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EFFECT OF PLANTING DATES AND VA-MYCORRHIZA ON THE PERFORMANCE OF TURMERIC (*CURCUMA LONGA* L.) CV. SALEM

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ABSTRACT
A field investigation was carried out to find out the suitable planting dates and with or without inoculation of VA-Mycorrhiza. Planting dates (fortnight intervals) starting from 2nd fortnight of April influenced the growth and yield of turmeric with or without inoculation of VA-Mycorrhiza. Various growth parameters (plant height, number of tillers per clump, number of leaves per clump and leaf area) of mean data were significantly varied at 180 days after planting in turmeric with or without inoculation of VA-Mycorrhiza. Highest plant height, number of tillers per clump, number of leaves per clump and leaf area were recorded by crop planted 2nd fortnight of May (102.79 cm, 9.20, 88.97, and 63.56 dm^2 respectively) followed by 1st fortnight of May (96.04 cm, 8.37, 83.70, and 60.16 dm^2 respectively). Fresh rhizome yield per hectare was also significantly higher by the crop planted in 2nd fortnight of May (47.32 t ha^{-1}) followed by 1st fortnight of May (38.03 t ha^{-1}). Similarly, the curing percentage and estimated cured yield were significantly higher by 2nd fortnight of May (34.00 % and 16.12 t ha^{-1}, respectively) compared to the lowest in 1st fortnight of July (20.68 % and 0.98 t/ha respectively). Hence, planting of turmeric during 2nd fortnight of May with inoculation of VA-mycorrhiza is ideal under northern dry zone of Karnataka.

INTRODUCTION

Turmeric (*Curcuma longa* L.), a herbaceous rhizomatous crop, belonging to zingiberaceae family is one of the most valuable spices all over the world. It is used as spice and condiment, dye stuff and in cosmetic and drug industry. India is the world's largest producer and exporter of turmeric and it produces nearly 50 per cent of global turmeric production. It is grown in an area of 2.33 lakh hectares with an average production of 11.90 lakh MT (Anon., 2015). The date of planting has a great impact on growth of turmeric. Early planting on 25th April and harvesting date of 5th March gave the highest yield, gross return and net return compared to May 10th and May 25th planting (Manhas *et al.,* 2010). Planting rhizome in the second week of March showed highest plant height, maximum number of tillers, maximum number of leaves and highest rhizome yield (Sengupta and Dasgupta, 2010).

Mycorrhizal fungi occur in most of the soils and colonize roots of many plant species. They are the structures resulting from the symbiosis between Mycorrhizal fungi and plant roots, and are directly involved in plant mineral nutrition. The symbiotic root-fungal association increases the uptake of less mobile nutrients (Ortas *et al.*, 2001), essentially phosphorus (P) but also of micronutrients like zinc (Zn) and copper (Cu), the symbiosis has also been reported as influencing water uptake. Mycorrhizal fungi can also benefit plants by stimulating the production of growth regulating substances, increasing photosynthesis, improving osmotic adjustment under drought and salinity stresses and increasing resistance to pests and soil borne diseases (Al-Karaki, 2006). These benefits are mainly attributed to improved phosphorous nutrition (Plenchette *et al.,* 2005). The fresh weight, biomass, chlorophyll, lipid, protein, carbohydrate and nucleic acid contents were significantly increased with application of VAM compared to all other treatments in sweet flag (Vijaya *et al.,*2008). Combined inoculation of *Glomus mosseae, G. fasciculatum* and azotobactor or with *G. mosseae* and *G. fasciculatum* or with *G. mosseae* or *G. fasciculatum* increased chlorophyll content, plant height, number leaves, leave area and tuber weight compared to un-inoculated coleus plants (Aruna *et al.,* 2007).

Although, several researchers published reports on dates of planting in turmeric. However, the information on mycorrhizal fungi in turmeric is limited. Therefore the present study was intended to find out the suitable planting dates and VA-mycorrhiza on performance of turmeric (*Curcuma longa* L.) cv.Salem.

MATERIALS AND METHODS

The experiment was conducted during 2011-2012 (one year) at K.R.C College of Horticulture, Arabhavi, Karnataka. Arabhavi is situated in northern dry zone of Karnataka state with mean rainfall of this area is about 523.10 mm which distributed between April to November. Experiment was laid out in split plot design with three replications. The experiment consisted of six fortnightly planting dates starting from 2nd fortnight of April to 1st fortnight of July as main treatment and two sub plot treatments *viz.*, with or without application of VAM. Healthy, uniform size rhizomes, having an average weight of 20-25 g

were utilized for planting after dipping in the solution of captan (3 g/L) and endosulphon (2 ml/L) for 30 minutes before planting (Manhas *et al.,* 2010). Recommended dose of farmyard manure (25 t/ha) and chemical fertilizers (180, 90 and 90 kg NPK/ ha) were applied. Half dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose. Remaining nitrogen was top dressed at 45 days after planting after weeding. The inoculation of VAM fungus (*Glomus fasiculatum*) to turmeric was done during planting by applying 5 grams (soil form) per rhizome, just before planting (Singh *et al.*, 2012). The uninoculated VAM rhizomes served as a control. The crop was harvested in the month of second week of February. Observations on growth parameters (at 180 days after planting) and seed to yield ratio were recorded on randomly selected thrice replicated plants. Fresh rhizome yield/ plant, yield/plot and estimated yield/ha and curing percentage was also worked out.

