contain sufficient amount of nutrients required for per day a person. The present review is focused on important, potent medicinal, nutritional, antimicrobial activity, antinutritional activity and phytochemical screening of *Pyracantha crenulata*. This compiled study revealed that plant possess antimicrobial and antifungal activity against selected bacterial and fungal strains. Which encourage developing a novel broad spectrum antimicrobial formulation in future. The reported research will be directed to develop a broad spectrum antimicrobial herbal formulation with this plant. Even at low concentrations, these plant species contained potent medicinal, nutritional value and also showed high antimicrobial and antifungal activity nearly equal to that of the commercial fungicide used as a positive control. So, this is a plant that can be exploited in better way for industrial purpose in future without any loss to natural count with advanced methods and techniques.

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Assessment of Combining Ability and Gene Action in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract

The current investigation was undertaken to assess of combining ability and gene action for grain yield and its related traits in pearl millet using sixty F_1 hybrids generated by utilizing three male sterile lines and twenty restorer lines in line x tester design. Analysis of variance and combining ability studies revealed that sufficient variability existed among the crosses. The estimates of GCA and SCA variance were significant for most of the traits in varying environmental conditions indicating influence of both additive and non additive gene action on character expression. On the basis of GCA effects parents ICMA 93333, BIB-46, BIB-53 and BIB-90 were better general combiners for grain yield per plant and other yield attributing traits in changing environment as well as over the environments. SCA effects revealed that positive and significant SCA effects for grain yield were shown by cross combinations ICMA 88004 X BIB-164, ICMA 97111 X BIB-179 and ICMA 93333 X BIB-145 in each environment as well as over the environment. These combinations have been identified as best hybrids for improving grain yield per plant and could be further evaluated to confirm their stable superior performance.

Key words : Pearl millet, combining ability, gene action, line x tester.

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is popularly known as bulrush, cattail, or spiked millet in English, bajra in Hindi, dukhn in Arabic and as mhunga or mahango in parts of southern Africa, is an important drought tolerant coarse grain cereal crop. It is a major crop in arid and semi arid region of the world. It originated in Sahel zone of West Africa (Vavilov, 1950 and Murdock, 1959), which is known to be the crop's main center of diversity, from where it spread to India and other countries. Due to protogynous flowering type, it is highly cross-pollinated and pollinates through wind. Pearl millet is a diploid ($2x=14$) annual C4 crop of family Poaceae (Gramineae), which is robust and quick growing rainy season cereal crop with large stem, leaves, heads, tall and vigour, with very high grain potential. Pearl millet accounts for almost half of global millet production and contributes to food security in regions of Africa and Asia.

Pearl millet is not expensive like pearl but definitely has pearl like quality which is beneficial to the body. 100 grams of pearl millet grain contains nutritional values as 360 calories energy, 12g moisture, 12g protein, 5g fat, 2g mineral, 1g fiber, 67g carbohydrate, 42mg Calcium, 242mg phosphorus and 8mg iron (Malik, S., 2015). As a food crop, pearl millet grain own the peaked amount of calories per 100 g (Burton *et al.*, 1972), which is mainly supplied by carbohydrates, fats and proteins (Flech, 1981).

It is one of the most important cultivated cereal in the world, ranking after rice, wheat, maize, barely and sorghum in terms of area planted to these crops (Khairwal *et al.*, 2007). In our country, it is grown in arid and semi-arid areas of central and western regions. The utmost pearl millet producing states are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana, covering nearly 90% acreage. It is grown on 9.13 million ha in India with a midpoint productivity of 1237 Kg/ha (Anonymous, 2018a). The highest acreage and production under pearl millet in the country is in Rajasthan. The total area under pearl millet in Rajasthan is governed by the onset of monsoon whereas, the total production is governed by the amount and distribution of rainfall. Rajasthan alone occupies 4.15 million hectares area, which is 55% of the national acreage. The total production of pearl millet in Rajasthan is 3.76 million tonnes, which is 47.7% of the national production with an average productivity of 906 kg/ha (Anonymous, 2018b). In Rajasthan, major pearl millet producing districts are Alwar, Sikar, Bharatpur, Karauli, Jaipur, Dausa, Dholpur, Jhunjhunu, Sikar, Nagaur, Swaimadhopur, Barmer, Bikaner, Jaisalmer and Churu.

The knowledge of combining ability effects and the corresponding variances is important in selecting parents and it can further be used for exploiting heterosis to produce high performing new hybrids. In India, attempts were made to produce hybrids as early as 1951 (Rao *et al.*, 1951) and commercial utilization of heterosis was

made after the availability of male sterile line 'Tift 23A' from Georgia (Burton, 1958) and leading to development of a series of hybrids from 'HB 1 to HB 5'. Line x Tester analysis helps in testing a large number of genotypes to assess the gene action and combining ability.

Materials and Methods

The experimental material for the present study was generated by using three male sterile lines (female) and twenty restorer lines (male pollinator) of pearl millet. These lines were crossed in line x tester mating design to develop 60 F₁ hybrids at The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad during Summer, 2018. The experiment was laid out in two environments during Kharif, 2018, one at research farm, ARS, Beechhwal, Bikaner (E₁), while another at research farm, College of Agriculture, Bikaner (E₂). This region falls under agro-climatic zone 1C of Rajasthan. The average rainfall is about 260 mm, which is mostly received during July-September. Experiment was laid out in randomized block design (RBD) with three replications in all the two environments. The experimental material comprised 60 hybrids and three commercially cultivated hybrids viz, HHB-67 Improved, RHB-177 and MPMH-17 as checks. Each hybrid consisted of two rows of 4 meter length. The spacing between rows was 60 cm and between plants was 15 cm. Observations were recorded on randomly selected five plants in each replication and crosses for days to 50% flowering, days to maturity, plant height (cm), total number of tillers, number of effective tillers, ear head length (cm), ear head diameter (cm), test weight (g), dry stover yield (g), grain yield (g) and harvest index (%). Pooled analysis of variance over the environments was determined for yield and its components. Combining ability analysis was computed by line x tester procedure as per Kempthorne (1957).

Results and Discussion

Combining ability analysis : Analysis of variance for combining ability over the environments exhibited that mean sum of squares due to replications were significant for plant height, total number of tillers per plant, flag leaf area and harvest index, whereas mean sum of squares due to environment were significant for all the characters studied. The variance due to replication x environment were significant for total number of tillers per plant and test weight. The variance due to crosses and line x tester were significant for all the traits studied, whereas due to lines, it is significant for plant height, total number of tillers per plant, flag leaf area, ear head length and ear head diameter. The variance due to testers were significant for all the traits studied except total number of tillers per plant,

effective number of tillers per plant, ear head diameter, test weight and harvest index. The variance due to environment x line x tester were non significant for all the traits studied in this experiment (Table-1).

The magnitude of variance due to SCA was higher as compared to the magnitude of GCA in each environment for all the traits studied except flag leaf area and ear head length (Table 2). The ratio of variances due to GCA/SCA was less than unity for most of the character studied, which indicated the preponderance of non additive components except for flag leaf area and ear head length. These results are supported by Vagadiya *et al.* (2010), Yadav *et al.* (2012) and Parmar *et al.* (2013) for days to 50% flowering, effective tillers per plant, plant height and grain yield per plant. Similar results were also revealed by Bhadalia *et al.* (2014), Bhardwaj *et al.* (2015) and Nandaniya *et al.* (2016). The ratio of additive variance to dominance variance was greater than unity for flag leaf area, ear head length and dry stover yield which represented the preponderance of additive gene action in the inheritance of these traits, whereas such ratio was less than unity for rest of the traits. The maximum contribution of lines to total variance was for plant height (58.23%) followed by ear head length (51.29%). The maximum contribution of testers to total variance was for flag leaf area (38.39%) followed by dry stover yield per plant (30.50%). In line x tester, the maximum contribution to total variance was showed by test weight (65.16%) followed by harvest index (62.86%) (Table2).

GCA and SCA effects : Line x tester analysis gives estimates of general combining ability (GCA) effects of lines, testers and specific combining ability (SCA) effects of crosses for each environment as well as over the environments. Among the female lines, good general combiner was ICMA 93333 for days to 50% flowering, days to maturity, plant height, flag leaf area, ear head length, test weight, dry stover yield and grain yield, while lines like ICMA 88004 was good general combiners for days to 50% flowering, days to maturity, plant height, total number of tillers per plant and ear head diameter, whereas female line ICMA 97111 was good general combiner for total number of tillers per plant, effective number of tillers per plant, flag leaf area, ear head length, test weight and harvest index. Among the testers good general combiners were BIB-46, BIB-53, BIB-90 and BIB-45 for grain yield and yield attributing characters, while BIB-75, BIB-90, BIB-46, BIB-102, BIB-85 for days to 50% flowering and days to maturity.

Selection of good specific cross combinations was based on SCA effects. Estimates of SCA effects revealed that ICMA 93333 X BIB-145 showed positive and significant SCA effects for grain yield per plant, dry stover

Table-1 : ANOVA for combining ability for grain yield per plant and its components based on data pooled over the environments.

Source of variation	d.f.	Mean squares											
		Days to 50% flowering	Days to maturity	Plant height	Total number of tillers/plant	Effective tillers/plant	Flag leaf area	Ear head length	Ear head diameter	Test weight	Dry stover yield/Plant	Grain yield/plant	Harvest index
Replication	2	1.43	1.87	114.13**	0.18*	0.05	84.44*	2.19	0.03	0.04	5.78	7.44	34.03**
Environments	1	152.10**	176.40**	376.18**	16.47**	5.98**	2325.73**	102.19**	2.38**	8.77**	1185.12**	740.52**	443.11**
Rep. / Env.	2	0.53	1.01	15.00	0.16*	0.01	12.51	0.17	0.00	0.37*	26.86	1.46	9.90
Crosses	59	21.46**	26.82**	525.38**	2.04**	1.80**	931.12**	32.49**	0.28**	2.53**	539.60**	132.22**	57.83**
Line(L)	2	25.47	34.41	950.01**	3.12*	2.30	891.62*	51.74**	0.43*	2.71	475.82	124.77	65.44
Tester(T)	19	67.22*	68.14*	1412.27**	0.30	2.14	10545.17**	246.04**	0.40	0.24	4855.68**	771.87**	11.94
L X T	38	17.05**	20.85**	266.38**	1.59**	1.53**	444.87**	11.62**	0.20**	2.56**	344.33**	102.28**	56.44**
Cross. x Env.	59	0.52	0.59	6.28	0.04	0.06*	14.33	0.27	0.01	0.08	8.54	2.09	2.04
L X E	2	0.59	0.89*	7.40	0.05**	0.09*	18.84	0.28	0.01	0.09	11.62	2.59	1.80
T X E	19	0.68	0.77	7.25	0.13**	0.04	16.92	0.33	0.05*	0.05	6.30	1.26	2.18
L X T X E	38	0.48	0.43	5.67	0.02	0.04	11.94	0.26	0.01	0.08	7.11	1.88	2.15
Pooled Error	236	0.90	0.89	23.27	0.05	0.04	25.21	0.89	0.01	0.10	18.34	3.42	6.95

** Significant at 5% and 1% level of significance, respectively.

*, ** Significant at 5% and 1% level of significance, respectively.

Table-2 : Estimates of combining ability variances, genetic components and proportional contribution of lines, testers and line x tester to total variance for various traits over the environments.

Source of variation	Days to 50% flowering	Days to maturity	Plant height	Total number of tillers/plant	Effective tillers /plant	Flag leaf area	Ear head length	Ear head diameter	Test weight	Dry stover yield/Plant	Grain yield/Plant	Harvest index
² GCA	0.66	0.73	16.78	0.02	0.03	82.51	2.14	0.01	0.02	38.37	6.45	0.46
² SCA	2.69	3.33	40.52	0.26	0.25	69.94	1.79	0.03	0.41	54.33	16.48	8.25
² GCA/6 ² SCA	0.24	0.12	0.41	0.07	0.12	1.17	1.19	0.33	0.04	0.70	0.39	0.05
² A	1.32	1.46	33.56	0.05	0.06	165.02	4.29	0.01	0.04	76.74	12.9	0.92
² D	2.69	3.33	40.52	0.26	0.25	69.94	1.79	0.03	0.41	54.33	16.48	8.25
² A/ ² D	0.48	0.43	0.82	0.18	0.25	2.35	2.39	0.37	0.09	1.41	0.78	0.11
Lines(L)	38.21	41.32	58.23	49.21	41.25	30.84	51.29	49.78	34.52	28.4	30.39	36.44
Testers (T)	10.62	8.61	9.11	0.51	4.04	38.39	25.67	4.84	0.32	30.5	19.79	0.70
Line x Tester	51.17	50.06	32.66	50.29	54.71	30.77	23.04	45.38	65.16	41.1	49.82	62.86

Table-3 : The best performing genotypes on the basis of GCA and SCA effects in pearl millet.

S.No.	Characters	Parents		Crosses
		Lines	Testers	
1.	Days to 50% flowering	ICMA 88004 ICMA 93333	BIB-46	ICMA 88004 X BIB-137
			BIB-75	ICMA 88004 X BIB-145
			BIB-90	ICMA 93333 X BIB-90
			BIB-90	ICMA 93333 X BIB-90
2.	Days to maturity	ICMA 88004 ICMA 93333	BIB-46	ICMA 88004 X BIB-137
			BIB-75	ICMA 88004 X BIB-145
			BIB-90	ICMA 93333 X BIB-90
3.	Plant height	ICMA 88004 ICMA 93333	BIB-147	ICMA 88004 X BIB-170
			BIB-170	ICMA 93333 X BIB-137
			BIB-179	ICMA 93333 X BIB-145
4.	Total number of tillers / plant	ICMA 88004 ICMA 97111	BIB-46	ICMA 88004 X BIB-90
			BIB-53	ICMA 88004 X BIB-170
			BIB-145	ICMA 97111 X BIB-179
5.	Effective tillers / plant	ICMA 97111	BIB-45	ICMA 88004 X BIB-75
			BIB-46	ICMA 97111 X BIB-173
			BIB-53	ICMA 97111 X BIB-179
6.	Flag leaf area	ICMA 93333 ICMA 97111	BIB-46	ICMA 88004 X BIB-90
			BIB-78	ICMA 88004 X BIB-170
			BIB-147	ICMA 93333 X BIB-145
7.	Ear head length	ICMA 93333 ICMA 97111	BIB-45	ICMA 88004 X BIB-170
			BIB-90	ICMA 93333 X BIB-85
			BIB-147	ICMA 93333 X BIB-147
8.	Ear head diameter	ICMA 88004	BIB-53	ICMA 88004 X BIB-163
			BIB-137	ICMA 93333 X BIB-60
			BIB-179	ICMA 97111 X BIB-53
9.	Test weight	ICMA 93333 ICMA 97111	BIB-46	ICMA 88004 X BIB-141
			BIB-90	ICMA 93333 X BIB-170
			BIB-164	ICMA 97111 X BIB-102
10.	Dry stover yield / plant	ICMA 93333	BIB-46	ICMA 93333 X BIB-145
			BIB-53	ICMA 93333 X BIB-147
			BIB-163	ICMA 97111 X BIB-46
11.	Grain yield / plant	ICMA 93333	BIB-46	ICMA 88004 X BIB-164
			BIB-53	ICMA 93333 X BIB-145
			BIB-90	ICMA 97111 X BIB-179
12.	Harvest index	ICMA 97111	BIB-45	ICMA 88004 X BIB-164
			BIB-46	ICMA 93333 X BIB-167
			BIB-90	ICMA 97111 X BIB-179

yield per plant, plant height and flag leaf area in both the environments as well as over the environments, whereas ICMA 97111 X BIB-179 for grain yield per plant, harvest index, total number of tillers per plant and effective tillers per plant in both the environments as well as over the environments. Apart from these crosses, some other cross combinations also possess significant SCA effects for yield and its attributing traits in this experiment. These cross combinations were ICMA 93333 X BIB-167, ICMA 88004 X BIB-149 and ICMA 93333 X BIB-147. Similar findings also observed by Dhuppe *et al.* (2006), Kumhar and Singhania (2007), Lakshmana *et al.* (2011), Khandagale *et al.* (2014), Kumar *et al.* (2017 a) and Saini

et al. (2018). Study of combining ability revealed that a number of testers viz., BIB-45, BIB-46, BIB-53, BIB-90 and BIB-164 were found good general combiner for grain yield per plant in each environment as well as over the environments. Tester BIB-46 was desired for days to 50% flowering, days to maturity, total number of tillers per plant, number of effective tillers per plant, flag leaf area, test weight, dry stover yield per plant and harvest index. Tester BIB-53 was desired for total number of tillers per plant, number of effective tillers per plant, ear head diameter and dry stover yield per plant. Tester BIB-90 was desired for days to 50% flowering, days to maturity, ear head diameter and dry stover yield per plant. Through

Table-4 : Promising crosses with high per se performance for grain yield per plant and their performance in related parameters.

Best Crosses	Mean yield per plant	Standard Heterosis	SCA effects	GCA effects		Significant S.H. for other traits
				P1	P2	
ICMA 93333 X BIB-46	24.49	72.46**	2.82**	2.73**	4.96**	Effective tillers per plant, flag leaf area
ICMA 93333 X BIB-167	24.44	72.18**	5.87**	2.73**	1.87**	Ear head length, Dry stover yield / plant
ICMA 93333 X BIB-53	24.28	71.06**	3.66**	2.73**	3.91**	Total number of tillers and effective tillers / plant
ICMA 93333 X BIB-145	22.58	59.01**	5.95**	2.73**	-0.09	Test weight, Dry stover yield / plant
ICMA 93333 X BIB-45	21.96	54.65**	2.58**	2.73**	2.66**	Ear head length, Ear head diameter
ICMA 93333 X BIB-147	21.71	52.96**	4.79**	2.73**	0.21	Ear head length, Dry stover yield / plant
ICMA 93333 X BIB-90	21.38	50.63**	1.68**	2.73**	3.00**	Ear head length, Dry stover yield / plant
ICMA 88004 X BIB-164	21.15	49.01**	7.50**	-2.28**	1.96**	Ear head diameter, Test weight
ICMA 97111 X BIB-53	20.57	44.86**	3.13**	-0.45**	3.91**	Ear head diameter, Test weight
ICMA 97111 X BIB-179	19.77	39.23**	6.33**	-0.45**	-0.09	Number of effective tillers / plant, Harvest index

current findings it is advisable that these can be used in development of synthetic varieties.

Among the female lines, good general combiner was ICMA 93333 for grain yield per plant and other yield attributing traits, while the female lines ICMA 88004 was good for days to 50% flowering, days to maturity and ear head diameter, ICMA 93333 was good for all the traits studied except total number of tillers per plant, number of effective tillers per plant, ear head diameter and harvest index, while ICMA 97111 was good for total and effective number of tillers, flag leaf area, ear head length, test weight and harvest index. These male sterile lines may be used as B line in hybridization programme for improvement in any trait.

Among the crosses, ICMA 88004 X BIB-164 was the best specific combination for grain yield per plant in both the environments as well as over the environments with other attributing traits followed by ICMA 97111 X BIB-179, ICMA 93333 X BIB-145, ICMA 93333 X BIB-167 and ICMA 88004 X BIB-149 (Table-3.).

In conclusion, the additive to dominance variance ratio was less than unity for most of the characters except flag leaf area, ear head length and dry stover yield which represented the preponderance of non-additive gene action in the inheritance of these traits. This indicates that mass selection or recurrent selection may be useful to exploiting additive gene action in population improvement in pearl millet. Combining ability study reveals that a number of testers like, BIB-46, BIB-53, BIB-90 and the female line ICMA 93333 were good general combiners for grain yield and other related traits, which can be utilized in development of synthetic population in pearl millet. The best five crosses over the environment for grain yield per plant were ICMA 93333 X BIB-46, ICMA 93333 X BIB-167, ICMA 93333 X BIB-53, ICMA 93333 X BIB-145

and ICMA 93333 X BIB-45 (Table 4.). These crosses were the best specific combinations for grain yield per plant in both the environments as well as over the environments with other attributing traits, which represents high SCA effects over the environments. To identifying promising hybrids in pearl millet improvement programme, these crosses could be tested for betterment and could be evaluated in multi-location yield trials for commercial exploitation.

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Effect of Soil Amendments with Bio-Resource on Disease Intensity of Purple Blotch (*Alternaria porri*) and Growth Parameters of Garlic

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Abstract

Garlic (*Allium sativum* L.), commonly known as “Lahsun,” is a vital spice within the *Amaryllidaceae* family and ranks as the second most extensively cultivated *Allium* plant after onions. The agricultural community and research sector have long grappled with the significant issue of purple blotch disease in *Allium spp.* crops, caused by *Alternaria porri*. This disease inflicts severe damage on crops and leads to a substantial reduction in yield. Consequently, field experiments were carried out in the Prayagraj district during the Rabi 2021-2022 season to assess the effectiveness of various soil amendments using bio-resources in managing purple blotch disease and enhancing the growth of garlic crops. A Randomized Block Design was adopted with three replicates for seven environmentally friendly treatment groups, denoted as T0 - Control (FYM) at a rate of 10 t/ha, T1 - Spent Mushroom Compost applied at 10 t/ha, T2 - Microalgae applied at 4 kg/ha, T3 - *Azospirillum* applied at 5 kg/ha, T4 - Spent Mushroom Compost at 10 t/ha + Microalgae at 4 kg/ha + *Azospirillum* at 5 kg/ha, T5 - Spent Mushroom Compost at 10 t/ha + Microalgae at 4 kg/ha and T6 - Spent Mushroom Compost at 10 t/ha + *Azospirillum* at 5 kg/ha. The study measured the percentage of disease intensity, plant height and the number of leaves per plant at three different time points: 30, 60 and 90 days after sowing (DAS).

Key words : Microalgae, spent mushroom compost, *Alternaria porri*, microalgae.

Introduction

Garlic, scientifically known as *Allium sativum* L. and commonly referred to as “Lahsun,” holds a significant position among spices, belonging to the *Amaryllidaceae* family. It stands as the second most widely cultivated *Allium species* after onion. Notably, garlic boasts superior nutritional content compared to other *Allium* plants. It is abundant in carbohydrates (29%), protein (6.3%), minerals (0.3%) and essential oils (0.1-0.4%). Additionally, garlic contains fat, vitamin C and sulfur. Particularly, green garlic exhibits a notably high content of ascorbic acid. Furthermore, garlic extracts and oil possess promising potential for use as effective insecticides and fungicides, aligning with the current trends favoring organic farming practices (Memane *et al.*, 2008). Purple blotch, caused by *Alternaria porri*, has been documented both in India and internationally (Hausbeck *et al.*, 1999). Fungal diseases pose significant challenges to the production of onions and garlic. Within the realm of fungal diseases, purple blotch, which is induced by *Alternaria porri*, stands out as a major threat to onion and garlic crops (Lancaster and Shaw, 1996). The impact of purple blotch is substantial and results in significant yield losses (Bisht and Thomas, 1992; Mishra *et al.*, 2009). The symptoms of purple blotch manifest as small, sunken whitish flecks with a purple hue on the stalks. Subsequently, these lesions

encircle leaves and stalks, causing them to droop. Oval-shaped tan and deep purple lesions also appear along the margins of the leaves. Additionally, concentric zones within the lesions are discernible. The initial signs of purple blotch consist of small, water-soaked lesions that emerge on older leaves. As the disease advances, these lesions turn yellow and concentric rings develop around their edges. Organic amendments and microorganisms used in the study offer a holistic approach to managing garlic purple blotch, addressing not only disease control but also soil health and overall crop performance.

Materials and Methods

The current research was conducted at the Central Research Farm, situated at the Department of Plant Protection farm within Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj. The study took place during the Rabi season, spanning from November 2021 to March 2022. To prepare the selected field, it was cleared of weeds, properly levelled and the soil was finely broken down. The entire area was divided into 21 plots. In these plots, recommended quantities of Farm Yard Manure (FYM) at a rate of 10 tons per hectare, Spent Mushroom Compost (SMC) at 10 tons per hectare and *Azospirillum* at 5 kilograms per hectare were incorporated during field preparation before planting the crops. The variety of garlic known as “Bhim Omkara” was chosen for

Table-1 : Effect of soil amendments with bio-resources on disease incidence and pre harvest parameters of garlic at 30, 60 and 90 DAS.

Sr. No	Treatments	Plant height (cm)			Number of leaves per plant			Per cent Disease intensity of <i>Alternaria porri</i>		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₀	Control (FYM)	25.72	40.01	43.32	4.33	5.93	7.17	9.21	22.07	35.42
T ₁	Spent Mushroom Compost + FYM	35.26	52.36	54.18	4.87	6.40	7.47	6.11	17.73	29.25
T ₂	Microalgae + FYM	38.69	54.14	56.93	5.27	7.27	8.33	3.41	12.64	20.70
T ₃	<i>Azospirillum</i> + FYM	29.96	49.97	52.19	4.80	6.47	8.27	6.32	17.69	24.65
T ₄	Spent Mushroom Compost + Microalgae + <i>Azospirillum</i> + FYM	30.99	49.82	51.65	4.80	6.40	7.87	6.87	16.48	25.52
T ₅	Spent Mushroom Compost + Microalgae + FYM	28.25	51.08	51.92	4.73	6.53	7.67	5.63	17.59	27.03
T ₆	Spent Mushroom Compost + <i>Azospirillum</i> + FYM	29.07	48.68	50.52	4.87	6.20	7.53	5.95	17.11	28.05
	C.D. (5%)	0.69	0.85	0.85	0.77	0.63	0.43	1.94	2.75	2.71
	S. Ed (±)	0.32	0.39	0.39	0.35	0.29	0.20	0.89	1.26	1.24

the experiment involving soil amendments with bio-resources to manage purple blotch disease. Microalgae in the form of slurry was applied to the field at a rate of 5 kilograms per hectare during the irrigation process. Disease severity and various plant growth parameters, including plant height and the number of leaves, were assessed in each plot by measuring them on five randomly selected plants. Percent disease intensity was calculated as per the 0-9 point rating scale based on leaf area covered by the pustules (Mayee and Datar, 1986).

Results and Discussion

The information presented demonstrates the impact of various soil amendments containing bio-resources on mitigating purple blotch disease in garlic plants after 30, 60 and 90 days in field conditions.

The data at the 30-day mark indicates that among all the treatments, T₂ (Microalgae, 3.41%) exhibited the highest effectiveness in significantly reducing disease severity. It was followed by T₅ (Smc + Microalgae, 5.63%), T₆ (Smc + *Azospirillum*, 5.95%), T₁ (Smc, 6.11%), T₃ (*Azospirillum*, 6.32%), T₄ (Smc + Microalgae + *Azospirillum*, 6.87%) and T₀ (Control, 9.21%). At the 60-day stage, the results showed that T₂ (Microalgae, 12.64%) was the most effective treatment in significantly decreasing disease intensity. It was followed by T₄ (Smc + Microalgae + *Azospirillum*, 16.48%), T₆ (Smc + *Azospirillum*, 17.11%), T₅ (Smc+Microalgae, 17.59%), T₃ (*Azospirillum*, 17.69%), T₁ (Smc, 17.73%) and T₀ (Control, 22.07%). Finally, at the 90-day mark, the data indicated that T₂ (Microalgae, 20.70%) was the most successful treatment in significantly reducing disease

severity. It was followed by T₃ (*Azospirillum*, 24.65%), T₄ (Smc + Microalgae + *Azospirillum*, 25.52%), T₅ (Smc + Microalgae, 27.03%), T₆ (Smc + *Azospirillum*, 28.05%), T₁ (Smc, 29.25%) and T₀ (Control, 35.42%).

At the 30-day stage (30 DAS), the highest recorded plant height was observed in T₂ (Microalgae, 38.69), with T₁ (Smc, 35.26) coming next, followed by T₄ (Smc + Microalgae + *Azospirillum*, 30.99), T₃ (*Azospirillum*, 29.96), T₆ (Smc + *Azospirillum*, 29.07), T₅ (Smc + Microalgae, 28.25) and T₀ (Control, 25.72). Moving to the 60-day stage (60 DAS), the maximum plant height was recorded in T₂ (Microalgae, 54.14), followed closely by T₁ (Smc, 52.36), T₅ (Smc + Microalgae, 51.08), T₃ (*Azospirillum*, 49.97), T₄ (Smc + Microalgae + *Azospirillum*, 49.82), T₆ (Smc + *Azospirillum*, 48.68) and T₀ (Control, 40.01). As for the 90-day stage (90 DAS), the treatments with the highest plant height were T₂ (Microalgae, 56.93), T₁ (Smc, 54.18), T₃ (*Azospirillum*, 52.19), T₅ (Smc + Microalgae, 51.92), T₄ (Smc + Microalgae + *Azospirillum*, 51.65), T₆ (Smc + *Azospirillum*, 50.52) and T₀ (Control, 43.32).

Among all the treatments, the highest number of leaves per plant at 30 days after sowing (30 DAS) was observed in T₂ (Microalgae, 5.27), followed by T₁ (Smc, 4.87), T₆ (Smc + *Azospirillum*, 4.87), T₃ (*Azospirillum*, 4.80), T₄ (Smc + Microalgae + *Azospirillum*, 4.80), T₅ (Smc + Microalgae, 4.73) and T₀ (Control, 4.33). At 60 days after sowing (60 DAS), the highest plant height was recorded in T₂ (Microalgae, 7.27), followed by T₅ (Smc + Microalgae, 6.53), T₃ (*Azospirillum*, 6.47), T₁ (Smc, 6.40), T₄ (Smc + Microalgae + *Azospirillum*, 6.40), T₆ (Smc + *Azospirillum*, 6.20) and T₀ (Control, 5.93). Finally, at 90 days after sowing (90 DAS), the maximum plant

height was observed in T2 (Microalgae, 8.33), followed by T3 (Azosprillium, 8.27), T4 (Smc + Microalgae + Azosprillium, 7.87), T5 (Smc + Microalgae, 7.67), T6 (Smc + Azosprillium, 7.53), T1 (Smc, 7.47) and T0 (Control, 7.80).

Conclusions

Based on the findings of the present study, it can be concluded that the treatment involving the application of 4 kg/ha of Microalgae was the most effective in reducing purple blotch disease incidence and promoting both maximum plant height and the highest number of leaves in garlic plants. The integration of microalgae into garlic farming practices can contribute to more sustainable and resilient agricultural systems.

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Effect of soil amendments in combination to bio-resource on disease intensity of black mold (*Aspergillus niger*) and post-harvest parameters of Garlic

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Abstract

Garlic (*Allium sativum*) is a widely cultivated herbaceous plant renowned for its strong flavor and diverse applications in both culinary and medicinal contexts. One significant challenge in the storage of garlic and onions is the presence of *Aspergillus niger*, a highly destructive fungal disease that can lead to substantial losses, often as high as 80 percent. *Aspergillus niger* is widely distributed and can thrive in various soil types. It possesses the ability to endure a broad range of environmental conditions, including pH variations, salinity, alkalinity and even soil pollutants like heavy metals. To address this issue, experiments were conducted during the *Rabi* season of 2021-2022 in the Prayagraj district. The aim was to evaluate the effectiveness of different soil amendments, utilizing bio-resources, in the management of black mold disease and the promotion of garlic bulb growth. A Randomized Block Design with three replicates was employed, featuring seven environmentally friendly treatment groups: T0 - Control (FYM) at a rate of 10 t/ha, T1 - Spent Mushroom Compost applied at 10 t/ha, T2 - Microalgae applied at 4 kg/ha, T3 - *Azospirillum* applied at 5 kg/ha, T4 - Spent Mushroom Compost at 10 t/ha + Microalgae at 4 kg/ha + *Azospirillum* at 5 kg/ha, T5 - Spent Mushroom Compost at 10 t/ha + Microalgae at 4 kg/ha and T6 - Spent Mushroom Compost at 10 t/ha + *Azospirillum* at 5 kg/ha. The study assessed post-harvest parameters, including disease intensity percentage, bulb weight, bulb diameter, number of cloves, length of cloves and weight of cloves. These investigations aimed to find effective strategies for managing black mold disease and optimizing garlic bulb production.

Key words : Microalgae, spent mushroom compost, *Aspergillus niger*, microalgae.

Introduction

Garlic (*Allium sativum* L.), commonly known as “Lahsun,” holds a prominent position as one of the most important spices within the *Amaryllidaceae* family, ranking second only to onions in terms of widespread cultivation among *Allium* species. Garlic stands out for its superior nutritional value when compared to other *Allium* plants. Beyond its nutritive properties, garlic plays a significant role in traditional Indian systems of medicine, such as Ayurveda, Unani and Siddha, where it is utilized as a carminative and gastric stimulant to aid in digestion and the absorption of nutrients. However, the cultivation of garlic is often plagued by various fungal diseases that lead to substantial losses at various stages, including growth, harvesting, post-harvest handling, processing and marketing. These diseases not only diminish the quality of garlic but also hamper its export potential. Numerous fungal pathogens, such as *Aspergillus* spp., *Penicillium* spp., *Fusarium* spp., *Rhizopus* spp., *Colletotrichum* spp., *Pseudomonas* spp., *Alternaria* spp., *Lactobacillus* spp., *Erwinia* spp. and *Botrytis* spp., pose threats to onion and garlic bulbs during post-harvest storage. Among these pathogens, *Aspergillus* spp. stands out as a particularly virulent fungal pathogen, both in the field and during storage (McDonald

et al., 2004; Kumar *et al.*, 2015). *Aspergillus niger*, in particular, is a devastating disease that can result in losses of up to 80 percent during storage (Futane *et al.*, 2018). This fungus is widely distributed and can thrive in various soil types (Domich *et al.*, 1980), demonstrating remarkable adaptability to varying pH levels, salinity, alkalinity and even soil contaminants, including heavy metals (Baytak *et al.*, 2005; Ahmad *et al.*, 2006). Black mold rot is a common outcome of *Aspergillus niger* infestation, often occurring at the neck of bulbs on injured or necrotic leaf tissues. However, it can also develop on injured or diseased roots or on damaged outer scales along the sides of bulbs. Consequently, the present study was undertaken to assess the impact of organic amendments and microorganisms on the occurrence of black mold disease during the post-harvest phase in garlic cultivation.

Materials and Methods

The research was carried out at the Central Research Farm, which is located within the Department of Plant Protection at Sam Higginbottom University of Agriculture, Technology and Science in Prayagraj. This study was conducted during the *Rabi* season, spanning from November 2021 to March 2022. To prepare the

Table-1 : Effect of soil amendments with bio-resources on different post harvesting parameter of garlic at harvest.

Sr. No.	Treatments	Bulb weight (gm)	Bulb size/diameter (cm)	No. of cloves per bulb	Length of cloves (cm)	Weight of cloves (gm)	Black mould PDI 60 DAH
T ₀	Control (FYM)	7.93	3.93	16.33	2.15	1.55	30.00
T ₁	Spent Mushroom Compost + FYM	14.50	4.50	18.33	2.39	1.66	20.30
T ₂	Microalgae + FYM	25.53	6.20	25.33	2.87	1.96	8.30
T ₃	<i>Azospirillum</i> + FYM	19.20	4.70	22.33	2.55	1.74	24.60
T ₄	Spent Mushroom Compost + Microalgae + <i>Azospirillum</i> + FYM	20.60	5.13	18.67	2.37	1.65	16.40
T ₅	Spent Mushroom Compost + Microalgae + FYM	21.67	5.23	19.33	2.60	1.67	19.90
T ₆	Spent Mushroom Compost + <i>Azospirillum</i> + FYM	18.77	4.47	19.00	2.47	1.76	16.90
	C.D. (5%)	1.98	0.80	1.91	0.25	0.06	2.26
	S. Ed (±)	0.91	0.37	0.88	0.11	0.03	1.04

designated field for experimentation, several steps were taken. Initially, the field was cleared of weeds, ensuring a clean and weed-free environment. Subsequently, it was leveled to create an even surface. The soil was meticulously broken down to achieve a fine texture suitable for planting. The entire area was then divided into 21 individual plots. During the field preparation phase prior to planting the garlic crops, specific organic amendments were applied to plots. For this experiment, the garlic variety known as “Bhim Omkara” was selected. The primary objective was to evaluate the impact of these organic amendments on the occurrence of black mold disease and the growth of garlic bulbs. During the irrigation process, microalgae was applied to the designated plots in the form of a slurry at a rate of 5 kilograms per hectare. The study involved the assessment of disease severity, along with various parameters related to bulb weight, bulb diameter, number of cloves, length of cloves and weight of cloves. Disease intensity was calculated as a percentage using a 0-5 point rating scale, following the methodology described by Wani and Nisa in 2011.

Results and Discussion

In the post-harvest phase, the results reveal that the treatment with the lowest disease intensity was T₂ (Microalgae, 8.30%), followed by T₄ (Smc + Microalgae + *Azospirillum*, 16.84%), T₆ (Smc + *Azospirillum*, 16.9%), T₅ (Smc + Microalgae, 19.9%), T₁ (Smc, 20.30%), T₃ (*Azospirillum*, 24.60%) and T₀ (Control, 30.00%). Among these treatments, T₁, T₅ and T₆ did not show statistically significant differences in disease intensity. Regarding bulb weight, T₂ (Microalgae) exhibited the highest weight at 25.53, followed by T₄ (Smc + Microalgae + *Azospirillum*, 20.60), T₅ (Smc + Microalgae, 21.67), T₃ (*Azospirillum*, 19.20), T₆ (Smc + *Azospirillum*, 18.77), T₁ (Smc, 14.50) and T₀ (Control, 7.93). For bulb size, T₂ (Microalgae) had the largest size at 6.20, followed by T₅ (Smc + Microalgae, 5.23), T₄ (Smc + Microalgae + *Azospirillum*, 5.13), T₃

(*Azospirillum*, 4.70), T₁ (Smc, 4.50), T₆ (Smc + *Azospirillum*, 4.47) and T₀ (Control, 3.93). In terms of the number of cloves, T₂ (Microalgae) had the highest count at 25.33, followed by T₃ (*Azospirillum*, 22.33), T₅ (Smc + Microalgae, 19.33), T₆ (Smc + *Azospirillum*, 19.00), T₄ (Smc + Microalgae + *Azospirillum*, 18.67), T₁ (Smc, 18.33) and T₀ (Control, 16.33). For the length of cloves, T₂ (Microalgae) recorded the longest at 2.87 cm, followed by T₅ (Smc + Microalgae, 2.60 cm), T₃ (*Azospirillum*, 2.55 cm), T₆ (Smc + *Azospirillum*, 2.47 cm), T₁ (Smc, 2.39 cm), T₄ (Smc + Microalgae + *Azospirillum*, 2.37 cm) and T₀ (Control, 2.15 cm). In terms of clove weight, T₂ (Microalgae) had the highest weight at 1.96 g, followed by T₆ (Smc + *Azospirillum*, 1.76 g), T₃ (*Azospirillum*, 1.74 g), T₅ (Smc + Microalgae, 1.67 g), T₁ (Smc, 1.66 g), T₄ (Smc + Microalgae + *Azospirillum*, 1.64 g) and T₀ (Control, 1.55 g).

Conclusions

Based on the outcomes of this research, it can be deduced that the treatment utilizing 4 kg/ha of Microalgae proved to be the most successful in mitigating the incidence of black mold disease and fostering favorable characteristics in garlic plants, such as increased bulb weight, bulb diameter, number of cloves, length of cloves and weight of cloves. The utilization of bio-resource amendments in the field offers an environmentally safe approach to disease management and yield enhancement. This approach is not only advantageous but also ecologically friendly. The incorporation of microalgae into garlic farming practices holds the potential to contribute to the development of more sustainable and resilient agricultural systems.

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Economic Evaluation of Various Soil Amendments in Conjunction with Bio-Resources for Controlling Purple Blotch (*Alternaria porri*) and Black Mold (*Aspergillus niger*) in Garlic Cultivation

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Abstract

Garlic, scientifically known as *Allium sativum*, is a pungent and flavorful herb that has been cultivated and used for both culinary and medicinal purposes for thousands of years. In order to determine the effectiveness of various soil amendments containing bio resources in mitigating purple blotch (*Alternaria Porri*) and black mold (*Aspergillus Niger*) diseases in garlic, each treatment was replicated three times and assessed for disease severity, as well as different growth and yield parameters of the garlic crop. Consequently, field experiments were carried out in the Prayagraj district during the Rabi 2021-2022 season to assess the effectiveness of various soil amendments using bio-resources in managing purple blotch disease and enhancing the growth of garlic crops. A Randomized Block Design was adopted with three replicates for seven environmentally friendly treatment groups. The following soil amendment treatments were employed for evaluation: T0 - Control (FYM) at a rate of 10 t/ha, T1 - Spent Mushroom Compost applied at 10 t/ha, T2 - Microalgae applied at 4 kg/ha, T3 - *Azospirillum* applied at 5 kg/ha, T4 - Spent Mushroom Compost at 10 t/ha + Microalgae at 4 kg/ha + *Azospirillum* at 5 kg/ha, T5 - Spent Mushroom Compost at 10 t/ha + Microalgae at 4 kg/ha and T6 - Spent Mushroom Compost at 10 t/ha + *Azospirillum* at 5 kg/ha. The economic analysis involved assessing the costs associated with each treatment, including the expenses for acquiring and applying soil amendments, labor and any other relevant inputs. Additionally, the benefits were determined by measuring the increase in garlic yield attributed to each treatment. The benefit-cost ratio (B: C) was then calculated for each treatment by dividing the total benefits by the total costs.

Key words : Microalgae, spent mushroom compost, benefit-cost ratio, microalgae.

Introduction

Garlic, scientifically known as *Allium sativum*, is a versatile and widely used herb and vegetable with a rich history and a distinctive flavor profile. It belongs to the *Allium* genus, making it a close relative of onions, leeks and shallots. Garlic is renowned for its pungent aroma and strong, savory taste, which adds depth and complexity to a wide range of culinary dishes. This remarkable herb has a global presence and has been cultivated and enjoyed by various cultures for thousands of years. Garlic is believed to have originated in Central Asia and its use in cooking and for medicinal purposes can be traced back to ancient civilizations such as the Egyptians, Greeks and Romans. Garlic's culinary versatility has made it an essential ingredient in numerous cuisines around the world, including Mediterranean, Asian, Middle Eastern and Latin American cooking. It is used in both raw and cooked forms, enhancing the taste of soups, sauces, stir-fries, roasts and countless other dishes. Garlic is also frequently incorporated into marinades, dressings and spreads, contributing its unique zesty and aromatic notes. Beyond its culinary significance, garlic has a long history of being

used for its potential health benefits. It is often regarded as a natural remedy for various ailments and is thought to have properties that can support the immune system, reduce the risk of cardiovascular diseases and possess anti-inflammatory and antioxidant effects. Uttar Pradesh ranks third in India with an area of 34,310 hectares, production of 2,27,340 tonnes and productivity of 6625 kg/ha. India 3,49,390 hectares, production of 29,23,150 tonnes and productivity of 8366 kg/ha (DASD, 2019-20). From different parts of the world, downy mildew, rust, purple blotch; *Stemphylium* blight, basal rot, have been observed leading to substantial losses garlic (*Allium sativum* L.) (Ahmad and Karimullah, 1998). Various aspects of Purple blotch (*Alternaria porri*) (Dhiman *et al.*, 1986); *Stemphylium* blight (Thind *et al.*, 1985) basal rot (*Fusarium oxysporum*) (Mathur and Sankhala, 1963) Rust (*Puccinia porri*) (Sandhu and Kang, 1988); garlic mosaic virus (Ahlawat, 1974), downy mildew (Singh *et al.*, 1987) are reported from India. Garlic crop suffers from many fungal diseases, which cause considerable losses during growing, harvesting, post harvesting, processing and marketing stages, which lower the quality and export potentiality of the crop. The B:C ratio is a useful indicator

Table-1 : Cost of cultivation per hectare.

S. No.	Unit	Qty.	Rate (ha ⁻¹)	Total cost (ha ⁻¹)
A. Land preparation				
1. Ploughing	Hours	3	500	1500
2. Layout of the field	Hours	10	300	3000
b. Seed rate 5 q/ha				
Seed	kg/ha	500 kg	80	40000
D. Spreading application				
1. Seed sowing charges	Labour	10	300	3000
E. Hand weeding (2 labours/ weeding)	Labour	10	300	3000
F. Irrigation				
1. 3 Irrigation tube well charges	Hours	5	400	2000
2. Labour for irrigation	Labour	7	200	1400
G. Harvesting	Labour	40	300	12000
I. Operation	Labour	10	200	2000
Total cost		Rs. 67,900		

Table-2 : Economics of different treatments and benefit cost ratio of soil amendments with bio-resources on yield of garlic.

S. N.	Treatments	Amount kg/ha	Cost (Rs)	Broad casting Labour Charge (Rs)	Total Treatment cost (Rs)	Total cost of production	Yield (q/ha)	Sale (q/ha)	Income yield over control (q/ha)	Net income	C:B ratio
T ₀	Control (FYM)	10 t/ha	1,00,000	2400	102400	1,70,300	42.09	8000	336720	1,66,420	1:1
T ₁	Smc @10 t/ha	10 t/ha	1,00,000	2400	102400	1,70,300	74.93	8000	599440	4,29,140	1:3
T ₂	Microalgae @ 4 kg/ha	4 kg/ha	1600	2400	4000	71,900	104.70	8000	837600	7,65,700	1:11
T ₃	Azospirillum @ 5 kg/ha	5 kg / ha	1000	2400	3400	71,300	79.35	8000	634800	5,63,500	1:8
T ₄	Smc 10 t/ha+ Microalgae 4kg/ha + Azospirillum 5kg/ha	10 t/ha+4 kg/ha+5 kg/ha	1,02,600	2400	105000	1,72,900	83.54	8000	668320	4,95,420	1:3
T ₅	Smc 10 t/ha + Microalgae 4 kg/ha	10 t/ha +4 kg/ha	1,01,600	2400	104000	1,71,900	87.97	8000	703760	5,31,860	1:3
T ₆	Smc 10 t/ha+ Azospirillum 5kg/ha	10 t/ha+5kg /ha	1,01,000	2400	103400	1,71,300	76.28	8000	610240	4,38,940	1:3

to evaluate the profitability of agricultural practices or treatments. Hence the present study was conducted to evaluate the most beneficial treatment in terms of economic and eco-friendly aspects in garlic production.

Materials and Methods

The current investigation was carried out at the Central Research Farm, which is located within the premises of the Department of Plant Protection at Sam Higginbottom University of Agriculture, Technology and Science in Prayagraj. This research project was conducted during the Rabi season, spanning from November 2021 to March 2022. In order to prepare the designated field for experimentation, the following steps were taken: removal of weeds, precise leveling of the terrain and thorough soil refinement. The entire experimental area was divided into 21 separate plots. Within these individual plots, the recommended quantities of Farm Yard Manure (FYM) at a rate of 10 tons per hectare, Spent Mushroom Compost

(SMC) at 10 tons per hectare and *Azospirillum* at 5 kilograms per hectare were integrated into the soil during the pre-planting field preparation. The cost of cultivation per hectare was calculated and the total yield was converted into monetary value using the market rate applicable during that period to determine the benefit-cost ratio.

Results and Discussion

All of the treatments demonstrated economic viability when compared to the T₀ control, but the most economically efficient treatment was T₂, involving the application of Microalgae at a rate of 4 kg per hectare, which yielded a remarkable benefit-cost ratio of 1:11. Following closely was T₃, which utilized *Azospirillum* at 5 kg per hectare, resulting in a benefit-cost ratio of 1:8. Meanwhile, treatments T₁ (incorporating SMC at 10 tons per hectare), T₄ (SMC at 10 tons per hectare + Microalgae at 4 kg/ha + *Azospirillum* at 5 kg/ha), T₅ (SMC at 10 tons

per hectare + Microalgae at 4 kg/ha) and T6 (SMC at 10 tons per hectare + *Azospirillum* at 5 kg/ha) were economically feasible as well, yielding benefit-cost ratios of 1:3. The control treatment, T0, achieved a benefit-cost ratio of 1:1. These findings indicate that all treatments provided a positive economic return, with T2 and T3 being particularly profitable in terms of cost-benefit analysis.

Conclusions

The most cost-effective treatment was the application of Microalgae at a rate of 4 kg per hectare, which resulted in an impressive benefit-cost ratio of 1:11. This economic analysis provides valuable insights into the cost-effectiveness of different soil amendments and their impact on garlic yield. Farmers and agricultural practitioners can use this information to make informed decisions about which treatment options are economically beneficial for their garlic cultivation.

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Multivariate Analysis of Genetic Diversity in Blackgram (*Vigna mungo* (L.) Hepper) Genotypes

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Abstract

The present study was undertaken to provide information on the nature and magnitude of genetic diversity among 45 blackgram genotypes for yield contributing traits by using Mahalanobis's D^2 statistics. Forty five genotypes could be grouped in 7 clusters, cluster VII showed maximum intra-cluster distance while the highest inter-cluster distance was observed between cluster I and VII. The cluster VII showed high mean values for cluster/plant, pods/cluster, seed yield/plant (gm), biological yield (gm). From the divergence analysis, it may be concluded that the genotypes belonging to different clusters separated by high estimated statistical distance may be used in the hybridization programme for developing high yielding blackgram varieties. The data of fourteen morphological traits were recorded and analyzed to find out principal components to reveal the diversity among the genotypes. It was observed that 5 out of 6 principal components with an eigen value of ≥ 1.0 calculated for 71.51% of the total diversity observed between 45 accessions of blackgram. PC 1 contributes the maximum towards the total variability (25.36). The characters viz., days to 50 percent flowering, Pod length (cm), Seed yield per plant (g) and Seed protein content (%) explained the maximum variance in PC 1.

Key words : Genetic diversity, blackgram, PCA analysis, multivariate analysis, cluster analysis.

Introduction

Blackgram (*Vigna mungo* (L.) Hepper) is an annual leguminous crop belongs to family fabaceae and sub-family papilionaceae with a chromosome number of $2n=22$ (Dana, 1980) and originated from Indian continent (De Candolle; 1882, Vavilov; 1926 and Zuckovskij, 1962). It is an economically important grain legume crop in Asia, widely cultivated on marginal lands with low inputs during *kharif*, *rabi* and summer seasons. Blackgram is the fourth important pulse crop in India which holds about 13 per cent of the total pulse area and contributing about 10 per cent to the total pulse production. It is grown in various agro-ecological conditions and cropping systems with diverse agricultural practices (Gupta *et al.* 2001). Several high yielding and disease resistant cultivars developed through routine breeding approaches have been released in blackgram. In spite of this, production, area and productivity remained virtually stagnant over the last 20 years in India. Hence, there is vast scope of genetic improvement in blackgram for developing superior high yielding varieties.

Materials and Methods

In this experiment, 45 genotypes including 2 checks of blackgram were collected from Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, (MS) and AICRP on MULLARP, ARS, Agriculture University, Kota (Table-1). These genotypes were evaluated during *kharif*, 2017 at Instructional Research Farm, Department of Plant

Breeding and Genetics, Rajasthan College of Agriculture, MPUAT, Udaipur. The experimental material was sown in randomized block design in 3 replications. 2 rows of each genotype were sown in 3-meter row length. The row to row and plant to plant distance was kept at 30 cm and 10 cm, respectively. Observations for the traits viz., days to 50 % flowering and days to 75 % maturity were recorded on plot basis. While traits viz., plant height (cm), number of branches per plant, number of clusters per plant, number of pods per plant, number of pods per cluster, pod length (cm), number of seeds per pod, seed yield per plant (g), biological yield per plant (g), harvest index (), 100-seed weight (g) and seed protein content () were recorded on randomly selected five competitive plants per plot in each replication. Statistical analysis was performed using Mahalanobis's D^2 statistics.

Results and Discussion

Grouping of genotypes into various clusters : Based on Mahalanobis D^2 , the forty-five genotype were grouped into seven clusters by the application of the clustering technique, cluster V comprised largest number of eleven genotypes followed by cluster IV and VII with eight genotypes, cluster II and VI with six genotypes, while cluster I and III with three genotypes each (Table 2). It shows that the selection of parents for hybridization based on geographical origin would be arbitrary. The distribution of genotypes from different eco-geographical regions into these clusters was apparently random. Genotypes from similar origin were grouped into different clusters. This

Table-1 : List of genotypes and Checks.

S. No.	Genotypes	Germplasm source	S. No.	Genotypes	Germplasm source
1.	KPU-1127	ARS, Kota	24.	TBU-6	Pulses Research Unit, Akola
2.	KPU-1097	ARS, Kota	25.	AKU-1603	Pulses Research Unit, Akola
3.	GP(U)KPU-1098	ARS, Kota	26.	KU-16-102	Pulses Research Unit, Akola
4.	KU-16-11	Pulses Research Unit, Akola	27.	AKU-1601	Pulses Research Unit, Akola
5.	KU-16-87	Pulses Research Unit, Akola	28.	AKU-13-02	Pulses Research Unit, Akola
6.	KU-16-105	Pulses Research Unit, Akola	29.	AKU-14-02	Pulses Research Unit, Akola
7.	GP(U)KPU-1137	ARS, Kota	30.	AKU-11-21	Pulses Research Unit, Akola
8.	KU-1698	ARS, Kota	31.	AKU-13-3	Pulses Research Unit, Akola
9.	KU-16-8	Pulses Research Unit, Akola	32.	AKU-11-3	Pulses Research Unit, Akola
10.	KU-16-5	Pulses Research Unit, Akola	33.	AKU-11-14	Pulses Research Unit, Akola
11.	GP(U)KPU-1143	ARS, Kota	34.	AKU-11-9	Pulses Research Unit, Akola
12.	KU-16-9	Pulses Research Unit, Akola	35.	AKU-11-23	Pulses Research Unit, Akola
13.	KU-16-97	Pulses Research Unit, Akola	36.	KU-16-90	Pulses Research Unit, Akola
14.	KU-16-92	Pulses Research Unit, Akola	37.	KU-16-96	Pulses Research Unit, Akola
15.	Vallabh U-1	ARS, Kota	38.	KU-16-6	Pulses Research Unit, Akola
16.	KPU-514-75	ARS, Kota	39.	KU-16-3	ARS, Kota
17.	AKU-1604	Pulses Research Unit, Akola	40.	KU-16-13	Pulses Research Unit, Akola
18.	KU-16-95	Pulses Research Unit, Akola	41.	AKU-11-15	Pulses Research Unit, Akola
19.	KPU-129-104	ARS, Kota	42.	AKU-13-15	Pulses Research Unit, Akola
20.	KU-16-89	Pulses Research Unit, Akola	43.	AKU-12-3	Pulses Research Unit, Akola
21.	KU-16-101	Pulses Research Unit, Akola	44.	Pratap Urd-1 (Check)	ARS, Kota
22.	AKU-11-12	Pulses Research Unit, Akola	45.	PU-31 (Check)	ARS, Kota
23.	TBU-2	Pulses Research Unit, Akola			

Table-2 : Cluster composition of 45 blackgram genotypes.

Cluster	Genotypes
Cluster 1	KPU-1098, AKU-11-15, KU-16-101 (3)
Cluster 2	KU-16-87, KPU-514-75, TBU-6, KU-16-6, Pratap Urd-1, AKU-11-14 (6)
Cluster 3	KU-16-9, KU-16-96, KU-1698 (3)
Cluster 4	GP(U) KPU-1137, AKU-11-21, GP(U) KPU-1098, KU-16-5, KU-16-13, Vallabh U-1, KU-16-90, KU-16-105 (8)
Cluster 5	KU-16-11, AKU-11-3, GP(U) KPU-1143, KU-1695, KPU-129-104, AKU-11-12, KU-16-89, KU-16-102, AKU-13-15, AKU-1601, AKU-11-9 (11)
Cluster 6	AKU-1604, AKU-13-3, AKU-1603, AKU-11-23, PU-31, AKU-14-02 (6)
Cluster 7	KU-16-8, KU-16-3, KU-16-97, TBU-2, AKU-1302, AKU-12-3, KPU-1127, KU-16-92 (8)

Table-3 : Inter-cluster and Intra-cluster (diagonal) D2 values of 45 blackgram genotypes (Ward method).

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
Cluster 1	28.003	113.241	94.055	136.351	127.327	123.146	213.040
Cluster 2		53.224	86.317	89.613	79.736	84.500	160.569
Cluster 3			51.004	117.612	92.955	135.104	206.275
Cluster 4				70.783	133.956	113.054	229.016
Cluster 5					51.194	82.692	102.042
Cluster 6						67.500	103.281
Cluster 7							80.001

tendency of genotypes to occur in clusters cutting across geographical boundaries demonstrates that geographical region is not only factor causing genetic diversity.

Intra and inter clusters distance : Maximum intra cluster distance was in cluster-VII (80.001) followed by IV (70.783), VI (67.500), II (85.313), IV (53.224), V (51.194),

III (51.004) and I (28.003). The high intra-cluster distance in cluster VII, indicated the presence of wide genetic diversity among the genotypes in this cluster. Highest inter cluster distance implied that the hybridization strategy including parents from the clusters decided to have superior occurrence of the enhanced segregates. The highest inter cluster distance was observed in between

Table-4 : Relative contribution of 14 characters to genetic diversity in 45 genotypes of blackgram.

S. No.	Statistics	Contribution %	Time Ranked 1st
1.	Days to 50% Flowering	1.31	13
2.	Days to 75% Maturity	1.62	16
3.	Plant Height (cm)	5.15	51
4.	Branches/Plant	26.36	261
5.	Cluster/Plant	12.93	128
6.	Pods/Plant	9.90	98
7.	Pods/Cluster	1.21	12
8.	Pod Length (cm)	6.06	60
9.	Seeds/Pod	3.33	33
10.	Seed Yield/Plant (gm)	0.20	2
11.	Biological Yield (gm)	1.01	10
12.	Harvest Index (%)	0.81	8
13.	100 Seed Weight (gm)	25.86	256
14.	Seed Protein Content (%)	4.24	42

Table-5 : Cluster means of fourteen characters in 45 blackgram genotypes (Tocher method).

	Days to 50% flowering	Days to 75% maturity	Plant height (cm)	Branches/plant	Cluster s/plant	Pods/plant	Pods/pluster	Pod length (cm)	Seeds/pod	Seed yield/plant (gm)	Biological yield (gm)	Harvest index (%)	100 seed weight (gm)	Seed protein content (%)
Cluster 1	43.77	77.77	22.21	5.41	6.55	20.23	3.11	4.15	5.93	4.94	14.80	33.48	5.19	21.85
Cluster 2	42.16	73.88	22.11	7.84	6.50	17.20	2.67	4.15	5.73	3.84	12.86	30.06	4.40	22.85
Cluster 3	43.33	76.33	26.940	6.41	7.40	16.38	2.23	4.53	5.46	3.76	13.21	28.60	5.12	24.42
Cluster 4	43.62	75.33	22.53	5.44	6.32	16.89	2.73	4.39	5.06	3.97	14.11	28.49	3.74	23.35
Cluster 5	43.39	76.09	21.28	8.691	8.01	19.58	2.46	4.53	5.31	4.56	15.78	29.22	4.60	24.12
Cluster 6	43.44	75.22	22.634	8.05	7.48	21.71	2.93	4.04	5.45	5.03	15.56	32.50	3.97	22.44
Cluster 7	42.95	74.50	22.32	10.00	9.68	22.90	2.39	4.07	5.64	5.41	17.55	31.25	4.22	22.87

Table-6 : Factor loadings of traits with respect to different principal factors in Blackgram genotypes.

S. No.	Statistics	PC1	PC2	PC3	PC4	PC5	PC6
1.	Days to 50% Flowering	0.008	0.318	0.280	0.145	0.317	0.627
2.	Days to 75% Maturity	0.091	0.500	-0.017	-0.388	-0.209	0.169
3.	Plant Height (cm)	0.026	-0.475	-0.116	-0.170	-0.287	0.364
4.	Branches/Plant	-0.405	-0.027	-0.316	0.202	0.221	-0.098
5.	Cluster/Plant	-0.414	0.094	-0.212	0.020	0.135	0.242
6.	Pods/Plant	-0.459	0.081	0.100	-0.138	-0.042	0.058
7.	Pods/Cluster	-0.182	0.091	0.355	-0.298	-0.026	0.069
8.	Pod Length (cm)	0.219	0.047	0.007	-0.122	0.694	-0.148
9.	Seeds/Pod	-0.105	-0.341	0.346	-0.237	0.340	-0.254
10.	Seed Yield/Plant (gm)	-0.445	0.001	0.268	0.034	0.047	0.015
11.	Biological Yield (gm)	-.347	-0.232	-0.156	-0.117	-0.037	0.027
12.	Harvest Index (%)	-0.170	0.458	-0.086	0.192	-0.161	-0.463
13.	100 Seed Weight (gm)	-0.036	0.105	-0.143	-0.709	0.008	-0.171
14.	Seed Protein Content (%)	0.036	0.048	-0.617	-0.148	0.272	0.186
	Eigen Value (Root)	3.551	2.117	1.782	1.393	1.167	0.895
	% var. Exp.	25.36	15.12	12.73	9.95	8.34	6.39
	Cum. Var. Exp.	25.36	40.48	53.22	63.17	71.51	77.91

average inter cluster values were maximum between cluster I and VII (185.037) followed by cluster II and VII (107.345) and cluster III and cluster VII (155.271 and cluster IV and cluster VII (158.233). For rest of the pairs, average divergence ranged from 50.848 (V and VII) and 35.781 (VI and VII). The average intra and inter cluster distance are given in Table 3. Minimum inter-cluster distance determines less heterogeneity in the genotypes.

The intra-cluster distance represented the low heterogeneity of the genotypes and the maximum intra-cluster distance indicated that the variability of the genotypes was low and that the selection for the character was less favorable.

Relative contribution of different characters : Relative contribution of each of the 14 characters towards the total

divergence was worked out using per cent I rank and some D^2 for each character over the pairs of genotypes (Table 4). Trend of contribution of different characters was same in both the methods. Maximum contribution towards the total D^2 using square of D^2 was found to be for branches/plant (26.36), followed by 100 seed weight (gm) (25.86 %), clusters/plant (12.93%), pods/plant (9.90%), pod length (cm) (6.06%), plant height (cm) (5.15%), seed protein content (%) (4.24), seeds/pod (3.33%), days to 75% maturity (1.62%), days to 50 % flowering (1.31%), pods/plant (1.21%), biological yield (gm) (1.01), harvest index (0.81%) and seed yield/plant (0.20%).

Cluster means : Perusal of data on cluster mean for various traits revealed wide difference in mean values under study (Table 5). The cluster VII showed high mean values for clusters/plant (9.68), pods/cluster (22.90), seed yield/plant (gm) (5.41) and biological yield (gm) (17.55) and cluster V showed high mean values for branches/plant (8.69) and pod length (cm) (4.53) and cluster III showed high mean values for plant height (cm)

(26.94), pod length (cm) (4.53) and seed protein content (%) (24.42) and cluster I showed high mean values for days to 50 % flowering (43.77), days to 75 % maturity (77.77), pods/plant (3.11), seeds/pod (5.93), harvest index(%) (33.48) and 100 seed weight (gm) (5.19).

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Effect of Nano DAP on Physico-Chemical Properties of Soil After Harvesting of Maize (*Zea mays* L.)

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Abstract

A field experiment was conducted during kharif 2022 at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur to study the Seed treatment and foliar applications of nano DAP under various treatments of maize (*Zea mays* L.) cultivar PHM-3 in sub-humid southern plain and Aravalli hill region of Rajasthan. The experiment was laid out in randomized block design with 3 replications and 12 treatments viz. T₁ (0% P₂O₅ with (100% N&K) control DAP), T₂ (100% P₂O₅ with Basal DAP (100% N&K), T₃ (25% P₂O₅ with Basal DAP (100% N&K)), T₄ (50% P₂O₅ with Basal DAP (100% N&K), T₅ (T₁ + ST @ 5ml kg⁻¹ seed + 1FS @ 2ml L⁻¹ with Nano DAP), T₆ (T₁ + ST @ 5ml kg⁻¹ seed + 2FS @ 2ml L⁻¹ with Nano DAP), T₇ (T₁ + ST @ 5ml kg⁻¹ seed + 1FS @ 4ml L⁻¹ with Nano DAP), T₈ (T₁ + ST @ 5ml kg⁻¹ seed + 2FS @ 4ml L⁻¹ with Nano DAP), T₉ (T₃ + ST @ 5ml kg⁻¹ seed + 1FS @ 2ml L⁻¹ with Nano DAP), T₁₀ (T₃ + ST @ 5ml kg⁻¹ seed + 2FS @ 2ml L⁻¹ with Nano DAP), T₁₁ (T₄ + ST @ 5ml kg⁻¹ seed + 1FS @ 2ml L⁻¹ with Nano DAP) and T₁₂ (T₄ + ST @ 5ml kg⁻¹ seed + 2FS @ 2ml L⁻¹ with Nano DAP). The Seed treatment and foliar applications of nano DAP with various treatments had no appreciable impact on the soil pH and EC and OC and available zinc, iron, manganese and copper. And available N, P and K content in soil after harvest stage of the crop increased significantly with treatment over the control. The maximum available nitrogen, phosphorus and potassium content in soil, (337.62 kg ha⁻¹), (23.16 kg ha⁻¹), (460.48 kg ha⁻¹) was observed under T₁₂ (T₄ + ST @ 5ml kg⁻¹ seed + 2FS @ 2ml L⁻¹ with Nano DAP) significantly superior over the control and rest of treatments. However, T₁₂ remain at par with T₁₁ (T₄ + ST @ 5ml kg⁻¹ seed + 1FS @ 2ml L⁻¹ with Nano DAP) with respect of available nitrogen, phosphorus and potassium content in soil.

Key words : Nano-DAP, maize, physico-chemical, soil, available.

Introduction

Maize (*Zea mays* L.) is one of the most adaptable crop among cereals. It is the third most expanded crop in the world and cultivated in arid and semi-arid conditions (Shahzad *et al.*, 2020). It has now become staple food crop for human beings across the world ensuring food and nutritional security and its demand is shifting to animal and poultry feed, at the same time it has significant importance in production of number of industrial products viz. maize corn, baby corn, corn starch, corn oil, popcorn etc. Maize is grown in 9.86 million hectares area with production of 30.1 million tonnes and average productivity of 3050 kg ha⁻¹ which is largely contributed by Andhra Pradesh, Karnataka, Rajasthan, Maharashtra (FAOSTAT, 2020). In Rajasthan, maize is widely cultivated under rainfed condition in *Kharif* season in Mewar, Wagad and Hadoti regions and rank first in respect of area, whereas this crop occupies an area of 0.99 million hectares having an annual production of 2.27 million tonnes and average productivity 2285 kg ha⁻¹ (INDIASTAT, 2021). Despite having high yield potential of maize, its productivity is low due to many constraints and one of them is nutrient deficient in the soil. All though, application of excess

quantity of fertilizer will not increase yield of maize, however, maize is a fertilizer responsive crop, but excessive, untimely and unscientific application of fertilizers will have a negative impact on the yield.

Nano fertilizer, the most important field of agriculture has been to the attention of the soil scientists as well as the environmentalists due to its capability to increase yield, improve soil fertility, reduce pollution and make a favorable environment for microorganisms. Application of nano fertilizers is a newly emerging technique that could be used in agriculture to improve the plant growth. The superiority of this technique over the conventional fertilizers is mainly managed by decreasing the wastage of fertilizers, and consequently, the risk of environmental pollution would be low as well. Nano fertilizer is that they can be used in fewer amounts than the ordinary fertilizers, which reduces the cost of fertilizer application and would be economical from the farmer's point of view. Consequently, the importance of promoting the efficiency of P uptake and use in agricultural crops while supplying nano fertilizers with phosphorus represents an alternative.

Materials and Methods

Experimental site and soil : The field experiment was

Table-1 : Effect of seed treatment and foliar application of nano DAP on pH, EC and Organic carbon of soil after harvest of maize.

Treatments	pH	EC	Organic carbon (%)
T ₁ 0% P ₂ O ₅ (100% N&K) control	8.44	0.52	0.58
T ₂ 100% P ₂ O ₅ with Basal DAP (100% N&K)	8.29	0.51	0.57
T ₃ 25% P ₂ O ₅ with Basal DAP (100% N&K)	8.46	0.51	0.53
T ₄ 50% P ₂ O ₅ with Basal DAP (100% N&K)	8.53	0.53	0.54
T ₅ T ₁ + ST @ 5ml kg ⁻¹ seed + 1FS @ 2ml L ⁻¹ with Nano DAP	8.55	0.43	0.61
T ₆ T ₁ + ST @ 5ml kg ⁻¹ seed + 2FS @ 2ml L ⁻¹ with Nano DAP	8.50	0.48	0.61
T ₇ T ₁ + ST @ 5ml kg ⁻¹ seed + 1FS @ 4ml L ⁻¹ with Nano DAP	8.41	0.54	0.63
T ₈ T ₁ + ST @ 5ml kg ⁻¹ seed + 2FS @ 4ml L ⁻¹ with Nano DAP	8.54	0.47	0.65
T ₉ T ₃ + ST @ 5ml kg ⁻¹ seed + 1FS @ 2ml L ⁻¹ with Nano DAP	8.31	0.54	0.68
T ₁₀ T ₃ + ST @ 5ml kg ⁻¹ seed + 2FS @ 2ml L ⁻¹ with Nano DAP	8.26	0.41	0.70
T ₁₁ T ₄ + ST @ 5ml kg ⁻¹ seed + 1FS @ 2ml L ⁻¹ with Nano DAP	8.57	0.45	0.64
T ₁₂ T ₄ + ST @ 5ml kg ⁻¹ seed + 2FS @ 2ml L ⁻¹ with Nano DAP	8.26	0.52	0.67
SEm±	0.158	0.029	0.036
CD (P=0.05)	NS	NS	NS

Table-2 : Effect of seed treatment and foliar application of nano DAP on available N, P and K in soil after harvest of maize.

Treatments	Available Nitrogen (kg ha ⁻¹)	Available Phosphorus (kg ha ⁻¹)	Available Potassium (kg ha ⁻¹)
T ₁ 0% P ₂ O ₅ (100% N&K) control	281.35	17.90	398.81
T ₂ 100% P ₂ O ₅ with Basal DAP (100% N&K)	290.18	26.23	411.19
T ₃ 25% P ₂ O ₅ with Basal DAP (100% N&K)	258.40	24.34	393.59
T ₄ 50% P ₂ O ₅ with Basal DAP (100% N&K)	297.52	19.73	420.55
T ₅ T ₁ + ST @ 5ml kg ⁻¹ seed + 1FS @ 2ml L ⁻¹ with Nano DAP	298.48	19.80	420.98
T ₆ T ₁ + ST @ 5ml kg ⁻¹ seed + 2FS @ 2ml L ⁻¹ with Nano DAP	310.42	23.58	431.74
T ₇ T ₁ + ST @ 5ml kg ⁻¹ seed + 1FS @ 4ml L ⁻¹ with Nano DAP	306.18	23.61	426.87
T ₈ T ₁ + ST @ 5ml kg ⁻¹ seed + 2FS @ 4ml L ⁻¹ with Nano DAP	292.64	20.61	410.36
T ₉ T ₃ + ST @ 5ml kg ⁻¹ seed + 1FS @ 2ml L ⁻¹ with Nano DAP	316.40	21.09	436.27
T ₁₀ T ₃ + ST @ 5ml kg ⁻¹ seed + 2FS @ 2ml L ⁻¹ with Nano DAP	322.60	21.89	441.16
T ₁₁ T ₄ + ST @ 5ml kg ⁻¹ seed + 1FS @ 2ml L ⁻¹ with Nano DAP	334.33	22.91	460.19
T ₁₂ T ₄ + ST @ 5ml kg ⁻¹ seed + 2FS @ 2ml L ⁻¹ with Nano DAP	337.62	23.16	460.48
SEm±	3.751	0.419	9.234
CD (P=0.05)	11.002	1.228	27.083

conducted during kharif 2020 at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur situated at an altitude of 579.5 m above mean sea level and at 24°03' latitude and 73°42' longitude. This region falls under agro-climatic zone-IVa (Sub- humid Southern Plain and Aravalli Hills) of Rajasthan.

The experimental soil was alkaline (pH 8.26±0.16), non-saline (with electrical conductivity of 0.631±0.01 dS m⁻¹) clay loam; medium in organic carbon (0.63±0.01%); low in available N (272±5 kg ha⁻¹), and available P (17.97 ±0.32 kg ha⁻¹); high in available K (352±7 kg ha⁻¹); and low in available zinc (0.59±0.01 mg kg⁻¹).

Experimental design and treatments : The experiment was laid out in randomized block design with 3 replications and 12 treatments viz. T₁ (0% P₂O₅ with (100% N&K) control DAP), T₂ (100% P₂O₅ with Basal DAP (100% N&K), T₃ (25% P₂O₅ with Basal DAP (100% N&K)), T₄ (50% P₂O₅ with Basal DAP (100% N&K), T₅ (T₁

+ ST @ 5ml kg⁻¹ seed + 1FS @ 2ml L⁻¹ with Nano DAP), T₆ (T₁ + ST @ 5ml kg⁻¹ seed + 2FS @ 2ml L⁻¹ with Nano DAP), T₇ (T₁ + ST @ 5ml kg⁻¹ seed + 1FS @ 4ml L⁻¹ with Nano DAP), T₈ (T₁ + ST @ 5ml kg⁻¹ seed + 2FS @ 4ml L⁻¹ with Nano DAP), T₉ (T₃ + ST @ 5ml kg⁻¹ seed + 1FS @ 2ml L⁻¹ with Nano DAP), T₁₀ (T₃ + ST @ 5ml kg⁻¹ seed + 2FS @ 2ml L⁻¹ with Nano DAP), T₁₁ (T₄ + ST @ 5ml kg⁻¹ seed + 1FS @ 2ml L⁻¹ with Nano DAP) and T₁₂ (T₄ + ST @ 5ml kg⁻¹ seed + 2FS @ 2ml L⁻¹ with Nano DAP). Maize variety PHM -3 was sown in lines 60 cm apart. As per the treatments, whole quantity of Nano DAP was used for Seed treatment. Nitrogen dose of 120 kg ha⁻¹ was applied in two equal splits the half was applied as basal and the remaining half was top-dressed at the time of first irrigation. The basal N dose was applied through urea after adjusting the quantity supplied through diammonium phosphate. The whole quantity of phosphorus (60 kg P₂O₅ ha⁻¹) through diammonium phosphate and potassium (30 kg K₂O ha⁻¹)

Table-3 : Effect of seed treatment and foliar application of nano DAP on available micronutrients in soil after harvest of maize.

Treatments		Available Zinc (mg kg ⁻¹)	Available Iron (mg kg ⁻¹)	Available Manganese (mg kg ⁻¹)	Available Copper (mg kg ⁻¹)
T ₁	0% P ₂ O ₅ (100% N&K) control	1.506	3.454	5.88	1.65
T ₂	100% P ₂ O ₅ with Basal DAP (100% N&K)	1.514	3.474	5.93	1.70
T ₃	25% P ₂ O ₅ with Basal DAP (100% N&K)	1.530	3.536	5.78	1.63
T ₄	50% P ₂ O ₅ with Basal DAP (100% N&K)	1.598	3.570	5.98	1.76
T ₅	T ₁ + ST @ 5ml kg ⁻¹ seed + 1 FS @ 2ml L ⁻¹ with Nano DAP	1.605	3.580	5.99	1.77
T ₆	T ₁ + ST @ 5ml kg ⁻¹ seed + 2 FS @ 2ml L ⁻¹ with Nano DAP	1.742	3.700	6.05	1.85
T ₇	T ₁ + ST @ 5ml kg ⁻¹ seed + 1 FS @ 4ml L ⁻¹ with Nano DAP	1.688	3.650	6.01	1.80
T ₈	T ₁ + ST @ 5ml kg ⁻¹ seed + 2 FS @ 4ml L ⁻¹ with Nano DAP	1.503	3.460	5.96	1.71
T ₉	T ₃ + ST @ 5ml kg ⁻¹ seed + 1 FS @ 2ml L ⁻¹ with Nano DAP	1.823	3.780	6.10	1.89
T ₁₀	T ₃ + ST @ 5ml kg ⁻¹ seed + 2 FS @ 2ml L ⁻¹ with Nano DAP	1.827	3.813	6.13	1.92
T ₁₁	T ₄ + ST @ 5ml kg ⁻¹ seed + 1 FS @ 2ml L ⁻¹ with Nano DAP	1.829	3.831	6.20	1.89
T ₁₂	T ₄ + ST @ 5ml kg ⁻¹ seed + 2 FS @ 2ml L ⁻¹ with Nano DAP	1.831	3.857	6.21	1.92
SEm±		0.095	0.160	0.185	0.094
CD (P=0.05)		NS	NS	NS	NS

through muriate of potash was basally applied. Foliar spray of Nano DAP was given after sowing.

Soil chemical determination : To assess the fertility status of soil, the soil sample (0-15 cm depth) from each plot at harvest of crop was taken. The samples were passed through 2 mm plastic sieve to avoid metallic contamination.

The pH, EC and OC was measured with the help of pH meter, EC meter and Walkley and Black's rapid titration and available nitrogen, phosphorus, potassium and Micronutrients was determined by alkaline permanganate method, colorimetrically and atomic absorption spectro-photometer in RCA lab.

Results and Discussion

Physico-chemical properties : The analysis of the data (Table-1) shows that the Seed treatment and foliar applications of nano DAP with various treatments had no appreciable impact on the soil pH and EC and OC and available zinc, iron, manganese and copper. And available N, P and K content in soil after harvest stage of the crop increased significantly with treatment over the control. The maximum available nitrogen, phosphorus and potassium content in soil, (337.62 kg ha⁻¹), (23.16 kg ha⁻¹), (460.48 kg ha⁻¹) was observed under T₁₂ (T₄ + ST @ 5ml kg⁻¹ seed + 2FS @ 2ml L⁻¹ with Nano DAP) significantly superior over the control and rest of treatments. However, T₁₂ remain at par with T₁₁ (T₄ + ST @ 5ml kg⁻¹ seed + 1FS @ 2ml L⁻¹ with Nano DAP) with respect of available nitrogen, phosphorus and potassium content in soil. Based on the result of different levels of nano-P fertilization, a convincing effect on the uptake of macronutrient was obtained. Wheat grain N, P, and K intake varied from 35.7 to 66.6, 3.37 to 11.5, and 9.98 to

18.4 kg ha⁻¹, respectively. The absorption of macronutrients (N, P, and K) in straw ranged from 14.9 to 27.1, 3.08 to 6.92, and 44.9 to 68.9 kg ha⁻¹, respectively. Treatment T₄ had significantly increased total N uptake (81.6% higher than RDF). Similarly, treatment T₄ had higher total P absorption (117% over RDF), while treatment T₄ had higher total K uptake (49.5% over RDF). All nano-P treatments were most effective in total macronutrient absorption by wheat in T₄ (100% NK + 75% P + 2 foliar sprays of nano-P at the tillering and panicle initiation stages). Total Cu, Mn, Zn, and Fe uptake ranged from 78.7 to 132, 101 to 135, 109 to 179, and 240 to 341 g ha⁻¹, as shown in. The treatments T₄ and T₆ had significantly higher grain and straw uptake of Cu (73.5 and 65.8 g ha⁻¹), Mn (82.1 and 55.7 g ha⁻¹), and Zn (98.5 and 85.6 g ha⁻¹); whereas, T₄ had the highest grain and straw uptake of Fe (227 and 114 g ha⁻¹). According to Soliman *et al.*, (2016), there is a positive relationship between P and N, indicating that as P intake increases, so does N uptake. The NCPC addition (NCPC-H) reported a 42% higher P uptake by pearl millet over CF (CF-H) (CF-H). Phosphorus uptake increased in broad bean by 6.7 and 5.24% in the straw and grain, respectively, after the application of nano-P fertilizer [12]. Kandil and Marie (2017) also reported that the combination of NF and amino acid sprayed on wheat plants had the maximum micronutrient uptake in grain and straw. Use of NF increased the micronutrient concentration in the roots and shoots of lettuce plants, which is reflected in plant growth.

Conclusions

From the present investigation it can be concluded that the physico-chemical properties of soil were recorded non-significantly affected by using Nano-DAP but data

were recorded significantly higher with the application of 100% NPK, the application of 100% recommended NPK dose, and 75% N, P, 100% K recommended dose with 0.2% foliar application of Nano DAP were found equally beneficial to the phosphorus dynamics of the soil, phosphorous use efficiency, and a minor improvement in residual fertility of the soil.

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Production, Productivity and Quality of Maize (*Zea mays* L.) Affected by Application of Zinc

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Abstract

A field experiment was conducted during Kharif, seasons of 2022 at Instructional Farm, Rajasthan College of Agriculture, Udaipur to evaluate the effect of application of zinc on yield and yield attributes of maize in Southern Rajasthan. The experiment was laid out in a randomized block design with three replications and six treatments of zinc. Significantly highest grain, stover and biological yield (4351.21, 6841.22 and 11192.43 kg ha⁻¹) were recorded with the application of zinc at tasseling stage over single stage foliar application. Similarly, different levels of zinc application significantly increased grain, stover and biological yield. Similarly, the significantly highest protein content of maize was found in with application of zinc. The significantly highest net return and B:C ratio were found under application of zinc 78977.28 and 3.14) and soil application of in maize

Key words : Zinc, yield, protein content, net return, maize.