Curcumin content was estimated by following the method suggested by (Manjunath *et al*., 1991). The volatile oil content was estimated as per the methods described in ASTA (Anon., 1968).

RESULTS AND DISCUSSION

The rhizome planted with VAM inoculation recorded lowest numbers of days (29.89) for sprouting as compared to uninoculated VAM (38.33) rhizome as indicated in (Table 1). Significantly minimum number of days was taken for germination by the rhizome planted in 2nd fortnight of May (29.17) while the maximum was recorded by April 1st fortnight (39.67). Plant height (90.20 cm), number of leaves per clump (81.96) and leaf area (56.25 dm^2) at 180 days were significantly higher by VAM inoculated plant compared to uninoculated control (84.82 cm, 73.77 and 47.85 dm^2 respectively). However, number of tiller per clump showed non-significant effect among the treatments. Among the different planting dates, planting in 2nd fortnight of May recorded the highest plant height of 102.79 cm, followed by 1st fortnight of May (96.04 cm) compared to the lowest recorded by 1st fortnight of July (67.81cm).

The highest number of tiller per clump (9.20), number of leaves per clump (88.97) and leaf area (63.56 dm^2) was recorded by the turmeric crop planted in 2nd fortnight of May which was on par with 1st fortnight of May (8.37, 83.70 and 60.16 dm^2 respectively) compared to the planting in July 1st fortnight (7.43, 66.25 and 37.93 dm^2 respectively).

This positive influence of growth parameters is attributed early sprouting of turmeric planted during May 1st and 2nd fortnight might have helped the plants to get better establishment and rapid growth thereby producing better vegetative performance compared to early and late planting. The atmosphere was also congenial for better growth as it was comparatively hot and humid during this period. There was decrease in growth attributes of turmeric crop planted beyond 2nd fortnight of May which may be attributed to reduced physiological conditions of rhizome for sprouting and establishment leading to poor field performance. Similar results were also reported by (Bandopadhyay *et al.,* 2005; Kandiannan and Chandaragir 2006; Shadap, 2010; Manhas *et al.,* 2010 and Singh *et al.,* 2013). Vegetative performance was higher in VAM inoculated plant compared to uninoculated control. This might be due to enhanced uptake of nutrients and water by the plant inoculated with VA-mycorrhiza leading to increased vegetative growth. Inoculation with arbuscular-mycorrhizal fungi improved the plant biomass and phosphorous uptake in *Coleus aromaticus* (Earanna *et al.,* 2001) and *Catharanthus roseus* (Karthikeyan *et al.,* 2008).

The data on fresh rhizome yield (g/clump), yield to seed ratio and yield (t/ha) differed significantly among different planting dates and VAM inoculation (Table 2). However, crop duration was non-significant among the treatments. Turmeric crop receiving VAM inoculation recorded significantly higher fresh rhizome yield per plant (378.54 g), yield to seed ratio (18.93) and yield (27.25 t/ha) compared to the uninoculated control (320.02 g, 16.00 and 22.85 t/ha respectively). Planting rhizome in 2nd fortnight of May resulted in the highest fresh rhizome yield per plant (532.23 g), yield to seed ratio (26.61) and yield (47.32 t/ha) compared to the lowest recorded by July 1st fortnight (114.43 g, 5.72 and 4.70 t/ha respectively). The crop duration ranged between 287.17 days (April 2nd

Table 1: Effect of planting dates and VA-Mycorrhiza inoculation on sprouting percentage and growth parameters in turmeric cv. Salem

Treatment	Days to Sprout (%)			Plant height (cm)			No of tillers clump^{-1}			No. of leaves clump^{-1}			Leaf area (dm^2)		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
D_1	35.00	44.33	39.67	93.86	86.98	90.42	8.80	8.47	8.63	84.47	78.47	81.47	58.16	49.93	54.05
D_2	30.33	38.67	34.50	98.21	93.87	96.04	8.60	8.13	8.37	88.23	79.17	83.70	64.74	55.59	60.16
D_3	25.33	33.00	29.17	105.79	99.79	102.79	9.40	9.00	9.20	93.30	84.63	88.97	68.83	58.28	63.56
D_4	27.00	37.33	32.17	91.89	86.63	89.26	8.40	7.80	8.10	78.97	70.27	74.62	53.54	46.13	49.83
D_5	29.33	37.33	33.33	80.96	76.50	78.73	8.00	7.40	7.70	76.83	67.53	72.18	50.61	42.94	46.77
D_6	32.33	39.33	35.83	70.47	65.15	67.81	7.60	7.27	7.43	69.93	62.57	66.25	41.62	34.24	37.93
Mean	29.89	38.33		90.20	84.82		8.47	8.01		81.96	73.77		56.25	47.85	
For comparison of mean															
	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)
D	1.28	4.02	9.19	1.76	5.55	4.93	0.359	1.130	10.683	3.63	11.44	11.41	1.23	3.89	5.81
S	0.60	1.86	7.49	0.92	2.85	4.48	0.181	NS	9.345	1.70	5.23	9.24	1.08	3.33	8.81
D x S	1.48	4.55		2.26	6.96		0.444	1.361		4.15	12.80		2.65	8.15	