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops of the world and finds a place in the human food, animal food, fodder and industrial raw material. Maize belongs to family Gramineae and popularly known as corn, ranking third among the food crops, next to rice and wheat in the world and ranking fourth after rice, wheat and sorghum in India. The productivity of maize is very high because of its C₄ nature of plants and it is very efficient in converting solar energy into production of dry matter. The crop has high genetic yield potential and hence, it is called as Miracle crop and as the “Queen of cereals”. In India occupying 9.86 m ha area with production of 32.42 million tones and productivity status of 2965 kg ha⁻¹, respectively (FAI, 2021-22). In the state of Rajasthan, it covers an area of 1.00 m ha with production and productivity of 2.27 million tone and 2148 kg ha⁻¹, respectively (FAI, 2021-22).

Currently, maize is cultivated over 9.72 m ha area with 28.64 m t production and an average yield of 29.45 q ha⁻¹ (Govt. of India. 2020) [2]. In Rajasthan, the crop occupies 0.97 m ha area with an annual production of 2.70 m t and average yield of 27.69 q ha⁻¹ (Govt. of India. 2021).

Zinc is considered the most important micronutrient for normal and healthy plant growth (Tahir *et al.*, 2018). Soil Zn applications have, however, small effectiveness on increasing grain Zn, while foliar Zn applications result

in remarkable increases in grain Zn concentration of wheat (Cakmak *et al.*, 2010a). By optimizing the timing and the solute concentration of foliar Zn application, wheat grain Zn concentration could be further increased, not only in whole grain but also in the endosperm (Zhang *et al.*, 2010). It is a structural component or cofactor of various enzymes involved in many biochemical processes. In plants, it is involved in photosynthesis, carbohydrate metabolism, protein metabolism, pollen formation, auxin metabolism, maintenance of membrane integrity, and induction of tolerance against various stresses (Alloway, 2008). It is also essential for nitrogen metabolism and important for the stability of cytoplasmic ribosome's, cell division, as co factor to enzymes like dehydrogenase, proteinase and peptidase in the synthesis of tryptophan, a component of some proteins and a compound needed for production of growth hormones (auxin) such as indole acetic acid (Singh and Singh, 1981). Therefore, if the soil is in short supply with respect to zinc, crop yields are further adversely affected. Hence, it becomes necessary to pay serious attention to the application and utilization of zinc.

Materials and Methods

The experiment was conducted during both the years at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, which is situated at 24° 35' N latitude, 72° 42' E longitude and an altitude of 579.5 m above mean sea level. It falls under agro-climatic zone IVa (Sub-Humid

Southern Plain and Aravalli Hills) of Rajasthan, India. The experimental soil was clay loam in texture, having alkaline reaction (7.6), medium in available nitrogen (292.0 kg ha⁻¹) and available phosphorus (21.8 kg ha⁻¹) but high in available potassium (303.1 kg ha⁻¹) and medium in available zinc (1.89 ppm). The experiment was conducted during kharif 2022. The experiment was laid out in RBD with three replications and six treatments.

Table-1: Details of treatment.

	Treatments	Symbols
i.	Control	Zn ₀
ii.	10 kg ZnSO ₄ ha ⁻¹ + 0.5% foliar spray of Zn ha ⁻¹	Zn ₁
iii.	15 kg ZnSO ₄ ha ⁻¹ + 0.5% foliar spray of Zn ha ⁻¹	Zn ₂
iv.	20 kg ZnSO ₄ ha ⁻¹ + 0.5% foliar spray of Zn ha ⁻¹ +ZSB	Zn ₃
v.	25 kg ZnSO ₄ ha ⁻¹ + 0.5% foliar spray of Zn ha ⁻¹ +ZSB	Zn ₄
vi.	30 kg ZnSO ₄ ha ⁻¹ + 0.5% foliar spray of Zn ha ⁻¹ +ZSB	Zn ₅

The recommended dose of fertilizer was 120 kg N, 60 kg P₂O₅ and 30 kg K₂O ha⁻¹. As per treatment entire quantity of phosphorus was applied at the time of sowing whereas nitrogen was applied in three split application viz., 1/3rd at sowing, 1/3rd at knee-high stage and remaining 1/3rd at 50 per cent tasseling stage. The maize crop variety Pratap Hybrid Maize-3 was sown using 25 kg seed ha⁻¹ with onset of rain on 21th July, during 2022 with a spacing of 60 x 25 cm. The crop was harvested at physiological maturity which was determined by formation of black layer in placental region of maize grain. Before harvesting the plants under each experimental unit, border row were harvested and removed from experimental field. Cobs from net plots were picked up and kept in gunny bags. After through drying these were shelled and grain yield of each net plot was weighed separately and expressed as grain yield in q ha⁻¹. After picking cobs, stover from net plot area was harvested and sun dried for few days and weighed for individual plot and also expressed as q ha⁻¹.

Results and Discussion

Pooled data pertaining in Table-2 revealed that grain, stover and biological yield (4351.21, 6841.22 and 11192.43kg ha⁻¹) of maize significantly increased to the application of zinc. Application of zinc significantly increased the yield attributes such as the weight of cobs per plant, number of pods per plant, number of grains per plant and test weight of maize over control. The maximum yield attributes viz., weight of cobs per plant, number of pods per plant, number of grains per plant and test weight of maize were recorded under treatment Zn₅ (30 kg ZnSO₄ ha⁻¹+0.5% foliar spray of Zn ha⁻¹ +ZSB) as compared to Zn₂ (15 kg ZnSO₄ ha⁻¹+0.5% foliar spray of Zn ha⁻¹), Zn₁

(10 kg ZnSO₄ ha⁻¹ +0.5% foliar spray of Zn ha⁻¹) treatments and control (Zn₀). However, the increase was significant upto Zn₃ (20 kg ZnSO₄ ha⁻¹+0.5% foliar spray of Zn ha⁻¹ +ZSB) which was also found to be statistically at par with Zn₄ (25 kg ZnSO₄ ha⁻¹+0.5% foliar spray of Zn ha⁻¹ +ZSB) and Zn₅ (30 kg ZnSO₄ ha⁻¹+0.5% foliar spray of Zn ha⁻¹ +ZSB).

The beneficial effects of applied zinc on these growth indices and yield characteristics can be attributed to zinc's catalysing or stimulating effects on the majority of physiological and metabolic functions in plants. In addition to serving as a metal activator, zinc is required for the activity of nitrogen-assimilating enzymes including proteinase and peptidase. Additionally, it facilitates the production of chlorophyll and is crucial for the metabolism of nitrogen. Zinc has also been discovered to play a significant role in controlling the auxin content in plants, leading to an increase in nitrogen uptake by the plants. Auxin concentration is diminished when there is a zinc shortage. Auxin concentration is diminished when there is a zinc shortage. Additionally, this zinc increases the cation exchange capability of roots, which improves the absorption of important nutrients. Thus, adding zinc to a soil that was lacking in it helped plants grow and develop more generally. This may be because a sufficient supply of zinc accelerated the metabolism of auxins and enzymatic activity in plants. Auxins are important in cell division and root formation, which led to an increase in the number of pods, seeds, and test weight per plant. These findings closely match those of Mahilane and Singh (2018), who found that the treatment of zinc significantly increased the amount of nodules per plant, pods per plant, seeds per pod and test weight in blackgram. In addition to Ali and Mahmoud (2014), Upadhyay and Singh (2016), Todawat *et al.* (2017), Mahilane and Singh (2018), Meena (2019) and Jat *et al.* (2021) in other crops, it was also observed that the application of zinc increased certain yield features.

Zinc spraying also greatly improved grain and stover yields. The beneficial effects of zinc application on grain and stover yield may be attributable to zinc's catalytic or stimulatory effects on the majority of plant physiological and metabolic processes. The fact that zinc plays a significant role in the production of indole acetic acid (IAA) and the initiation of the primordial for reproductive portion, which have favoured the metabolic reaction inside plants, may account for the rise in seed and straw yield with zinc fertiliser application. The fact that the initial level of accessible zinc in the experimental soil was low may be responsible for the rise in yield brought on by the application of zinc. Increased zinc availability to plants as

Table-2 : Effect of application of zinc levels on yield, economics and quality of maize.

Treatments	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Net Return (Rs, ha ⁻¹)	B : C ratio
Application of zinc					
Control (Zn ₀)	3353.57	5408.65	8762.22	57593.09	2.504
10 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ (Zn ₁)	3646.22	5833.45	9479.67	63758.09	2.684
15 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ (Zn ₂)	3962.36	6289.25	10251.61	70920.26	2.949
20 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ + ZSB (Zn ₃)	4272.79	6584.09	10856.88	77365.93	3.153
25 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ + ZSB (Zn ₄)	4311.27	6716.48	11027.75	78166.59	3.146
30 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ + ZSB (Zn ₅)	4351.21	6841.22	11192.43	78977.28	3.140
S.Em±	91.606	110.323	148.121	1871.251	0.050
CD (P=0.05)	276.130	332.548	446.486	5640.559	0.151

a result of its addition to the soil, which promoted healthy growth and development, may be the cause of the improvement in yield qualities. Zinc fertilisation resulted in a considerable increase in straw output, which might be attributed to the enhanced biomass production and plant development, presumably as a result of nutrient uptake. Additionally, these results are supported by Tripathi *et al.* (2011), Roy *et al.* (2013), Khan and Prakash (2014), Tak *et al.* (2014), Mahilane and Singh (2018), Kumar *et al.* (2019) and Jat *et al.* (2021) in different crops. According to Pedababu *et al.* (2007), the higher carbohydrate synthesis and subsequent transfer to the site of grain production may be the cause of the increased yield. Treatments including zinc administration improved absorption, which in turn aided photosynthetic activity and efficient translocation to storage organs, potentially increasing production.

Conclusions

The present study's finding indicates that application of zinc significantly increased the Based on the above findings it inferred that substantial improvement grains yield, stover yield, biological yield, BC ratio and net return could be obtained with the application of zinc @ 20 kg ZnSO₄ ha⁻¹ + 0.5% foliar spray of Zn ha⁻¹ + ZSB of maize.

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Effect of Different Sources of Zinc Application on Productivity of Wheat (*Triticum aestivum* 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, Udaipur (Rajasthan) to study the effect of different sources of zinc application on productivity of wheat (*Triticum aestivum* L.) in Typic Haplustepts soil. The experiment was laid out according to Randomized Block Design with four replications. The treatments comprised of six treatments of zinc through soil and foliar application (Control, 10 kg ZnSO₄ + 0.5% foliar spray of Zn ha⁻¹, 15 kg ZnSO₄ + 0.5% foliar spray of Zn ha⁻¹, 20 kg ZnSO₄ + 0.5% foliar spray of Zn ha⁻¹ + ZSB, 25 kg ZnSO₄ + 0.5% foliar spray of Zn ha⁻¹ + ZSB, 30 kg ZnSO₄ + 0.5% foliar spray of Zn ha⁻¹ + ZSB) were applied to the wheat var. Raj.4238. The application of 30 kg ZnSO₄ + 0.5% foliar spray of Zn ha⁻¹ + ZSB (Zn₅) recorded significantly highest number of effective tillers (75.71), test weight (43.29 g), grain yield (4665 kg ha⁻¹), straw yield (6605 kg ha⁻¹) and biological yield (12270 kg ha⁻¹) over control. Based on the above findings it may be inferred that substantial improvement in number of effective tillers, test weight, grain yield, straw yield and biological yield.

Key words : Zinc, biofortification, grain yield, straw yield, biological yield.

Introduction

Wheat (*Triticum aestivum* L.) is one of the three major cereal crops worldwide and represents a main dietary source of calories, proteins and micronutrients for the majority of world's population, especially in the developing world (Shewry, 2009). Wheat is responsible up to 70% of daily calorie intake of the population living in rural regions and an important source for Zn for human beings living in the developing world (Cakmak, 2008). For example, wheat-based food products supply more than 20% of dietary Zn in China (Ma *et al.*, 2008). China, India, Kazakhstan, Mexico, Pakistan and Turkey are some of the major wheat producing countries and responsible for more than 30% of the global wheat production (FAO database, 2010). These countries are also among the regions where Zn deficiency is most frequently reported in soils, crops and human population (Alloway, 2008). Increasing grain Zn concentration in those countries representing about 45% of world's population would be, therefore, an important global achievement for better human nutrition. In India, it is grown in an area of 29.55 mha (13.43% of global area) with a production of 101.20 mt (12.96% of world production) and productivity of 3424 kg ha⁻¹ (FAI, 2019-20). In Rajasthan, it is grown in an area of 2.88 mha with a production and productivity of 9.60 mt and 3334 kg ha⁻¹, respectively (FAI, 2019-20). Biofortification is a

process of making essential nutrients bio-available to crops during crop growth using agronomic and genetic methods (Bouis *et al.*, 2011). Several methods have been used for the biofortification of crops, namely; breeding and agronomic approach using inorganic fertilizer (Cakmak, 2008). Rice has been bio-fortified with zinc in Bangladesh using a breeding method whereas Zuo and Zhang (2008) reported an increase in the concentration of zinc by up to 20 parts per million in wheat seeds in India and Pakistan by foliar spray, but in maize and rice, foliar spray of zinc resulted in only a small effect (Phattarakul *et al.*, 2012). The biofortification of local staples will help to bridge this micronutrients and vitamins gaps thereby reducing disease prevalence among the rural populace. Cakmak (2008) reported the daily requirement of zinc for different age groups (10 mg for children, 12 mg for women and 15 mg for men) whereas Pavlotska (2007) noted that nursing mothers require 25 mg per day of zinc.

Materials and Methods

Location of experimental site and soil : The experiment was conducted during *rabi* season of 2021-22 at the Institutional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur situated at an altitude of 582.2 meters above mean sea level and at 24°35' latitude and 73°42' longitude. The region falls under agro-climatic zone-IVa (Sub-humid Southern Plain and Aravalli Hills) of

Table-2 : Initial soil properties of experimental field.

S. No.	1.1.1 Soil properties	1.1.2 0-15 cm depth
Physical properties		
1.	Mechanical composition	
(i)	Sand (%)	38.81
(ii)	Silt (%)	25.93
(iii)	Clay (%)	34.90
(iv)	Textural class	Clay loam
2.	Particle density (Mg m^{-3})	2.63
3.	Bulk density (Mg m^{-3})	1.49
4.	Porosity (%)	43.34
Chemical properties		
(i)	Organic carbon (%)	0.628
(ii)	Available N (kg ha^{-1})	298.45
(iii)	Available P_2O_5 (kg ha^{-1})	17.05
(iv)	Available K_2O (kg ha^{-1})	358.20
(v)	Available Zn (mg kg^{-1})	0.591
(vi)	EC (dSm^{-1} at 25°C)	0.581
(vii)	pH (1:2 soil water suspension)	8.22
Biological properties		
(i)	Acid phosphatase activity ($\text{ig PNP g}^{-1} \text{ soil h}^{-1}$)	17.21
(ii)	Dehydrogenase activity ($\text{ig TPF g}^{-1} \text{ soil h}^{-1}$)	10.01
(iii)	Bacteria population (cfu g^{-1})	62.35
(iv)	Fungi population (cfu g^{-1})	22.43
(v)	Actinomycetes population (cfu g^{-1})	33.01

Table-3 : Treatments and their symbols.

	Treatments	Symbols
i.	Control	Zn_0
ii.	10 kg ZnSO_4 + 0.5% Foliar spray of Zn ha^{-1}	Zn_1
iii.	15 kg ZnSO_4 + 0.5% Foliar spray of Zn ha^{-1}	Zn_2
iv.	20 kg ZnSO_4 + 0.5% Foliar spray of Zn ha^{-1} + ZSB	Zn_3
v.	25 kg ZnSO_4 + 0.5% Foliar spray of Zn ha^{-1} + ZSB	Zn_4
vi.	30 kg ZnSO_4 + 0.5% Foliar spray of Zn ha^{-1} + ZSB	Zn_5

Table-4 : Effect of zinc application on number of effective tillers and test weight of wheat.

Treatments	Number of effective tillers	Test weight (g)
Control (Zn_0)	60.21	39.24
10 kg ZnSO_4 + 0.5% foliar spray of Zn ha^{-1} (Zn_1)	65.63	41.07
15 kg ZnSO_4 + 0.5% foliar spray of Zn ha^{-1} (Zn_2)	70.52	41.73
20 kg ZnSO_4 + 0.5% foliar spray of Zn ha^{-1} + ZSB (Zn_3)	74.18	42.65
25 kg ZnSO_4 + 0.5% foliar spray of Zn ha^{-1} + ZSB (Zn_4)	75.07	43.12
30 kg ZnSO_4 + 0.5% foliar spray of Zn ha^{-1} + ZSB (Zn_5)	75.71	43.29
S.Em+	0.95	0.22
CD ($P=0.05$)	2.87	0.66

Rajasthan. In order to ascertain the physico-chemical characteristics of the soil, soil samples were collected from different spots of the experimental field randomly from 0-15 cm soil depths and representative composite sample were subjected to physical and chemical analysis separately.

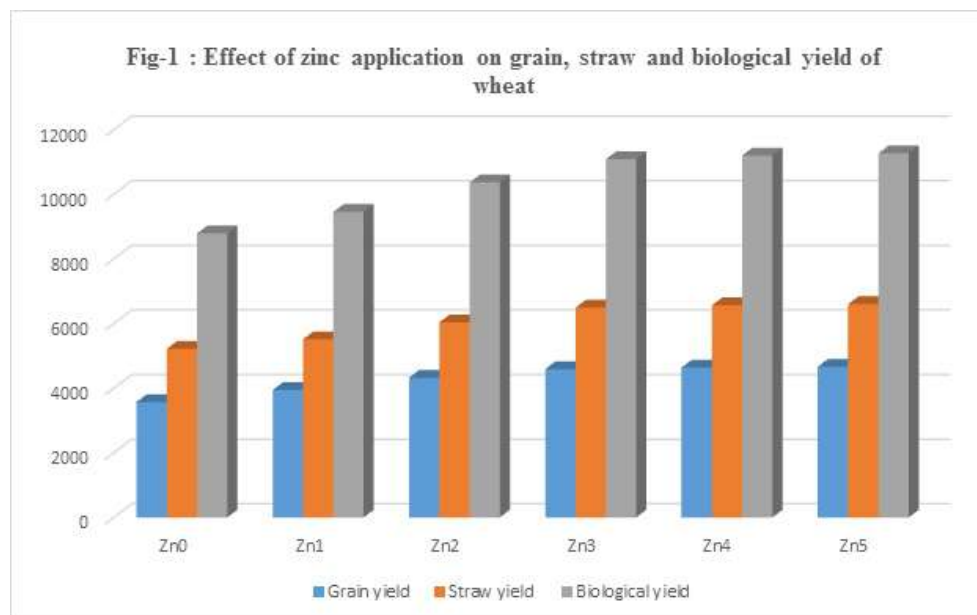
Experimental design and treatments : The experiment with 6 treatment combinations and four replications with

24 plots was laid out in Randomized Block Design (RBD). The treatments were randomly allotted to different plots using a random number table (Fisher and Yates, 1963). Zinc was applied in the field as per treatments 10,15,20,25,30 kg ha^{-1} with 0.5% foliar spray of Zn ha^{-1} .

Harvesting details : The crop was harvested on 10th March, 2022 from a net plot size of 4.0 m x 2.7 m (10.8 m²) separately, tied in bundles, tagged and sun dried. After

Table-5 : Effect of zinc application on grain, straw and biological yield of wheat.

Treatments	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)
Control (Zn ₀)	3572.01	5219.94	8791.95
10 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ (Zn ₁)	3945.05	5513.13	9458.18
15 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ (Zn ₂)	4327.05	6040.00	10367.05
20 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ + ZSB (Zn ₃)	4594.04	6494.00	11088.04
25 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ + ZSB (Zn ₄)	4638.01	6565.00	11203.01
30 kg ZnSO ₄ + 0.5% foliar spray of Zn ha ⁻¹ + ZSB (Zn ₅)	4665.00	6605.00	11270.00
S.Em+	42.96	73.88	107.26
CD (P=0.05)	129.49	222.71	323.32



complete drying, bundles were weighed to record biological yields. Thereafter, threshing was done by beating the plants with sticks. The seed and straw were separated by manual winnowing and their yield in kg per plot was recorded and converted into kg ha⁻¹.

Methodology for observations recorded

Yield attributes and yield : Numbers of effective tillers, test weight (1000g) of seeds, grain yield (kg h⁻¹), straw yield (kg h⁻¹) and biological yield (kg h⁻¹) were recorded in each plot.

Results and Discussion

Effect of zinc application on number of effective tillers and test weight(g) : Data presented in Table 4.1 indicated that the different sources of zinc application significantly increased the number of effective tillers and test weight of wheat as compared to control (Zn₀). The maximum number of effective tillers (75.71) was recorded under the treatment Zn₅ (30 kg ZnSO₄ + 0.5% foliar spray of Zn ha⁻¹ +ZSB) while the minimum (60.21) number of effective tillers was observed under control (Zn₀). However, the increase was significant up to Zn₃ which was

found to be statistically at par with Zn₄ and Zn₅. However, the difference between Zn₃ & Zn₄, Zn₄ & Zn₅ and Zn₃ & Zn₅ treatments was also found to be statistically at par. The treatments Zn₁, Zn₂, Zn₃, Zn₄ and Zn₅ increased the number of effective tillers to the extent of 9.00, 17.12, 23.20, 24.68 and 25.74 per cent, respectively over control (Zn₀). The maximum test weight (43.29 g) was observed under the treatment Zn₅ (30 kg ZnSO₄ + 0.5% foliar spray of Zn ha⁻¹ +ZSB) and the minimum (39.24 g) under control (Zn₀). However, the increase was significant up to Zn₃ which was found to be statistically at par with Zn₄ and Zn₅. However, the difference between Zn₃ & Zn₄, Zn₄ & Zn₅ and Zn₃ & Zn₅ treatments was also found to be statistically at par. The treatments Zn₁, Zn₂, Zn₃, Zn₄ and Zn₅ increased the test weight to the extent of 4.76, 6.35, 8.69, 9.89 and 10.32 per cent, respectively over control (Zn₀).

The favourable influence of applied zinc on number of effective tillers and test weight of wheat may be ascribed to catalytic or stimulatory effect of zinc on most of the physiological and metabolic processes of the plant, Khardia *et al.* (2022). Zinc also acts as a metal activator and is an essential component of enzymes such as proteinase and peptidase which are responsible for

assimilation of nitrogen. It also helps in chlorophyll formation and plays an important role in nitrogen metabolism Tahir *et al.* (2023). Thereby, resulting into increased uptake of nitrogen by the plants zinc has also been reported to play an important role in regulating the auxin concentration in plants. Zinc deficiency result in a decreased content of auxin. Besides, this zinc also enhances the absorption of essential elements by increasing the cation exchange capacity of roots Shambhavi *et al.* (2020) Thus, the application of zinc in a soil deficient in its content, improved the overall growth and development of plant. This might be due to adequate supply of zinc contributed to accelerate the enzymatic activity and auxin metabolism in plants, as auxins are involved in cell division and root formation resulted in greater number of effective tillers and test weight. These results are in close conformity with those of Mahilane and Singh (2018) who reported significant increase in the number of nodules per plant, number of pods per plant, number of seeds per pod and test weight in black gram due to application of zinc. The increase in these yield attributes due to application of zinc was also reported by Ali and Mahmoud (2014), Upadhyay and Singh (2016), Todawat *et al.* (2017), Mahilane and Singh (2018), Meena (2019) and Jat *et al.* (2021) in different crops.

Effect of zinc application on grain yield, straw yield and biological yield (kg ha^{-1}) : Data presented in table-4 and Figure-1 indicated that the application of zinc significantly increased the grain yield over control (Zn_0). The highest grain yield was recorded under Zn_5 ($4665.00 \text{ kg ha}^{-1}$) followed by Zn_4 , Zn_3 , Zn_2 and Zn_1 treatments as compared to control (Zn_0). The lowest grain yield ($3572.01 \text{ kg ha}^{-1}$) was recorded under control (Zn_0). However, the difference between Zn_3 & Zn_4 , Zn_4 & Zn_5 and Zn_3 & Zn_5 treatments was also found to be statistically at par. The treatments Zn_1 , Zn_2 , Zn_3 , Zn_4 , and Zn_5 increased the grain yield to the extent of 10.44, 21.14, 28.61, 29.84 and 30.60 per cent, respectively as compared to the control (Zn_0). The application of zinc significantly increased the straw yield over control (Zn_0). The highest straw yield was recorded under Zn_5 ($6605.00 \text{ kg ha}^{-1}$) followed by Zn_4 , Zn_3 , Zn_2 and Zn_1 treatments as compared to control (Zn_0). The lowest straw yield ($5219.94 \text{ kg ha}^{-1}$) was recorded under control (Zn_0). However, the difference between Zn_3 , & Zn_4 , Zn_4 & Zn_5 and Zn_3 & Zn_5 treatments was also found to be statistically at par. The treatments Zn_1 , Zn_2 , Zn_3 , Zn_4 and Zn_5 increased the straw yield to the extent of 5.62, 15.71, 24.41, 25.77 and 26.53 per cent, respectively as compared to the control (Zn_0). The application of zinc significantly increased the biological yield over control (Zn_0). The highest biological yield was recorded under Zn_5 ($11270.00 \text{ kg ha}^{-1}$) followed by Zn_4 , Zn_3 , Zn_2 and Zn_1 treatments as compared to control (Zn_0). The lowest

biological yield ($8791.95 \text{ kg ha}^{-1}$) was recorded under control (Zn_0). However, the difference between Zn_3 & Zn_4 , Zn_4 & Zn_5 and Zn_3 & Zn_5 treatments was also found to be statistically at par. The treatments Zn_1 , Zn_2 , Zn_3 , Zn_4 and Zn_5 increased the biological yield to the extent of 7.58, 17.92, 26.12, 27.42 and 28.19 per cent, respectively as compared to the control (Zn_0).

The increased in grain and straw yield with zinc application may be due to catalytic or stimulatory effect of zinc on most of the physiological and metabolic processes of plants. The increase in grain and straw yield with zinc fertilizer application might be due to the fact that zinc plays an important role in biosynthesis of indole acetic acid (IAA) and initiation of primordial for reproductive part which have favored the metabolic reaction within plant. The increase in the yield due to zinc application may be attributed to the fact that the initial status of available zinc in the experimental soil was low. The increase in yield attributes may be due to increased supply of available zinc to plants by way of its addition to soil which resulted in proper growth and development. The significant increase in straw yield due to zinc fertilization could be attributed to the increased plant growth and biomass production, possibly as a result of the uptake of nutrients. These findings are also supported by Tripathi *et al.* (2011), Roy *et al.* (2013), Khan and Prakash (2014), Tak *et al.* (2014), Mahilane and Singh (2018), Kumar *et al.* (2019) and Jat *et al.* (2021) in various crops. Pedababu *et al.* (2007) also reported that yield increase may be due to enhanced synthesis of carbohydrate and their transport to the site of grain production. The treatments involving application of zinc resulted in better absorption and in turn helped the photosynthetic activity and effective translocation to storage organs which might have increased the yield.

Conclusions

Based on the above findings it may be inferred that substantial improvement in the number of effective tillers, test weight, grain yield, straw yield and biological yield could be obtained with the application of zinc @ $30 \text{ kg ZnSO}_4 + 0.5\% \text{ foliar spray of Zn ha}^{-1} + \text{ZSB}$.

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Isolation of Rhizobia from Root Nodules of Pea Collected from Southern Part of Rajasthan

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Abstract

The present research delves into the rich biodiversity of rhizobium bacteria thriving in the agro-ecological landscapes of Udaipur and Dungarpur, two prominent districts in Rajasthan, India. Isolation efforts from nineteen distinct locations within these regions led to the collection of a diverse set of rhizobium strains. Comprehensive analysis of these isolates was conducted using Yeast Extract Mannitol Agar (YEMA) to elucidate their metabolic and phenotypic attributes. Subsequently, colonies were meticulously examined for morphological variations and the presence of distinctive traits. Furthermore, the characteristics of these rhizobium isolates were correlated with the specific soil types found at each sampling location. This study not only sheds light on the rhizobium diversity within these regions but also establishes vital connections between soil properties and the physiological behavior of rhizobium bacteria. These findings hold significant implications for sustainable agricultural practices, as they provide valuable insights into harnessing the potential of rhizobium strains tailored to the unique soil conditions prevalent in Udaipur and Dungarpur.

Key words : Rhizobium bacteria, YEMA analysis, Isolation, Symbiotic relationships, Soil-microbe interactions.

Introduction

Peas, scientifically referred to as *Pisum sativum*, are a prominent member of the Fabaceae family, also known as Leguminosae. Commonly recognized by their straightforward name “peas,” they are also referred to as “garden peas” (Dobrovolna *et al.*, 2022). Within this family, peas hold a significant place due to their historical cultivation and their widespread utilization in diverse culinary and nutritional practices. Peas have a fascinating origin that traces back to ancient times. Believed to have originated around the Mediterranean region and west central Europe (Grela *et al.*, 2010), these legumes hold a history deeply intertwined with human cultivation. Their journey began as wild peas that gradually attracted the attention of early agricultural communities due to their palatable and nutritious nature. Over time, these wild varieties were selectively cultivated and domesticated, leading to the development of the cultivated garden pea that we are familiar with today. The Mediterranean region served as the cradle of this domestication process, from where the cultivation of peas spread across various parts

of the world, becoming an essential and enduring part of global agriculture and cuisine. Pea cultivation extends across a diverse array of global regions. Notable regions of pea cultivation encompass North America, where both the United States and Canada engage in pea farming for fresh consumption and processing (Nonnecke 1989). Across Europe, countries such as France, the United Kingdom, Germany, and the Netherlands are renowned contributors to pea cultivation. The practice extends to Asian countries like China, India, and Russia, where peas feature prominently in traditional culinary practices. Africa, with countries like Ethiopia, Egypt, and Kenya, also partakes in pea cultivation, as do nations in Oceania, including Australia and New Zealand, with an emphasis on exportation. India is a significant producer of peas, contributing to both the fresh market and processed food industries (Mahajan *et al.*, 2011). The country's diverse climatic zones allow for pea cultivation in various seasons. States like Uttar Pradesh, Madhya Pradesh, Maharashtra, Rajasthan and Punjab are prominent contributors to India's pea production. Peas are grown during the Rabi season (winter) and account for a considerable portion of

the legume production in the country. In the Indian state of Rajasthan, pea cultivation plays a notable role in the state's agricultural landscape. Rajasthan's climatic conditions are suitable for Rabi season crops, making it an appropriate region for pea cultivation. The state's progressive approach to agriculture, including the adoption of advanced farming techniques and irrigation systems, has supported pea production. In Rajasthan, Jaipur district is on top of fir cultivation of pea.

Rhizobia, a group of soil bacteria, establishes a symbiotic relationship with leguminous plants like peas (*Pisumsativum*) (Mazoyon *et al.*, 2023). This mutualistic interaction revolves around their remarkable capacity to fix atmospheric nitrogen into a plant-usable form, particularly vital in nitrogen-deficient soils. Acting as nitrogen-fixing agents, rhizobia possess the enzyme nitrogenase, converting atmospheric nitrogen into ammonia, a nutrient readily absorbed by plants (Aasfar *et al.*, 2021). This process occurs within specialized root nodules, where the plant supplies the bacteria with carbohydrates, while the rhizobia contribute fixed nitrogen to the plant (Mahmud *et al.*, 2020). This intricate partnership is initiated by chemical signals exchanged between the two parties: flavonoids released by the plant attract rhizobia, which in turn release Nod factors that stimulate nodule formation. Within these nodules, rhizobia reside as bacteroids, nested within plant cell membranes to facilitate nitrogen fixation. Beyond benefiting plant growth, the nitrogen fixation accomplished by rhizobia significantly enhances soil fertility, making them integral components of sustainable agricultural practices and ecosystems.

Isolating rhizobia involves a range of techniques aimed at extracting these beneficial soil bacteria for study or agricultural purposes. One common method is the serial dilution and plate count technique (Datta *et al.*, 2015), which entails diluting soil samples and then plating them onto growth media to facilitate the growth of individual colonies. Selective media provide an environment that encourages rhizobia growth while inhibiting other microorganisms. Enrichment culture involves incubating soil or root samples in liquid media to amplify rhizobia populations, which can then be streaked onto solid media. Additionally, trap plants, often leguminous, are employed to attract and collect rhizobia from their root nodules. A statistical approach called the Most Probable Number (MPN) method estimates viable rhizobia numbers based on nodulation occurrences (Catroux *et al.*, 2001). Modern molecular techniques, such as PCR and DNA sequencing, enable genetic identification and isolation of specific rhizobial strains. Antibody techniques leverage specific antibodies to

detect and isolate rhizobia from samples. The choice of technique hinges on research goals, with successful isolation serving as a foundational step for understanding rhizobial diversity, optimizing nitrogen fixation benefits, and advancing agricultural practices. It's important to tailor the technique to the context, whether it involves soil, plant, or specific research requirements.

Natural occurring rhizobia, without any intentional inoculation or seed treatment, plays a critical role in the establishment of symbiotic relationships with leguminous plants. In the absence of human intervention, these indigenous rhizobia form partnerships with the plant's root systems, facilitating the process of nitrogen fixation and enhancing soil fertility. These naturally occurring rhizobia interact with the plant's root exudates, responding to chemical signals that lead to the formation of root nodules. Inside these nodules, rhizobia converts atmospheric nitrogen into a form that the plant can utilize, while the plant supplies the bacteria with energy in the form of carbohydrates. This harmonious relationship supports the growth of both the plant and the rhizobia population, contributing to sustainable agriculture and ecosystem health. Natural rhizobial communities vary based on factors such as soil type, climate, and plant species, showcasing the adaptability and complexity of these intricate plant-microbe interactions. In this investigation we are going to research the natural occurring rhizobia and their isolation will also done to find out the numbers of bacteria in different type of soil in Southern Rajasthan.

Materials and Methods

The experiment was carried out in department of molecular biology and biotechnology, Rajasthan College of Agriculture, Udaipur during 2022-2023.

Collection of Pea nodule sample from different area of Rajasthan : The pea plant samples were collected from Udaipur and Dungarpur districts of Rajasthan.

Sampling technique : The plants were carefully uprooted and roots were cleaned by keeping them in running tap water 2 to 3 times and then by sterile distilled water to remove attached soil particles. The roots were then cut and preserved in sterile falcon tubes containing 40% double autoclaved glycerol. These falcon tubes were then stored in ice box at 4°C temperature.

Isolation techniques : Isolation of Rhizobia from root nodules of pea was done by method of (Somasegaran and hoben, 1985; Boakye *et al.*, 2016).

Material required : Yeast Mannitol Broth (YEMA broth).

Table-1 : Collection of Pea from different regions.

S. No.	Sample name	Location
1.	R1.1	Luniyara, Udaipur
2.	R1.2	Belwaatdarmyra, Udaipur
3.	R3.1	Tumder, Udaipur
4.	R3.3	Amaliaya, Udaipur
5.	R4.1	Karelamaliaya, Udaipur
6.	R4.4	Kaya, Udaipur
7.	R4.5	Bhamti, Udaipur
8.	R5.1	Nichalisikari, Udaipur
9.	R6.1	Upperisikari, Udaipur
10.	R10.2	Naiwela, Udaipur
11.	R12.2	Jawar, Udaipur
12.	R13.2	Balvibarolia, Udaipur
13.	R14.2	Kakardhara, Dungarpur
14.	R15.2	Bichiwada, Dungarpur
15.	R16.2	Jhalan, Dungarpur
16.	R17.2	Bichiwada, Dungarpur
17.	R18.2	Faloj, Dungarpur
18.	R19.2	Bichiwada, Dungarpur
19.	R20.2	Vedawara, Dungarpur

Procedure : the healthy intact nodules were selected and washed with distilled water. The nodules were dipped in sodium hypochlorite solution for 1-2 minutes for sterilization and washed repeatedly with sterile distilled water to remove excess of disinfectant chemical (Anjum *et al.*, 2011). These rinsed nodules were then washed with 70% ethyl alcohol for 1-2 minutes and again rinsed with sterile distilled water 2-3 times. Each nodule was crushed with sterile glass rod or forceps. The fluid oozed out from the nodules was then streaked on the surface of yeast mannitol agar (YEMA) with the help of sterile glass rod. The streaked plates were wrapped and incubated in BOD incubator at 28°C for 4-5 days. The growth obtained on the medium was again streaked on YEMA to get pure colonies. The pink colour gummy colonies were picked for further studies.

Statistical analysis : Relevant Statistical studies were done to find out the spatial variability in the rhizobia count in the sampling data and measures of dispersion such as CV(%), SD and mean were estimated.

Results and Discussion

In this study, 19 rhizobial isolates were isolated from 19 root nodules collected from plants of different regions of Rajasthan. The glycerol stocks of pure cultures were preserved and stored in Molecular Biology and Biotechnology Department of Rajasthan College of Agriculture, Udaipur.

Isolation of rhizobia : In this study, 19 nodule samples were collected from Dungarpur and Udaipur and 19 cultures were isolated from them. These cultures were streaked on YEMA plates and stored in refrigerator at -20°C for preservation and further studies.

Morphological characterization of Rhizobia : Rhizobial strains were characterized on the basis of morphology characteristics. Colonies of the bacteria were obtained on YEMA plates incubated at 28°C for 1-2 days. Single colony was isolated and purified by repeated streaking on YEMA medium. Colony morphology was identified on the basis of characteristics such as shape, and color. Based on this colony morphology, the isolates were grossly identified as *Rhizobium* as defined by (Somasegaran and Hoben, 1985). All 19 pea isolates were further subjected to microscopic studies all these strains showed Gram negative staining. Pink colored gram-negative rods were observed under microscope. Isolated colonies were characterized on the basis of cell shape as reported by Graham, 1963.

Colony Morphology :

Table-2 : Colony morphology of rhizobia after testing on YEMA.

S. No.	Sample name	Characteristicson YEMA
1.	R1.1	Pink, small, wavy, dry colonies
2.	R1.2	Pink, small, wrinkled, dry colonies
3.	R3.1	Pinkish, small, round, dry smooth
4.	R3.3	Pink, small, wavy, dry wrinkled
5.	R4.1	Pink, small, round, dry smooth
6.	R4.4	Pink, medium, flat, irregular, gummy
7.	R4.5	Pink, medium, flat, dry Colonies
8.	R5.1	Pink, small, round, dry Colonies
9.	R6.1	Pink, small, round, dry undulated wavy
10.	R10.2	Pink, medium, flat, Irregular, gummy
11.	R12.2	Pink, medium, flat, Irregular, gummy
12.	R13.2	Pink, small, round, dry Smooth
13.	R14.2	Pink, medium, flat, Irregular, gummy
14.	R15.2	Pink, small, round, dry Smooth
15.	R16.2	Pink, small, round, dry Smooth
16.	R17.2	Pink, small, round, dry Smooth
17.	R18.2	Pink, small, round, dry Smooth
18.	R19.2	Pink, small, round, dry Smooth
19.	R20.2	Pink, small, round, dry Smooth

Table-2 presents a list of samples of rhizobia, a group of soil bacteria that form a beneficial symbiotic relationship with legume plants, helping them to fix nitrogen from the atmosphere. Each sample is identified by a code, such as R1.1 or R4.4, and is described based on its colony morphology, which refers to the visible characteristics of the bacterial colonies when grown on a culture medium. The characteristics mentioned in the table include the color of the colonies (in this case, pink), the size (ranging from small to medium), and the texture or structure of the colonies. Texture descriptions vary from small, round, and dry to medium, flat, irregular, and gummy. These characteristics are essential for microbiologists and researchers as they can provide insights into the specific strain of rhizobia and its potential effectiveness in nitrogen fixation.

In the context of rhizobial strains, it's important to note the correlation between colony morphology and their

effectiveness. As stated in the provided information, the most ineffective sub-strains tend to form large, gummy colonies (Herridge and Roughley, 1975), which could be indicative of reduced nitrogen-fixing capabilities or other limitations in their symbiotic relationship with legumes. On the other hand, the most effective sub-strains are associated with pinpoint, dry colonies, suggesting that they are better suited for nitrogen fixation and establishing a successful symbiotic partnership with legume plants (Herridge and Roughley, 1975). This information highlights the importance of colony morphology in the initial assessment of rhizobial strains and their potential utility in agricultural practices, particularly in enhancing soil fertility through nitrogen fixation.

Soil factors affecting rhizobium activeness

Jhadol tehsil : In the Jhadol region of Udaipur, located in the western Indian state of Rajasthan, the soil composition plays a crucial role in influencing the effectiveness of rhizobium bacteria. The soil in this area is characterized as loamy clay, a type known for its ability to retain moisture and nutrients, making it particularly suitable for agriculture. Additionally, the soil exhibits a relatively high zinc content, which can contribute to the overall health and vitality of plants. Furthermore, the erosion levels in Jhadol are moderate, and the terrain features gentle slopes, further enhancing the soil's stability and fertility (Shyampura and Sehgal, 2002). The pH level of the soil is neutral, creating an optimal environment for microbial activity (Shyampura and Sehgal, 2002). These unique soil conditions in Jhadol create an ideal habitat for rhizobium bacteria, which are crucial for nitrogen fixation in leguminous plants. Rhizobium bacteria are known to thrive in soils with such characteristics, resulting in their increased effectiveness. This is evident in the formation of pin-point dry colonies of rhizobium in the region. These colonies play a vital role in the nitrogen-fixing process, fostering a symbiotic relationship with leguminous plants, thereby enriching the soil with essential nutrients and improving crop yields. Understanding the interplay between soil composition and rhizobium effectiveness in Jhadol can have significant implications for sustainable agriculture practices and crop productivity in this region.

Balvi Barolia, (Vallabnagar) : situated in the Udaipur region, share similar favorable soil characteristics. Both areas feature loamy clay soil with high zinc content, moderate erosion, gentle slopes, and a neutral pH (Shyampura and Sehgal, 2002). These conditions support the effective colonization of rhizobium bacteria, facilitating nitrogen fixation and improving agricultural productivity.

Bichiwara, Jhalan, Faloj and Vadawara within Dungarpur : Rajasthan, the soil composition presents an intriguing environment that significantly enhances the effectiveness of rhizobium bacteria. These areas boast

soil that is rich in zinc, with adequate copper levels, making them unique in terms of nutrient content (Shyampura and Sehgal, 2002). Moreover, the soil is characterized by the absence of sodicity and calcareousness, features that contribute to its overall quality (Shyampura and Sehgal, 2002). The erosion levels are moderate, and the terrain features gentle slopes, which promote soil stability and minimize nutrient runoff. Additionally, the pH level of the soil remains neutral, ensuring an optimal environment for microbial activity. The combination of these favorable soil attributes in Bichiwara, Jhalan, Faloj, and Vadawara creates an ideal habitat for rhizobium bacteria, leading to their increased effectiveness in these regions. One notable manifestation of this effectiveness is the formation of distinct, pin-point dry colonies of rhizobium. These colonies play a pivotal role in nitrogen fixation, establishing a symbiotic relationship with leguminous plants that enriches the soil with essential nutrients. Understanding the interplay between the unique soil properties and rhizobium activity in these regions is of paramount importance for sustainable agriculture practices and the enhancement of crop yields. This research sheds light on the significance of local soil conditions in optimizing rhizobium's pivotal role in agricultural productivity within the Dungarpur district.

Jhadol, BalviBarolia, Vallabnagar and Girwa, Udaipur : presents a challenging scenario for rhizobium bacteria and agricultural productivity. This area is plagued by heavy metal pollution, resulting in elevated pH levels primarily due to the presence of harmful contaminants like Cadmium, Lead, and Chromium (Golui *et al.*, 2020); (Shyampura and Sehgal, 2002). The high pH levels induced by these heavy metals have a detrimental impact on rhizobium bacteria (Labrazi and Fikri, 2018). These essential microorganisms responsible for nitrogen fixation and symbiotic relationships with leguminous plants struggle to thrive in such adverse conditions. The heavy metal pollution not only inhibits rhizobium growth but also disrupts their ability to establish beneficial associations with crops (Labrazi and Fikri, 2018). Consequently, this compromised symbiosis significantly reduces the fertility and nutrient content of the soil, posing a significant challenge to sustainable agriculture in Girwa, Udaipur. Addressing the issue of heavy metal pollution and its adverse effects on soil quality and rhizobium activity is imperative to restore agricultural productivity in this region. Remediation efforts, including soil treatment and pollution control measures, must be implemented to mitigate the negative impact of heavy metals on soil health and promote successful rhizobium-plant interactions. Such interventions are vital to ensuring the long-term sustainability of agriculture in areas affected by heavy metal contamination, like Girwa, Udaipur.

Sagwara, Dungarpur : the soil presents a challenging environment for rhizobium bacteria, crucial for nitrogen fixation and symbiotic plant relationships. Low levels of zinc, steep slopes, and severe salinity (Shyampura and Sehgal, 2002) collectively contribute to a reduced concentration of rhizobium in the soil, leading to limited symbiosis. The scarcity of zinc hinders rhizobium growth, while steep slopes increase erosion, disrupting their distribution. Additionally, severe salinity creates an inhospitable habitat for these beneficial microbes. These combined factors create an unfavorable environment for rhizobium, ultimately impacting agricultural productivity in the region. Addressing these soil challenges through appropriate management practices is imperative to bolster rhizobium effectiveness and support sustainable agriculture in Sagwara, Dungarpur.

Conclusions

In this comprehensive study, we explored the diversity of rhizobium bacteria across nineteen distinct locations in the Udaipur and Dungarpur regions of Rajasthan, India. Through the isolation and characterization of rhizobium strains using Yeast Extract Mannitol Agar (YEMA) analysis, we have gained valuable insights into the metabolic and phenotypic variations of these vital microorganisms. Our findings not only underscore the wide-ranging diversity of rhizobium strains in these regions but also highlight the intriguing correlations between their characteristics and the specific soil types at each sampling location. This study proved that rhizobium synthesis is directly depends on soil properties (Stambulska *et al.*, 2018). This research provides a foundation for understanding the complex interplay between rhizobium bacteria and their local soil environments, shedding light on the potential for tailored microbial solutions to enhance agricultural sustainability. Ultimately, this knowledge paves the way for more effective strategies in harnessing the benefits of rhizobium in optimizing soil health and crop productivity in the unique agro-ecological landscapes of Udaipur and Dungarpur, fostering a more sustainable and resilient agricultural future.

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Screening of Isolates for PGPR Activities and Abiotic Stress Tolerance

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Abstract

In the pursuit of sustainable agricultural practices and enhanced crop yield, this research paper delves into the critical realm of Plant Growth-Promoting Rhizobacteria (PGPR). A comprehensive screening of 19 *Rhizobium* strains was conducted, assessing their potential as PGPR agents along with their abiotic stress tolerance capabilities. The strains were rigorously evaluated across a spectrum of abiotic stress factors, including temperature, pH, salinity, and drought tolerance. Our findings shed light on the multifaceted adaptability and effectiveness of these *Rhizobium* isolates, revealing their capacity to thrive and enhance plant growth under adverse environmental conditions. The results of this study not only contribute to the selection of promising PGPR candidates for sustainable agriculture but also deepen our understanding of the intricate interplay between rhizobial strains and abiotic stress factors, paving the way for more resilient and productive agricultural ecosystems.

Key words : *Rhizobium* strains, PGPR activities, abiotic stress tolerance, temperature tolerance, pH tolerance, salinity tolerance.

Introduction

The botanical name of peas is "*Pisumsativum*," and they belong to the family Fabaceae (also known as Leguminosae) (Dobrovolna *et al.*, 2022). The Fabaceae, or pea family, stands as one of the most expansive and economically significant plant families globally (Smykal *et al.*, 2015), boasting an impressive roster of approximately 18,000 species that span diverse ecosystems (Zhu *et al.*, 2005). Among its ranks, one finds an array of familiar plants like peas, beans, lentils, soybeans, peanuts, and clover. Characterized by their compound leaves composed of multiple leaflets along a central stalk, their distinctive butterfly-like flowers featuring five petals—banner, wings, and keel—and their capacity to form root nodules in collaboration with nitrogen-fixing bacteria, these plants stand as a botanical marvel. Their fruit often assumes the form of a pod that splits upon maturation (Atkins *et al.*, 1977), liberating seeds of various sizes and shapes. Many members of this family are renowned for their exceptional protein content, serving as pivotal sources of plant-based protein. Additionally, they provide a wealth of dietary fiber, endowing benefits like digestive facilitation, satiety promotion, and blood sugar level regulation.

Rhizobia, a group of nitrogen-fixing bacteria, establish a vital symbiotic relationship with leguminous plants (Mazoyon *et al.*, 2023). This intricate partnership benefits both parties by converting atmospheric nitrogen into usable forms for plant growth, ultimately enhancing soil fertility (Aasfaret *et al.*, 2021). Rhizobia initiate nodule formation on the roots of plants like peas, beans, and clover, where they interact closely with the host plant. This remarkable interaction starts with chemical signals emitted by plant roots, attracting the bacteria to root hairs and initiating nodule development. The significance of rhizobia lies in their role as natural nitrogen fixers, enriching the soil with essential nutrients and reducing the need for synthetic fertilizers in agricultural practices (Sahu *et al.*, 2012). With leguminous plants, each species exhibiting a tailored affinity for specific hosts. Among these, *Rhizobium leguminosarum* holds prominence, engaging in partnerships with cool-season legumes like peas, lentils, and vetch. Its capacity to fix atmospheric nitrogen is pivotal, contributing to enhanced soil fertility and nutrient availability. *Bradyrhizobium* spp., encompassing various species, demonstrate a remarkable adaptability, collaborating with an array of leguminous plants such as soybeans, peanuts, and

tropical legumes. This versatility fosters nitrogen fixation across diverse geographical and climatic settings. Meanwhile, *Sinorhizobium spp.* engage in alliances with alfalfa, sweet clover, and select tree species, playing a crucial role in enriching ecosystems with fixed nitrogen. The specificity of these interactions relies on molecular communication, where leguminous plants emit flavonoids, attracting compatible rhizobia (Horiuchi *et al.*, 2005), leading to the production of nod factors and eventual nodule development. This dynamic interplay between bacteria and legumes showcases nature's intricacy, illustrating how these symbiotic relationships underpin sustainable agriculture, soil health, and ecological balance.

Abiotic stress constitutes a formidable challenge to the intricate and finely tuned symbiotic relationship between rhizobia and leguminous plants. Abiotic stresses, ranging from drought and salinity to extreme temperatures and soil pollutants and pH wield the power to disrupt the harmonious equilibrium that these nitrogen-fixing bacteria establish with their host plants (Abdul *et al.*, 2021). Drought stress, a consequence of water scarcity, can trigger a cascading impact, starting with reduced water availability for the plant. This, in turn, hampers the plant's ability to engage in the intricate signaling necessary for effective rhizobial colonization of the roots. The result is compromised nodulation and, subsequently, diminished nitrogen fixation capacity. Salinity, another abiotic stressor, poses a two-fold challenge to the rhizobia-legume symbiosis. High soil salinity levels can directly inhibit the rhizobia's capacity to colonize the root surface and establish nodules. Simultaneously, the host plant's physiological processes are hampered by salinity, leading to reduced nutrient uptake and impaired nitrogen fixation, thus culminating in a reciprocal and detrimental feedback loop. Extreme temperatures represent another key abiotic stress that reverberates through the rhizobia-legume partnership. Both cold and heat extremes can disrupt the intricate signaling processes pivotal for initiating and maintaining symbiosis. Under extreme cold, root nodule formation can be hindered, while under excessive heat, the mutual communication between the host plant and the rhizobia may falter, leading to diminished nodule functionality and nitrogen fixation efficiency. Adding another layer of complexity, soil pollutants, including heavy metals and industrial chemicals, further challenge the vitality of the rhizobia-legume symbiosis (Stambulska, and Bayliak, 2020). These pollutants, often originating from human activities, can impede the growth and survival of rhizobia within the rhizosphere, compromising their ability to contribute to nitrogen fixation. pH Stress, often driven by

soil conditions or environmental changes, can profoundly impact both sides of the symbiotic equation. Low pH, indicating acidity, can directly impede the survival and activity of rhizobia, hindering their capacity to colonize the root surfaces and initiate nodulation. The acidic conditions can also limit nutrient availability, including essential minerals and metals, required for the growth and function of both the rhizobia and the host plants. The impact of pH on the symbiotic relationship between rhizobia and leguminous plants is multifaceted. Incompatibility between the pH requirements of the host plant and the optimal pH range for rhizobial growth and function can lead to reduced nodule formation and nitrogen fixation efficiency. This, in turn, impacts the plant's nitrogen supply and overall growth. In present investigation we are going to explore, how the abiotic stress affects the rhizobium and legume symbiosis.

Materials and Methods

(a) Temperature tolerance : Rhizobium cultures were streaked on YEMA plates, the plates were incubated separately at 20°C, 40°C, 50°C and 60°C for 24 hours. Growth of cultures was observed.

(b) pH Tolerance : pH tolerance was carried out at different pH according to procedure described by (Jimenez, *et al.*, 2011). Rhizobium strains were grown on YEMA broth tubes at different pH conditions (pH 4.0, 6.0, 8.0, 10.0.) and control tubes were at pH 7.0. The pH was adjusted by using 1N NaOH and 1N HCl. After inoculation, all the tubes were incubated at 100rpm at 28±2°C.

(c) Salinity tolerance : YEMA media was prepared for different concentrations of NaCl (0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0%), these flasks with different NaCl 21 concentrations were autoclaved at 121°C for 15psi pressure and was plated in petri plates. Different cultures were streaked on these plates and incubated at 28±2°C and then their growth was observed after 3-4 days.

(d) Drought tolerance : PEG molecules are inert, non-ionic, and virtually impermeable to cell membranes and can induce uniform water stress without causing direct physiological damage (Lu and Neumann, 1998). The strains were tested for their tolerance to osmotic stress on YEMA broth medium supplemented with poly ethylene glycol (PEG) at 10%, 20%, 30% and 40% w/v concentration. The tubes were filled with different PEG concentrations solutions and inoculated by bacterial strains and kept for incubation at 28°C for 3 days until become turbid (Abolhasani *et al.*, 2010).

Statistical analysis : Relevant Statistical studies were done to find out the spatial variability in the rhizobia count

Table-1 : Temperature tolerance of Rhizobial strains.

S. No.	Strain	20°C	40°C	50°C	60°C
1.	R1.1	-	+	+	-
2.	R1.2	-	++	-	-
3.	R3.1	+	+	+	+
4.	R3.3	+	+++	++	+
5.	R4.1	-	++	+	-
6.	R4.4	++	+	+	-
7.	R4.5	-	+	-	-
8.	R5.1	+	+	+	+
9.	R6.1	+	++	+	-
10.	R10.2	+	+	+	-
11.	R12.2	+	+	+	+
12.	R13.2	-	+	+	-
13.	R14.2	-	++	+	+
14.	R15.2	+	+	+	-
15.	R16.2	-	+	+	-
16.	R17.2	+	+	++	-
17.	R18.2	+	+	+	+
18.	R19.2	+	++	++	+
19.	R20.2	-	+	-	-

(-) = No production; (+) = Weak production; (++) = Moderate production; (+++) = High production.

Table-2 : pH tolerance of Rhizobial strains.

S. No.	Strain	pH =4	pH =6	pH =8	pH =10
1.	R1.1	-	+	-	-
2.	R1.2	+	+	+	-
3.	R3.1	+	+	+	-
4.	R3.3	+	++	++	+
5.	R4.1	-	+	++	-
6.	R4.4	-	++	++	-
7.	R4.5	-	+	+	+
8.	R5.1	-	+	-	+
9.	R6.1	+	+++	+++	-
10.	R10.2	+	+	+++	+
11.	R12.2	+	+	++	-
12.	R13.2	-	++	+	-
13.	R14.2	-	+	++	+
14.	R15.2	+	+	-	+
15.	R16.2	-	+	+	+
16.	R17.2	+	+	+	-
17.	R18.2	+	+	++	+
18.	R19.2	+	++	+++	-
19.	R20.2	-	+	+	+

(-) = No production; (+) = Weak production; (++) = Moderate production; (+++) = High production

Table-3 : Salinity tolerance of Rhizobial strains.

S. No.	Strains	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1.	R1.1	+	+	+	+	+	+	+	-	-	-	-
2.	R1.2	+	+	+	+	+	+	+	-	-	-	-
3.	R3.1	++	+	+	+	++	++	+	+	+	-	-
4.	R3.3	++	+	++	+	+	+	+	+	+	+	+
5.	R4.1	++	+	++	+	+	++	+	+	+	-	+
6.	R4.4	+	++	+	+	+	+	+	+	+	+	-
7.	R4.5	+	+	++	+	-	+	+	-	+	-	-
8.	R5.1	+	+	+	-	-	+	-	+	-	+	-
9.	R6.1	++	++	++	+	+	+	+	+	+	-	-
10.	R10.2	++	++	++	+	++	+	+	+	+	+	+
11.	R12.2	++	+	+	++	++	+	+	+	+	+	+
12.	R13.2	+	+	++	+	++	+	+	+	+	+	+
13.	R14.2	++	++	++	++	+	++	+	+	+	+	-
14.	R15.2	+	+	+	-	-	+	-	-	+	-	-
15.	R16.2	+	+	+	-	+	-	-	+	-	+	-
16.	R17.2	++	+	+	++	+	++	+	+	+	+	-
17.	R18.2	++	+	+	+	++	++	+	+	+	-	-
18.	R19.2	++	+	++	+	+	++	+	+	+	+	+
19.	R20.2	+	+	+	+	-	-	+	+	-	-	-

(-) = No production; (+) = Weak production; (++) = Moderate production; (+++) = High production.

Table-4 : Drought tolerance of Rhizobial strains (Absorbance of bacterial strains at 660 nm).

S. No.	Strain	10% PEG	20%PEG	30% PEG	40% PEG
1.	R1.1	0.311	0.189	0.099	0.098
2.	R1.2	0.389	0.201	0.101	0.092
3.	R3.1	0.457	0.350	0.201	0.115
4.	R3.3	0.426	0.441	0.111	0.110
5.	R4.1	0.722	0.239	0.117	0.114
6.	R4.4	0.668	0.320	0.165	0.125
7.	R4.5	0.454	0.197	0.080	0.065
8.	R5.1	0.506	0.208	0.100	0.085
9.	R6.1	0.640	0.602	0.436	0.153
10.	R10.2	0.678	0.428	0.271	0.191
11.	R12.2	0.823	0.696	0.259	0.247
12.	R13.2	1.179	0.314	0.246	0.124
13.	R14.2	0.758	0.314	0.296	0.198
14.	R15.2	0.447	0.156	0.088	0.074
15.	R16.2	0.377	0.145	0.071	0.050
16.	R17.2	0.800	0.494	0.391	0.268
17.	R18.2	0.520	0.277	0.174	0.115
18.	R19.2	0.772	0.673	0.205	0.112
19.	R20.2	0.419	0.221	0.092	0.088

in the sampling data and measures of dispersion such as CV (%), SD and mean were estimated.

Results and Discussion

Temperature tolerance : All the bacterial strains were

streaked on YEMA plates and allowed to grow at different temp. Rhizobial growth and symbiosis are greatly affected by the surrounding temp. Most Rhizobia grow in the range of 28°C-30°C but some also show activity at 37°C. In this study all bacterial strains were streaked on media and

growth was observed at 20°C, 40°C, 50°C and 60°C temperature. All the bacterial isolates were showing growth in 40°C and 50°C. R3.1, R3.3, R5.1, R12.2, R18.2 and R19.2 had growth in all these temperatures.

Statistical analysis : The drought tolerance of various strains of rhizobia was investigated at different temperature levels (20°C, 40°C, 50°C, and 60°C). Table 1 revealed significant variations in rhizobia production levels in response to these temperature conditions. At 20°C, the strains exhibited a relatively low level of rhizobia production, with an average score of 1.63, indicating a “Weak production” response. However, as the temperature increased to 40°C, there was a notable boost in production, with an average score of 7.11, signifying a shift to “Moderate production.” The most remarkable finding was observed at 50°C, where the rhizobia strains demonstrated the highest average production level of 9.68, falling within the “High production” category. Nevertheless, at 60°C, although still in the “High production” range, the average production level decreased slightly to 6.68, suggesting a temperature threshold beyond which productivity may decline. These results underscore the strong influence of temperature on rhizobia’s drought tolerance, with a peak in productivity occurring at 50°C. This statistical analysis showed that rhizobium synthesis is directly correlated with temperature (Zahran *et al.*, 1999).

pH tolerance : Bacteria and other micro-organisms have a very low range of pH for survival and growth, they have varying abilities of growth under acidic and alkaline environments. Majority of them are found to grow best under neutral pH. All bacterial strains grew in pH=6. R3.3, R10.2, R18.2 had growth in all pH ranges experimented.

Statistical analysis : The pH tolerance of various rhizobia strains was investigated at pH levels of 4, 6, 8, and 10. The results showed that at pH 4, rhizobia exhibited weak growth (average score of 1.53), whereas at pH 6, they displayed moderate production (average score of 7.37), indicating their adaptability and productivity in slightly acidic to neutral conditions. At pH 8, growth remained moderate (average score of 6.58), but under highly alkaline conditions at pH 10, rhizobia growth weakened (average score of 4.89). These findings underscore the pH sensitivity of rhizobia growth, with optimal performance in slightly acidic to neutral environments and reduced growth in highly alkaline conditions, which has significant implications for various agricultural and ecological applications. So these findings proved that rhizobium synthesis is highly dependent on the soil pH (Alexandre and Oliveria, 2013); (Jaiswal *et al.*, 2018).

Salinity tolerance : Salinity in medium can be altered by using NaCl salt, high salt concentration shows high salinity of the medium while low salt conc. depicts low salinity. Salinity tolerance was studied using different salt concentrations: 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9% and 10%(w/v) of the YEMA medium for cultures. Salinity is one major limiting factor to plant growth and crop productivity, high salinity found to reduce the growth of roots and inhibits nodule formation, thereby decreasing sites for potential rhizobial infection. All bacterial isolates were growing in NaCl concentration of 0%, 1% and 2%. R3.3, R10.2, R12.2, R13.2 and R19.2 were able to grow in all salinity ranges.

Statistical analysis : The table represents the salinity tolerance of rhizobia across varying levels of soil salinity, ranging from 0% to 10%. The data reveals a clear trend in rhizobia’s response to increasing salinity levels. At the lowest salinity level of 0%, there was no observed production (average score of 2.53), categorized as “No production.” As salinity increased to 1%, rhizobia displayed weak production (average score of 9.21), and this pattern continued with higher salinity concentrations. The peak in production occurred at 10% soil salinity, with an average score of 9.74, falling into the category of “Moderate production.” These findings underscore the dose-response relationship between soil salinity and rhizobia productivity (Thrall *et al.*, 2008), suggesting that as soil salinity levels rise, rhizobia exhibit varying levels of tolerance and productivity.

Drought tolerance of Rhizobial strains : Limited water supply can be described as drought. Micro-organisms can tolerate drought to a certain extent. All bacterial strains were inoculated in 10%, 20%, 30% and 40% of Poly Ethylene Glycol (PEG). All strains were showing growth in 10% PEG tube and only a few had growth in 40% PEG.

Statistical analysis : The table-4 presents data on the drought tolerance of different Rhizobial strains measured in terms of absorbance at 660nm under various PEG concentrations (10% PEG, 20% PEG, 30% PEG, and 40% PEG). The results indicate the range of absorbance values for each concentration level. The maximum absorbance values range from 1.179 at 10% PEG to 0.268 at 40% PEG, while the minimum values range from 0.311 at 10% PEG to 0.05 at 40% PEG. Additionally, a class value is provided for each PEG concentration, representing the mean or central tendency of the absorbance data. These results offer insights into the drought tolerance of the Rhizobial strains under varying PEG-induced osmotic stress conditions, with lower absorbance values indicating reduced bacterial growth and potential drought sensitivity as the PEG concentration increases (Mohammad *et al.*, 1991); (Salam *et al.*, 2010).

Conclusions

Comprehensive screening of 19 Rhizobium strains for PGPR activities and abiotic stress tolerance, encompassing temperature, pH, salinity, and drought tolerance parameters, has revealed promising prospects for sustainable agriculture. Certain strains not only exhibit significant PGPR potential but also demonstrate resilience under adverse environmental conditions (Ahmad *et al.*, 2021). This dual functionality positions them as valuable assets for enhancing crop productivity in regions facing temperature fluctuations, pH variations, salinity stress, and drought conditions. Our findings emphasize the potential of harnessing plant-microbe synergy to mitigate the detrimental effects of abiotic stressors on crop growth while underscoring the need for ongoing research to fully exploit the benefits of PGPRs in modern agriculture, contributing to environmental sustainability and food security.

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Comparative Study of Growth Media and Biological Efficiency of *Agaricus bisporus* on Different Substrate

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Abstract

Fungi can be unicellular or very complex multicellular organisms. They are found in almost any habitat, but most live on land, plant materials and mainly on the soil etc. A group called the decomposers grow in the soil or on dead plant matter. *Agaricus bisporus* belongs to Basidiomycetes family and the most important commercially cultivated mushroom in the world. The rich nutrients like carbohydrates, proteins, lipids, fibers, minerals, and vitamins present this mushroom as famous healthy food. The mycelium growth performance of *Agaricus bisporus* on two different culture media was investigated such as Potato Dextrose Agar Medium (PDA) and Malt Extract Agar Medium (MEA). The studies revealed that PDA medium have very abundant mycelia growth rate and followed by MEA medium. The mother spawn was prepared from three different cereals i.e. wheat (*Triticum aestivum*), barley (*Hordeum vulgare*) and Millets (*Setaria italica*). It has been cultivated on wheat straw, paddy straw and wheat bran. The wheat bran showed faster mycelial growth with greater mushroom biomass weight. While the biological efficiency ranged between 30.16 - 77.45%. The lowest biological efficiency was observed on wheat straw and paddy straw (1:1) and the highest on wheat bran respectively.

Key words : Fungi, culture media, mushroom substrate, biological efficiency.

Introduction

The global population continues to grow at an alarming rate, to tackle the global food demand, especially for protein, one economically viable and sustainable biotechnological solution is the conversion of lignocellulosic agricultural residues into protein-rich mushrooms. Since the late 1990s, the global yield of edible mushrooms has increased significantly due to appropriate cultivation conditions and awareness of their high nutritional value. The utilization of edible fungi to fulfil human nutritional needs has been a shared practice (Sanchez, 2004; Pathak *et al.*, 2009). Mushrooms, also known as macro-fungi, are unique organisms that produce distinctive fruiting bodies. Over 14,000 mushroom species have been identified, with approximately 2,000 of them being edible (Raja *et al.*, 2017; Kumar *et al.*, 2021). Recent studies suggest that mushrooms possess medicinal and preventive properties, making them potential agents for human health (Raja *et al.*, 2017; Kumar *et al.*, 2021). They are a valuable natural source of food and medicine.

Mushrooms contain essential nutrients, including water, proteins, carbohydrates, fiber, fat, ash, minerals, and essential amino acids, making them a cost-effective and protein-rich food source in the fight against malnutrition. Mushroom extracts are increasingly available as dietary supplements, particularly for enhancing immune function and combating cancer.

(Heleno *et al.*, 2010). One well-known edible mushroom is the white button mushroom (*Agaricus bisporus*), also referred to as the table mushroom or cultivated mushroom. It belongs to the Higher Basidiomycota group. Button mushroom (*Agaricus bisporus*) was widely cultivated and consumed worldwide, accounting for 15% of the global mushroom production.

The *A. bisporus* mycelium subsequently colonises the composted substrate by degrading the organic material to release nutrients (Gee, 2018; Ramos *et al.*, 2019). Andrade *et al.* (2010) the *in vitro* mycelium growth of *Agaricus bisporus* on different strains was evaluated performed by means of measurements of four diameters of the colonies, every 48 hours, during 12 days of incubation in darkness under 20 to 25°C. According to Baars *et al.*, 2020 *A. bisporus* mushrooms can be found in different colours (white, off-white and brown), sizes (min. 15 mm cap diameter to large mushrooms with a cap diameter of 50 mm and so longer) and levels of maturation (fully closed caps up to fully opened caps). The pileus diameters recorded for our strains are comparable to the values of 7.24-10.2 cm reported by Wang *et al.* (2010), 37 mm by Savoie *et al.*, (2013), and 33.3 mm reported by Pardo-Giménez & Pardo González (2008) in commercial cultures of Spanish strains and are considered an acceptable size for commercialization.

Agaricus bisporus is the most widely cultivated mushroom species in the world. Cultivation is commenced by inoculating beds of semi-pasteurised

composted organic substrate with a pure spawn of *A. bisporus*. The rates of growth varied slightly depending on the types of growth. Mycelium covering whole grain in days and wheat, mycelium growth on maize grain substrate, the most efficiency being in wheat grain. (Ahmed *et al.*, 2009; Atila *et al.*, 2017). In present time, the commercial substrate for cultivation is mainly consisted of wheat straw, poultry manure, paddy straw, nitrogen-containing additives (soybean meal or synthetic nitrogen), and gypsum under appropriate conditions by microbial situation (Kertesz *et al.*, 2018; Yuan *et al.*, 2020; Kuck *et al.*, 2014). The substrate compositions exhibited to have significant effects on growth, chemical and nutritional compositions, growth of mycelium, fruiting body of cultivated mushrooms (Qiu, *et. el.*, 2022 and Chilanti *et al.*, 2022).

Composed is usually prepared by decomposing wheat straw together with common fertilizers. There are several formulae of ingredients for preparation of compost (Kayastha *et al.*, 2022). It is commonly cultivated using agro-wastes such as wheat straw, reed plant wastes, waste paper, oat straw, waste tea leaves, chicken, horse, or pigeon manures, as well as straw residues from wheat, oat, Tifton, reed crops and certain water plants (Rehman *et al.*, 2016; Andrade *et al.*, 2003; Heleno *et al.*, 2010; Alispahic *et al.*, 2015). It is a protein-rich mushroom, with protein content ranging from 24 to 44% of its dry weight. Additionally, it has a low fat content, ranging from 1.7 to 8.0% by weight, making it an ideal food choice with positive effects on human health (Sobieralski, 2011; Siddiqui, *et al.*, 2020). It combines high nutritional value with potential medicinal properties.

The formulation of different substrate materials used for mushroom cultivation can influence the biological properties of the substrate, including the population and activity of microbes present, as well as the overall biological efficiency of mushroom cultivation using agro-industrial waste. This can include both composted substrates, which are fermented substrates, and non-composted substrates (Zied, *et al.*, 2019). The maximum biological efficiencies of *A. bisporus* the four selected strains were 50.8 to 95.5% (Salmones *et al.*, 2013). The present study aims to investigate the optimal media and formulas based on raw materials including wheat straw, paddy straw and wheat bran. The cultivated button mushroom was comparatively evaluated regarding mycelium growth, yield and biological efficiency. Furthermore, our results may provide a novel idea for recycling the agricultural residues.

Materials and Methods

(i) Study area and Culture : A pure culture of *Agaricus bisporus* was obtained from the Mushroom Laboratory in

the Department of Botany at Meerut College, Meerut. The focus of the study was to assess the substrate quality of three different grains and sawdusts, namely Wheat (*Triticum aestivum*), Barley (*Hordeum vulgare*) & Millets (*Setaria italica*) and sawdust waste i.e. wheat straw, paddy straw, and wheat bran for the cultivation of *Agaricus bisporus*. Grains and sawdust waste were collected from the Shatabdinagar in Meerut

(ii) Preparation of Culture Media : We have to take two types of media like as Potato Dextrose Agar (PDA) and Malt Extract Agar (MEA). The Composition of media as following :

Table-1 : Media composition of PDA and MEA.

Potato Dextrose Agar (PDA)	Component Amount (mg/ml)	Malt Extract Agar (MEA)	Component Amount (mg/ml)
Potato	100 gm	Malt Extract	10 gm
Dextrose	10 gm	Dextrose	10 gm
Agar-Agar	7.5 gm	Agar-Agar	10 gm
Distilled water	500 ml	Distilled water	500 ml

To prepare the Potato Dextrose Agar (PDA) medium, sliced potatoes were boiled in distilled water for approximately 25-30 minutes until they became soft. The resulting extract was then filtered using a muslin cloth. To this filtrate, 10gm of dextrose and 7.5gm of agar powder were added while stirring over a hot plate. The volume of the medium was adjusted to 500ml by adding the required amount of distilled water. The medium was then transferred to separate flasks, plugged with non-absorbent cotton, and sterilized in an autoclave at 121°C (15 psi) for 30 minutes. After sterilization, the medium was allowed to solidify in a slant position. Similarly, the Malt Extract Agar (MEA) medium was prepared following a similar process as the PDA medium, according to the given composition in the table 1. The MEA medium was also sterilized and allowed to solidify in a slant position.

To obtain a pure culture of *Agaricus bisporus*, the original culture was transferred aseptically to individual PDA and MEA slants within a UV-fitted inoculation chamber. The cultures were then incubated at 25°C until sufficient mycelial growth was observed. Pure cultures were obtained by sub-culturing in fresh PDA and MEA media. The slant cultures were transferred to petriplates and incubated at 25°C for 7 days. Once the mycelium had fully invaded the agar medium, the culture was ready for spawn preparation.

(iii) Mother spawn preparation : A variety of grains such as Wheat (*Triticum aestivum*), Barley (*Hordeum vulgare*), and Millets (*Setaria italica*) were purchased for use as substrate in spawn preparation. Traditionally, Wheat,

Table-2 : Effect of different media on Number of colony and radial growth.

S. No.	No. of Days	Different media (Radial Growth 10CM)					
		PDA		MEA		Combined	
		NC	RG	NC	RG	NC	RG
1.	3	1.3	1.14	1.34	1.06	1.67	0.95
2.	6	4.83	2.15	4.23	1.94	3.92	1.83
3.	9	5.93	2.62	5.34	2.52	5.11	2.47
4.	12	7.5	2.65	6.92	2.58	6.34	2.51
5.	15	7.5	2.68	6.94	2.59	6.67	2.52

NC = No. Of colony; RG = Radial Growth (cm)

Table-3 : Effect of different composts on different parameters.

S. No.	Parameters	Substrates		
		Wheat straw	Paddy straw	Wheat Bran
1.	No of fruiting bodies	33	26.3	39.6
2.	Pileus diameter (cm)	5.03	4.3	4.1
3.	Pileus thickness (cm)	0.58	0.52	0.5
4.	Diameter of stipe (cm)	7.5	6.6	6.33
5.	Length of stipe (cm)	3.5	3.16	3.7

Table-4 : Effect of different substrates and substrate combinations on yield of *Agaricus bisporus*.

Type of Substrate	Yield (gm fresh weight/kgs dws)		Biological Efficiency (%)
	1st BATCH	2nd BATCH	
Wheat straw	302.48	278.7	67.65
Paddy straw	262.43	128.64	46.66
Wheat bran	385.5	206.75	77.45
Wheat straw + paddy straw (1:1)	182.67	118.35	30.16
Paddy straw + wheat bran (2:1)	237.34	105.15	34.34
Wheat bran + wheat straw (1:3)	310.76	201.61	51.52
Mean	280.19	173.2	51.29
Standard deviation	61.54	65.36	***

Barley, and Millets grains were used for the mother spawn preparation. However, in this study, a non-traditional approach was taken by using a combination of these grains in equal ratios as a support medium for spawn production. The grains were boiled in water for 30 minutes and then mixed with CaCO_3 and CaSO_4 (10g/kg) in respect to the quantity of Wheat and Barley grains (1:5). The mixture was placed in polythene bags and securely fastened with rubber bands, then wrapped with foil paper. The bags were autoclaved at 121°C for 20 to 30 minutes. After cooling overnight, the autoclaved bags were gently shaken to restore transparency. Aseptically, mycelial bits from the slant culture were inoculated into the bags. These bottles were then incubated at $22\pm 1^\circ\text{C}$ for 15-20 days.

The resulting culture bag served as the mother culture. After 10 days, the mother culture was shaken, allowing the grains to be transferred into 10-15 freshly prepared bags. These spawn bags were stored at 25°C and used for spawning the substrate. The bottles were subsequently incubated at $24\pm 3^\circ\text{C}$ for 15-20 days until the mycelia had fully invaded the grains. After 20 days, the grain spawn was ready to be used for further cultivation.

(iv) Substrate preparation and Cultivation conditions :

The experiment was conducted to compare the growth of *Agaricus bisporus* under different substrates. The substrates used included wheat straw, paddy straw and wheat bran compost. Five kilograms of each substrate was placed on a clean polythene paper. The substrates were watered to maintain the right moisture content. After 24 hours, the spawn was then inoculated in the composted substrates for growth. The incubation period lasted for 15 days at $24-25^\circ\text{C}$ and after mycelial growth; casing was done with an overlay of 5 cm. The substrate was further incubated for 15 days at 24°C at 90 % relative humidity (measure by thermo-hygrometer). The mushrooms were harvested when the pileus opened and the veil broke provided by Oei (2003).

(v) Data collection and analysis : The growth and development of the *Agaricus bisporus* were carefully observed on a daily basis. Various growth parameters, including stipe length (cm), stipe diameter (cm), pileus diameter (cm), and pileus thickness (cm), were measured. Additionally, yield parameters, such as the number of fruiting bodies and the total fresh weight (g) of the



(i) Potato Dextrose Agar Medium (PDA), (ii) Malt Extract Agar Medium (MEA), (iii) Combined (PDA & MEA)
Fig.-1 : mycelia growth rate of *Agaricus bisporus* on different media.

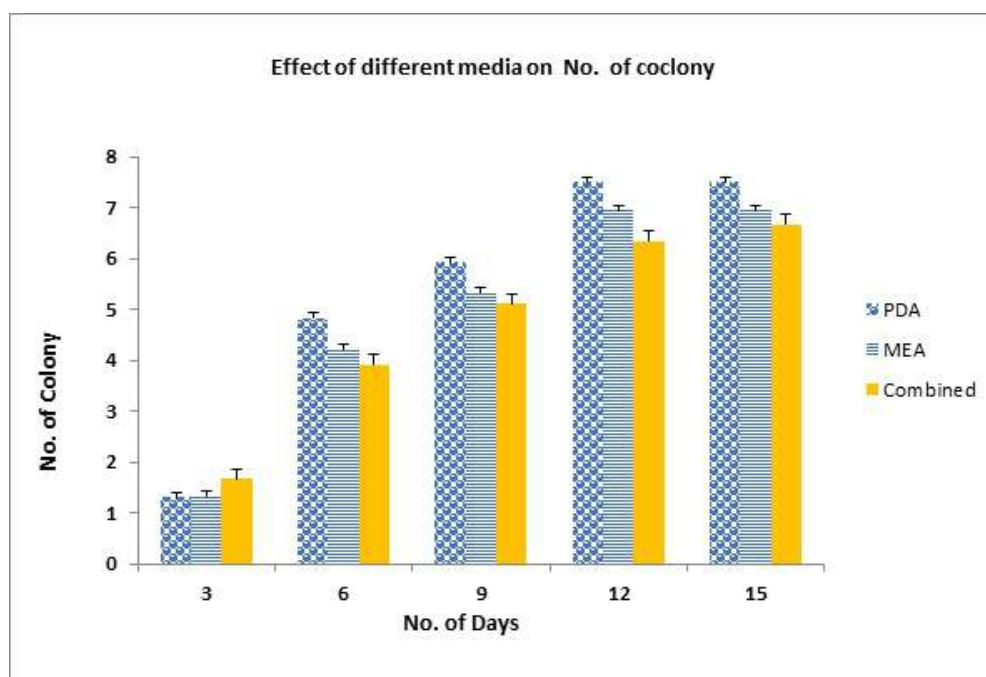


Fig.-2 : Effect of different media on No. of coclony.

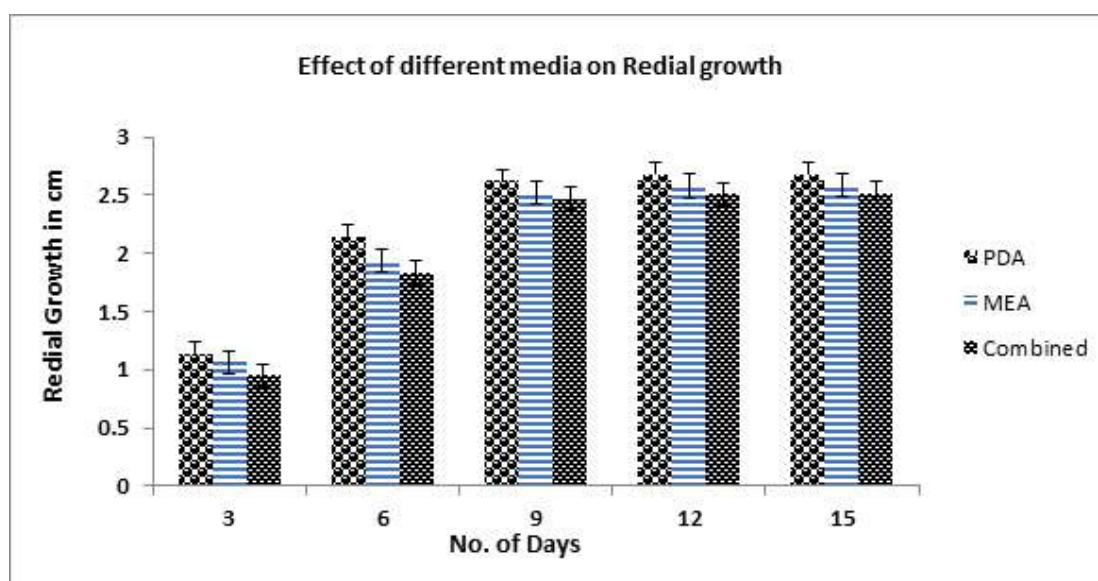


Fig.-3 : Effect of different media on Radial growth.