Main plot (D): Dates of planting

D_1 - 2nd fortnight of April, 2011
D_2 - 1st fortnight of May, 2011
D_3 - 2nd fortnight of May, 2011
D_4 - 1st fortnight of June, 2011
D_5 - 2nd fortnight of June, 2011
D_6 - 1st fortnight of July, 2011

Sub plot (S): VAM application

S_1- With VAM
S_2- Without VAM

NS - Non significant

Table 2: Effect of planting dates and VA-Mycorrhiza inoculation on fresh rhizome yield and crop duration in turmeric cv. Salem

Planting date	Yield per plant (g/clump)		Mean	Yield to seed ratio		Mean	Yield (t/ha)		Mean	Crop duration (days)		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
D_1	401.93	377.40	389.67	20.10	18.87	19.48	31.29	22.72	27.00	291.67	282.67	287.17
D_2	524.27	438.00	481.13	26.21	21.90	24.06	41.56	34.50	38.03	285.33	277.33	281.33
D_3	590.73	473.73	532.23	29.54	23.69	26.61	50.62	44.03	47.32	270.00	261.67	265.83
D_4	367.87	307.53	337.70	18.39	15.38	16.88	18.93	18.11	18.52	251.67	243.33	247.50
D_5	261.13	219.93	240.53	13.06	11.00	12.03	15.77	13.67	14.72	232.67	227.33	230.00
D_6	125.33	103.53	114.43	6.27	5.18	5.72	5.35	4.05	4.70	206.33	199.67	203.00
Mean	378.54	320.02		18.93	16.00		27.25	22.85		256.28	248.67	
For comparison of mean												
	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at5%	CV (%)	S.Em±	C.D. at5%	CV (%)
D	13.64	42.98	9.57	0.68	2.15	9.57	1.85	5.82	18.07	3.48	10.97	3.38
S	6.98	21.52	8.48	0.35	1.08	8.48	1.41	4.36	23.92	2.71	NS	4.57
D x S	17.10	52.71		0.85	2.64		3.46	10.67		6.65	20.49	

Main plot (D): Dates of planting

D_1 - 2nd fortnight of April, 2011
D_2 - 1st fortnight of May, 2011
D_3 - 2nd fortnight of May, 2011
D_4 - 1st fortnight of June, 2011
D_5 - 2nd fortnight of June, 2011
D_6 - 1st fortnight of July, 2011

Sub plot (S): VAM application

S_1- With VAM
S_2- Without VAM

NS: Non-significant

Table 3: Effect of planting dates and VA-Mycorrhiza inoculation on quality parameters in turmeric cv. Salem

Planting date	Curing percentage		Mean	Estimated cured yield (t/ha)		Mean	Curcumin content (%)		Mean	Volatile oil (%)		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
D_1	29.73	25.23	27.48	9.28	5.70	7.49	4.93	4.36	4.64	1.33	1.25	1.29
D_2	34.38	29.28	31.83	14.32	10.09	12.20	5.20	4.72	4.96	1.28	1.15	1.22
D_3	35.27	32.73	34.00	17.85	14.40	16.12	4.60	4.22	4.41	1.12	0.80	0.96
D_4	30.46	27.31	28.88	6.19	4.97	5.58	4.22	3.89	4.06	1.08	0.75	0.91
D_5	27.19	24.00	25.59	4.30	3.28	3.79	4.07	3.67	3.87	0.78	0.70	0.74
D_6	21.57	19.79	20.68	1.16	0.81	0.98	3.73	3.33	3.53	0.78	0.63	0.70
Mean	29.77	26.39		8.85	6.54		4.46	4.03		1.06	0.88	
For comparison of mean												
	S.Em±	C.D. at5%	CV(%)	S.Em±	C.D. at5%	CV(%)	S.Em±	C.D. at5%	CV (%)	S.Em±	C.D. at5%	CV(%)
D	0.532	1.686	4.650	0.499	1.579	15.876	0.122	0.395	7.260	0.022	0.087	6.781
S	0.297	0.919	4.483	0.243	0.748	13.385	0.059	0.181	5.877	0.021	0.061	8.527
D x S	0.727	2.241		0.594	1.838		0.144	0.447		0.052	0.143	

Main plot (D): Dates of planting

D_1 - 2nd fortnight of April, 2011
D_2 - 1st fortnight of May, 2011
D_3 - 2nd fortnight of May, 2011
D_4 - 1st fortnight of June, 2011
D_5 - 2nd fortnight of June, 2011
D_6 - 1st fortnight of July, 2011

Sub plot (S): VAM application

S_1- With VAM
S_2- Without VAM

fortnight) and 203.00 days (July 1st fortnight).

Higher fresh yield and yield attributes in turmeric planted during 2nd and 1st fortnight of May might be attributed to better growth and development during the growth period due to higher growth attributes like ample number of functional leaves, more number of tillers and higher leaf size. Vigorous plant growth must have contributed for higher yield due to higher photosynthesis. Further, it also must have resulted in higher sink capacity and accumulation of more of carbohydrates and its translocation into rhizome thereby increased the fresh rhizome yield. Similar results were also reported by Bandopadhyay *et al*. (2005), Kandiannan and Chandaragir (2006) and Manhas *et al*. (2010).

The increase in fresh rhizome weight in inoculated plants also could be correlated with increased mycorrhizal colonization. The reason may also be due to the formation of external mycelium around the roots by VAM fungi. Inoculation of VAM must have helped to increase the mineral phosphorous uptake in the plant and might have resulted in the higher fresh rhizomes yield. These results are agreement with the findings of earlier Investigators (Aruna *et al.,* 2007; Karthikeyan *et al.,* 2008 and Vijaya *et al.,* 2008).

Crop receiving application of VAM showed the higher curing percentage (29.77), estimated cured yield (8.85 t/ha), content of curcumin (4.46%) and volatile oil (1.06%) than the control (26.39, 6.54 t/ha, 4.03 and 0.88% respectively) (Table 3). Significantly higher curing percentage (34.00) and estimated cured yield (16.12 t/ha) were recorded by 2nd fortnight of May compared to the lowest recorded by 1st fortnight of July (20.68 and 0.98 t/ha respectively). However, early planting i.e., May

1st fortnight and April 2nd fortnight recorded the higher curcumin (4.96%) and volatile oil content (1.29%).

The variation in quality parameters *viz.,* curing percentage, cured yield, curcumin and volatile oil content might be due to the longer crop duration which might have increased the dry matter accumulation in the crop as crop duration of earlier planting was more than later planting dates. The rhizome formation starts early and gets more time for development thus resulting in more accumulation of dry matter and curcumin content in early planted crops than the late planted crops. The results in the present investigation are in conformity with earlier finding of (Kandiannan and Chandaragir, 2006; Shadap, 2010 and Singh *et al.,* 2013). Application of VAM might have helped to increase the quality parameters of turmeric. This may be due to the role of VAM (*Glomus fasciculatum*) in increased mineralization of organic matter. P is one of the main nutrients involved in the synthesis of secondary metabolites as their production demands ATP (Sangwan *et al.,* 2001). The increase in availability of P through mycorrhizal association would probably underlie the increase of curcumin. Similarly, the result was supported with earlier finding (Silva *et al*., 2008 in ginger and Yamawaki *et al.,* 2013 in turmeric) inoculated mycorrhizal fungi found oil concentration was modulated according to VAM.

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EFFECT OF DIFFERENT GROWTH REGULATORS ON *IN VITRO* MICROTUBERIZATION OF *SOLANUM TUBEROSUM*

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ABSTRACT
An efficient protocol has been developed for microtuberization in potato cv. Kufri Frysona, world's most important tuber crop. Nodal segments from *in vitro* established multiplied shoots were inoculated on MS basal medium supplemented with different combinations and concentrations of cytokines, auxins and sugar. Maximum number of microtubers (2.5) were obtained on medium PTM_3 (MS basal salt + 0.01mg/l BAP + 0.01mg/l NAA + 0.1mg/l GA_3 + Sugar 80g/l) in 52.3 days with maximum 9.0 mm size and 0.27 g weight .Maximum percent survival rate (60%) of microtubers was obtained under field conditions.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the world's most important tuber crop, belongs to family Solanaceae. It as a vegetable is very important for its high quality proteins, substantial amounts of 12 essential vitamins, minerals, an extremely high content of vitamin C, trace elements, very low fat content, medicinal properties and best known for its carbohydrate content, (Gray and Hughes, 1978). Potato starch is used in the food industry as thickeners and binders of soups and sauces, in the textile industry as adhesives and for the manufacturing of papers and boards. India is the second largest producer of potato in the world after China, and the crop occupies 1.9 million hectares with a total production of 45.34 million tonnes (Anonymous, 2012).

Conventionally potato is propagated vegetatively using seed tubers, however, disadvantages of this method is that it take long time, low multiplication rate in the field and high susceptibility of potato to viral, bacterial and fungal diseases. At present, the central seed production agencies of India state and are able to meet only 20-25% requirement of quality seed potatoes. For bridging this wide gap, large scale integration of conventional and innovative methods like micro-propagation at commercial level is needed for producing enough quantity of healthy seed tubers in minimum duration (Pandey, 2006).

Micro-propagation is the most effective method and is the alternative to conventional propagation of potatoes. It has been proved to be very efficient technique to speed-up the production of high quality disease-free plantlets, in terms of genetic and physiological uniformities round the year (Sathish *et al*., 2011). And microtubers are formed under aseptic conditions, they are produced when potato shoot cultures are grown in the presence of high level of sucrose. Among the three different explants (nodal segment, sprout and shoot apex) nodal cutting showed the best performance for initiating *in vitro* cultures, microtuber formation, and average weight of microtubers. On the other hand (Sharma *et al*., 2011; Venkatasalam *et al*., 2012) observed that Using double node segments as explants was better over single node some of the potato cultivars for growth vigour of plantlets, whereas, some other cultivars performed equally well with either of the explants. Potato microtubers formed *in vitro* are small less in weight, easy for storage and transportation as comparison to conventional seed potato. Keeping in view all the points stated, the present study was undertaken to develop protocol for efficient microtuberization in potato cv. Kufri Frysona.

MATERIALS AND METHODS

The present study on Effect of different growth regulators on *in vitro* microtuberization of Solanum *tuberosum* was conducted in the Department of Vegetable Science CCSHAU, Hisar and Plant Tissue Culture Laboratory of the Centre for Plant Biotechnology, Government of Haryana, CCSHAU Hisar during 2013 to 2014.