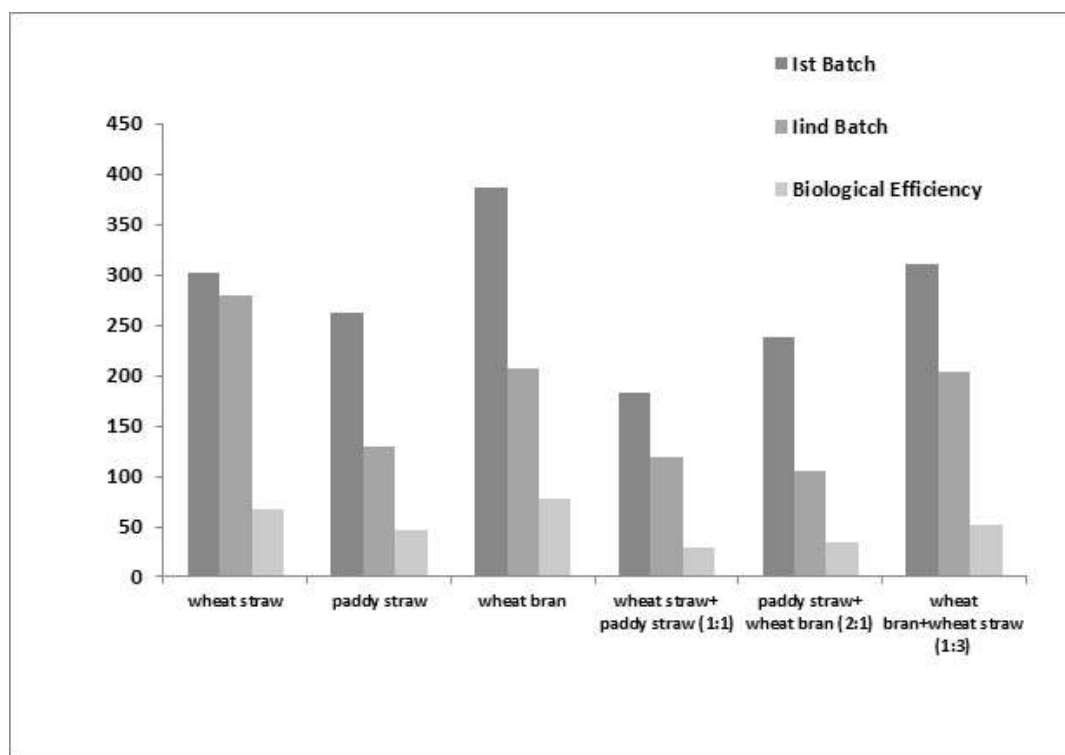


Fig-4 : Effect of different substrates and substrate combinations on yield of *Agaricus bisporus*.

mushrooms, were recorded at the time of harvest. The biological efficiency (%) was calculated using the following formula:

Biological efficiency (B.E.) in % = $\frac{\text{yield of fresh mushroom (gm)}}{\text{total weight of the dry substrate}} \times 100$

Result and Discussion

The results presented in Table-2 showed that *A. bisporus*, the effect of different culture media on mycelia growth was studied. The three different culture media were tested for radial growth and measured three days apart. Mycelia growth on PDA of all three mediums was achieved rapidly and full growth (5 cm) was completed in 3, 6, 9, 12 and 15 days. *A. bisporus* showed the best radial growth on PDA medium (Figure 1), with radial growth of 1.01 cm, 0.47 cm, 0.03 cm and 0.03 cm per day, respectively. So, the growths of mycelia in PDA medium are good performance of *A. bisporus* and followed by MEA and Combined. Similar work by Rashid et al, 2020; Yadav and Chandra (2014) observed mycelial growth on different growth media of *A. bisporus* of 7 strains were examined. The mycelial growth rates were higher on PDA (potato/dextrose/agar) than on other media in all strains examined.

Fruiting bodies were harvested on the day when fruiting bodies presented the pileus in almost flat format, harvest point for fruiting bodies was considered, they were weighed and number of clusters, basidium,

peduncle measurements such as the average size of the pilus and the average diameter of the pilus were taken. The stipe length and cap diameter of *A. bisporus* was measured in an average upto two harvests and observed the significant difference among the substrate (Table-4). The highest stipe length was obtained in wheat bran 3.7cm followed by wheat straw and paddy straw were 3.5cm and 3.16 cm respectively. Likewise, pileus diameter was also found in wheat straw, paddy straw and wheat bran i.e. 5.03cm, 4.3cm and 4.1cm and in case of pileus thickness of wheat straw, paddy straw and wheat bran are found, which were 0.58cm, 0.52cm and 0.5cm respectively under similar environment and cultural practices among other substrates. Khanna and Kapoor, 2007 & 2016; Kerketta, 2020 reported that the stipe length, pileus diameter and total yield of mushroom was higher in Wheat straw than in wheat bran. These results are also similar to the findings of our research. The dry weight was obtained by drying the fruit bodies in an oven with ventilation at 35 °C. Biological efficiency (BE) is calculated as follows :

The effect of different substrates and their combination on the yield of *Agaricus bisporus* was determined in terms of biological efficiency. From Table 4, it was observed that biological efficiency ranged from 30.16–77.45%. The lowest biological efficiency was observed in wheat straw + paddy straw (1:1) and the highest was that on wheat bran, respectively Singh, et al., 2020 was approximately similar results for biological

efficiency. It was observed that the substrates had a significant effect on the average biological efficiency of the substrates and their combinations. In case of third batch the minimum mean value was around 59.27. Additional study revealed that the second batch was associated with the highest standard deviation value of 65.36 which was the maximum upgrade in the second batch.

Conclusions

The composition of solid growth media determines the extent and effectiveness of growth of the culture inoculated. In the present study Potato Dextrose Agar Medium (PDA) and Malt Extract Agar Medium (MEA) were found to stimulate luxuriant mycelial growth rate and whereas comparatively less mycelial growth was recorded on Malt Extract Agar Medium (MEA). Mushroom mycelium is the most excellent tool for categorize necessary nutrients for the production of fruiting bodies. It's showed the highest biological efficiency in wheat bran and with combination of wheat straw.

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Effect of crop establishment methods and nitrogen management on growth and yield of timely sown wheat (*Triticum aestivum*) in Bundelkhand region of Uttar Pradesh

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Abstract

A field experiment was conducted during winter season of 2021-22 at the Research Farm of Banda University of Agriculture and Technology, Banda (U.P) to study the effect of crop establishment methods and nitrogen management on growth and yield of timely sown wheat in Bundelkhand region of Uttar Pradesh. Experiment was laid out in split plot design replicated thrice with two establishment method and seven nitrogen management options were tested. Results revealed that crop grown under zero tillage produce higher yield as compared to conventional tillage. Application of nitrogen through SPAD based treatments performed superior over LCC based and FTNM (100% RDF). Grain yield of wheat was recorded higher in SPAD (40-42) followed by SPAD 42 and SPAD 40 and significantly higher as compared to LCC based treatments and RDF at fixed time nitrogen management.

Key words : Wheat, crop establishment, nitrogen, SPAD, LCC, growth, yield.

Introduction

Wheat is second most important food crop in India after rice, it contributes nearly 55% of its carbohydrates and 20% of food calories. It is widely cultivated in India. In the past few decades, wheat has contributed greatly to increasing and stabilizing the food production of the country and maintained the food security. In India it was cultivated on an average of 31.13 million hectares; the wheat production reached 109.59 million tons with an average national productivity of 35.21 q ha⁻¹ during 2020-21. (Anonymous, 2022). The cost of cultivation is increased as a result of land preparation operations requiring high input energy. In the Eastern Indo-Gangetic Plains, wheat suffers from high temperature stress at grain filling, resulting in productivity losses of up to 30% (Malik *et al.*, 2013). Similarly, wheat crop facing forced maturity in Bundelkhand region of U.P due to early summer. Due to blanket fertilizer recommendations, crop demand for fertilizer does not vary spatially or temporally, resulting in low fertilizer use efficiency, environmental pollution, and higher cultivation costs (Ghosh *et al.*, 2018). In order to maximize crop productivity and profitability, nutrient management programs must supply plant nutrients in sufficient quantities so that they do not negatively impact the environment. (Jat *et al.*, 2013). The conservation agriculture (CA) strategy reduces soil disturbance and maintains organic soil cover, in addition to being economically viable and efficient. Farmers in north-west and eastern India have widely adopted NT for wheat

production, primarily to facilitate early planting of wheat in rice-growing areas, reduce production costs, and increase yield (Chhokar *et al.*, 2007). Precision nutrient management based on conservation agriculture (CA) may be a viable solution. An alternative agricultural production system that also contributes to climate change adaptation and mitigation is also known as a climate-smart strategy. N fertilization applied according to crop needs would be more effective both agronomically and physiologically (Hussain *et al.*, 2000). N inputs should be adopted to crop conditions in order to maximize their efficiency. (Soil Plant Analysis Development or SPAD 502®) and leaf colour chart (LCC) may be helpful to saving of nitrogen and meet out the hidden hunger of plant for nitrogen. On the basis of above facts, an experiment was conducted on crop establishment methods and nitrogen management may be increased the yield of crops.

Materials and Methods

Field experiment was conducted at the University Research Farm, Banda University of Agriculture and Technology Banda Uttar Pradesh during Rabi season of 2021-22. The experimental site is located in the Central Plateau and Hills Region. It is situated at latitude of 28°38'23"N and longitude 78°2' 45" E with an altitude of 228.61 meters above mean sea level, receives an average annual rainfall of (900 mm). The climate here is dry and sub-humid. The soil of the experimental site was clay loam in texture, bulk density of soil is (1.33 g cc⁻¹), PD

of the soil is (2.62 g/cc), low in organic matter (0.41%), low in available nitrogen (216), available phosphorus (16.5 kg ha⁻¹) and high to medium in available potassium (286 kg ha⁻¹) with slightly alkaline in soil reaction (7.60). General weather condition during experiment was found maximum temperature varied from (17.0°C to 43.6°C) and minimum temperature varied from (8.6°C to 24.9°C). The average relative humidity and rainfall was (73.94% and 71.4 mm), respectively. These data were recorded by agro-meteorological observatory of Banda University of Agriculture & Technology, Banda, and Uttar Pradesh. The experiment was carried out in split plot design with replicated three times. Out of the two crop establishment methods i.e., zero till sowing and conventional sowing in main plots treatments and seven nitrogen management options were taken in sub plot viz SPAD = 40 basal, and split 30 kg N on the basis of SPAD and SPAD will be taken from 25 DAS to anthesis, N₂-SPAD = 42 basal 40 kg nitrogen and split with 30 kg, SPAD (40-42) basal 60 kg nitrogen and SPAD value = 40 than 40 kg split dose, when SPAD 40-42 than split 30 kg and when SPAD>42 than 20 kg split dose 30 kg at 45 DAS and 65 DAS, LCC =4 when 6 reading out of 10 reading, recorded = 4 nitrogen will be applied basal equal to 40 kg nitrogen, LCC =4.5 basal equal to 40 kg N, FTNM (100% RDF at 40 kg basal, 40 tillering and 40 before panicle stage), Control (No nitrogen full dose of P & K). Nitrogen was applied as per technical programme and treatment; fertilizer was applied through the urea, single super phosphate (SSP) and muriate of Potash (MOP), respectively. Full dose of phosphorus and potash was applied as basal dose application. Nitrogen fertilizer was applied as per the treatment guided by LCC and SPAD. Both LCC and SPAD readings were taken at 25 DAS to anthesis at the interval of 10 days during 8-10 am. The reading was taken from topmost fully expanded leaf of 10 healthy plants. Emergence was counted at 20 DAS in row length basis and presented on number per square meter basis and also count the number of days it takes for a majority of the seeds in the plot to germinate. Root length of wheat was recorded from border row and uprooted the roots carefully. The root portion was separated using scissor or knife from the upper portion of the plant. The root length was measured from the stem base up to the tip of roots with the help of scale. Dry matter accumulation per meter row length was recorded randomly selected places using a one-meter row length in each plot was cut close to the ground to record dry matter accumulated at 60, 90, DAS and at harvest and converted into square meter. Chlorophyll content in leaves was measured with the help of widely used method SPAD (Soil-Plant Analysis Development) meter. The seed obtained after threshing and winnowing of each plot were weighed in kilograms.

The grain yield was further converted on hectare basis and expressed quintals.

$$\text{Grain yield (q/ha)} = \frac{\text{Net plot grain weight}}{\text{Net plot area (m sq.)}} \times 10000$$

Results and Discussion

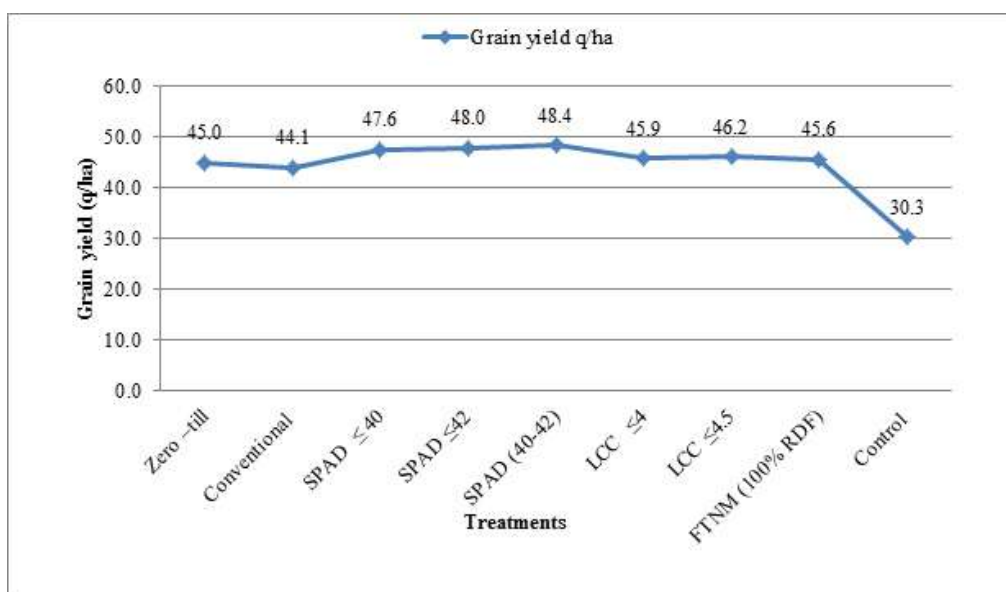
Results revealed that minimum days taken to germination was recorded in zero till sowing which was significantly lower when compared to conventional sowing. (Table-1) The beneficial impact of zero till in early germination of wheat due to no obstacles and coleoptiles were emerges quickly at optimum moisture and depth. Early absorption of water at optimum to high moisture is responsible for early emergence and a minimum day takes for germination over conventional sown wheat. A similar finding was reported by Kumar *et al.*, (2005). However, nitrogen management options did not affect the days taken to germination. Similarly, Maximum germination count was recorded with zero till sowing which was significantly superior over conventional sowing of wheat. However, nitrogen management was not affected significantly to germination count. Similar results were observed by Rawat and Varma, (2006), Khan *et al.*, (2017). Maximum root length of wheat was recorded with zero till sown conditions as compared to conventional. The maximum root length of wheat was found in zero till wheat due to uniform sowing depth and root penetrate to lateral or vertically and minimum root length was recorded in conventional sown conditions. Nitrogen management also influenced significantly on root length of wheat and maximum root length was recorded with SPAD (40-42), however the differences was at par with SPAD 42, and SPAD 40, similar results was reported by Merrill *et al.*, (1996). Similarly, higher dry matter accumulation was also observed with zero tillage sown wheat when compared to conventional tillage. With the increasing the dose of nitrogen and splitting and right dose at right time increased the number of tillers and dry matter accumulation at respective stages of crop growth. Similarly, application of higher doses of nitrogen through based on SPAD and LCC treatment recorded comparatively higher values of growth, development and chlorophyll content in leaf which ultimately reflected yield of crop.

Higher grain yield of wheat was recorded with SPAD based treatments compared to LCC and FTNM. Adoption of zero tillage improves the physical and chemical properties of soil due to slowly decomposition of organic matter in rice wheat system. High yield is the result of all positive impact on soil properties and water storage capacity of soil which supply the nutrients to plants in right pace and right amount (Fig.1). Similarly, sensor based nitrogen management is the tools of precision nitrogen

Table-1 : Effect of crop establishment methods and nitrogen management on days to germination, emergence count, root length, DMA (g/m², chlorophyll content in wheat.

Treatments	Days taken to germination	Emergence count (m ⁻²)	Root length(cm)		Dry matter accumulation (g)/meter row length			Chloro- phyll Content of leaf At tillering stage
			At tillering	At flower- ing	60 DAS	90DAS	At maturity	
Crop establishment Methods								
Zero Tillage (ZT)	6.0	97.0	21.3	25.2	51.6	150.3	209.9	40.9
Conventional Tillage (CT)	8.0	94.2	19.4	22.5	48.6	147.6	207.8	39.6
SEm±	0.06	0.14	0.13	0.30	0.43	0.45	0.36	0.50
CD(P=0.05)	0.35	0.87	0.77	1.85	2.61	2.74	2.22	NS
Nitrogen management								
SPAD = 40	7.0	95.7	21.4	25.2	51.8	152.8	214.4	42.6
SPAD = 42	7.0	95.2	21.5	25.7	52.2	153.1	215.0	42.8
SPAD (40-42)	7.0	95.7	22.2	26.7	53.1	154.0	216.0	43.8
LCC = 4	7.0	95.9	20.2	22.8	50.2	150.3	211.9	39.8
LCC = 4.5	7.0	95.5	20.3	23.2	49.5	149.9	211.2	40.1
FTNM (100% RDF)	7.0	95.4	19.9	22.3	48.7	149.2	210.0	39.4
Control	7.0	95.6	17.4	21.2	45.1	133.4	183.5	33.3
SEm±	0.11	0.67	0.34	0.61	0.52	0.71	0.80	0.66
CD (P=0.05)	NS	NS	0.98	1.79	1.52	2.07	2.34	1.93
Interaction effect (Crop establishment x Nitrogen management)								
SEm±	0.15	0.95	0.48	0.87	0.74	1.00	1.13	0.94
CD (P=0.05)	NS	NS	1.39	NS	2.15	NS	NS	NS

ZT, Zero tillage; FTNM, fixed time nitrogen management; SPAD, soil plant analysis development; LCC, leaf colour chart; DAS, days after sowing; CT, conventional tillage.

Fig-1 : Effect of crop establishment methods and nitrogen management on grain yield of wheat (q ha⁻¹).

management, SPAD based N application are helpful to provide nitrogen in adequate amount and right time. Therefore nitrogen use efficiency may increase and finally yield of wheat was obtained higher in SPAD based treatments compared to LCC based treatment and fixed

time nitrogen management in wheat. Similar results were reported by Mitra *et al.* (2023), Barad *et al.* (2018). On the basis of results obtained, crop establishment through zero tillage and SPAD based application of nitrogen may be a good option for getting higher yield and saving of nitrogen

which will be helpful for controlling of soil pollution and enhancing nitrogen use efficiency.

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Genome Editing Technology for Post-Harvest Losses Reduction in Tomato

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Abstract

Tomato is widely acceptable vegetable crop. This review paper delves into the post-harvest loss of tomatoes, analyzing its implications for farmers and the supply chain. It explores gene editing tools, including TALEN, ZFN, and CRISPR/Cas9, and their advantages and disadvantages. The paper focuses on how genome editing techniques can be applied to enhance tomato post-harvest life and quality. Challenges in implementing gene editing solutions are discussed, and potential ways to overcome them are proposed. Overall, the study emphasizes the promising potential of gene editing to reduce post-harvest losses and improve tomato production efficiency.

Key words : Genome editing, CRISPR/Cas9, tomato, post-harvest.

Introduction

India is the second-largest producer of tomatoes in the world. Tomato holds the title of the world's largest vegetable crop, renowned for its exceptional nutritional value and extensive cultivation. It is highly regarded as a protective food due to its special nutrient content and its wide availability. Being one of the essential vegetable crops, tomatoes are primarily grown for their juicy and fleshy fruits. They hold significant commercial and dietary importance, making them vital to global agriculture and diets. (Quinet et al., 2019). In 2011, worldwide tomato production reached approximately 160 million tonnes, accounting for approximately 15 percent of the total vegetable production. On average, individuals globally consumed about 20 kilograms of tomatoes per year. (FAOSTAT, 2014). In 2022, the global consumption of processed tomatoes amounted to 79.52 million tons. It is projected that this consumption will continue to increase, with estimates indicating it will reach 99.46 million tons by the year 2028. (Source- Research and markets, Global Tomato Industry Report- 2020: Trends and Opportunities by Country, Consumption, Production, Price Developments, Imports and Exports (2007-2025), Dublin, Feb. 14, 2020 (GLOBE NEWSWIRE)) Tomatoes are a versatile food item with widespread culinary applications. They are a good source of vitamin C and the phytochemical lycopene. They are consumed fresh in salads, cooked as a vegetable, and incorporated into various dishes. Additionally, a significant portion of the global tomato harvest is used for processing. Processed tomato products include canned tomatoes, tomato juice, ketchup, puree, paste, and "sun-dried" tomatoes or dehydrated pulp. Tomato plants are herbaceous annuals known for yielding edible fruit. They have a maximum height of 2 meters and possess stems covered in rough

hairs, along with leaves arranged spirally. These plants produce yellow flowers, which ultimately transform into round fruits of diverse colors. Typically, tomato plants are climbing vines requiring support as they can sprawl up to 3 meters tall. Optimal growth conditions involve well-drained locations that receive abundant sunlight throughout the day and slightly acidic soil. However, excessive nitrogen may lead to lush foliage but limited fruit production. (Prasad, personal communication, July 22, 2023).

Tomato Production : China is the largest producer of tomatoes (66.14 million tons during 2020-21) in the world. It contributes about 34% of the world's total tomato production. India contributes to about 10% of the world's total tomato production with a production of 20.87 million tons. Turkey and The United States of America are the third and fourth-largest producers of tomatoes. Turkey has seen rapid growth of tomato production in the last five years. However, when it comes to export, Mexico contributes more whereas, in countries like India and China, the tomatoes are consumed locally or exported in the form of Tomato paste or other processed food products.

Losses after production : Post-harvest losses of tomatoes can greatly affect farmers and the entire supply chain. Tomatoes are highly susceptible to such losses, which can amount to as much as 50 percent of the total harvest. These losses not only result in the wastage of saleable and consumable produce but also lead to a significant squandering of resources like land, water, fertilizers, and chemicals. On average, for each tonne of tomatoes produced, about 21 kg of fertilizers are lost due to post-harvest losses. Additionally, tomato losses also account for a substantial 86 cubic meters of water per tonne of tomatoes. (Thole et al., 2021). Post-harvest losses of tomatoes take place at multiple stages, including

harvesting, transportation, storage, and prior to reaching consumers. These losses have adverse consequences, resulting in reduced profits for growers, processors, and traders, and ultimately impacting the country's foreign exchange earnings. Based on the regression analysis, several factors were identified as significant determinants of the level of post-harvest losses in tomatoes. These factors include the gender of the farmer, household size, farm size, duration of storage, membership in a Farmer Based Organization (FBO), and the type of tomato variety cultivated. (Alidu et al., 2016). The size of the household and the overall value of post-harvest losses were discovered to have a significant negative impact on the per-capita income and welfare of tomato farmers. (Adeopju, A.O., 2014). As post-harvest losses increase due to inefficiencies in harvesting, transportation, storage, or other factors, the financial stability and living conditions of the farmers and their families are adversely affected. Consequently, finding effective strategies to minimize post-harvest losses and enhance the value of produce becomes crucial for improving the economic well-being and overall welfare of tomato farmers.

Deterioration of tomatoes after harvest : Post-harvest losses of tomatoes can be attributed to various factors. These encompass mechanical losses arising from inadequate handling during harvesting and storage, microbial activity driven by microorganisms such as bacteria, fungi, and yeasts that impact perishable food crops like fruits and vegetables, and environmental elements like temperature and humidity. These environmental factors, particularly temperature, and humidity, stand out as the primary contributors to post-harvest losses. (Mohan et al., 2023) (Emana et al., 2017) (Goka et al., 2021).

Physiological disorders : Physiological disorders in harvested tomato fruit refer to irregularities in fruit shape, color, or both, which are not caused by infectious diseases or insect infestations. Instead, these abnormalities stem from environmental stress experienced by the plant. Several factors contribute to these disorders, including high temperature and intense light exposure, excessively rapid fruit growth resulting in cracking, varietal differences among cultivars leading to varying susceptibility to cracking, boron deficiency (particularly in calcareous soil), and concentric cracking caused by fruit exposure to sunlight. (Masarirambi et al., 2009).

Gene editing tools and its types : Genome editing, also known as gene editing, refers to a set of powerful technologies that empower scientists to modify an organism's DNA. These cutting-edge tools enable precise manipulation of genetic material, enabling the addition, removal, or alteration of specific locations within the

genome. Various methods for genome editing have been created and refined, providing researchers with unprecedented capabilities to engineer DNA with high precision and accuracy.

TALEN :

TALEN (Transcription Activator-Like Effector Nucleases) is a powerful genome editing tool that can target and cut DNA at specific locations. It consists of two components: a TALE domain that recognizes the target DNA sequence and a FokI nuclease domain that facilitates the DNA cleavage when two TALEN units bind in opposite orientations. The cell's natural repair mechanisms then come into play, leading to mutations or precise alterations if a repair template is provided. TALEN can be easily customized to target virtually any DNA sequence by rearranging the repeats in the TALE domain, with each repeat recognizing a single nucleotide. TALEN has found applications in genome editing across various organisms, including plants, animals, and humans, for purposes such as enhancing crop traits, creating animal models, and potentially treating diseases.

Advantages-1-High specificity and programmability by rearranging repeat units and choosing suitable RVDs for binding to any desired DNA sequence. 2-Flexible design, adjusting length and position to match the target site. 3-Discrimination between methylated and unmethylated cytosines with some RVDs recognizing different methylation states. 4-High activity in heterochromatic regions, less affected by chromatin compared to CRISPR/Cas9. 5-Ability to edit mitochondrial and chloroplast DNA by fusing a targeting signal for these organelles. 6-Capability for creating novel genome editing tools by combining with various functional domains like base editors, transposases, nickases, activators, recombinases, and epigenomic modifiers.

Limitations-1-Higher cost and complexity in the lab compared to CRISPR/Cas9. Each edit necessitates constructing a new TALEN protein, which can be challenging and prone to errors. 2-Lower multiplexing capacity, as two TALEN monomers are required for each target site, limiting simultaneous editing. 3-Potential for unwanted off-target effects due to binding to similar genomic sequences, especially if lacking strong RVDs or using non-conventional RVDs. 4-Risk of TALE repeats being lost through recombination when delivered by viral vectors. 5-Induction of large deletions at the target site due to the NHEJ repair mechanism. 6-Potential cell toxicity when fused with a deaminase domain that acts on double-stranded DNA. (Becker and Boch, 2021)

ZFN :

Zinc Finger Nuclease is a gene editing tool that consists of

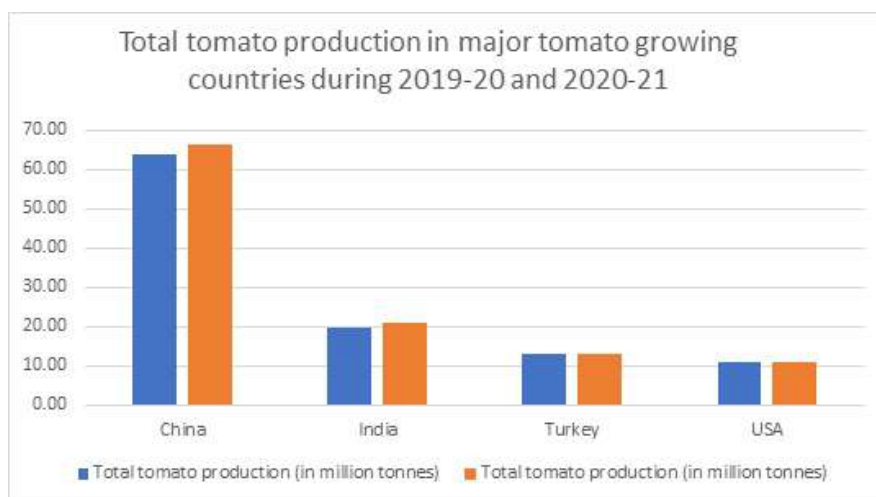


Figure-1 : Major tomato-producing countries of the world.
(Source-FAOSTAT UN)

zinc finger protein domains for specific DNA binding and a nuclease domain for DNA cleavage. They can be designed to target virtually any DNA sequence, leading to the creation of targeted DNA double-strand breaks (DSBs). The repair of these DSBs can result in genetic modifications, such as small insertions, deletions, or rearrangements through non-homologous end joining (NHEJ), or specific sequence modifications or gene integration through homology-directed repair (HDR) using investigator-designed donor DNA.

Advantages-1- They can target and create DNA double-strand breaks (DSBs) at specific locations in the genome, allowing precise modifications. **2-ZFN-mediated DSBs** can lead to gene-specific mutations through error-prone repair processes like non-homologous end joining (NHEJ). **3-Specific DNA sequence modifications** can be achieved through homology-directed repair (HDR) using donor DNA templates, enabling targeted mutagenesis, gene deletion, editing, and transgene integration. **4-ZFNs** can enhance our understanding of plant gene function and improve crop traits like herbicide resistance, stress tolerance, yield, and quality. **5-ZFNs** can be delivered to plant cells using various methods, and modified genomes can be propagated through in vitro cell and tissue culture systems. (Petolino, J.F., 2015)

Limitations-1- ZFNs can bind to DNA sequences that are similar but not identical to the target sequence, leading to off-target effects. **2. ZFNs** require the design and construction of a new protein for each target site. **3- ZFNs** can cause double-strand breaks at sites other than the intended target site. **4- The design of ZFNs** is limited by the requirement for two specific DNA-binding domains.

CRISPR/Cas9 :

Clustered regularly interspaced short palindromic repeats

is a versatile genome editing technology that uses a Cas9 enzyme and guide RNA to target and cleave specific DNA sequences. The guide RNA can be a single guide (sg) RNA or a complex of crRNA and tracrRNA. The DNA break is typically 3 base pairs upstream of a protospacer adjacent motif (PAM), necessary for Cas9 binding. Repair mechanisms like NHEJ or HDR can result in indel mutations or targeted gene replacement. CRISPR/Cas9 is applicable to various organisms through delivery methods like plasmids, viruses, or nano particles. It finds diverse applications in research, biotechnology, and medicine, including gene knockouts, knockins, gene regulation, and correcting genetic diseases.

Advantages of CRISPR/Cas9 over TALEN and ZFN- CRISPR/Cas9 is simpler to design and construct, as it only requires a short RNA sequence to target a specific DNA sequence, while ZFNs and TALENs require engineering large modular proteins. **2-CRISPR/Cas9** is more versatile and can target a wider range of DNA sequences, as long as they are adjacent to a PAM sequence, while ZFNs and TALENs have more stringent requirements for target recognition. **3-CRISPR/Cas9** is more suitable for multiplex gene editing, as multiple sgRNAs can be co-delivered with Cas9 to the cell, enabling simultaneous editing of more than one target at the same time, while ZFNs and TALENs are less efficient for this purpose.

Limitations- CRISPR/Cas9 has potential off-target effects, leading to unintended mutations and possible harmful outcomes. Its efficiency varies depending on target sequence, cell type, delivery method, and repair mechanism, posing challenges for editing certain targets and cell types. (Belhaj *et al.*, 2015).

Abbreviations- SlbZIP1- Basic region leucine zipper (bZIP) transcription factor 1 in tomato, SIRT-

Table-2 : Post-harvest pathogens of tomato fruit.

Disease	Pathogen	Symptoms
Bacterial soft rot	<i>Erwinia carotovora</i>	Water soaking brown discoloration at wounds
Sour rot	<i>Geotrichum candidum</i>	White crusty growth
Rhizopus rot	<i>Rhizopus stolonifer</i>	Gray to white mold on lesions
Black mold rot	<i>Alternaria alternata</i>	Lesions with black mold
Buckeye rot	<i>Phytophthora capsici</i>	Greyish-brown lesions, buckeye-like rings
Gray mold rot	<i>Botrytis cinerea</i>	Water-soaked light brown center

(Source-Bartz, J.A., 1991)

Table-3 : Physiological post-harvest disorder of tomato fruit.

Disease	Symptoms
Blossom end rot	Light tan, water-soaked lesion, expands and becomes leathery.
Catfacet	Deformed with enlarged scars and holes
Sunscald	Due to exposure to sun, whitish shin blisters, become sunken and pale yellowish
Cracking	Splitting of epidermis in circular patterns or splitting that radiates towards blossom end from the stem scar

(Source-University of Illinois, Report on plant disease, RPD No.981, December 2014)

Applications of genome editing techniques in tomato.

Mutation type	Target gene	Target gene function	Outcome
Knockout	SlbZIP1	SIRT	Increase in sugar and AA.
Knockout	SI7-DR2	Encodes 7-dehydrocholesterol reductase (VitD3 precursor)	Accumulation of VitD3 precursor, Decrease in -tomatine
Knockout	SIINVINH1 & SIVPE5	Inhibits sugar accumulation	Higher glucose, fructose & TSS levels.
Knockout	SIAPX4	Mediates ascorbate decrease	Increase in ascorbate content in ripe tomato
Knockout	SGR1	Carotenoid biosynthesis	Increase in carotenoids

Sucrose-induced repression of translation, AA-Amino acids, SI7-DR2 -7-dehydrocholesterol reductase 2, SIINVINH1- Solanum lycopersicum invertase inhibitor 1, SIVPE5- Solanum lycopersicum vacuolar processing enzyme 5, TSS- Total soluble solid, SIAPX4- Solanum lycopersicum ascorbate per-oxidase 4, SIINVINH1- Solanum lycopersicum invertase inhibitor 1, SGR1-Stay-Green 1, SIATG5-Solanum lycopersicum Autophagy-related gene 5, NBS-LRR- Nucleotide-binding site-leucine-rich repeat, SIPLC2- Tomato phospholipase C2 gene, XSP10-Xylem sap protein 10, SISAMT -Salicylic acid methyl transferase, SIXTH5- Solanum lycopersicum Xyloglu- can endotransglucosylase/hydrolase 5, SIPG -Tomato Poly-galacturonase Gene

Challenges and Solution : Genome editing is a groundbreaking technology in molecular biology that enables accurate and targeted modifications within the genome. In the field of plant breeding, it is considered a remarkable innovation as it offers the ability to create precise changes in plants' genetic makeup. This revolutionary approach allows for the rapid generation of novel plants, free from transgenes, and comparable to those achieved through traditional breeding methods. Nevertheless, employing genome editing tools to tackle

post-harvest loss in tomatoes may present certain challenges. ZFNs and the TALENs system have shown promise in inducing targeted mutations (In- Dels) in various horticultural crops to address and improve post-harvest storage quality concerns. (Kumari C. et al, 2022). The limited genetic diversity in tomatoes presents significant obstacles in breeding. However, the emergence of CRISPR- associated protein9 (CRISPR/Cas9) genome editing has revolutionized tomato breeding, enabling rapid and efficient advancements in the field. (Tiwari et al., 2023). The CRISPR-Cas9 system is a highly effective and precise genome manipulation tool inspired by the bacterial adaptive immune system. It utilizes an endonuclease to create double-stranded breaks at specific DNA target sites, guided by a single guide RNA. These breaks can be repaired by cellular mechanisms, resulting in small indels at the cut sites. Compared to other editing tools like ZFN, TAL- ENs, and mega nucleases, CRISPR-Cas9 stands out for its simplicity, user-friendliness, and minimal off-target effects. This technology has been successfully applied in various horticultural and industrial crops to enhance stress tolerance, shelf life, nutritional quality, flavor, and metabolite content. (Sharma et al., 2023).

Table-4 : Application of CRISPR/Cas9 to enhance nutritional quality and taste.

Mutation type	Target gene	Target gene function	Outcome
Knockout	SIATG5	Involved in autophagy	Inhibits autophagy, boosts <i>B. cinerea</i> susceptibility.
Knockout	miR482b & miR482c	Target NBS-LRR genes involved in <i>P. infestans</i>	<i>P. infestans</i> resistant tomatoes
Knockout	SIPLC2	Involved in <i>B. cinerea</i> susceptibility	Improved resistance to <i>B. cinerea</i>
Knockout	XSP10 & SISAMT	Negative regulator of defense against <i>F. oxysporum</i>	Strong phenotypic tolerance to <i>F. oxysporum</i>

Table-5 : Application of CRISPR/Cas9 to enhance post-harvest resistance in tomatoes.

Mutation type	Target gene	Target gene function	Outcome
Knockout	SINAC4	Enhances tomato ripening and softening	Fruit ripening was delayed
Knockout	SIXTH5	Regulator of fruit softening	Firmer pericarp, reduced color index, delayed ripening.
Knockout	SIPG	Breakdown of pectin	Delayed softening, enhanced firmness.
Knockout	SIYTH2	Regulates tomato ripening	Delayed fruit ripening

Conclusions

In conclusion, genome editing, especially the CRISPR-Cas9 system, offers a promising solution to reduce post-harvest loss in tomatoes. By precisely modifying key genes, we can extend shelf life, enhance fruit quality, and improve stress tolerance. This technology holds the potential to revolutionize tomato breeding and contribute to sustainable agriculture and food security. However, ethical and biosafety considerations must accompany its deployment. With continued research and responsible implementation, genome editing can lead to a future where tomatoes reach consumers with improved freshness and nutritional value, minimizing food waste and maximizing agricultural productivity.

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Mulch Colour Influences Growth and Yield Characteristics of Ashwagandha under Tarai condition of Uttarakhand

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Abstract

Ashwagandha, valued for its medicinal properties, is a highly demanded plant by pharmaceutical industry. In order to meet the industrial demand, both quality as well as yield of ashwagandha needs to be improved agronomically. Due to its immunity boosting activities, it is also termed as 'Indian Ginseng' and an integral ingredient of many herbal drinks, powders, tablets, and syrups. However, this plant is hardy and stress tolerant but responds well to improved cultural practices. Therefore, present investigation was conducted to evaluate the impact of different types of mulch colour (transparent, black, and silver-black) on growth and yield of ashwagandha. The results revealed that there were significant differences in plant height (cm), leaf weight (fresh and dry) and economically important root parameters. Overall results suggested that silver-black mulch was found to be the most effective in improving the growth and yield parameters as maximum plant height, leaf fresh and dry weight, root length, root diameter, fresh and dry weight of roots as well as root yield per hectare were observed in this treatment. It was also observed that economic (root) yield increment over control were 36.46 percent in silver-black mulched plants, 26.21 per cent in black mulched plants and 10.18 per cent in transparent mulched plants.

Key words : Ashwagandha, mulch colour, plant growth, root yield.

Introduction

Ashwagandha [*Withania somnifera* (L.) Dunal] is highly valued medicinal herb extensively being used in Indian traditional systems of medicine, Ayurveda, Siddha and Unani. This solanaceous plant is also known as 'Indian Ginseng' and grown for its roots. The active chemical constituents present in its roots are withanolides and withanone. It possesses several pharmacological properties such as anti-oxidant, anti-carcinogenic, anti-apoptotic, anti-tumor, bone healing, neuroprotective, cardioprotective, anti-tumor, anti-oxidant, immuno-modulatory, anti-stress, and anti-inflammatory (1 & 2). Due to its immunity boosting activities, it is an integral ingredient of many herbal drinks, powders, tablets, and syrups (3). Ashwagandha is cultivated commercially in semi- arid and arid zones across the globe such as India, South-Africa, Morocco, Jordan, Pakistan, Baluchistan, Sindh, Egypt, Afghanistan and distributed in the Mediterranean regions (4). The major growing states in India are Gujarat, Madhya Pradesh, Punjab, Uttar Pradesh, Haryana, Maharashtra, Rajasthan and Telangana (5). The estimated area under this crop is approximately 10,780 hectares in India, with a total dry root yield of 8,429 tonnes. India exported a total amount of about 132.72 tonnes valuing 8.17 crores (US\$ 1,202,740) during 2014–2016 (6). As per an estimate, there is a huge

gap between its production in the country and its indigenous demand as well as for export (7). The productivity is low due to abiotic stresses as it is mostly being grown under marginal and neglected conditions. Thus, the focus should be on increasing its productivity as well quality by providing better growth conditions. Being a root crop, its productivity can be enhanced by providing better rhizospheric environment. Mulches are also known as the growers' first line of defense in providing ideal conditions for plants with highly cost efficient. Mulches could potentially minimize water runoff, improving filtration capacity of soil, restrain weed population via shading and perform as obstacle in evapotranspiration (8, 9 & 10). Mulching has also some other positive environmental effects such as temperature regulation of soil and plant roots, minimum nutrient losses, cutdown soil erosion and compactness and improved physical conditions of soil (11, 12 & 13). Mulching is also very effective in improving water productivity as it reduces water loss hence considered as an integral component of water conservation in horticulture production (10 & 14). Considering the medicinal value of ashwagandha and importance of enhancing its productivity and quality and owing to multi-benefits of mulching in combating abiotic stresses and its efficacy in improving yield and quality, a research trial has been designed to evaluate influence of mulch colour on yield and quality of ashwagandha.

Materials and Methods

The present study was conducted at Medicinal Plants Research and Development Centre, Govind Ballabh Pant University of Agriculture and Technology, Udham Singh Nagar (Uttarakhand) during 2021 and 2022 (September to March). The experimental site was located at 79.5° E longitude and 29° N latitude with average annual rainfall of 1420 mm in Tarai belt of Shivalik range of Himalayas (15). The soil of the experimental area was silty clay loam in texture. The chemical characteristics indicated low availability of nitrogen (210.26 kg ha⁻¹), high availability of phosphorus (27.89 kg ha⁻¹), medium availability of potassium (246 kg ha⁻¹) and high organic carbon (0.87%) content and almost neutral in reaction (pH 7.2). The gross and net plot sizes were 6.0 m x 4.8 m and 3.6 m x 2.8 m, respectively. The ashwagandha variety 'Poshita' was sown at 30 cm X 10 cm spacing on and uniform cultural practices were adopted for raising the crop except the variation in mulch treatments. The experiment consists of four treatments i.e., three coloured mulches along with control (T₁- black, T₂- white, T₃- silver colour), with five replications applied in randomized complete block design. Different types of mulch were applied at the time of sowing. All the three polyethylene mulches were of 30 micron thick and transplanting was done by cutting out holes at 25 cm X 15 cm apart. The data related to plant height, leaf fresh weight, leaf dry weight, shoot fresh weight, shoot dry weight, root length and diameter per plant, root fresh and dry weight per plant, dry shoot and root yield per hectare were recorded for comparing the results of various mulch colour on ashwagandha plant. Harvesting was done at the initiation of flowering. The observed data were analyzed by the standard procedures. The data recorded were pooled and analyzed for variance as per standard procedure of Randomized Block Design (RBD) using OPSTAT programme developed by the CCSHAU, Hisar. Data were analyzed using the software and the analyzed data were compiled in the tables.

Results and Discussion

Plant growth characteristics : The plant height of Ashwagandha was significantly influenced by mulch colour at different stages of crop growth (Table 1). The plant heights were recorded 60 and 120 days after transplanting (DAT) as well as finally at harvest. At 60 days after transplanting, the maximum plant height (21.29 cm) was noted in plants managed under silver-black mulched plastic sheet (T₃) followed by the black mulched plants (19.59 cm), however, both values were significantly different with each other. The minimum plant height of 12.68 cm was observed in unmulched control plants. The treatments showed the same trend at 120 days after

transplanting as the maximum plant height was observed in silver-black mulched plants (40.49 cm) followed by black mulched plants (37.45 cm) and transparent mulched plants (34.29 cm) with least plant height in unmulched plants (30.49). All the values for plant height exhibited significant differences with each other at harvest. The data pertaining to leaf fresh weight and dry weight indicated that the highest leaf fresh as well as dry weight (67.10 and 10.81 gm/ plant, respectively) were reported in T₃- the silver-black mulched plants followed by black mulched plants (61.73 and 10.03 gm/ plant, respectively) and transparent mulched plants (47.97 and 7.54 gm/ plant, respectively) having significant differences among these values. The minimum values for leaf fresh as well as dry weight (47.97 and 7.54 gm/ plant, respectively) were observed in non-mulched plants. Plastic mulches enhanced plant growth and development by creating optimum growing conditions, such as adequate humidity and temperature in the root zone (11, 12 & 16). Additionally, plastic mulching contributed towards a better microclimate around plants, which increased cell growth and elongation as compared to non-mulch condition resulted in better plant growth characteristics. Similar findings have been reported, where black plastic mulch resulted in increase in plant height of bell peppers (17) and in pickling cucumber (18).

Yield and yield contributing traits : Root parameters viz., root length, root diameter, root fresh weight and root dry weight of ashwagandha plant are directly linked with its economic value. Marked variation has been observed with the mulch colour variation and non-mulch condition on root characteristics (Table-2). Among all the mulch treatments, the maximum root length and root diameter per plant were observed in T₃ (21.23 and 3.87 cm, respectively) treatment which was followed by T₂ (18.57 and 3.31 cm, respectively), however, both treatments were significantly different with each other for the traits. The least values for both the characters (13.08 and 2.38 cm) were noted in non-mulch plants. Significant influence of different mulches was observed with respect to root fresh and dry weight per plant. A perusal of the Table 2 indicated highest values for both the economically important parameters in treatment T₃ (Silver-black mulch) i.e., 54.85 gm and 15.33 gm per plant, respectively. These were followed by the values obtained in treatment T₂ (black mulched plants). The minimum values for root fresh as well as dry weight (34.33 gm and 10.97 gm per plant, respectively) were obtained from non-mulched plants. The root yield (kg/ha) also followed the same trend as maximum yield was noticed with silver-black mulched plants (1075.30 kg/ha) followed by black mulched plants (994.52 kg/ha) but both the treatments differed significantly in their values. The minimum root yield was

Table-1 : Effect of mulch colour on plant growth characteristics of ashwagandha.

S. No.	Treatment details	Plant height (cm)			Leaf fresh weight (gm/ plant)	Leaf dry weight (gm/ plant)
		60 DAT*	120 DAT	At harvest		
1.	T ₀ -Control (no mulch)	12.68	30.49	38.76	47.97	7.54
2.	T ₁ -Transparent mulch	15.11	34.29	42.55	49.72	8.02
3.	T ₂ -Black mulch	19.59	37.45	51.10	61.73	10.03
4.	T ₃ -Silver-black mulch	21.29	40.49	55.41	67.10	10.81
	C.D. (P = 0.05)	1.05	2.37	2.95	3.68	0.75

*DAT= Days after transplanting

Table-2 : Effect of mulch colour on yield and yield components in ashwagandha.

S. No.	Treatment details	Root length/ plant (cm)	Root diameter/ plant (cm)	Root fresh weight/plant (gm)	Root dry weight/plant (gm)	Economic (Root) yield (kg/ha)
1.	T ₀ -Control (no mulch)	13.08	2.38	34.33	10.97	788.00
2.	T ₁ -Transparent mulch	16.70	3.03	40.77	11.50	868.25
3.	T ₂ -Black mulch	18.57	3.31	47.46	13.65	994.52
4.	T ₃ -Silver-black mulch	21.23	3.87	54.85	15.33	1075.30
	C.D. (P = 0.05)	1.72	0.35	3.41	1.85	23.78

noted in unmulched control plants (788.00 kg/ha). It was also observed that economic yield increment over control were 36.46 percent in T₃, 26.21 per cent in T₂ and 10.18 per cent in T₁. Adequate weather and soil moisture condition are the essential factors which were affecting these traits. Further, reduction in weed population with mulch allowed more space for spread of plants, less competition for water, nutrient and solar radiation with higher photosynthetic efficiency which ultimately resulted in better growth and higher yield. The positive impact on yield parameters due to mulch effect might be attributed to increased available water in root zone, less evaporation losses and lesser competition with weeds. The similar findings with mulch impact were also noticed in guava (9, 10 & 13), chilli (19) and kalmegh (20).

Conclusions

The experimental results have shown that all the mulching treatments were effective in improving plant growth and yield attributes of ashwagandha cv. Poshita. However, silver-black mulch was found to be the most effective in improving the growth and yield parameters studied. Improved soil moisture conservation, soil temperature and nutrient availability as a result of reduced leaching of nutrients and reduced weed infestation provided by mulching might have contributed to the better growth and yield of ashwagandha. In conclusion, it can be opined that though ashwagandha is a hardy and less care requiring crop but the growers should adopt simple and cheap floor management practice (mulching) in their fields. This practice does not only improve the yield but also conserves natural resources (soil and water).

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Costs and Returns Analysis of Jatropha Plantation and Other Major Crops Grown in Coimbatore District of Tamil Nadu, India

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Abstract

Energy security, emissions control and environmental concerns are some of the issues that drive India to search for bio-fuels in general and bio-diesel in particular as an alternative source of energy. The inception of National Biofuel Mission in 2003 has resulted in expansion of jatropha plantations in different states in India. In TamilNadu, jatropha plantation was started in 2008 onwards, mostly at small farmers' level with direct and indirect initiatives of the government and the private sector. However, adoption and expansion of jatropha plantation in the rural areas largely depend on profitability from such plantations at farmers' level. The study has shown positive returns from the investment on jatropha plantation, making it an economically viable venture for the growers of the state. Four villages one each predominantly cultivating the selected crops were grown in Periyanaicken Palayam block have been identified and 10 farmers from each of the selected villages were chosen randomly (constituting a total sample size of 40). The net return per hectare per month was Rs.4687.72 for Bengal gram, Rs.5344.80 for maize, Rs.3902.60 for cowpea and Rs.1233.40 for sorghum. From third year onwards the jatropha plant started producing seeds. From the fifth year onwards, the yield is expected to stabilize. The cost and returns of the possible major other crops for jatropha, namely; Bengal gram, maize, cow pea and sorghum, which occupy 46.80 per cent of the total cropped area in the sample farms revealed that the net returns per hectare remained positive with Rs. 14063.15 for Bengal gram, Rs.21379.20 for maize, Rs.11707.80 for cow pea and Rs.4933.58 for sorghum. Accordingly for jatropha the net return per hectare per month worked out to Rs.1232.38 and Rs.2004.88 for the 3rd and 4th year, respectively and from the fifth year onwards, it was estimated to be Rs.2181.54. Thus, the net return per hectare per month from jatropha was clearly short of those from other crops grown in that block villages in TamilNadu with the exception of sorghum. The rising demand for fossil fuel along with its limited stock will increase fuel price further, which in turn will result in a higher market demand for bio-diesel. Under such a situation, one may expect that the price of bio-diesel would increase in the near future.

Key words : *Jatropha, Establishment cost, Maintenance cost, Tamil Nadu, costs and returns*

Introduction

Production and use of bio-diesel are becoming an important concern across different countries of the world including India. A limited stock of fossil fuels, problems of global warming, generation of employment and income opportunities, etc., are a few driving forces for increased use of bio-diesel (Mathys, 2008). Along with higher economic growth and changing living standards of people, the demand for energy is fast increasing in India (World watch Institute, 2008).

As India meets its major energy requirement through the consumption of diesel, the demand for diesel will increase further in the coming years and, by 2025, almost 90 per cent of India's fuel requirement will be fulfilled only through import (CSIS, 2006). The blending of bio-diesel with diesel can reduce the quantum of such import. The Government of India has launched a National Biofuel Mission in the year 2003, which mandates blending of bio-diesel with high speed diesel at 5 per cent by the year 2012, 10 per cent by 2017 and 20 per cent after 2017 (Shinoj *et al.*, 2010). Therefore, interest on

Jatropha as the primary source of bio-diesel is increasing in the country(India).

Jatropha seed is a good feedstock for the bio-diesel industry and plantation of jatropha is beneficial to poor growers in areas where there are few opportunities for alternative farming strategies and livelihood option. (Freim, 2008). Although the higher economic growth has lifted many people out of the poverty in the country, millions more remain marginalized from the booming economy, which is a difficult task to achieve without alternative employment opportunities in the agricultural sector (Rhoads, 2007). Besides energy security and environmental benefits, jatropha offers a potential opportunity to address the issues of rural livelihoods and poverty (Brittaine and Lutaladio, 2010). Adoption and expansion of any agricultural activity mostly depend upon the profitability in such investment besides other factors. In the case of jatropha, there are uncertainties involved in profitability from plantation at farmers' level. Growers here are engaged in the feed stock production as the first component of bio-fuel value chain (Tomomatsu and Swallow, 2007), which may be a risky enterprise with low

profitability (Messemaker, 2008). The possibility of over-estimation of yield and profitability are the issues of concern in India (Singh *et al.*, 2006). Proper investigations that take into account the costs and benefits resulting from jatropha plantation are needed, which may help in reducing economic risks and influence in adoption and expansion of such plantations. Therefore, there is a need to investigate the potentials of jatropha plantation by examining its costs and returns in such plantations. The present study has analysed the cost and returns of jatropha plantation and other crops grown in TamilNadu through cost and return analysis.

Cost and Return analysis of Jatropha and other major crops was done for the Periyanaicken Palayam block in Coimbatore district of TamilNadu to assess profitability of Jatropha and in other crops grown were worked out. Accordingly, the following major crops grown in this block was identified: Bengal gram, cow pea, maize and sorghum in Periyanaicken Palayam block in Coimbatore district of Tamil Nadu.

Materials and Methods

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). 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 results of the analysis of data collected from the sample farmers are presented in Table-1 to 7. The major results and inferences are given below :

The cropping pattern in the sample farms reveals a diversified set of crops grown with sorghum (16.73 per cent), coconut (13.45 per cent), cow pea (11.55 per cent), Bengal gram (11.35 per cent), sugarcane (10.36 per cent), banana (9.16 per cent) and maize (7.17 per cent) accounting for considerable share of 79.67 per cent (all put together). Jatropha occupied only 2.79 per cent of the total cropped area (Table-1).

The cost and returns of the possible major grown crops for jatropha, namely; Bengal gram, maize, cow pea and sorghum, which occupy 46.80 per cent of the total cropped area in the sample farms revealed that the net returns per hectare remained positive with Rs. 14063.15 for Bengal gram, Rs.21379.20 for maize, Rs.11707.80 for cow pea and Rs.4933.58 for sorghum. The duration of these crops however are approximately 3 months, 4 months, 3 months and 4 months, respectively unlike Jatropha which is a perennial crop and annual yields are computed on yearly basis hence effectively 12 months. Therefore, the net return per month considering the duration of the crops was also worked out for the grown other crops and jatropha.

The net return per hectare per month was Rs.4687.72 for Bengal gram, Rs.5344.80 for maize, Rs.3902.60 for cowpea and Rs.1233.40 for sorghum.

Whereas, 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

Table-1 : Cropping Pattern in the Sample Farms In Periya Naicken Palayam Block of Tamil Nadu. (Ha)

S. No.	Crops	Periyanaicken Palayam Block				All
		Gudur	Chinnamattham palayam	Thadagam	Pannimadai	
1.	Sorghum	6.4 (14.68)	0.8 (5.48)	2.4 (8.95)	7.2 (46.75)	16.8 (16.73)
2.	Maize	1.5 (3.44)	4.9 (33.56)	0.8 (2.99)	0 (0.00)	7.2 (7.17)
3.	Black gram	1.2 (2.75)	0 (0.00)	2.3 (8.58)	0 (0.00)	3.5 (3.49)
4.	Green gram	0 (0.00)	0 (0.00)	2.3 (8.58)	0 (0.00)	2.3 (2.29)
5.	Cowpea	0 (0.00)	0 (0.00)	11.6 (43.28)	0 (0.00)	11.6 (11.55)
6.	Bengal gram	11.4 (26.15)	0 (0.00)	0 (0.00)	0 (0.00)	11.4 (11.35)
7.	Sugarcane	7.0 (16.05)	1.4 (9.59)	0 (0.00)	2.0 (12.99)	10.4 (10.36)
8.	Jatropha	2.8 (6.42)	0 (0.00)	0 (0.00)	0 (0.00)	2.8 (2.79)
9.	Coconut	7.7 (17.66)	2.6 (17.81)	0.4 (1.49)	2.8 (18.18)	13.5 (13.45)
10.	Banana	5.2 (11.93)	0.8 (5.48)	0 (0.00)	3.2 (20.78)	9.2 (9.16)
11.	Flowers	0 (0.00)	0 (0.00)	0.2 (0.74)	0 (0.00)	0.2 (0.20)
12.	Vegetables	0.2 (0.46)	2.4 (16.44)	0.8 (2.99)	0 (0.00)	3.4 (3.39)
13.	Gingelly	0(0.00)	0 (0.00)	1.8 (6.72)	0 (0.00)	1.8 (1.79)
14.	Horse gram	0 (0.00)	0 (0.00)	4.0 (14.93)	0 (0.00)	4.0 (3.98)
15.	Turmeric	0 (0.00)	0.4 (2.70)	0 (0.00)	0 (0.00)	0.4 (0.40)
16.	Tapioca	0 (0.00)	0.4 (2.72)	0 (0.00)	0 (0.00)	0.4 (0.40)
17.	Others	0.2 (0.46)	1.1 (7.53)	0.2 (0.75)	0 (0.00)	1.5 (1.49)
	Total	43.6 (100.00)	14.6 (100.00)	26.8 (100.00)	15.4 (100.00)	100.4 (100.00)

(Numbers in parentheses indicate percentage to total cropped area.)

Table-2 : Cost and returns of Bengal Gram (Local traditional Red) Cultivation in Sample Farms in Periyanaickenpalayam Block of Tamil Nadu (Year 2012-13). (Rs/ha)

S. No.	Particulars	Qty	Value (Rs)
1.	Human Lab our (Man days)	88.92	19436 (36.78)
2.	Bullock power (hrs)	19.76	494 (0.93)
3.	Machine power (hrs)	37.05	13401 (25.36)
4.	Seeds (Kg)	98.80	4940 (9.35)
5.	Manures (tonnes)	6.175	6175 (11.69)
6.	Fertilizer nutrients (Kg)		4446 (8.41)
	N	0	
	P	0	
	K (Potash)/DAP	308.75 247	
7.	Plant protection chemicals (MI) (Monocrotophos, Split)	2470	3953 (7.48)
8.	Total variable cost (Rs)		52845 (100.00)
9.	Yield (quintal)		16.79
10.	Price (Rs/quintal)		3985
11.	Gross return (Rs)		66908.15
12.	Net return (Rs)		14063.15

(Numbers in parentheses indicate percentage to total cost.)

S. No.	Particulars	Value (Rs)
1.	Net returns per month	Rs. 4687.72

Table-3 : Cost and returns of Maize (hybrid) Cultivation in Sample Farms in Periyanaickenpalayam Block of TamilNadu (Year 2012-13). (Rs/ha).

S. No.	Particulars	Qty	Value (Rs)
1.	Human labour (Man days)	155.61	28405 (51.80)
2.	Machine labour (hrs)	24.7	4940 (9.01)
3.	Seeds (Kg)	12.35	3705 (6.76)
4.	Manures (tonnes)	7.41	11115 (20.27)
5.	Fertilizer nutrients (Kg) N (Urea) P K (Potash)/DAP	247 0 123.5 123.5	5928 (10.81)
6.	Plant protection chemicals (gms) (Weedicides)	4940	741 (1.35)
7.	Total variable cost (Rs)		54834 (100.00)
8.	Yield (quintal)		50.64
9.	Price (Rs/quintal)		1505
10.	Gross return (Rs)		76213.20
11.	Net return (Rs)		21379.20

(Numbers in parentheses indicate percentage to total cost).

S. No.	Particulars	Value (Rs)
1.	Net returns per month	Rs. 5344.80

Table-4 : Cost and returns of Cowpea (Co4) Cultivation in Sample Farms in Periyanaickenpalayam Block of TamilNadu (Year 2012-13). (Rs/ha)

S. No.	Particulars	Qty	Value (Rs)
1	Human labour (Man days)	74.1	12597 (49.71)
2.	Machine labour (hrs)	4.94	3766.75 (14.86)
3.	Seeds (Kg)	24.7	1482 (5.85)
4.	Manures (Tonnes)	3.705	2531.75 (9.99)
5.	Fertilizer nutrients (Kg) N P K 20:20: 0 complex	123.5	1951.30 (7.70)
6.	Plant Protection Chemicals (MI) (Endosulphon, Dithane M- 45)	3705	3013.4 (11.89)
7.	Total variable cost (Rs)		25342.20 (100.00)
8.	Yield (quintal)		12.35
9.	Price (Rs/quintal)		30
10.	Gross return (Rs)		37050
11.	Net return (Rs)		11707.80

(Numbers in parentheses indicate percentage to total cost.)

S. No.	Particulars	Value (Rs)
1.	Net returns per month	Rs. 3902.60

return per hectare per month was worked out to Rs.1232.38 and Rs.2004.88 for the 3rd and 4th year, respectively and from the fifth year onwards, it was estimated to be Rs.2181.54. Thus, the net return per hectare per month from jatropha was clearly short of those from the grown other crops with the exception of

sorghum. Lack of marketing opportunities is a discouragement for the jatropha growers. (Table 2 to 7).

Conclusions

The study has revealed that jatropha plantation in TamilNadu was slightly viable, though not highly profitable

Table-5 : Cost and returns of Sorghum (Local traditional Yellow) Cultivation in Sample Farms in Periyanaickenpalayam Block of TamilNadu (Year 2012-13). (Rs/ha)

S. No.	Particulars	Qty	Value (Rs)
1.	Human labour (Man days)	44.46	8496.80 (35.35)
2.	Machine labour (hrs)	7.41	2902.25 (12.08)
3.	Seeds (Kg)	44.46	3112.20 (12.95)
4.	Manures (Tonnes)	4.94	5051.15 (21.02)
5.	Fertilizer nutrients (Kg)		4470.70 (18.60)
	N Urea	247	
	P		
	K		
	DAP	123.5	
6.	Total variable cost (Rs)		24033.1 (100.00)
7.	Yield (quintal)		9.4354
8.	Price (Rs/quintal)		3070
9.	Gross return (Rs)		28966.68
10.	Net return (Rs)		4933.58

(Numbers in parentheses indicate percentage to total cost.)

S. No.	Particulars	Value (Rs)
1.	Net returns per month	Rs. 1233.40

Table-6 : Establishment Cost of Jatropha Plantations by Sample Farmers in Periyanaickenpalayam Block of TamilNadu (Year 2012-13) (First Year) (Rs/ha)

Sl. No.	Particulars	Month of Operation	Quantity/ ha	Unit Cost	Rs /ha (1Year)
I	Preparatory cultivation	April / May			
a.	Land preparation		2 Ploughing	Rs. 875 / Ploughing	1750 (8.17)
b.	Digging pits (1x1x1 foot)		1860	Rs. 1 per pit	1860 (8.68)
II	Planting	June / July			
a.	Cost of seedling (including Transport)		1860 plants / Ha	Rs. 2.50 per plant	4650 (21.71)
b.	Planting labour		1860	Rs. 1.00 per pit	1860 (8.68)
c.	Basin formation		1860	Rs. 1.00 per pit	1860 (8.68)
III	Weeding (2 weeding)	Oct / Nov			
a.	Labour cost		8 women / weeding	Rs. 90 / woman / day	1440 (6.72)
IV	Manure &Fertilizers application	June / July/August			
a.	Farm yard manure (FYM)		3.5 tons	Rs. 600 / tonne	2100 (9.81)
b.	Cost of application		4 men	Rs 120 / man / day	480 (2.24)
c.	Fertilizers		80Kg 85Kg 86Kg	Rs.4.5/Kg Rs.17/Kg Rs.5.50/Kg	360 (1.68) 1445 (6.75) 473 (2.21)
d.	Cost of application		3 women	Rs.90/woman/day	270 (1.26)
V	Plant protection				
a.	Cost of pesticides	(one-time insecticide and fungicide spray)			1500 (7.01)
b.	Cost of application		1 women, 1men	Rs.90/ woman / day, Rs.120/men/ Day(Rs.20/tank @ totally10tanks)	410 (1.92)
VI	Irrigation	2 times			
a.	Labour cost		2 men / irrigation	Rs. 120 / man/day	480 (2.24)
VII	Pruning	Dec / Jan			
a.	Labour cost		4 men / Ha	Rs. 120 / man / day	480 (2.24)
	Application of Gibberellic acid				0
VIII	Harvest				
a.	Labour cost				0
	Total Cost				21418 (100.00)
	YIELD	Tons / Ha			NIL
	Gross returns	Rs. / Ha			NIL
	Average No. of Plants per ha, Net returns		1860		-21418.00
	Cost per Plant				11.52

Table-7 : Maintenance Cost of Jatropha Plantations by Sample Farmers in Periyanaickenpalayam Block Of TamilNadu (Rs/ha) (Year 2012-13) (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	1111.50 (9.33)	1111.50 (11.21)	1111.50 (10.56)	1111.50 (10.22)
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(3mandays)	450 (3.78) 1750 (14.69) 550 (4.62) 360 (3.02)	450 (4.54) 1750 (17.66) 550 (5.55) 360 (3.63)	450 (4.28) 1750 (16.63) 550 (5.23) 360 (3.42)	450 (4.14) 1750 (16.10) 550 (5.06) 360 (3.31)
3.	Plant Protection a. Cost of Pesticide 410 b. Cost of application (1men,1women Rs.20/tank @ totally10tanks)	1600 (13.43) 410 (3.44)	1700 (17.15) 410 (4.14)	1800 (17.11) 440 (4.18)	1800 (16.56) 470 (4.32)
4.	Earthing up	3060 (25.69)	0 (0.00)	0 (0.00)	0 (0.00)
5.	Irrigation a.Labour cost	960 (8.06)	960 (9.69)	1120 (10.64)	1120 (10.30)
6.	Pruning(two prunings at flowering) a. Labour Cost	960 (8.06)	480 (4.84)	560 (5.32)	640 (5.89)
7.	Application of Gibberellic acid	700 (5.88)	700 (7.06)	700 (6.65)	700 (6.44)
8.	Harvest a. Labour cost	0 (0.00)	1440 (14.53)	1680 (15.97)	1920 (17.66)
	Total Cost	11911.50 (100.00)	9911.50 (100.00)	10521.50 (100.00)	10871.50 (100.00)
	YIELD (tons/Ha)	0	2.470	3.458	3.705
	Cost per plant(Rs)	6.40	5.33	5.66	5.84
	Gross returns (of seed)	0	24700	34580	37050
	Net return (Rs)	-11911.50	14788.50	24058.50	26178.50

S.No.	Particulars	Value (Rs)			
1.	Net returns per month	2 nd year	3 rd year	4 th year	5 th year onwards

at the present. Since the cost needed for plantation is relatively lower for jatropha than other crops alternatives in the state, resource-poor growers may look for investment in jatropha plantation. The major cost component of jatropha plantation is labour cost, which is incurred on operation and maintenance, harvesting and seed separation activities. Among these, cost on cleaning and weeding has been found the highest in the state, followed by costs on pruning and replanting. The plantation activities would become attractive for the growers, if they get adequate financial support for

operating and maintaining their plantation sites. In this context MGNREGA can help the growers by creating employment opportunities in various operations, needed during a year. Further, research and development efforts on new seed varieties, post management operations, better market price, etc. will make jatropha plantation more attractive. The analyses so far are based on the assumption that price would remain constant over the years. But, it does not seem to remain so as there is an increasing demand for fossil fuel (oil) in the world market. The rising demand for fossil fuel along with its limited stock

will increase fuel price further, which in turn will result in a higher market demand for bio-diesel. Under such a situation, one may expect that the price of bio-diesel would increase in the near future. Accordingly, any future step to increase the procurement price of jatropha seeds will support the growers in TamilNadu.

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Rainfall Prediction in Western Haryana through Stochastic Time Series Auto-Regressive Integrated Moving Averages (ARIMA) Model

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Abstract

Due to changeability in terms of time and area, as well as the impossibility to access all the components impacting rainfall across a region, rainfall forecasting is seen as a tough undertaking. Although forecasting is related to watershed management and agriculture, which both have a substantial economic impact. Given that it is highly irregular and complicated, the prediction of rainfall requires mathematical modelling and simulation. In this order, an Autoregressive Integrated Moving Average (ARIMA) Model was used to analyse monthly rainfall in district Hisar and Bhiwani of western Haryana. However, ACF and PACF were applied to find the models by the help of optical assessment. The analysis revealed that best model for precipitation was ARIMA (0,0,0) (0,1,1). The majority of the points in both series fell on a line, hence model residuals were almost normal. It was discovered that the model's efficiency was adequate for forecasting and therefore, it can be used for future water planning projections concerning monthly rainfall in the Hisar and Bhiwani regions of western Haryana conditions.

Key words : ARIMA, Autocorrelation function, Prediction, Rainfall model, Variability.

Introduction

Rainfall is a natural climatic phenomenon that is difficult to forecast. Given how much the agriculture industry contributes to the country's economy, its prediction is especially pertinent to that industry. Numerous efforts have been undertaken globally to forecast its behavioural pattern using different methodologies (Patel *et al.*, 2014). Time series forecasting has drawn a lot of interest from scholars in recent years. Time series forecasting techniques are required for planning, developing, managing, and other crucial operations in all sectors of engineering and other fields.

Traditionally, academics have used Box-Jenkins methods of AR (Auto-regressive), ARMA (Auto-regressive Moving Average), ARIMA (Auto-regressive Integrated Moving Average), ARMAX (Auto-Regressive Moving Average), etc., for time modelling, series analysis, and forecasting. The technical community has long relied on the traditional time series modelling techniques, however they only give fair accuracy and have problems with linear and stationary assumptions (Patel *et al.*, 2014). For water demand by various industries, droughts, environmental flows, reservoir level maintenance, and calamities, rainfall forecasting is crucial. There have been several attempts in recent years to model and forecast rainfall using a variety of methodologies, with time series techniques proving to be the most popular (Jha 2013). The seasonal differenced series eliminates the trend impact as a result of their differentiation, and the series

then becomes stationary. The SARIMA models for subseries also demonstrate the stability of the monthly average temperature structure. The predicted outcomes demonstrate how well the SARIMA models match the data. Consequently, a statistical approach may be used to assess the Stockholm monthly temperature. (Moller 2009).

To enable the development of synthetic data sequences as well as projections of the data one or more time periods in the future. In the past, values for several hydrological variables have been generated and forecast on a weekly, fortnightly and monthly basis using the multiple seasonal ARIMA. (Popale and Gorantiwar 2014). The ARIMA process is a potent method for predicting and modelling time series that allows for the flexible incorporation of a wide range of time series properties. ARIMA models have been effectively applied to hydrological time series modelling in the past. to enable the development of synthetic data sequences as well as projections of the data one or more time periods in the future.

In the past, the ARIMA has been used to generate and forecast values for several hydrological variables on a weekly, fortnightly, and monthly basis. The ARIMA process is a potent method for predicting and modelling time series that allows for the flexible incorporation of a wide range of time series properties. The purpose of this study is to determine if the ARIMA class of models is appropriate for generating and forecasting weekly rainfall.

Materials and Methods

Data used and inputs procedure : The data analysis was done using statistical software SPSS. The ARIMA model was developed for forecasting of temperature using SPSS software adopting procedures that discussed above. The temperature data was collected from the Climatic Research Unit (CRU), University of East Anglia (<https://www.uea.ac.uk>) on a grid basis. Temperature data of 31 years (1985-2016) were used for developing ARIMA models. Data was used for diagnostic, calibration and forecasting of temperature.

Location : North India's state Haryana is a landlocked region between 74°28' and 77°36' E longitude and the latitude of 27°39' and 30°35' N. 4.42 million hectares make up the entire state's geographic area which is 1.4% of the entire nation. Between 200 and 1200 metres above sea level, Haryana's elevation ranges from 700 to 3600 feet. Only 4% of the area in Haryana is covered by forests, compared to 21.85% nationwide. In western Haryana, at 29.09°N 75.43°E, Hisar district is typically 215 metres (705 feet) above mean sea level. The Bhiwani district, on the other hand, is situated at 28.78°N 76.13°E and is on average 225 metres (738 feet) above sea level.

Climate : Around 45 °C (113 °F) is the average summer temperature of Haryana, and the winters are pleasant. The warmest and coldest months are May, June and December, January respectively.

The average annual rainfall is 354.5 millimetres in this dry to semi-arid region. Approximately 29% of the total rainfall fell between July and September, with the rest amount falling between December and February. It experiences warm winters and extremely scorching summers due to its continental climate. The Hisar's climate is primarily characterised by dryness, high temperature swings, and little rainfall. Summertime maximum daily temperatures range from 104 and 115 °F (40 and 46 °C), 32.3 °C (90.1 °F) and 15.4 °C (59.7 °F) are the average maximum and lowest temperatures each year, respectively. 5 to 100% relative humidity is typical. The south-west monsoon reaches outer region's where the Hisar is situated. The majority of the year's rainfall, about 429 mm (16.9 in), falls between July and August. The climate of the nearby steppe has an impact on the Bhiwani. In the Bhiwani district, the temperature ranges from 2°C to 45°C. The Bhiwani reported an average temperature of 25.2 °C. The months of July and August saw the most of the little rainfall (483 mm of annual rainfall).

Model used

Box-Jenkins Method : This investigation applies

Box-Jenkins approach for modelling. The method contains 4 stages procedure that includes :

(a) Model identification : For model identification a correct model structure of AR, MA or ARIMA and order of model was recognized. Moreover, models may be recognized by the plots study of the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) (Box and Jenkins, 1976).

(b) Estimation of model parameters : Estimation of the model coefficients involved the maximum likelihood estimation methods or application of non-linear least squares. A more intricate iterative process becomes necessary during the estimation of the ARMA and MA models parameters. (Chatfield, 2004; Box and Jenkins, 1976).

(c) Diagnostic checking : It was essential for making sure the model was appropriate. Additionally, the model's residuals must be white noise & the derived attributes must be significant statistically. Anderson (1977), described errors may be detected using plots of the residual means and variance over time, plots of the ACF and PACF of the residuals, and the Box-ljung test.

(d) Forecasting : Anticipated values were obtained in this case by estimating the relevant model. While multivariate time series include measurements for many variables, univariate time series only include measurements for a single variable. According to the situation where the measurements are made, time series might potentially be continuous or discrete. A continuous measurement is one that is taken at every moment of time, whereas a discrete measurement is one that is taken at different (discrete) points of time, such as yearly, monthly, weekly etc. It is similar to an ARMA model to describe an autoregressive integrated moving-average (ARIMA) model. The key distinction is that ARIMA is applicable when the underlying data is non-stationary and has to be differentiated in order to become stationary. The technique turns into an ARMA procedure once the data has been differentiated. The effects of the original differencing are then reversed using the results from the ARMA process. In order to eliminate non-stationarity while employing the ARIMA model, finite differencing is performed to the data.

The non -seasonal differencing is expressed as:

The model referred to as an ARIMA (p, d, q) and is represented algebraically as :

$$\phi(B)(1-B)^d X_t = \theta(B) \epsilon_t, \epsilon_t \sim WN(0, \sigma^2)$$

Where :

(i) *WN* stands for white noise.

(ii) Non-seasonal differencing is represented by d,

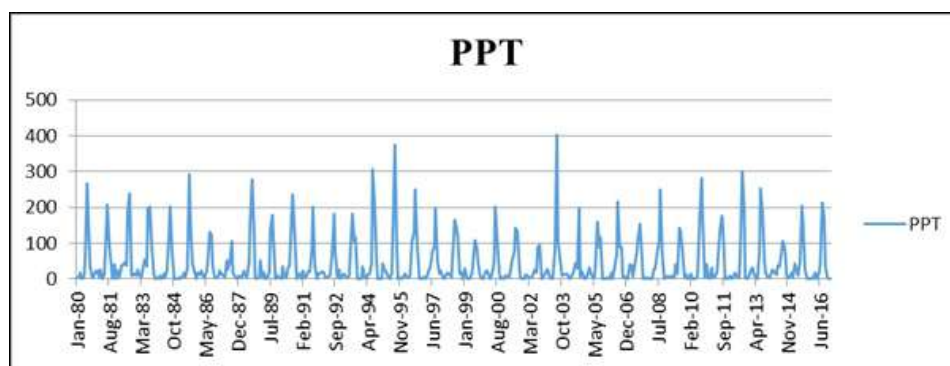


Figure-1 : The graph showing time plot of precipitation changes in the Hisar conditions.

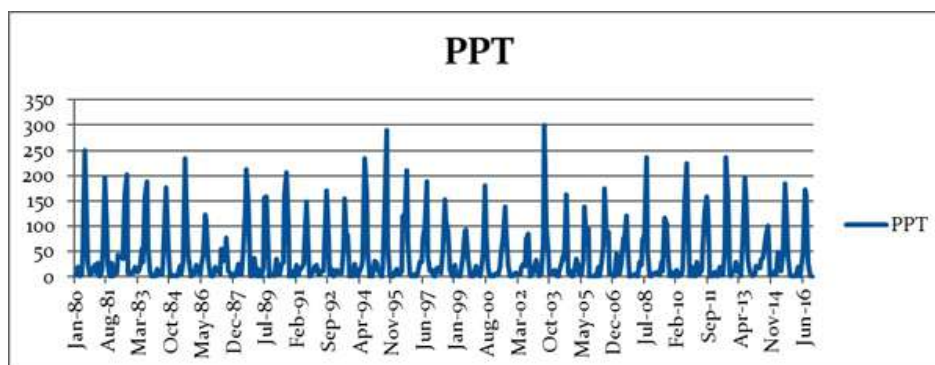


Figure-2 : The graph showing time plot of precipitation changes the Bhiwani.

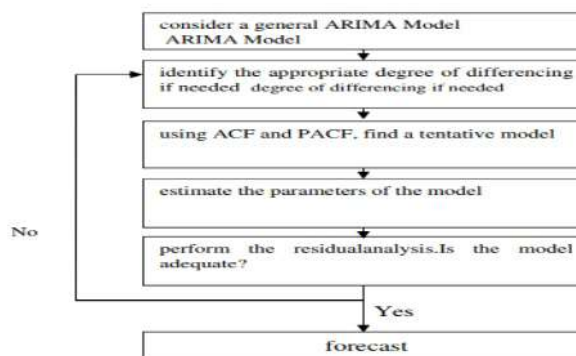
Non-seasonal AR order is represented by p , and Non-seasonal MA order is represented by q .

In general, $d = 1$ suffices. The model becomes an ARMA (p, q) model if d is equal to 0.

In case a series has both seasonal and non-seasonal behaviours then the ARIMA model may mislead to the selection of a wrong order for non-seasonal component because it may not be able to capture the behaviour along the seasonal part of the series.

Where, ' p ' denotes non-seasonal AR order, ' d ' denotes non seasonal differencing, ' q ' denotes non-seasonal MA order, ' P ' denotes seasonal AR order, ' D ' denotes seasonal differencing, ' Q ' denotes seasonal MA order, ' S ' denotes seasonal order (for monthly data $S = 12$), ' y_t ' denotes time series data at period t , ' B ' is the backward shift order operator ($B^k y_t = y_{t-k}$) and ' ϵ_t ' is the random shock (white noise error). In this model non-stationarity is removed from the series using the appropriate order of seasonal differencing. A first order seasonal difference is computed as $Z_t = y_t - y_{t-12}$ and represents the difference between an observation and its comparable observation from the previous year. ($S = 12$, for monthly time series).

Non-seasonal differencing is also necessary if a trend is present in the data. Often a first non-seasonal difference will "detrend" the data (Abdul-Aziz *et al.* 2013).



Results and Discussion

In both districts >90% of annually rainfall for the period of south west monsoon (June-Sept.). Annual rainfall of the Hisar and Bhiwani was recorded as 429 mm and 465 mm, respectively. We found that the performance of ARIMA (0,0,0) (0,1,1) ARIMA (0,0,1) (0,1,1) and ARIMA (0,0,0) (0,1,0) ARIMA (1,0,0) (0,1,1) was evaluated by forecasting the data from 1985-2016 both the forecasted and observed monthly rainfall data were fitted on the same plot and indicate the model accuracy/adequacy for performance purpose. The similarity in matching between the forecasted and observed rainfall were good. Both the seasonal ARIMA model and the traditional ARIMA model are used to forecast monthly precipitation for the years 2017-2025. While the standard seasonal model

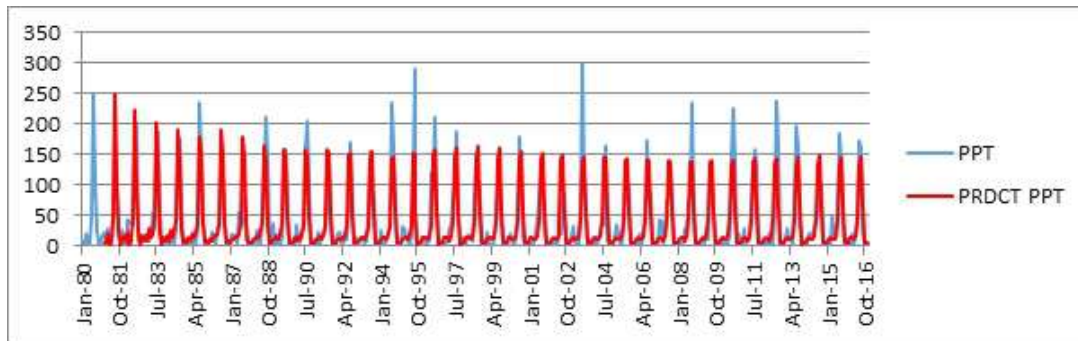


Figure-3 : Graphical representation of perceived and fitted values of rainfall series for the Hisar conditions.

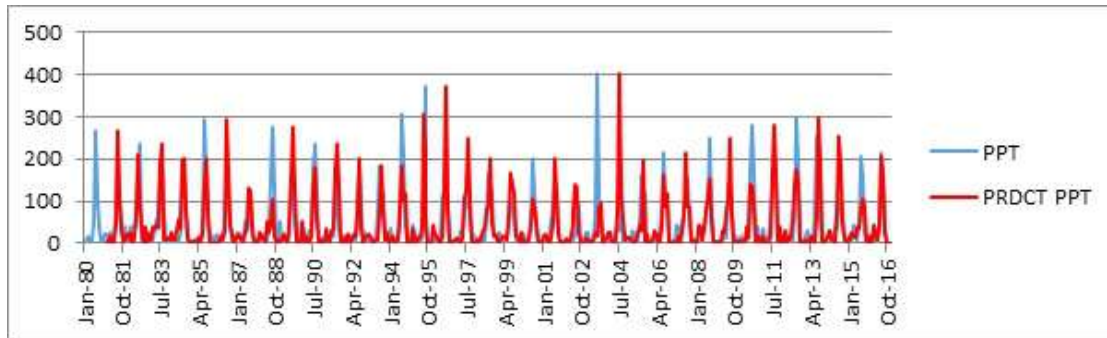


Figure-4 : Graphical representation of perceived and fitted values of rainfall series for the Bhiwani conditions.

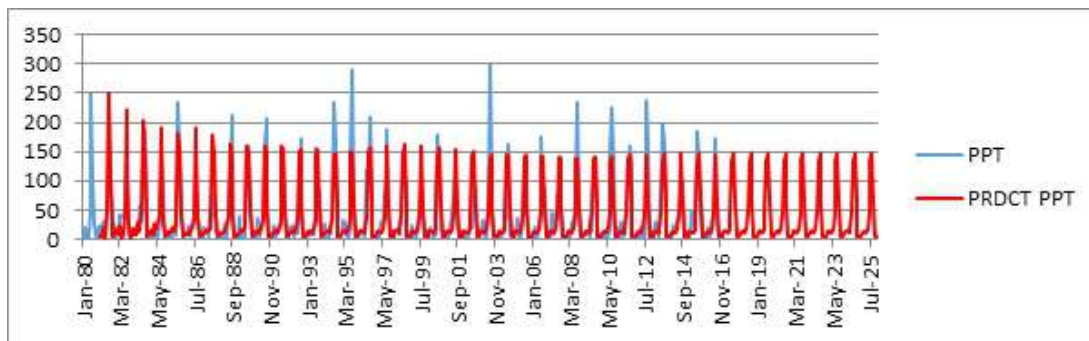


Figure-5 : Graphical representation of perceived and forecast values of rainfall series for the Hisar conditions.

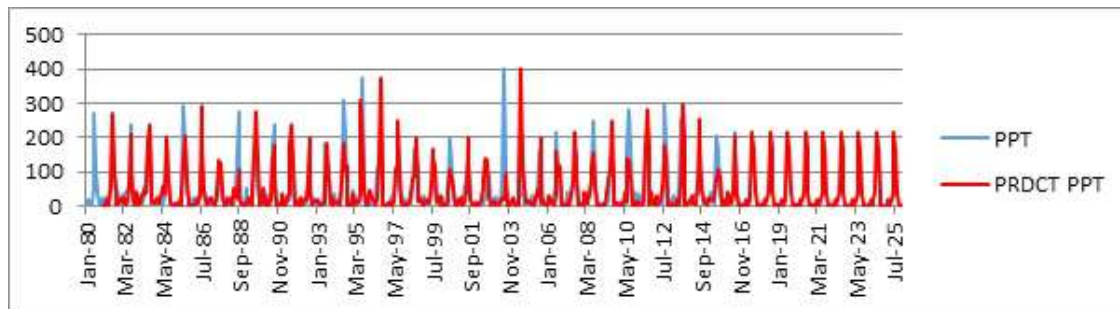


Figure-6 : Graphical representation of perceived and forecast values of rainfall series for the Bhiwani conditions.

considerably overestimates precipitation, the ARIMA model accurately forecasts monthly precipitation and generally captures the right trend. This comparison increases the confidence with seasonal ARIMA over the conventional seasonal model to represent the rainfall data at the Hisar and Bhiwani district of Haryana and this may be used for forecasting of the near future rainfall data. Analysis revealed that a best model for precipitation was

ARIMA (0,0,0) (0,1,1). Model residuals for the series was near to normality as most of the points fall on a single straight line. White noise is also proven to be present in the residuals. According to the findings of the model validation, the projected values did not suit the actual data very well, with the majority of the rainfall data being included in the bottom and higher bounds. However, according to the findings of the model validation, the

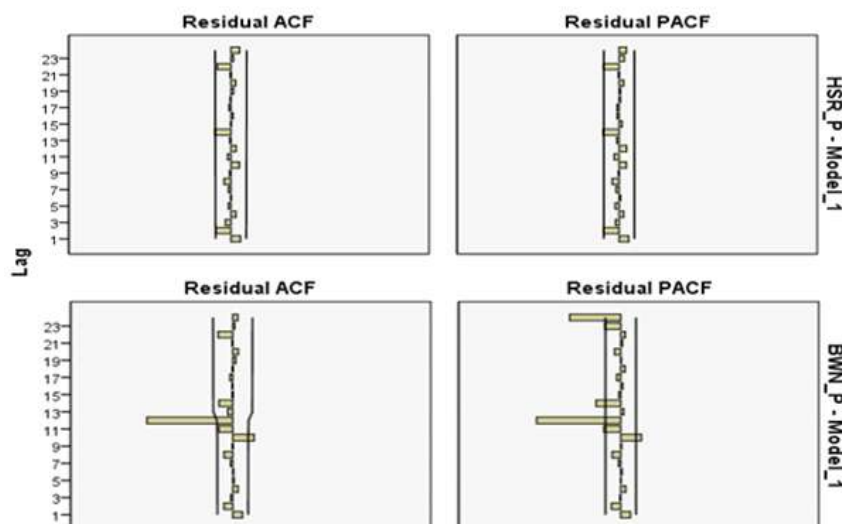


Figure-7 : Residual ACF and PACF of rainfall and temperature model of the Hisar and the Bhiwani districts.

projected values were accurately corrected using the original data, with the majority of the temperature original data found in the lower and higher bounds. The discovered models may thus be used to predict monthly temperatures in Hisar and Bhiwani.

According to similar study comprehensive multivariate analysed in digital data that essential for a balanced declaration on precipitation. After preliminary identification and diagnostic testing, the models have been examined and verified, and the chosen models have proven appropriate and suitable for the projection of future annual precipitation value in the Tordzie watershed zone (Nyatuame and Agodzo, 2018). Moreover, the study showed that the Atalanti meteorological station's rainfall time series data were statistically and stochastically examined throughout Central and Eastern Greece. Since the average of the observed and anticipated data is nearly identical, the seasonal multiplicative decomposition approach allows for highly accurate forecasting of monthly mean rainfall future values (Lappas, and Matiatos, 2013).

Conclusions

Its strength comes from the fact that the approach may be applied to any time series with any type of change pattern and that the forecaster is not required to select a previous value for any parameter. A reliable method for determining the size of any variable is the ARIMA model. In our study Haryana region consists great variety as well as diversity of weather conditions as many as two major agro-climatic zones were demarcated. Therefore, the Hisar and the Bhiwani district belongs to the western zone of Haryana. In Both districts >90% of annually rainfall was received for the period of south west monsoon (June-Sept.). Annual rainfall of the Hisar is 429 mm. and the Bhiwani 465 mm. It

was found that performance of ARIMA (0,0,0) (0,1,1) with R-squared value (0.712) and ARIMA (0,0,0) (0,1,0) with R-squared (0.440) were evaluated by forecasting the data since 1985-2016 both the forecasted and observed monthly rainfall data found to be fitted on the same plot that indicated model adequacy for performance purpose. The similarity in matching between the forecasted and observed rainfall was recorded good. It is revealed that monthly precipitation in the years of 2017-2025 are predicted using Seasonal ARIMA model and Conventional ARIMA model. The analysis revealed that the best model for precipitation is ARIMA (0,0,0) (0,1,1). As maximum points fall on a single straight line, the model residuals for rainfall series are close to being normal.

As per the investigation concluded that methodology of Box-Jenkins (ARIMA) model is appropriate being its application in case of tool to predict the monthly rainfall for the up-coming 10 years. Furthermore, approach can assist local farmers in planning their agricultural activities to increase the amounts of land that can be farmed utilising supplementary irrigation. Because the ARMA family of models is so good at measuring short-term durability, the ARIMA model was shown to be useful for short-term series forecasting. Given that it struggles with long-term forecasting, the Auto Regressive (AR) model is a predictable memory model.

Table-1 : Forecasting Accuracy Statistics of the Hisar and the Bhiwani districts of Haryana.

Parameters	Rainfall model ARIMA (0,0,0)(0,1,1)	Rainfall model ARIMA (0,0,0)(0,1,0)
R-squared	0.712	0.440
RMSE	30.235	50.004
MAPE	304.64	325.977
MAE	17.844	26.884

Whereas, model identification is a critical step of ARIMA model so that p, q & d had to be determined visually & they dependent on the modeller's judgment and experience (Machekposhti *et al.*, 2017).

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Analysis of Yield, Performance and Adoption of Pusa Basmati-1509 in Shamli District (U.P.)

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Abstract

Rice Variety Pusa Basmati 1509 is the first early maturing Basmati rice variety with seed to seed maturity of only 120 days. Pusa Basmati-1509 was disseminated through Front line Demonstrations at farmer's field in Shamli district. The demonstrations conducted during last Three years 2019, 2020 & 2021 were considered for the study. Adoption of Pusa Basmati-1509 has significant impact on seed yield and yield gap. Yield increased in demonstration field due to adoption of newly release variety. Adoption percentage ranged between 9.67 to 13.54 with a mean percent increase of 10.13 % as compare to local check. The result obtained clearly indicate the technology gap with an overall mean difference of 5.70. The results indicate that adoption of this variety significantly Increased due to higher productivity, and short duration in comparison to other varieties which ultimately resulted in more return.

Key words : Pusa Basmati-1509, yield gap, performance and adoption.

Introduction

Basmati rice from the Indian subcontinent is high priced in the international market for its unique quality. In Shamli district total area under paddy is about 37,560 ha, out of that 28,270 ha area is under scented rice, Commonly grown rice varieties are Pusa Basmati-1, Pusa 1121, Pusa Basmati 2, and Pusa Basmati -3. Traditional basmati varieties are tall, prone to lodging. photoperiod and temperature sensitive and very low yielding. An improvement over basmati variety, Pusa Basmati-1509 is released by IARI, New Delhi in 2011. The plant stature is short and tolerant to lodging. In terms of grain and cooking quality traits Pusa Basmati - 1509 has significant improvement. It grains on cooking have uniform shape compared to tapering end in Pusa-1121, it has strong aroma and chalky grains.

Rice Variety Pusa Basmati 1509 is the first early maturing Basmati rice variety with seed to seed maturity of only 120 days and average yield of 5.25 t/ ha. It recorded an average yield advantage of 5.46 % over Taraori Basmati and 9.6 % over Pusa Basmati 1121. In Basmati growing regions of the north western India, there is a growing concern of reducing water table due to pumping of underground water for puddling operation before transplanting and frequent irrigation of rice crop. There is a sizeable area of 2.0 million ha under Basmati rice which provides steady income earner for farmers and there is no obvious alternative crop with similar economic returns. Therefore, there was a necessity to develop Basmati rice variety that would facilitate less use of water, make best use of rain water during the crop growth. Pusa

Basmati 1509 is a semi-dwarf (95-100 cm) Basmati rice variety with sturdy stem and plant height ranging from 95 - 100 cm. Therefore, it does not lodge. It takes 115-120 days for seed to seed maturity, the shortest duration for any Basmati rice variety released so far. Quality wise, this genotype possesses aromatic extra long slender grains (8.41mm) with very occasional grain chalkiness, very good kernel length after cooking (19.1 mm), desirable ASV (7.0) and intermediate amylose content (21.24%). Pusa Basmati 1509 offers several advantages over other Basmati rice varieties in the country such as 25-30 days earliness compared to popular Basmati rice variety Pusa Basmati 1121, which takes 145 days for seed to seed maturity; non-shattering at maturity; non-lodging habit due to short stature and sturdy stem; owing to its early maturity, cultivation of Pusa Basmati 1509 can help saving up to 5-6 irrigations (about 33% saving of irrigation water) compared to Pusa Basmati 1121; when transplanting is carried out in the last week of July, large quantity of ground water would get saved as by then monsoon rains would have ensued and timely puddling and transplanting can be taken up; because of shorter duration, it also economizes the cost of agri-inputs and result in higher cropping intensity leading to better economic gains to the farmers; as a result of reduced plant height, this variety produces almost half biomass as compared to Pusa Basmati 1121 and thus will reduce environmental pollution due to burning of paddy straw.

Materials and Methods

The front line demonstrations were conducted during 2019, 2020 and 2021 in Unn, Shamli, Thanabawan, Kandhala and Kairana blocks of district Shamli at 45 farmer

Table-1 : Yield extension, Technology gaps and economics of Pusa Basmati-1509.

Name of Block	No. of demo	Duration Study of (Years)	Avg. yield (qt. / hr.)			% Yield increased (qt. / hr.)	Techno-logy Gap	Extension Gap (qt. / hr.)	Adoption % within 3 year	Techno-logical index (%)
			P	IP	FP					
Unn	5	3	65.50	58.70	47.85	20.78	6.80	10.85	13.54	10.38
Shamli	5	3	65.50	59.50	49.65	22.42	6.00	09.85	12.87	9.16
Thanabhawan	6	3	65.50	60.40	48.60	24.27	5.10	11.80	9.67	7.78
Kandhala	4	3	65.50	59.80	47.78	23.04	5.70	12.02	11.17	8.70
Kairana	5	3	65.50	60.60	49.12	24.69	4.90	11.48	10.31	7.48
Mean	25	3	65.60	59.80	48.60	23.04	5.70	11.20	11.51	8.68

P = Potential, IP= Improved Practice, FP= Farmer Practice.

Table-2 : Economics of block wise Basmati variety 1509.

Block	Yield (qt/ha.)	Cost of cultivation Rs./ha.	Gross Return Rs./ha.	CB Ratio	% of additional yield over local check (qt/ha.)	Additional net return over local check (Rs/ha.)
Unn	58.70	38450	146750	1:3.82	20.78	25250.00
Shamli	59.50	38566	148750	1:3.86	22.42	27250.00
Thanabhawan	60.40	39450	151000	1:3.82	24.27	29500.00
Kandhala	59.80	39900	149500	1:3.75	23.04	28000.00
Kairana	60.60	38970	151500	1:3.89	24.69	30000.00
Mean	59.80	39067	149500	1:3.83	23.04	28000.00
FP (P.B.-1)	48.60	36780	121500	1:3.30	-	-

field for evaluation of performance, effectiveness and adoption of Pusa Basmati 1509 comparison to farmers practice and crop cafeteria at Krishi Vigyan Kendra, Shamli. The yield data from front line demonstration, as well farm farmers practice were recorded by representative samples from different locations.

The following formulae have been used for estimation of technology, extension gap and technology gap :

1. Technology gap = Potential yield - Demonstration yield.

2. Extension gap = Demonstration yield - farmers yield.

3. Technology Index = [(Potential yield – Demonstration yield)/ Potential yield] x 100.

Results and Discussion

The potential and field performance of the Pusa Basmati1509 alongwith the local check, were evaluated and data are given in Table-1 and 2.

From the data given in Table-1 (diagram-1) it is quite clear that seed yield increased significantly in the range of 58.70 to 60.60 qt ha in different blocks of Shamli district, as compared to local check. In 2006. Singh and Rana reported seed yield increase up to 20.70 qt./ha by Pusa Barani Variety of mustard crop under irrigation condition in 1908, Biswas et al also reported varietal difference of grain yield in scented rice

The cost benefit ratio of Pusa Basmati 1509 was

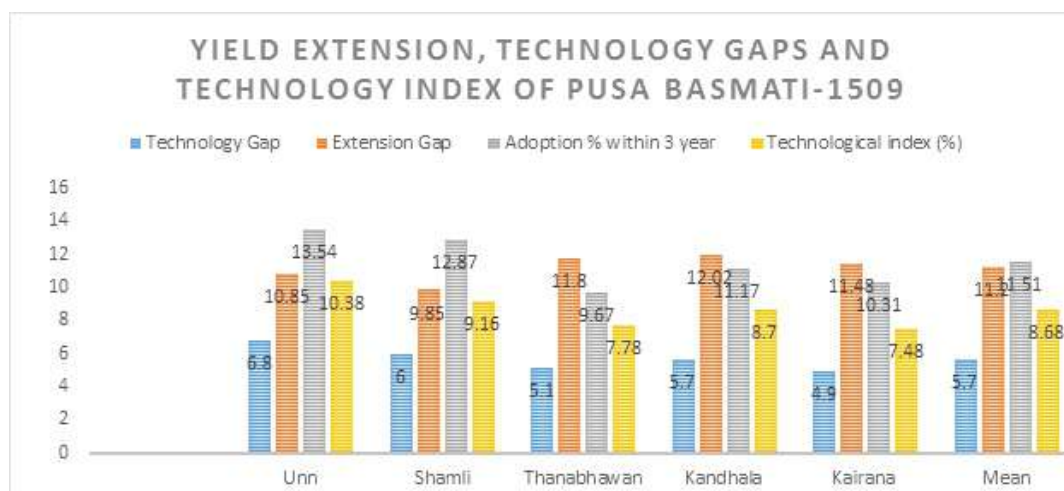
also higher in all the blocks in comparison to local check. it varied from 1:3.75 to 1:3.89 (Table-2). In 2006, Hedge reported that mustard crop by nature is hardy and mostly grown under rainfed condition and can impart stability of production system under harsh condition.

Adoption of Pusa Basmati-1509 has significant impact on seed yield and yield gap. Yield increased in demonstration field due to adoption of newly release variety. Adoption percentage ranged between 9.67 to 13.54 with a mean percent increase of 10.13 % as compare to local check. Rana *et al* (2002) reported that the demonstration are quite successful in farmer practice.

The result obtained clearly indicate the technology gap with an overall mean difference of 5.70. Kadian *et al*. (1997) reported that technology gap can be narrowed down only by location specific technology based recommendations.

The 45 demonstration, conducted at farmers field during 2019,2020 and 2021 resulted in average gross return of Rs. 1,49,500 per ha. In comparison to other basmati varieties which gave average gross return of Rs. 1,21,500. The higher cost benefit ratio of Pusa Basmati - 1509 led to higher adoption and which two years this variety has spread on 19,175 ha area. The variety Pusa Basmati- 1509 fast replacing Pusa - 1121 and Pusa Basmati -1. The demand of quality seed of this variety is also increasing which has led to participatory seed production at farmer field.

There is clear-cut and significant yield gap between



farmers practice and demonstration field of Front line demonstration. The choice of Pusa Basmati 1509 paddy variety is also an important factor leading to additional net return. The extension and technology gap can be bridged by sustained effort of extension agencies and by adopting location specific technologies. The demand of quality seed of Pusa Basmati 1509 paddy variety is also increasing which has led to participatory seed production at farmer's field.

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Assessment of Late Sown Wheat Varieties for Better Yield and Yield Gap Analysis in District Shamli of Western Uttar Pradesh

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Abstract

In Shamli district (Western U.P., India) the total cropped area under wheat is about 33500 ha. About 41% area is under late sown conditions. Sugarcane-Wheat is the most common rotation in the district, A study was undertaken to assess the yield performance and yield gap evaluation of twelve late sown wheat varieties viz DBW-90, WH-1124, DBW-173, DBW-71, PBW 590, DBW-16, WH 1021, PBW-373, UP-2338, Raj-3765, HD-3059 and PBW-226 under irrigated late sown conditions. The analysis of the data indicated that there was considerable yield increase ranging from 10.16 to 43.55 percent between varieties over farmers practice. Variety DBW 71 yielded highest i.e. 47.30 qt per hectare with the net return of Rs. 56160.00 and Cost Benefit Ratio of 1:2.93.

Key words : Late sown wheat varieties, Net return, Yield and yield gap analysis.

Introduction

The important wheat growing countries are China, USA, India, and France. In the world, wheat is cultivated in an area of about 239 million hectares with a total production of 425.5 million tonnes of grains. Wheat is the foremost among the world's crops with regards to its antiquity and its importance as a staple food of mankind. India, one of the greatest success stories of green revolution, is the second largest producer of wheat in the world after china and contributes more than 12% to the global wheat basket. The country's wheat production is likely to set a new record of more than 112 million tonnes in the 2022-23 crop year. In India, The cultivation of wheat in India is confined mainly to the states of Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Rajasthan, Bihar, Maharashtra, and Gujarat. Among all the states, Uttar Pradesh contributes maximum acreage and production; however, Punjab stands first with respect to average productivity followed by Haryana.

In Shamli district (Western U.P., India) the total cropped area under wheat is about 33500 ha. About 41% area is under late sown conditions. Sugarcane-Wheat is the most common rotation in the district, which leads to late sowing of wheat and in the other way responsible for the supply of cane to the factories. The choice of right varieties under late sown conditions is one of the crucial points to determining the yield of wheat. The yield of late sown wheat varieties is less or stagnant due to farmers unawareness about high yielding varieties and also non availability of varieties with higher yield potential as compared to the existing varieties under changing climatic conditions. In present study the late sown wheat varieties

DBW-90, WH-1124, DBW-173, DBW-71, PBW 590, DBW-16, WH 1021, PBW-373, UP-2338, Raj-3765, HD-3059 and PBW-226 were selected for assessment, higher yield and yield gap analysis.

Materials and Methods

The Front Line Demonstrations and Crop cafeteria testing were conducted during 2019-20, 2020-21 and 2021-2022 at krishi vigyan Kendra, shamli, Uttar Pradesh. In Shamli district Sugarcane-Wheat is the most common rotation in the district, which leads to late sowing of wheat and in the other way responsible for the supply of cane to the factories. The choice of right varieties under late sown conditions is one of the crucial points to determining the yield of wheat. The yield of late sown wheat varieties is less or stagnant due to farmers unawareness about high yielding varieties and also non availability of varieties with higher yield potential as compared to the existing varieties under changing climatic conditions. Twelve late sown wheat varieties including farmer's practice, namely PBW-226 (Farmer practice), DBW-90, WH-1124, DBW-173, DBW-71, PBW 590, DBW-16, WH 1021, PBW-373, UP-2338, Raj-3765 and HD-3059 were used for analysis. The seed yield and net returns data were put under analysis.

For the estimation of technology gap, extension gap and technology index, the formulae were used as per method of Samui et al. (2000) and Sagar and Chandra (2004).

Technology gap = Potential yield - Demonstration yield.

Extension gap = Demonstration yield - farmers yield.

Technology Index = [(Potential yield – Demonstration yield)/ Potential yield] x 100.

Table-1 : Productivity yield gap, Extension gap of late sown wheat variety.

Varieties	Avg. Yield (qt. / ha.)			% Yield increased (t./ha.)	Tech. gap (qt./ha.)	Ext. gap (qt./ha.)	Techno-logical Index
	VP	DP	FP				
DBW-90	66.60	43.30	32.95	31.41	23.30	10.35	34.98
WH-1124	56.10	42.40	32.95	28.67	13.70	09.45	24.42
DBW-173	57.00	45.80	32.95	37.48	11.20	12.85	19.64
DBW-71	68.90	47.30	32.95	43.55	21.60	14.35	31.34
PBW 590	73.20	42.60	32.95	29.28	30.60	09.65	41.80
DBW-16	56.40	38.70	32.95	17.45	17.70	05.75	31.38
WH 1021	62.50	39.40	32.95	19.57	23.10	06.45	36.96
PBW-373	43.90	39.60	32.95	20.18	04.30	06.65	09.79
UP-2338	49.00	40.40	32.95	22.16	08.60	07.45	17.55
Raj-3765	51.00	36.30	32.95	10.16	14.70	03.35	28.82
HD-3059	59.40	41.30	32.95	25.34	18.10	08.35	30.60
Mean	58.54	41.55	32.95	26.10	16.99	08.60	29.02

Table-2 : Economics of late sown wheat varieties.

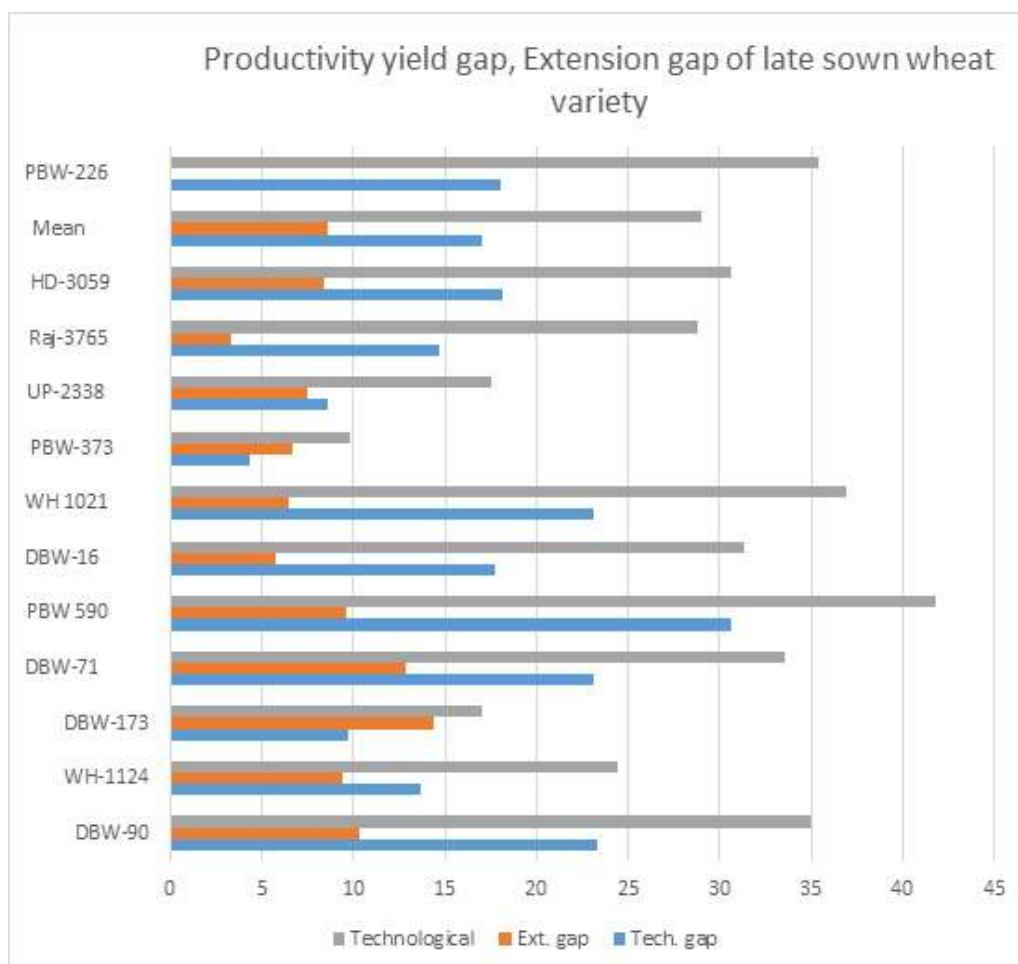
Varieties	Grain yield (qt/ha.)	Cost of Cultivation (Rs./ha.)	Gross return (Rs. /ha.)	Net Return (Rs./ha.)	CB ration	% of additional yield over local check (qt./ha.)	Additional net return over local check (Rs./ha.)
DBW-90	43.30	28640.00	77940.00	49300	1:2.72	31.41	18630
WH-1124	42.40	29155.00	76320.00	47165	1:2.61	28.67	17010
DBW-173	45.80	28864.00	82440.00	53576	1:2.85	37.48	23130
DBW-71	47.30	28980.00	85140.00	56160	1:2.93	43.55	25830
PBW 590	42.60	28756.00	76680.00	47924	1:2.66	29.28	17370
DBW-16	38.70	28791.00	69660.00	40869	1:2.41	17.45	10350
WH 1021	39.40	29062.00	70920.00	41858	1:2.44	19.57	11610
PBW-373	39.60	28962.00	71280.00	42318	1:2.46	20.18	11970
UP-2338	40.40	29110.00	72720.00	43610	1:2.49	22.16	13410
Raj-3765	36.30	29040.00	65340.00	36300	1:2.25	10.16	6030
HD-3059	41.30	28785.00	74340.00	45555	1:2.58	25.34	15030
Mean	41.55	28922.00	74798.00	45876	1:2.58	26.10	15488
PBW-226	32.95	27850.00	59310.00	31460	1:2.12	-	-

Results and Discussion

The productivity, potential and economics of the wheat varieties along with local check were evaluated and data are given in Tables-1&2. It is revealed from Table 1 that the highest percent increase in the yield over local check was 43.55 for DBW-71 and for other varieties also it was highly significant. The seed yield increased significantly in the range of 10.60 to 43.55 qt. per ha in late sown wheat varieties as compared to farmer's practice (32.95 qt. per ha). This indicates that field demonstrations are quite successful in bridging up yield gaps between improved practice and farmer's practices (Rana et al., 2002). Singh and Rana (2006) reported that seed yield increased up to 20.70 qt. per hectare through Pusa Barani, a variety of

mustard crop. Biswas et al. (1998) also reported the varietal differences of grain yield in scented rice.

The economics of demonstrations presented in Table-2, indicates that the additional return of late sown wheat varieties over farmers practice ranged from Rs 6030.00 to 25830.00 per hectare. It is high in DBW-71 (Rs. 25830.00). The gross return of late sown wheat varieties ranged between Rs. 65340.00 to 85140.00 per hectare. It can also be seen that net return varied from Rs 36300.00 to 56160.00 per hectare. The highest net return with Rs 56160.00 per hectare of DBW-71 is in line with the findings of Singh and Rana (2006), who reported about Rs 13149.00 per hectare of net return in mustard crop.



The cost benefit ratio (Table-2), of late sown wheat variety DBW-71 ranked first (1:2.93) followed by DBW-173 (1:2.85) and DBW-90 (1:2.72). Hedge (2006) reported that mustard crop by nature is hardy and mostly grow under rainfed conditions can impart stability of production system under harsh conditions.

Technological gap (Table 1) ranged from 9.79 to 41.80 per hectare with an overall mean difference of 18.05 qt. per hectare. This gap was minimum in PBW-373 (9.79) and maximum in PBW-590 (41.80) as noticed under study. The gaps between potential and front line demonstrations are due to climatic, edaphic, socio-economic and management practices. Kadian et al. (1997) reported that technological gap can be narrowed down only by location specific technology based recommendations.

Table-1 showed that the extension gap ranged from 3.35 to 14.35 qt. per hectare with an overall mean difference of 8.60 qt. per hectare. High extension gap (14.35 qt. per ha.) was recorded from variety DBW- 71, followed by DBW-173 (12.85) and DBW-90 (10.35) qt. per ha. This indicates that there is need to educate the farmers through various extension tools. These results

are also in confirmation with those of Gupta and Sharma (2005).

There is clear-cut and significant yield gap between farmers practice and demonstration field of Front line demonstration and crop cafeteria. The choice of late sown wheat variety is also an important factor leading to additional net return. The extension and technology gap can be bridged by sustained effort of extension agencies and by adopting location specific technologies. The demand of quality seed of late sown wheat varieties is also increasing which has led to participatory seed production at farmer's field.

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To Evaluate the Potential of Single Bud Technology on Sugarcane Productivity, Profitability and Sustainability in Real Farming Situations of Western U.P.

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Abstract

The western U.P. has sub-tropical weather conditions with severe cold during the period December-January and scorching heat during May-June. Thus, the climate of U.P. is suitable for optimum growth of sugarcane crop only during the period July-October, after which time there is a drop in temperature which induces sugar accumulation and ripening. Sugarcane (*Saccharum* Spp. hybrids) is planted by pieces of cane stalk known as cane setts. This method of conventional sugarcane propagation in India has not become expensive as the cost of seed cane material used and quantity of seed material required for such planting accounts for around 20% of the total cost of cultivation. An alternative way of using only single bud holds promise to reduce the huge seed cane material in commercial sugar cane planting. In this context, an on-farm trial in a participatory mode at ten farmers' fields was conducted consecutively during 2018-2019 and 2019-2020 cropping seasons at Shamli district in U.P. with a view of assessing the advantages of single bud technology of cane cultivation over conventional sugarcane planting. The results of on-farm field trial indicated that sugarcane cultivation by single bud technology produced cane yield of 114.6 t/ha which was 18.14% higher than that of conventionally planted cane crop (97 t/ha). The cost of cultivation was Rs. 225200.00/ha in conventional cane cultivation as against Rs. 214040.00/ha under single bud technology. Single bud technology produced 35.91% higher net returns than that obtained from conventional sugarcane cultivation of Rs. 90050.00/ha. Sugarcane planting by single bud technology has thus proved to be more productive with reduced cost on planting material since it fetched more net returns per unit area and time, and would be a better option for the farmers of western U.P.

Key words : Sugarcane, single bud technology, yield, sustainability.

Introduction

Sugarcane (*Saccharum* spp. hybrids) crop possesses the potentiality of converting solar energy into sugars and other renewable sources of energy by virtue of its unique C4 photosynthetic pathway. In India, it is grown in an area of 48.41 lakh ha with a total production of 341.20 m t of sugarcane and 27.25 m t of sugar with cane productivity of 67.44 t/ha. It is propagated commercially by planting pieces of cane stalk known as seed cane setts or seed cane. For commercial cultivation, a huge quantity (6-8 t/ha) of cane stalk cuttings having two to three bud pieces (25-30 cm long segments) are required for planting in one ha of field which cost about 22 to 25% of the total production cost (Srivatava et al. 1981). Therefore, one of the major items of expenses incurred in sugarcane production is the huge quantity of seed cane material required for its planting. Reducing the seed cane quantity by way of introducing bud chip technology would be the best alternative to cut down the cost and accordingly enhance the returns and sustain sugarcane growing particularly in Odisha where its cultivation is primarily done by small and marginal farmers (Mohanty and Nayak 2011).

In coastal Odisha, sugarcane is the most preferred crop especially for small and marginal land holding

farmers (Mohanty *et al.* 2014). Bud chip technology of sugarcane growing has been preferred by many farmers particularly farm women because of drudgery reduction and easy-to-do-planting operations viz., bud chipping, placing bud chips in coco-pith-filled plastic cone trays, nursery raising, transplanting of seedlings in furrows etc. Sugarcane cultivation by single bud chip technology can improve soil rhizospheric environment, root growth and the nutrients availability in soil due to microbial abundance and diversity besides saving of water, if drip irrigation is adopted (Ramamoorthy and Ramanuja 1993). Therefore, single bud technology has attracted the attention of large number of sugarcane farmers, development workers in government and sugar sector for its large-scale promotion and adaptation. In light of above, the present on-farm trial was conducted to assess the potentiality of single bud technology on sugarcane productivity, profitability and sustainability in real farming situations of western U.P. at farmers' fields in a participatory mode during 2018-2019 and 2019-2020 cropping seasons comparing its performance with conventional method of planting.

Materials and Methods

An on-farm trial in a farmer; participatory mode was conducted for the two consecutive cropping seasons of

Table-1 : Growth and yield of sugarcane grown through single bud technology and conventional planting methods (Mean of 2018-2019 and 2019-2020 cropping seasons).

Treatments	Germination of cane buds (%) at 45 DAP	Number of shoots/clump at 120 DAP	Number of tillers (000/ha) at 120 DAP	Length of cane (cm)	Girth of Cane (cm)	Weight of cane (kg)	Number of millable canes (000/sh)	0Bris	Cane yield (/ha)
Conventional 3 bud setts planting	58.69	4.6	88.32	265	2.8	1.26	86.26	16.90	97.0
Single Bud method of planting	93.8	7.9	98.21	291	3.2	1.78	98.79	18.6	114.60

Table-2 : Economics of sugarcane cultivation in single bud and conventional methods of sugarcane planting (mean 2018-2019 and 2019-2020 cropping seasons).

Sr. No.	Particulars of Sugarcane Cultivation	Single bud technology of sugarcane planting			Conventional method of sugarcane planting		
		Units	Per unit cost (Rs.)	Total (Rs.)	Units	Per unit cost (Rs.)	Total (Rs.)
1.	Land preparation (Ploughing days)	12.5	800	10000	12.5	800	10000
2.	Farm yard manure(t)	20	12,00	24,000	20	12,00	24,000
3.	Seed Cane (t)	1	325	3250	8	3250	26,000
4.	Hiring charges of plastic contrays and bud cutter	25	140	3500	0	0	0
5.	Cost of coco pith/coir dust (in bags	10	100	1000	0	0	0
6.	Cutting of bud chips (in man days)	10	200	2000	0	0	0
7.	Bud/sett treatment (in man days)	3	300	900	3	300	900
8.	Furrows opening (ploughing days	3	600	1800	4	600	2400
9.	Planting operation (in man days)	15	300	4500	10	300	3000
10.	Bio-fertilizers (kg)	10	50	500	0	0	0
11.	Crop protection measures	1	2000	2000	1	2000	2000
12.	Inorganic fertilizers (NPK 250:100:60/ha)2	-	-	12,000	-	-	12,000
13.	Herbicide (Atrazine) (kg)	2	120	240	0	0	0
14.	Intercultural operations 2 (in230 man days)	109	300	32,750	120	300	36,000
15.	Detrashing, wrapping and propping (in man days)	100	300	30,000	108	300	32,400
16.	Harvesting and detrashing and transportation by human labour up to truck (in man days)	230	300	69,000	230	300	69,000
17.	Irrigation	17	500	8500	15	500	7500
	Total cost of cultivation (Rs./ha)			214040.00	-	-	225200.00
	Gross return (Rs./ha)			372450.00	-	-	315250.00
	Net Return (Rs./ha)			158410.00	-	-	90050.00

2018-2019 and 2019-2020 at Jasala, Taprana and banat villages under Khandla and shamli blocks of shamli district in western U.P. The main objective was to find out the biologically most efficient, suitable, feasible and sustainable planting technique in sugarcane cultivation in the farmers field. The soil of the experimental field was sandy loam in texture with medium organic carbon content (0.547%) having slightly alkalic (pH 7.61) in reaction, low in available nitrogen (117.8 kg/ha) and medium range of phosphorus (13.82 kg/ha.) and potassium (142.32 kg/ha.). Soil samples from ten farmers; fields at 0-15 cm soil depth were collected for status of available plant nutrients before planting of sugarcane crop. The plot size was kept at 2000 m² for each individual farmer field during both the cropping seasons. Single bud technology was thus assessed and compared for cane yield increments and economic returns with that of conventionally planted crop at all the ten locations during both the years of experimentation.

In single bud technology, the single bud were cut out from upper portion of seed canes of sugarcane variety –

Co 0238 using a locally fabricated single bud cutter machine and then placed in the nurserybeds on 13 January, 2018 and 19 January, 2019. All the single buds were dipped in the slurry of 2.5 kg Trichoderma culture and 10L of cow urine mixed in 50 L of water for 30 min. Approximately, 15,600 buds/ha were used for planting in the farmers; field. The plot size was kept at 2000 m² for each individual farmer field during both the cropping seasons. The above-mentioned single bud were then after implanted facing buds upward in 1040 numbers of plastic trays each having 50 cones and half filled with mixture of well-rotten coco pith and 200-kg well-decomposed farm yard manure in 1:1 ratio. After that all the buds were completely covered with mixture of coco-pith and decomposed farm yard manure. These trays were placed one above the other and at the last, an empty tray was put upside down on the top of the stack with a view to maintain the humidity inside the trays. In this method, the eight sets of trays were arranged and wrapped tightly with black polythene sheet and kept in this

Table-3 : Sustainability score of ten farmers on sugarcane cultivation in single bud and conventional methods of sugarcane planting (mean of 2018-19 and 2019-2020 cropping seasons).

Sr. No.	Sustainability dimension	Sugarcane planting by single bud method	Sugarcane planting by 3-bud setts method	Total score	Rank
1.	Technological appropriateness	24	15	39	III
2.	Economic viability	26	19	45	II
3.	Environmental soundness	17	16	33	VI
4.	Socio-cultural compatibility	20	17	37	V
5.	Productivity	19	16	45	I
6.	Adaptability	18	16	34	IV
	Total score	124	99	223	
	Rank	I	II		

way to produce optimum temperature (28-32 °C) and good humidity(80-90%) around implanted buds. These buds sprouted after 7 days of implantation were removed from the polythene sheet and then kept them side by side on the field to sprinkle water. Recommended doses of N, P₂O₅ and K₂O fertilizers were given at 30:80:60 kg per ha and applied as per recommended package of practices. Before transplanting of single bud technology grown plantlets in the field, chlorpyrifos 50% EC was applied at 2 liters/ha to control the incidence of termite and early shoot borer. Before transplanting of the single bud technology grown plantlets, well-decomposed farm yard manure at 20 tones/ha was mixed up with 1/3rd of total recommended dose of N, full doses of phosphorous and half of total K fertilizers and were applied in the furrows following a light irrigation. Twenty-nine days old plantlets as grown through the technique were transplanted in the farmers' fields on 15 February, 2018 and 17 February, 2019 at a spacing of 120x45 cm spacing. As a precautionary measure, pre-emergence herbicidal application of Atrazine at 2 Kg a.i./ha at 2 days after planting (DAP) and two hand weeding's at 60 and 90 DAP were done to manage the incidence of weeds. Remaining 2/3rd dose of N was applied as top dressing in two equal splits at proper soil moisture, one at the start of tillering and rest one with remaining dose of K at 90 DAP along the furrows after carrying out intercultural operations. At 75 DAP, Azotobacter and phosphorus solubilizing bacteria each at 5 kg/ha were mixed thoroughly with 0.25 t of well-decomposed farm yard manure and applied to the field accordingly. The crop was harvested on 21 February, 2019 and 24 February, 2020. All agronomical packages of practices were followed to raise the crop in both the cropping seasons. Observations on sugarcane growth, yield attributes, and cane yield were recorded at the appropriate stages of sugarcane crop, and compared accordingly after working out economics of both the techniques of sugarcane cultivation.

In a focus group discussion with farmers of the village, six dimensions of sustainability indices (Yadav et

al. 2007) for agricultural viz., technological appropriateness, economic viability, environment friendly, socio – cultural compatibility and adaptability were discussed and agreed upon by the farmers to assess the sustainability of the both planting systems of sugarcane cultivation on which participatory on-farm trials were undertaken. A matrix ranking exercise with ten selected farmers was done. In this exercise, each farmer was asked to weigh using a scale of 1 to 5 in every sustainability dimension for both the planting techniques under study. The total sustainability score for the respective planting technique was calculated by adding scores obtained against the components of sustainability dimension. Finally, on the basis of sustainability score, planting techniques were ranked accordingly.

Results and Discussion

Plant Population : Data on per cent survival of seedlings developed through single bud technology and percentage cane buds germination in conventionally planted crop were compared and are presented in Table 1. The results showed that the seedling survival rate was 93.8% in single bud technology as compared to only 58.69% bud germination in conventional method, creating a marked difference in initial plant population density which is ultimately responsible for higher number of millable canes in single bud technology as compared to conventional method. Moreover, this technique also provides scope for gap filling with nursery raised seedlings which helps to ensure the initial optimum plant stand in the field after transplantation.

Growth and Yield Attributes : Data given in Table-1 indicate that single bud planting technology produced markedly higher number of shoot-s/clump (7.9) at 120 days after planting (DAP) and number of tillers ('000/ha) (98.21) at 120 DAP as compared to 4.6 and 88.32 respectively, obtained under conventional method of sugarcane planting. Uniform growth of initially emerged higher number of shoots obtained under single bud planting technology paved the way higher number of tall,

thick and heavy millable canes compared with the conventional method of planting. This may be attributed to the fact that uniform initial planting density with better availability of natural resources and nutrition to the crop under single bud method of planting provided optimum plant population as compared to the crop raised under conventional method of planting. Length and girth of cane were also higher in single bud planting technology as compared to crop raised by planting of three bud setts. Length and girth of canes in single bud technology were 291 and 3.2 cm. respectively, as compared to 265 and 2.7 cm in conventional method of planting. Initial higher plant population on account of optimum spacing must have enjoyed the benefit of conjunctive use of chemical and bio-fertilizers at the tillering phase which paved the way for higher yield attributing characters in bud chip planting technology (Mohanty 2014).

Yield : Similarly, number of millable canes were also higher (98.79'000/ha) in single bud technology as compared to conventionally planted crop (82.37 '000/ha) which clearly endorses the result of higher number of millable canes/clump under single bud technology. Average cane weight of 500 randomly selected canes per plot was 1.78 kg in single bud technology as compared to 1.07 kg in conventional method of planting. Higher initial plant population along with higher yield attributing characters resulted in higher cane yield of 114.60 t/ha in bud chip technology as compared to 97.00 t/ha under conventional three bud setts planting.

Economics : Economics worked out for single bud technology and conventional method of planting clearly indicated that the total cost of cultivation was Rs. 225200.00/ha in conventional cane farming which reduced to Rs. 214040/ha when the crop was grown by single bud technology. After harvesting the crop, the cane yield thus obtained was sold at Rs. 3250/t which provided a gross return of Rs. 372450/ha in single bud technology of cane cultivation as compared to Rs. 315250/ha in conventionally planted crop. The higher cane yield (124.60 t/ha) from single bud technology and reduced cost of cultivation helped to realize higher net return of Rs. 158410/ha as against Rs. 90050/ha in conventionally planted sugarcane crop. the major difference in cost of cultivation was due to the enhanced cost of seed cane material (8 t/ha) in conventional method of sugarcane planting. Cane quality in terms of ⁰Brix was also higher in sugarcane plants raised through the single bud planting method compared with conventionally grown crop (Table 2). Uniform growth of cane plants under single bud technology got optimum time for their maturity and accordingly exhibited higher ⁰Brix values.

Sustainability of Technology : The pooled scores of ten

farmers for each of the sustainability dimensions against every planting technique are presented in Table 3. It is evident from Table 3 that the sugarcane planting by single bud and conventional methods was ranked-I and II on the sustainability index with a total sustainable score of 124 and 99, respectively. Farmers rated sugarcane planting by the single bud method as the most sustainable planting method in their system due to good fitness in terms of economic viability, productivity, technological appropriateness, adaptability, socio-cultural compatibility and environment soundness in local agricultural production system.

Conclusions

On-farm trial results clearly indicated that the single bud technology provided higher cane yield 114.60 t/ha as against 97.00 t/ha under conventionally planted crop by 3-bud setts, which was higher by 18.14% over conventional method of planting. The study thus suggests that the single bud technology of sugarcane planting is worth adopting particularly by the small and marginal farmers in western U.P. since it is not only high yielding but also cost effective and sustainable.

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Study on Genetic Variability, Heritability and Genetic Advance in Rice (*Oryza sativa* L.) Genotypes Under Humid South-Eastern Plain Zone of Rajasthan

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Abstract

The present investigation was carried out during Kharif-2022 at Agricultural Research Station, Ummedganj, Kota, Rajasthan (India) to determine level of genetic variability, heritability and genetic advance among 30 rice genotypes for yield and its component traits. The experiment was conducted in a randomized block design with 3 replications. Analysis of variance revealed the existence of significant difference for all the traits under study. High PCV and GCV were recorded for number of unfilled grains per panicle and grain yield per plant while number of effective tillers, test weight and plant height had medium and remaining traits showed low PCV and GCV. High heritability was estimated for all the traits suggesting these traits are under high genetic control. High heritability coupled with high genetic advance as per cent of mean was recorded for number of unfilled grains per panicle, grain yield per plant, plant height, test weight and number of effective tillers per plant indicating effectiveness of selection for the improvement of these traits due to additive gene effect.

Key words : genetic advance, genetic variability, heritability.

Introduction

Rice (*Oryza sativa* L., $2n=2x=24$) is a semi-aquatic grass, annual, self-pollinating, monocotyledonous and short day plant. It is cultivated in more than one hundred countries in the world (Singh *et al.*, 2020) and consumed by at least 2.7 billion people globally (Devi *et al.*, 2017), for that, it is named as “Global Grain” in some references (Prasad *et al.*, 2018). Asia is recognized as the world’s “rice bowl,” as it produces and consumes more than 90 per cent of the world’s rice. In India, rice is grown in almost all the states, covering more than 30 per cent of total cultivated area and contributing more than 40 per cent of the country’s total food grain production. It is grown in an area of 45.00 million hectares with production of 130.80 million tonnes and with productivity of 2843 kg/ha in India (Anonymous, 2021). In Rajasthan rice occupies in an area of 0.19 million hectares with a production of 0.47 million tonnes and with productivity of 2473 kg/ha (Anonymous, 2021).

The demand for rice is increasing day by day, there is a need to increase the production of rice by 40 per cent by 2030 in view of the growth rate of world population and food security with decrease in arable land in the world (Khush, 2005). Therefore, keeping in view of the future demand of rice as a food for human, there is urgent need to increasing the grain yield of rice by developing new varieties which can break the yield boundaries. A better understanding of the relationship between grain yield and

its component traits becomes necessary for making an efficient selection for the development of new varieties with improved economically important traits. The understanding of genetic variability present in a given crop species for the traits under improvement is imperative for the success of any plant breeding program.

Variability means differences among the individuals of a single species or different species. The variability may be due to environment or genotype or resultant effect of interplay between both. The PCV and GCV are beneficial in find out the amount of variation present in genetic material, which aids in the development of an effective breeding plan. Heritability (h^2) is a predictor in crop breeding programs because it is an index of character transmissibility from parents to off spring (Khan and Naqvi, 2011). Heritability coupled with genetic advance helps in understanding the mode of inheritance of quantitative traits (Patidar *et al.*, 2018). Hence, the present study was conducted to find out genetic variability, heritability and genetic advance in rice genotypes so as to identify superior genotypes for future breeding programs.

Materials and Methods

The present investigation was carried out during Kharif-2022 at Agricultural Research Station, Ummedganj, Agriculture University Kota. The site of experiment is at an elevation of about 271 meter (889ft)

above mean sea level with 25.18°N latitude and 75.83°E longitude. Experimental materials consisted of 30 rice genotypes (table 1) which received from Indian Institute of Rice Research (IIRR), Hyderabad, Telangana. All the genotypes were sown in flat bed nursery and 29 days old seedlings were transplanted to the main field in randomized block design with three replications by adopting a spacing of 20 x 10 cm. Recommended agronomic practices were followed for good crop maintenance. Five competitive plants were randomly chosen from each plot to record observations of 10 traits viz., plant height (cm), number of effective tillers per plant, panicle length (cm), number of filled grains per panicle, number of unfilled grains per panicle, spikelet fertility percentage, test weight (g) and grain yield per plant (g) whereas, days to 50 per cent flowering and days to maturity were recorded on a full plot basis. Biometrical analyses were done by following procedures of Panse and Sukhatme (1985) for analysis of variance, Burton (1952) for phenotypic and genotypic coefficients of variability, Burton and De Vane (1953) for heritability, Johnson *et al.* (1955) for genetic advance, Singh and Chaudhary (1979) for correlation coefficients and Dewey and Lu (1959) for path coefficients analysis.

Results and Discussion

In any crop the genetic variability is a pre-requisite for selection of superior genotypes. The results on analysis of variance (ANOVA) for yield and yield component traits revealed highly significant mean squares due to genotypes for all traits studied, indicating the existence of sufficient variation among the genotypes and therefore an ample scope for effective selection (Table-2). Phenotypic variance was higher than the genotypic variances for all the traits thus indicated the influences of environmental factor on these traits. Similar finding was reported earlier by Prajapati *et al.* (2011).

The results on mean, range, Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), heritability and genetic advance as per cent of mean for the yield and yield component traits are furnished in table 3. A perusal of these results revealed maximum range of variability for the trait plant height (96.36 - 173.85) while minimum range was recorded for number of effective tillers per plant (7.60 - 12.87). High genotypic and phenotypic coefficients of variation (>20%) was recorded for number of unfilled grains per panicle (GCV=31.66, PCV=32.72) and grain yield per plant (GCV=21.78, PCV=23.51) indicating that these traits were under the major influence of genetic control and less variable due to environmental factors. Similar results were reported earlier by Satyapal *et al.* (2015), Prasad *et al.* (2017), Saha *et al.* (2019) and Loitongbam *et al.* (2020).

Further, moderate estimates (10-20%) of PCV and GCV were observed for traits viz., number of effective tillers (GCV=13.37, PCV=15.38), test weight (GCV=13.44, PCV=13.77) and plant height (GCV=17.12, PCV=17.62) indicating that selection for improvement of these traits may be rewarding. These results are in accordance with the finding of Sumanth *et al.* (2017) for number of effective tillers, Pratap *et al.* (2018) for test weight (g), Nath and Kole (2021) and Maurya *et al.* (2022) for plant height. In contrast, low (<10) estimates of GCV and PCV were observed for spikelet fertility percentage (GCV=3.14, PCV=3.33) followed by days to maturity (GCV=4.55, PCV=4.97), panicle length (GCV=5.36, PCV=6.31) and days to 50 per cent flowering (GCV=3.14, PCV=3.33) indicating that there is limited scope for improvement through selection for these traits. Similar results was found by Maurya *et al.* (2022) for spikelet fertility percentage, Saha *et al.* (2019) for days to maturity, panicle length and days to 50 per cent flowering. Generally, heritability in broad sense estimate varied from 66.48 per cent for number of filled grains per panicle and 95.19 per cent for test weight respectively.

In the present investigation, high heritability was recorded for all the traits viz., test weight (95.19%) followed by plant height (94.31%), number of unfilled grains per panicle (93.63%), days to 50 per cent flowering (93.18%), spikelet fertility percentage (88.53%), grain yield per plant (85.78%), days to maturity (83.82%), number of effective tillers per plant (75.55%), panicle length (72.18%) and number of filled grains per panicle (66.48%). These findings are in close agreement with the earlier findings of Sudeepthi *et al.* (2020) and Kunta *et al.* (2021) for days to 50 per cent flowering, grain yield per plant and test weight, Pratap *et al.* (2018) for days to maturity, Sudeepthi *et al.* (2020) and Maurya *et al.* (2022) for plant height and panicle length, Kunta *et al.* (2021) for number of effective tillers per plant and number of filled grains per panicle. Similar findings for spikelet fertility percentage was supported by Sudeepthi *et al.* (2020) and Maurya *et al.* (2022), whereas high heritability for number of unfilled grains per panicle was also reported by Kunta *et al.* (2021). This indicated that selection of these traits would be more effective as compared to others.

Similarly, genetic advance as per cent of mean was ranged between 8.59 per cent for days to maturity and 63.11 per cent for number of unfilled grains per panicle.

High heritability does not always indicate high genetic gain. Heritability and genetic advance are important selection parameters. Heritability estimates along with genetic advance as per cent of mean are normally more helpful in predicting the gain under selection than heritability estimates alone. In the present

Table-1 : List of rice genotypes used in the experiment.

S. No.	Name of genotypes	Source of genotypes	S. No.	Name of genotypes	Source of genotypes
1.	CGIL-833-3	IIRR, Hyderabad	16.	CGIL-801-1	IIRR, Hyderabad
2.	CGIL-303-3	IIRR, Hyderabad	17.	CGIL-1354-1	IIRR, Hyderabad
3.	CGIL-1371-3	IIRR, Hyderabad	18.	CGIL-1352-3	IIRR, Hyderabad
4.	CGIL-926-1	IIRR, Hyderabad	19.	CGIL-317-1	IIRR, Hyderabad
5.	CGIL-1325-3	IIRR, Hyderabad	20.	CGIL-263-2	IIRR, Hyderabad
6.	CGIL-852-1	IIRR, Hyderabad	21.	CGIL-922-1	IIRR, Hyderabad
7.	CGIL-433-1	IIRR, Hyderabad	22.	CGIL-1246-2	IIRR, Hyderabad
8.	CGIL-1353-2	IIRR, Hyderabad	23.	CGIL-682-1	IIRR, Hyderabad
9.	CGIL-306-1	IIRR, Hyderabad	24.	CGIL-1406-3	IIRR, Hyderabad
10.	CGIL-528-3	IIRR, Hyderabad	25.	CGIL-1391-2	IIRR, Hyderabad
11.	CGIL-1304-2	IIRR, Hyderabad	26.	CGIL-867-1	IIRR, Hyderabad
12.	CGIL-1403-1	IIRR, Hyderabad	27.	CGIL-1258-3	IIRR, Hyderabad
13.	CGIL-1420-2	IIRR, Hyderabad	28.	NH-162	IIRR, Hyderabad
14.	CGIL-1349-1	IIRR, Hyderabad	29.	NH-686	IIRR, Hyderabad
15.	CGIL-1242-1	IIRR, Hyderabad	30.	NH-228	IIRR, Hyderabad

Table-2 : Analysis of variance (ANOVA) for yield and its component traits in rice genotypes.

Source of variation	Degree of freedom (Df)	Mean sum of squares									
		Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Number of effective tillers per plant	Panicle length (cm)	Number of filled grains per panicle	Number of unfilled grains per panicle	Spikelet fertility percentage	Test weight (g)	Grain yield per plant (g)
Replications	2	0.544	0.278	8.60	4.405	3.909	238.33	30.839	5.245	0.480	1.271
Genotypes	29	142.159**	104.011**	1257.71**	6.3903**	6.323**	673.61**	77.334**	24.839**	28.447**	100.819**
Error	58	3.384	6.289	24.82	0.6222	0.719	96.93	1.715	1.028	0.471	5.281

** Significant at 1% level

Table-3 : Genetic variability parameters for yield and its attributing traits in rice genotypes.

S. No.	Characters	Range	Mean	GCV (%)	PCV (%)	Heritability % (bs)	Genetic advance	Gen. Adv. as % of mean
1.	Days to 50 per cent flowering	79.00 - 114.33	90.02	7.56	7.83	93.18	13.52	15.02
2.	Days to maturity	113.67 - 142.67	125.32	4.55	4.97	83.82	10.76	8.59
3.	Plant height (cm)	96.36 - 173.85	118.45	17.12	17.62	94.31	40.55	34.24
4.	Number of effective tillers per plant	7.60 - 12.87	10.37	13.37	15.38	75.55	2.48	23.94
5.	Panicle length (cm)	21.47 - 29.15	25.49	5.36	6.31	72.18	2.39	9.38
6.	Number of filled grains per panicle	107.40 - 165.1	140.53	9.83	12.10	66.48	23.29	16.57
7.	Number of unfilled grains per panicle	7.13 - 28.93	15.86	31.66	32.72	93.63	10.01	63.11
8.	Spikelet fertility percentage	84.89 - 95.48	89.84	3.14	3.33	88.53	5.46	6.08
9.	Test weight	17.10 - 29.71	22.73	13.44	13.77	95.19	6.14	27.01
10.	Grain yield per plant	18.59 - 40.38	25.91	21.78	23.51	85.78	10.77	41.55

set of materials, high heritability coupled with high genetic advance as per cent of mean was recorded for number of unfilled grains per panicle, grain yield per plant, plant height, test weight and number of effective tillers per plant indicating effectiveness of selection for the improvement of these traits due to additive gene effect. Similar results were obtained earlier by Rashmi *et al.* (2017), Pratap *et al.* (2018), Sudeepthi *et al.* (2020) and Kunta *et al.* (2021) for grain yield per plant, plant height, test weight and number of effective tillers per plant. Similar findings for number of unfilled grains per panicle was supported by Saha *et al.* (2019) and Kunta *et al.* (2021).

Conclusions

From this study, we conclude that the genotypes exhibited a wide range of variability for all of the traits. This indicated that there is ample scope for selection of promising genotypes from present set of genotypes for yield improvement. On the basis of mean performance, genotypes *viz.*, CGIL-1242-1, CGIL-922-1, CGIL-1304-2, NH-162 and CGIL-1371-3 were found to be the best for yield and yield contributing traits. Therefore, these can be successfully utilized as parents in hybridization program to obtain potential transgressive segregants. Genotype CGIL-1420-2 was earliest in flowering and maturity suggesting that this genotype can be used as a donor in hybridization program for evolving early maturing rice variety. Traits *viz.*, number of unfilled grains per panicle, grain yield per plant, plant height, test weight and number of effective tillers per plant showed high heritability coupled with high genetic advance indicating these traits can be considered for the rice improvement through adapting selection without progeny testing.

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Sesame Quality (*Sesamum indicum* L.) is Influenced by Potassium and Sulphur

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Abstract

At the agronomy farm, S.K.N. College of agriculture in Jobner (Rajasthan), a field experiment on loamy sand soil was conducted in kharif 2014. The trial included 16 treatment combinations with four amounts of potassium and sulphur (0, 25, 50, and 75 kg/ha) in each. The findings demonstrated that gradually raising the levels potassium up to 50 kg K₂O/ha and sulphur to 40 kg S/ha considerably improved sesame quality.

Key words : Potassium, sulphur and quality.

Introduction

Sesame is called as 'the queen of canvases' because of redundant ordinary ornamental and skin care rates. It's grown in all seasons of the time and being a short duration crop, fit well into colorful cropping sequences systems. Encyclopedically, sesame is grown on 6.57 million hectares with product of 2.94 million tones with productivity of 448 kg ha⁻¹. In India, it's cultivated on 17 lakh hectares and the total product of 7.48 lakh tones with productivity of 439 kg ha⁻¹ (Anonymous, 2013). Potassium plays an important part in activation of enzymes and resistance to cold, complaint, water stress and other adverse conditions. Sulphur an essential factory nutrient can play a crucial part in accelerating the product and productivity of oilseeds in the country as it has a significant influence on quality and development of oil painting seeds and stylish known for its part in the conflation of proteins, canvases and vitamins. Keeping this in view, the disquisition was carried out to study the effect of potassium and sulphur on growth, yield attributes, yield and quality of sesame crop.

Materials and Methods

A field was conducted at the Agronomy farm, S.K.N. College of Agriculture, Jobner (Raj.) in a randomized block design, with four replication using sesame cv. RT-46. There were 16 treatments conforming of four situations of K (and 75 kg K₂O/ ha applied as gypsum) and four situations of S (and 60 kg S/ ha applied as sulphate of potash) experimental soil was loamy sand in texture with high infiltration rate (22.4 cm hr⁻¹) and impregnated hydraulic conductivity 10.20 cm hr⁻¹. The soil was low in organic carbon (0.21), low available nitrogen (125.64 kg N ha⁻¹), medium in available phosphorus (18.43 kg P₂O₅ ha⁻¹) and in available potassium (178.05 kg K₂O/ ha) while the soil was deficient in available sulphur (7.95 mg kg⁻¹).

The soil was non saline with a response 8.2. All the treatments i.e. situations of sulphur after conforming sulphur entered from potassium sulphate applied through gypsum 21 days before sowing and potassium as per treatments were applied previous to sowing and incorporated manually in top 15 cm soil. The recommended cure of N and P in the form of urea and DAP were applied through broadcasting before sowing. The crop was raised with standard package of practices. The crop was gathered at maturity and plot wise fodder and grain yield recorded after sundry as well as factory height, number of branches per factory, number of capsule per factory, number of seed per capsule and 1000 seed test weight were also recorded.

Results and Discussion

Effect of potassium : oil painting and protein content in sesame has a great bearing and it determines request price for growers. The oil painting and protein content of the crop were significantly told with the operation of potassium. The significantly maximum oil painting and protein content were observed with the operation of potassium@ 50 kg K₂O ha⁻¹ (Table 1). The increase in oil painting yield and protein content with the operation of potassium is consequence of the increase in oil painting content and protein content and grain yield (Mondal *et al.*, 1997). There was a spectacular increase in oil painting and protein content under balanced fertilization (Brar *et al.*, 2010).

Effect of sulphur : Data presented in Table-1 showed that operation of sulphur to sesame significantly enhanced the oil painting content and protein content. The significantly loftiest oil painting and protein content of sesame were observed with operation of 40 kg S ha⁻¹. Sonia *et al.*, (2014) also reported that significant enhancement in oil painting and protein content of the crop with the advanced rates of operation of sulphur. The

Table-1 : Effect of potassium and sulphur on Protein content, oil content and oil yield of sesame.

Treatments	Protein content (%)	Oil content (%)	Oil yield (kg ha ⁻¹)
Potassium levels			
K ₀	17.92	39.20	259.56
K ₂₅	21.29	43.06	332.01
K ₅₀	23.20	46.82	394.64
K ₇₅	23.64	46.99	404.27
SEm+	0.69	1.25	7.39
CD (P=0.05)	1.98	3.61	21.35
Sulphur levels			
S ₀	18.25	39.11	254.20
S ₂₀	21.31	43.01	335.53
S ₄₀	22.94	46.75	394.82
S ₆₀	23.56	47.21	405.91
SEm+	0.69	1.25	7.39
CD (P=0.05)	1.98	3.61	21.35

increase in oil painting and protein content might be due to further sulphur storehouse in the factory. Sulphur is the integral part of natural moles like cyteine and methionine which beget variation in oil painting and protein content. This may also be due to advanced vacuity of sulphur in the root zone of the crop which might have rebounded in enhanced sulphur storehouse which involved in oil painting and protein conformation (Tahir *et al.*, 2014).

Conclusion

Grounded on the experimental results, it was concluded that better quality of sesame crop can be attained by the operation of potassium@ 50 kg K₂O ha⁻¹ and sulphur@ 40 kg S ha⁻¹.

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Effect of Cocopeat with Agrowaste as Casing Materials on Development of Pinheads of White Button Mushroom [*Agaricus bisporus* (Lange) Imbach]

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Abstract

An experiment was conducted at the Mushroom Crop Room, Department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The main objectives were to check the effect of cocopeat with agrowaste as casing materials on growth and yield of white button mushroom. The study was conducted in Completely Randomised Design under the agro-climatic conditions of Prayagraj (2021-22). The results revealed that the highest yield was observed in T₅ [Cocopeat + Pomegranate skin waste (3:1)] contains potassium, sodium, iron and zinc which favours the better growth of mycelium. The maximum development of pinheads (number) of mushroom was recorded in T₅ [Cocopeat + Pomegranate skin waste (3:1)] respectively T₂ [Cocopeat + Tea waste], T₃ [Cocopeat + Turmeric leaf (3:1)], T₁ [Cocopeat + Drumstick leaf (3:1)], T₂ [Cocopeat + Garlic leaf (3:1)], and respectively minimum T₀ Cocopeat.

Key words : *Agaricus bisporus*, casing, cocopeat, *Trichoderma harzianum*, yield.

Introduction

White button mushroom, scientifically called as *Agaricus bisporus* is an edible basidiomycetes fungus that belongs to the genus *Agaricus*. Globally, China is the largest producer of mushrooms in the world followed by USA, Netherlands, Poland and Spain (FAO, 2021). During the period between 2021- 2022, Bihar tops the list followed by Maharashtra, Orissa, Haryana, Uttarakhand in the top mushroom producing states in India [Agricultural and processed food products export development authority of India (APEDA), 2021].

Mushrooms can uptake heavy metals from substrate through the spacious mycelium by biosorption. Mushroom cultivation signifies one of the economically workable processes for bioconversion of agricultural wastes into a protein rich food, making it an effective weapon against malnutrition in developing countries like India which has lowest per capita consumption of protein in the world. Agricultural wastes are available richly in our country which is primarily used as cattle feed and remaining part which are being burnt or spread over the field. About 500 Metric tons of agricultural wastes are generated in India per annum., approximately 92 Metric tons of crop waste is burned per annum in India in the absence of adequate sustainable management practices, causing excessive particulate matter emissions and pollution. Most of the agricultural wastes contain about 80% cellulose, hemicellulose, lignin which are not easily degradable. Different organic wastes such as wheat straw, paddy straw, burnt

rice husk, sugarcane leaves, etc., can be used for the cultivation of mushrooms. So, if even 1% of the farm waste is used for the mushroom production, India can dominate the world in terms of production and marketing (Ebadi *et al.*, 2012); (Pawar *et al.*, 2021).

Mushrooms are considered as delicious food with high nutritional and functional value, and they are also accepted as nutraceutical foods; they are of special interest due to their medicinal properties, and economic significance. However, there is not an easy distinction between edible and medical mushrooms because many of the common edible species have therapeutic properties and several species used for medical purposes are also edible (Chinara *et al.*, 2014).

Casing mixtures for their influence on growth, physical parameters and yield of *Agaricus bisporus*. The results showed that the maximum yield was recorded in coco coir pith (CCP) + vermicompost (VC) + Sand, whereas the maximum fruiting body weight was recorded in CCP + VC + FYM + saw dust (Ram *et al.*, 2009)

Tea production waste as a new casing material in mushroom (*Agaricus bisporus*) cultivation. Some physical and chemical characteristics of tea waste, fermented tea waste and a mixture of tea waste with peat were compared with that of peat casing, as were their effects on yield, mixture of tea production waste with peat in 1:1 (v:v) ratio increased the yield (Gulser *et al.*, 2002). Pomegranate peels were found as effective substrate material at 50% pomegranate peels + 50% wheat straw

Table-1 : Effect of cocopeat with agrowaste as casing materials on development of pinheads.

Symbols	Treatments	After 6 days of mycelium run	After 12 days of mycelium run
T ₀	Cocopeat (Control),	2.75	5.0
T ₁	Cocopeat + Drumstick leaf (3:1)	5.75	7.5
T ₂	Cocopeat + Tea waste (3:1)	7.75	7.7
T ₃	Cocopeat + Turmeric leaf (3:1)	6.0	7.5
T ₄	Cocopeat + Garlic leaf (3:1)	5.0	5.50
T ₅	Cocopeat + Pomegranate skin waste (3:1)	10.25	12.50
	F-test	S	S
	S. Em	0.425	0.421
	CD (0.05)	1.262	1.250

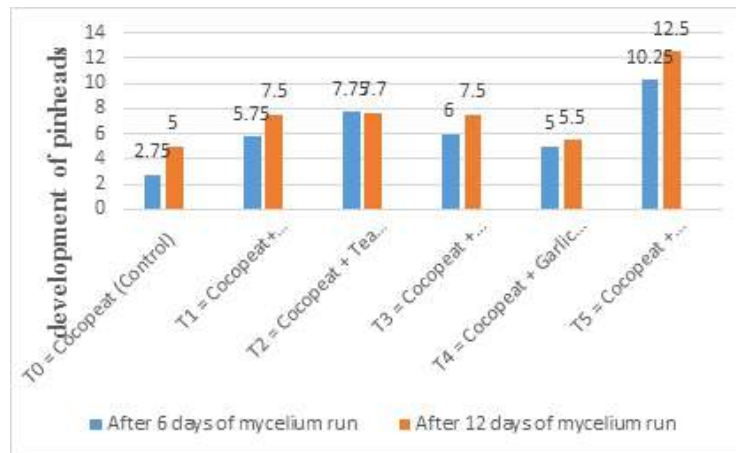


Fig-1 : Effect of cocopeat with agrowaste as casing materials on development of pinheads.

ratios for mushroom cultivation. It has been determined as effective on some parameters, especially yield (Nadir *et al.*, 2019). Leaves of *Moringa olifera*, bark of *Cinnamom zeylanicum*, fruits of *Corindrum sativum* at 5 and 10% concentrations were found to be the best one for the growth and yield (Sailaja *et al.*, 2020).

There are more than 2000 species of mushrooms out of which only 22 species are widely proposed for cultivation. Unlike plants, they do not contain green pigment chlorophyll. There are many commercial and semi commercially cultivated mushroom species in India, out of which *Agaricus bisporus* (white button mushroom), *Pleurotus spp.* (oyster mushroom), *Volvariella spp.* (paddy straw mushroom) have much importance with vast cultivation and consumption (Shah *et al.*, 2011).

In addition to protein, mushroom is an excellent source of Vitamin- D, minerals such as potassium, iron, copper, zinc and manganese, low in calories, fat free, cholesterol free, gluten free and very low in sodium. From 2010- 2017, the mushroom industry in India has registered an average growth rate of 4.3% per annum. Out of the total mushroom produced, white button mushroom share is 73% followed by oyster mushroom (16%), paddy straw mushroom (7%) and milky mushroom (3%) (Sharma *et al.*, 2017).

In white button mushroom, many biotic and abiotic factors affects the crop yield, which include competitor moulds, nematodes, fungi, insects, bacteria and viruses. Many yield losses have been recorded in white button mushroom cultivation due to competitor moulds and fungi depending upon different regions (Gea *et al.*, 2005).

Materials and Methods

In-vivo experiment was be conducted in the Mushroom Cultivation Room, Department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P). Wheat straw was selected as substrate for composting. Long method composting was followed which took 35 days to complete where 2 additional turnings were given due to the presence of ammonia smell. Spawn of *Agaricus bisporus* was procured from the Directorate of Mushroom Research, Solan, Himachal Pradesh, India. Spawn strain was DMR-A 121. Spawn was applied @7.5g/kg compost (Kapoor, 2004). Four kilograms of compost was filled in each bag. A total of six treatments replicated four times including a control were taken up under Completely Randomized Design. Compost filled bags were kept in the dark room until complete colonization was done with fungal mycelium for casing. The casing materials are

Table-2 : Effect of cocopeat with agrowaste as casing materials on the percent increase in yield over control.

Treatment	Treatment weight (gm)	Control (gm)	Yield percentage increase in yield over control	Mean of percent increase
T ₁	367	169	53.95	53.2
T ₂	395	169	57.21	
T ₃	325	169	48	
T ₄	254	169	33.46	
T ₅	687	169	75.40	

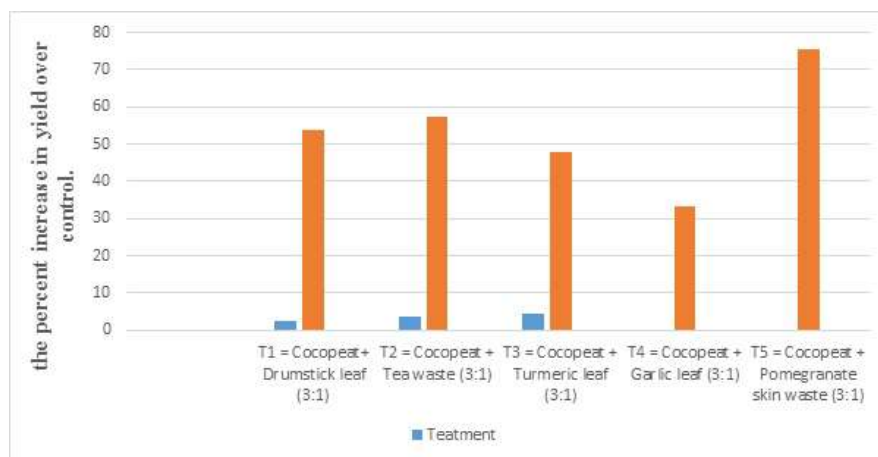


Fig.-2 : Effect of cocopeat with agrowaste as casing materials on the percent increase in yield over control.

T₀-Cocopeat(control), T₁-Cocopeat+ Drumstick leaf powder(3:1), T₂-Cocopeat + Tea waste powder (3:1), T₃-Cocopeat + Turmeric leaf powder(3:1), T₄-Cocopeat + Garlic leaf powder (3:1), and T₅-Cocopeat + Pomegranate peel powder(3:1) and applied at 3 cm thickness in cylindrical polythene bags 36×22 cm of 100 gauge. After casing is done the temperature of the room is again maintained at 23±2° and relative humidity of 85-90% for another 8-10 days. Low CO₂ concentration is favorable for reproductive growth at this stage. For fruiting under favorable environmental condition viz. temperature (initially 23 ± 2° for about week and then 16 ± 2°), moisture, (2-3 light sprays per day for moistening the casing layer) humidity (about 85%) proper ventilation and CO₂ concentration (0.08-0.15%) the fruit body initials which appear in the form of pin heads start growing and gradually develop into button stage. Harvesting was done by holding them gently and twisting them in clockwise and anti- clockwise directions without any residues of stub and without disturbing the other fruiting bodies

Results and Discussion

Temperature and humidity play a major role on the mycelium run of mushroom. During this process of cultivation process, maximum temperature was 35.6° during the (4th week of October) and minimum temperature was 5.2° during the (3rd week of January) The maximum development of pinheads (number) of mushroom was recorded in T₅ [Cocopeat + Pomegranate

skin waste (3:1)] respectively T₂[Cocopeat + Tea waste], T₃[Cocopeat + Turmeric leaf (3:1)], T₁[Cocopeat+ Drumstick leaf (3:1), T₂[Cocopeat + Garlic leaf (3:1)],and respectively minimum T₀ Cocopeat.

Conclusions

From present study, it was concluded that T₅ [Cocopeat + Pomegranate skin waste (3:1)] when incorporated into casing mixture containing maximum percent increase in yield over control (75.40) days for pinhead initiation (16.25), and the maximum percent increase in yield over control (75.40). The maximum development of pinheads (number) of mushroom was recorded in T₅ [Cocopeat + Pomegranate skin waste (3:1)] respectively T₂[Cocopeat + Tea waste], T₃[Cocopeat + Turmeric leaf (3:1)], T₁[Cocopeat+ Drumstick leaf (3:1), T₂[Cocopeat + Garlic leaf (3:1)],and respectively minimum T₀ Cocopeat. The results of the present study are of one crop season (October 2021-March 2022) under Prayagraj agro climatic conditions as such more trials should be carried out in future to validate the present findings.

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Efficacy of Botanicals against Shoot and Fruit Borer (*Earias Vittela*) on Okra (*Abelmoschus esculentus* L.) Moench.

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Abstract

The present investigation was conducted during July to December 2018 at Central Research Farm, SHUATS, Naini, Prayagraj. Eight treatments were evaluated against *Earias vittela* i.e., Aloe vera extract 5%, Dhatura leaf extract 5%, Neem leaf extract 10%, Garlic bulb extract 3%, Pongamia oil 3%, Calotropis leaf extract 5% and Untreated control. Minimum per cent of shoot infestation, fruit infestation and B:C ratio were recorded in Aloe vera extract 5% (12.66%, 14.01%, 1:1.82), Dhatura leaf extract 5% (9.88%, 10.93%, 1:2.90), Neem leaf extract 10% (12.25%, 13.50%, 1:2.30), Garlic bulb extract 3% (11.64%, 12.94%, 1:2.76), Pongamia oil 3% (9.08%, 9.99%, 1:3.05), Calotropis leaf extract 5% (11.86%, 13.19%, 1:2.60) and Untreated control (18.18%, 20.12%, 1:1.35) respectively.

Key words : Okra, *Earias vittela*, benefit cost ratio, efficacy.

Introduction

Okra (*Abelmoschus esculentus* L.) belongs to family Malvaceae or Mallow, which is locally known as Bhindi and Lady's finger worldwide. It is very popular summer vegetable for home gardening while it is also grown commercially throughout the world especially in Indo-Pakistan sub-continent. It is probably originated in Ethiopian region of Africa. Sustained maintenance of good health in third world countries, particularly in children food, enrichment through fruits and vegetables is necessary. India stands second in vegetable production next to China and having area of 4.98 lakh hectares with an annual production of 57.84 lakh tonnes and productivity of 11.6 tonnes ha⁻¹. It is also cultivated in Nigeria, Sudan, Pakistan, Ghana, Egypt, Benin, Saudi Arabia, Mexico and Cameroon. India ranks first in okra production (72% of the total world production) having area of 533 hectares with an annual production of 6346 million tonnes and productivity of 11.9 million tonnes ha⁻¹ (source: FAO 2015).