For establishment of multiple shoot cultures, young shoot tips explants 2-3cm size were collected from plants grown in green house were brought to the laboratory,. Excised explants were first soaked in mild detergent for 5-10 min (Bhat *et al*., 2015). Followed by washing in running tap water, so that all detergent from the explant could be removed. The explants were then

treated with 0.2% bavistin and 0.2-0.4% streptocyclin for 45 min followed by 4-6 washing with double distilled water. The explants were treated with 0.1 % $HgCl_2$ treatments for 45sec to 120 seconds. Finally the explants were washed with sterile water for 4-5times to remove toxic $HgCl_2$. Sterlized explants were inoculated on different media combinations having MS basal salt supplemented with different concentration of cytokynins and auxins, *In vitro* multiple shoot cultures were established on MS basal medium supplemented with 0.25 mg/l BAP + 0.01 mg/L IAA (Mohapatra *et al*., 2014)

(Pawer *et al.,* 2015) Nodal segments give good response for *in vitro* regeneration. Nodal segments were taken from already established multiple shoot cultures (as above) for microtu berization studies and were used as explants. The explants were then inoculated in various media fortified with different composition of growth regulators. The experiments for *in vitro* studies were conducted under controlled light and temperature and the culture room was fitted with photoperiodic controller and sequential timer. Temperature was maintained at 25 ± 1^0C and light intensity of 1000 lux was provided using florescent tubes. Photoperiod of 16 hrs/8hrs of light and dark was provided. The data related to various characters were recorded in replicated form using complete randomized design (CRD). Data were analyzed statistically with one factor analysis using OPSTAT software on CCS HAU website.. To judge the significant difference between means of two treatments, the critical difference (C.D.) was used.

RESULTS AND DISCUSSION

The data taken on number of microtuber were affected significantly due to concentration of different medium. Data presented in Table 1 revealed that the maximum number of microtuber (2.5) were observed on MS basal salt supplemented with 0.01mg/l BAP , 0.01mg/l NAA and 0.1mg/l GA_3 along with the application of 80g/l Sugar (PTM_3) in 52.3 days and it was found significantly superior to all other treatments . Zhang *et al*., (2005b) observed the effect of BA and IBA on the formation of micro tubers in potato and reported that combination of growth regulators improved the number and yield of micro-tubers and they found that medium containing 3 mg BA/l + 0.05 mg IBA/l, 3 mg BA/l + 3 mg IBA/l and 1.0 mg BA/l were the most optimum concentration of BA and IBA for microtuberization in potato These results also corroborate with the results of present study where medium PTM_3 supplemented with MS basal + 0.01mg/l BAP + 0.01mg/l NAA + 0.1mg/l GA_3 + Sugar 80g/l was found most effective for *in vitro* microtuberization of potato cv. Kufri Frysona.Khuri and Moorby, (1995) reported more and large microtubers on higher concentration of sugars than lower concentrations.Fatima *et al*., (2005) also reported that number and weight of microtuber, formation of shoots, shoots length were found superior at sugar concentration of 8%.The uses of a higher concentration of sucrose have also been recommended by many workers (Hussey and Stacey, 1984 and Gopal *et al*., 1998) as it promotes microtuberization, and thus would produce more microtubers of bigger size. Altaf *et al.,* (2013) reported the highest number of tubers on media containing 2 mg/l BAP + 10.0 g and 12.0 g sugar concentration, i.e., 8.66 and 9.00 tubers with average weight 94.80 and 91.73 mg reSize of the microtubers was also significantly influenced by the different treatments. The maximum size of the microtubers (9.0 mm) was recorded in medium PTM_3 (0.01mg/lBAP + 0.01mg/lNAA + 0.1mg/lGA_3 + Sugar 80g/l) which was found significantly superior to all other treatments expect PTM_1. Gami *et al*., (2013) also reported that by useing half strength MS supplemented with 8% sucrose media developed tuber with the size of 4-5mm. These results are supported by the findings of Uddin, (2006), which showed that the presence of high level sucrose (8%) was beneficial and led to the production of slightly larger microtuber and higher yield.

Data recorded on weight of tubers (g) revealed that differences were not found significant due to different media treatments, however the maximum weight of microtuber (0.27g) was recorded in medium PTM_3 0.01mg/lBAP + 0.01mg/lNAA + 0.1mg/lGA_3 + Sugar 80g/l. Khuri and Moorby, (1995) reported more and large microtubers on higher concentration of sugars than lower concentrations. These results are also partially supported by the findings of Al-Abdallat and Suwwan, (2002), who reported that microtuberization of potato cv. Spunta and recorded highest microtuber weight on 6% sucrose level. Microtubers were cultured on MS basal medium and after twenty one days data were recorded for percent microtuber forming shoots and shoots /microtuber. (Table 2) Kufri Frysona form hundred percent shoots from microtuber

Table 1: Microtuberization response in cv. Kufri Frysona

Medium cod	Medium concentration(mg/l)	Number of microtuber	Days required forTuberizatio (mm)	Size of nmiocrotuber formed(g)	Weight of microtuber
PTM_1	0.01mg/l BAP + 0.01mg/l NAA + 0.1mg/l GA_3 + Sugar 50g/l	2.2 ± 0.11	55.7 ± 2.04	8.4 ± 0.28	0.20 ± 0.10
PTM_2	0.01mg/l BAP + 0.01mg/l NAA + 0.25mg/l GA_3 + Sugar 50g/l	2.2 ± 0.22	51.6 ± 0.66	6.8 ± 0.26	0.26 ± 0.01
PTM_3	0.01mg/l BAP + 0.01mg/l NAA + 0.1mg/l GA_3 + Sugar 80g/l	2.5 ± 0.11	52.3 ± 3.02	9.0 ± 0.04	0.27 ± 0.02
PTM_4	5mg/l KIN + Sugar 80g/l	2.0 ± 0.00	68.6 ± 1.34	4.9 ± 0.22	0.20 ± 0.07
PTM_5	5mg/l KIN + Sugar 100g/l	1.8 ± 0.11	68.2 ± 1.61	4.8 ± 0.12	0.10 ± 0.02
	CD at 5%	0.42	6.08	0.67	N.S.

Table 2: *In vitro* multiplication using microtubers

Sr. No.	Cultivar	(%) microtuber forming Shoots	No. of shoots/microtuber
1	Kufri Frysona	100	3.2 ± 0.29

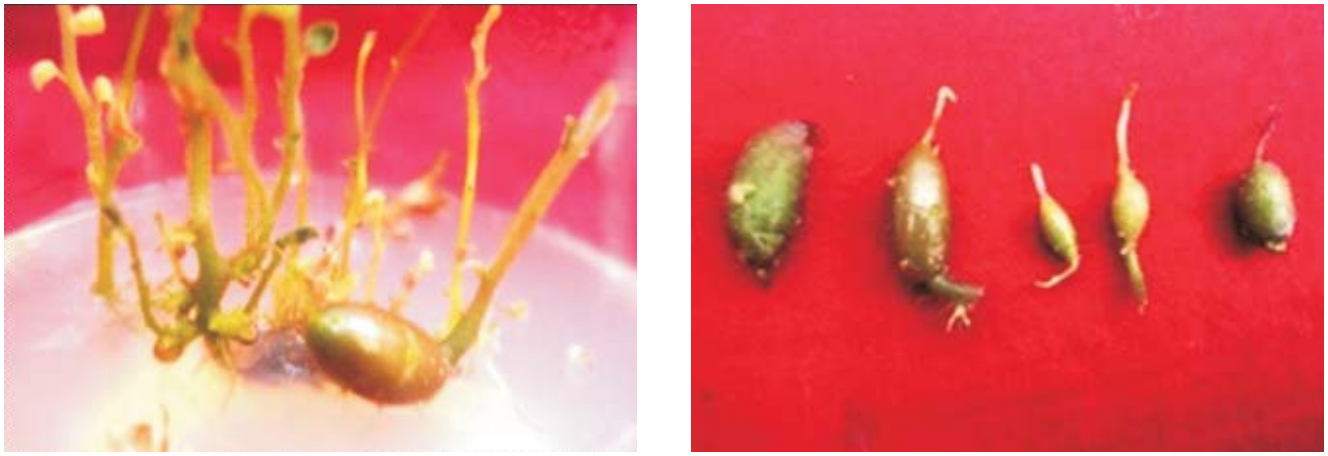
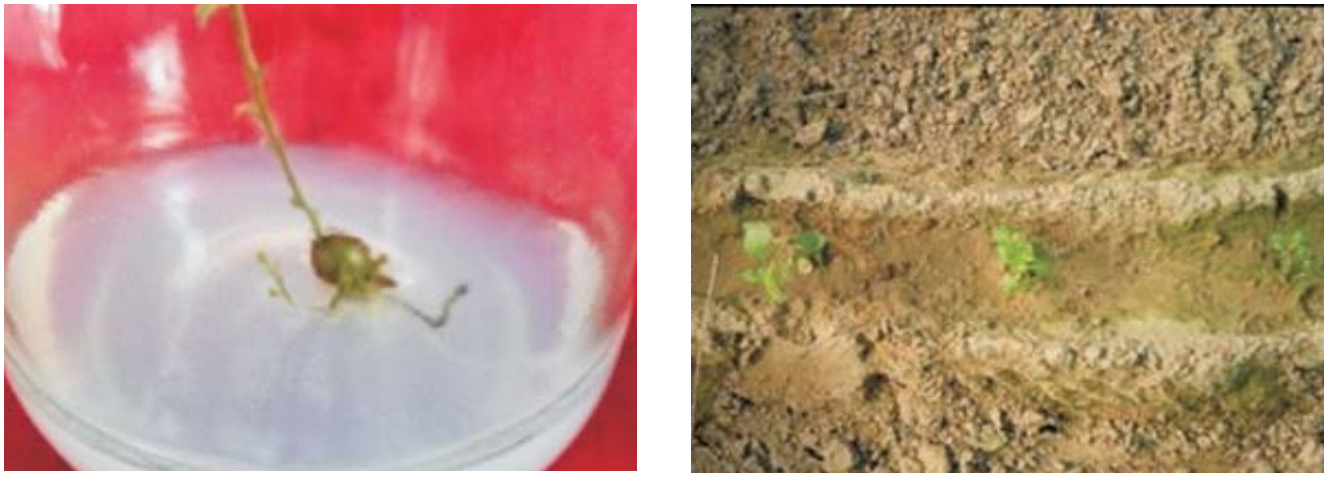