Okra plant was attacked by twenty insect pests during different growth stages (Butani and Verma, 1976). Most of the pests attacking okra also attack cotton crop. The major notorious pests, which attack the crop, are fruit borer (*Earias vittella*), aphids (*Aphis gossypii*), leaf hopper (*Amrasca biguttula*), Thrips (*Thrips tabaci*) and whitefly (*Bemisia tabaci*). Further, sucking insects adversely affect the plant physiology particularly the rate of photosynthesis.

Materials and Methods

The present investigation was undertaken to evaluate efficacy of botanicals against shoot and fruit borer, (*Earias vittella* Fab.) on okra [*Abelmoschus esculentus* (L.) Moench] during *Kharif* season 2018 at Central research farm, SHUATS, Naini, Prayagraj (U.P.)

Field trial was laid out in randomized block design (RBD) with 3 replications and 8 treatments including untreated control during kharif 2018-19 to evaluate the efficacy of six botanicals i.e., Aloe Vera Extract 5%, Dhatura leaf Extract 5%, Neem leaf Extract 10%, Garlic Bulb Extract 3%, Pongamia oil 3%, and Calotropis leaf Extract 5%, and one chemical Imida-clopride 17.80% SL against shoot and fruit borer on okra. Crop was raised in plots measuring 2x2 m with a spacing 60x60 cm between rows and plant, respectively. Two rounds of botanicals spray of different treatment were imposed on need basis during the crop season.

Preparation of Extract : Leaves were collected and shade - dried and were grind with a domestic grinder. Known quantity of well powdered leaf material was soaked in one-third of water and kept overnight. Stirring was done frequently. Then the material was filtered through a clean muslin cloth and the clear filtrate was mixed with the remaining two-third portion of water.

Data collection : The incidence of the borer on the shoot and the fruit was recorded from the five randomly selected

Table-1 : Efficacy of botanicals on shoot borer in okra (*Abelmoschus esculentus* Moench) (First spray).

Treatments		1 DBS	3 DAS	7 DAS	14 DAS	Mean
T ₁	Aloevera Extract 5%	17.31 (24.58)	13.09 (21.21)	12.38 (20.59)	12.51 (20.71)	12.66 (20.84)
T ₂	Dhatura Leaf Extract 5%	17.45 (24.68)	10.03 (18.46)	9.70 (18.14)	9.91 (18.35)	9.88 (18.35)
T ₃	Neem leaf extract 10%	17.69 (24.87)	12.56 (20.75)	12.01 (20.28)	12.18 (20.42)	12.25 (20.49)
T ₄	Garlic Bulb Extract 3%	17.50 (24.73)	12.02 (20.28)	11.37 (19.70)	11.54 (19.85)	11.64 (19.95)
T ₅	Pongamia Oil 3%	17.58 (24.79)	9.37 (17.82)	8.85 (17.30)	9.03 (17.40)	9.08 (17.54)
T ₆	Calotropis Leaf Extract 5%	17.50 (24.72)	12.28 (20.50)	11.68 (19.98)	11.64 (19.94)	11.86 (20.15)
T ₇	Imidacloprid 17.8 SL	17.74 (24.91)	7.78 (16.19)	7.41 (15.80)	7.56 (15.96)	7.58 (15.99)
T ₀	Untreated	17.67 (24.85)	17.67 (24.85)	18.73 (25.64)	18.13 (25.20)	18.18 (25.23)
Overall Mean		17.55	11.84	11.51	11.56	11.64
F-test		NS	S	S	S	S
S. Ed. (±)		0.64	0.28	0.27	0.28	0.24
C. D. (P = 0.05)		1.38	0.59	0.58	0.59	0.52

*Figures in parenthesis are arcsine-transformed values. DBS-Days before spray, DAS-Days after spray.

Table-2 : Efficacy of botanicals on fruit borer in okra (*Abelmoschus esculentus* Moench) (Second spray).

Treatments		1 DBS	3 DAS	7 DAS	14 DAS	Mean
T ₁	Aloevera Extract 5%	17.68 (24.86)	14.13 (22.08)	13.88 (21.87)	14.01 (21.98)	14.01 (21.98)
T ₂	Dhatura Leaf Extract 5%	17.86 (24.99)	11.10 (19.46)	10.78 (19.16)	10.93 (19.30)	10.93 (19.31)
T ₃	Neem leaf extract 10%	18.26 (25.29)	13.63 (21.66)	13.36 (21.44)	13.51 (21.56)	13.50 (21.56)
T ₄	Garlic Bulb Extract 3%	17.80 (24.95)	13.07 (21.19)	12.83 (20.99)	12.93 (21.07)	12.94 (21.08)
T ₅	Pongamia Oil 3%	17.96 (25.07)	10.12 (18.53)	9.87 (18.30)	9.99 (18.41)	9.99 (18.43)
T ₆	Calotropis Leaf Extract 5%	18.13 (25.20)	13.31 (21.39)	13.08 (21.20)	13.18 (21.28)	13.19 (21.29)
T ₇	Imidacloprid 17.8%	18.19 (25.24)	8.61 (17.06)	8.28 (16.72)	8.45 (16.89)	8.45 (16.89)
T ₀	Untreated	18.09 (25.16)	18.76 (25.66)	20.26 (26.74)	21.36 (27.52)	20.12 (26.65)
Overall Mean		17.99	12.84	12.79	13.04	12.89
F-test		NS	S	S	S	S
S. Ed. (±)		0.56	0.35	0.39	0.41	0.40
C.D. (P = 0.05)		1.20	0.76	0.83	0.84	0.85

*Figures in parenthesis are arcsine-transformed values. DBS-Days before spray, DAS-Days after spray.

plants. Observations was recorded one day before spray and 3rd, 7th, 14th, days after spraying. The extent of the damage, was computed by using the formula :

Number of infested shoot

$$= \frac{\text{Number of infested shoot}}{\text{Total number of shoot}} \times 100$$

Similar observation was taken for fruit infestation with the following formula :

Number of infested fruit

$$= \frac{\text{Number of infested fruit}}{\text{Total number of fruit}} \times 100$$

The mean data on the percent infestation of shoot borer revealed that the chemical treatments were significantly superior over control. Among all the treatments lowest percent infestation of shoot and fruit borer was recorded in Imidacloprid (7.58%). These finding are in support with Das *et al.* (2001). Pongamia Oil

(9.08%) is found to be the next best treatment which is in line with the findings of Pandey and Thakur (2017) followed by Dhatura Leaf Extract (9.88%). Treatments Garlic Bulb Extract (11.64%) Subbireddy *et al.* (2018) Calotropis Leaf Extract (11.86%), which were statistically at par with each other. Treatments Neem leaf extract (12.25%), Aloe vera Extract (12.66%) were least effective among control.

The mean data on the percent infestation of shoot borer revealed that the chemical treatments were significantly superior over control. Among all the treatments lowest percent infestation of shoot and fruit borer was recorded in Imidacloprid (8.45%) Dhar and Bhattacharya (2015) followed by Pongamia Oil (9.99%) which were most effective treatments against Shoot and fruit borer (*Earias vittella* Fab.) on okra which is in line with the findings of Sahana *et al.* (2017) which was followed by Dhatura Leaf Extract (10.93%). The treatments Garlic Bulb Extract (12.94%), Calotropis Leaf Extract (13.19%) and Neem leaf extract (13.50%), were statistically at par with each other. Treatment Aloe vera Extract (20.12%) was least effective among all the treatments. Murugesan and Murugesan (2009) botanicals are moderate in their efficacy in reducing the fruit borer damage.

The yields among the treatment were significant. The highest yield was recorded in T₇ Imidacloprid (98.88q/ha) similar result found in Dhar and Bhattacharya (2015) followed by T₅ Pongamia Oil (90.53q/ha) these similar result also find by Shobharani and Nandihalli (2010). T₂ Dhatura Leaf Extract (86.33q/ha), T₄ Garlic Bulb Extract (82.38q/ha), T₆ Calotropis Leaf Extract (77.52/ha), T₃ Neem Leaf Extract (68.70/ha), T₁ Aloe vera Extract (54.21q/ha), as compared to control T₀ (43.78q/h). When cost benefit ratio was worked out, interesting result was achieved. Among the treatment studied, the best and

most economical treatment was T₇ (1:3.31), followed by T₅ (1:3.05), T₂ (1:2.90), T₄ (1:2.76), T₆ (1:2.60), T₃ (1:2.30), T₁ (1:1.82), as compared to control T₀ (1:1.3) Das *et al.* (2001) followed by imidacloprid (Rs. 1149). The highest cost benefit ratio was also recorded from acephate (1:5.58), followed by imidacloprid (1:4.63).

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Management of Phosphorus in Cowpea [*Vigna unguiculata* (L.) Walp] through PROM and Phosphatic Inoculants - A Review

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Abstract

Cowpea [*Vigna unguiculata* (L.) Walp] is one of the important *kharif* pulse crops in India referred as *lobia* and developed for vegetable, grain, forage and green manuring. This crop has great significance due to its short duration, high yielding and rapid growing variety. The vegetable cowpea pods contain 84.6% moisture, 4.3% protein, 8.0% carbohydrate and 0.2% fat. Cowpea seeds contain about 21.2% to 30.6% protein, 60.3% carbohydrate, 1.85 fat and is also good source of calcium, phosphorus and iron. Phosphorus is the second most important nutrient next to nitrogen. Indian soils are poor to medium in available phosphorus. In conventional agriculture, to ameliorate its deficiency, expensive phosphatic fertilizers are applied in enormous amounts. Excessive application of these chemical fertilizers over long period has ruined natural properties of soils by killing soil micro flora and fauna leading to diminished agricultural production. In this way, chemical phosphatic fertilizers pose two fold issues, in that, on the one hand almost 85% of the applied P is lost perpetually which results in environmental pollution and second soil ill health. Sustainable agriculture based on utilization of organic and biological fertilizers is an effective solution for submounting these problems. Phosphate Rich Organic Manure (PROM) also referred as "green chemistry phosphatic fertilizer" is an effective source of P to replace the costly chemical phosphatic fertilizers and proves a better source for phosphorus application. PROM is a combination of well-composted organic manure and high-grade rock phosphate mineral. Inoculation of legume seeds with phosphate solubilizing bacteria (PSB) enhances nodulation, available phosphorus content of the soil and root and shoot biomass. PSB release the acidic substances and convert the unavailable phosphorus to available form for plants. Mycorrhiza association is a symbiotic non-pathogenic association between plant roots and fungal hyphae with a fungal relation between soil and the root. Vesicular Arbuscular Mycorrhizas (VAMs) can supply as high as 80% of P and 25% of N needed by its symbiotic partner. The joint inoculation of N₂-fixers, PSB, and mycorrhizal fungi could be more powerful than single organism for supplying a more balanced nutrition for legume plants under conditions of decreased nutrient inputs.

Key words : Phosphorus, Cowpea, PROM, VAM.

Effect of PROM

Growth Parameters : Meena (2005) at Udaipur carried out an experiment to study the response of soybean to PR (34/74) incubated with non-edible oil cakes, PSB and FYM. The treatments consisted of application of 60 kg P₂O₅/ha through DAP and PROM [an incubated product of PR (34/74) and non-edible oil cakes] along with PSB and FYM @ 2 and 4 t/ha and an absolute control. The results revealed that application of PROM (34/74) + castor cake + FYM @ 4 t/hain soybean significantly increased the plant height, number of primary and secondary branches/plant and dry matter accumulation of system over control and PR (34/74) alone and found at par with DAP equivalent to 60 kg P₂O₅/ha. Babu (2006) in his study conducted at ANGRAU, Andhra Pradesh observed that increase in the proportion of FYM in PROM made either with recommended (RD) and double recommended dose (DRD) from 1:2 to 1:4 ratio increased the plant height and dry matter accumulation during all the growth stages of soybean. The maximum numbers of nodules/plant at 30

DAS were observed with RD of P₂O₅ through SSP which was closely followed by the treatments of PROM with higher proportions of FYM. Nodule dry weight was maximum with the application of PROM made of DRD of P₂O₅ in 1:4 ratios. The growth parameters recorded by PROM made of DRD of P₂O₅ were superior over PROM made of RD of P₂O₅. The number of days taken to maturity was significantly reduced by phosphorus application through PROM and SSP over no phosphorus application. Singh *et al.* (2015) conducted a field experiment at Jobner to evaluate the response of different sources and levels of phosphorus on yield, nutrient uptake and net returns on mungbean under rainfed condition during *kharif*, 2008. They noticed that among the different sources, phosphorus rich organic manure (40 kg P₂O₅/ha) significantly increased the number of effective nodules/plant (32.27) by 13.02 and 10.89 per cent, respectively in comparison to diammonium phosphate (28.55) and single super phosphate (29.10). Application of PROM also significantly increased the number of total nodules/plant by 11.81 and 10.11 per cent over DAP and

SSP, respectively. However, SSP and DAP remained statistically at par with each other. Khangarot (2020) conducted an experiment at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during on loamy sand soil to evaluate the effect of phosphate rich organic manure (PROM) and microbial inoculants in mungbean. The combined application of PROM + PSB + VAM + PF resulted in the maximum value of most of the growth determining characters viz., plant height, number of branches/plant, dry matter accumulation at all the stages, number and weight of root nodules/plant, CGR, LAI and chlorophyll content.

Yield attributes and yield : Singh (2010) conducted a field experiment at Jobner to study the response of mungbean to different sources and levels of phosphorus under rainfed conditions and reported that application of phosphorus through PROM @ 40 and 60 kg P_2O_5 /ha recorded significantly higher number of pods/plant, seeds/pod, test weight and seed and straw yields of mungbean in comparison to SSP, DAP and control. While carrying out a field study at Jobner, Singh *et al.* (2015) reported that application of PROM at 40 kg P_2O_5 /ha in mungbean recorded significantly more number of pods/plant (31.97), number of seeds/pod (11.46), test weight (33.12 g), seed (8.36 q/ha) and straw (13.73 q/ha) yield as compared to control, DAP and SSP. They further explained that PROM was superior in increasing the seed yield by 17.7 and 12.2 per cent, respectively, as compared to DAP and SSP. Aechra *et al.* (2017) conducted a pot experiment at Jobner during *kharif* season on cowpea and reported that application of phosphorus through PROM recorded significantly higher total and effective nodules, nodule index, number of pods/plant, number of seeds/pod, seed yield, straw yield and root biomass of cowpea in comparison to SSP and DAP. Khangarot (2020) reported from Jobner that maximum grain, straw and total biological yield were noticed under the combined application of PROM + PSB + VAM + PF. The combined application of PROM + PSB + VAM + PF fetched the highest net returns of 50920/ha.

Nutrient concentration, uptake and quality : Khandelwal *et al.* (2004) conducted an experiment on clusterbean at ARS, Durgapura, Jaipur and reported that application of 40 kg P_2O_5 /ha through organic manure along with 50% RD of phosphatic fertilizer indicated an increase in protein content of clusterbean over the RD of 40 kg P_2O_5 /ha through DAP. Singh (2010) while studying the response of mungbean to different sources and levels of phosphorus at SKRAU, Bikaner reported significant increase in N, P, K and protein content in seed and straw as well as their uptake with application of PROM @ 40 kg P_2O_5 /ha in comparison to DAP and SSP. However, DAP and SSP were found statistically at par with each other.

Singh *et al.* (2015) at Jobner studied the influence of PROM application at 40 Kg P_2O_5 /ha in mungbean and recorded significantly higher N (3.85 & 1.29%), P (0.46 & 0.211 %) and K (0.39 & 1.15%) contents in seed and straw and their uptake, protein content (24.06%) in seed and net returns as compared to control. In an experiment conducted at Jobner by Khangarot (2020) found that being at par with PROM + PSB + VAM application of PROM + PSB + VAM + PF witnessed significantly higher concentration of N and P in grain and straw, protein content in seed and uptake of N, P and K by crop.

Effect of Phosphatic inoculants

Growth parameters : Amit *et al.* (2010) conducted an experiment during *kharif* season to study the response of greengram to biofertilizers under different fertility levels. Inoculation of *Rhizobium* + PSB and application of 15 kg N + 20 kg P_2O_5 /ha significantly increased the number of branches and root nodules/plant as compared to control. Kumawat *et al.* (2010) conducted a field experiment at SKRAU, Bikaner and result revealed that inoculation of mungbean seed with *Rhizobium* + PSB significantly increased the plant height and number of branches/plant as compared to control, *Rhizobium* and PSB, alone. While investigating the effect of *Rhizobium* and vesicular arbuscular mycorrhizal fungi (VAM) on greengram under temperate condition, Bhat *et al.* (2011) found that combined inoculation of VAM fungi and *Rhizobium* significantly increased the dry weight of nodules/plant at flowering and at harvest stage, respectively. Inoculation with VAM alone yielded 42.40 and 30.26 mg dry weight of nodules/plant at these stages that were significantly higher than control. Das *et al.* (2011) while studying the effect of INM on cowpea demonstrated that number of leaves, plant height, number of pods, branches/plant, diameter and length of pods were significantly improved by the application of 75 per cent RDF + Vermicompost + *Rhizobium* + PSB as compared to only RDF which resulted in saving of 25 per cent chemical fertilizer. Saharan and Nehra (2011) reported that inoculation of plants with certain strains of plant growth promoting rhizobacteria (PGPR) like *Pseudomonas fluorescens* improved the biomass production through direct effects on root and shoots growth. They further stated that PGPR enhanced the seedling germination, stand health, plant height, chlorophyll content and nodulation in legumes as compared to control. Yaseen *et al.* (2011) while studying the effect of arbuscular mycorrhizal (AM) inoculation on nutrient uptake, growth and productivity of cowpea reported that AM inoculated plants out performed than non-inoculated plants in terms of growth parameters like plant height, number of nodules and flowers/plant. They reported gain in shoot and root dry weight of cowpea plants over AM- uninoculated. Prasad *et al.* (2012) while

studying the effect of different nitrogen sources and phosphate solubilizing bacteria on growth and yield of cowpea reported that inoculation of PSB+ *Rhizobium* along with 20 kg N/ha in cowpea considerably augmented the growth factors such as crop growth rate, plant height, plant dry weight, number of root nodules/plant. Patel *et al.* (2013) conducted a field experiment on *kharif* greengram at Sardarkrushinagar, Gujarat on loamy sand soil and observed that PSB inoculation significantly increased the number of branches/plant, plant spread, number of nodules/plant and dry matter accumulation over uninoculated control. Kumar *et al.* (2014) conducted a field experiment at Baghpat in U.P and observed that dual inoculation of blackgram seed with PSB + VAM significantly increased the number of branches/plant, dry matter production and root nodules/plant as compared to no inoculation and PSB alone. Satodiya *et al.* (2015) while studying the effect of planting density and INM on flowering and growth of cowpea reported that seed inoculation with PSB + *Rhizobium* along with spacing of 60 cm x 30 cm + 15:30:0 kg NPK/ha significantly enhanced the height of cowpea plant that is by 48.19 cm, which was greater than other treatments. Result of the field study conducted by Chauhan *et al.* (2016) on INM in cowpea revealed that by the use of biofertilizers *i.e.*, 2.4 kg/ha *Rhizobium* + 2.5 kg/ha PSB along with 2.64 t/ha neem cake + 0.66 t/ha vermicompost + 165 kg/ha mustard cake enhanced the height of plant by 57.73 cm. They opined that it may be due to seed treatment with PSB + *Rhizobium* which hastened the root development. Nadeem *et al.* (2017) conducted an experiment to study the influence of phosphorus and bio-fertilizers on growth and yield of cowpea and observed that combined inoculation of seed with *Rhizobium* + PSB along with 40 kg P/ha significantly increased the stem girth, total dry matter, green pod yield and soil nutrient status in acid soil (pH 6.2) over rest of the treatment combinations. A field experiment was conducted by Kumar and Yadav (2018) at Jobner during *kharif*, 2014. The experiment consisted of four levels of phosphorus and bio-organics (Control, PSB, VAM, vermicompost at 2 t/ha and VC at 2 t/ha + VAM). Results indicated that application of vermicompost at 2 t/ha + VAM recorded significantly the highest value of growth attributes *viz.*, plant height, number of branches/plant, dry matter accumulation, total and effective nodules/plant, fresh and dry weight of nodules and CGR of mungbean over control, PSB, VAM and vermicompost @ 2 t/ha, respectively. Singh *et al.* (2018) reported from Faizabad (UP) that integrated treatment of 80 kg P₂O₅/ha + PSB significantly increased the plant height, LAI, dry matter accumulation and number of branches/plant in mungbean in comparison to 60 kg P₂O₅/ha and absolute control. A pot experiment was

conducted by Bhabai *et al.* (2019) at Coochbehar, West Bengal to investigate the effect of biofertilizer on production potential of greengram. The plants were grown in pots containing soils amended with consortium of *Rhizobium* + VAM + PSB. They found that agronomic parameters like, plant height, shoot and root length, effective root nodules/plant, dry matter accumulation etc. were significantly increased by the addition of biofertilizer packages along with graded doses of phosphorus upto 60 kg/ha over uninoculated control.

Yield attributes and yield : Choudhary *et al.* (2010) conducted a field experiment at Anand in Gujarat and observed that inoculation of greengram seed with *Rhizobium* + VAM attained significantly higher number of pods/plant, pod length, test weight, number of seeds/pod, protein content and seed yield over control. Kumawat *et al.* (2010) studied the effect of biofertilizers under different fertility levels and reported that inoculation of mungbean seed with *Rhizobium* + PSB significantly improved the number of pods/plant, pod length, test weight and number of seeds/pod as compared to control and PSB alone. Rathore *et al.* (2010) investigated the effect of P application through different sources on yield of blackgram. They found that combined effect of FYM @ 5 t/ha + 40 kg P₂O₅/ha + dual inoculation with PSB + VAM and 40 kg P₂O₅/ha + dual inoculation with PSB + VAM produced significantly higher grain yield as well as number of pods/plant and seeds/pod. Bhat *et al.* (2011) in their experiment on greengram found that combined inoculation of VAM + *Rhizobium* recorded maximum grain and straw yields that were significant over control or single inoculation. They opined that it might be due to positive influence of VAM fungi and *Rhizobium* inoculation on yield attributing characters, better N-fixation, availability and solubilization of phosphorous. Khandelwal *et al.* (2012) in their study on cowpea observed that with the application of 30 kg P and 15 kg N/ha in addition to inoculation of seeds with PSB + *Rhizobium*, the yield and yield attributing traits were found superior *i.e.*, pod/plant, seeds/pod, straw yield and seed yield. It was also reported that the application of PSB + *Rhizobium* inoculation increased the pods/plant by 8.52, seed yield by 9.20 q/ha, straw yield by 20.12 q/ha and seeds/pod by 8.11. While studying the effect of integrated nutrient management on yield and economics of cowpea, Patel *et al.* (2012) reported that application of 20 kg N and 40 kg P₂O₅/ha along with PSB and *Rhizobium* inoculation significantly increased the seed yield over 10 kg N + 20 kg P₂O₅/ha but it was at par with 10 kg N + 20 kg P₂O₅/ha alongwith PSB which indicated that PSB+ *Rhizobium* or PSB inoculation saved 50 percent nitrogen and phosphorus as chemical fertilizers. Senthilkumar and Sivagurunathan (2012) observed that inoculation of *Rhizobium* + phosphobacteria increased

number of nodules/plant, number of flower /plant and number of pods/plant in cowpea and mungbean than control and *Rhizobium* inoculation. Sivakumar *et al.* (2013) examined in a study that cowpea when inoculated with bacterial fertilizers *i.e.*, phosphobacteria + *Azospirillum* + *Rhizobium* reported significant effect on number of pods/plant by 4.2 which was greater than other treatments. Kumar *et al.* (2014) conducted a field experiment and observed that inoculation of blackgram seed with PSB + VAM had significantly higher pods/plant, number of seeds/pod, test weight, seed yield and biological yield over no inoculation. Khan *et al.* (2015) reported that the seed inoculation in cowpea with *Rhizobium*+PSB increased the microbial population and their activities in soil and increase the total and effective nodules/plant, number of pods/plant as well as number of seed/pods over no inoculation. Meena *et al.* (2015) reported that seed inoculation with *Rhizobium* + PSB in cowpea significantly increased the plant height and number of branches/plant, total and effective nodules/plant, number of pods/plant and number of seed/pods over control. Rani *et al.* (2016) reported from NDUAT, Kumarganj, Faizabad (U.P.) that inoculation of mungbean seed with PSB significantly increased the pods/plant and seeds/pod. An increase of 3.88% in seed and 3.99% in stover yield was also recorded with PSB inoculation than un-inoculation. Aechra *et al.* (2017) carried out a pot experiment at Jobner during *kharif* season and reported that dual inoculation with PSB + VAM recorded significantly higher total and effective nodules, nodule index, number of pods/plant, number of seeds/pod, grain and straw yield and root mass of cowpea over rest of the treatments but in case of nodule index, it remained at par with PSB. Kumar and Yadav (2018) based on their studies at Jobner reported that application of vermicompost @ 2 t/ha + VAM registered significantly the highest number of pods/plant, grains/pod, test weight and grain, straw and biological yields of mungbean over vermicompost at 2 t/ha, PSB, VAM and control, respectively. Pargi *et al.* (2018) conducted an experiment in Gujarat and reported that *Rhizobium* + PSB + 100% RDF application induced 11.48 g of seed index in cowpea which was higher than other treatments, this was due to proper uptake of fertilizers by plants. Singh *et al.* (2018) conducted a field trial at Faizabad to know the effect of phosphorus and PSB on yield attributes of greengram. Results showed that the yield contributing characters *viz.*, number of pods/plant, seeds/pod, test weight, biological yield and seed as well as stover yield was maximum at 80 kg P₂O₅/ha + PSB followed by 60 kg P₂O₅/ha + PSB. Ajiboye *et al.* (2019) studied the effect of VAM on seedling growth and pod production of cowpea. Results revealed that fungal organisms greatly influenced the fresh and dry

shoot and root mass. The VAM was also found to greatly improve the seed and pod production of the cowpea when compared with the untreated seedlings.

Nutrient concentration, uptake and quality :

Choudhary *et al.* (2010) at AAU, Gujarat observed significantly higher protein content (23.42%) in *kharif* greengram under *Rhizobium* + VAM over control which was at par with *Rhizobium* (22.83%) and *Rhizobium* + PSB (21.63%). Kumawat *et al.* (2010) at SKRAU Bikaner observed that inoculation of greengram seed with *Rhizobium* + PSB significantly improved the nitrogen and phosphorus uptake. The magnitude of increase in N uptake was 72.8, 33.7 and 39.64 per cent in seed and 66.3, 25.1 and 32.2 per cent in straw. The corresponding increase in phosphorus uptake was 83.1, 36.8 and 29 per cent in seed and 59.1, 22.5 and 17.9 per cent in straw over control, *Rhizobium* and PSB, respectively. Rathore *et al.* (2010) investigated the effect of P application through different sources on yield and nutrient uptake by urdbean. They found that FYM at 5 t/ha + 40 kg P₂O₅/ha, 5 t/ha of FYM + dual inoculation with PSB + VAM and 40 kg P₂O₅/ha + dual inoculation with PSB + VAM produced significantly higher yield and uptake of N, P and K by urdbean. Bhat *et al.* (2011) in their experiment on greengram reported that the interaction effect of VAM + *Rhizobium* exhibited significant increase of total N and P uptake over uninoculated control or single inoculation in greengram. Dekhane *et al.* (2011) conducted an experiment at Junagadh in Gujarat and observed that inoculation of cowpea seed with *Rhizobium* significantly increased the protein and N, P content as well as uptake of N and P by grain and stover as compared to PSB and control. Yaseen *et al.* (2011) from Pakistan reported that maximum uptake of nutrients (Ca, K, Mg, P, Fe, S and Si) in cowpea was attained in mycorrhizal plants over control. Khandelwal *et al.* (2012) conducted an experiment at Jobner on cowpea and reported that dual seed inoculation of *Rhizobium* + PSB recorded significantly enhanced N and P content in cowpea seed and straw and their total uptake by the crop as well as protein content in seed over control and PSB. However, inoculation with PSB was also found significantly superior over control in respect to increasing the quality parameters. Senthilkumar and Sivagurunathan (2012) observed that inoculation of seed with *Rhizobium* + Phosphobacteria significantly increased the chlorophyll content, protein content, carbohydrate, amino acids, inorganic phosphorus, nitrogen content of cowpea than control and *Rhizobium* alone treatment. Dhanya and Adeline (2014) found that mungbean plant treated with *Pseudomonas fluorescens* and other PGPRs showed higher protein content as compared to individual inoculation. Khan *et al.* (2015) observed that seed inoculation of cowpea with *Rhizobium* + PSB gave

significantly higher protein content in seed as compare to control. Meena *et al.* (2015) reported that application of nutrients through 75% RDF + 2.5 t/ha vermicompost + *Rhizobium* + PSB significantly improved the protein content, nutrient content and uptake by cowpea when compared with other combinations. Tripura *et al.* (2017) conducted an experiment at Jobner and reported that higher values of N, P and K content, their uptake and protein content in seeds of cowpea were obtained with the application of potassium humate @10 mg/kg soil + *Rhizobium* + VAM + PSB seed inoculation than other treatments. Birla *et al.* (2018) conducted an experiment and evaluated that under the treatment of 50 per cent nitrogen through FYM + PSB + 50 per cent nitrogen through vermicompost the higher protein content in seeds of cowpea was reported *i.e.*, 22.50 per cent. Results of a field experiment laid out by Kumar and Yadav (2018) showed that application of vermicompost @ 2 t/ha + VAM in mungbean recorded the significantly highest N, P and K content in grain and straw, their total uptake of nitrogen, phosphorus and potassium and protein content than vermicompost at 2 t/ha, PSB, VAM and control. Rekha *et al.* (2018) reported from Gujarat that application of phosphorus at 40 kg/ha+ PSB + FYM @ 10 t/ha recorded the maximum removal of nutrients by cowpea from the soil. The maximum N, P, K, S, Fe and Zn content and their uptake by crop was recorded due to application of phosphorus at 40 kg/ha+ PSB over rest of the treatments.

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Morphological and Biochemical Characterization of Rhizobia in Pea

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Abstract

This research paper presents a comprehensive study focusing on the morphological and biochemical characterization of 19 rhizobial strains collected from different regions in Southern Rajasthan, India, with a particular emphasis on their interactions with pea plants. The investigation involves Gram's staining test to categorize the strains based on cell wall properties, and their growth patterns on YEMA medium supplemented with Lactose Yeast extract Agar (LYA), Bromo Thymol Blue (BTB), and Glucose Peptone Agar (GPA) to assess their biochemical properties and metabolic capabilities. The results reveal a diverse array of morphological and biochemical traits within these rhizobial strains, shedding light on their potential for nitrogen fixation and their suitability for enhancing pea plant growth. This research not only contributes to understanding rhizobial diversity in Southern Rajasthan but also lays the groundwork for future studies aimed at optimizing pea-rhizobia symbiosis for sustainable agriculture.

Key words : Rhizobia, Gram's Staining, YEMA Medium, Lactose Yeast Extract Agar (LYA), BromoThymol Blue (BTB), Glucose Peptone Agar (GPA)

Introduction

Pea plants (*Pisumsativum*), members of the Fabaceae family (Dobrovolna *et al.*, 2022), are dicotyledonous annual herbs with compound leaves, zygomorphic flowers arranged in racemes, and distinctive pod-like fruits containing nutritious seeds. Their climbing growth habit is facilitated by tendrils, and their flowers exhibit bilateral symmetry. Pea plants have historical significance in genetics, thanks to Gregor Mendel's pioneering studies. In addition to their genetic importance, peas contribute to sustainable agriculture through nitrogen fixation and are valued for their nutritional value and diverse cultivars (Lithourgidis *et al.*, 2011). Legume plants, diverse family encompassing crops like peas, beans, and lentils, play a pivotal role in global agriculture due to their high nutritional value and contribution to soil fertility. One of the most remarkable attributes of legumes is their unique ability to form a symbiotic relationship with nitrogen-fixing bacteria known as Rhizobia (Liu *et al.*, 2020). This interaction is not only a fascinating biological phenomenon but also a critical ecological process with profound implications for sustainable agriculture and environmental health (Sharma

et al., 2023). At the heart of this mutualistic association lies the capacity of Rhizobia to convert atmospheric nitrogen into a biologically accessible form, ammonia, through the process of nitrogen fixation. Nitrogen, an essential component of amino acids and proteins, is a limiting factor for plant growth (Ohya, 2010). By partnering with Rhizobia, legume plants can harness this atmospheric nitrogen source, thus reducing the dependence on synthetic fertilizers that can contribute to environmental degradation and resource depletion. The significance of Rhizobia-legume symbiosis extends beyond its role in enhancing plant nutrition. Pea plants, among the prominent members of the legume family, exhibit intricate root-nodule formations when colonized by compatible Rhizobia strains (Sharma *et al.*, 2020). These nodules, specialized structures resulting from a complex molecular dialogue between the plant and bacteria, provide a microenvironment favorable for nitrogen fixation to occur. Additionally, the presence of Rhizobia has been linked to improvements in soil structure, water retention, and overall soil health due to the secretion of extracellular polysaccharides and other compounds (Coasta *et al.*, 2018). In recent years, as the global demand for

sustainable agricultural practices intensifies, there has been a renewed interest in understanding the diversity and functional attributes of Rhizobia populations associated with legumes. At the heart of legume-Rhizobia interaction lies a remarkable example of mutualism, where both partners benefit from their association (Lau *et al.*, 2012). Legume plants, including peas, possess specialized structures known as root nodules. These nodules are formed in response to the recognition of specific Rhizobia strains by the plant's roots. This recognition triggers a series of molecular signals and exchanges, leading to the initiation of nodule development. Within these nodules, Rhizobia undergo a remarkable transformation. They differentiate into bacteroids, a specialized form capable of atmospheric nitrogen fixation. Nitrogen, a vital component of proteins and nucleic acids, is abundant in the Earth's atmosphere but is not directly usable by plants in its gaseous form. Rhizobia possess the enzyme nitrogenase, which has the unique ability to convert atmospheric nitrogen (N_2) into ammonium (NH_4), a biologically available form that plants can utilize for growth (Borchado *et al.*, 2023). In return for this invaluable service, legume plants provide Rhizobia with a hospitable environment and nutrients, such as carbohydrates, to fuel the energy-intensive process of nitrogen fixation. The plant's root nodules offer a protected niche where oxygen levels are controlled to accommodate the nitrogenase enzyme, which is highly sensitive to oxygen. This delicate balance of oxygen supply is maintained through the plant's hemoglobin-like proteins known as leghemoglobins. The assimilation of fixed nitrogen by the legume plant results in enhanced growth, development, and overall productivity. By deciphering the intricacies of Rhizobia-legume interactions, we can unlock new avenues for optimizing agricultural practices and addressing the challenges of food security and environmental sustainability in an ever-changing world. This symbiotic partnership bestows legumes with a competitive advantage in nitrogen-deficient soils, allowing them to thrive even in challenging environments. Moreover, the reduced reliance on synthetic nitrogen fertilizers has positive implications for both economic and environmental sustainability, as excess nitrogen fertilizer application can lead to water pollution and other ecological imbalances. The objective of this study is to thoroughly explore the morphological and biochemical traits exhibited by Rhizobia bacteria within pea plants (*Pisum sativum*). This research endeavors to offer a comprehensive understanding of the intricate symbiotic relationship between these microorganisms and legumes, with a particular emphasis on the phenomenon of nitrogen fixation. By investigating the visual characteristics and structural attributes of Rhizobia through advanced

microscopy techniques, we seek to uncover potential correlations between their morphology and nitrogen-fixing efficiency. Furthermore, we aim to evaluate the nitrogen fixation capabilities of distinct Rhizobia strains associated with pea plants by some biochemical tests. Through the analysis of biochemical properties, including the activity and expression of key enzymes such as nitrogenase and leghemoglobin, we intend to shed light on the functional aspects of this symbiotic partnership. Ultimately, our research aspires to enrich the agricultural and microbiological knowledge surrounding Rhizobia-legume interactions, potentially influencing the development of improved inoculation strategies for legume crops and fostering sustainable agricultural practices.

Materials and Methods

Characterization of rhizobia isolates:

Gram's staining test : Gram Staining is the common, important, and most used differential staining technique used for classification and differentiation of micro-organisms. Different Rhizobium were grown on YEMA medium for gram's staining (Makkar and Jangra, 2017). Crystal violet stain, Gram's Iodine solution, ethanol and safranin required for gram Staining test.

Procedure : The bacterial culture was taken in loop and smear was made on sterile slide, air dried and heat fixed. Crystal violet was poured and kept for 30 seconds to 1 minute and rinsed with water. Gram's iodine was flooded and kept for 30 seconds to 1 minute and again rinsed with water. 95% ethanol was then added to the slide for 30 seconds again rinsed with water. Safranin was placed on the slide and kept for 1 minute, again rinsed with water, air dried and then observed under light microscope with magnification power of 40X and 100X. Rhizobium cells were classified as Gram negative or Gram positive.

Growth on YEMA with Lactose Yeast extract Agar (LYA) : YEMA medium was prepared by using lactose instead of mannitol, cultures were streaked on this LYA medium. These LYA plates were then incubated at 28°C for a week. These plates were then treated with benedict's reagent. *Rhizobia* strains showed negative reaction due to absence of yellow colour around the bacteria. Thus, confirming presence of *Rhizobia* (Miret *et al.*, 2020).

Growth on YEMA with BromoThymol Blue (BTB) : BTB agar test (Somasegaran and Hoben, 1994) is done to differentiate slow growing and fast-growing bacteria. YEMA plates were supplemented with BTB (5% alcoholic solution added in 2ml/lit concentration) at pH 6.8, each culture was inoculated on the medium and incubated for 48 hours. Acidic and alkaline reaction of these spotting were observed on the plate. Slow growing bacteria produced an alkaline reaction and turns medium to blue

while fast growing bacteria like *Rhizobia* turn medium yellow due to acidic reaction.

Growth on YEMA with Glucose Peptone Agar (GPA) :

Glucose-peptone media was used to differentiate *Rhizobia*, which usually shows little or no growth on the media (Sharma *et al.*, 2010) without altering the pH of the media, contaminants like *Agrobacteria*, shows massive growth on the media with a distinct change in pH. Glucose peptone agar medium with Bromo-thymol blue (indicator) is widely used for isolating pure *Rhizobial* colonies. The *rhizobium* cultures were spotted on GPA. The plates are then incubated at 28°C for 48 hours.

Statistical analysis : Relevant Statistical studies were done to find out the spatial variability in the *rhizobia* count in the sampling data and measures of dispersion such as CV (%), SD and mean were estimated.

Results and Discussion

Morphological and biochemical characterization of rhizobia :

Rhizobial strains were characterized on the basis of morphology and PGPR characteristics. Colonies of the bacteria were obtained on YEMA plates incubated at 28°C for 1-2 days. Single colony was isolated and purified by repeated streaking on YEMA medium. Colony morphology was identified on the basis of characteristics such as shape, and color. Based on this colony morphology, the isolates were grossly identified as *Rhizobium* as defined by (Somasegaran and Hoben, 1985). All 19 pea isolates were further subjected to microscopic studies all these strains showed Gram negative staining. The results were same as described by (Hamza and Alebejo, 2017) and pink coloured gram-negative rods were observed under microscope. Isolated colonies were characterized as *Rhizobia* on the basis of colony morphology and color as reported by (Aneja, 2007) and on the basis of cell shape as reported by (Bisset, 1959). The characteristic biochemical tests of *Rhizobia* were performed viz. growth on Lactose medium, growth on YEMA containing BPB, growth on GPA.

Gram's staining : Gram's staining was used to differentiate bacteria on the basis of cell morphology, stain absorbed, shape of colonies and other morphological characteristics that were observed under microscope. All bacterial isolates were found to be gram negative, were rod shaped cells and pink in colour.

Table-1 : Gram's staining test.

S. No.	Strain No.	Gram Staining
1.	R1.1	-ve
2.	R1.2	-ve
3.	R3.1	-ve
4.	R3.3	-ve
5.	R4.1	-ve

6.	R4.4	-ve
7.	R4.5	-ve
8.	R5.1	-ve
9.	R6.1	-ve
10.	R10.2	-ve
11.	R12.2	-ve
12.	R13.2	-ve
13.	R14.2	-ve
14.	R15.2	-ve
15.	R16.2	-ve
16.	R17.2	-ve
17.	R18.2	-ve
18.	R19.2	-ve
19.	R20.2	-ve

-ve=gram negative

Lactose Yeast Extract (LYA) test : The 19 pure isolated bacterial cultures were grown on LYA medium at 28°C for 7 days. All 19 strains were blue, showed negative results when treated with benedict's reagent confirming *Rhizobia* strains. Gaur *et al.*, 1973 distinguished *rhizobium* from *agrobacterium* by 3-ketalactose test, precipitates of CuO around bacterial colonies when plates were flooded with benedict's reagent.

Table-2 : Lactose Yeast Extract (LYA) test.

S. No.	Strain No.	Gram Staining
1.	R1.1	B
2.	R1.2	B
3.	R3.1	B
4.	R3.3	B
5.	R4.1	B
6.	R4.4	B
7.	R4.5	B
8.	R5.1	B
9.	R6.1	B
10.	R10.2	B
11.	R12.2	B
12.	R13.2	B
13.	R14.2	B
14.	R15.2	B
15.	R16.2	B
16.	R17.2	B
17.	R18.2	B
18.	R19.2	B
19.	R20.2	B

B=Blue



Figure : Lactose Yeast Mannitol Agar test

BTB test : BTB in YEMA medium selectively identifies *Rhizobia*. The plates were spotted with bacterial cultures and incubated at 28 for 4-5 days. All 19 cultures shown yellow colour of the colonies which states that these were fast growing colonies. Slow growing colonies shows an alkaline reaction in the medium and the dye turns to blue colour, while fast growing colonies turn media into yellow colour. The rhizobial isolates streaked on YEMA with bromothymol blue changed to yellow colour showing the production of acid which is the characteristic of *Rhizobium* (De-Vries *et al.*, 1980; Singh *et al.*, 2008).

Table-3 : BTB test.

S. No.	Strain No.	BTB
1.	R1.1	F
2.	R1.2	F
3.	R3.1	F
4.	R3.3	F
5.	R4.1	F
6.	R4.4	S
7.	R4.5	F
8.	R5.1	F
9.	R6.1	F
10.	R10.2	S
11.	R12.2	S
12.	R13.2	F
13.	R14.2	S
14.	R15.2	F
15.	R16.2	F
16.	R17.2	F
17.	R18.2	F
18.	R19.2	F
19.	R20.2	F

F=Fast growing; S=Slow growing



Figure : Bromo Thymol Blue (BTB) test.

Statistical analysis : 19 different strains of rhizobia from different part of southern Rajasthan were evaluated for their growth performance in YEMA medium, with the presence of bromothymol blue (BTB) used as an indicator. The results of the experiment are summarized in the table

3. Out of the 19 tested strains, 15 of them exhibited fast growth. These strains can be categorized as fast-growing variants of rhizobia. On the other hand, the remaining four strains, exhibited slow growth. It is noteworthy that these slow-growing variants were found in soils characterized by specific conditions. The soils where these slow variants were discovered were found to have a high pH, elevated salinity levels, a reduced quantity of zinc, and a steep slope (Shyampura and Sehgal, 2002).

The association between the slow growth of these rhizobia strains and the adverse soil conditions suggests that these particular strains may be more adapted to challenging environments, such as those with high pH and salinity. This adaptation could be related to their ability to form mutualistic symbiotic relationships with host plants under stressful conditions. Further research is needed to explore the specific mechanisms by which these rhizobia strains adapt to such environments and their potential applications in improving soil fertility and plant growth in similar challenging soils, such as those found in Udaipur and Dungarpur districts where the samples were collected.

Glucose Peptone Agar (GPA) test : GPA assay was performed to determine the ability of the *Rhizobia* to utilize glucose as the sole carbon source for growth (Kucuk *et al.*, 2006). After incubation at 28°C for 4-5 days, *Rhizobia* had shown very poor growth on GPA. It implies that the test is positive for *Rhizobia*. All 19 *Pea Rhizobia* showed positive result.

Table-4 : GPA test.

S. No.	Strain No.	GPA
1.	R1.1	P
2.	R1.2	P
3.	R3.1	P
4.	R3.3	P
5.	R4.1	P
6.	R4.4	P
7.	R4.5	P
8.	R5.1	P
9.	R6.1	P
10.	R10.2	P
11.	R12.2	P
12.	R13.2	P
13.	R14.2	P
14.	R15.2	P
15.	R16.2	P
16.	R17.2	P
17.	R18.2	P
18.	R19.2	P
19.	R20.2	P

P=Positive

Characteristics on YEMA : All nineteen strains of rhizobia were examined and characterized based on their

growth and colony morphology on YEMA (Yeast Extract Mannitol Agar) medium. The strains exhibited distinct characteristics as outlined in the table 5. The strains vary in colony size, shape, texture, and overall appearance. They all exhibit pink pigmentation and fall under the category of small to medium-sized colonies with various degrees of irregularity, waviness, smoothness, and undulation. The GPA (Growth Pattern Assessment) classification for all strains is “P,” indicating that they possess plant growth-promoting activities. The diversity in colony characteristics suggests potential variations in growth-promoting capabilities among these rhizobia strains.

Table-5 : Characteristics on YEMA.

S. No.	Sample name	Characteristicson YEMA
1.	R1.1	Pink, small, wavy, dry Colonies
2.	R1.2	Pink, small, wrinkled, dry Colonies
3.	R3.1	Pinkish, small, round, dry Smooth
4.	R3.3	Pink, small, wavy, dry Wrinkled
5.	R4.1	Pink, small, round, dry Smooth
6.	R4.4	Pink, medium, flat, Irregular, gummy
7.	R4.5	Pink, medium, flat, dry Colonies
8.	R5.1	Pink, small, round, dry Colonies
9.	R6.1	Pink, small, round, dry undulated wavy
10.	R10.2	Pink, medium, flat, Irregular, gummy
11.	R12.2	Pink, medium, flat, Irregular, gummy
12.	R13.2	Pink, small, round, dry Smooth
13.	R14.2	Pink, medium, flat, irregular, gummy
14.	R15.2	Pink, small, round, dry Smooth
15.	R16.2	Pink, small, round, dry Smooth
16.	R17.2	Pink, small, round, dry Smooth
17.	R18.2	Pink, small, round, dry Smooth
18.	R19.2	Pink, small, round, dry Smooth
19.	R20.2	Pink, small, round, dry Smooth

Statistical analysis : The results of the experiment involving 19 different strains of rhizobia cultured in YEMA medium have been categorized based on the appearance of their colonies: gummy and wet and pinpoint and Dry. Among the tested strains, a majority, consisting of 14 strains exhibited the formation of “Pinpoint and Dry” colonies, which typically signifies compatibility and higher efficiency. Such colonies are generally preferred in rhizobial studies due to their association with improved rhizobial performance and their ability to promote plant growth effectively. On the other hand, four strains formed “Gummy and wet” colonies, which are often considered less efficient and less compatible. The presence of these gummy colonies may suggest less optimal growth conditions for rhizobia. Interestingly, these gummy colonies were primarily observed in soils with adverse conditions, including extreme pH levels, steep slopes, heavy metal content, and potentially overall poor soil quality (Shyampura and Sehgal, 2002). Rhizobia are

known to be sensitive to their environmental surroundings, and their capacity to form compatible and efficient colonies can be influenced by the quality of the soil they inhabit.

In summary, the results of this experiment underscore the relationship between colony appearance and soil conditions for rhizobia. “Pinpoint and Dry” colonies are indicative of more compatible and efficient rhizobia strains (Herridge and Roughley, 1975), whereas “Gummy and wet” colonies suggest less favorable soil conditions that may hinder rhizobial growth and performance (Herridge and Roughley, 1975). This understanding is valuable for selecting appropriate rhizobial strains for agricultural purposes and improving the effectiveness of plant-microbe symbiosis, especially in challenging environmental contexts.

Conclusions

In conclusion, this research has provided valuable insights into the morphological and biochemical diversity of rhizobia strains isolated from pea plants in various locations across Southern Rajasthan, India. The comprehensive analysis, which included Gram’s staining test and growth assessments on different media, has revealed a wide range of traits and capabilities among these rhizobial strains. These findings underscore the rich potential for harnessing rhizobia-pea symbiosis for sustainable agriculture in the region. The varying responses to different growth media highlight the adaptability and versatility of these rhizobia strains, suggesting their suitability for diverse soil and nutritional conditions. Understanding the characteristics of these rhizobia strains is not only important for enhancing pea crop yields but also holds broader implications for improving soil fertility and agricultural practices in similar agroecological contexts globally (Khan *et al.*, 2009). Moving forward, further research on the specific functional attributes of these strains and their interactions with pea plants will be essential for maximizing their utility in sustainable agricultural systems.

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The Profile Characteristics of PG Students of Swami Keswanand Rajasthan Agriculture University and Rajasthan University of Veterinary and Animal Sciences, Bikaner about the Social Media

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Abstract

The study therefore aims to find out the utilization pattern of the popular social media for educational purpose. The study will explore how and to what extent students use social media for educational purposes. The study was being undertaken in the constituent campus colleges of SKRAU and RAJUVAS, Bikaner. Under SKRAU, Bikaner three colleges were selected for the present study which is situated in SKRAU, Bikaner campus. One college under the RAJUVAS, were selected for the present study which is situated in RAJUVAS, Bikaner. To have an appropriate proportion of representation from both the universities, the technique of proportionate random sampling was applied. The total numbers of 160 respondents (109 Master level students and 51 Ph.D. level students) were selected.

Majority of the students in master level were in 23 to 25 years age category, whereas in Ph.D. were in above 25 years age category. Revealed that majority of students of master level and Ph.D. level students belonged to the Other Backward Caste (OBC). Most of the master level and Ph.D. students belonged to rural background. Majority of master level and Ph.D. students were unmarried. Revealed that most of master and Ph.D. students were from nuclear family. Reported that the overall master and Ph.D. students belonged to the family having Small (up to 5 members). Found that majority of the master level and Ph.D. level students were from Rs.3.14Lakh family income. The majority of the master level and Ph.D. level students preferred books for learning. Master level and Ph.D. level students were observed possessing mobile phone, Internet, with them. Extent of contact, in case of formal sources, the master level and Ph.D. level students assigned rank first to Agricultural college/university, likewise in case formal extension contact. In case of informal sources, the master level students and was ranked first to Family members and in Ph.D. students were ranked first to Friends. That vast majority of the master level and Ph.D. level students possessed Mobile phone. Maximum number of master level and Ph.D. level students was found had medium level (41.71 to 47.31) of scientific orientation.

Key words : Social Media, SKRAU, RAJUVAS, COA, CCS, IABM.

1. Profile characteristics of PG students of SKRAU & RAJUVAS, Bikaner

The results regarding age, education, caste composition, marital status, family type, family size, communication media possession, annual family income, family occupation, extension contact, Job aspiration, preferred learning mode, mass media contact, possession of ICT tools/ devices, scientific orientation, have been presented in subsequent tables.

1.1 Age of respondents : On the basis of age, the respondents were categorised into three categories i.e. up to 23 years, 23 to 25 years and above 25 years. The overall data regarding age are presented in Table-1.1 show that most of the students (66.06 %) in master level were in 23 to 25 years age category followed by 17.43 per cent students were in above 25 years age category and 16.51 per cent students were in below 23 years age category.

The most of the Ph.D. students (72.55 %) were in above 25 years age category followed by 27.45 per cent

students were in 23-25 years age category. Further analysis of data represent that majority of students of COA, Bikaner, CCS, Bikaner, IABM, Bikaner and CVAS, Bikaner i.e. 69.70 per cent, 50 per cent 66 per cent, and 63.64 per cent, respectively were 23 to 25 years age category of the master level students, while 18.18 per cent, 20.00 per cent, and 13.64 per cent, respectively in above 25 years age category. Remaining 12.12, 50.00, 14.00 and 22.73 per cent master level students of COA, Bikaner, CCS, Bikaner, IABM, Bikaner and CVAS, Bikaner were in below 22 years age category. The explanation for this current study is based on postgraduate students from Agriculture University may be admitted to colleges in the same years.

The present findings are similar with the findings of Patel and Vyas (2016) who reported that majority of respondents (55.77%) were fallen under 22 to 27 years of age followed by 26.92 and 17.31 per cent had 28-32 years and above 32 years of age, respectively about use of social networking sites. Similar findings are also reported by Orifah *et al.* (2017) and Kumar (2018).

1.2Caste : Caste refers to hierarchical position of respondent based on the endogamous and heredity sub division. The respondents were asked to indicate their caste at the time of enquiry. The respondents were grouped in four categories according to their caste as general caste, other backward caste, Scheduled caste and Scheduled tribe on the basis of selected respondents.

Data given in Table-1.2 revealed that majority of students of master level (44.04%) and Ph.D. level (37.25%) belonged to the Other Backward Caste (OBC) followed by 22.94 per cent master level students in the category of General caste and 23.53 per cent Ph.D. level students belonged to SC caste.

While 21.10 per cent master level students observed in Scheduled caste and 21.57 per cent Ph.D. level students belonged to General caste category. Likewise, 11.93 per cent and 7.84 per cent were belonged to Scheduled tribe in master' level and Ph.D. students, respectively.

Further analysis of data in table show that most of the master level students of COA, Bikaner, CCS, Bikaner, IABM, Bikaner and CVAS, Bikaner i.e. 45.45, 50.00, 44.00 and 31.18 per cent students of master level were from OBC category, respectively. Similarly 48.39, 40.00, 50.00 and 40.91 per cent Ph.D. level students also reported under OBC category from COA, Bikaner, CCS, Bikaner, IABM, Bikaner and CVAS, Bikaner, respectively. The representations of Scheduled Caste category of students were not more than 25.00 per cent in all colleges at master' level and Ph.D. level students. While, 12.12, 12.00 and 13.64 per cent master level students of COA, Bikaner, IABM, Bikaner and CVAS, Bikaner belonged to Scheduled Tribe category, respectively. Only 9.68, and 13.64 per cent Ph.D. level students of COA, Bikaner, and CVAS, Bikaner, respectively belonged to Scheduled Tribe category, respectively.

The results were in conformity with the finding of Bhatt (2019) who revealed that majority of students belonged to other backward class.

1.1 Locality address: Rural/Urban : Locality address means the place where a person actually lives and provides child care. On the basis of residence they are classified as rural and urban areas.

Table-1.3 revealed that majority of master level students of COA, Bikaner, CCS, Bikaner, IABM, Bikaner and CVAS, Bikaner i.e. 57.58, 75.00, 58.00 and 63.64 per cent were from rural areas, respectively. Whereas, 58.06, 60.00, 50.00 and 63.64 per cent, Ph.D. students were belonged to rural background, respectively.

Similarly, 42.42, 25.00, 42.00 and 36.36 per cent,

master' students and 41.94, 40.00, 50.00 and 36.36 per cent, Ph.D. students of COA, Bikaner, CCS, Bikaner, IABM, Bikaner and CVAS, Bikaner, were from urban background, respectively.

Table further shows that most of the master and Ph.D. level students belonged to rural background, while remaining master level students (40.37%) and Ph.D. level students (41.18%) belonged to urban background. It might be due to the fact that majority of students from rural areas and they have more interest in agriculture as compared to urban area.

The results are in line with the results of Doddamani (2020) who found that majority of students (66.67%) belonged to rural area and rest of the students belonged to urban areas (33.33%).

1.2 Marital status : The overall data regarding marital status show that majority of master level students (77.06%) and Ph.D. level students (62.75%) were unmarried, whereas 22.94 per cent master level students and 37.25 per cent Ph.D. scholars were married.

Analysis of data in the Table-1.4: depicts that most of the master level students of COA, Bikaner, CCS, Bikaner, IABM, Bikaner and CVAS, Bikaner having 75.76, 75.00, 78.00 and 77.27 per cent were unmarried, respectively. Likewise, 64.52, 60.00, 75.00 and 63.64 per cent Ph.D. students were also unmarried, respectively. Whereas 24.24, 25.00, 22.00 and 22.73 per cent master level students and 35.48, 40.00, 25.00 and 36.36 per cent Ph.D. level students of COA Bikaner, CCS Bikaner, IABM Bikaner and CVAS Bikaner were married, respectively.

The similar findings of Orifah *et al.* (2017) found that majority of students (85.70%) were unmarried and remaining students were married (14.70%). Prema and Kalpana (2020) also reported that majority of respondents (74.00 %) were unmarried and remaining were married.

1.1 Type of family : Family is the basic unit of society that is includes closely blood relation. Basically two type of family i.e. nuclear and joint family are present in the society. The overall distribution of data reveal that most of master students (63.30 %) and Ph.D. students (70.59%) were from nuclear family whereas, 36.70 per cent master level and 29.41 per cent Ph.D. students were belongs to joint family.

It is evident that the majority of COA, Bikaner, CCS, Bikaner, IABM, Bikaner and CVAS, Bikaner master level students (57.58, 50.00, 68.00 and 63.64 per cent) and 70.97, 80.00, 75.00 and 63.64 per cent Ph.D. students were from nuclear family, respectively. Whereas, 42.42, 50.00, 32.00 and 36.36 per cent master level students and 29.00, 20.00, 25.00 and 36.36 per cent Ph.D. students of

Table-1.1 : Distribution of post graduate students based on their age.

S. No.	Age	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Less than 23 years	4 12.12 %	0	2 50.00%	0	7 14.00%	0	5 22.73%	0	18 16.51%	0
2.	23-25 years	23 69.70 %	10 32.26%	2 50.00%	2 40.00%	33 66.00%	1 25.00%	14 63.64%	1 9.09%	72 66.06%	14 27.45%
3.	Above 25 years	6 18.18 %	21 67.74%	0	3 60.00%	10 20.00%	3 75.00%	3 13.64%	10 90.91%	19 17.43%	37 72.55%

This table indicates the frequency and percentage.

Table-1.2 : Distribution of post graduate students based on their caste.

S. No.	Caste	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	General	6 18.18%	6 19.35%	1 25.00%	2 40.00%	13 26.00%	1 25.00%	5 22.73%	5 22.73%	25 22.94 %	11 21.57%
2.	OBC	15 45.45%	15 48.39%	2 50.00%	2 40.00%	22 44.00%	2 50.00%	7 31.18%	9 40.91%	48 44.04%	24 37.25%
3.	ST	4 12.12%	3 9.68%	0	0	6 12.00%	0	3 13.64%	3 13.64%	13 11.93%	4 7.84%
4.	SC	8 24.24%	7 22.58%	1 25.00%	1 20.00%	9 18.00%	1 25.00%	4 18.18%	5 22.73%	23 21.10%	12 23.53%

Table-1.3 : Classification of post graduate students based on Locality Address.

S. No.	Locality Address	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Rural	19 57.58%	18 58.06%	3 75.00%	3 60.00%	29 58.00%	2 50.00%	14 63.64%	7 63.64%	65 59.63%	30 58.82%
2.	Urban	14 42.42%	13 41.94%	1 25.00%	2 40.00%	21 42.00%	2 50.00%	8 36.36%	4 36.36%	44 40.37%	21 41.18%

This table indicates the frequency and percentage

Table-1.4 : Classification of post graduate students based on marital status.

S. No.	Marital status	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Unmarried	25 75.76%	20 64.52%	3 75.00%	3 60.00%	39 78.00%	3 75.00%	17 77.27%	7 63.64%	84 77.06%	32 62.75%
2.	Married	8 24.24%	11 35.48%	1 25.00%	2 40.00%	11 22.00%	1 25.00%	5 22.73%	4 36.36%	25 22.94%	19 37.25%

This table indicates the frequency and percentage.

COA, CCS, IABM and CVAS, Bikaner were from joint family, respectively.

The findings are similar with the findings of Choudhary (2016) who found that 53.90 per cent of respondents were from nuclear family and 46.10 per cent were from joint family. Doddamani (2020) also found that majority of students (59.16%) were from nuclear family

1.2 Family size : On the basis of their family size respondents were classified into three categories i.e. Small (up to 5 members), medium (6-14 members) and large family size (above 15 members)

Table-1.6 shows that the overall 55.96 per cent masters level and 50.98 per cent Ph.D. level students

Table-1.5 : Categorization of postgraduate students based on their family type.

S. No.	Family type	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Nuclear/Single	19	22	2	4	34	3	14	7	69	36
		57.58%	70.97%	50.00%	80.00%	68.00%	75.00%	63.64%	63.64%	63.30%	70.59%
2.	Joint	14	9	2	1	16	1	8	4	40	15
		42.42%	29.03	50.00%	20.00%	32.00%	25.00%	36.36%	36.36%	36.70%	29.41%

This table indicates the frequency and percentage

Table-1.6 : Distribution of the respondents on the basis of family size.

S. No.	Family size	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Small (up to 5 members)	20	15	2	2	26	2	13	7	61	26
		60.61%	48.39%	50.00%	40.00%	52.00%	50.00%	59.09%	63.64%	55.96%	50.98%
2.	Medium (6-14)	10	11	2	3	21	2	8	3	41	19
		30.30%	35.48%	50.00%	60.00%	42.00%	50.00%	36.36%	27.27%	37.61%	37.25%
3.	Large (>15)	3	5	0	0	3	0	1	1	7	6
		9.09%	16.13%			6.00%		4.55%	9.09%	6.42%	11.76%

This table indicates the frequency and percentage

Table-1.7 : Distribution of postgraduate students on the basis of their annual family income.

S. No.	Income group	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Low (< Rs. 1.90 Lakh)	10	4	1	1	13	1	6	2	30	8
		30.30%	12.90%	25.00%	20.00%	26.00%	25.00%	27.27%	18.18%	27.52%	15.69%
2.	Medium (Rs. 1.90 Lakh to Rs. 3.14 Lakh)	13	10	1	1	17	1	6	4	37	16
		39.39%	32.26%	25.00%	20.00%	34.00%	25.0%	27.27%	36.36%	33.94%	31.37%
3.	High (>Rs.3.14Lakh)	10	17	2	3	20	2	10	5	42	27
		30.30%	54.84%	50.00%	60.00%	40.00%	50.00%	45.45%	45.45%	38.53%	52.94%

Mean-2.51, SD-0.62

Table-1.8 : Distribution of the respondents on the basis of Family Occupation.

S.No.	Family Occupation	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Agriculture	37	25	4	5	56	3	18	10	115	43
		35.58%	21.17%	22.22%	25.00%	28.00%	18.75%	20.45%	23.81%	26.26%	22.28%
2.	Services	22	27	4	5	50	5	18	12	94	49
		21.15%	23.48%	22.22%	25.00%	25.00%	27.78%	20.45%	28.57%	21.96%	25.39%
3.	Business	15	20	2	3	30	3	15	10	62	36
		14.42%	17.39%	11.11%	15.00%	15.00%	16.67%	17.05%	23.81%	14.49%	18.65%
4.	Labour	7	8	0	0	10	0	2	0	19	8
		6.73%	6.96%			5.00%		2.27%		4.04%	4.15%

belonged to the small family, 37.61 percent master level and 37.25 per cent Ph.D. level students belongs to medium size family and rest of the master level and Ph.D. level students i.e. 6.42 per cent and 11.76 per cent belongs to the large size family category.

It is evident that the majority of master level students 60.61, 50.00, 52.00, and 59.09 per cent and Ph.D. level students 48.39, 40.00, 50.00 and 63.64 per cent belong to

small family while, 30.30, 50.00, 42.00 and 27.27 per cent master level students and 35.48, 60.00, 50.00 and 37.61 per cent Ph.D. level students belongs to the medium family size whereas, rest of master level and Ph.D. level students of all colleges belonged to large family.

1.1 Annual family income : To classify the students on the basis of annual family income, three categories were

Table-1.9 : Classification of postgraduate students on the basis of their job aspiration.

S. No.	Job aspiration	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Administrative	36.36 VI	35.48 VII	50.00 II	40.00 III	48.00 VI	50.00 IV	45.45 III	54.55 II	35.96 VII	36.01 VII
2.	Banking	48.48 III	58.06 II	50.00 II	60.00 II	56.00 IV	50.00 IV	36.36 IV	27.27 IV	47.71 VI	48.83 VI
3.	Entrepreneurship	36.36 VI	41.94 VI	75.00 I	60.00 II	48.00 VI	50.00 IV	54.55 II	54.55 II	53.48 IV	51.62 V
4.	Govt. Dept.	72.73 I	83.87 I	75.00 I	80.00 I	70.00 III	75.00 I	63.64 I	72.73 I	70.34 I	77.90 I
5.	Management/Private Companies	42.42 IV	48.39 V	75.00 I	80.00 I	80.00 I	75.00 I	36.36 IV	27.27 IV	58.45 III	57.66 III
6.	Teaching/Research	39.39 V	54.84 III	50.00 II	60.00 II	76.00 II	75.00 I	31.82 V	45.45 III	49.30 V	58.82 II
7.	Other jobs	54.55 II	51.61 IV	75.00 I	60.00 II	52.00 V	50.00 IV	63.64 I	54.55 II	61.30 II	54.04 IV

This table indicates the MPS.

Table-1.10 : Classification of respondents on the basis of preferred learning mode.

S. No.	Source/Method of instruction	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Books	90.91 I	74.19 I	75.00 I	80.00 I	92.00 I	75.00 I	54.55 IV	63.64 III	78.11 ?	73.21 ?
2.	Classroom interaction with teacher	57.58 IV	51.61 VI	75.00 ?	60.00 II	92.00 I	75.00 I	59.09 III	63.64 III	70.92 II	62.56 IV
3.	Online sources	57.58 IV	58.06 III	50.00 II	40.00 III	60.00 III	50.00 II	68.18 II	54.55 IV	58.94 V	50.65 VII
4.	Journal/ magazine	36.36 VI	38.71 VII	50.00 II	60.00 II	54.00 V	75.00 I	54.55 IV	63.64 III	48.73 VI	59.34 V
5.	Practical application	63.64 III	70.97 II	75.00 I	80.00 I	56.00 IV	50.00 II	81.82 I	72.73 II	69.11 III	68.42 II
6.	Library	63.64 II	58.06 III	75.00 I	80.00 I	76.00 II	50.00 II	54.55 IV	81.82 I	67.30 IV	67.47 III
7.	Any others	30.30 VII	54.84 V	50.00 II	60.00 II	32.00 VI	50.00 II	59.09 III	63.64 III	42.85 VII	57.12 VI

This table indicates the MPS.

formulated on the basis of mean and SD i.e. less than Rs.1.90 Lakh per annum, Rs. 1.90 Lakh to Rs.3.14 Lakh per annum and above Rs.3.14 Lakh per annum.

The overall data regarding annual family income presented that 38.53 per cent of the master level and 52.94 per cent of the Ph.D. level students were from higher family income group i.e. Above Rs.3.14 Lakh followed by 33.94per cent and 31.37per cent of master level and Ph.D. level students having income between Rs. 1.90 Lakh to Rs.3.14 Lakh per annum, respectively whereas, only 27.52per cent master level and 15.69per cent Ph.D. level students having annual family income below Rs. 1.90 Lakh.

Table-1.7 depicts that most of the students of COA, CCS, IABM, and CVAS, Bikaner i.e. 45.45, 75.00, 62.00, 63.64 per cent master level and 54.58, 60.00, 75.00,

72.73 per cent Ph.D. students had above Rs.3.14 Lakh family income, respectively likewise, 39.39, 25.00, 38.00, 27.27 per cent of master level and 32.26, 50.00, 25.00, 27.27 per cent of Ph.D. level students had 1.90 Lakh to Rs.3.14 Lakh family income, respectively whereas, only 15.15, 9.09 per cent of master level students of COA, and CVAS, Bikaner and 12.90 per cent of Ph.D. level students of COA, Bikaner had less than Rs.1.90 Lakh family income.

Similar findings reported by Kumar (2018).

1.2 Family Occupation : On the basis of their family occupation respondents were classified in to four categories i.e. agriculture, service, business, and labour.

Table-1.8 reveals that Agriculture was main family occupation of the 26.26 per cent master level students,

Table-1.11 : Classification of respondents on the basis of Use of communication media.

S. No.	Use of communication media	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Mobile phone	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I
2.	T.V./ L.C.D	9.09 IX	16.13 IX	25.00 IV	40.00 IV	18.00 VIII	25.00 IV	9.09 IX	9.09 VII	19.72 VIII	22.55 VIII
3.	Agricultural journals	45.45 V	58.06 VI	50.00 III	60.00 V	50.00 V	75.00 II	54.55 VI	54.55 IV	50.00 VI	61.90 VI
4.	Agriculture magazine	36.36 VI	64.52 V	75.00 II	80.00 II	34.00 VII	75.00 II	63.64 V	72.73 III	52.25 V	73.06 IV
5.	Agriculture books	96.97 II	96.77 II	100.00 I	80.00 II	98.00 II	100.00 I	72.73 III	100.00 I	91.92 II	94.19 II
6.	Laptop	54.55 IV	80.65 III	75.00 II	80.00 II	78.00 III	100.00 I	90.91 II	81.82 II	74.61 III	85.62 III
7.	Internet	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I	100.00 I
8.	News paper	72.73 III	74.19 IV	50.00 III	60.00 III	68.00 IV	75.00 II	68.18 IV	72.73 III	64.73 IV	70.48 V
9.	Tablet	15.15 VIII	22.58 VIII	25.00 IV	20.00 V	16.00 IX	25.00 IV	22.73 VIII	18.18 VI	15.39 IX	21.44 IX
10.	Desktop	30.30 VII	48.39 VII	50.00 III	40.00 IV	40.00 VI	50.00 III	27.27 VII	36.36 V	36.89 VII	43.69 VII

Table-1.12 : Classification of respondents on the basis of Extension contact.

S.No.	Name of the information source	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
A. Formal sources											
1.	AO/AAO	65.91 V	75.00 II	75.00 II	80.00 II	80.00 II	75.00 II	81.82 II	81.82 II	75.68 III	77.95 II
2.	Agri. College/University	92.42 I	93.55 I	93.75 I	85.00 I	86.50 I	93.75 I	86.36 I	84.09 I	89.76 I	89.10 I
3.	KVKs	68.18 III	68.55 III	62.50 IV	60.00 V	67.50 V	75.00 II	70.45 III	72.73 III	67.16 V	69.07 IV
4.	Agri. scientists	76.52 II	75.00 II	75.00 II	70.00 III	79.00 III	75.00 II	82.95 II	56.82 V	78.37 II	69.20 III
5.	Agri. Supervisor	67.42 IV	68.55 III	68.75 III	65.00 IV	70.50 IV	68.75 III	70.45 III	50.00 VII	69.28 IV	63.07 V
6.	VDO	55.30 VI	51.61 IV	50.00 V	55.00 VI	48.00 VI	56.25 IV	61.36 IV	70.45 V	53.67 VI	58.33 VI
7.	BDO	36.36 VII	34.68 V	50.00 V	45.00 VII	48.00 VI	43.75 V	59.09 V	52.27 VI	48.36 VII	43.93 VII
B. Informal sources											
1.	Family members	90.91 I	89.52 I	81.25 I	80.00 I	89.00 I	81.25 II	82.95 I	81.82 I	86.03 I	83.15 II
2.	Neighbours'	70.45 III	72.58 III	68.75 II	65.00 II	59.00 III	75.00 III	59.09 III	56.82 II	64.32 III	67.35 III
3.	Friends	84.85 II	86.29 II	81.25 I	80.00 I	81.00 II	93.75 I	79.55 II	81.82 I	81.66 II	85.46 I
4.	Relatives	57.58 IV	61.29 IV	62.50 III	60.00 III	58.00 IV	56.25 IV	57.95 IV	56.82 II	59.01 IV	58.59 IV
5.	Local leaders	45.45 VI	46.77 VI	43.75 V	45.00 V	52.00 V	50.00 V	51.14 VI	56.82 II	48.09 VI	49.65 VI
6.	Progressive farmers	48.48 V	53.23 V	50.00 IV	50.00 IV	46.00 VI	50.00 V	53.41 V	56.82 II	49.47 V	52.51 V

Table-1.13 : Distribution of respondents on the basis of possession of ICT tools/devices.

S.No.	ICT tools/ Devices	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Mobile phones	33 100.00%	31 100.00%	4 100.00%	5 100.00%	50 100.00%	4 100.00%	22 100.00%	11 100.00%	109 100.00%	51 100.00%
2.	Laptop	18 54.55%	25 80.65%	3 75.00%	4 80.00%	39 78.00%	4 100.00%	20 90.90%	11 100.00%	80 73.39%	44 86.27%
3.	iPhone	2 6.06%	4 12.90%	0	1 20.00%	4 20.00%	1 25.00%	2 9.09%	2 18.18%	8 7.33%	8 15.68%
4.	Tablet	5 15.15%	7 22.58%	1 25.00%	1 20.00%	8 16.00%	1 25.00%	5 22.73%	2 18.18%	19 17.43%	11 21.57%
5.	Desktop	12 36.36%	13 41.34%	2 50.00%	2 20.00%	20 40.00%	2 50.00%	6 27.27%	4 36.36%	40 36.70%	21 41.18%

Table-1.14 : Distribution of the respondents on the basis of scientific orientation.

S.No.	Categories	COA Bikaner (n ₁ =64)		CCS Bikaner (n ₂ =9)		IABM Bikaner (n ₃ =54)		CVAS Bikaner (n ₄ =33)		Total (N=160)	
		Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level	Master level	Ph.D. level
1.	Low (up to 41.71)	5 15.15%	1 3.23%	3 75.00%	0	11 22.00%	1 25.00%	1 4.55%	2 18.18%	20 18.35%	4 7.84%
2.	Medium (41.71 to 47.31)	25 75.76%	25 80.65%	0	4 80.00%	34 68.00%	3 75.00%	18 81.82%	9 81.82%	77 70.64%	41 80.39%
3.	High (above 47.31)	3 9.09%	5 16.13%	1 25.00%	1 20.00%	5 10.00%	0	3 13.64%	0	12 11.01%	6 11.76%

Mean=44.51, SD=2.8

whereas 25.39 per cent Ph.D. level students reported that main occupation of their family was service. Likewise service by 21.96 per cent master level students. Ph.D. students, 22.28 per cent respondents agriculture as main occupation. Business is the third main occupation in master level and Ph.D. Students as reported by 14.49 and 18.65 per cent, respectively and least number of master level (4.04%) and Ph.D. students (4.15%) family occupation is labour.

Similar pattern follow in COA, Bikaner, main occupation of the 35.58 per cent master level students family main occupation is agriculture, and 21.17 per cent Ph.D. students family main occupation is service. In CCS, Bikaner main occupation of the 22.22 per cent master level students and 25.00 per cent Ph.D. students' family is agriculture, and service, respectively. Among the IABM, Bikaner, 28.00 per cent master students main occupation of the Family was agriculture and 27.78 per cent Ph.D. students family main occupation is service. Likewise, CVAS, Bikaner, 20.45 per cent master's students' main occupation of the Family was agriculture and service. Among 28.57 per cent Ph.D. level students family main occupation is service Labour is the least occupation of the all master level and Ph.D. level students, respectively.

1.3 Job aspiration : Data present in Table-1.9 indicate MPS and multiple responses were collected from all selected students.

Majority of master level and Ph.D. level students first choice to pursue Government department service with overall MPS 70.34 and 77.90, respectively. Similar pattern followed in COA, CCS, IABM and CVAS, Bikaner with MPS 72.73, 75.00, 70.00, 63.64 and 83.87, 80.00, 75.00, and 72.73. Whereas master level students preferred to join other sector and Ph.D. level students of COA, CCS, IABM and CVAS, Bikaner preferred to join Teaching/ Research services with the MPS 54.55, 75.00, 52.00, 63.64 and 54.84, 60.00, 75.00, 45.45 ranked second, respectively.

From the above data it can be concluded that there was no uniformity in job aspiration of the students, students wants to secure job security in one or more field based on their interest, priorities and motivation.

Analysis of Table-1.9 further reported that the management, entrepreneurship, teaching/research, banking or administrative job were considered as important by the master level students with overall MPS 58.45, 53.48, 49.30, 47.71 and 35.96, respectively. Whereas, the Ph.D. students prefer management, other jobs, entrepreneurship, banking, and administrative services with overall MPS 57.66, 54.04, 51.62, 48.83 and 36.01, respectively.

Separate data of each college depicts that in case of COA, Bikaner students wanted to choose their career in

banking sector followed by CCS, IABM and CVAS, Bikaner who less preferred Entrepreneurship.

1.1 Preferred learning mode : Table-1.10 clearly shows that students didn't rely on one single approach for learning. The majority of the master level and Ph.D. level students with MPS 78.11 and 73.21 respectively preferred firstly books for learning, whereas with MPS 42.85, 50.65 master level and Ph.D. students, referred any other and online sources for gaining knowledge, respectively.

Similar pattern followed in COA, CCS, IABM and CVAS, Bikaner with MPS 57.58, 75.00, 92.00, 59.09 were ranked 2nd in master students and 70.97, 80.00, 50.00, and 72.73 were ranked 2nd in Ph.D. students to preferred classroom interaction with teacher to for practical application for learning, respectively.

Table further shows that the practical application, Library, Online sources, Journal/ magazine or Any others were considered as wanted to preferred by the master students with overall MPS 69.11, 67.30, 58.94, 48.73, and 42.85 similarly, preferred by the Ph.D. level students to the library, classroom interaction with teacher, Journal/ magazine, Any others, and online sources with overall MPS 67.47, 62.56, 59.34 and 57.12, respectively.

Table-1.10 further shows that taking the frequent awareness programmes should be organized for the users to educate them about e-learning or social media. Social media can also be an effective medium for learning because it can provide a good platform for discussion.

1.2 Use of communication media : Table-1.11 indicates that the all master level and Ph.D. level students were possessed mobile phone, Internet and preferred it on priority to get information. Other communication media being used by students in descending order were agriculture books with MPS 91.92 and 94.19, Laptop with MPS 74.61 and 85.62 and ranked second and third, respectively on master level and Ph.D. level students, use of tablet ranked last with MPS 15.30 and 21.44 respectively by master level and Ph.D. level students.

Explain that all students were using mobile phone for Internet. Similar pattern followed in COA, CCS, IABM and CVAS, Bikaner with MPS 96.97, 100.00, 98.00 and 72.73 in master level and 96.77, 80.00, 100.00, and 100.00 MPS in Ph.D. level students ranked third in master level and Ph.D. level students regarding using agricultural books.

Table-1.11 shows that the Laptop, Newspaper, agricultural magazine, agriculture journal, and Desktop, or T.V/L.C.D, Tablet were considered as wanted to using for learning by the master level students with MPS 74.61, 64.37, 52.25, 50.90, 36.89, 19.72 and 15.30. Whereas, Ph.D. level students wanted to use for learning the

Laptop, agriculture magazine, Newspaper, agriculture Journals, Desktop, T.V/L.C.D. and Tablet with MPS 85.62, 73.06, 70.48, 61.90, 43.69, 22.55, and 21.44, respectively.

Thus, it can be inferred that mobile phone, Internet and agriculture books were main sources for getting information and recreation purpose.

1.1 Extension contact : The Table-1.12 shows the extent of contact of respondents with different information sources used by them for the information's as well as academics purposes. The information sources were categories namely, formal sources, Informal sources, to find out the extent of contact of students.

In case of formal sources, the master level and Ph.D. level students with MPS 89.76, 89.10 and assigned rank first to agricultural college/university formal extension contact, and followed by master students with MPS 78.37 and was ranked second to agriculture scientists, while, 77.95 MPS and ranked second to AO/AAO formal extension contact by Ph.D. level students, Respectively.

In case of informal sources, the master level students with MPS 86.03 and was ranked first to family members informal extension contacts, and in Ph.D. students with MPS 85.46 and ranked 1st to friends. Followed by master' level students MPS 81.66 and was ranked second to Friends, while with MPS 83.15 and ranked second to family member's informal extension contacts by Ph.D. students respectively.

Explain that the majority of the formal sources, agri. College/University with MPS 89.76 and 89.10 and was ranked first, master and Ph.D. students were observed. Similar pattern followed in COA, Bikaner, CCS, IABM and CVAS, Bikaner with MPS 78.37 among master level students to Agriculture scientists, and with MPS 77.95 among Ph.D. students to AO/AAO formal extension contacts was ranked 2nd. The table shows that the least formal contact of the master level students with MPS 67.16 and followed by formal contact of Ph.D. students with Agriculture supervisor MPS 63.07 was ranked 5th.

So far as informal sources like family members with MPS 86.03 ranked 1st in using informal contact and in case of Ph.D. student's friend's informal extension contact MPS 85.46 ranked 1st.

Similar pattern followed in COA, CCS, IABM and CVAS, Bikaner with MPS 81.66 master students with Friends, and with MPS 83.15 Ph.D. students with Family members informal extension contacts was ranked 2nd, as well as in master level and Ph.D. level students last rank 6th observed in informal contact with 48.09 and 49.65 MPS, respectively.

1.1 Possession of ICT tools/ devices : It is clear from the data that vast majority of the master level and Ph.D. level students preferably possessed Mobile phone is the first ICTs tool and Laptop is the second ICTs tool possessed by the 73.39 per cent master level and 86.27 per cent Ph.D. level students. While, Very few students i.e. 7.33 and 15.68 per cent possessed iPhone by master level and Ph.D. level students, respectively.