Figure 1: A-B *In vitro* microtubers formation in medium containing MS basal salt + 0.01 mg/l BAP + 0.01 mg/l NAA + 0.1 mg/l GA_3 + Sugar 80g/L



(A) *In vitro* **(B) Field**

Figure 2: A-B Micro tuber were grown *in vitro* on MS basal medium and Microtuber raised under field condition

and produces 3.2 number of shoots/microtuber. Sharma *et al*. (2012) also found that viability, sprouting percent; number of sprouts per microtuber as well as physiological loss in weight were significantly affected by the genotypes as well as by the size and physiological stage of micro-tubers. They further reported that sprouting was maximum (98.8%) in large microtubers, 85% in medium, 83.9% in small micro-tubers. In the present study Microtuber raised plants were hardened in green house condition for one month after that they were grown under field condition . survival percentage was found 60 % in Kufri Frysona under field condition. Similar results were also given by Vecchio *et al*. (2000) they have reported that sprouting was influenced in potato under different culture conditions.

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EVALUATION OF DIVERSITY OF FREE LIVING PLANT GROWTH PROMOTING RHIZOBACTERIA OF WHEAT GROWN IN SALINE SOIL

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ABSTRACT
A study was conducted to find out the microbial diversity of the rhizosphere of wheat and screening of the effective PGPR isolate with multiple traits under saline soil conditions. Total 59 rhizobacteria were isolated from rhizosphere using different media *viz*., NA, King's B medium, and Jensen's medium while predominant genera found were *Pseudomonas, Bacillus* and *Azotobacter*. All the isolates were screened in vitro for their plant growth promoting traits. Ammonia production was most common trait of *Pseudomonas* (37.03%) and *Azotobacter* (100.00%) and *Bacillus* (100.00%). Phosphorus solubilization was detected in the isolates of *Azotobacter* (66.23%), *Pseudomonas* (45.35%), and *Bacillus* (23.80%). Thirty seven (63%) isolates restricted the growth of the test fungus *Alternaria alternate*. Twelve isolates (four isolates from each medium) were selected on the basis of qualitative screening for plant growth promoting traits. The amount of IAA produced by selected isolates was in the range of 63.60μg/ml to 306.60μg/ml. The selected isolates were also tested for salt (NaCl) tolerance at 3% to 10% concentration and found *Pseudomonas* (75%) *Bacillus* (75%) and *Azotobacter* (100%) isolates tolerant at 10% NaCl concentration . With this work it can be concluded that the rhizobacteria isolated from the rhizospheric soils of wheat would be useful as inoculants for saline soil conditions.

INTRODUCTION

Rhizosphere is a rich niche of microbes and should be explored for obtaining potential plant growth promoting rhizobacteria (PGPR), which can be useful in developing bio-inoculants for enhancement of growth and yield of crop plants. Wheat is one of the major cereal crops in India. Wheat is grown in temperate climate and it is staple food for 35% of world population. Plant productivity in saline soils is considerably reduced due to improper nutrition of plant along with osmotic and draught stress (Benlloch-Gonalez *et al.,* 2005). About 65% yield loss occurs in moderately saline area. The use of PGPR may prove to be useful in developing strategies to facilitate wheat growth in saline area. Plant Growth Promoting Rhizobacteria (PGPR) is a group of bacteria that actively colonize plant root and increase plant growth by production of various plant growth hormones, phosphate solubilizing activity, N_2 fixation HCN, siderophore , ammonia production and other biological activities (Deshwal *et al.,* 2011,Deshwal& Kumar 2013, Kushwaha *et al.,* 2013, Mohite, 2013).Few strains from genera such as *Pseudomonas*, *Azospirillium*, *Azotobacter*, *Bacillus*, *Burkholderia*, *Enterobacter*, *Rhizobium*, *Erwinia* and *Flavobacterium* are well known PGPRs (Kloepper, 1993, Joshi and Bhatt, 2011). Reports suggest that amount of salt that affected land worldwide is estimated to be 900 million ha; it's 6% of the global total land mass. The saline area under agriculture is increasing every year across the globe (Paul and Nair, 2008). Salinity reported as one of the major anthropogenic as well as environmental stresses that reduced plant growth (Tank and Saraf, 2010). Previously, it has been observed that increasing salinity in the soil decreased plant growth, photosynthesis, stomatal conductance, chlorophyll content and mineral uptake compared to soil without salinity (Hans and Lee 2005). Salinity also adversely affects plant growth and development of the plants (Shukla *et al.,* 2012). Salt tolerant plant growth promoting rhizobacteria reduced the impact of salinity on plant growth and improved productivity. Salt-tolerant PGPR can play an important role in alleviating soil salinity stress during plant growth and bacterial exopolysaccharide (EPS) can also help to mitigate salinity stress by reducing the content of Na+ available for plant uptake (Upadhyay *et al*., 2009). Any microbial utilization in agriculture requires on evaluation of the environmental risks associated with the introduction of indigenous and un-indigenous microorganisms into the plant rhizosphere as well as assessment of most desirable condition for the effective and successful establishment of plant growth promoting rhizobacteria (PGPR) as inoculants in the rhizosphere of host plant (Rangrajan *et al.,* 2002). The isolated PGPR strains from region may not perform in the same way in other soil and climate conditions (Johnson *et al.,* 1998). Isolation of native strains adapted to the environmental then study may contribute to the formulation of inoculants to be used in region crops. The different stages of life cycle of wheat consist of elongation, flowering stage, fruiting stage and ripening. It is found that rate of roots exudates released by the

root of the wheat at flowering stage is higher as compared to other stages (Huddedar *et al.,* 2000).