The similar pattern followed in COA, CCS, IABM and CVAS, Bikaner mobile phone is the preferred firstly used ICTs tools possessed by the all master level and Ph.D. level students, and iphone was less possessed ICT tool by the all students.

It can be found that possession of Mobile phone and laptop was highest among the students which indicate that Mobile phone and laptop have become basic need of the students rather than luxury items. This showed that students are gradually becoming digitally advance. It can also be noted that portable and handy feature of the laptop had replaced the desktop gradually. High cost of quality iPhone might be the reason behind its low possession rate.

1.2 Scientific orientation : The overall data regarding scientific orientation in the Table-1.14 that 70.64 per cent master level and 80.39 per cent Ph.D. level students were found medium level of scientific orientation, while 18.35 per cent and 11.01 per cent master level students in low level and high level, respectively. Similarly, 11.76 per cent and 7.84 per cent Ph.D. students in high level and low level, respectively.

Major Findings of the Present Study :

Personal profiles of the student's : The overall data regarding age showed that most of the students (66.06 %) in master level were in 23 to 25 years age category followed by 17.43 per cent students was in above 25 years age category and 16.51 per cent students were in below 23 years age category.

Revealed that majority of students of master level (44.04%) and Ph.D. level students (37.25%) belonged to the Other Backward Caste (OBC) followed by 22.94 per cent master level students in the category of General caste and 23.53 per cent Ph.D. level students belonged to SC caste. While 21.10 per cent master level students observed in SC caste and 21.57 per cent Ph.D. level students belonged to General caste.

Most of the master level and Ph.D. level students (59.63%) and (40.37%) belonged to rural background and remaining master level and Ph.D. level students (40.37 %), (41.18 %) belonged to urban background.

The overall data regarding marital status shows that

majority of master (77.06%), Ph.D. students (62.75%) were unmarried, whereas master level students 22.93 per cent and 32.25 per cent Ph.D. scholars' were married.

The overall distribution of data shows that most of master (63.30 %) and Ph.D. students 70.59 per cent were from nuclear family and 36.70 per cent and 29.41 per cent master level and Ph.D. students were from joint family.

The overall 55.96 per cent masters level and 50.98 per cent Ph.D. level students belonged to the small family, 37.61 percent master level and 37.25 per cent Ph.D. level students belongs to medium size family and rest of the master level and Ph.D. level students i.e. 6.42 per cent and 11.76 per cent belongs to the large size family category.

The overall data regarding annual family income that 38.53 per cent of the master level and 52.94 per cent of the Ph.D. level students were from higher family income group ie. Above Rs.3.14 Lakh followed by 33.94 per cent and 31.37 per cent of master level and Ph.D. level students having income between Rs. 1.90 Lakh to Rs. 3.14 Lakh per annum, respectively, whereas, only 27.52 per cent master level and 15.69 per cent Ph.D. level students having annual family income below Rs. 1.90 Lakh.

Results further revealed that that Agriculture was main family occupation of the 26.26 per cent master students, 26.26, whereas 25.39 per cent Ph.D. students, reported that the main occupation of family is service. Followed by service by 21.96 per cent master students and in case of Ph.D. students 22.28 per cent respondents Agriculture as main occupation, Business is the third main occupation in master 4.04 per cent as well as Ph.D. Students' family, respectively and least number of master level and Ph.D. students 4.15 per cent family occupation is labour.

The maximum number of master level and Ph.D. level student's choice to pursue Government department service with overall MPS 70.34 and 77.90. Whereas master level students preferred to join other sector and Ph.D. level students preferred to join Teaching/ Research services with the MPS 54.55, 75.00, 52.00, 63.64 and 54.84, 60.00, 75.00, 45.45 ranked second.

The majority of the master level and Ph.D. level students with 78.11, 73.21 MPS respectively preferred firstly books for learning, whereas with MPS 42.85, 50.65 master level and Ph.D. students referred any other and online sources for gaining knowledge, respectively.

Majority of master level and Ph.D. level students were possessed mobile phone, Internet to get information with 100 MPS. The other communication media being used by students in descending order agriculture books

with MPS 91.92 and 94.19, Laptop with MPS 74.61 and 85.62 and ranked second and third respectively on master and Ph.D. level students, Tablet ranked forth with 15.30 and 21.44 respectively by master and Ph.D. level students. The extent of contact of respondents with different information sources as used by them for the informations as well as academics purposes. The information sources were categories namely, formal sources, Informal sources, to find out the extent of contact of students. In case of formal sources, the master level and Ph.D. level students with MPS 89.76, 89.10 and assigned rank first to Agricultural college/university formal extension contact, and followed by master students with MPS 78.37 and was ranked second to Agriculture scientists, while, 77.95 MPS and ranked second to AO/AAO formal extension contact by Ph.D. level students, respectively.

In case of informal sources, the master level students with MPS 86.03 and was ranked first to Family member's informal extension contacts, and in Ph.D. students with MPS 85.46 and ranked 1st to Friends. Followed by master' level students 81.66 mean per score and was ranked second to Friends, while with MPS 83.15 and ranked second to Family member's informal extension contacts by Ph.D. students, respectively.

The vast majority (100 %) master level and Ph.D. level students possessed Mobile phone is the first and Laptop is the second ICTs tool possessed by the 73.39 per cent master level and 86.27 per cent Ph.D. level students. While, Very few students i.e. 7.33 and 15.68 per cent possessed iPhone among master level and Ph.D. level students, respectively.

The majority of 70.64 per cent master level and 80.39 per cent Ph.D. level students were found had medium level (41.71 to 47.31) of scientific orientation, while (18.35%), low level of master level students and (11.76 %) high level observed by Ph.D. students, and high level (11.01%) and low level (7.84%), least amount of master level and Ph.D. level students were found in the scientific orientation, respectively.

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Investigation on Genetic Variability, Correlation and Path Coefficient in Fennel (*Foeniculum vulgare* Mill) Germplasm

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Abstract

Fifteen genotypes were used to studies the genetic variability, heritability, genetic advance, correlation and path coefficient for growth and yield attributing characters in fennel. The highest PCV and GCV were recorded in seed yield per plant, number of secondary branches per plant and number of primary branches per plant. The highest heritability was noticed for seed yield per plant, number of umbelles per plant and number of secondary branches per plant. Plant height, days to 50% flowering and days to first flowering exhibited highest genetic advance as percentage of mean. The seed yield per plant had significant and positive correlation with number of number of secondary branches per plant, plant height, number of umbellates per umbel and test weight. Number of secondary branches per plant, days to 50% flowering, test weight and number of umbellates per umbel had direct effect on seed yield per plant. Therefore, greater emphasis should be given on these characters for genetic improvement of fennel.

Key words : Genetic variability, genotypic and phenotypic correlation coefficient, path coefficient, fennel and seed yield.

Introduction

Fennel (*Foeniculum vulgare* Mill) belonging to family Apiaceae, is a cross pollinated crop and a diploid species with chromosome number, $2n = 22$. It is native of Europe and Meditanean region (Agarwal *et al*, 2001). Fennel is an annual, aromatic herb of 100-180 cm height. Mature fennel fruits and essential oil are used as flavouring agents in food products such a liqueurs, bread, pickles, pastries, and cheese (Zoubiri *et al*. 2014). Fennel is cultivated throughout the temperate and subtropical region in the world mainly in the countries like, Romania, Russia, Hungary, Germany, France, Italy, India, Sri Lanka, Malaysia, Japan, Argentina and USA. In India, it is mainly grown in the states of Gujarat and Rajasthan and to some extent in U.P., Karnataka, A.P., Punjab, M.P., Bihar, Haryana and J & K. Total area under the crop in India is about 94070 hectares with production of 135930 tonnes. Fennel is a cross pollinated crop with high heterozygosity prevailing in the natural population. Genetic variability is prerequisite for any crop improvement in a crop. The survey of genetic variability with the help of suitable genetic parameters like genotypic and phenotypic coefficients of variations, heritability estimates and genetic advance as percentage of mean are indispensable in breeding programmes aimed at improvement of seed yield. The heritability measures the contribution of genetic variability to the total variability i.e. phenotypic variability observed for any quantative trait. The estimated heritability can be utilized for the estimation of genetic gain expected for the selection of top 5 per cent individuals. Such studied enable the breeders to have a maximum

selection response of the variance exhibited by population which is largely due to additive gene effects.

Materials and Methods

The experimental materials are consisting of fifteen genotypes of fennel and evaluated at Vegetable Research Farm, Maharajpur, Department of Horticulture, JNKVV, Jabalpur during 2017- 2018. The collected genotypes were sown in Randomized Complete Block design with three replications, whereas, the row to row and plant to plant distance was 30 and 10 cm respectively. Standard techniques were adopted in data collection from five selected plants from each genotypes for nine characters viz. plant height, number of primary branches per plant, number of secondary branches per plant, days to first flower initiation, days to 50% flowering , number of umbels per plant, number of umbellets per plant, test weight and seed yield per plant.

Coefficient of variation, heritability and genetic advance were estimated as formula given by Panse and Sukhatme (1976).The genotypic and phenotypic correlation coefficients were calculated as the formula by Miller *et al*. (1958) and path analysis on basis of method by Fisher and Yates (1963).

Results and Discussion

The analysis of variance revealed significant differences among the germplasms for most of the characters. The phenotypic coefficient of variance (PCV) was higher than genotypic coefficient of variance (GCV) for all the characters.

Table-1 : Estimates of genetic parameters of variations for various characters in Fennel.

Characters	Grand Mean	Range Min.	Coefficient of variations			Heritability % (BS)	Genetic Advance	GA as % of mean
			Max.	Phenotypic	Genotypic			
Plant height (cm)	166.03	141.45	182.68	8.38	7.67	83.80	24.02	14.47
No. of primary branches plant ⁻¹	6.74	5.31	8.54	15.12	13.62	81.09	1.70	25.24
No. of secondary branches plant ⁻¹	17.12	10.68	21.32	17.26	16.37	90.01	5.48	32.01
Days to 1st flowering	90.16	82.67	97.67	5.60	5.06	81.53	8.48	9.41
Days to 50% flowering	113.31	105.67	121.67	4.74	4.18	77.88	8.61	7.60
No. of umbels plant ⁻¹	14.72	12.45	17.45	12.45	11.91	91.50	3.45	23.47
Number of umbellate umbel ⁻¹	20.10	15.46	25.43	14.82	12.72	73.62	4.52	22.48
Test weight (g)	5.22	4.40	6.01	9.86	8.30	70.85	0.75	14.39
Seed yield plant ⁻¹	6.08	2.54	10.73	45.62	43.70	91.77	5.24	86.19

Table-2 : Estimates of genotypic and phenotypic correlation coefficients among seed yield and its attributing traits in Fennel.

Characters		No. of primary branches plant ⁻¹	No. of secondary branches plant ⁻¹	Days to 1st flowering	Days to 50% flowering	No. of umbels plant ⁻¹	Number of umbellate umbel ⁻¹	Test weight (g)	Seed yield plant ⁻¹
Plant height (cm)	G	-0.045	0.898	-0.107	-0.513	-0.234	0.627	0.771	0.997
	P	0.044	0.851**	-0.105	-0.425**	-0.213	0.559**	0.413**	0.837**
No. of primary branches plant ⁻¹	G		0.115	0.320	0.078	-0.060	0.051	0.063	0.073
	P		0.067	0.222	-0.069	-0.046	0.095	0.067	0.041
No. of secondary branches plant ⁻¹	G			-0.089	-0.518	-0.254	0.572	0.476	0.964
	P			-0.043	-0.430**	-0.206	0.489**	0.319*	0.877**
Days to 1st flowering	G				0.651	0.351	-0.042	-0.085	-0.049
	P				0.517**	0.323*	-0.101	-0.064	-0.021
Days to 50% flowering	G					0.698	-0.583	-0.565	-0.532
	P					0.543**	-0.446**	-0.458**	-0.410**
No. of umbels plant ⁻¹	G						-0.289	-0.282	-0.319
	P						-0.233	-0.261	-0.305*
Number of umbellate umbel ⁻¹	G							0.597	0.634
	P							0.403**	0.534**
Test weight (g)	G								0.573
	P								0.465**

Significant at 5% level = *Significant at 1% level = **

The phenotypic coefficient of variation ranged between 4.75% (days to 50% flowering) to 45.62 % (seed yield per plant) (Table-1). The highest phenotypic coefficient of variations was recorded in seed yield per plant (45.60%), number of secondary branches per plant (17.26%) and number of primary branches per plant (15.12%) while it was lowest for days to 50% flowering (4.47%). Genotypic coefficient of variation of fennel genotypes varied from 4.18% (days to 50% flowering) to 43.70 % (seed yield per plant). The highest GCV was found in seed yield per plant (43.70%), number of secondary branches per plant (16.37%) and number of primary branches per plant (13.62%), however it was noticed low for days to 50% flowering (4.18%). The highest heritability was observed for seed yield per plant (91.77%), number of umbelles per plant (91.50%) and number of secondary branches per plant (90.01%), however it was lowest for test weight (70.85%). Plant

height (24.02), days to 50% flowering (8.61) and days to first flowering (8.48) exhibited highest genetic advance as percentage of mean.

The correlation coefficients were calculated at phenotypic and genotypic basis to assess the specific role of each character in determining yield. The seed yield per plant had significant and positive correlation with number of number of secondary branches per plant (0.877), plant height (0.837), number of umbellates per umbel (0.534) (Dashora and Sastry (2011) and test weight (0.465), while it was also found significant but negative correlated with days to 50% flowering (-0.410) and number of umbels per plant (-0.305). The results are in conformity with the findings of Lal (2007), Meena et al. (2010), Dashora and Sastry (2011) and Meena et al. (2013). Plant height was found significant correlated with seed yield per plant (0.837), number of secondary branches per plant (0.851), number of umbellates per umbel (0.559) and test

Table-3 : Genotypic and phenotypic path coefficients showing direct and indirect effects of different characters on seed yield plant⁻¹ (g) in Fennel.

Characters		Plant height (cm)	No. of primary branches plant ⁻¹	No. of secondary branches plant ⁻¹	Days to 1 st flowering	Days to 50% flowering	No. of umbels plant ⁻¹	Number of umbellate umbel ⁻¹	Test weight (g)	Seed yield plant ⁻¹
Plant height (cm)	G	-2.050	0.017	2.335	0.064	-0.798	0.127	0.207	1.095	0.997
	P	0.224	-0.002	0.534	-0.004	-0.048	0.031	0.033	0.069	0.837**
No. of primary branches plant ⁻¹	G	0.093	-0.385	0.298	-0.193	0.121	0.033	0.017	0.090	0.073
	P	0.010	-0.036	0.042	0.010	-0.008	0.007	0.006	0.011	0.041
No. of secondary branches plant ⁻¹	G	-1.841	-0.044	2.600	0.053	-0.806	0.137	0.189	0.676	0.964
	P	0.190	-0.002	0.628	-0.002	-0.049	0.030	0.029	0.054	0.877**
Days to 1st flowering	G	0.219	-0.124	-0.231	-0.601	1.014	-0.190	-0.014	-0.121	-0.049
	P	-0.023	-0.008	-0.027	0.043	0.059	-0.048	-0.006	-0.011	-0.021
Days to 50% flowering	G	1.051	-0.030	-1.345	-0.391	1.558	-0.378	-0.193	-0.803	-0.532
	P	-0.095	0.002	-0.270	0.022	0.114	-0.080	-0.026	-0.077	-0.410**
No. of umbels plant ⁻¹	G	0.480	0.023	-0.660	-0.211	1.087	-0.542	-0.095	-0.401	-0.319
	P	-0.048	0.002	-0.129	0.014	0.062	-0.148	-0.014	-0.044	-0.305*
No. of umbellate umbel ⁻¹	G	-1.285	-0.020	1.487	0.025	-0.908	0.156	0.331	0.848	0.634
	P	0.125	-0.003	0.307	-0.004	-0.051	0.034	0.058	0.068	0.534**
Test weight (g)	G	-1.581	-0.024	1.237	0.051	-0.881	0.153	0.197	1.420	0.573
	P	0.092	-0.002	0.200	-0.003	-0.052	0.039	0.024	0.168	0.465**

Residual effect Genotypic = 0.4092 Residual effect Phenotypic = 0.3

weight (0.413), while it was also found significant but negative correlated with days to 50% flowering (-0.425). Number of number of primary branches per plant had non-significant positive correlation with days to first flowering (0.222). Number of number of secondary branches per plant was found significant and positive correlation with seed yield per plant (0.877), number of umbellates per umbel (0.489) and test weight (0.319). Similar result correlated with Rohit et al. (2017), while it was also found significant but negative correlation with days to 50% flowering (-0.430). Days to first flowering had significant and positive correlation with days to 50% flowering (0.517) and number of umbels per plant (0.323). Days to 50% flowering was found positive correlation with number of umbels per plant (0.543), while it was significant but negative correlation with number of umbellates per umbel (-0.446) and test weight (-0.458). Number of umbels per plant had also recorded significant but negative correlated with seed yield per plant (-0.305). Number of umbellates per umbel was found significant and positively correlated with seed yield per plant (0.534) and test weight (0.403). Test weight was recorded significant and positively correlated with seed yield per plant (0.465).

Path coefficient analysis based on genotypic correlation coefficient was also carried out and following Fisher and Yates (1963). The results indicated that number of secondary branches per plant (2.600), days to 50% flowering (1.558), test weight (1.420) (Dashora, 2011) and number of umbellates per umbel (0.331) had direct effect on seed yield per plant. This finding is

correlated with Agnihotri et al. (1995). The direct effect of plant height (-0.2.050), number of primary branches per plant (-0.385), days to first flowering (-0.601) and number of umbels per plant (-0.542) was negative.

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Effects of Drought Stress on the Physiology and Yield of the Indian Wheat Germplasms

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Abstract

Drought stress is the most important factor and ever-growing problem limiting wheat (*Triticum aestivum* L.) productivity worldwide. Wheat has physiological mechanisms that enable them to adapt drought stress and this adaptation may vary among different genotypes. This study was performed to investigate the physiological responses in ten wheat genotypes under drought stress to identify drought tolerant genotypes. Stress was imposed by growing the genotypes under four irrigation treatments (T1-380 ml, T2-190 ml, T3-126 ml and T4-95 ml) with each fifteen days interval. The results revealed that electrolytes leakage was increased and other physiological characteristics such as turgidity, relative leaf water contents and plant yield were decreased during the increase in drought stress. The Tatara, ZAS-08, ZAS-42 and Ghaznavi-98 wheat genotypes exhibited the normal physiology and were considered as drought tolerant genotypes. The drought tolerant genotypes specified in this study will be grown in rain fed regions in order to improve the crop productivity and will be used in wheat breeding programs to produce a stress tolerant genotype.

Key words : *Triticum aestivum*, physiological characteristics, drought stress.

Introduction

Drought stress is one of the most important factors limiting plant growth and crops production worldwide more than any other biotic or abiotic stress [1, 2]. It is an ever-growing problem that harshly limits the crop production and result in important agricultural losses especially in arid and semiarid areas [3]. The response of plants to drought stress is very complicated and they manage stress through stress avoidance approaches that depends on genotype. Plants under stress try to maintain their metabolic and structural capacity to improve their potential under that vary stress through modified gene expression [4]. Wheat is the most important food crop cultivated throughout the world and is the major source of proteins and calories which are almost 72% is an average diet [5]. Although, breeders are working hard to improve wheat production, however increasing wheat production in drought environments has been more complex to achieve [6]. Presently, wheat is growing under diverse agro-climatic conditions in India and occupies the area around 29.8 m. ha. with a production about 95.6 m.t. and productivity of 3100 kg/ha. Wheat production and area in the year 2015-16 was 93.82 million metric tons and 31.53 million hectares respectively. (FAOSTAT 2015 www.faostat.org). Yield component and drought resistance are controlled at independent genetic loci, therefore the identification of physiological traits that are responsible for drought tolerance should be considered in the breeding programs [7]. Breeding efficiency can be improved if existing physiological and morphological characteristics associated with yield components under an environmental stress could be identified and used as selection criteria for

traditional plant breeding [8]. According to the previous literatures, there is an association between physiological responses and tolerance mechanisms of plant against drought stress i.e. membrane stability [9] high relative water content [10] pigment content stability [11, 12]. It was reported that drought tolerant varieties in barley maintained higher relative water content (RLWC) under drought stress [13]. The breeding approaches to develop new or improved cultivars against stress need a thorough understanding of the reactions of plant tissues or organs against the specific stress. Thus, it is very important to identify those wheat genotypes which have the ability to tolerate water stress. These stress tolerant genotypes can be used as reliable selection criteria in the breeding programs.

The main objective of this work was to investigate physiological traits that are associated with drought stress in wheat genotypes and to find out the drought tolerant genotypes that could be used for yield improvement either by introducing these genotypes in rain fed area or using in wheat breeding programs. Different physiological traits of wheat plant play a critical role in increasing its yield. The unit leaf area is the basis of measuring productivity in different plant species during their growth and development under particular environmental condition prevailing over the season (Larcher, 1995). As the leaf area increases, a greater photo synthetically active surface area becomes available.

Materials and Methods

Physiological Studies : Twelve wheat genotypes were chosen (Table-1) and seeds were collected from IIWBR

spring wheat nurseries and sown under four irrigation conditions (T1-385 ml, T2-195 ml, T3-130 ml and T4-100 ml) with each 15 days interval. After maturation, investigations were made to see the effect of drought stress on physiological characteristics and yield trait. Physiological characteristics (Electrolytes leakage, Turgidity, Relative leaf water contents) were measured at three different stages *i.e.* 60 days, 95 days and 120 days after sowing was measured in 5 cm² leaf discs after exposure to various stress treatments with a Consort C-931 conductivity meter. The leaf discs were incubated in 5 ml double distilled water for 3 hours at 25°C with shaking and initial conductivity of the solution was determined. Final conductivity of the solution was determined after autoclaving the samples (100% electrolyte leakage). The amount of electrolytes leakage attributable to different growth conditions and varieties were estimated as a percentage of initial to final conductivity. Electrolytes leakage was calculated by using following formula.

$$\text{Electrolytes leakage (\%)} = \frac{\text{Initial reading}}{\text{Final reading}} \times 100$$

Turgidity : Calculating turgidity, weighted fresh leaf (W1) and then kept the leaf in distilled water for 24 hours and weighted again (W2). Turgidity was calculated from the following formula.

$$\text{Turgidity (gm)} = W2 - W1$$

Relative leaf water contents : The relative water content was estimated by the method prescribed by Barrs and Weatherly (1962). Ten discs from the leaves three sample were collected randomly in each treatment and weighed accurately upto fourth decimal on an electrically operated single pan analytical balance. This was considered as the fresh weight. The weighed leaf discs were allowed to float on distilled water in a Petri dish and allowed to absorb water for four hours. After four hours, the leaf discs were taken out and their surface was blotted gently and weighed. This was referred to as turgid weight after drying these leaf discs in an oven at 70°C for 48 hours, the dry weight was recorded and designated as dry weight. The RWC was calculated by the following formula.

$$\text{RWC (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

Yield Trait : Plants were randomly selected and hand threshed separately, average number of grains per spike and yield per plant were recorded in grams. Average grain yield per plant was estimated for each genotype in each replication.

Results and Discussion

Drought stress affect wheat productivity grown in dry and semidry areas and reduces plant yield more than any other environmental stress [14-17]. In this study,

significant differences were reported in total yield per plant (YPP) and number of grains per spike (NGPS) amongst different varieties in water stress. Drought stress negatively affect yield per plant and number of grains per spike, as drought stress increased from T1 to T4, the YPP and NGPS decreased. Yield of wheat varieties were considerably decreased when they were allowed to grow in minimum annual rainfall region [20]. Highest YPP mean values were reported in decreasing order as tataru (7.40 gm), Ghaznavi-98 (6.35 gm), Zas-08 (6.10) and Zas-42 (5.60 gm) while lowest YPP mean values in increasing order as 26-ESWYT-124 (1.45 gm), Zas-34 (2.02 gm) and 38-IBWSN-1077 (2.40 gm) (Table-2). The result revealed that tataru, Ghaznavi-98, Zas-08 and Zas-42 genotypes has given optimal yield per plant at all the three treatments. Similarly numbers of grains per spike were also reduced with an increase in drought stress. Highest NGPS mean values were reported in decreasing order as tataru (25.2), Zas-42 (24.7), SCO-27 (23.5) and Zas-08 (21.6) and lowest values in increasing order as 38-IBWSN-1059 (14.05), 38-IBWSN-1077 (14.12) and Zas-70 (14.50) (Table-2). This is also supported by the findings of Chandler and Singh (2008) that numbers of grains per spike were decreased under drought stress [18]. Water stress has been reported to affect all the yield components, mainly the number of grains per spike and the number of spikes per plant [19, 20]. It has been recognized that decrease in yield and yield components under drought stress is a key concern in developing countries of the world [21].

The biotic and abiotic stresses target the cell membrane of plants at first; however, the drought tolerant plants maintain its integrity and stability in drought stress. Membrane stability is important for plant growth and development as it tolerate drought stress against plants, since drought stress caused water loss from plant tissues which damage membrane structure and function [24] due to electrolytes leakage. In this study the lowest mean values of electrolytes leakage were reported for Zas-42 (9.14%) after 60 days of sowing which increased to 13.0% and 15.1% after 95 and 120 days of sowing, respectively (Table 2). It revealed that when plants progressed toward maturity, the electrolytes leakage increased gradually with an increase in drought stress. The treatments differences were statistically significant at all the three stages. The genotypic differences and the interaction of the treatments with genotypes (varieties) were also significant at all the three stages. Electrolytes leakages revealed positive correlations with drought stress at all three stages as given in Table-2. As drought stress was increased from T₁ to T₄, it resulted in an increase in electrolytes leakage. The leakage was due to cell membranes rupture which becomes more permeable [25]. After 120 days, the lowest

Table-1 : Pedigree of the twelve wheat genotypes including 10 wheat advance lines used in this study.

Varieties/Adv.Lines	Pedigree	Source/origin
WH 147	E4870/C286/C273 /4/S339/PV18	HAU, Hisar
HUW 234	HUW 12* 2 / CPAN 1666// HUW 12	BHU, Varanasi
RAJ 3765	HD 2402/VL639	Durgapura
WH 730	ALD 'S' HUAC // HD 2285 /3/ HFW-17	
	NP 760 /RIONEGRO	
NP 846	RGN/CSK3 //2*C591/3/C217/N14 //C281	HAU, Hisar
C 306	CPAN1962/TONI//LIRA S/RRL S	BHOWALI/ DELHI
HUW 468		HAU, Hisar
		BHU, Varanasi
HD 2967	ALD/COC//URES/HD2160M/HD2278	IARI, New Delhi
DBW 17	CMH79A.95/3*CNO 79//RAJ3777	DWR, Karnal
UP 2382	CPAN 2004 / HD 2204	GBPUAT, Pantnagar
HD 3043		N.A
HD 2888		N.A

Table-2 : The physiological characteristics of twelve wheat genotypes in mean values for different treatments and different stages (drought stress).

Varieties	RLWC (%)			Turgidity (gm)		Electrolytes leakage (%)		NGPS		YPP (gm)	
	After 60 days	After 95 days	After 120 days	After 60 days	After 95 days	After 120 days	After 60 days	After 95 days	After 120 days	Mean values	Mean values
WH 147	76.775	66.775	64.125	0.039	0.036	0.023	18.233	20.475	23.600	24.367	3.378
HUW 234	76.125	70.450	65.475	0.037	0.033	0.014	19.342	20.750	23.867	19.875	3.257
RAJ 3765	74.550	70.225	67.300	0.023	0.020	0.013	17.300	19.675	24.575	14.233	2.475
WH 730	68.300	63.100	60.900	0.021	0.018	0.017	15.500	17.800	18.250	14.122	4.300
NP 846	70.750	62.450	59.050	0.042	0.039	0.012	16.200	19.575	19.225	19.500	1.525
C 306	72.350	74.942	72.075	0.054	0.051	0.045	10.575	12.875	16.425	22.807	6.175
HUW 468	71.250	67.450	66.450	0.039	0.036	0.020	19.892	21.825	23.425	16.735	2.105
HD 2967	73.992	81.223	76.800	0.054	0.050	0.052	09.225	13.500	15.500	25.752	5.700
DBW 17	71.950	77.680	72.400	0.047	0.080	0.023	16.525	20.025	21.800	16.777	2.875
UP 2382	79.500	74.913	69.950	0.054	0.049	0.029	17.483	20.325	23.200	14.637	2.875
HD 3043	78.625	71.960	68.600	0.069	0.064	0.047	13.475	16.300	20.775	18.388	6.400
HD 2888	88.525	79.330	74.250	0.079	0.073	0.068	11.217	14.475	17.250	25.940	7.450

RLWC; Relative leaf water content, NGPS; Number of grains per spike, YPP; Yield per plant.

electrolyte leakage was reported for ZAS-42 (15.5%), ZAS-08 (16.4%) and Tatara (17.2%). These wheat genotypes were considered as drought avoidant genotypes as they avoided drought stress by maintaining cell membrane stability, resulted in low electrolytes leakage and hence given high yield. ZAS-70, ZAS-67 and 38-IBWSN-1077 wheat genotypes have the ability of tolerating low electrolytes leakage to produce reasonable yield. The poor yield of 38-IBWSN-1052, SCO-27 and ZAS-34 wheat genotype under drought stress was related to their inability to avoid or tolerate stress and high electrolytes leakage that was recorded 23.8%, 23.6% and 23.4%, respectively. The results obtained from electrolyte leakage in this study revealed that membrane integrity of drought tolerant genotypes was stable as compared to other genotypes; this association of electrolyte leakage

and drought tolerance was also reported by other researchers [26, 27].

The RLWC of the leaves indicate the water condition of the cells and have important correlation with biotic and abiotic stress tolerance [28]. It has been reported that, RLWC of the leaves has strong association with drought tolerance [29] and it is a good indicator of drought stress than other [29] physiological and biochemical characteristics of the crop plants [30]. Our results revealed significant differences in RLWC among varieties at three different stages and showed that, retention ability of the plant was significantly different at different growth stages. The maximum RLWC was reported in Tatara 88.5%, 79.3% and 74.2% after 60, 95 and 120 days of sowing, respectively (Table-2). It showed that RLWC was decreased with the age of plant because RLWC was high

after 60 days in comparison to 95 and 120 days of the sowing; this is also supported by other literatures that as plants progressed toward maturity, water retention ability decreased^[31]. Similarly turgidity was also decreased with an increase^[31] in drought stress, because weight of plants was high during 60 days in comparison to 95 and 120 days. This means that plants were more turgid at 60 days as compared to 95 and 120 days of the sowing (Table 2). This variation in RLWC of leaf and turgidity may be due to the ability of the tested wheat genotypes to absorb more water from soil and also to control water loss through the stomata^[32]. It may also be due to the variation in the ability of wheat genotypes to avoid stress by maintaining tissue turgor osmotically. Highest RLWC after 120 days of sowing was reported in Zas-42 (76.8%), Tatara (74.2%), Zas-67 (72.4%) and Zas-08 (72.0%) as given in Table 2. This revealed that, at all the three stages, ZAS-08, ZAS-42, Tatara, and ZAS-67 maintained higher RLWC and is considered as drought tolerant genotypes while SCO-27, 26-ESWYT-124, 38-IBWSN-1059, ZAS-34 have low RLWC and is considered moderate drought tolerant genotypes. These results were supported by Schonfeld *et al.*, (1988) that RLWC may be used as a selection criterion in breeding for improved drought resistance in wheat genotypes^[32].

This study allowed us to recognize those physiological characteristics that are associated with drought stress, and screen out appropriate wheat genotypes, which can be introduced in arid area to produce high yield in drought conditions and can be further used in breeding programs to produce a stress tolerant genotype.

Conclusions

It has been concluded that wheat yield was significantly affected by physiological traits in drought stress conditions. With respect to physiological and yield traits, Tatara, Ghaznavi-98, ZAS-08 and ZAS-42 wheat genotypes revealed maximum drought tolerance and can be successfully grown in arid region without much loss of wheat productivity. Thus, screening of drought tolerant wheat genotypes on the basis of physiological traits may be a useful tool for the breeding programs.

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Drought Tolerance in Wheat

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Abstract

Drought is one of the most important phenomena which limit crops' production and yield. Crops demonstrate various morphological, physiological, biochemical, and molecular responses to tackle drought stress. Plants' vegetative and reproductive stages are intensively influenced by drought stress. Drought tolerance is a complicated trait which is controlled by polygenes and their expressions are influenced by various environmental elements. This means that breeding for this trait is so difficult and new molecular methods such as molecular markers, quantitative trait loci (QTL) mapping strategies, and expression patterns of genes should be applied to produce drought tolerant genotypes. In wheat, there are several genes which are responsible for drought stress tolerance and produce different types of enzymes and proteins for instance, late embryogenesis abundant (leA), responsive to abscisic acid (Rab), rubisco, helicase, proline, glutathione-S-transferase (GST), and carbohydrates during drought stress. This review paper has concentrated on the study of water limitation and its effects on morphological, physiological, biochemical, and molecular responses of wheat with the possible losses caused by drought stress.

Introduction

Drought is one of the most common environmental stresses that affect growth and development of plants. Drought continues to be an important challenge to agricultural researchers and plant breeders. It is assumed that by the year 2025, around 1.8 billion people will face absolute water shortage and 65% of the world's population will live under water-stressed environments. Tolerance to water stress is a complicated parameter in which crops' performance can be influenced by several characteristics. Tolerance can be divided into two parts including drought avoidance and dehydration tolerance. Drought avoidance includes root depth, reasonable use of available water by plants, and changes in plants' lifestyle to use rainfall. Dehydration tolerance consists of plants' capability to partially dehydrate and grow again when rainfall continues. Adaption of plants to drought stress is a vital issue to develop new improved methods for increasing stress tolerant plants. Many factors can affect plants' responses to drought stress such as plant genotype, growth stage, severity and duration of stress, physiological process of growth, different patterns of genes expression, different patterns of the activity of respiration, activity of photosynthesis machinery, and environmental factors. Drought stress can also influence plants in terms of protein changes, antioxidant production, osmotic adjustment, hormone composition, root depth and extension, opening and closing of stomata, cuticle thickness, inhibition of photosynthesis, decrease in chlorophyll content, reduction in transpiration, and growth inhibition to stand with some osmotic changes in their organs. Drought can also cause pollen sterility, grain loss,

accumulation of abscisic acid in spikes of drought-susceptible wheat genotypes, and abscisic acid synthesis genes in the anthers. Dat et al. claimed that increase in ROS can be caused by drought stress in which oxidative balance of the cell is changed. Rosenberg et al. observed that transpiration decreased significantly under drought stress; then heat can slowly be lost from the leaves and leaf temperature can be increased. As a result, CO₂ concentrations and photosynthesis are increased which affect plant's growth and finally, water use efficiency can be improved. Ribas-Carbo et al. suggested that the increase in AOX pathway under water stress could be prompted by the inhibition of cytochrome pathway.

2. Physiological Derivations of Drought Tolerance in Wheat

Physiological responses include closure of stomata, decrease in the activity of photosynthesis, development of oxidative stress, alteration in the integrity of cell wall, production of metabolites which are toxic and cause plants' death, signal recognition of roots, turgor loss and adjustment of osmosis, reduction in water potential of leaf, decrease in stomata conductance to CO₂, reduction of internal CO₂ concentration, and reduction of growth rates. According to researchers, there is a relationship between different physiological responses of crops and their resistance functions under drought such as high amount of relative water and potential water and integrity of membrane. For measuring drought tolerance, various scientists

Considered maintenance of membrane integrity and its role under water stress. Sink strength can be reduced

in drought stress during early grain filling which results in reducing endosperm cell number and metabolic activity.

2.1 Yield potential : The classical plant-breeding axiom that a high-yielding variety will perform well under most environments is still widely accepted by breeders. This is not an untrue axiom. The heart of the matter is the definition of 'most environments' and the delineation of those environments where high yield potential will not suffice for sustained performance. A delineation of such environments can be assessed by the crossover interaction, whereas under a particular pressure of environmental stress, cultivars with high yield potential produce less than certain cultivars that have lower yield potential but seem to be better adapted to stress. For most cereals grown under water-limited conditions the crossover occurs at a yield level of around 2–3 t/ha (e.g. Blum and Pnuel 1990; Ceccarelli and Grando 1991), which is approximately one-third of the yield potential.

Such a dehydration-avoidant phenotype, which is characterised by the maintenance of high plant water status under stress, can present, for example, any of the following features: early flowering, smaller plant, small leaf area, or limited tillering (in cereals) (e.g. Blum 1988), all of which are in contrast to a high yield potential phenotype.

2.2 Drought resistance : Drought resistance and its components are almost constantly being 'redefined', whereas newcomers to this discipline often express outstanding inventive capacity for terminology. For their benefit they are reminded that the original terminology and definitions of Levitt (1972) still hold very well. This is not nostalgia; it is a matter of scientific correctness (see Introduction).

It is not absolutely clear whether the capacity for developing longer roots under stress is compatible with a high yield potential phenotype. When all their requirements are effectively supplied, plants do not need a large root. Root mass under very productive drip irrigation systems is relatively small. In such a system a large potential root is a waste of dry matter. However, under conditions of unsecured soil resources, a potentially large root is required to ensure capture of resources under erratic conditions.

2.3 Dehydration avoidance : Dehydration avoidance is defined as the plant capacity to sustain high plant water status or cellular hydration under the effect of drought. Hence, by this mechanism the plant avoids being stressed because plant functions are relatively unexposed to tissue dehydration. Crop plants avoid dehydration by enhanced capture of soil moisture, by limited crop water loss, and by retaining cellular hydration despite the reduction in plant water potential

2.4 Enhanced capture of soil moisture : Genetic variation exists in potential root length (maximum root length measured under non-stress and non-restrictive soil conditions). However, when plants are exposed to a drying soil, root morphology and growth can change to the extent that the potential root length, whether it is short or long, becomes irrelevant. In cereals a drying, hard topsoil resists the penetration and establishment of adventitious (crown) roots while existing roots receive all transient assimilates and grow deeper (Blum and Ritchie 1984; Asseng et al. 1998). Shoot/root dry matter ratio increases under drought stress, not because of an increase in root mass but due to a relatively greater decrease in shoot mass.

2.5 Reduced water use : Plants are developmentally and physiologically designed by evolution to reduce water use (WU) under drought stress. Since plant production is a function of WU the issue for the breeder is how to reduce WU under stress while minimising the associated reduction in production. It would seem that this is a question of the genetic scatter around the very firm regression of biomass production on crop water use.

2.6 Osmotic adjustment and conserved cellular water content : An increasing number of reports provides evidence on the association between high rate of osmotic adjustment (OA) and sustained yield or biomass under water-limited conditions across different cultivars of crop plants (Table 1). Since OA helps to maintain higher leaf relative water content (RWC) at low leaf water potential (LWP), it is evident that OA helps to sustain growth while the plant is meeting transpirational demand by reducing its LWP

2.7 Dehydration (desiccation) tolerance : Dehydration tolerance as an effective drought-resistance mechanism in crop plants is rare. It exists in the seed embryo, but once germinated the plant loses its tolerance. Extreme desiccation tolerance is known in resurrection plants and some attempts are made in various laboratories to use this tolerance for improving crop plants. Results are still imminent. Dehydration tolerance, like freezing tolerance, requires that the plant enter a quiescent or a dormant state.

2.8 Water-use efficiency : WUE is often equated in a simplistic manner with drought resistance without considering the fact that it is a ratio between 2 physiological (transpiration and photosynthesis) or agronomic (yield and crop water use) entities. As a ratio it is often susceptible to misinterpretation, especially when the dynamics of the nominator and the denominator are obscure.

Table-1 : Yield losses at vegetative growth stages under drought in wheat.

Vegetative stage	Yield loss (%)
Early season stress	22
Midseason stress	58
Tillering stage	46.85
1000-grain weight (vegetative stage)	38.67
Earlier stages	79.7
Spike length (vegetative stage)	16.90
Number of spikelets per spike (vegetative stage)	28.63
Grains number (vegetative stage)	72.51
Grain yield (vegetative stage)	61.38

Table-2 : Correlation coefficients between drought tolerance indices.

YS	Yp	STI	GMP	MP	TOL	SSI	YI	YSI	HAM	DI	ATI	SSPI	SNPI	K2
1														
0.61*	1													
0.87**	0.91**	1												
0.89**	0.90**	0.99**	1											
0.82**	0.95**	0.99**	0.99**	1										
0.13	0.86**	0.59*	0.56**	0.67**	1									
-0.45	0.41	0.03	-0.00	0.13	0.81**	1								
1**	0.61*	0.87**	0.89**	0.82**	0.13	-0.45	1							
0.45	-0.41	-0.03	0.01	-0.13	-0.81**	-1**	-0.45	1						
0.94**	0.83**	0.98**	0.98**	0.95**	0.43	-0.14	0.94**	0.14	1					
0.86**	0.14	0.51	0.54*	0.42	-0.38	-0.84**	0.86**	0.84**	.65**	1				
0.38	0.96**	0.78**	0.76**	0.84**	0.96**	0.63	0.38	-0.63*	.66**	-0.12	1			
0.13	0.86**	0.59**	0.56*	0.67**	1.00**	0.81**	0.13	-0.81**	0.43	-0.38	0.96**	1		
0.98**	0.49	0.78**	0.81**	0.72**	-0.01	-.58*	0.98**	0.58*	0.88**	0.93**	0.24	-0.01	1	
0.99**	0.61*	0.87**	0.88**	0.81**	0.12	-0.45	0.99**	0.45	0.94**	0.86**	0.38	0.12	0.98**	1
0.57**	0.99**	0.89**	0.88**	0.94**	0.88**	0.45	0.57*	-0.45	0.80**	0.09	0.97**	0.88**	0.45	0.57*

*and ** Significant at 1 and 5 percent respectively.

3. Effects of Drought on Plants

The effects of drought range from morphological to molecular levels and are evident at all phenological stages of plant growth at whatever stage the water deficit takes place. An account of various drought stress effects and their extent is elaborated below.

3.1 Crop growth and yield : The first and foremost effect of drought is impaired germination and poor stand establishment (Harris *et al.*, 2002). Drought stress has been reported to severely reduce germination and seedling stand (Kaya *et al.*, 2006). In a study on pea, drought stress impaired the germination and early seedling growth of five cultivars tested (Okcu *et al.*, 2005). Moreover, in alfalfa (*Medicago sativa*), germination potential, hypocotyl length, and shoot and root fresh and dry weights were reduced by polyethylene glycol-induced water deficit, while the root length was increased (Zeid and Shedeed, 2006). However, in rice, drought stress during the vegetative stage greatly reduced the plant growth and development.

Growth is accomplished through cell division, cell enlargement and differentiation, and involves genetic,

physiological, ecological and morphological events and their complex interactions. The quality and quantity of plant growth depend on these events, which are affected by water deficit. Cell growth is one of the most drought-sensitive physiological processes due to the reduction in turgor pressure (Taiz and Zeiger, 2006). Under severe water deficiency, cell elongation of higher plants can be inhibited by interruption of water flow from the xylem to the surrounding elongating cells (Nonami, 1998).

3.2 Water relations : Relative water content, leaf water potential, stomatal resistance, rate of transpiration, leaf temperature and canopy temperature are important characteristics that influence plant water relations. Relative water content of wheat leaves was higher initially during leaf development and decreased as the dry matter accumulated and leaf matured (Siddique *et al.*, 2001). Obviously, water-stressed wheat and rice plants had lower relative water content than non-stressed ones. Exposure of these plants to drought stress substantially decreased the leaf water potential, relative water content and transpiration rate, with a concomitant increase in leaf temperature (Siddique *et al.*, 2001). A conservative

influence of decreased stomatal conductance in non-irrigated plants was negated by a leaf-to-air vapor pressure difference caused by the associated higher leaf temperature. Transpiration rates were similar in both treatments and the lower total water use of the non-irrigated stand resulted entirely from a smaller leaf area index (Craufurad *et al.*, 2000).

3.3 Yield potential : The classical plant-breeding axiom that a high-yielding variety will perform well under most environments is still widely accepted by breeders. This is not an untrue axiom. The heart of the matter is the definition of 'most environments' and the delineation of those environments where high yield potential will not suffice for sustained performance. A delineation of such environments can be assessed by the crossover interaction, whereas under a particular pressure of environmental stress, cultivars with high yield potential produce less than certain cultivars that have lower yield potential but seem to be better adapted to stress. For most cereals grown under water-limited conditions the crossover occurs at a yield level of around 2–3 t/ha (e.g. Blum and Pnuel 1990; Ceccarelli and Grando 1991), which is approximately one-third of the yield potential.

4. Drought resistance

Drought resistance and its components are almost constantly being 'redefined', whereas newcomers to this discipline often express outstanding inventive capacity for terminology. For their benefit they are reminded that the original terminology and definitions of Levitt (1972) still hold very well. This is not nostalgia; it is a matter of scientific correctness (see Introduction). When a genotype yields better than another under a severe (below the 'crossover') strain of drought, it is relatively more drought resistant. The strain of drought is developed when crop demand for water is not met by the supply, and plant water status is reduced. Plants can resist drought by either dehydration avoidance or by dehydration tolerance. Drought resistance in terms of the physiology involved interacts with the magnitude and the timing of the stress. Timing here refers to the stage of plant development when stress occurs. For example, drought resistance in seedlings grown in a pot has nothing to do with drought resistance during grain filling in the field.

4.1 Dehydration avoidance : Dehydration avoidance is defined as the plant capacity to sustain high plant water status or cellular hydration under the effect of drought. Hence, by this mechanism the plant avoids being stressed because plant functions are relatively unexposed to tissue dehydration. Crop plants avoid dehydration by enhanced capture of soil moisture, by limited crop water loss, and by retaining cellular hydration despite the reduction in plant water potential.

4.2 Enhanced capture of soil moisture : Much has been written and debated about roots and soil moisture uptake. At the end of the day the essence of the matter is that where deep soil moisture is available a long root to reach this moisture is simply as effective as a long rope in a deep well

4.3 Reduced water use : Plants are developmentally and physiologically designed by evolution to reduce water use (WU) under drought stress. Since plant production is a function of WU the issue for the breeder is how to reduce WU under stress while minimising the associated reduction in production. It would seem that this is a question of the genetic scatter around the very firm regression of biomass production on crop water use.

5. Molecular mechanisms

Plant cellular water deficit may occur under conditions of reduced soil water content. Under these conditions, changes in gene expression (up- and down-regulation) take place. Various genes are induced in response to drought at the transcriptional level, and these gene products are thought to function in tolerance to drought (Kavar *et al.*, 2007). Gene expression may be triggered directly by the stress conditions or result from secondary stresses and/or injury responses. Nonetheless, it is well established that drought tolerance is a complex phenomenon involving the concerted action of many genes (Agarwal *et al.*, 2006; Cattivelli *et al.*, 2008)

Heat shock proteins belong to a larger group of molecules called chaperones. They have a role in stabilizing other proteins' structure. Low-molecular-weight heat shock proteins are generally produced only in response to environmental stress, particularly high temperature (Wahid *et al.*, 2007). But many heat shock proteins have been found to be induced by different stresses such as drought, anaerobic conditions and low temperatures (Coca *et al.*, 1994). They are reported to serve as molecular chaperones that participate in adenosine triphosphate-dependent protein unfolding or assembly/disassembly reactions and prevent protein denaturation during stress (Gorantla *et al.*, 2006).

A number of phospholipid systems are activated by osmotic stress, generating an array of messenger molecules, some of which may function upstream of the osmotic stress-activated protein kinases. Absciscic acid biosynthesis is regulated by osmotic stress at multiple steps. Both absciscic acid-dependent and -independent osmotic stress signaling first modify constitutively expressed transcription factors, leading to the expression of early response transcriptional activators, which then activate downstream stress tolerance effector genes (Zhu, 2002). Recently, Wan *et al.* (2007) reported that

amongst the 29 calcium-dependent protein kinase genes identified so far, all contained multiple stress-responsive cis-elements upstream in the promoter region (1 kb). Sucrose non-fermenting 1-related protein kinase 2 has also been reported to be capable of mediating signals initiated during drought stress, resulting in appropriate gene expression (Umezawa *et al.*, 2005).

Many laboratory and field studies have shown that transgenic expression of some of the stress-regulated genes results in increased tolerance to drought and other stresses. These transgenic approaches are currently the mainstream method to bioengineer drought tolerance in crop plants (Bahieldina *et al.*, 2005). However, enhanced expression of these genes is frequently associated with retarded growth and thus may limit its practical applications.

Conclusions

Constitutive whole-plant traits have a major role in affecting plant water use and plant dehydration avoidance under stress. These largely determine some of the negative relations between yield potential and the ability to sustain yield under severe water shortage. Crops and native vegetation that are adapted to waterlimited conditions in terms of growth and productivity achieve adaptation mainly by dehydration avoidance and escape rather than by desiccation tolerance and the ability to function in a dehydrated state. Besides various developmental and phenological attributes that affect crop performance under drought, osmotic adjustment is a major cellular drought-responsive trait that contributes to cellular dehydration avoidance and yield under stress. Despite past voiced speculations, there is no definitive proof that the capacity for OA entails a cost in terms of reduced yield potential.

Indiscriminant selection for higher WUE with the assumption that it equates with improved drought resistance or improved yield under stress might bring about serious negative consequences. High WUE is largely a function of reduced water use rather than a net improvement in plant production or biochemistry of assimilation. Therefore, in selection programs it may constitute a marker for reduced water use commonly achieved via moderated growth, reduced leaf area, and short growth duration. If low water use is the breeder's target it is highly probable that selection for low water use can be achieved by directly selecting for these simple plant traits, without measuring WUE.

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Evaluation of Genetic Parameters of Morpho-Physiological traits of Water Stress in Wheat (*Triticum aestivum* L.) using Diallel Mating Design

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Abstract

Drought is one of the major environmental factors which threaten wheat production worldwide. In order to study the genetic parameters of field and morpho-physiological indicators of drought tolerance in bread wheat, a 10 x 10 diallel cross, excluding reciprocals, was grown in a randomized complete block design (RCBD) with three replications under normal (NC) and water stress condition (WC). The mean data of these twenty two traits except phenol colour reaction were subjected to statistical and biometrical analysis, to work out the analysis of variance, combining ability variances and their effects, components of genetic variances, manifestation of heterosis, drought susceptibility, and coefficient of variation (gcv and pcv), heritability, genetic advance, correlation coefficient and path coefficient analysis. The analysis of variance exhibited significant differences under (normal and water stress condition) the among treatments, parents and hybrid except days to 50% flowering, spike length, grain yield per plant, harvest index, chlorophyll content, days to maturity etc. On the basis of overall gca effects, the parents viz; WH-147, RAJ-3765, WH-730, HUW-468, DBW-17 were the best general combiners for maximum number of characters under normal and water stress condition. Under the specific combining ability effects, five crosses viz; WH-730 x C-306, WH-147 x HD-2967, WH-147 x WH-730, NP-846 x C-306 and RAJ-3765 x HD-2967 under water stress condition were found as good specific combiner for grain yield per plant. The estimates of additive genetic variance D^* was noted as highly significant for the traits viz; plant height, number of grains per spike, flag leaf area, harvest index, shoot length, chlorophyll content, membrane stability index and ash content under water stress condition. Grain yield per plant best five crosses viz; DBW-17 x UP-2382, DBW-17 x UP-2382, WH-147 x NP-846, HUW-234 x UP-2382, HUW-234 x UP-2382 showed significant and positive heterosis under water stress condition. High heritability and high genetic advance was observed for the traits viz; plant height, number of grains per spike, biological yield per plant, shoot length, excised leaf water retention, relative water content, membrane stability index under normal and water stress condition.

Keywords : Drought susceptibility, coefficient of variation, heritability, genetic advance.

Introduction

Drought is one of the most important abiotic stress factors, which affects almost every aspect of plant growth (Ludlow and Muchow, 1990; Shiri et al., 2010). Wheat is a self-pollinated crop of the member of Poaceae family. It is the most important food crop of India and is a main source of protein and energy. In India, wheat is the second most important food crop after rice both in terms of area and production. Among cultivable species hexaploid wheat (*Triticum aestivum* L., $2n=42$) is the most common wheat and occupies more than 90% of the total area under wheat cultivation. Other cultivable species are *Triticum durum* (tetraploid $2n=28$) and *Triticum dicoccum* (Tetraploid, $2n=28$). Out of these species *Triticum dicoccum* is under least cultivation in peninsular zone of India. The primary centre of origin of *Triticum aestivum* is Central Asia Centre (syn. Afghanistan Centre).

The hexaploid wheat came into existence by virtue of spontaneous evolutionary process with having three

genomes (AABBDD) coming from different species and diploid condition of hexaploid wheat arose through a natural amphidiploids process. In wheat gene responsible for dwarfness is *Rht1* and *Rht2*. Wheat production and area in the year 2014-2015 is 95.85 million metric tons and 31.53 million hectares respectively. Productivity of wheat during 2014-2015 is 3.04 metric tons per hectare.

Diallel cross technique developed and illustrated by Hayman (1954a, b) and Jinks (1954) provides information in early generations on genetic mechanism involved in character expression. The combining ability analysis developed by Griffing (1956) provides useful information regarding the selection of parents in terms of the performance of their hybrids.

Selection efficiency could be improved if particular physiological and/or morphological attributes related to yield under a stress environment could be identified and employed as selection criteria for complementing traditional plant breeding (Acevedo, 1991). Wheat has gained special attention in respect to morphological and

physiological characters affecting drought tolerance, including stomata (size, number, aperture); leaf (area, shape, expansion, orientation, senescence, pubescence, waxiness, cuticular resistance); root (length, density, dry weight); water-use efficiency; relative water content; evapo-transpiration efficiency; abscisic acid levels; cell membrane stability; heat-shock proteins and carbon isotope discrimination (Dencic *et al.*, 2000).

Materials and Methods

The experimental material considered of 10 accessions of wheat. The material was grown in complete randomized design with three replication at the experimental farm of Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), during *Rabi* season of 2014-2015 under two environments i.e. timely (E_1) and late (E_2) sown conditions. Each individual plot considered of 3 rows, each of 5m length. All the recommended agronomic and cultural practices were followed for raising a good crop. Data were recorded on five randomly selected plants per replication of each genotype for the following twenty two morpho-physiological traits namely days to 50% flowering, plant height, number of spike per plant, spike length, number of spikelet per spike, number of grains per spike, grain yield per plant, biological yield per plant, harvest index, 1000-grain weight, shoot length, root length, excised leaf water retention, proline content, chlorophyll content, relative water content, flag leaf area, days to maturity, membrane stability index, gluten percentage, ash content and drought susceptibility index.

Results and Discussion

The analysis revealed significant differences among the genotypes for all the traits under study (Table 1). The analysis of variance revealed significant differences showed the treatments, parents and hybrids were significant for all the characters under study, except spike length, number of spikelet per spike, proline per cent, days to maturity, gluten per cent in case of normal condition. Parent vs hybrid showed significant differences for all the traits except for days to 50% flowering, plant height, spike length, grain yield per plant, 1000-grain weight, root length and flag leaf area; However, under water stress condition showed significant differences for treatments, parents and hybrids for all the characters under study, except days to 50% flowering, number of spikelet per spike, harvest index on case of parents. Parents vs hybrid showed significant differences for all the traits except for plant height, spike length, number of grains per spike, 1000-grain weight, harvest index, shoot length, root length indicate the presence of adequate variability among the materials.

Combining ability analysis : Analysis of variance for

combining ability revealed that both general and specific combining ability variances were responsible for all the traits. Thus, additive and non-additive gene action was important in controlling the inheritance of all the traits. The variance due to gca was equal to that part of genetic variance which is due to additive and additive x additive effects, while variances due to sca was ascribed to non-additive components of variance that include dominance and epistatic variance.

Hayman numerical analysis : The estimate of additive genetic variance (σ_a^2) was noted that as highly significant for the traits viz; days to 50% flowering, plant height, spike length, harvest index, 1000-grain weight, chlorophyll content, flag leaf area in normal condition; and characters i.e. plant height, shoot length, root length, proline content, days to maturity, drought susceptibility index under water stress condition.

The estimate of h^2 were found significant and positive for plant height, number of spikelet per spike, shoot length, chlorophyll content, relative water content in normal condition; and days to 50% flowering, spike length, root length, proline content, days to maturity, dry gluten content and ash content in water stress condition, indicating that dominant genes are controlling these traits. However, non-significant values were reported for number of grains per spike, root length, days to maturity in both the conditions. Whereas, days to 50% flowering, spike length, flag leaf area, harvest index, excised leaf water retention, chlorophyll content, membrane stability index, ash content in normal way, indicating partial dominance for these traits.

Average degree of dominance (H_1/σ_a^2) were found were found to be more than unity for all the characters in case of normal condition indicating that these traits are governed by over-dominance gene action. The proportion of genes with positive and negative effects in the parents ($H_{2/4} H_1$) was found less than its theoretical value (0.25) for all the characters except days to 50% flowering indicating asymmetrical distribution of positive and negative alleles among the parent under normal condition; except shoot length and ash content in water stress condition.

The ratio $[(4 - H_1)^{1/2} + F/(4 - H_1)^{1/2} - F]$ proportion of dominance and recessive alleles in this parents. The ratio were more than one for sixteen characters viz. days to 50% flowering, plant height, number of spikes per plant, spike length, number of spikelets per spike, number of grains per spike, grain yield per plant, biological yield per plant, root length, proline content, chlorophyll content, relative water content, days to maturity, membrane stability index, gluten content and ash content indicated more dominant alleles in the parents. While, this ratio was

Table-1 : Analysis of variance for parents + F₁ for twenty two characters of wheat under normal (NC) and water stress (WS) conditions.

Source of variance	d.f	Conditions	Days to 50% flowering	Plant height (cm)	No. of spikes /plant	Spike length (cm)	No. of spikelet/spikes	No. of grains /spike	Grain yield/plant (g)	Biological yield/plant (g)	Harvest index (%)	1000-grain weight (g)	Shoot length (cm)
Replications	2	NC	0.81	1.15	0.22	0.05	0.92	0.08	0.13	1.39	0.24	1.22	1.26
		WS	1.48	0.75	1.53	0.08	0.04	0.19	0.04	4.58	0.70	3.66	0.02
Treatments	54	NC	22.15**	268.07**	13.05*	1.05**	6.58**	169.25**	27.07**	334.24**	26.17**	14.09**	168.81**
		WS	16.60**	240.02**	12.19 *	0.97 **	14.32 **	229.98 **	17.53 **	206.35 **	1.17 **	22.43 **	150.60 **
Parents	9	NC	37.19**	527.05**	6.65*	1.33**	5.84**	119.29**	29.54**	342.46**	2.30**	12.30**	380.38**
		WS	39.11**	491.76**	7.99 *	0.50 *	3.04	139.05 **	9.93 **	126.31 **	1.25 *	15.17 **	307.09 **
Crosses	44	NC	19.54**	221.04**	13.45**	1.00**	6.65**	176.04**	27.15**	338.32**	31.22**	14.77**	122.56**
		WS	8.74**	193.89**	13.08 **	1.09 **	16.74 **	253.69 **	18.80 **	218.49 **	1.16 **	24.42 **	122.01
Parents Vs crosses	1	NC	1.51	6.60	53.60**	0.66	10.19*	320.08**	1.13	80.84*	18.89**	0.41	299.86**
		WS	159.38**	4.22	10.67 *	0.19	9.50 *	5.18	29.70 **	392.73 **	0.92	0.03	0.34
Error	108	NC	1.42	1.89	1.74	0.35	1.88	3.34	1.18	12.20	0.66	1.55	1.24
		WS	1.16	1.58	1.77	0.21	1.84	8.34	1.34	19.77	0.44	1.61	0.84
Total	164	NC	8.24	89.52	5.45	0.58	3.41	57.93	9.69	118.11	9.05	5.67	56.41
		WS	6.25	80.08	5.20	0.46	5.93	81.22	6.65	81.02	0.69	8.49	50.14

Table-1: Continue.....

Source of variance	d.f.	Conditions	Root length (cm)	Excised leaf water retention (%)	Proline content (mg/gm)	Chlorophyll I content	Relative water content (%)	Flag leaf area (cm ²)	Days to maturity	Membrane stability index	Gluten (%)	Ash content (mg)	Drought susceptibility index
Replications	2	NC	0.05	0.02	0.01	10.74	0.46	1.25	2.41	0.12	0.03	3.74	—
		WS	0.63	0.28	0.04	4.01	0.78	0.26	0.15	0.38	0.01	0.01	33.77
Treatments	54	NC	10.98**	179.83**	3.95**	28.53**	78.30**	26.18**	19.22**	134.46**	1.49**	436.98**	—
		WS	8.77 **	182.65 **	2.60 **	41.27 **	109.12 **	49.42 **	22.05 **	81.39 **	1.48 **	299.14 **	499.43 **
Parents	9	NC	22.77**	196.40**	0.54**	8.37	126.74**	63.58**	8.68**	37.44**	1.19**	401.32**	—
		WS	10.94 **	196.39 **	1.44 **	33.64 **	185.84 **	96.25 **	10.17 **	36.74 **	1.78 **	196.94 **	546.14 **
Crosses	44	NC	8.80**	174.54**	4.40**	32.59**	60.46**	18.97**	21.54**	133.03**	1.56**	450.51**	—
		WS	8.51 **	179.04 **	2.73 **	42.94 **	84.03 **	39.67 **	24.49 **	78.61 **	1.35 **	317.36 **	491.59 **
Parents Vs crosses	1	NC	0.51	263.10**	14.92**	31.53*	426.89**	7.01*	12.15**	1070.40**	1.07**	162.45**	—
		WS	0.51	217.62 **	7.20 **	36.49 **	522.73 **	57.26 **	21.21 **	605.48 **	4.97 **	417.32 **	424.09
Error	108	NC	1.12	0.69	0.04	5.44	1.57	1.64	1.52	2.32	0.08	8.72	—
		WS	0.32	0.30	0.02	1.76	1.39	1.99	1.23	1.26	0.06	2.41	13.38
Total	164	NC	4.35	59.66	1.33	13.11	26.82	9.71	7.36	45.80	0.54	149.67	—
		WS	3.10	60.34	0.87	14.79	36.85	17.59	8.07	27.63	0.53	100.09	173.67

**, * significant at 5% and 1% level of significance, respectively.

Table-2: Analysis of gca and sca variances for different twenty two characters wheat under normal (NC) and water stress (WS) conditions in diallel analysis.

Source of variance	d.f.	Conditions	Days to 50% flowering	Plant height (cm)	No. of spikes /plant	Spike length (cm)	No. of spikelets/ Spikes	No. of grains /spike	Grain yield/ plant (g)	Biological yield/ plant (g)	Harvest index (%)	1000-grain weight (g)	Shoot length (cm)
GCA	9	NC	32.57**	497.97**	7.65**	0.57**	2.36**	171.18**	11.85**	233.02**	23.23**	8.62**	284.57**
		WS	6.90**	415.89**	12.54**	0.35**	4.35**	176.21**	13.46**	169.90**	0.91*	14.90**	256.85**
SCA	45	NC	2.35**	7.64**	3.69**	0.31**	2.16**	33.46**	8.46**	87.09**	5.82**	3.91**	10.61**
		WS	5.26**	12.83**	2.37**	0.32**	4.86**	56.75**	4.32**	48.56**	0.29*	5.99**	8.87**
Error	108	NC	0.47*	0.63	0.58	0.12	0.63	1.11	0.39	4.07	0.22	0.52	0.41
		WS	0.39	0.53	0.59	0.07	0.61	2.78	0.45	6.59	0.15	0.54	0.28

Table-2 : Continue.....

Source of variance	d.f.	Conditions	Root length (cm)	Exoised leaf water retention (%)	Proline content (mg/gm)	Chlorophyll content	Relative water content (%)	Flag leaf area (cm ²)	Days to maturity	Membrane stability index	Gluten (%)	Ash content (mg)	Drought susceptibility index
GCA	9	NC	7.24**	95.82**	0.99**	13.80**	20.15**	15.67**	5.99**	84.43**	0.96**	167.47**	—
		WS	4.55**	116.67	2.71**	39.19**	95.26**	24.98**	9.94**	53.54**	0.87**	34.10**	448.19**
SCA	45	NC	2.94**	52.77**	1.38**	8.65**	27.29**	7.34**	6.49**	36.90**	0.40*	143.30**	—
		WS	2.60**	49.73**	0.50*	8.67**	24.60**	14.77**	6.83**	21.85**	0.42**	112.84**	110.14**
Error	108	NC	0.37	0.23	0.01	1.81	0.52	0.55	0.51	0.77	0.03	2.91	—
		WS	0.11	0.10	0.01	0.59	0.46	0.66	0.41	0.42	0.02	0.80	4.46

*, ** significant at 5% & 1% probability levels, respectively.

less than unity for days to 50% flowering, chlorophyll content, relative water content and ash content in normal condition sown and plant height, number of spike per plant, proline content, drought susceptibility index, ash content in water stress condition, reflecting more recessive alleles in the parents for this trait.

The additive genetic variance (VA) was found for the traits viz; 1000-grain weight, number of grains per spike, flag leaf area, biological yield per plant, plant height, harvest index, root length, proline content, chlorophyll content, relative water content, days to maturity indicating the involvement of the additive gene effects in both condition for all these attributes. The dominance variance (VD) was found for all the traits viz. plant height, spike length, number of spikelet per spike, biological yield per plant, 1000-grain weight, shoot length, excised leaf water retention, relative water content, flag leaf area, membrane stability index indicating the dominance gene effects of these attributes under normal and water condition.

The ratio of h^2/H_2 was more than one of four characters viz; plant height, number of spike per plant, chlorophyll content and ash content in F_1 generation in normal and water stress condition., which indicates that more than one major gene groups were responsible for controlling these traits. However, the rest of character ratio of h^2/H_2 is less than unity indicating the presence of at least one major gene group were governing these traits.

Conclusions

The analysis of variance exhibited that significant differences for treatments, parent and hybrid for most of the characters under study under both the environment, indicating the presence of adequate variability among the materials and gives broad scope for selection of desirable traits. Analysis of variance for combining ability showed that both additive and non-additive gene action was important in controlling the inheritance of all the traits. For the exploitation of both additive and non-additive component of variation, material may be handled through pedigree method, reciprocal recurrent selection or biparental mating for obtaining superior segregants *vis-à-vis* improvement in wheat. Based on the results of drought susceptibility index, parents viz; HUW-468, HD-2967, DBW-17 and UP-2382; and ten hybrids viz; WH-147 x UP-2382, HUW-234 x HD-2967, AJ-3765 x HUW-468, WH-730 x DBW-17, NP-846 x UP-2382, HUW-468 x HD-2967, HUW-468 x UP-2382, HD-2967 x DBW-17, HD-2967 x UP-2382, DBW-17 x UP-2382 exhibited positively number of grains per spike, biological yield per plant, 1000-grain weight, root length, proline content, flag leaf area, membrane

Table-3 : Estimate of genetic components and its related statistics for twenty two characters in bread wheat under normal (NC) and water stress (WC) conditions.

Characters	Environment	Generation	Days to 50% Flowering	Plant Height (cm)	Spikes/ Plant	Spike Length (cm)	Spikelet/ Spikes	Grains/ Spike	Grain Yield/ Plant (g)	Biological Yield/ Plant (g)	harvest Index	1000 Grain Weight
Genetic components												
$\hat{D}$	NC	F ₁	11.93	0.86	175.06*	4.83	1.61	0.99	0.33	0.11	1.33	0.56
	WS	F ₁	12.65	1.74	163.40	6.50	2.07	1.06	0.10	0.10	0.41	2.36
$\hat{F}$	NC	F ₁	2.04	1.98	12.37	11.14	2.36	2.29	0.28	0.25	2.02	1.29
	WS	F ₁	19.67	4.03	41.57	15.00	-0.56	2.46	0.10	0.23	0.84	5.45
$\hat{H}_2$	NC	F ₁	8.05	1.83	30.10	10.28	15.42	2.11	1.02	0.23	8.06	1.19
	WS	F ₁	23.74	3.71	59.45	13.84	9.44	2.27	1.20	0.22	19.48	5.02
$\hat{H}_1$	NC	F ₁	8.81	1.55	28.51	8.74	11.42*	1.79	0.92	0.19	6.61	1.01
	WS	F ₁	15.17	3.16	45.40	11.76	7.26	1.93	1.08	0.18	17.17*	4.27
$\hat{h}_2$	NC	F ₁	0.03	1.04	0.65	5.85	6.87	1.20	0.05	0.13	1.12	0.68
	WS	F ₁	20.90	2.11	0.37	7.87	1.20	1.29	0.024	0.12	1.04	2.86
$\hat{E}$	NC	F ₁	0.47	0.26	0.62	1.46	0.57	0.30	0.12	0.03	0.62	0.17
	WS	F ₁	0.39	0.53	0.52	1.96	0.59	0.32	0.07	0.03	0.60	0.71
$(\hat{H}_2/\hat{D})^{0.5}$	NC	F ₁	0.86	1.46	0.41	1.46	3.09	1.46	1.76	1.51	2.47	1.46
	WS	F ₁	1.37	1.46	0.60	1.46	2.13	1.46	3.50	1.46	6.89	1.46
$(\hat{H}_2/4\hat{H}_1)$	NC	F ₁	0.278	0.212	0.237	0.212	0.185	0.219	0.226	0.212	0.205	0.212
	WS	F ₁	0.16	0.21	0.19	0.212	0.192	0.212	0.225	0.215	0.220	0.212
$\frac{(4\hat{D}\hat{H}_1)^{0.5} + F}{(4\hat{D}\hat{H}_1)^{0.5} F}$	NC	F ₁	1.221	8.557	1.186	8.557	1.621	8.560	1.632	8.560	1.897	8.557
	WS	F ₁	3.624	8.557	1.535	8.557	0.882	8.557	1.327	8.557	1.351	8.557
$\hat{h}^2/\hat{H}_2$	NC	F ₁	0.78	1.14	1.09	0.08	0.60	0.98	0.05	0.09	0.17	0.06
	WS	F ₁	1.38	0.25	0.01	0.06	0.16	0.60	0.06	0.25	0.06	0.04
R	NC	F ₁	0.95	0.48	0.95	0.08	0.13	0.35	0.65	0.22	0.59	0.19
	WS	F ₁	0.62	0.80	0.91	0.26	0.72	0.29	0.37	0.19	-0.41	0.28

*, significantly at 5% probability levels.

Table-3 : Contd.....

Characters	Environment	Generation	Shoot Length (cm)	Root Length (cm)	Exised Leaf Water Retination (%)	Proline Content Mg/gm	Chlorophyll Content	Relative Water Content (%)	Flag Leaf Area	Days to Maturity	Mem-brane Stability Index	Gluten Percenta - ge	Ash Content (mg)	Drought Suscep-tibility Index
Genetic components														
$\hat{D}$	NC	F ₁	38.67	12.77	9.46	3.15	110.15	28.65	0.55	5.24	3.59	1.56	126.38*	—
	WS	F ₁	15.18	43.62	2.87	3.23	35.61	38.09	0.12	4.51	2.25	3.54	1.04	0.27
$\hat{F}$	NC	F ₁	5.38	29.46	12.35	7.28	74.94	66.11	-1.95	12.09	3.69	3.60	46.63	—
	WS	F ₁	35.02	20.10	1.30	7.45	20.83	87.88*	0.27	0.77	5.20	4.96	2.40	0.20
$\hat{H}_2$	NC	F ₁	148.83*	27.18	37.44*	6.72	366.14*	60.99	27.85	11.15	16.64	3.32	44.46	—
	WS	F ₁	32.31	250.75*	18.38	6.87	209.75	81.07	0.25	23.66*	4.80	12.14	2.21	0.96
$\hat{H}_1$	NC	F ₁	116.24	23.10	30.68	5.71	324.26	51.83	19.91	9.48	13.40	2.82	34.03	—
	WS	F ₁	27.46	205.74	14.64	5.84	156.55	68.90	0.22	22.25	4.08	9.13	1.88	0.72
$\hat{h}_2$	NC	F ₁	41.86	15.46	0.01	3.82	9.23	34.69	2.41	6.34	-0.13	1.89	39.43	—
	WS	F ₁	18.38	-0.30	3.76	3.91	49.50	46.12	0.14	-0.19	2.73	0.03	1.26	0.07
$\hat{E}$	NC	F ₁	1.09	3.85	0.39	0.95	4.00	8.64	0.22	1.58	0.51	0.47	0.41	—
	WS	F ₁	4.58	2.73	0.44	0.97	6.50	11.48	0.04	0.55	0.68	0.11	0.31	0.15
$(\hat{H}_2 / \hat{D})^{0.5}$	NC	F ₁	1.96	1.46	1.99	1.46	1.82	1.47	7.11	1.46	2.15	1.46	0.59	—
	WS	F ₁	1.46	2.40	2.53	1.48	2.43	1.46	1.46	2.29	1.46	1.85	1.46	1.89
$(\hat{H}_2 / 4\hat{H}_1)$	NC	F ₁	0.195	0.212	0.205	0.212	0.221	0.219	0.179	0.212	0.201	0.212	0.191	—
	WS	F ₁	0.205	0.212	0.199	0.265	0.187	0.212	0.188	0.212	0.235	0.210	0.188	0.272
$\frac{(4\hat{D}\hat{H}_1)^{0.5} + F}{(4\hat{D}\hat{H}_1)^{0.5} F}$	NC	F ₁	1.073	8.559	1.977	8.557	1.459	8.557	0.601	8.557	1.627	8.557	1.903	—
	WS	F ₁	1.213	8.557	1.197	8.557	1.274	8.559	1.478	8.557	1.077	8.553	2.219	8.557
$\hat{h}^2 / \hat{H}_2$	NC	F ₁	0.36	0.35	0.43	0.40	1.26	0.85	0.12	0.09	-0.01	0.21	1.16	—
	WS	F ₁	0.19	0.53	0.26	0.73	0.32	0.36	0.17	-0.01	0.45	0.10	1.29	0.09
R	NC	F ₁	0.50	0.41	-0.11	0.13	-0.02	0.44	0.89	0.54	0.46	-0.40	0.97	—
	WS	F ₁	0.60	0.62	-0.49	0.39	-0.37	0.29	0.65	0.64	0.35	-0.23	0.93	0.32

*, significantly at 5% probability levels.

stability index showed positive response in terms of tolerance (low DSI values). So, these traits could be taken as selection parameters for breeding wheat genotypes suitable for drought stress conditions. From the past study, it may be concluded that grain yield is related with various morphological, physiological parameters and yield components; such as plant height, spike length, number of spikelet per spike, number of grains per spike, biological yield per plant, harvest index, 1000-grain weight, grain yield per plant, flag leaf area and days to maturity, chlorophyll content, relative water content, proline content, drought susceptibility index etc. play important role to improve yield potential and stability under normal and stress conditions. Breeding for yield related components and the modification of the plant architecture offer possibilities to develop plant type for enhanced grain yield under diverse environments. In the present study, grain yield per plant was positive and significantly associated with number of spikelet per spike, number of grains per spike, biological yield per plant, harvest index, 1000-grain weight, flag leaf area and days to maturity in both the environment. Therefore, these traits should be improved so that yield can be improved in rainfed (water stress) conditions as well as normal sown conditions.

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To Study the Profile of SHGs Members in Bikaner District of Rajasthan

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Abstract

The Self Help generally refers to groups that involve people who have similar needs, and are operated on informal and nonprofit basis. SHG are affinity groups of rural poor voluntary formed to save and mutually agree to contribute to a common fund to enable the lending of small interest-bearing loans to their members. In India, many SHGs are 'linked' to banks for the delivery of micro credit. SHGs are member-based microfinance intermediaries inspired by external technical support that lie between informal financial market actors like moneylenders, collectors, and formal actors like microfinance institutions and banks on the other. This can be possible only with the help of SHGs. Self Help Groups (SHGs) are considered as one of the means to empower women by providing easy access to credits. It is believed that easy access to credit would enable women to participate in income generating activities by establishing microenterprises and in the process enhance wellbeing in the households. The ability to generate own income would perhaps help women to derive more power and choices related to household decision making in consumption, education and health related matters, and also open up opportunities to take part in other socio-economic activities. The study was conducted in Bikaner district of Rajasthan. There are seven panchayat samities in Bikaner district. These are namely – Bikaner, Lunkaransar, Sri Dungargarh, Khajuwala, Kolayat, Nokha and Panhu. Kolayat panchayat samiti was selected purposively because maximum no. of SHGs (794) are running there. There are total 37 Gram panchayat which comes under kolayat panchayat samiti of Bikaner district. For study purpose, a total of 10 Gram panchayat were selected randomly. From each selected Gram panchayat 1 SHGs was selected. Therefore total 10 SHGs were selected present investigation. After that 12 members from each SHG were selected for the study. Majority of members reported noticeable change to significant change due to membership in SHGs regarding income level, credit availability, access to formal institutions, saving habit, Income generating assets, Monthly expenditure, Employment throughout year, Cost of credit. Socio economic impact of SHGs on members was positive.

Key words : Self Help Groups, women

Introduction

In India, many SHGs are 'linked' to banks for the delivery of micro credit. SHGs are member-based microfinance intermediaries inspired by external technical support that lie between informal financial market actors like moneylenders, collectors, and formal actors like microfinance institutions and banks on the other. This can be possible only with the help of SHGs.

A self-help group consists of 10-20 members drawn from a relatively homogeneous economic class (i.e. poor), self-selected on the basis existing affinities and mutual trust; members meet regularly at a fixed time and place and pool their savings into a common fund from which they take need based loans. SHG has become a ladder for the poor to bring them up not only economically but also socially, mentally and attitudinally. One of the primary benefits of participation in a SHG is the opportunity to

save regularly, access formal savings institutions and participate in the management of these savings. The group develops its own rules and regulations and sanctions for violations; the meeting procedures and processes, leadership change norms, intensive training and handholding, are designed to enable SHGs to function in a participatory and democratic manner.

Research Design

The study was conducted in Bikaner district of Rajasthan. The area was well known to the researcher and was easily accessible. There are seven Panchayat samities in Bikaner district. These are namely – Bikaner, Lunkaransar, Sri Dungargarh, Khajuwala, Kolayat, Nokha and Panchu. Kolayat panchayat samiti was selected purposively because maximum no. of SHGs (794) are running there.

Selection of self help group : For selection of SHGs one SHGs was selected from each selected Gram panchayat by simple random (chit) sampling. There for total 10 SHGs was selected for present investigation.

Selection of respondents : The respondents for the present study consists of members of SHGs from selected 10 gram panchayat, 12 members from each SHG were selected for the study. Hence, the total sample constitutes 120 SHG members.

Research procedure

Research tool developed by investigator : The interview schedule was used to collect required information from the respondents. The tool was consisted of following sub-parts :

(a) General information : This will include the information about the age, caste, education, family type, family size, family occupation, monthly income, land holding, marital status, training attending, saving in SHGs, and utilization pattern of credit of individual respondents

(b) Specific information : A detailed interview was prepared keeping in view of the objective of the study :

To analyze the impact of self-help group on economic empowerment-It this section prepared a questioner related impact of SHGs in economic empowerment to women their monthly income, monthly income before and after joining of SHGs, financial position and socio – economic empowerment.

To identify the constraints faced by SHGs members-In this section a questioner was prepared related constraints faced by SHGs members the constraints categorized personal .

Result and Discussion

The finding related to the profile of the respondents. It include age, caste, education, type of family, family size,family occupation, monthly income land holding, marital status , training attending saving in SHG, utilization pattern of credit.

(1) Age

Table-1 : Distribution of the respondents according to Age. n=120

S. No.	Category	(f)	(%)
1.	Young (16-32 year)	8	6.7
2.	Middle (32-48 year)	57	47.5
3.	Old (Above 48 year)	55	45.8

The data in table-1 reveals that majority of the respondents were from middle age category (47.5%) followed by old age category (45.8) and only (6.7%) respondents were from young age category.

(2) Caste

Table-2 : Distribution of the respondents according to their Caste. (n=120)

S. No.	Category	(f)	(%)
1.	General caste	102	85.0
2.	Schedule caste	9	7.5
3.	Schedule tribe	3	2.5
4.	Other backward caste	6	5.0

Table-2 shows that most of the respondents were from general caste (85.0%) ,followed by the schedule caste (7.5%), other backward caste (5%).Only 2.5 per cent respondents were the found in schedule tribe caste category.

(3) Education

Table-3 : Distribution of the respondents according to their Education. (n =120)

S. No.	Category	(f)	(%)
1.	Illiterate	8	6.67
2.	Can read only	17	14.17
3.	Can read and write	11	9.17
4.	Primary	43	35.8
5.	Middle	21	17.5
6.	High and Above	20	16.67

Table-3 reveals that majority of the respondents were from primary (35.8%), followed by middle (17.5%), high and above (16.67%), can read only(14.17%),can read and write(9.17%),only (6.67%) respondents were the found illiterate category.

(4) Type of family

Table-4 : Distribution of the respondents according to their Type of Family. (n = 120)

S. No.	Category	(f)	(%)
1.	Nuclear	76	63.3
2.	Joint	44	36.7

Table-4 reveals the most of the respondents belonged to nuclear family (63.3%), followed by joint family (36.7%).

(5) Family size

Table-5 : Distribution of the respondents according to the Family Size. (n=120)

S. No.	Category	Frequency	Percentage
1.	Small (up to 4 member)	61	50.8
2.	Medium (5 to 8 member)	35	29.2
3.	Large (Above 8 member)	24	20.0

Table-5 the indicate that most of the respondent were from small family (50.8%), followed by medium family (29.2%), Large family (20%) category.

(6) Family occupation**Table-6 : Distribution of the respondents according to Family occupation. (n = 120)**

S. No.	Category	(f)	(%)
1.	Agriculture	40	33.3
2.	Service	47	39.2
3.	Artisan	13	10.8
4.	Farm labour	20	16.7

Table-6 reveals that majority of the respondents were from service (39.2%), followed by agriculture (33.3%), farm labour (16.7%), only (10.8%) artisan category.

(7) Land holding**Table-7 : Distribution of the respondents according to Land holding. (n = 120)**

S. No.	Category	(f)	(%)
1.	Landless (No land)	32	26.67
2.	Marginal (Below 2 hectare)	45	37.5
3.	Small (land 2 to 4 hectare)	25	20.8
4.	Large (land more than 4 hectare Above)	18	15.0

Table-7 show that most of the respondents belonged to marginal land holding category (37.5%), followed by landless category (26.67%), small land holding category (20.8%). Only (15.0%) respondents were from large land holding category.

(8) Marital status**Table-8 : Distribution of the respondents according to Marital status. (n=120)**

S. No.	Category	(f)	(%)
1.	Married	81	67.5
2.	Unmarried	16	13.3
3.	Widow	13	10.8
4.	Divorced	10	8.3

Table-8 shows that most of the respondents belonged to married category (67.5%) followed by unmarried (13.3%), widow (10.3%). Only (8.3%) divorced category.

(9) Saving**Table-9 : Distribution of the respondents according to their Saving. (n=120)**

S. No.	Category	(f)	(%)
1.	Low	11	9.2
2.	Medium	90	75.0
3.	High	19	15.8

Table-9 show that majority the respondents were fall in medium saving category (75.0%) followed by high saving category (15.8%). Less than 10 per cent of the respondents were for in low saving category (9.2%).

(10) Training attended**Table-10 : Distribution of the respondents according to Training attended in SHG. (n = 120)**

S. No.	Category	(f)	(%)
1.	Yes	64	53.3
2.	No	56	46.7

Table-10 predicts that most of the respondents had attended training programme of SHGs (53.3%), followed by never attended any training programme of SHG (46.7%).

(11) Utilization pattern of credit**Table-11 : Distribution of the respondents according to Utilization pattern of credit. (n=37)**

Category	(f)
(A) Productive	22 (59.46)
(a) Live stock	7 (18.91)
(b) Crop production	10 (27.02)
(c) Development of micro enterprises (stitching, parlor, Badi making, Papad making)	5 (13.51)
(B) Unproductive	15 (40.54)
(a) Medical check up	2 (5.40)
(b) Construction work	3 (8.10)
(c) Marriage	4 (10.81)
(d) Repayment of past loans	6 (16.21)

Table-11. reveals that majority of the respondents used the credit for productive purpose i.e. 27.2 per cent used for crop production, followed by (18.91%) respondents used for live stock and only (13.51%) respondents used for development of micro enterprises category.

Table-11 further reveals that respondents used the loan for unproductive purpose i.e. 16.21 per cent used for respondents used for repayment of past loan, followed by (10.81%) respondents used for marriage purpose, (8.10%) respondents used for construction work and only (5.40%) respondents used for medical checkup.

Major finding of the profile of the respondents is that majority of rural women belonged to middle age group, general caste, primary education, nuclear family, small size up to 4 members, family occupation is services, marginal land holding, married women, medium saving category, attending training, and utilization pattern of credit was for productive purpose.

Conclusions

On the basis of above findings it can be concluded that majority of the members belonged to middle age category, general caste, had education up to primary level, nuclear and small family size, service as family occupation, marginal land holding. Most of the members were attended training regularly, and used loan for productive purpose.

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Evaluation of Micronutrient Neem Cake and Plant Growth Promoting Rhizobacteria (PGPR) on Soil Properties and Yield of Maize (*Zea mays* L.)

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Abstract

The experiment conducted during the kharif season of 2016-17 aimed to assess the impact of micronutrient neem cake and Plant Growth Promoting Rhizobacteria (PGPR) on soil properties and maize (*Zea mays* L.) yield. The researchers used a 3x3 randomized block design, with three levels of NPK (Nitrogen, Phosphorus, and Potassium) and Zinc and three levels of neem cake and PGPR. The treatments were as follows: NPK and Zinc at 0%, NPK and Zinc at 50%, NPK and Zinc at 100%, Neem cake and PGPR at 0%, Neem cake and PGPR at 50%, Neem cake and PGPR at 100%, NPK, Zinc, Neem cake, and PGPR at 0%, NPK and Zinc at 100%, Neem cake, and PGPR at 100%. Among all the treatments, the best-performing one was T₈ - {I₂ + N₂}, which consisted of 100% NPK and Zinc, along with 100% neem cake and PGPR. This treatment showed a significant increase in the enrichment of soil fertility status, with higher levels of N, P, K, and Zinc. The combination of neem cake and PGPR resulted in a slight decrease in pH (7.08) and an increase in electrical conductivity (EC) (0.36 dSm⁻¹), organic carbon (OC) content (0.67%), pore space (54.22%), water holding capacity (55.92%), and available N (311.60 kg ha⁻¹), P (28.27 kg ha⁻¹), K (182.54 kg ha⁻¹), and Zinc (0.52 ppm) in the soil. The treatment T₈ also showed a significant increase in nitrogen, phosphorus, potassium, and zinc levels, leading to the highest cost benefit ratio of 1:2.55, the maximum net return of 51819, and the highest maize yield of 44.60 quintals per hectare (q ha⁻¹). These results indicate that the combination of 100% NPK and Zinc with 100% neem cake and PGPR had a positive impact on soil fertility and nutrient availability, resulting in increased maize yield and economic benefits for the farmers. The use of neem cake and PGPR as soil amendments could potentially be a sustainable and cost-effective approach to enhance crop productivity and soil health in maize cultivation during the kharif season.

Key words : Soil nutrients, yield attributes, Neem cake, PGPR and micronutrient, NPK and maize.

Introduction

Maize (*Zea mays* L.) holds significant importance in the world agricultural economy, serving both as a staple food for humans and as fodder and feed for cattle and poultry. The composition of maize grain is rich in various nutrients, including 72% starch, 10% protein, 4.8% oil, 5.8% fiber, 3.0% sugar, and 1.7% ash. Additionally, it contains essential vitamins such as vitamin A, vitamin E, nicotinic acid, and riboflavin, making it a nutritionally valuable crop. Compared to rice, maize also has higher phosphorus content. Moreover, it is utilized in various industries like textiles, starch, and dye due to its versatility (Rai 2006).

India, being a significant maize-producing country, cultivates maize over an area of 9.2 million hectares, producing 24.17 million tonnes with a productivity of 2.56 tonnes per hectare (DMR, Annual report 2014-15). Uttar Pradesh, one of the prominent maize-producing states,

accounts for 0.71 million hectares of maize cultivation and a production of 1275 million tonnes (Department of Agriculture, Govt. of UP 2014-15).

Zinc is an essential micronutrient vital for normal plant growth and development. However, excessive zinc can disrupt electron transport, membrane permeability, and nutrient uptake and translocation within plants (Wang *et al.* 2009b).

In recent years, the use of Plant Growth Promoting Rhizobacteria (PGPR) has gained attention for enhancing crop yield and improving agricultural sustainability. PGPR play significant roles in increasing nitrogen uptake through biological nitrogen fixation, phytohormone synthesis, mineral solubilization (e.g., phosphorus), and siderophore production, which enhances iron availability to plant roots (Ahemad and Kibret *et al.* 2014).

Neem cake, a by-product of neem seed processing,

possesses various beneficial properties without any toxic reactions. It is utilized in plant protection and management due to its insect growth regulator (IGR) properties, as well as its ability to control nematodes and fungi. Neem cake is used in various forms, such as neem insecticide, neem pesticide, neem pest fumigant, neem fertilizer, neem manure, neem compost, neem urea coating agent, and neem soil conditioner. Its composition includes 5.2% nitrogen, 1.0% phosphorus, and 1.4% potassium. Neem cake also acts as a nematocide and a nitrogen inhibitor, slowing down nitrification and supplying available nitrogen to the soil over an extended period (Katyayan, 2012).

In the context of improving soil properties and maize yield, the present study investigated the combined application of micronutrient-enriched neem cake and PGPR, exploring their potential synergistic effects on soil fertility and crop productivity. The results indicated that the treatment with 100% NPK and Zinc, along with 100% neem cake and PGPR ($T_8 - \{I_2 + N_2\}$), demonstrated the most significant improvements in soil properties and yielded the highest maize crop productivity, highlighting the potential benefits of this integrated approach for sustainable agriculture.

Materials and Methods

A field experiment was conducted at the research farm of the Department of Soil Science and Agricultural Chemistry, SHUATS Allahabad, Uttar Pradesh, India. The soil in the experimental area belonged to the Inceptisol order and had an alluvial nature.

The experimental design utilized for statistical analysis was a 3x3 randomized block design with three factors: NPK (Nitrogen, Phosphorus, and Potassium) and Zinc, each with three levels (0, 50, and 100%), and Neem cake and PGPR, each with three levels (0, 50, and 100%). The sources of NPK, Zinc, Neem cake, and PGPR used were Urea, DAP (Diammonium phosphate), MOP (Muriate of potash), $ZnSO_4$ (Zinc sulfate), Neem cake, and Azotobacter, respectively.

Physical and chemical analyses of the soil were performed before the experiment. The physical analysis included determining bulk density (1.42 Mg m^{-3}), particle density (2.67 Mg m^{-3}), and percentage pore space (43.58%) using the Bouyoucos hydrometer method (Muthuaval *et al.*, 1992). Water holding capacity (47.58%) was determined by the cylinder method (Black, 1965).

The chemical analysis of the soil included determining p^H (7.37) and electrical conductivity (EC) (0.17 dSm^{-1}) using standard methods (Jackson, 1958). Organic carbon (OC) content (0.58%) was estimated using the Walkley and Black method (1947). Available

nitrogen ($290.62 \text{ kg ha}^{-1}$) was determined using the alkaline permanganate method (Subbiah and Asija, 1956). Available phosphorus (22.53 kg ha^{-1}) was analysed using Olsen's colorimetric method (Olsen *et al.*, 1954), while available potassium ($156.47 \text{ kg ha}^{-1}$) was determined using the flame photometric method (Blancher, 1986). Available zinc content (0.30 ppm) was analysed following the method by Lindsay and Norvell (1978).

The experiment involved the rearrangement of the soil properties through the application of various treatments, including different levels of NPK, Zinc, Neem cake, and PGPR. The study aimed to investigate the combined effects of these treatments on soil properties and maize yield in the experimental plot. Subsequent measurements and observations were made during the growing season, and data were collected for statistical analysis to evaluate the impact of the different treatment combinations on soil fertility and crop productivity.

Results and Discussion

Table-2 and Figures-1 and 2 illustrate the interaction effects of NPK, zinc, neem cake, and PGPR on the physical and chemical properties of post-harvest soil. The study found that the combination of NPK, zinc, neem cake, and PGPR had significant effects on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), and pore space (%), but no significant effect on water holding capacity (%). The highest particle density and bulk density were observed in treatment $T_0 \{I_0 + N_0\}$ [$@ 0\%$ NPK, zinc + $@ 0\%$ neem cake and PGPR], with values of 2.55 Mg m^{-3} and 1.39 Mg m^{-3} , respectively. The treatment $T_8 \{I_2 + N_2\}$ [$@ 100\%$ NPK, zinc + $@ 100\%$ neem cake and PGPR] exhibited the highest pore space (54.22%) and water holding capacity (55.92%). These findings are consistent with previous studies by Pratap *et al.* (2016), Brar *et al.* (2015), and Awad *et al.* (2014), which also reported positive effects of soil organic matter on physical properties, as supported by Bharti and Sharma (2017), Prajapati and Swaroop (2018), Choudhary *et al.* (2018), and Sengupta *et al.* (2020).

Regarding the chemical properties of the post-harvest soil, the study noted that the highest p^H (7.32) was observed in treatment $T_0 \{I_0 + N_0\}$ [$@ 0\%$ NPK, zinc + $@ 0\%$ neem cake and PGPR], while the lowest p^H (7.08) was recorded in treatment $T_8 \{I_2 + N_2\}$ [$@ 100\%$ NPK, zinc + $@ 100\%$ neem cake and PGPR]. Comparing these values with the p^H of the pre-sowing soil sample (7.37), there was a slight decrease in p^H after crop harvest. The application of increasing doses of NPK, zinc, and neem cake with PGPR led to a mild decrease in soil p^H , likely due to increased crop growth and respiration, which produces carbon dioxide that reacts with water to form carbonic acid in the soil. The chemical properties of

Table-1 : Treatment combination of NPK, Zinc, Neem cake and PGPR.

Symbol	Treatment details
T ₀	: Control
T ₁	: (T ₁ = I ₀ + N ₁) (@ 0% NPK, Zinc + 50% Neem cake and PGPR)
T ₂	: (T ₂ = I ₀ + N ₂) (@ 0% NPK, Zinc + 100% Neem cake and PGPR)
T ₃	: (T ₃ = I ₁ + N ₀) (@ 50% NPK, Zinc + 0% Neem cake and PGPR)
T ₄	: (T ₄ = I ₁ + N ₁) (@ 50% NPK, Zinc + 50% Neem cake and PGPR)
T ₅	: (T ₅ = I ₁ + N ₂) (@ 50% NPK, Zinc + 100% Neem cake and PGPR)
T ₆	: (T ₆ = I ₂ + N ₀) (@ 100% NPK, Zinc + 0% Neem cake and PGPR)
T ₇	: (T ₇ = I ₂ + N ₁) (@ 100% NPK, Zinc + 50% Neem cake and PGPR)
T ₈	: (T ₈ = I ₂ + N ₂) (@ 100 % NPK, Zinc + 100% Neem cake and PGPR)

Table-2 : Response of Micronutrient Neem Cake and PGPR on Post-harvest soil properties of Maize (*Zea mays* L.).

Treatment Combination	Bd (Mg m ⁻³)	Pd (Mg m ⁻³)	WRC (%)	Pore space (%)	p ^H	EC (dSm ⁻¹)	°C (%)	N (Kg ha ⁻¹)	P ₂ O ₅ (Kg ha ⁻¹)	K ₂ O (Kg ha ⁻¹)	Zn (ppm)
T ₀ (I ₀ +N ₀)	1.39	2.55	48.38	44.81	7.32	0.32	0.53	286.19	20.69	152.19	0.18
T ₁ (I ₀ +N ₁)	1.37	2.51	50.70	45.61	7.14	0.32	0.57	287.78	21.74	154.13	0.33
T ₂ (I ₀ +N ₂)	1.35	2.52	51.84	50.79	7.26	0.33	0.57	290.67	22.79	155.60	0.47
T ₃ (I ₁ +N ₀)	1.33	2.48	51.14	49.77	7.24	0.34	0.59	293.03	23.56	157.07	0.20
T ₄ (I ₁ +N ₁)	1.29	2.43	52.66	52.90	7.12	0.34	0.61	297.57	24.82	161.17	0.38
T ₅ (I ₁ +N ₂)	1.24	2.45	53.06	51.03	7.18	0.34	0.58	300.65	25.65	166.03	0.45
T ₆ (I ₂ +N ₀)	1.20	2.42	52.93	53.88	7.16	0.35	0.62	303.64	26.44	170.76	0.27
T ₇ (I ₂ +N ₁)	1.15	2.41	54.19	54.12	7.13	0.35	0.61	308.93	25.80	177.78	0.40
T ₈ (I ₂ +N ₂)	1.10	2.39	55.92	54.22	7.08	0.36	0.67	311.60	28.27	182.54	0.52
S. Em (±)	0.013	0.004	3.162	0.542	0.153	0.002	0.018	0.039	0.873	0.242	1.232
C. D. at 5%	0.027	0.009	NS	1.150	NS	0.004	0.037	NS	1.852	0.513	2.611

the post-harvest soil, including electrical conductivity (EC in dSm⁻¹), organic carbon (%), available nitrogen, phosphorus, potassium (kg ha⁻¹), and zinc (ppm), increased significantly with different treatment combinations of NPK, zinc, neem cake, and PGPR. Specifically, the maximum values recorded for EC, organic carbon, available nitrogen, phosphorus, potassium, and zinc were 0.36 dSm⁻¹, 0.67%, 311.60 kg ha⁻¹, 28.27 kg ha⁻¹, 182.54 kg ha⁻¹, and 0.52 ppm, respectively. Available zinc (ppm) and p^H, on the other hand, were found to be non-significant, while available organic carbon (%), EC, nitrogen, phosphorus, and potassium were significant. The increase in soil organic carbon was attributed to the direct addition of organic carbon through FYM, as well as enhanced root development and root exudates resulting from the application of organic and inorganic fertilizers. Furthermore, the combined use of organic and inorganic nitrogen amendments was found to significantly increase cation exchange capacity (CEC) of the soil, leading to improved nutrient availability and uptake by plants, promoting higher vegetative growth, as observed in studies by Parihar (2002), Bharti and Sharma (2017), and Prajapati and Swaroop (2018). In summary, the study demonstrated the significant influence of various treatment combinations on both physical and chemical

properties of post-harvest soil. The findings support the beneficial effects of soil organic matter and the combined application of organic and inorganic fertilizers in improving soil health and nutrient availability for enhanced crop growth.

Conclusions

In conclusion, the trial demonstrated that various levels of NPK, zinc, neem cake, and PGPR used in the experiment had a significant impact on maize (*Zea mays* L.) var. hybrid (SMH-3031) production and soil physical and chemical properties. Among the treatment combinations tested, treatment T₈ - (N₁₂₀ P₆₀ K₆₀ Zn₂₀ kg ha⁻¹ + NC₁₀ q ha⁻¹ PGPR 20 g 1 kg seed) stood out as the best-performing treatment. It resulted in highest benefit of 51,819.00 and had highest cost-benefit ratio of 1:2.55. This treatment is recommended for profitable maize production, as it not only led to higher yields but also had positive effects on soil health and fertility. The integrated nutrient management approach, which combines organic and inorganic fertilizers along with PGPR, proved to be beneficial in sustaining soil health and enhancing maize productivity. In summary, the study highlights the importance of using a well-balanced combination of nutrients and soil amendments to achieve optimal crop yields while simultaneously maintaining and improving soil

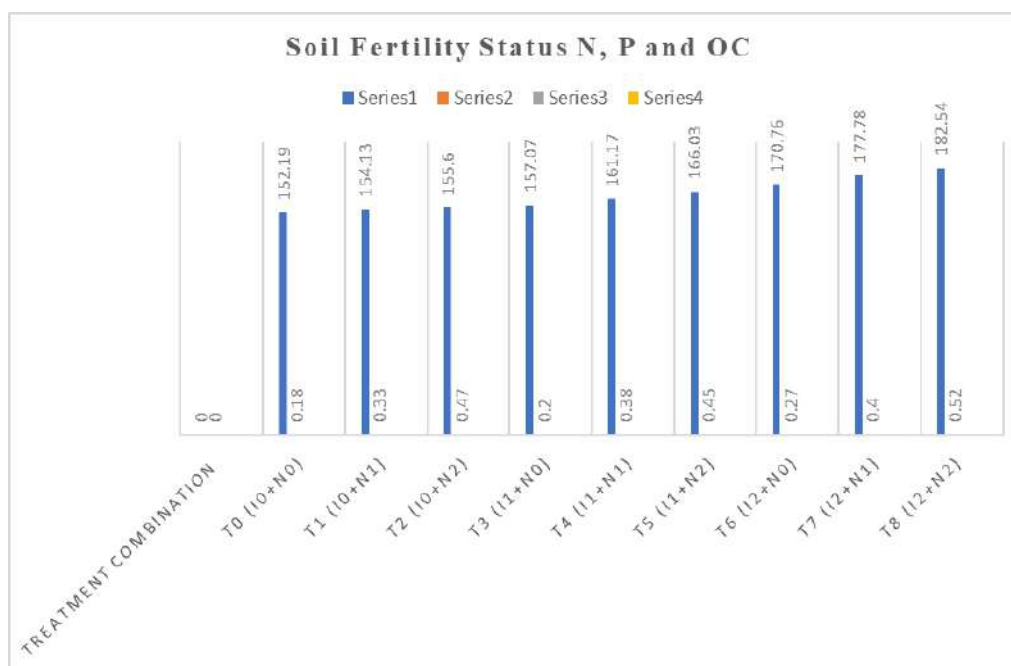


Fig-1 : Response of Micronutrient Neem Cake and PGPR on Post-harvest soil properties of status organic carbon, nitrogen and phosphors.

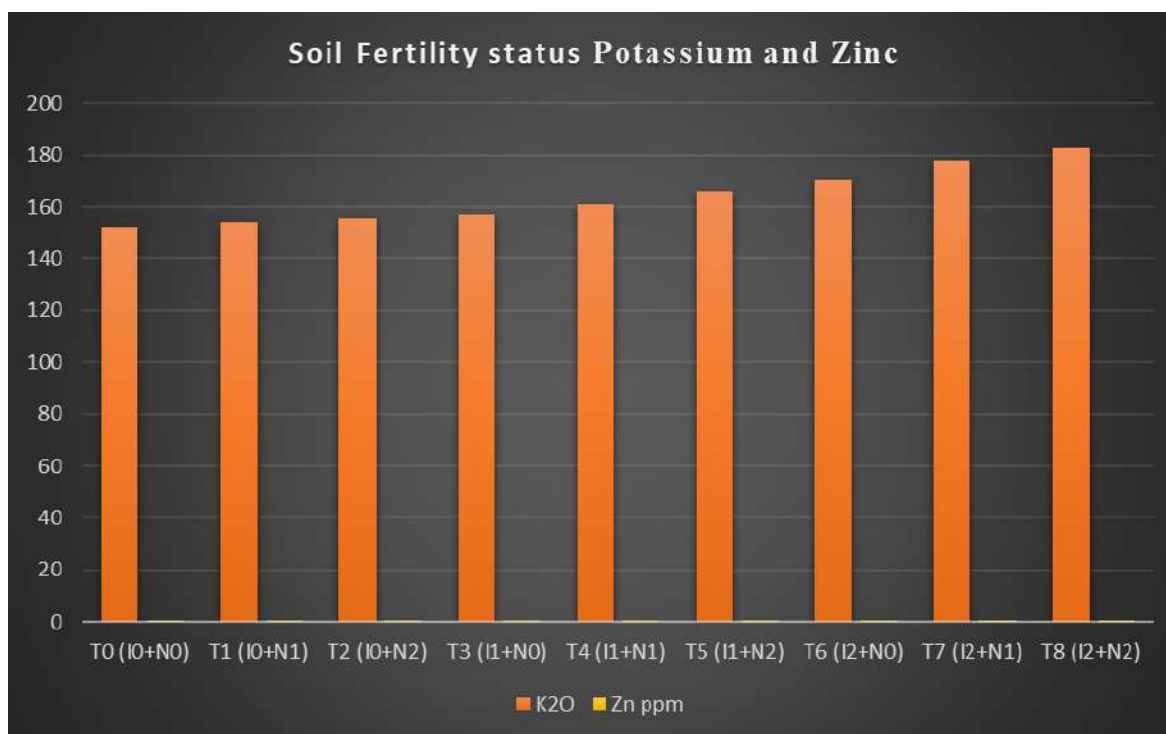


Fig-2 : Response of Micronutrient Neem Cake and PGPR on Post-harvest soil properties of status potassium and zinc.

quality. By adopting integrated nutrient management practices, farmers can achieve profitable maize production and contribute to sustainable agricultural practices. Further research and adoption of such practices can pave the way for improved agricultural productivity and environmental sustainability in maize cultivation.

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Qualitative Estimation of Sorgoleone from Phule Suchitra Cultivar of Sorghum (*Sorghum bicolor* L.)

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Abstract

Stressed sorghum material from the Phule Suchitra cultivar was subjected to qualitative analysis to determine the presence of sorgoleone. The sorghum material was finely chopped and subjected to sorgoleone extraction using both a methanol-based solvent and an aqueous medium. This extraction process was conducted on a hot water bath until complete dryness was achieved. Following extraction, sample solutions derived from the sorghum material were subjected to thin layer chromatography for the purpose of assessing sorgoleone's presence. The identification of sorgoleone was accomplished by comparing the relative front ($R_f = 0.24$) obtained in this study with the relative front values obtained in previous researches. The finding of this study suggests an accumulation of sorgoleone in stressed sorghum plants, particularly those cultivated in rain-fed areas. This finding holds significant implications for sustainable weed management strategies. The sorghum material containing sorgoleone exhibits potential as an environmentally sustainable tool for weed control, offering an alternative to potentially harmful chemical herbicides. This research underscores the value of exploring natural plant compounds for effective and eco-friendly approaches to agricultural practices.

Key words : Sorgoleone, thin layer chromatography, relative front, sorghum allelopathy, solvent extraction.

Introduction

The allelopathic potential of sorghum has been extensively studied and documented in the various literatures. This phenomenon has significant implications for various cropping systems. Sorghum exerts its allelopathic influence through the synthesis and release of various allelochemicals. The primary allelochemicals of significance in sorghum are hydrophobic p-benzoquinone (sorgoleone), phenolics, and cyanogenic glycoside. These compounds play a central role in sorghum's allelopathic effects on surrounding vegetation. (Weston *et al.*, 2013). Sorgoleone stands out as the most potent allelochemical exuded by sorghum roots. Specialized root hair cells in sorghum plants serve as the main producers of sorgoleone (Weston *et al.*, 2012; Netzly and Butler, 1986).

The phytotoxic mechanisms induced by sorgoleone involve the inhibition of photosynthesis and oxygen evolution through interactions with components of photosystem II (Rimando *et al.*, 1998). Sorgoleone specifically inhibits the chloroplast electron-transport chain, acting in a similar way as triazine herbicides such as atrazine (Nimbal *et al.*, 1996). The underlying mechanisms seem to be the inhibition of electron transport between plastoquinone compounds in photosystem II (PS II) by binding to the Plastoquinone B (PQ-B) electron acceptor at the D1 protein (Mets and Thiel, 1989; Gonzalez *et al.*, 1997). Sorgoleone also disrupts the biosynthesis of carotenoids by inhibiting

hydroxyphenylpyruvate dioxygenase (HPPD), resulting in foliar bleaching (Meazza *et al.*, 2002). Inhibition of H⁺-ATPase in plant roots by sorgoleone decreases water uptake by plants and causes ionic imbalance (Hejl and Koster, 2004).

The potent weed-suppressive capability of sorghum, coupled with the phytotoxic nature of sorgoleone, presents intriguing prospects for implementing highly efficient biorational strategies in weed management (Maigwaram *et al.*, 2020). It's worth noting that the degree of allelopathic activity exhibited by sorghum can vary considerably based on factors such as cultivar type, environmental conditions, and the specific stage of plant growth. So efforts are made to search presence of sorgoleone in Phule Suchitra cultivar of sorghum through this study.

Materials and Methods

A lab experiment was conducted at Department of Biochemistry, MPKV, Rahuri during 2021 to qualify sorgoleone in Phule Suchitra cultivar of sorghum.

Solvent extraction of Sorgoleone : Stressed sorghum material (shoot along with root) of Phule Suchitra cultivar was collected from Sorghum Improvement Project of MPKV, Rahuri. This material is chopped into small pieces with the help of fodder cutter machine. Twenty five gram of crushed sorghum sample (root and shoot material) was added to 500 ml conical flask to which 250 ml of 80% methanol was added (*i.e.* 1:10 W/V ratio) later, content

Table-1 : Distance travelled by allelochemicals of sorghum on TLC plates and their relative front (R_f) values as influenced by extraction methods.

Allelochemical compounds	Methanol extract				Distilled water extract			
	Sample-I		Sample-II		Sample-I		Sample-II	
	Distance travelled (cm)	R _f value	Distance travelled (cm)	R _f value	Distance travelled (cm)	R _f value	Distance travelled (cm)	R _f value
Allelochemical 'a'	2.3	0.24	2.4	0.25	0.9	0.09	0.9	0.09
Allelochemical 'b'	3.6	0.37	3.9	0.41	1.9	0.20	1.4	0.14
Allelochemical 'c'	4.7	0.49	5.1	0.53	2.6	0.27	2.3	0.24
Allelochemical 'd'	5.4	0.56	5.7	0.60	4.6	0.48	4.4	0.46
Allelochemical 'e'	6.3	0.66	7.1	0.74	5.3	0.55	4.9	0.51

Distance travelled by solvent front was 9.5 cm.

Relative front (R_f) value for sorgoleone is 0.24 (Czarnota et al., 2003)

was refluxed on boiling water bath for 2 hours. After boiling, content was filtered through Whatman No. filter paper. Thereafter filtrate was collected and reduced to dryness. Dried extract was scraped, weighed and preserved for qualitative estimation *i.e.* Thin Layer Chromatography. Again, 25 gram of sorghum sample extracted with distilled water by following same step as that of methanol extraction.

Thin layer chromatography : Thin layer chromatography (TLC) can also be used to separate allelochemicals. TLC consists of a thin layer of stationary phase, such as silica, on an inert solid support. After dotting a sample on the plate, it is placed in a closed tank with a layer of 96% hexane/4% isopropyl alcohol as the developing solvent at the bottom. Capillary action of the solvent transports both solvent and sample upwards over the plate and separation occurs (Van Beek, 1999). Comparison of distances travelled up the plate between the standard and the sample allows for a fast preliminary confirmation of the presence of the compound of interest.

Thin marks are made at the bottom of the TLC plate with the help of a pencil in order to apply sample spots. Later sample solutions were prepared by dissolving dried exudates in methylene chloride (1 mg/100 µl), and 1 µl of sample was applied to the plate on the marked spots. Mobile phase was poured into the TLC chamber. Sample dotted plate was placed in the TLC chamber and closed with a lid; it was kept in such a way that the sample faces the mobile phase. Plates were immersed for the development keeping the sample spots well above the level of the mobile phase. After development of spots plates were taken out and dried, thereafter the sample spots were observed under a UV light (254 nm) chamber. Later relative front of each spot was calculated by taking the ratio of distance travelled by a substance to distance travelled by a solvent front (Czarnota et al., 2003).

Relative front (R_f)

$$= \frac{\text{Distance travelled by the compound (cm)}}{\text{Distance travelled by the solvent front (cm)}}$$

Results and Discussion

Data presented in Table-1 indicated that extraction methods considerably influenced qualitative estimation of allelochemicals present in sorghum material. These results provide a quantitative assessment of the movement of allelochemical compounds in both the methanol and distilled water extracts. R_f values help in identifying and comparing these compounds based on their mobility on the thin layer chromatography plate. The exudates of the sorghum material revealed characteristic TLC profile. The relative front value of 0.24 revealed the presence of sorgoleone in sorghum material taken from the cultivar Phuel Suchitra. The same relative front value for sorgoleone was confirmed by Czarnota et al., 2003.

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Exploitation of Heterosis for Grain Yield and Quality Characters in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract

The current investigation was undertaken to assess of standard heterosis for grain yield and it's related traits in pearl millet using sixty F₁ hybrids generated by utilizing three male sterile lines and twenty restorer lines in line x tester design. Sixty F₁ hybrids were evaluated with three standard check hybrids viz., MPMH-17, RHB-177 and HHB-67 improved, in randomized block design in three replications with two different environments at Agricultural Research Station and College of Agriculture, Bikaner during *Kharif* 2018. Analysis of variance revealed that sufficient variability existed among the crosses. The magnitude of heterosis determines the extent of commercial utilization of hybrid vigour. Significant and positive standard heterosis for grain yield per plant were reported in 13 crosses over the environment in total sixty cross combinations. The best five crosses over the environment for grain yield per plant were ICMA 93333 X BIB-46, ICMA 93333 X BIB-167, ICMA 93333 X BIB-53, ICMA 93333 X BIB-145 and ICMA 93333 X BIB-45. These crosses were also found superior for some other yield attributing traits. The cross that exhibited highest positive standard heterosis was ICMA 97111 X BIB-179 for total number of tillers per plant and number of effective tillers per plant, ICMA 93333 X BIB-147 for ear head length, ICMA 97111 X BIB-53 for ear head diameter and test weight, ICMA 93333 X BIB-145 for dry stover yield per plant, ICMA 97111 X BIB-179 for harvest index. These cross combinations have high heterotic effect on yield and it's attributing traits, so these were considered promising for use in yield improvement.

Key words : Standard heterosis, line x tester analysis, hybrid vigour.

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is popularly known as bulrush, cattail, or spiked millet, bajra, is an important drought tolerant coarse grain cereal crop. It is a major crop in arid and semi arid region of the world. It originated in Sahel zone of West Africa (Vavilov, 1950 and Murdock, 1959). Pearl millet is a diploid (2x=14) annual C₄ crop of family Poaceae (Gramineae), which is robust and quick growing rainy season cereal crop with large stem, leaves, heads, tall and vigour, with very high grain potential.

Pearl millet is not expensive like pearl but definitely has pearl like quality which is beneficial to the body. 100 grams of pearl millet grain contains nutritional values as 360 calories energy, 12g moisture, 12g protein, 5g fat, 2g mineral, 1g fiber, 67g carbohydrate, 42mg Calcium, 242mg phosphorus and 8mg iron (Malik, S., 2015). As a food crop, pearl millet grain own the peaked amount of calories per 100 g (Burton *et al.*, 1972), which is mainly supplied by carbohydrates, fats and proteins (Flech, 1981). It is one of the most important cultivated cereal in the world, ranking after rice, wheat, maize, barely and sorghum in terms of area planted to these crops (Khairwal *et al.*, 2007). Pearl millet is highly cross pollinated crop due to protogynous condition and cyto-genetic male sterility system is available for hybrid seed production on

commercial scale and therefore, heterosis *per se* is of economic importance. Heterosis breeding enables an opportunity for utilization available variability and creating new variability, which is improvement for development of climate resiliant hybrid varieties.

Materials and Methods

The experimental material for the present study was generated by using three male sterile lines (female) and twenty restorer lines (male pollinator) of pearl millet. These lines were crossed in line x tester mating design to develop 60 F₁ hybrids at The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad during *Summer*, 2018. The experiment was laid out in two environments during *Kharif*, 2018, one at research farm, ARS, Beechhwal, Bikaner (E₁), while another at research farm, College of Agriculture, Bikaner (E₂). This region falls under agro-climatic zone 1C of Rajasthan. The average rainfall is about 260 mm, which is mostly received during July-September. Experiment was laid out in randomized block design (RBD) with three replications in all the two environments. The experimental material comprised 60 hybrids and three commercially cultivated hybrids viz, HHB-67 Improved, RHB-177 and MPMH-17 as checks. Each hybrid consisted of two rows of 4 meter length. The spacing between rows was 60 cm and between plants was

15 cm. Observations were recorded on randomly selected five plants in each replication and crosses for days to 50% flowering, days to maturity, plant height (cm), total number of tillers, number of effective tillers, ear head length (cm), ear head diameter (cm), test weight (g), dry stover yield (g), grain yield (g) and harvest index (%). Pooled analysis of variance over the environments was determined for yield and its components. Standard heterosis is estimated for 60 hybrids according to Meredith and Bridge (1972).

Results and Discussion

Analysis of variance stipulated the presence of significant genetic variability among the crosses for all the characters deliberated. Pooled analysis of variance over the environments was determined for yield and its components. Pooled ANOVA indicated that mean sum of squares caused by environments were highly significant for all the characters which disclosed the sufficient diversity among the two environments. Interaction between crosses and environments were found highly significant for all the traits specified the differential retaliations of the genotypes to the environments for all the characters (Table-1). In this experiment, RHB-177 was the best check for days to 50% flowering, days to maturity, plant height, total number of tillers per plant, number of effective tillers per plant, flag leaf area, ear head length, ear head diameter, test weight, dry stover yield per plant, grain yield per plant and harvest index. While, for traits like days to 50% flowering, days to maturity, flag leaf area and ear head diameter, check RHB-177 was *at par* to the next best check, MPMH-17. In the present study RHB-177 was used to compute standard heterosis for all the traits. In line x tester design, standard heterosis was estimated over pooled basis for all the traits studied.

Maximum numbers of crosses with significant desirable standard heterosis were found for ear head diameter, dry stover yield per plant, number of effective tillers per plant, test weight and grain yield per plant. Similar results were also reported by Rathore *et al.* (2004) for grain yield per plant and panicle girth, Bhasker *et al.* (2017) for number of effective tillers per plant.

In extreme adverse condition of western Rajasthan, genotypes with early flowering and maturity have a special significance in crop survival and production. In present experiment, some crosses showed significant negative standard heterosis for days to 50% flowering and days to maturity like ICMA 88004 X BIB-46, ICMA 88004 X BIB-75, ICMA 88004 X BIB-137, ICMA 93333 X BIB-90 and ICMA 93333 X BIB-102 (Table-2).

Significant and positive standard heterosis for grain yield per plant were reported in 13 crosses over the

Table-1 : ANOVA for grain yield per plant and its components based on data pooled over the environments.

Source of variation	d.f.	Mean squares											
		Days to 50% flowering	Days to maturity	Plant height	Total number of tillers/plant	Effective tillers /plant	Flag leaf area	Ear head length	Ear head diameter	Test weight	Dry stover yield/ plant	Grain yield/ Plant	Harvest index
Replication	2	1.7010	2.1613	94.5886	0.1622	0.0790	79.0135	2.4822	0.0252	0.0212	7.2616	7.4672	39.7203*
Environment	1	1.3994**	0.9550*	34.2604*	0.0270	0.1911**	25.7507*	0.0238	0.0006	0.3658	0.1226	0.0046	1.0059
Interactions	2	0.0978	0.1772	7.9664	0.0591	0.0003	4.4986	0.4422	0.0017	0.1905	13.4367	6.2673	3.0574
Overall Sum	5	0.9994	1.1264	47.8741	0.0939	0.0699	38.5550	1.1745	0.0109	0.1578	8.3038	5.4947	17.3123
Treatments	62	16.4168**	19.7130**	300.4670**	1.2720**	1.2425**	638.3500**	19.8230**	0.2372**	1.5431**	397.6010**	97.1884**	40.0534**
Error	310	2.2639	2.7318	84.6592	0.2810	0.1649	93.9694	3.3498	0.0292	0.3212	43.8525	11.7041	11.1846

*, ** Significant at 5% and 1% level of significance, respectively.

Table-2 : Top 3 best performing hybrids based on standard heterosis.

S. No.	Characters	Crosses	Standard heterosis
1.	Days to 50% flowering	ICMA-93333 X BIB-90	-8.42**
		ICMA-88004 X BIB-75	-5.26**
		ICMA-88004 X BIB-46	-4.21**
2.	Days to maturity	ICMA-93333 X BIB-90	-5.76**
		ICMA-88004 X BIB-75	-3.60**
		ICMA-88004 X BIB-46	-2.88**
3.	Plant height	ICMA-97111 X BIB-149	-25.79**
		ICMA-97111 X BIB-167	-24.50**
		ICMA-97111 X BIB-137	-23.89**
4.	Total number of tillers per plant	ICMA-97111 X BIB-179	26.47**
		ICMA-88004 X BIB-170	20.59**
		ICMA-93333 X BIB-145	20.59**
5.	Number of effective tillers per plant	ICMA-97111 X BIB-179	91.43**
		ICMA-97111 X BIB-53	82.86**
		ICMA-97111 X BIB-46	77.14**
6.	Flag leaf area	ICMA-93333 X BIB-46	8.45*
		ICMA-93333 X BIB-145	6.77
		ICMA-93333 X BIB-147	3.45
7.	Ear head length	ICMA-93333 X BIB-147	28.54**
		ICMA-97111 X BIB-90	23.82**
		ICMA-93333 X BIB-90	19.31**
8.	Ear head diameter	ICMA-97111 X BIB-53	29.17**
		ICMA-88004 X BIB-90	22.92**
		ICMA-88004 X BIB-137	22.92**
9.	Test weight	ICMA-88004 X BIB-90	12.02**
		ICMA-97111 X BIB-53	10.93**
		ICMA-97111 X BIB-46	10.38**
10.	Dry stover yield per plant	ICMA-93333 X BIB-145	92.09**
		ICMA-93333 X BIB-147	79.68**
		ICMA-97111 X BIB-46	61.06**
11.	Grain yield per plant	ICMA-93333 X BIB-46	72.46**
		ICMA-93333 X BIB-167	72.18**
		ICMA-93333 X BIB-53	71.06**
12.	Harvest index	ICMA-97111 X BIB-179	17.13*
		ICMA-93333 X BIB-46	13.01
		ICMA-93333 X BIB-90	13.01

*,** Significant at 5% and 1% level of significance, respectively.

environment in total sixty cross combinations. The best crosses over the environment for grain yield per plant were ICMA 93333 X BIB-46, ICMA 93333 X BIB-167, ICMA 93333 X BIB-53, ICMA 93333 X BIB-145 and ICMA 93333 X BIB-45. These crosses were also found superior for some other yield attributing traits. The cross that exhibited highest positive standard heterosis was ICMA 97111 X BIB-179 for total number of tillers per plant and number of effective tillers per plant, ICMA 93333 X BIB-147 for ear head length, ICMA 97111 X BIB-53 for ear head diameter and test weight, ICMA 93333 X BIB-145 for dry stover yield per plant, ICMA 97111 X BIB-179 for harvest index. These cross combinations have high heterotic effect on yield and its attributing traits, so these were considered promising for use in yield improvement.

Similar results were also revealed in their experiments by Davda *et al.* (2008), Patel *et al.* (2008), Vetriventhan *et al.* (2008), Vagadiya *et al.* (2010b), Bhadalia *et al.* (2013) and Parmar *et al.* (2015).

Crosses ICMA 93333 X BIB-45, ICMA 93333 X BIB-46, ICMA 93333 X BIB-53, ICMA 93333 X BIB-60, ICMA 93333 X BIB-145, ICMA 93333 X BIB-147, ICMA 93333 X BIB-167, ICMA 88004 X BIB-164, ICMA 97111 X BIB-53 and ICMA 97111 X BIB-179 showed significant positive standard heterosis for dry stover yield per plant and grain yield per plant along with significant positive SCA and high GCA effects for ICMA 93333 and testers, which used in aforesaid crosses. Similar results also revealed with Kumar *et al.* (2017a,b), Badurkar *et al.* (2018) and Saini *et al.* (2018).

The magnitude of heterosis and feasibility of hybrid seed production determines the intensity of exploitation of hybrid vigour. Present study revealed that the crosses ICMA 93333 X BIB-46, ICMA 93333 X BIB- 167, ICMA 93333 X BIB-53, ICMA 93333 X BIB-145 and ICMA 93333 X BIB-45 showing significant standard heterosis for grain yield per plant and other yield attributing traits in both environments as well as over the environments (Table-2). These crosses having high heterotic values for grain yield per plant may be used in yield improvement programme.

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Influence of Flyash Seed Pelleting on Growth and Yield Attributes of Tomato (*Lycopersicon esculentum*)

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Abstract

The present investigation was undertaken to assess Effect of Fly ash pelleting on growth and yield of Tomato using different concentration. Total 12 treatments were taken. The results revealed that Tomato plants with treatment 8 is good and gave better than other treatments. Maximum Field emergence (83.750) was seen compared to other treatments. It has taller plants with the plant height (147.550cm), Maximum number of leaves per plant (56.00), maximum number of primary branches (36.850), early Days to 50% flowering (55.250), early Days to initial flowering (46.250), early Days to 50% fruit setting (65.500), Maximum flowers per cluster (9.900), Maximum number of cluster per plant (16.500), Maximum number of fruits per cluster (8.100), Maximum number of fruits per plant (136.500), Weight of the fruit (23.740gm), Maximum fruit diameter (6.685mm) and high fruit yield per plot (6.543). The next best treatment which gave good results was Fly ash pelleting with 200g per kg of seed which is Treatment – 9. Field emergence was (79.250), plant height was (142.750cm), Number of leaves per plant (53.000), Number of primary branches (33.800), days to 50% flowering (56.750), days to initial flowering (48.750), days to 50 % fruit setting (66.250), number of flowers per cluster (9.550), number of cluster per plant (15.950), number of fruit cluster per plant (7.35), weight of the fruit (23.330g), Fruit diameter (6.275mm), Fruit yield per plot (6.250kg).

Key words : Fly ash, pelleting, tomato

Introduction

Tomato (*Lycopersicon esculentum*), a member of family solanaceae is one of the most popular vegetables. It is universally known as 'protective food'. It is extensively grown all over the world for both fresh market and processing. It is one of the most important, popular and extensively used vegetable as fresh fruit and also in the form of processed products (Toor and Savage, 2005) which belongs to the family solanaceae. It is widely grown all over the world (mainly tropics and subtropics). It is native of Peru-Equator region (Rick, 1969). The Portuguese merchants and the English traders of East-India Company introduced it to India. In India, it is a very popular vegetable. The fruits are available in the market throughout the year (Choudury, 1998).

Fly ash is a product of "Thermal Power Plant", which is produced during burning of coal for energy purpose, is a major concern. Recently, more than 175 mt of fly ash is generated in India from several thermal power plants and it is expected about 300 mt of fly ash will be generated in the year of 2016-17 (Das *et al.*, 2011). Fly ash an amorphous ferroaluminosilicate, physically fly ash occurs as fine particles (60-70%) which has a size below 0.075 mm is a by-product of pulverized coal fired thermal power station and has low to medium bulk density, high surface area and very light texture with pH varying from 4.5 to 12 depending upon S content in the coal (Lal *et al.*, 2012).

Being a vegetative fossil fly ash consist of mineral matter which plant have up taken from the soil. It can act as a secondary source of fertilizer nutrients like P, K, Ca, Mg, S, Cu, Fe, Zn, Mn, Mo etc. (Totawat *et al.*, 2002).

Fly ash application can alter the water holding capacity (Pathan *et al.*, 2003) and available water content of soils (Adriano and Weber, 2001). Presence of organic matter in soil has an additive effect as it reduces the concentration of toxic metals through sorption, lowers the C/N ratio and provides organic compounds, which promote microbial proliferation and diversity (Wong and Wong, 1986; Pitchel and Hayes, 1990). The disposal of fly ash by conventional methods leads to degradation of arable land and contamination of ground water. Therefore, development of proper technologies for disposal of this solid waste in an eco-friendly manner becomes essential to derive maximum benefit from its heterogeneous nature, since it is a storehouse of readily available plant macro and micronutrients. In conjunction with organic manure, microbial inoculants or fertilizers with fly ash can be used to design a soil benefaction strategy, which can help in improving soil properties and enriching its nutrients status. The presence of almost all essential plant nutrients in ionic form and the ameliorating effect on the physical, chemical and microbial nature of soil makes fly ash an important input for biomass production, especially on variously degraded soils and wastelands.

Materials and Methods

The present investigation was carried out during Rabi 2022 at Department Laboratory, Department of Genetics and Plant Breeding, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad. The farm situated at 25° 57' N latitude, 87° 50' E longitude and at an altitude of 98 meter above mean sea level. This area is situated on the right side of the river Yamuna and opposite side of Prayagraj city. All the facilities required for crop cultivation are available. The experiment was laid out in completely randomized design with twelve treatment along with control and the number of replications was four. The treatment consists of Fly ash seed pelleting with different concentrations.

The one-way analysis of variance (ANOVA) was performed to determine the level of significance at 1% and 5% (The data were analysed using software INDOSTAT).

S. No.	Code	Treatment	Concentration
1.	T ₁	Control	-
2.	T ₂	Fly ash pelleting	25g per kg of seed
3.	T ₃	Fly ash pelleting	50g per kg of seed
4.	T ₄	Fly ash pelleting	75g per kg of seed
5.	T ₅	Fly ash pelleting	100g per kg of seed
6.	T ₆	Fly ash pelleting	125g per kg of seed
7.	T ₇	Fly ash pelleting	150g per kg of seed
8.	T ₈	Fly ash pelleting	175g per kg of seed
9.	T ₉	Fly ash pelleting	200g per kg of seed
10.	T ₁₀	Fly ash pelleting	225g per kg of seed
11.	T ₁₁	Fly ash pelleting	250g per kg of seed
12.	T ₁₂	Fly ash pelleting	275g per kg of seed

BINDING MATERIAL : MAIDA STARCH @10% (100 ML PER KG OF SEEDS)

Results and Discussion

Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum field emergence (83.750) . Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum Plant height (147.550). Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum Number of leaves per plant (56.000) . Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum Number of primary branches (36.850) . Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded early Days to 50% flowering (55.250) . Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded early Days to Initial flowering (46.250) . Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded early Days to 50% fruit setting (65.500) . These results are in close conformity with the findings of Aggarwal *et al* (2009).

Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum number of flowers per cluster (9.900). Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum number of flowers cluster per plant (16.500) . Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum number of fruits per cluster (8.100) . Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum number of fruits per plant (136.500) . Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum Weight of the fruit (gm) (23.740). Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum Fruit diameter (mm). Fly ash pelleting @ 175g per kg of seed that is treatment –T₈ recorded maximum Fruit yield per plot (kg) (6.543). These results are corroborated with the findings of Prakash *et al*. (2014).

Table-1 : Analysis of variance for various growth and yield related traits.

S. No.	Characters	Treatment (d.f=11)	Error (d.f=36)
1.	Field emergence	205.197*	5.236
2.	Plant height (cm)	1.023*	0.003
3.	Number of leaves per plant	1.181*	0.070
4.	Number of primary branches per plant	0.678*	0.048
5.	Days to 1st flowering	0.671*	0.015
6.	Days to 50% flowering	56.839*	4.715
7.	Days to fruit setting	71.356*	2.972
8.	Number of flower per cluster	5.374*	0.354
9.	Number of flower cluster per plant	23.708*	0.659
10.	Number of fruit set per cluster	7.480*	0.352
11.	Number of fruits per plant	8.528*	0.169
12.	Weight of the fruit (gm)	3.206*	0.036
13.	Fruit diameter (mm)	2.227*	0.269
14.	Fruit yield per plot (kg)	5.454*	0.461

Table-2 : Mean performance of 12 different treatments for growth and earliness characters in Tomato.

	Field emergence	Plant height	No. of leaves per plant	No. of primary branches	Days to 50% flowering	Days to initial flowering	Days to 50% fruit setting
T ₁	73.750	137.350	41.850	26.550	58.250	53.500	68.250
T ₂	74.000	133.050	47.100	29.900	57.250	57.750	67.250
T ₃	74.000	127.450	40.600	28.150	57.500	56.500	67.250
T ₄	67.500	122.750	36.600	25.650	63.500	59.750	71.250
T ₅	64.750	117.250	37.300	23.050	61.500	59.250	72.000
T ₆	72.750	112.650	30.350	23.250	63.00	66.000	74.250
T ₇	78.500	140.050	49.550	30.750	57.750	50.250	67.500
T ₈	83.750	147.550	56.000	36.850	55.250	46.250	65.500
T ₉	79.250	142.750	53.000	33.800	56.750	48.750	66.250
T ₁₀	72.750	136.100	42.750	25.550	61.000	59.750	71.250
T ₁₁	62.500	126.650	38.550	25.150	66.000	59.000	77.500
T ₁₂	59.500	114.050	44.750	22.100	66.500	65.500	77.500

Table-3 : Mean performance of 12 different treatments for Yield characters in tomato.

	Number of flowers per cluster	Number of flower cluster per plant	Number of fruits per cluster	Number of fruits per plant	Weight of the fruit (gm)	Fruit diameter (mm)	Fruit yield per plot (kg)
T ₁	6.900	13.200	4.850	68.950	9.050	5.765	3.548
T ₂	7.800	12.500	5.800	70.950	7.000	5.730	4.220
T ₃	7.900	12.650	5.750	61.500	7.370	5.280	3.763
T ₄	7.500	13.400	4.100	55.550	7.710	4.345	2.840
T ₅	5.850	10.850	4.700	52.950	6.510	4.485	4.715
T ₆	6.800	8.800	4.350	99.350	12.360	5.060	5.478
T ₇	8.600	15.150	6.950	77.600	21.970	5.580	5.830
T ₈	9.900	16.500	8.100	136.500	23.740	6.685	6.543
T ₉	9.550	15.950	7.35	119.600	23.330	6.275	6.250
T ₁₀	7.050	13.000	6.950	71.250	7.160	5.775	4.983
T ₁₁	7.300	11.900	4.750	60.400	8.215	4.590	4.320
T ₁₂	7.300	8.950	4.300	49.700	7.035	4.635	3.613

Conclusions

By this study, it can be concluded that the Treatment 8 i.e., Fly ash pelleting with 175 g per kg of seed has high performance over control with significant increase in Field emergence, Good Plant height, Maximum of Number of leaves per plant, Maximum Number of primary branches, Early Days to 50% flowering, Early Days to initial flowering, Early Days to 50% fruit setting, Maximum Number of flowers per cluster, Maximum Number of fruits per cluster, Maximum Number of fruits per plant, Maximum weight of the fruit, Good Fruit diameter (mm) and Maximum Fruit yield per plot (kg) followed by the Treatment 9 i.e. Fly ash pelleting with 200g/Kg of seed.

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Morphological, Physiological and Bio-Chemical Characterization of Amaranth (*Amaranthus* spp.) Genotypes

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Abstract

The Present study entitled "Morphological, Physiological and Bio-Chemical characterization of Amaranth (*Amaranthus* spp.) genotypes" was carried out with 12 amaranth genotype including two check variety (Pusa Kirti and Pusa Kiran) during Rabi 2022-2023 in RBD with three replication at Field Experimentation Centre, Department of Genetic and Plant Breeding, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, (U.P.). The outcome of the study and Analysis of variance showed highly significant differences among 12 Amaranth genotypes. It was revealed that Genotype G-45 performed best for Leaf length, Leaf breadth, Leaf area, Chlorophyll content, Days to maturity and Harvest Index, and G-50 performed best for Days to 50% flowering, Plant height, Inflorescence length, Stem diameter, Number of Primary branches per plant, Number of leaves per plant, Seed Yield per plant, Seed Yield per plot, Seed Yield per hectare, Test weight, Biological Yield, Fibre content and Oil content. So, genotype G-45 and genotype G-50 has performed best in Prayagraj Agro-climatic region. So, these two Genotypes G45 (IC - 35568) and G50 (IC - 35573) are recommended for Prayagraj Agro-Climatic Region for further studies and evaluation.

Key words : RBD, morphological, physiological and bio-chemical

Introduction

Amaranth (*Amaranthus hypochondriacus* L.) is a protein rich pseudo-cereal crop belongs to family *Amaranthaceae* and are characterized by monoecious compound inflorescence. Grain Amaranth having its origin in America and Europe and it is being cultivated as a grain since 8000 years ago (O'Brien and Price, 1983). Earlier Amaranth species were grown as the principle grain crop by the Aztecs, synonyms such as "mystical grains of the Aztecs," "super grain of the Aztecs," and the "golden grain of the Gods", used to describe nutritious amaranth grain commonly known as amaranth. Some Amaranth species are also cultivated as leafy vegetables, pseudo cereals, and ornamental plants. This crop can be grown in a wide range of agro-climatic conditions (temperature 20-40°C, elevation 500-2500 m amsl and rainfall 800 mm to 1500 mm) (Anonymus, 1984; Sreelathakumary and Peter, 1993; Grubben, 1993). Most of the species from amaranth are summer annual weeds.

Grain amaranth, an underutilized crop can be one of the ideal future crop having better nutritional properties endowed with C, metabolism suited to survive and thrive in an environment affected by climate change to achieve food and nutritional security. In this crop, approximately 60 species are recognized, out of which nearly 18 species are occurring in India (Singh and Thomas, 1978).

Various amaranth species are cultivated as leaf

vegetables, pseudo-cereals, and ornamental plants. Members of this genus share many characteristics and uses with members of the closely related genus *Celosia*. Amaranth is not a true grain or cereal because the plant does not belong to the grass family (*Poaceae*), but is known as a "Pseudo-cereal" because the flavour, appearance, and cooking of many species exhibit similarities to grain (Rathod *et al.*, 2021).

Four species are grown for grain purpose, are *Amaranthus hypochondriacus* L., (2n=32), *Amaranthus cruentus* L., (2n=34), *Amaranthus caudatus* L., (2n=32) and *Amaranthus edulis* L., (2n=32) (Singh and Thomas, 1978) with golden yellow seed.

A. blitum L. and *A. dubius* Mart. ex Thell. (also referred to as *A. dubius*) are associated with weedy species, nevertheless, they are also valued as vegetables in most Asian and African countries (Costea *et al.* 2003; Grubben 2004). The prominent vegetable species is *A. tricolor* L., whose leaves are served as an affordable protein source in South-East Asia (Grubben 1994). The young leaves of the ornamental amaranths *Celosia* spp., which still belong to the Family *Amaranthaceae* (Grubben 1976) are highly appreciated for human consumption in many African countries (Denton 2004; Olaniyi and Ojetayo 2012).

The extensive research on grain amaranth at Himalayan region was carried out by Joshi (1987)

mentioned the following list of current vernacular names used for grain amaranth Ramdana (Bihar), Rajgira (Deccan), Kola bhaji (Bombay), Bathu (Shimla), Siriara (Kulu, H.P), Rajagira (Marathi) and Marcha (Garhwal and Nepal).

In the middle of the 20th century after knowing the biochemistry the nutritional qualities especially the higher protein and lysine content of grain amaranth was known and the crop started gaining importance and emerged as one of the Health Care Crops in the world. The proteins present in seed are significantly richer in essential dietary amino acids, particularly lysine, which is often limited in other cereal grains (Drzewiecki *et al.* 2003; Andini *et al.*, 2013). Amaranth species are receiving a great deal of attention in developing countries as a means to fight protein malnutrition due to the presence of high seed protein (about 16 %) which is much higher than most of the common grains (Singhal and Kulkarni, 1988; Oleszek *et al.*, 1999). The seed protein contains a balanced amino acid composition with high lysine content ranging from 0.73 to 0.84 % of total protein content (Bressani *et al.*, 1987, Bressani, 1989; Bressani and Garcia-Vela, 1990).

The “protein complement” of amaranth grain is very near to the levels recommended by FAO/WHO. The starch components are characterized by low gelatinization temperature, good stability during freezing and thawing, and high swelling power (Yanez *et al.*, 1986). Many compounds and extracts from amaranths have antidiabetic, antihyperlipidemic, and spermatogenic effects (Sangameswaran and Jayakar 2008; Girija *et al.*, 2011) and antioxidant and antimicrobial activities (Alvarez-Jubete *et al.*, 2010; Tironi and Anon 2010). Amaranth grain contains 6 to 10% oil found mostly within the embryo (Betschart *et al.*, 1981, Lorenz and Hawang, 1985; Garcia *et al.*, 1987). The oil is predominantly an unsaturated oil (76%) rich in linoleic acid necessary for human nutrition. The average content of three major fatty acids i.e. palmitic, oleic and linoleic in grain amaranth remain 22.2, 29.1, and 44.6%, respectively (Ping *et al.*, 2002). Amaranth grain contains Tocotrienols (unsaturated fatty acids) and squalene compounds, which are known to affect cholesterol biosynthesis, lowers total serum triglycerides and levels of low density lipoproteins (LDL) which help to prevent Cardio Vascular Disease (CVD) in humans (Martirosyan *et al.*, 2007) and animal (Escudero *et al.*, 2006).

Sarker *et al.* (2014) revealed that Amaranth has a flavor that is equal to or better than that of Spinach. It also consists of significantly more protein (14-30% dry weight), minerals (Fe, Mn, and Zn) and antioxidants such as beta carotenoids (90-200 mg/kg) and ascorbic acid

(approximately 28mg/100g) than any other leafy vegetables.

With regard to the distribution of grain amaranth, it is widely distributed throughout the old and new world. In Asia-Pacific region covering India, China, Manchuria, Nepal, Bhutan, Afghanistan, Indonesia, Japan, Thailand and Israel this is cultivated as minor crops.

In India, amaranth is mainly cultivated in the rural areas and is well adapted to diverse climatic conditions, highly resistance to stresses (including diseases and pests). Amaranths crop also have very high variability in leaf size, leaf shape, branching, flower colour and flowering pattern (Khurana *et al.*, 2013). These are cultivated both in hills as well as plains covering states of J&K, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Tripura, Jharkhand, Chhattisgarh, Maharashtra, Gujarat, Orissa, Karnataka, Kerala and Tamil Nadu. The exact information about the statistics on acreage and production in India are still not known. However, as a grain crop it is estimated to be grown in about 40-50 thousands ha. (Dua *et al.*, 2009). Hand harvested yields have been as high as 4000 kg/ha in Montana (Cramer 1988) and 6000 kg/ha in Peru (Sumar 1986), between 2500 and 3300 kg/ha in southwest Germany (Aufhammer and Kubler 1998) between 2100 and 2700 kg/ha in Slovak Republic (Jamriska, 2002), 1200 kg/ha in India (Dua *et al.*, 2009) and 1234 kg/ha in Chhattisgarh (Yadav 2016).

In India, the research work on grain amaranth is coordinated by NBPGR, ICAR, New Delhi, through All India Coordinated Research Network (AICRN) on Potential Crops operating in 23 centers in different states of the country.

However, due to a lack of several factors such as producer knowledge of the crop's nutritional benefits, acceptable high-yielding varieties and better production techniques, the production of Amaranth has declined. In every crop improvement initiative, assessing germplasm variability is a preliminary step that will aid in selecting types with high variability and desirable yield enhancing characteristics. Since yield is a complex character that is impacted by several component characteristics, knowledge of the size and direction of connection between yield and its component traits would aid in the establishment of selection criteria for improved genotype selection. Despite its great economic importance and the availability of a significant genetic variety in plant and reproductive characteristics, the genetic potentialities of Grain Amaranth remain largely unexplored, with few attempts to enhance its genetics done thus far (Olaniyi 2022).

Materials and Methods

The present investigation was carried out at the Field Experimentation Centre of Department of Genetics and Plant Breeding, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. during Rabi 2022-2023. The farm situated at 25° 57' N latitude, 81° 50' E longitude and at an altitude of 98 meter above mean sea level. The University is on the left side of Prayagraj - Rewa National Highway, about 5 km away from Prayagraj city. All types of facilities necessary for cultivation of successful crop including field preparation, inputs, irrigation facilities and labourers were provided from the Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P.

Experimental materials

Source of material : Experimental materials for this study was consisted of 12 genotypes (including 2 check varieties) of Amaranth which were obtained from NBPGR (National Bureau of Plant and Genetic Resources), New Delhi.

List of Genotypes

1. IC – 35564 (G41)
2. IC – 35565 (G42)
3. IC – 35566 (G43)
4. IC – 35567 (G44)
5. IC – 35568 (G45)
6. IC – 35569 (G46)
7. IC – 35570 (G47)
8. IC – 35571 (G48)
9. IC – 35572 (G49)
10. IC – 35573 (G50)
11. PUSA KIRTI (GENOTYPE CHECK – 1)
12. PUSA KIRAN (GENOTYPE CHECK – 2)

The one-way analysis of variance (ANOVA) was performed to determine the level of significance at 5% (Fisher and Yates, 1938). The data were analyzed using software OPSTAT.

Results and Discussion

The mean sum of squares value for 19 characters (Days to 50% flowering, Plant height (cm), Stem diameter (cm), Number of Branches per plant, Number of leaves per plant, Inflorescence length (cm), Days to maturity, Leaf color, Stem color, Inflorescence color, Seed color, Seed yield/plant (gm), Leaf length and Breadth (cm), Biological Yield (gm), Harvest Index (%), Test weight of seeds (gm),

Chlorophyll content of leaves, Leaf area (cm²), Fibre content (%), Oil Content (%)) were subjected to analysis of variance for experimental design.

The analysis of variance for different characters is presented in Table-1. The mean sum of squares due to genotypes showed significant difference for 19 characters studied. The mean sums of squares were suggesting that the selected genotypes were genetically variable and considerable amount of variability existed among them.

Days to 50% flowering was ranged from 64 to 47 with a mean of 57.09. The genotype G50 (IC – 35573) was recorded as the 1st genotype to reach 50% flowering stage, at 47 days after sowing followed by G45 with 49 days to reach 50 % flowering stage and G47 (IC – 35570) was the last genotype to reach 50% flowering stage at 64 days after sowing. These findings are supported by Srivastava *et al.* (2020) and Paliwal *et al.* (2022).

Plant height was ranged from 118.60 to 75.53 cm with a mean of 95.10 cm. The genotype G50 (IC – 35573) was longest in plant height (118.60 cm), followed by CHECK-2 (113.87 cm) and genotype G43 (IC-35566) was lowest 75.53 cm. These findings are supported by Ahammed *et al.* (2012) and Jangir *et al.* (2019).

Inflorescence length was ranged from 11.66 to 47.73 cm with a mean of 32.79 cm. The genotype G50 (IC-35573) was longest in Inflorescence length (47.73 cm), followed by G47 (IC-35570) with 40.07 cm and genotype CHECK-1 was lowest 11.66 cm. These findings are supported by Kumar and Yassin (2014) and Dinssa *et al.* (2018).

Stem diameter was ranged from 0.50 to 1.17 cm with a mean of 0.92 cm. The genotype G50 (IC-35573) was thickest in stem diameter 1.17 cm, followed by G46 (IC-35569) with 1.14 cm and genotype CHECK-1 was lowest with 0.50 cm. These findings are supported by Bhalekar *et al.* (2019) and Jangir *et al.* (2019).

Number of Primary Branches was ranged from 26.80 to 9.47 with a mean of 18.86. The genotype G50 (IC-35573) was having highest number of branches, followed by G49 (IC-35572) with 25.60 branches and genotype CHECK-1 was lowest with 9.47 branches. These findings are supported by Dinssa *et al.* (2018) and Srivastava *et al.* (2020).

Number of Leaves was ranged from 272.93 to 127.53 with a mean of 177.41. The genotype G50 (IC-35573) was having highest number of leaves, followed by G48 (IC-35571) with 227.47 leaves and genotype G41 (IC-35564) was lowest with 127.53 leaves. These findings are supported by Dinssa *et al.* (2018) and Bashyal *et al.* (2022).

Table-1 : Analysis of variance for 19 characters in 12 Amaranth genotypes during Rabi 2022-2023.

S. No.	Observations	Replication (d.f. = 2)	Genotypes (d.f. = 11)	Error (d.f. = 22)
1.	Days to 50% flowering	6.5	96.97*	7.2
2.	Plant Height (cm)	2.94	576.39*	8.39
3.	Inflorescence length (cm)	17.53	304.19*	8.13
4.	Stem diameter (cm)	0.005	0.105*	0.0015
5.	Number of Primary Branches per plant	1.01	94.29*	0.32
6.	Number of leaves per plant	3.6	6083.84*	4.12
7.	Days to maturity	13.30	232.29*	4.83
8.	Seed Yield per plant (gm)	0.94	144.31*	1.11
9.	Seed yield per plot (gm)	106.61	7609.68*	36.05
10.	Seed yield per ha. (q)	1.76	86.35*	1.12
11.	Leaf length (cm)	0.034	11*	0.23
12.	Leaf Breadth (cm)	0.059	7.07*	0.14
13.	Biological yield (gm)	14.29	395.95*	8.66
14.	Harvest index (%)	5.50	940.84*	2.64
15.	Test weight of seeds (gm)	0.00016	0.082*	0.0006
16.	Chlorophyll content of leaves (g cm ⁻²)	2.01	47.56*	1.22
17.	Leaf area (cm ²)	2.04	234.29*	2.33
18.	Fibre content (%)	0.05	1.22*	0.04
19.	Oil content (%)	0.001	2.67*	0.05

*Significant at 5% level of significance

Leaf Length (cm) was ranged from 6.46 to 12.64 with a mean of 9.69. The genotype G45 (IC-35568) was having longest leaf length with 12.64 cm, followed by G46 (IC-35569) with 11.44 cm and genotype G41 (IC-35564) was having shortest leaf length with 6.46 cm. These findings are supported by Kumar *et al.* (2019) and Bashyal *et al.* (2022).

Leaf Breadth (cm) was ranged from 2.94 to 7.86 with a mean of 5.51. The genotype G45 (IC-35568) was highest in leaf breadth i.e., 7.86 cm, followed by G48 (IC-35571) 7.84 cm and genotype G43 (IC-35566) was having lowest leaf breadth i.e., 2.94 cm. These findings are supported by Kumar *et al.* (2019) and Bashyal *et al.* (2022).

Leaf area (cm²) was ranged from 13.61 to 41.94 with a mean of 25.83. The genotype G45 (IC-35568) was largest with 41.94 cm², followed by G46 with 38.12 cm² and genotype G43 (IC-35566) was smallest with 13.61 cm². These findings are supported by Chaudhari *et al.* (2010) and Managa and Nemadodzi (2023).

Chlorophyll Content (g cm⁻²) was ranged from 22.12 to 34.83 with a mean value of 29.28. The genotype G45 (IC-35568) was highest with 34.83 g cm⁻², followed by G49 (IC-35572) with 33.02 g cm⁻² and genotype G44 (IC-35567) was lowest with 22.12 g cm⁻². These findings are supported by Gendy *et al.* (2018) and Managa and Nemadodzi (2023).

Days to maturity was ranged from 100.33 to 127.33 with a mean of 114.42. The genotype G45 (IC-35568) was first one to get matured with 100.3 days after sowing, followed by G48 (IC-35571) with 101.67 days and genotype G43 (IC-35566) was last one with 127.33 days to maturity. These findings are supported by Dinssa *et al.* (2018) and Bhalekar *et al.* (2019).

Seed Yield per plant (gm) was ranged from 2.60 to 23.24 with a mean of 16.83. The genotype G50 (IC-35573) was having highest yield with 23.24 gm, followed by G41 (IC-35564) with 22.10 gm and genotype CHECK-1 was having lowest yield with 2.60 gm. These findings are supported by Kumar and Yassin (2014) and Bhalekar *et al.* (2019).

Seed Yield per plot (gm) was ranged from 78 to 235.80 with a mean of 178.47. The genotype G50 (IC-35573) was having highest yield with 235.80 gm, followed by G46 (IC-35569) with 221 gm and genotype CHECK-1 was having lowest yield with 78.00 gm. These findings are supported by Kumar *et al.* (2019) and Bhalekar *et al.* (2019).

Seed Yield per hectare (q) was ranged from 6.82 to 23.20 with a mean of 17.85. The genotype G50 (IC-35573) was having highest yield with 23.20 q/ha, followed by G48 (IC-35571) with 22.14 q/ha and genotype CHECK-1 was having lowest yield with 6.82 q/ha. These findings are supported by Bhalekar *et al.* (2019) and Bashyal *et al.* (2022).

Table-2 : Mean Performance and Range for 19 characters of 12 Amaranth species.

Genotypes	Days to 50% flowering	Plant height (cm)	Inflorescence length (cm)	Stem diameter (cm)	No. of primary branches per plant	No. of leaves per plant	Days to maturity	Seed yield per plant (gm)	Seed yield per plot (gm)	Seed yield per ha. (q)	Leaf length (cm)	Leaf breadth (cm)	Biological yield (gm)	Harvest index (%)	Test weight of seeds (gm)	Chlorophyll content of leaves (g cm ⁻²)	Leaf area (cm ²)	Fibre content (%)	Oil content (%)
G41	60.00	85.03	36.50	0.96	16.60	127.53	115.67	22.10	220.47	22.06	6.46	4.55	47.52	46.35	0.85	31.66	22.10	7.00	6.17
G42	59.00	100.13	35.70	0.88	19.60	176.53	122.67	18.42	185.53	17.12	11.20	5.90	45.09	58.57	0.66	29.00	34.89	6.15	6.07
G43	62.67	75.53	35.90	0.78	18.53	129.40	127.33	20.53	206.47	21.88	7.20	2.94	63.95	25.47	0.76	32.95	13.61	5.86	5.44
G44	52.67	85.50	34.63	1.01	16.73	141.47	125.00	19.13	193.53	19.50	10.24	4.61	67.97	37.71	0.99	22.12	24.22	7.58	7.43
G45	49.00	76.43	32.97	0.94	23.33	133.20	100.33	15.68	156.10	15.34	12.64	7.86	50.38	62.76	0.74	34.83	41.94	7.63	7.12
G46	63.67	95.47	37.27	1.14	12.07	172.33	105.33	21.93	221.00	20.60	11.44	5.09	76.17	37.23	1.01	24.03	38.12	6.22	6.05
G47	64.00	85.87	40.07	1.06	20.53	223.07	113.00	17.34	174.53	18.61	8.13	5.83	52.45	33.07	0.94	30.05	25.19	7.42	8.18
G48	54.67	99.47	37.87	1.08	24.47	227.47	101.67	20.60	205.33	22.14	9.54	7.84	61.12	31.34	0.65	26.17	31.27	7.18	7.49
G49	61.67	98.20	27.20	0.79	25.60	188.53	109.67	17.59	179.43	18.90	9.48	6.96	71.52	41.75	0.94	33.02	18.01	7.17	8.15
G50	47.00	118.60	47.73	1.17	26.80	272.93	118.67	23.24	235.80	23.20	10.81	5.92	81.21	37.52	1.04	26.77	19.40	7.94	8.31
CHECK-1	56.40	107.13	11.66	0.50	9.47	157.40	118.47	2.60	78.00	6.82	7.94	3.57	60.44	4.37	0.58	32.92	18.03	7.02	7.21
CHECK-2	54.40	113.87	16.05	0.85	12.67	179.07	115.33	2.90	85.47	8.09	11.29	5.07	56.03	5.25	0.64	27.94	23.20	6.85	6.56
Mean	57.09	95.10	32.79	0.92	18.86	177.41	114.42	16.83	178.47	17.85	9.69	5.51	61.15	35.11	0.81	29.28	25.83	7.00	7.02
Max	64.00	118.60	47.73	1.17	26.80	272.93	127.33	23.24	235.80	23.20	12.64	7.86	81.21	62.76	1.04	34.83	41.94	7.94	8.31
Min	47.00	75.53	11.66	0.50	9.47	127.53	100.33	2.60	78.00	6.82	6.46	2.94	45.09	4.37	0.58	22.12	13.61	5.86	5.44
SE m	1.55	1.67	1.64	0.02	0.32	1.17	1.26	0.61	3.46	0.61	0.27	0.22	1.69	0.94	0.01	0.63	0.88	0.12	0.13
CD 5%	4.54	4.90	4.83	0.06	0.96	3.43	3.72	1.79	10.10	1.79	0.82	0.65	4.98	2.77	0.04	1.87	2.58	0.36	0.40
CV	4.70	3.04	8.60	4.25	3.02	1.14	1.92	6.20	3.36	5.93	4.99	6.98	4.81	4.67	3.00	3.78	5.91	3.10	3.36

Test weight (gm) was ranged from 0.58 to 1.04 with mean value of 0.81. The genotype G50 (IC-35573) was highest with 1.04 gm, followed by genotype G46 (IC-35569) with 1.01 gm and genotype CHECK-1 was lowest with 0.58 gm. These findings are supported by Dinssa *et al.* (2018) and Kumar *et al.* (2019).

Biological Yield (gm) was ranged from 45.09 to 81.21 with a mean of 61.15. The genotype G50 (IC-35573) was highest with 81.21 gm, followed by G46 (IC-35569) with 76.17 gm and genotype G42 (IC-35565) was lowest with 45.09 gm. These findings are supported by Rana *et al.* (2020) and Srivastava *et al.* (2020).

Harvest Index (%) was ranged from 4.37 to 62.76 with a mean of 35.11. The genotype G45 (IC-35568) was highest with 62.76 %, followed by G42 (IC-35565) with 58.57% and genotype CHECK-1 was lowest with 4.37 %. These findings are supported by Jangir *et al.* (2019) and Rana *et al.* (2020).

Fibre content (%) was ranged from 5.86 to 7.94 with a mean of 7.00. The genotype G50 (IC-35573) was highest with 7.94 %, followed by genotype G45 (IC-35568) with 7.63 % and genotype G43 (IC-35566) was lowest with 5.86 %. These findings are supported by Dinssa *et al.* (2018) and Singh and Punia (2020).

Oil content (%) was ranged from 5.44 to 8.31 with a mean of 7.02. The genotype G50 (IC-35573) was highest with 8.31 %, followed by G47 (IC-35570) with 8.18 % and G43 (IC-35566) was lowest with 5.44 %. These findings are supported by Garcia and Diaz (2019) and Singh and Punia (2020).

Conclusions

From the above results it is concluded that the genotype G50 (IC-35573) has shown best performance for Parameters like Days to 50% flowering, Plant height (cm), Inflorescence length (cm), Stem Diameter (cm), Primary Branches per plant, Number of leaves per plant, Test weight of seeds (gm), Seed Yield per plant (gm), Seed Yield per plot (gm), Seed Yield per hectare (q), Biological weight (gm), Fibre content (%) and Oil content (%), as compared with check variety Pusa Kirti and Pusa Kiran.

And, G45 (IC-35568) has shown best performance for Parameters like Leaf Length (cm), Leaf Breadth (cm), Harvest Index (%), Chlorophyll content (ig cm⁻²), Leaf area (C) and Days to Maturity, as compared with check variety Pusa Kirti and Pusa Kiran.

From the above conclusion it is clear that two genotypes, G45 (IC – 35568) and G50 (IC-35573) has performed best in Prayagraj Agro-climatic region. So, these two Genotypes G45 (IC-35568) and G50 (IC-35573) are recommended for Prayagraj Agro-Climatic Region for future studies.

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Effect of Biofortification with Zinc and Iron on Growth and Yield Attributes of Groundnut (*Arachis hypogaea* L.) Var. GG-14

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Abstract

The present investigation was undertaken to assess "Effect of bio fortification of zinc and iron on growth and yield of ground nut" using different concentration of foliar spray. Total 13 treatments were taken. The results revealed that groundnut plants with foliar application of ZnSO_4 @ 3% that is treatment 12 is good and gave better results than other treatments. It has taller plants with the plant height (55.933 cm), and good spreading with the width of plant (45.000 cm), has maximum root length at 15DAS (9.100 cm), and maximum root length at harvest (22.600 cm), early days to initial flowering (22.133) and early days to 50% flowering (32.100), higher number of branches per plant (12.767), maximum number of pods per plant (43.467), maximum number of kernels per pod (2.267), high seed yield per plot (2 kg), High seed yield per hectare (388.66 q/ha) maximum pod yield per plant (58.300), higher seed index (43.067), high harvest index with (33.167%) an high amount of oil content (49.067) and good amount of protein content (28.400). The next best treatment which gave good results was foliar application of FeSO_4 @ 3% which is Treatment 7. The plant height was (53.233 cm), width of the plant was (44.400), root length at 15 DAS was (8.967 cm), root length at harvest was (22.267 cm), days to initial flowering (22.567), days to 50% flowering (32.167), Number of branches per plant was (12.767), Number of pods per plant was (42.933), number of kernels per pod was (2.133), pod yield per plant was (58.200), seed index was (42.733), harvest index was (33.133 %), oil content (48.567%) and protein content was (27.733).

Key words : ZnSO_4 , FeSO_4 , Bio fortification, groundnut.

Introduction

Ground nut (*Arachis hypogaea* L.) is an important oil seed crop and food grain legume. It belongs to the family Leguminosae. Groundnut is the largest oilseed crop in India in terms of production. It is one of the most important cash crops of our country and also known as "King of oilseed crops", is believed to be native of Brazil (South America). It was introduced in India during first half of the sixteenth century. Groundnut is a self-pollinated crop (Patra *et al.*, 2011).

Zinc deficiency is responsible for many severe health complications including impairments of physical growth, immune system and learning ability, combined with increased risk of infections, DNA damage and cancer development. However, in India due to low productivity, the per capita availability of groundnut is less. High Zn density groundnuts may be a solution to ensure adequate level of Zn intake (Singh and Lal, 2007) which necessitates increasing Zn concentration of seed through fortification and selection of high Zn density genotypes. Thus, an effort was made to increase the seed Zn content in a number of groundnut cultivars through soil and foliar application of Zn.

Iron plays an important role in the plant growth. It is a

cofactor for approximately 140 enzymes that catalyze unique biochemical reactions. Deficiency or low activity of iron in the plant causes chlorophyll is not produced in sufficient quantities and the leaves are pale. It helps in the formation of chlorophyll and is constituent of enzyme systems which bring about oxidation reductions in plants. Fe is essential for respiration, photosynthesis and fixation of atmospheric nitrogen by nitrogen fixing organisms.

Biofortification Greek word "bios" means "life" and latin word "forticare" means "make strong". Thus biofortification is the process of increasing bio available concentration of essential elements in edible portion of crop plant through agronomic or genetic / molecular approach. Application of fertilizers to soil and foliar to improving grain nutrient concentration and the potential of nutrient containing fertilizers for increasing nutrients concentrations of grains.

Materials and Methods

The present investigation was carried out during *kharif*, 2021- 22 at College Research Farm, Department of Genetics and Plant Breeding, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad. The farm situated at 25° 57' N latitude, 87° 05' E longitude and at an altitude of 98 meter above mean sea level. This area is situated on the right

side of the river Yamuna and opposite side of Allahabad city. All the facilities required for crop cultivation are available. The experiment was laid out in Randomized block design with thirteen treatment combinations along with control and the number of replications was three. The treatment consists of foliar application with ZnSO_4 and FeSO_4 with different concentrations.

S. No.	Code	Treatment	Concentration
1.	T ₀	Control	-
2.	T ₁	Foliar application with FeSO_4	0.2%
3.	T ₂	Foliar application with FeSO_4	0.4%
4.	T ₃	Foliar application with FeSO_4	0.6%
5.	T ₄	Foliar application with FeSO_4	1%
6.	T ₅	Foliar application with FeSO_4	2%
7.	T ₆	Foliar application with FeSO_4	3%
8.	T ₇	Foliar application with ZnSO_4	0.2%
9.	T ₈	Foliar application with ZnSO_4	0.4%
10.	T ₉	Foliar application with ZnSO_4	0.6%
11.	T ₁₀	Foliar application with ZnSO_4	1%
12.	T ₁₁	Foliar application with ZnSO_4	2%
13.	T ₁₂	Foliar application with ZnSO_4	3%

The one-way analysis of variance (ANOVA) was performed to determine the level of significance at 1% and 5% (The data were analyzed using software INDOSTAT.

Results and Discussion

Foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded maximum Plant height (55.933). These results are in close conformity with the findings of Dadhich and Gupta (2003). Foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded early Days to initial flowering (22.133) Days to 50% flowering. Foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded early Days to 50% flowering (32.100). These results are corroborated with the findings Eman-Abdel-Latif and El Haggan (2014).

Foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded Maximum number of branches per plant (12.767) Foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded maximum number of pods per plant (43.467) foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded Maximum pod yield per plant (58.300) foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded maximum number of kernels per pod (2.267) foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded maximum seed index (43.067) foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded maximum seed yield per plot (2 kg), Foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded maximum seed yield per hectare (388.66 q/ha) Foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded Harvest index (%) (33.167) Foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded Oil content (%) (49.067). These results are corroborated with the findings Eman-Abdel-Latif and El Haggan (2014). Foliar application of ZnSO_4 @ 3% that is treatment T₁₂ recorded Protein content (%) (28.400). These results are in close conformity with the findings of Dadhich and Gupta (2005).

Conclusions

It is concluded from the present investigation that the different concentrations of foliar application showed a significant effect on growth and yield parameters with ZnSO_4 and FeSO_4 improves the performances of crop over the control. Foliar application of ZnSO_4 @ 3% concentration has high performance over control with significant increase in Plant height, Width of the plant, Root length at 15 DAS, Root length at Harvest, Days to Initial flowering, Days to 50% flowering, Number of branches per plant, Pod yield per plant, Seed Index,

Table-1 : Analysis of variance for various growth and yield related traits.

S. No.	Characters	Replication (DF=2)	Treatment (DF=12)	Error (DF=24)
1.	Field emergence	0.896	0.372*	0.262
2.	Plant height (cm)	0.004	0.380*	0.010
3.	Width of the plant (cm)	0.008	0.233*	0.007
4.	Root length at 15DAS (cm)	0.001	0.098*	0.004
5.	Root length at harvest (cm)	0.283	2.996*	0.438
6.	Days to initial flowering	1.21	2.127*	1.027
7.	Days to 50% flowering	0.567	2.083*	0.502
8.	Number of branches per plant	1.564	6.832*	0.228
9.	Number of pods per plant	1.60	21.056*	2.555
10.	Number of kernels per pod	1.30	0.274*	0.085
11.	Pod yield per plant	3.60	15.082*	0.970
12.	Seed index	4.58	24.482*	7.584
13.	Harvest index (%)	1.59	4.906*	0.329
14.	Oil content (%)	3.33	6.075*	3.204
15.	Protein content (%)	0.78	8.857*	1.003
16.	Seed yield per plot	4.44	7.415*	1.670
17.	Seed yield per hectare	1.63	1.938*	0.841

Table-2 : Mean performance of 13 different treatments for pre harvest characters in Groundnut.

	Field emergence	Plant height	Width of the plant	Root length 15DAS	Root length at harvest	Days to initial flowering	Days to 50% flowering	Number of branches per plant
T ₀	68.800	41.967	33.667	6.400	18.767	24.633	34.533	8.233
T ₁	69.067	42.800	37.200	6.600	20.267	24.000	33.200	9.100
T ₂	68.233	42.733	37.167	6.967	21.067	23.367	34.033	9.733
T ₃	79.367	44.133	40.433	7.433	21.067	23.700	32.800	10.233
T ₄	73.867	45.700	41.333	7.567	21.000	23.767	32.867	11.067
T ₅	74.667	46.400	43.700	8.300	22.000	22.567	32.533	12.467
T ₆	73.967	53.233	44.400	8.957	22.267	21.867	32.167	12.700
T ₇	76.000	43.467	42.367	6.200	20.633	24.167	34.500	9.200
T ₈	56.633	45.600	43.067	6.500	20.900	23.767	34.000	8.900
T ₉	69.267	50.300	43.567	7.600	21.733	23.300	33.100	10.633
T ₁₀	67.700	51.733	44.133	8.467	21.400	23.933	32.900	10.367
T ₁₁	72.700	55.333	44.900	9.067	22.000	22.533	32.533	11.567
T ₁₂	71.367	55.933	45.000	9.100	22.600	22.133	32.100	12.767

Table-3 : Mean performance of 13 different treatments for post harvest characters in Groundnut.

	No. of pods per plant	No. of kernels per pod	Pod yield per plant	Seed index	Harvest index (%)	Oil content (%)	Protein content (%)	Seed yield per plot (g)	Seed yield per Ha (q/ha)
T ₀	35.033	1.333	51.167	51.167	29.193	44.600	23.300	255.825	341.1
T ₁	36.500	1.533	53.367	53.367	30.467	45.733	24.200	266.835	355.7
T ₂	36.833	1.833	53.500	53.500	30.550	46.633	24.933	267.5	356.6
T ₃	37.767	1.400	54.233	54.233	30.960	45.300	23.567	271.165	361.5
T ₄	36.900	1.867	57.167	57.167	32.650	46.600	26.733	285.635	381.1
T ₅	38.667	1.833	57.967	57.967	33.067	47.133	26.867	289.835	384.1
T ₆	42.993	2.133	58.200	58.200	33.133	48.567	27.733	291.05	388.06
T ₇	38.333	1.400	53.400	53.400	30.467	44.100	23.933	267.05	356.06
T ₈	37.800	1.667	53.967	53.967	30.933	45.667	25.667	269.835	359.7
T ₉	39.300	2.067	54.800	54.800	31.133	46.467	24.800	274.65	366.6
T ₁₀	40.667	1.667	55.000	55.000	32.107	46.033	27.133	275.01	356.59
T ₁₁	42.367	2.033	56.333	56.533	32.293	47.400	27.267	282.665	376.88
T ₁₂	43.467	2.267	58.300	58.300	33.167	49.067	28.400	291.05	388.66

Harvest Index, Oil content, Protein content, Seed yield per plot and Seed yield per Hectare.

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Effect of Post-Harvest Treatments on Shelf Life of Banana

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Abstract

A laboratory experiment entitled "Effect of Post-harvest Treatments on Shelf Life of Banana" was carried out in laboratory of Guru Kashi University, Talwandi Sabo (Bathinda) during 2020. The experiment comprising total 11 post-harvest treatments such as control, fruit kept in perforated polythene bag at room temp., fruit kept in non-perforated polythene bag at room temp., fruit kept in perforated polythene bag at 15° C temp., fruit kept in non-perforated polythene bag at 15° C temp., fruit treated with BA @ 30 ppm at room temp., fruit treated with GA₃ @ 150 ppm at room temp., fruit treated with BA @ 30 ppm at 15° C temp., fruit treated with GA₃ @ 150 ppm at 15° C temp., fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at room temp. and fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. Results showed that fruits kept in perforated polythene bag at 15° C temp. remained statistically at par with fruits treated with GA₃ @ 150 ppm at 15° C temp. and fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. and recorded significantly lowest physiological loss of weight per cent, pulp to peel ratio, spoilage per cent, TSS, total sugar, reducing sugar and non-reducing sugar as compared to rest of treatments, whereas highest in control. Results further showed that fruits kept in perforated polythene bag at 15° C temp. recorded significantly higher fruit firmness and self-life of fruits as compared to rest of treatments, but it was at par with fruits treated with GA₃ @ 150 ppm at 15° C temp. and fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp.

Key words : Banana, physiological loss, reducing sugar, post-harvest, shelf life and fruit firmness.

Introduction

Banana (*Musa* sp.) is one of the ancient fruit of the world belonging to the family Musaceae. It is also known as apple of the paradise and is the tallest of the herbaceous plants with pseudo stem (Rahman and Kabir, 2006). It is equally liked by all age group of people because it is easily digestible and palatable. From nutritional point of view, it has high calorific and nutritional values. It contains carbohydrates, crude fiber, proteins, fat, ash, phosphorous, iron, α - carotene, riboflavin, niacin and ascorbic acid (Akter *et al.*, 2013). The banana fruit can be eaten raw or cooked. It can be processed into flour and can be fermented for the production of beverages such as banana juice, vinegar and wine (Pillay and Tripathi, 2007). Nowadays, demand of banana consumption is increasing day by day due to its high caloric and nutritional value, but non-availability of adequate postharvest storage facilities has posed a great threat to the commercial cultivation of banana. Appropriate storage facilities and knowledge about storage are insufficient. As a result, considerable amount of banana is spoiled every year. It is a perishable fruit and its postharvest losses range from 25-50% (Amiruzzaman, 1990). This loss occurs during transporting and marketing due to adverse physiological changes (loss of weight due to increased respiration and transpiration), softening of flesh and lack of resistance capacity against microbial attack.

Extended storage of bananas can be obtained when

ripening is not induced by a large ethylene exposure (exogenous or endogenous). Shelf life can be extended by different processes such as modified atmosphere packaging (MAP) (Basel *et al.*, 2002). Prolongation of shelf life may be achieved by several methods. Scott *et al.* (1971) mentioned that the ripening of banana is delayed when stored in sealed polythene cover and the minimal fruit losses were recorded in sealed polythene along with KMnO₄ (Bhadra and Sen, 1997). The use of synthetic chemicals for the reduction of postharvest losses and extrusion of shelf life of perishables is a threat to human health and environment. Recently, a number of chemicals have been withdrawn from the market upon report of health hazards. Efforts should be made to optimize or develop suitable alternatives such as modified atmosphere packaging with or without ethylene scavenging compounds, hot water treatments, cooling, etc. for postharvest reduction loss of banana extension of shelf life with retained quality. Therefore to reduce the post-harvest losses bananas are harvested green and are normally artificially ripened with the use of ripening agents (Temi *et al.*, 2014). These include ethylene gas, ethephon, ethrel which helps in early and uniform ripening of banana fruits with good colour development and taste. Ethrel treatment of fruits results in high marketable fruit, minimum spoilage percentage and higher peel: pulp ratio. Therefore, improvement of shelf life of banana is an urgent need to reduce the postharvest losses and contribute to the uplift of the national economy. Hence, it

is necessary to reduce enormous postharvest spoilage. Efforts to find out suitable method of storage and shelf life extension are important for reducing post-harvest losses.

Materials and Methods

A laboratory experiment entitled “Effect of Post-harvest Treatments on Shelf Life of Banana” was carried out in laboratory of Guru Kashi University, Talwandi Sabo (Bathinda) during 2020. The orchard is located at 30°157' N latitude and 74°33'E longitude and altitude of 186 meters above the sea level. Banana fruits were obtained from orchard of GKU and Fruits were harvested at the immature stage and uniformity of size and freedom for blemishes and were washed with water to remove the latex and dust. The experiment was conducted in complete randomized block design with three replications. The experiment comprising of eleven treatments viz. (T₀) Control, (T₁) Fruit kept in perforated polythene bag at room temperature, (T₂) Fruit kept in non-perforated polythene bag at room temperature, (T₃) Fruit kept in perforated polythene bag at 15° C temperature, (T₄) Fruit kept in non-perforated polythene bag at 15° C temperature, (T₅) Fruit treated with BA (6-Benzyl adenine) @ 30 ppm at room temperature, (T₆) Fruit treated with GA₃ @ 150 ppm at room temperature, (T₇) Fruit treated with BA @ 30 ppm at 15° C temperature, (T₈) Fruit treated with GA₃ @ 150 ppm at 15° C temperature, (T₉) Fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at room temperature and (T₁₀) Fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temperature.

Physiological loss in weight (%): The physiological loss in weight of fruits was calculated on initial weight basis. The percent loss in weight after each storage interval was calculated by subtracting final weight from initial weight of the fruits and then converted into percentage value. The cumulative loss in weight was calculated on fresh weight basis.

Firmness (kg cm⁻²): Fruit firmness was measured by using a stand penetrometer of 0-20 kg scale (Deccan Techno Corporation). A plunger of 6 mm diameter was used for the determination of rupture force and the readings were expressed as kg cm⁻².

Pulp to peel ratio: The pulp and peel weights at regular intervals of time were recorded till the end of storage period and their ratio was calculated.

Spoilage (%): The number of fruits spoiled in a replication was counted and expressed in percentage. The spoilage was determined based on the visual observations.

$$\text{Spilage (\%)} = \frac{\text{Number of spoiled fruits}}{\text{Total number of fruits}} \times 100$$

Shelf life: The shelf life of fruits was determined by

recording the number of days the fruits remained in good condition in storage. The stage where in more than 50 percent of the stored fruits became unfit for consumption was considered as end of shelf life in that particular treatment and expressed as mean number of days.

Total soluble solids (%): The total soluble solids of fruits were determined by using hand refractometer having a range of 0 to 32, by placing a drop of juice and taking the readings.

Sugar: Both were estimated as per the method given by A.O.A.C. (2000).

Juice content (%): The fruits were cut into equal halves and their juice was extracted with simple juice extractor and was strained through mesh (32 mm). The juice was weighed with electronic balance and percentage of juice was worked out on the basis of total weight of fruit and the weight of juice.

Sugar content (%): Sugars were determined by the method of Lane and Eyon (AOAC, 1965).

Results and Discussion

Physiological loss in weight (%): Data presented in Table-1 indicated that the physiological loss in weight (%) as influenced by different post-harvest treatments during storage. Weight losses increased significantly in all the treatments with increase in storage period. However, the increase had been at a reduced rate in all the treated fruits as compared to control. On 3rd day of storage, the lowest PLW (%) was recorded in (T₃) fruit kept in perforated polythene bag at 15° C temp. (0.45 %) followed by (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (0.50 %) which was on par with (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (0.57). Highest PLW was recorded in (T₀) control (2.14 %). Similar trend was observed on 6th and 9th day of storage. On 12th day of storage, the lowest PLW was recorded in (T₃) fruit kept in perforated polythene bag at 15° C temp. (5.58 %) followed by (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (5.81 %), which was at par with (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (6.33%), whereas highest was recorded in (T₂) Fruit kept in non-perforated polythene bag at room temp. (11.17 %). On 15th day of storage, the lowest PLW was recorded in (T₃) fruit kept in perforated polythene bag at 15° C temp. (6.42 %) followed by (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (6.69 %), which was on par with (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (7.28%), whereas highest was recorded in (T₅) fruit treated with BA @ 30 ppm at room temp. (9.28 %).

Physiological weight loss refers to the overall amount of moisture lost during storage and ripening,

Table-1: Effect of post-harvest treatments on physiological loss in weight (%) of banana.

Treatments	3 rd day	6 th day	9 th day	12 th day	15 th day	18 th day
T ₀	2.14	4.51	8.73	-	-	-
T ₁	0.89	1.82	4.69	9.48	-	-
T ₂	0.95	2.05	5.52	11.17	-	-
T ₃	0.45	1.01	2.76	5.58	6.42	8.42
T ₄	0.83	1.62	4.23	8.54	-	-
T ₅	0.81	1.58	3.99	8.07	9.28	-
T ₆	0.74	1.45	3.82	7.73	8.88	-
T ₇	0.67	1.31	3.37	6.81	7.83	10.83
T ₈	0.57	1.11	3.13	6.33	6.94	10.28
T ₉	0.70	1.37	3.77	7.62	8.76	-
T ₁₀	0.50	1.12	2.88	5.81	6.69	9.02
S.Em±	0.04	0.04	0.16	0.30	0.27	0.14
CD at 0.05%	0.012	0.12	0.46	0.87	0.81	0.42

Table-2 : Effect of post-harvest treatments on fruit firmness (kg cm⁻²) of banana.

Treatments	3 rd day	6 th day	9 th day	12 th day	15 th day	18 th day
T ₀	2.26	2.26	2.12	-	-	-
T ₁	2.55	2.55	2.37	2.12	-	-
T ₂	2.48	2.48	2.31	2.06	-	-
T ₃	3.60	3.60	3.26	2.91	2.46	2.24
T ₄	2.62	2.62	2.43	2.18	-	-
T ₅	2.75	2.75	2.54	2.27	1.94	-
T ₆	2.90	2.90	2.66	2.38	2.04	-
T ₇	3.16	3.16	2.88	2.58	2.21	2.01
T ₈	3.38	3.38	3.07	2.75	2.35	2.11
T ₉	3.08	3.08	2.82	2.52	2.16	-
T ₁₀	3.47	3.47	3.15	2.82	2.41	2.16
S.Em±	0.07	0.07	0.06	0.06	0.04	0.04
CD at 0.05%	0.20	0.20	0.17	0.17	0.12	0.10

Table-3 : Effect of post-harvest treatments on pulp to peel ratio of banana.

Treatments	3 rd day	6 th day	9 th day	12 th day	15 th day	18 th day
T ₀	1.40	1.95	2.07	-	-	-
T ₁	1.35	1.83	1.90	2.31	-	-
T ₂	1.39	1.90	2.01	2.43	-	-
T ₃	1.25	1.53	1.46	1.82	2.27	2.74
T ₄	1.33	1.79	1.82	2.22	-	-
T ₅	1.33	1.73	1.76	2.16	2.68	-
T ₆	1.31	1.71	1.63	2.01	2.50	-
T ₇	1.28	1.65	1.57	1.96	2.41	2.75
T ₈	1.28	1.63	1.56	1.93	2.40	2.91
T ₉	1.31	1.70	1.62	1.99	2.48	0.00
T ₁₀	1.26	1.57	1.53	1.89	2.35	2.85
S.Em±	0.05	0.05	0.05	0.05	0.06	0.03
CD at 0.05%	NS	0.14	0.15	0.15	0.17	0.10

Table-4 : Effect of post-harvest treatments on spoilage (%) of banana.

Treatments	3 rd day	6 th day	9 th day	12 th day	15 th day	18 th day
T ₀	3.48	20.15	51.80	83.06	-	-
T ₁	0	4.09	11.71	29.75	66.08	-
T ₂	0	4.62	13.80	35.04	74.29	-
T ₃	0	0	0	0	36.43	50.42
T ₄	0	0	10.55	26.81	61.84	-
T ₅	0	0	9.97	25.33	57.37	-
T ₆	0	0	0	23.46	53.08	-
T ₇	0	0	0	0	47.53	76.25
T ₈	0	0	0	0	40.57	51.37
T ₉	0	0	0	20.80	50.76	-
T ₁₀	0	0	0	0	38.70	51.35
S.Em±	0.09	0.08	0.29	0.90	2.37	0.78
CD at 0.05%	0.25	0.25	0.84	2.65	6.95	2.30

Table-5 : Effect of post-harvest treatments on self-life of banana.

Treatments	Days
T ₀	9.82
T ₁	14.87
T ₂	12.91
T ₃	20.61
T ₄	15.37
T ₅	16.06
T ₆	16.84
T ₇	18.25
T ₈	19.43
T ₉	17.83
T ₁₀	19.96
S.Em±	0.54
CD at 0.05%	1.58

Table-6 : Effect of post-harvest treatments on TSS (°Brix) of banana.

Treatments	3 rd day	6 th day	9 th day	12 th day	15 th day	18 th day
T ₀	14.53	21.22	15.25	-	-	-
T ₁	7.20	10.31	16.23	21.99	-	-
T ₂	7.54	10.95	17.41	23.17	-	-
T ₃	5.84	6.67	11.19	16.91	17.42	19.27
T ₄	6.86	9.69	15.08	21.19	-	-
T ₅	6.77	9.47	14.67	20.89	21.52	-
T ₆	6.74	9.06	13.97	20.42	21.03	-
T ₇	6.52	8.57	13.68	18.97	19.53	22.12
T ₈	6.32	7.50	12.57	18.65	19.21	20.79
T ₉	6.62	8.89	14.04	19.56	20.15	-
T ₁₀	6.13	7.36	12.46	18.16	18.71	19.94
S.Em±	0.19	0.35	0.53	0.53	0.34	0.38
CD at 0.05%	0.57	1.04	1.57	1.56	1.01	1.12

Table-7 : Effect of post-harvest treatments on total sugar (%) of banana.

Treatments	3 rd day	6 th day	9 th day	12 th day	15 th day	18 th day
T ₀	7.88	15.36	16.03	-	-	-
T ₁	6.78	8.34	13.42	17.45	-	-
T ₂	7.17	8.82	14.32	18.62	-	-
T ₃	5.09	6.41	10.09	14.12	16.52	17.52
T ₄	6.39	7.86	12.54	16.30	-	-
T ₅	6.25	7.69	12.23	15.90	19.33	-
T ₆	5.79	7.19	11.28	15.66	18.56	-
T ₇	5.69	7.00	10.96	15.25	16.53	19.91
T ₈	5.44	7.10	10.80	15.04	17.35	18.21
T ₉	5.54	7.14	11.26	15.64	18.17	-
T ₁₀	5.33	6.97	10.56	14.73	16.89	17.94
S.Em±	0.18	0.33	0.51	0.59	0.87	0.35
CD at 0.05%	0.53	0.96	1.50	1.72	2.54	1.03

resulting in desiccation and shrivelling of the fruit. It might be due to synergistic effects of GA₃ which might have retained more water against the force of transpiration and also due to reduced rate of respiration and transpiration. The present observation is in conformity with the results reported by Rao and Chundawat (1988); Patil and Hulamani (1998); Unithan and Desai (2002); Patel (2004) in banana. Stover and Simmonds (1987) reported that banana fruits loss weight due to respiration and

transpiration as a result of the appearance, textural and nutritional qualities of the fruit were negatively affected.

Firmness (kg cm⁻²): Critical examination of data presented in Table 2 showed that fruit firmness influenced due to different post-harvest treatments during storage period. On 3rd day of storage, highest fruit firmness was recorded in (T₃) fruit kept in perforated polythene bag at 15° C temp. (3.60 kg cm⁻²) followed by (T₁₀) fruit treated

Table-8 : Effect of post-harvest treatments on reducing sugar (%) of banana.

Treatments	3 rd day	6 th day	9 th day	12 th day	15 th day	18 th day
T ₀	4.28	5.99	6.43	-	-	-
T ₁	4.18	4.24	4.32	7.99	-	-
T ₂	4.21	4.25	4.36	8.03	-	-
T ₃	3.12	3.15	3.23	6.35	6.57	6.80
T ₄	4.07	4.11	4.21	7.81	-	-
T ₅	3.99	4.03	4.13	7.69	7.96	-
T ₆	3.89	3.93	4.03	7.54	7.81	-
T ₇	3.69	3.73	3.82	7.24	7.49	7.75
T ₈	3.60	3.64	3.73	7.10	7.34	7.60
T ₉	3.77	3.81	3.90	7.35	7.61	-
T ₁₀	3.33	3.37	3.45	6.67	6.91	7.15
S.Em±	0.14	0.13	0.15	0.21	0.15	0.09
CD at 0.05%	0.40	0.39	0.44	0.63	0.43	0.27

Table-9 : Effect of post-harvest treatments on non-reducing sugar (%) of banana.

Treatments	3 rd day	6 th day	9 th day	12 th day	15 th day	18 th day
T ₀	3.60	9.37	9.60	-	-	-
T ₁	2.60	4.10	9.10	9.46	-	-
T ₂	2.97	4.57	9.97	10.59	-	-
T ₃	1.97	3.26	6.86	6.78	9.95	10.72
T ₄	2.32	3.75	8.33	8.49	-	-
T ₅	2.27	3.66	8.10	8.21	11.37	-
T ₆	1.90	3.26	7.25	7.12	10.75	-
T ₇	2.00	3.27	7.13	7.01	9.04	12.16
T ₈	1.83	3.46	7.07	6.94	10.01	10.61
T ₉	1.77	3.34	7.36	7.29	10.56	-
T ₁₀	2.00	3.60	7.11	7.05	9.98	10.79
S.Em±	0.27	0.40	0.51	0.60	0.90	0.43
CD at 0.05%	0.79	1.16	1.48	1.75	2.65	1.25

with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (3.47 kg cm⁻²) which was on par with (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (3.38 kg cm⁻²). Similar trend was observed on 6th and 9th day of storage. On 12th day of storage, the highest fruit firmness was recorded in (T₃) fruit kept in perforated polythene bag at 15° C temp. (2.91 kg cm⁻²) followed by (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (2.82 kg cm⁻²), which was at par with (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (2.75 kg cm⁻²), whereas lowest was recorded in (T₂) Fruit kept in non-perforated polythene bag at room temp. (2.06 kg cm⁻²). On 15th day of storage, the highest fruit firmness was recorded in (T₃) fruit kept in perforated polythene bag at 15° C temp. (2.46 kg cm⁻²) followed by (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (2.41 kg cm⁻²), which was on par with (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (2.35 kg cm⁻²). It might also be due to its antagonistic effect on IAA that enhances hydrolytic and oxidative enzymes like amylase, phosphorylase, phosphatase, catalase and peroxidase. The results are agreement with those of Desai *et al.* (1984); Patil and Hulamani (1998); Unitthan and Desai (2002); Patel (2004) in banana.

Pulp to Peel ratio: The data on pulp to peel ratio as influenced by different post-harvest treatments during storage were presented in Table 3. On 3rd day of storage, pulp to peel ratio in all the treatments were not significantly influenced. On 6th day, higher pulp to peel ratio was observed in (T₀) control (1.95) followed by (T₂) fruit kept in non-perforated polythene bag at room temp. (1.90), whereas it was lower in (T₃) fruit kept in perforated polythene bag at 15° C temp. (1.39) which was on par with (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (1.57) and (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (1.63). Similar trend was observed on 9th day of storage. On 12th day higher pulp to peel ratio was noticed in (T₂) Fruit kept in non-perforated polythene bag at room temp. (2.43) followed by (T₁) fruit kept in perforated polythene bag at room temp. (2.31), while it was lower in (T₃) fruit kept in perforated polythene bag at 15° C temp. (1.82) and was found to be at par with (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (1.89) and (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (1.93). On 15th day highest pulp to peel ratio was observed in (T₅) Fruit treated with BA @ 30 ppm at room temp. (2.68) followed by (T₆) fruit treated with GA₃ @

150 ppm at room temp. and least was observed in (T₃) fruit kept in perforated polythene bag at 15° C temp. (2.27), which was at par with (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (2.35) and (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (2.40). It is observed from the data that the pulp to peel ratio increased in all the treatment from 3rd day to 15th day. Increase in narrow pulp to peel ratio due to its antagonistic effect on ethylene. Similar inferences were reported by Vijaya Raju (1989) in banana.

Spoilage (%): The data on spoilage percentage as influenced by post-harvest treatments is presented in Table 4. On 3rd day of observation no spoilage was recorded in all the treatments except (T₀) control (3.48 %). On 6th day also highest spoilage was recorded in (T₀) control (20.15 %) and followed by (T₂) fruit kept in non-perforated polythene bag at room temp. On 9th day, minimum spoilage was recorded in (T₅) fruit treated with BA @ 30 ppm at room temp. (9.97 %). followed by (T₄) fruit kept in non-perforated polythene bag at 15° C temp. (10.55 %) and maximum spoilage was recorded in (T₀) control (51.80%). On 12th day, minimum spoilage was recorded in (T₉) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at room temp. (20.80 %). followed by (T₆) fruit treated with GA₃ @ 150 ppm at room temp. (23.46 %) and maximum spoilage was recorded in (T₀) control (83.06%). On 15th day minimum spoilage was recorded in (T₃) fruit kept in perforated polythene bag at 15° C temp. (36.43 %) followed by (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (38.70 %) and (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (40.57%) and maximum spoilage was recorded in (T₂) Fruit kept in non-perforated polythene bag at room temperature (74.29%). On 18th day minimum spoilage was noticed in (T₃) fruit kept in perforated polythene bag at 15° C temp. (50.42 %) followed by (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (51.35 %) and (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (51.37%) and maximum spoilage was recorded in (T₇) fruit treated with BA @ 30 ppm at 15° C temp. (76.25 %). A progressive increase in the spoilage of fruits was observed with progress in storage period. Spoilage of fruits was directly related to the rate of respiration of fruits which leads to deterioration of the fruits (Srivastava *et al.*, 1961). The rate of spoilage increased with the progressive its increase in ripening and days to storage (Khumbhar and Desai, 1986; Willis *et al.*, 1983). Maximum spoilage was observed in control which might be due to high rate of respiration when compared to other treatments, causing early ripening and decay. Fruits kept in perforated polythene bag at 15° C temperature, fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temperature and fruit treated with GA₃ @ 150 ppm at 15° C temp. recorded the lower spoilage percentage, and

reduced decay loss which is in conformity of studies by Bharathi (2002) in sapota.

Shelf life (Days): The data pertaining to the shelf-life of banana with post-harvest treatments is presented in Table 5. The maximum shelf life was recorded in (T₃) in fruit kept in perforated polythene bag at 15° C temp. (20.61days) followed by (T₁₀) fruit treated with GA₃ @ 150 ppm + BA @ 30 ppm at 15° C temp. (19.96 days) and (T₈) fruit treated with GA₃ @ 150 ppm at 15° C temp. (19.43 days). It is evident from the data that fruit kept in perforated polythene bag at 15° C temp. recorded the highest shelf life. This may be due to that Gibberellic acid might have controlled the ethylene production as well as enzymatic activity resulting into reduction in ripening process. Collaborative results were obtained by Rao and Rao (1979); Patil and Hulamani (1998); Rao and Chundawat (1991); Unittan and Desai (2002); Patel (2004) in banana.

Total soluble solids (°Brix): The change in TSS content of fruits was significantly affected by treatments during storage was presented in Table 6. It is revealed that during the storage period (3rd and 6th day) lowest percent of TSS was observed in (T₃) (5.84 and 11.19°Brix) followed by (T₁₀ and T₈) whereas highest percent of TSS was recorded in (T₀) control. Similar results was observed in (9th 12th 15th and 18th) day respectively minimum content of TSS was observed in (T₃) (11.19, 16.91, 17.42 and 19.27 °Brix) followed by (T₁₀) (12.46, 18.16, 18.71 and 19.94°Brix) and (T₈) (12.57, 18.65, 19.21 and 20.79 °Brix) whereas maximum content of TSS varied from (T₂) - on 9th day (17.41 °Brix) and on 12th day (23.17 °Brix), (T₅) on 15th day (21.52 °Brix) and (T₇) 18th day (22.13 °Brix) respectively. Stover and Simmonds (1987) reported that the conversion of starch into sugars to be the most important change in ripening bananas. Un-perforated polyethylene bags are known to reduce loss of moisture and hydrolysis of polysaccharides resulting in less increase in TSS. The present findings are in conformation with Dhua *et al.* (2006) in Sapota.

Total sugars (%): Data presented in Table 7 indicated that the change in total sugar content was significantly influence by various treatments. It has been noticed that during the storage period (3rd and 6th day) lowest percent of total sugar was observed in (T₃) (5.09 and 6.41 %) followed by (T₁₀) (5.33 and 6.97) whereas highest percent of total sugar was recorded in (T₀) control (7.88 and 15.36%). During the storage period (9th, 12th, 15th and 18th day) similar trend was noticed in terms of total sugar. Minimum percent of total sugar was observed in (T₃) (10.09, 14.12, 16.52 and 17.52%) followed by (T₁₀) (10.56, 14.73, 16.89 and 17.94%) and (T₈) (10.80, 15.04, 17.35 and 18.21%) whereas maximum percent of total sugar varied from (T₀) on 9th day (16.03 %), (T₂) on 12th day

(18.62 %), (T₅) on 15th day (19.33 %), (T₇) on 18th day (19.91 %), respectively. It is observed from the data the total sugar percentage increased up to ripening and then showed a decreasing trend. The present study was in line with the report of Dadzie and Orchard (1997) that, the most striking postharvest chemical change which occurs during the postharvest ripening of banana is the hydrolysis of starch and the accumulation of sugar (that is, sucrose, glucose and fructose) which are responsible for the sweetening of the fruit.

Reducing sugars (%): The change in reducing sugar content was significantly influence by various treatments was studied and detail furnished in Table 8. It has been noticed that during the storage period (3rd and 6th day) lowest percent of reducing sugar was observed in (T₃) (3.12 and 3.15 %) followed by (T₁₀) (3.33 and 3.37) whereas highest percent of total sugar was recorded in (T₀) control (4.28 and 5.99%). During the storage period (9th, 12th, 15th and 18th day) similar trend was noticed in terms of total sugar. Minimum percent of total sugar was observed in (T₃) (3.23, 6.35, 6.57 and 6.80%) followed by (T₁₀) (3.45, 6.67, 6.91 and 7.15 %) whereas maximum percent of reducing sugar varied from (T₀) on 9th day (6.43 %), (T₂) on 12th day (8.03 %), (T₅) - on 15th day (7.96 %), (T₇) on 18th day (7.75 %) respectively. It is observed from the data the reducing sugar percentage increased up to ripening and then showed a decreasing trend. The increase in the reducing sugar content of banana fruits could be due to hydrolysis of starch into soluble sugars as banana fruit ripen (Stover and Simmonds, 1987).

Non-reducing sugars (%): Data presented in Table-9 indicated that the change in non-reducing sugar content was significantly influence by various treatments was studied. It has been noticed from the table that during the storage period (3rd and 6th day) lowest percent of non-reducing sugar was observed in (T₃) (1.97 and 3.26 %) followed by (T₁₀) (2.00 and 3.60) whereas highest percent of total sugar was recorded in (T₀) control (3.60 and 9.37%). During the storage period (9th, 12th, 15th and 18th day) similar trend was noticed in terms of total sugar. Minimum percent of non-reducing sugar was observed in (T₃) (6.86, 6.78, 9.95 and 10.72%) followed by (T₁₀) (7.11, 7.05, 9.98 and 10.79%) and (T₈) (7.07, 6.94, 10.01 and 10.61%) whereas maximum percent of non-reducing sugar varied from (T₂) on 9th day (9.97%) and on 12th day (10.59%), (T₅) on 15th day (11.37%), (T₇) on 18th day (12.16%) respectively. The reducing, total and non-reducing sugar content found to increase upto ripening thereafter a decline at the end of shelf life in the all the treatments. There was a gradual increase in reducing sugar content which reached its maximum at table ripe stage and thereafter gradually decreased. This may be due to the hydrolysis of starch during ripening resulting in

an accumulation of sucrose (Laxminarayana and Bazaquezainas, 1978). It is observed from the data the total sugar percentage increased up to ripening and then showed a decreasing trend. The present study was in line with the report of Dadzie and Orchard (1997) that, the most striking postharvest chemical change which occurs during the postharvest ripening of banana is the hydrolysis of starch and the accumulation of sugar (that is, sucrose, glucose and fructose) which are responsible for the sweetening of the fruit. Similar finding were marked by Dhua *et al.* (2006) in Sapota.

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Studies on Enhancement of Shelf Life of Kinnow

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Abstract

A field experiment was carried out at different farmer's field Abohar, Fazilka district of Punjab during June to December 2021. In total 27 kinnow plants were selected for the study. The results reported that the fruits treated with GA₃ (20 ppm) and Kinetin (25 ppm) is best option to enhancement shelf life of Kinnow under Abohar conditions of Punjab.

Key words : Kinnow, physiological loss, acidity, shelf life and fruit firmness.

Introduction

Kinnow is a hybrid between King and Willow leaf mandarin developed by Dr. H. B. Frost at California during the year 1935. In India, it was introduced during mid-sixties at Regional Fruit Research Station, Abohar (Punjab). Kinnow constantly performed well in semi-arid and sub-mountainous tract of India. Kinnow fruits display changes in fruit texture, colour, aroma and biochemical characteristics beside fruit quality parameters viz., fruit weight, fruit colour, taste, total soluble solids, acidity and sugars, which are immensely influenced with storage, resulting of poor fruit quality and post-harvest losses. Various factors have been reported to be associated with post-harvest losses of Kinnow mandarin. Post-harvest losses caused by fungal diseases and physiological activities (respiration, ethylene liberation and enzyme) are the major factors responsible for limiting the shelf life of Kinnow (Singh and Mandal, 2006). It is important to store the Kinnow fruits for an ample period to avoid a surplus in the market during harvesting season. The fruits may be contaminated in orchards right from the setting to harvesting stage leading to pre-mature fruit drop, and incipient pre-harvest infections causes subsequent post-harvest decaying during storage and transit under cordial conditions of temperature and moisture (Naqvi, 1993). Currently, the control of post-harvest losses depends mainly on the use of synthetic chemicals. Application of coating on fruit is simple and effective technique, which can help in decreasing the post-harvest losses and enhance the shelf life of fruits by reducing the rate of respiration, transpiration and other metabolic processes of fruits (Zagory and Kader, 1988). Edible coatings provide barricade in contrary to external elements and therefore prolongs the shelf life by reducing gas exchange, loss of water and soluble migration towards the cuticle (Guilbert *et al.*, 1996).

The uses of food-grade wax coatings on fresh fruits

and vegetables have been approved by the Food Safety and Standard Authority of India under regulation 7.3.1 (FSSAI, 2006). Application of plant growth regulators is also successful technique, which can decrease the post-harvest losses by reducing physiological loss in weight and decaying and improves the shelf life of fruits by sustaining total soluble solids, ascorbic acid and juice content. Use of plant bio regulators has become an important part of modern agro-techniques in most of the fruit plants. Auxins and gibberellins are used to control the fruit drop and to improve the fruit quality in citrus.

However, information regarding study on enhancement of shelf life of kinnow in Abohar, Fazilka district of Punjab is lacking. Keeping in view the above discussed facts of sufficient information and sparse related research, the present survey was undertaken "Studies on enhancement of shelf life of Kinnow" in Fazilka district of Punjab conditions.

Materiala and Methods

A field experiment entitled "Studies on enhancement of shelf life of Kinnow" was carried out at different farmer's field Abohar, Fazilka district of Punjab during June to December 2021. The area extent of Abohar city of Punjab is confined within northern latitudes of 30°14' 52'9" N and eastern longitudes of 74°19' 93'0" E and 215 meters (705 feet) above sea level is located in Northern India. It is located on the Ganganagar-Delhi railway route, nearly 50 km from Ganganagar district of Rajasthan. This city is also known as the "California of Punjab" for its rich soil, good irrigation sources, and particularly for the production of kinnow, a fruit of the orange family. Uniform cultural practices and plant protection measures were followed for selected trees throughout the study period as per package of practice (PAU). The healthy Kinnow trees in orchard were selected for experimentation.

Harvesting: Mature Kinnow fruits of uniform size, bruise

and disease free were harvested from all four sides of the Kinnow tree canopy to get homogenous fruit samples during third week of December. Fruits were harvested with the help of secateurs by clipping the fruit stalk just above the point of attachment to the fruit.

Washing, sorting and grading: The harvested Kinnow fruits were subjected to post-harvest grading and washing. The Kinnow fruits were subjected to washing with chlorine solution (100 ppm) to remove adhering extraneous matters on the fruit surface and sorting was carried out to separate damaged/puncture fruits and to select uniform coloured fruits. The Kinnow fruits were graded to obtain uniform size fruits for further handling. After grading the fruits were collected in plastic crates and shifted to post-harvest laboratory for different treatments in Department of Horticulture, Guru Kashi University, Punjab.

Storage of fruits: The treated fruits were packed in Corrugated Fibre Board (CFB) boxes with newspaper lining. Growth regulators were applied when majority of fruits attains 30-50 mm size. The experiment was laid out with three replications and each replication comprised of four kilogram fruits. The boxes were kept at an ambient temperature (7-20°C) and relative humidity (80-85% RH) in the post-harvest laboratory. The physico-chemical changes in the fruit were recorded at harvest and at five days interval during storage.

Physiological loss in weight (%): The physiological loss in weight of fruits was calculated on initial weight basis. The percent loss in weight after each storage interval was calculated by subtracting final weight from initial weight of the fruits and then converted into percentage value. The cumulative loss in weight was calculated on fresh weight basis.

Decay loss (%): Decay loss of fruits was calculated by weight of decayed fruits divided by initial weight of fruits and then converted into percentage value.

Fruit firmness (kg cm⁻²): Fruit firmness was measured by using a stand penetrometer of 0-20 kg scale (Deccan Techno Corporation). A plunger of 6mm diameter was used for the determination of rupture force and the readings were expressed as kg cm⁻².

Total soluble solids (%): The total soluble solids of fruits were determined by using hand refractometer having a range of 0 to 32, by placing a drop of juice and taking the readings.

Acidity (%) and Ascorbic acid (mg/100 ml): Both were estimated as per the method given by A.O.A.C. (2000).

Juice content (%): The fruits were cut into equal halves and their juice was extracted with simple juice extractor

and was strained through mesh (32 mm). The juice was weighed with electronic balance and percentage of juice was worked out on the basis of total weight of fruit and the weight of juice.

Sugar (%): Sugars were estimated by using the method of Hulme and Narain (1931).

Results and Discussions

Physiological loss in weight (%): It is evident from the data (Table 1) that the physiological loss in weight was significantly affected by the treatments and storage duration. The data indicates that the physiological loss in weight was significantly minimum (5.17 and 5.22%) in fruits treated with GA₃ (20 ppm) and Kinetin (25 ppm), respectively in an ascending order and both these treatments are at par, followed by GA₃ at 15 ppm (5.28%). The physiological loss in weight increased significantly from the minimum (2.43%) at 5th day of storage to the maximum (8.48%) at 15th day of storage period. The possible reason for reduced weight loss by growth regulators may be that growth regulators cause some chemical changes within the fruits resulting in retention of more water against the force of evaporation. Alteration of proteinaceous constituents in the cells can also cause increased affinity for water (Devi *et al.*, 2016). Rizk-Alla *et al.* (2011) reported that GA₃ (20 ppm) + NAA (75 ppm) at pre-harvest stage resulted in lowest weight loss after four weeks of cold storage period. Tecchio *et al.* (2009) also found that NAA significantly reduced the increase in weight loss (per cent) during storage of grapes. Application of GA₃ and NAA decreases fruit weight loss percentage (Kaseem *et al.*, 2011). Fruits treated with Kinetin and stored under cold storage condition and ambient storage condition recorded minimum loss in weight as compared to control. This may be because kinetin reduces senescence, the rate of respiration and ripening of fruits (Kaur *et al.*, 2014).

Decay loss (%): Decay loss was observed on 15th day of storage period was given in Table 2. Decay loss was minimum in fruits treated with GA₃ (20 ppm) and Kinetin (25 ppm). The lesser decay loss percentage in GA₃ treated fruits could be due to anti-senescent and anti-respirant properties of the gibberellins which prevent the cellular disintegration with enhancing resistant ability in the fruit (Rokaya *et al.*, 2016). These findings are conformity with the report of Brahmachari and Rani (2005) in guava who reported decrease in weight loss of fruits during storage. Rotting per cent was found to be very slow in fruits treated with kinetin (20 ppm) as compared to control. This may be because kinetin reduces senescence, the rate of respiration and ripening of fruits (Kaur *et al.*, 2014).

Table-1 : Effect of pre-harvest spray of GA₃ and Kinetin on physiological loss in weight (%) in Kinnow stored under ambient conditions.

Treatments	Days after storage			Mean
	5	10	15	
Control (water spray)	2.56	5.32	8.74	5.54
Kinetin (15 ppm)	2.50	5.30	8.71	5.50
Kinetin (20 ppm)	2.44	5.24	8.62	5.43
Kinetin (25 ppm)	2.36	5.03	8.28	5.22
Kinetin (30 ppm)	2.40	5.15	8.41	5.32
GA ₃ (5 ppm)	2.48	5.25	8.49	5.41
GA ₃ (10 ppm)	2.40	5.21	8.45	5.35
GA ₃ (15 ppm)	2.36	5.11	8.38	5.28
GA ₃ (20 ppm)	2.34	4.94	8.24	5.17
Mean	2.43	5.17	8.48	
Initial value			0.00	
CD at 5% level of significance		Treatment	Storage	Interaction
	0.11	0.06	NS	NS

Table-2 : Effect of pre-harvest spray of GA₃ and Kinetin on decay loss (%) in Kinnow stored under ambient conditions.

Treatments	Days after storage		
	5	10	15
Control (water spray)	-	-	3.56
Kinetin (15 ppm)	-	-	3.20
Kinetin (20 ppm)	-	-	3.16
Kinetin (25 ppm)	-	-	2.47
Kinetin (30 ppm)	-	-	2.58
GA ₃ (5 ppm)	-	-	3.21
GA ₃ (10 ppm)	-	-	3.14
GA ₃ (15 ppm)	-	-	3.20
GA ₃ (20 ppm)	-	-	2.37

Table-3 : Effect of pre-harvest spray of GA₃ and Kinetin on fruit firmness (kg cm⁻²) in Kinnow stored under ambient conditions.

Treatments	Days after storage				Mean
	0	5	10	15	
Control (water spray)	1.49	1.38	1.26	1.08	1.30
Kinetin (15 ppm)	1.51	1.40	1.28	1.11	1.32
Kinetin (20 ppm)	1.52	1.41	1.29	1.12	1.34
Kinetin (25 ppm)	1.61	1.50	1.37	1.20	1.42
Kinetin (30 ppm)	1.59	1.48	1.35	1.17	1.40
GA ₃ (5 ppm)	1.49	1.38	1.26	1.10	1.31
GA ₃ (10 ppm)	1.51	1.40	1.26	1.09	1.32
GA ₃ (15 ppm)	1.55	1.44	1.31	1.13	1.36
GA ₃ (20 ppm)	1.63	1.53	1.39	1.24	1.45
Mean	1.54	1.44	1.31	1.14	
CD at 5% level of significance		Treatment	Storage	Interaction	
		0.02	0.01	NS	

Table-4 : Effect of pre-harvest spray of GA₃ and Kinetin on total soluble solids (%) in Kinnow stored under ambient conditions.

Treatments	Days after storage				Mean
	0	5	10	15	
Control (water spray)	9.55	9.85	10.20	10.55	10.04
Kinetin (15 ppm)	9.70	9.90	10.50	10.50	10.08
Kinetin (20 ppm)	9.70	9.90	10.15	10.45	10.05
Kinetin (25 ppm)	10.00	10.10	10.25	10.40	10.19
Kinetin (30 ppm)	9.90	10.05	10.20	10.45	10.15
GA ₃ (5 ppm)	9.70	9.90	10.15	10.40	10.04
GA ₃ (10 ppm)	9.80	10.00	10.25	10.50	10.14
GA ₃ (15 ppm)	9.85	10.10	10.30	10.50	10.19
GA ₃ (20 ppm)	10.05	10.15	10.30	10.50	10.25
Mean	9.81	9.99	10.22	10.47	
CD at 5% level of significance		Treatment	Storage	Interaction	
		NS	0.10	NS	

Table-5 : Effect of pre-harvest spray of GA₃ and Kinetin on acidity (%) in Kinnow stored under ambient conditions.

Treatments	Days after storage				Mean
	0	5	10	15	
Control (water spray)	0.54	0.50	0.47	0.43	0.49
Kinetin (15 ppm)	0.55	0.51	0.48	0.44	0.50
Kinetin (20 ppm)	0.56	0.53	0.51	0.47	0.52
Kinetin (25 ppm)	0.59	0.56	0.53	0.49	0.54
Kinetin (30 ppm)	0.58	0.55	0.52	0.48	0.53
GA ₃ (5 ppm)	0.55	0.52	0.48	0.45	0.50
GA ₃ (10 ppm)	0.55	0.52	0.48	0.45	0.50
GA ₃ (15 ppm)	0.57	0.54	0.52	0.47	0.53
GA ₃ (20 ppm)	0.60	0.57	0.54	0.50	0.55
Mean	0.56	0.53	0.50	0.47	
CD at 5% level of significance	Treatment		Storage		Interaction
	0.01		0.01		NS

Table-6 : Effect of pre-harvest spray of GA₃ and Kinetin on ascorbic acid (mg/100 ml) in Kinnow stored under ambient conditions.

Treatments	Days after storage				Mean
	0	5	10	15	
Control (water spray)	24.24	23.61	22.25	20.87	22.74
Kinetin (15 ppm)	24.28	23.65	22.44	20.91	22.82
Kinetin (20 ppm)	24.35	23.69	22.49	20.97	22.87
Kinetin (25 ppm)	24.49	23.79	22.70	21.11	23.02
Kinetin (30 ppm)	24.45	23.74	22.64	21.06	22.97
GA ₃ (5 ppm)	24.30	23.60	22.47	20.92	22.82
GA ₃ (10 ppm)	24.38	23.67	22.56	20.98	22.90
GA ₃ (15 ppm)	24.42	23.71	22.58	21.02	22.93
GA ₃ (20 ppm)	24.56	23.86	22.77	21.18	23.09
Mean	24.39	23.70	22.54	21.00	
CD at 5% level of significance	Treatment		Storage		Interaction
	NS		0.23		NS

Fruit firmness (kg cm⁻²): The data in Table-3 indicates that the fruit firmness was maximum (1.45 kg cm⁻²) in fruits treated with GA₃ (20 ppm) followed by Kinetin at 25 ppm (1.42 kg cm⁻²) and Kinetin at 30 ppm (1.40 kg cm⁻²). Firmness of the fruits diminishes as the storage period progressed. The fruit firmness decreased significantly from the maximum (1.54 kg cm⁻²) to the minimum (1.14 kg cm⁻²) during 15 days of storage period.

The decline in the firmness might be due to moisture loss from the fruit cells. Softening of fruits is caused either by the breakdown of insoluble proto pectins into soluble pectin or by hydrolysis of starch (Mattoo *et al.*, 1975). Fruit softening is attributed to the degradation of cell wall components, mainly pectin, due to action of specific enzymes such as polygalacturonase. Fruit firmness diminishes as the degree of ripening increases due to the action of pectolytic enzymes (Muramatsu *et al.*, 1996). The loss of pectic substances in the middle lamella of the cell wall is perhaps the key steps in the ripening process that lead to the loss of cell wall integrity thus cause loss of firmness and softening (Solomos and Laties, 1973). The higher fruit firmness in GA₃ treated fruits could be due to

anti-senescent and anti-respirant properties of the gibberellins which prevent the cellular disintegration with enhancing resistant ability in the fruit (Rokaya *et al.*, 2016). Similar results were also found by Kaur *et al.* (2008) in Plum.

Total soluble solids (%): The data presented in Table 4 indicates that total soluble solids increased significantly from the minimum (9.81%) to the maximum (10.47%) during the storage period of 15 days. Treatments has no significant effect on total soluble solids and maximum total soluble solids were found in fruits treated with GA₃ (20 ppm) and Kinetin (25 ppm) during ambient storage. During initial days of storage the total soluble solids increases due to loss in moisture from fruit surface and breakdown of complex organic metabolites into simple molecules or due to hydrolysis of starch into sugars (Wills *et al.*, 1980). Plant growth regulators alone and their interaction with storage had no significant effect on total soluble solids (Khalid *et al.*, 2012). Similar results on total soluble solids with the application of GA₃ were described in grapefruit (Ferguson *et al.*, 1982) and in other fruits like apples with the application of GA₃ and BA (Koukourikou- Petridou *et al.*,

Table-7 : Effect of pre-harvest spray of GA₃ and Kinetin on juice content (%) in Kinnow stored under ambient conditions.

Treatments	Days after storage				Mean
	0	5	10	15	
Control (water spray)	46.20	45.09	43.77	42.12	44.29
Kinetin (15 ppm)	46.32	45.12	43.80	42.20	44.36
Kinetin (20 ppm)	46.45	45.24	43.86	42.30	44.46
Kinetin (25 ppm)	46.85	45.58	44.31	42.59	44.84
Kinetin (30 ppm)	46.82	45.52	44.23	42.54	44.78
GA ₃ (5 ppm)	46.35	45.15	43.84	42.23	44.39
GA ₃ (10 ppm)	46.41	45.20	43.87	42.27	44.44
GA ₃ (15 ppm)	46.54	45.34	43.97	42.34	44.55
GA ₃ (20 ppm)	46.94	45.69	44.39	42.68	44.92
Mean	46.54	45.33	44.01	42.36	
CD at 5% level of significance	Treatment NS		Storage 0.46		Interaction NS

Table-8 : Effect of pre-harvest spray of GA₃ and Kinetin on reducing sugar (%) in Kinnow stored under ambient conditions.

Treatments	Days after storage				Mean
	0	5	10	15	
Control (water spray)	3.19	3.32	3.48	3.64	3.41
Kinetin (15 ppm)	3.33	3.41	3.53	3.63	3.47
Kinetin (20 ppm)	3.38	3.45	3.57	3.69	3.52
Kinetin (25 ppm)	3.44	3.53	3.64	3.75	3.59
Kinetin (30 ppm)	3.42	3.50	3.62	3.74	3.57
GA ₃ (5 ppm)	3.34	3.41	3.54	3.66	3.49
GA ₃ (10 ppm)	3.35	3.46	3.55	3.67	3.51
GA ₃ (15 ppm)	3.41	3.51	3.64	3.74	3.57
GA ₃ (20 ppm)	3.49	3.57	3.69	3.80	3.64
Mean	3.37	3.46	3.58	3.70	
CD at 5% level of significance	Treatment 0.04		Storage 0.03		Interaction NS

2007) and by BA alone in guava (Jayachandran *et al.*, 2007).

Acidity (%): The results presented in the Table 5 revealed that acidity was significantly affected by the treatments and storage duration and maximum acidity (0.55 and 0.54%) was in fruits treated with GA₃ (20 ppm) and Kinetin (25 ppm), respectively in an descending order and both these treatments are at par.

Treatments has significant effect on acidity and maximum acidity was found in fruits treated with GA₃ (20 ppm) and Kinetin (25 ppm) during ambient storage. The decreasing trend in the fruit acidity with the increasing storage period might be due to the oxidation of organic acid and its further utilization in metabolic processes (Obenland *et al.*, 2011). The reduction in the acidity of kinnow fruit juice during storage has also been noticed earlier by Thakur *et al.* (2002) and this might be due to utilization of acids by the respiratory process and conversion in sugars and salts. Acidity was higher in plant growth regulators treated fruits after harvest and also retains acidity during storage as compared to control (Khalid *et al.*, 2012).

Ascorbic acid (mg/100 ml): The ascorbic acid (Table 6) decreased significantly from the maximum (24.39 mg/100 ml) at first day of storage to the minimum (21.00 mg/100 ml) at 15th day of storage period. Treatments has no significant effect on ascorbic acid and maximum ascorbic acid was found in fruits treated with GA₃ (20 ppm) and Kinetin (25 ppm) during ambient storage. Ascorbic acid is highly sensitive to oxygen and is susceptible to oxidative deterioration as well as mild oxidation resulting in the formation of dehydro ascorbic acid. Presence of oxygen accelerates oxidation process in fruits (Ahmad, 1982). Rokaya *et al.* (2016) observed the effect of GA₃ on mandarin fruit quality and shelf life and found that treated fruits had non-significant effect on ascorbic acid, although GA₃ treated fruits had higher ascorbic acid than control. Plant growth regulators significantly increase the ascorbic acid content of Kinnow fruits (Nawaz *et al.*, 2008).

Juice content (%): The juice content (Table 7) decreased significantly from the maximum (46.54%) at first day of storage to the minimum (42.36%) at 15th day of storage period. Treatments has no significant effect on juice content and maximum juice content was found in fruits treated with GA₃ (20 ppm) and Kinetin (25 ppm) during

ambient storage. The decrease in juice content of fruits during storage is due to loss of moisture from fruit surface. As the storage period increases, the moisture loss continues and results into decrease in juice content with storage. Kaur *et al.* (2014) observed the fruits treated with Kinetin and stored under cold storage and ambient conditions shows non-significant difference between treatments and control, but maximum juice content was found with Kinetin (20 ppm). Khalid *et al.* (2012) reported that GA₃ and higher concentrations of BA and kinetin significantly increased juice mass percentage and decreased the rag mass percentage as compared to control. Plant growth regulators significantly increase the juice content of Kinnow fruits (Nawaz *et al.*, 2008).

Reducing sugar (%): The data (Table 8) indicates that the reducing sugar was maximum (3.64%) in fruits treated with GA₃ (20 ppm) followed by Kinetin at 25 ppm (3.59%) and Kinetin at 30 ppm (3.57%). The reducing sugar increased significantly from the minimum (3.37%) at first day of storage to the maximum (3.70%) at 15th day of storage period. The increase in fruit sugars content during storage may be attributed to reduction of fruit moisture content, degradation of complex insoluble compounds to simple soluble compounds and accumulation of sugars in fruit juice (Siddiqui *et al.*, 2011 and Jawandha *et al.*, 2012). During post-harvest storage the increase in sugars in the juice was also due to cell wall hydrolysis by various enzymes such as pectinase, hemi-cellulase and cellulose (Echeverria and Ismail, 1987). Applications of plant growth regulators retained higher reducing sugars content in comparison to control during storage. This might be due to their effect on degradation of sugars as well as on the rates of respiration (Devi *et al.*, 2016). More retention of total soluble solids during storage might be due to the treatment effect on physiological ageing and change in metabolism (Bhardwaj *et al.*, 2010). Reducing sugar was higher in plant growth regulators treated fruits after harvest and also retains more reducing sugar during storage as compared to control (Khalid *et al.*, 2012).

Conclusions

From the above information it may be concluded that the fruits treated with GA₃ (20 ppm) and Kinetin (25 ppm) is best option to enhancement shelf life of Kinnow under Abohar conditions of Punjab.

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Biodiesel Production Process from Waste Rice Bran Oil

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Abstract

Response surface methodology (RSM) based on central composite rotatable design (CCRD) was used to study the effects of different variables in bringing down the free fatty acids (FFA) of crude rice bran (RBO) oil to less than 1% and also for biodiesel production from pretreated oil by transesterification process. The three important reaction variables methanol quantity (M), acid concentration (C) and reaction time (T) significantly affected the reduction of FFA oil, methanol quantity being the most effective followed by acid catalyst concentration and reaction time. Using RSM a quadratic polynomial equation was obtained for predicting the acid value by multiple regression analysis. Similarly, two important reaction variables-methanol quantity and reaction time affected the transesterification process of the pretreated oil, methanol being the most effective followed by reaction time. Verification experiments confirmed the validity of the both the predicted models. The optimum combustion for reducing the FFA of RBO from 12.5% less than 1% after pretreatment was found to be 1.41% v/v H_2SO_4 acid catalyst, 0.30 v/v methanol-to-oil ratio and 60 min reaction time at a reaction temperature of 58 to 60°C. for producing biodiesel from pretreated oil, 0.23 v/v methanol-to-pretreated oil ratio and 30 minutes of reaction time at a reaction temperature of 58 to 60°C were found to be the optimum combination. A yield of 98% was obtained following this two step process. The fuel properties of RBO so obtained were found to be within the range of American and European standards prescribed.

Introduction

The growing concern due to environmental pollution caused by the conventional fossil fuels and the realization that they are nonrenewable have led to search for more environment friendly and renewable fuels. Among various options investigated for diesel fuel, biodiesel obtained from vegetable oils has been recognized world over as one of the strong contenders for reductions in exhaust emissions. Several countries including India have already begun substituting the conventional diesel by a certain amount of biodiesel. Worldwide biodiesel production is mainly from edible oils such as soybean, sunflower and canola oils. Since, India is not self sufficient in edible oil production, hence, some non-edible available in the country are required to be tapped for biodiesel production. RBO could be one such oil as India has a total annual production of 8 million tones of rice bran, which can yield oil to the tune of 2 million tons. Though this oil is edible but it is not commonly used as its quality deteriorates with times i.e. its free fatty acids (FFA) contents increase with time and thus make it unsuitable for edible purposes (Chakraverty, 1994). Stabilization of FFA of RBO is virtually impossible for dispersed nature of rice milling. Hence, an attempt was made to produce biodiesel from RBO at IIT, Kharagpur to utilize this resource effectively.

Materials and Methods

Rice bran oil was purchased from Madhav Rice Mill located in Misnapur, west Bamgal, India. Methanol (Extrapure AR Grade) Di-ethyl ether, ethanol, KOH, Phenolphthalein indicator and sulfuric acid (ACS grade,

98%) were purchased from local market. The KOH in pellet form was used as a base catalyst for transesterification reaction. Experiment were conducted in the laboratory scale setup, which consist of a 500 cc glass flasks (Duran) with airtight caps that retained any vaporized methanol to be reacting mixture. The flasks were kept in a water bath maintained at 58 to 60°C just below the boiling point of methanol. The mixture was stirred at the same rate for all run by manually shaking the flasks at every 5 minute interval.

Esterification (Pretreatment) : Crude non-edible RBO was highly viscous and dark brownish in colour. RBO was passed through a 5 micron filter and heated up to 45 to 60°C temperature for one hour, after that its FFA content was examined by standard titimetry method (Anonymous, 2003). This oil had an initial acid value of 24 ± 1 mg KOH/g corresponding to a FFA of 12 ± 0.5 which is far above the 1% limit for satisfactory transesterification reaction using alkaline catalyst. Therefore, FFA were first converted to esters in a pretreatment process with methanol using an acid catalyst (H_2SO_4). After the reaction, mixture was allowed to settle for six hours and the methanol water suspension that separated at the top was removed in a separating funnel. The acid value of the product separated at the bottom was determined. The product having acid value less than 2 ± 0.25 mg KOH/g was used for the transesterification reaction.

Transesterification : The transesterification reaction was carried out with 0.20 v/v methanol-to-oil ratio (i.e. 5:1 molar) using 0.55% w/v KOH as an alkaline catalyst. The amount of KOH (5.5 g per liter of pretreated rice bran oil)

was arrived based on the amount needed to neutralize the untreated acids (i.e. 3 mg KOH/g) in the second stage product plus 0.35% for virgin oil. The reaction was carried out at 58 to 60°C for half an hour. The reaction products were allowed to settle for overnight period before removing the glycerol layer from the bottom in a separating funnel to get the ester layer on the top, separated as biodiesel.

Fuel properties : The fuel properties namely, density at 15°C, kinetic viscosity at 40°C, flash point, pour point, water content, ash content, carbon residue, acid value and calorific value of RBO, rice bran biodiesel and conventional diesel were determined as per the prescribed methods and compared with the latest American and European standards for biodiesel (Anonumus, 2003; EN 14214, 2003).

Experimental Design : The experimental plan was made using CCRD to provide data to model the effects of the impendent variables: methanol-to-oil ratio, acid concentration, reaction time on the pretreatment step as compared to methanol-to-pretreated oil ratio, reaction time on the transesterification step of the rice bran biodiesel production process.

Pretreatment process : A five-level-three-factor CCRD was employed in this optimization study requiring 34 experiments (Cochran and Cox, 1992; Ghadge and Raheman, 2006). Methanol-to-oil ratio (M), catalyst concentration (C) and reaction time (T) were the independent variables selected to be optimized for the reduction of acid value (AV) of crude RBO. The coded and uncoded levels of the independent variables are given in Table 1. Two replications were carried out for all design points (Factorial and central) except the centre point (0, 0, 0) and the experiments were carried out in randomized order.

Transesterification process : A five-level-three-factor CCRD was employed in this optimization study requiring 21 experiments (Shieh et al., 2003). Methanol-to-oil ratio (M), and reaction time (T) were the independent variables selected to be optimized the transesterification of pretreated RBO. The coded and uncoded levels of the independent variables are given in Table 2. Two replications were carried out for all design points (Factorial and axial) except the centre point (0, 0) and the experiments were carried out in randomized order.

Results and Discussion

Pretreatment (esterification) : The experimental acid value responses were obtained from the design points. All the three variables for esterification process are presented in two forms, coded and un-coded (actual) in Table 3. Multiple regression coefficient obtained by using a least

square technique to predict the acid value given in Table 4. From the table, it is observed that the linear term of methanol quantity (M), linear and quadratic term of acid concentration (C), linear term of reaction time (T) and interaction term MC are significant model terms reducing the acid value at 5 percent level of significance. However, quadratic terms of methanol, reaction time and other interaction terms are not significant. The model was tested for adequacy by analysis of variance. The regression model for pretreatment is highly significant with a coefficient of determination of 0.90. The predicted model for acid value is given as follows.

$$\text{Acid value} = 78.299 - 123.920 * M - 73.887 * C - 0.02 * T + 76.014 * M * C - 0.035 * M * T + 0.011 * C * T + 20.874 * M^2 + 16.21 C^2 + 3.193 E - 005 * T^2$$

The effect of all the three independent variables (M, C and T) on acid value reduction is shown in Figs. 1-3 in the form of contour lines as obtained from above developed model. Using Design Expert (DX-7.0) software, the optimized critical values were obtained as 0.30 v/v methanol-to-oil ratio, 1.41% v/v catalyst concentration and 60 min reaction time and selecting a stationary point in the experimental region.

Effect of parameters : The contour line, drawn at constant value of 60 min reaction time (T), 1.41% v/v catalyst concentration (C) and 0.30 v/v methanol-to-oil ratios (M) respectively are shown in Figs. 1, 2 and 3. The responses corresponding to the contours plots of second-order predicted model indicated that for low methanol-to-oil ratio, acid value reduces with increasing catalyst concentration (Fig. 1) and reaction time (Fig. 2), reaction time being less effective. Maximum conversion of FFA was, therefore, obtained for large catalyst concentration followed by methanol-to-oil ratio, as these parameters were the most significant with negative effect (seen in predicted model). However, at higher methanol-to-oil ratio there was no significant change acid value with increase in reaction time (Fig. 2) but there was increase in acid value with increase in catalyst concentration (Fig. 1). This could be due to greater positive coefficients of methanol-catalyst (MC) than methanol-time (MT) interactions.

At low catalyst concentration there was a slight decrease in acid value with increase in reaction time, since the time effect was slight positive (Fig. 2). For higher catalyst concentration, the decrease of acid value with increase in time became non-significant. It was also observed that increasing reaction time beyond 90 minutes, there was no significant reduction in acid value as desired (Fig. 2 and Fig. 3). This might be due to the effect of water produced during the esterification of free fatty acids, which prevented further reaction.

Table-1 : Independent variables and their levels used for CCRD in esterification process.

Variables	Symbols	Levels*				
		-1.682(?)	-1	0	+1	+1.682(?)
Methanol-to-oil ratio (v/v)	M	0.20	0.24	0.30	0.36	0.40
H ₂ SO ₄ concentration (%v/v)	C	1.2	1.28	1.4	1.52	1.6
Reaction Time (minute)	T	30	42.16	60	77.84	90

*Transformation of variables levels from coded (X) to uncoded could be obtained as: $M=0.30+0.06X$, $C=1.45+0.12X$ and $T=60+17.84X$

Table-2 : Independent variables and their levels used for CCRD in transesterification process.

Variables	Symbols	Levels*				
		-1.414(?)	-1	0	+1	+1.414(?)
Methanol-to-oil ratio (v/v)	M	0.15	0.16	0.20	0.24	0.25
Reaction Time (minute)	T	20	23	30	37	40

*Transformation of variables levels from coded (X) to uncoded could be obtained as: $M=20+0.4X$ and $T=30+7.0X$

Table-3 : Central composite rotatable design (CCRD) arrangement and responses for esterification process.

Treatment	Random	Point Type	Level of variables [(coded)actual]			Acid values (responses)	
			M	C	T	Experimental	Predicted
1	34	Fact	(-1)0.24	(-1)1.28	(-1)42.16	4.61	4.50
2	4	Fact	(-1)0.24	(-1)1.28	(-1)42.16	4.60	4.50
3	14	Fact	(+1)0.36	(-1)1.28	(-1)42.16	2.51	2.63
4	1	Fact	(+1)0.36	(-1)1.28	(-1)42.16	2.52	2.63
5	30	Fact	(-1)0.24	(+1)1.52	(-1)42.16	2.35	2.15
6	8	Fact	(-1)0.24	(+1)1.52	(-1)42.16	2.34	2.15
7	27	Fact	(+1)0.36	(+1)1.52	(-1)42.16	2.27	2.47
8	29	Fact	(+1)0.36	(+1)1.52	(-1)42.16	2.28	2.47
9	3	Fact	(-1)0.24	(-1)1.28	(+1)77.84	4.60	4.10
10	33	Fact	(-1)0.24	(-1)1.28	(+1)77.84	4.61	4.10
11	7	Fact	(+1)0.36	(-1)1.28	(+1)77.84	2.24	2.07
12	9	Fact	(+1)0.36	(-1)1.28	(+1)77.84	2.23	2.07
13	22	Fact	(-1)0.24	(+1)1.52	(+1)77.84	2.32	1.84
14	20	Fact	(-1)0.24	(+1)1.52	(+1)77.84	2.31	1.84
15	31	Fact	(+1)0.36	(+1)1.52	(+1)77.84	2.23	2.01
16	11	Fact	(+1)0.36	(+1)1.52	(+1)77.84	2.22	2.01
17	32	Axial	(-?)0.20	(-1)1.28	(-1)42.16	2.89	3.32
18	12	Axial	(-?)0.20	(-1)1.28	(-1)42.16	2.90	3.32
19	19	Axial	(+?)0.40	(-1)1.28	(-1)42.16	2.21	1.90
20	15	Axial	(+?)0.40	(-1)1.28	(-1)42.16	2.22	1.90
21	24	Axial	(0)0.30	(-?)1.20	(-1)42.16	3.97	4.06
22	21	Axial	(0)0.30	(-?)1.20	(-1)42.16	3.96	4.06
23	10	Axial	(0)0.30	(+?)1.60	(-1)42.16	2.05	2.04
24	16	Axial	(0)0.30	(+?)1.60	(-1)42.16	2.00	2.04

Requirement of high amount of methanol (0.30v/v methanol-to-oil ratio) for pretreatment step to lower the FFA below 1% could be reduced by recovering part of it by fractional distillation of methanol-water suspension, which is separated from the top after pretreatment process.

Transesterification : Alkaline-catalyzed transesterification was carried out by using the pretreatment oil sample which had an acid value of 2.0 mg KOH/g.

Experimental values of percentage conversion obtained as response at the design points are presented in Table 5. The two variables are shown in both, coded and uncoded (actual) form. Multiple regression coefficients indicated in Table 5 were obtained by using a least square technique to predict a model for percent conversion. From the table it is observed that the linear terms of methanol quantity (M) and interaction term MT are significant model terms at 1 and 5 percent levels of significance. However, linear term

Table-4 : Regression coefficient of predicted quadratic polynomial model for esterification.

Terms	Regression coefficient	Standard error
Intercept		
0	+78.299**	0.13
Linear		
1	-123.910**	0.059
2	-73.887**	0.059
3	+0.021*	0.059
Quadratic		
11	+20.874	0.065
22	+16.218**	0.065
33	+3.193E-005	0.065
Interaction		
12	+76.014**	0.077
13	-0.035	0.077
23	+0.011	0.077

* & ** Significant at 0.05 and 0.01 level res $R^2 = 0.90$, $F_{\text{value}} = 0.0001$

Table-5 : Central composite rotatable design arrangement and responses for transesterification process.

Treatment	Random		Point Type		Biodiesel yield (responses)	
			M	T	Experimental	Predicted
1	19	Fact	(-1)0.16	(-1)22.93	97	95.84
2	16	Fact	(-1)0.16	(-1) 22.93	97	95.84
3	12	Fact	(+1)0.24	(-1) 22.93	100	99.49
4	2	Fact	(+1)0.24	(-1) 22.93	100	99.49
5	13	Fact	(-1)0.16	(+1)37.07	94	93.75
6	15	Fact	(-1)0.16	(+1)37.07	94	93.75
7	9	Fact	(+1)0.24	(+1)37.07	100	100.79
8	8	Fact	(+1)0.24	(+1)37.07	100	100.79
9	11	Axial	(-?)0.15	(0)30.00	93	94.13
10	5	Axial	(-?)0.15	(0)30.00	93	94.13
11	20	Axial	(+?)0.25	(0)30.00	100	100.81
12	3	Axial	(+?)0.25	(0)30.00	100	100.81
13	7	Axial	(0)0.20	(-?)20.00	97	97.75
14	14	Axial	(0)0.20	(-?)20.00	97	97.75
15	6	Axial	(0)0.20	(+?)40.00	98	97.19
16	4	Axial	(0)0.20	(+?)40.00	98	97.19
17	18	Center	(0)0.20	(0)30.00	98	97.47
18	21	Center	(0)0.20	(0)30.00	98	97.47
19	10	Center	(0)0.20	(0)30.00	98	97.47
20	17	Center	(0)0.20	(0)30.00	98	97.47
21	1	Center	(0)0.20	(0)30.00	97	97.47

of reaction time (T) was insignificant. The model was tested for adequacy by analysis of variance and found to be highly significant with a coefficient of determination as 0.90. The predicted model in terms of un-coded (actual) factors for % conversion is as given below :

Percent conversion

$$= 102.953 - 23.180 \cdot M - 0.628 \cdot T + 3.000 \cdot M \cdot T$$

Effect of the independent variables (M and T) on percent conversion is shown in Fig 4 in the form of contour plots

drawn from the above developed model. The optimized critical values of these variables obtained using Design Expert software were found to be 0.23 v/v methanol-to-oil ratio and 30 min reaction time selecting a stationary point in the experimental region. The verification of experiment showed reasonably close value of 99±1% conversion to the predicted value for the stationary point as 100% conversion and thus confirmed the adequacy of the predicted model.

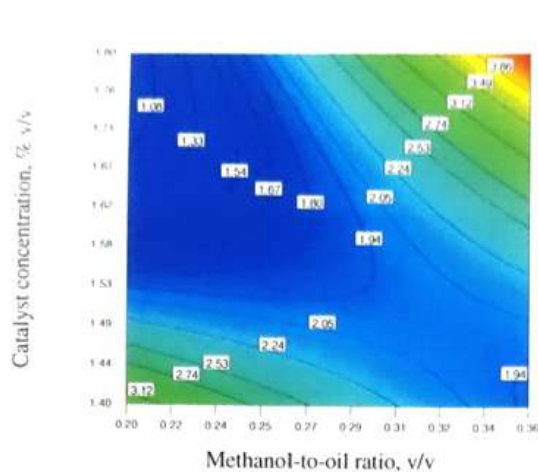
Table-6 : Regression coefficient of predicted quadratic polynomial model for esterification.

Terms	Regression coefficient	Standard error
Intercept		
γ_0	+102.953**	0.17
Linear		
γ_1	-23.180**	0.20
γ_2	-0.628**	0.20
Interaction		
γ_{12}	+3.000**	0.28

* & ** Significant at 0.05 and 0.01 level res $R^2 = 0.897$, $F_{\text{value}} = 49.49$, $P_{\text{value}} = 0.0001$

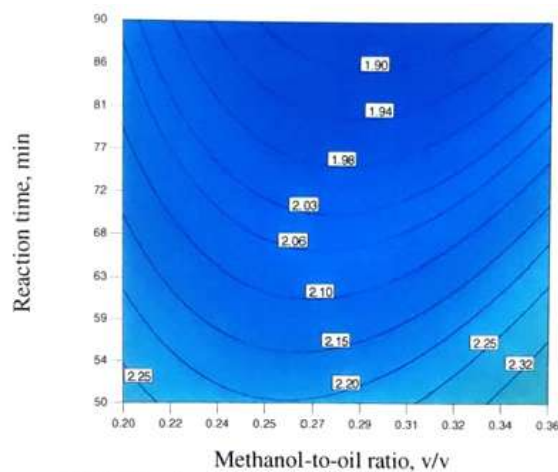
Table-8 : Fuel properties of rice bran oil and its biodiesel.

Property	Unit	Rice bran oil	Rice bran biodiesel	Diesel	Biodiesel standards	
					ASTM D 6751-02	EN 14214
Density at 15°C	Kg/m ³	882	868	850	870-900	860-900
Viscosity 15°C	Mm ² /s	27	3.50	2.60	1.9-6.0	3.5-5.0
Flash point	°C	215	195	68	>130	>120
Pour point	°C	8	4	-20	-15 to 10	-
Water content	%	1.0	0.02	0.02	<0.03	<0.05
Ash content	%	1.0	0.02	0.01	<0.02	<0.02
Carbone residue	%	1.5	0.20	0.17	-	<0.30
Acid value	Mg KOH/g	25	0.45	-	<0.80	<0.50
Calorific value	MJ/kg	36	40.0	42	-	-



(a) 77 min reaction time

Fig.-1



(b) 1.51% v/v catalyst concentration

Fig.-2

Effect of parameters : Contours were drawn with methanol-to-oil ratio on x-axis and reaction time on y-axis shown in Fig.-4. The responses corresponding to the contour plots of predicted model indicated that there is one optimum values of methanol-to pretreated oil ratio (M), where percent conversion is closer to 100. At low methanol-to-oil ratio there was a moderate decrease in the percent conversion with increase in reaction time due to the fact that time effect was negative. For higher methanol-to-pretreated oil ratio there was a moderate increase in the percent conversion with increase in

reaction time. This could be due to positive methanol-time interaction term.

Rice bran biodiesel fuel properties : Following the esterification and transesterification process a yield of 98% biodiesel was obtained from RBO. The fuel properties of rice bran biodiesel i.e. the density, viscosity, flash point, pour point, water content, ash content, carbon residue, acid value and calorific value were found to be 868 kg/m³, 3.48 mm²/s, 95°C, 4°C, 0.02%, 0.02%, 0.25%, 0.45 mg KOH/g and 40MJ/kg. These values are within the

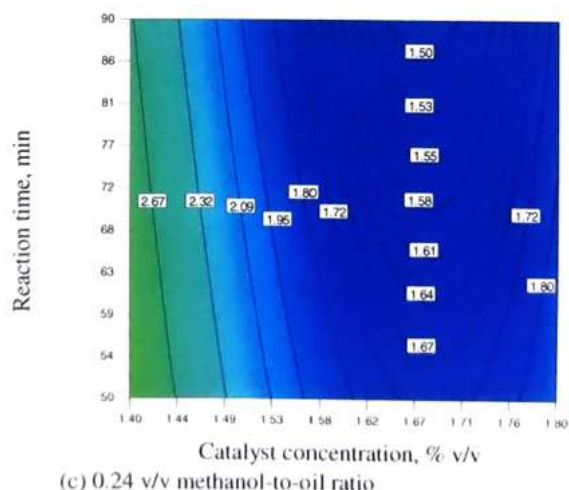


Fig.-3

range of biodiesel standards as recommended in ASTM D 6751-02 and EN 14214. Fuel properties of RBO and its biodiesel are presented in the Table 7.

Conclusions

The FFA (12.5%) level of crude rice bran oil could be reduced to less than 1% by its pretreatment with methanol (0.30 v/v) using H₂SO₄ as catalyst (1.41%v/v) in one hour reaction at 58 to 60°C temperature. A second order model was obtained to predict acid value as a function of methanol-to-oil ratio, catalyst concentration and reaction time. The model was found to describe adequately the experimental range studied. After pretreatment step, settling time of minimum 6 hours was required for removal of methanol-water mixture. The product was used for the final alkaline-catalyzed (0.55%w/v KOH) transesterification reaction with methanol (0.23v/v) and reaction time 30 min to produce biodiesel. This process gave yield of 98% rice bran biodiesel having properties satisfying both American and European Standards for biodiesel.

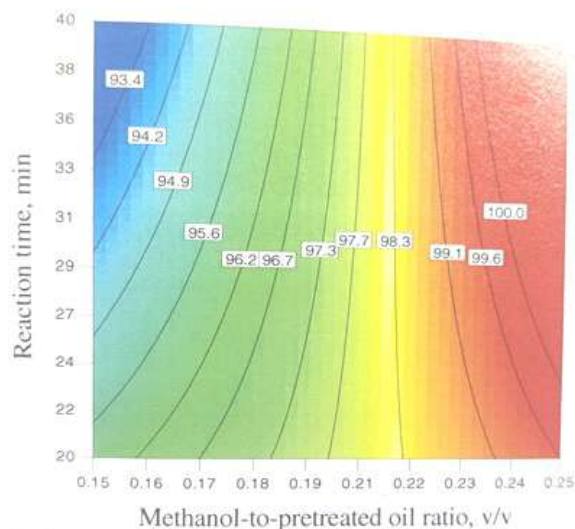


Fig-4

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