The present study has the view to isolate the salt tolerant bacteria from rhizosphere of wheat grown in various salt affected regions of Uttar Pradesh and screening for their ability to enhance the growth and yield of wheat under the saline condition. As the cultures are isolated from the saline soil samples that show the bacterial cultures have the salt tolerance power. We can treat the problem of salinity stress on wheat plants with the help of these isolates, as they are naturally occurring in the rhizospheric saline soil where wheat plants grow. The future aspect of our work is to make the formulation of these cultures so that the problem of salinity stress on wheat plants can be treated. These formulations cannot only provide tolerance against the salt but also have antifungal activity, catalytic activity and can work as plant growth promoting rhizobacteria.The work was designed to evaluate the diversity of free living plant growth promoting rhizobacteria of wheat grown in saline soils.

MATERIALS AND METHODS

Sample collection

The root adhering soil (RAS) samples were collected from wheat crop. The soil was sampled from different locations in the districts viz., Faizabad (FZD), Sultanpur(SUT), Gonda(GND), Barabanki(BBK), Lucknow(LKO), Unnao(UNO), Kanpur Dehat (KNP) and Mathura (MTH) of Uttar Pradesh Uttar Pradesh, India.

Soil analysis

Physiochemical parameters of soil were analyzed viz., pH, electrical conductivity (EC) andESP (%) presented in table-1.

Isolation of rhizobacteria

Serial dilution of each soil sample was made upto 10^{-4}, 10^{-3} and 10^{-4} dilution were plated on to three media, Jensen's medium, King's B (KB) medium and nutrient agar (NA) medium. Plates were incubated at 28ºC for 72 hours.

Morphological and biochemical characterization by Bergey's manual

On the basis of cultural, morphological (Form, Elevation, Margin, Color, Appearance, Texture and Surface) , cell morphology (Shape, Gram reaction and Arrangement) and biochemical characteristics a total of 59 bacterial isolates were identified as *Pseudomonas Bacillus* and *Azotobacter*as described in Bergey's manual of determinative bacteriology (Holt *et al.,* 1994).

Screening of isolates for salt tolerance

Salt tolerance in PGPRs was determined by procedure given by Yildirim *et al.,* 2008. The tolerance of the isolates against salinity was evaluated by observing the growth on Nutrient Agar (NA) medium amended with different concentration of NaCl (i.e., 3% to 10%). Control plate was also maintained with 0.05% NaCl. Plates were incubated for 72 hours at 28ºC and the growth on NaCl amended medium was compared with control plates.

Screening for plant growth promoting attributes

IAA production

The production of indole acetic acid (IAA) was determined as per the method of Gordon and Weber (1951) with some modifications using IAA as standard. Cultures were incubated at 28ºC for 24 hrs in Luria Bertani (LB) broth. Cells were removed from the media by centrifugation at 10,000 rpm for 15 minutes. The Ortho-phosphoric acid (2-3 drops) was added to 2ml of supernatant and was mixed vigorously with 4ml of Salkouski's reagent (0.5M solution prepared in 50ml of 35% $HClO_4$) and incubated at room temperature for 25 minutes and observed for the color formation (Fisher *et al.,* 2007). Concentration of IAA in supernatant was calculated by spectrophotometer at 530nm.

Ammonia production

The ammonia production was determined by the method as described by Cappuccino and Sherman (1992) and Shifraw *et al*. (2004). Isolates were incubated for 4 days in peptone water (Peptone 10 g, NaCl 5g in litre, pH 7.0). Nessler's reagent (1ml) was added in each tube and observed for color formation.

Phosphate solubilization

Test for phosphate solubilisation was done as per the method of Goldstein (1986) and Frioni(1990)with some modifications. The plates were prepared with Pikovskaya's medium. All the bacterial isolates streaked on the surface of Pikovskaya's agar plate and phosphate solubilizing activity was estimated after 4 days of incubation at 28ºC. Phosphate solubilization activity was determined by the development of the clear zone around the bacterial colonies.

Antifungal activity test

The antagonistic activity of each selected bacterial isolate against *Alternaria alternate* was studied by using a dual culture plate assay (Sharma *et al.,* 2003). A loopful of 48 hrs old culture was spotted in the centre of the potato dextrose agar plate and 6 mm disc of pre grown phyto-pathogenic fungi inoculated on both sides of the plate. The plates with only fungal disc without bacterial streaks served as control. All in vitroantagonism assays were done in triplicate. The percent inhibition was determined after incubating for 3-5 days at 28ºC. The percentage growth inhibition was calculated using the following calculation:

$$I = \frac{C-T}{C} X\ 100$$

Where, I= Per cent inhibition, C= Growth in control, T= Growth in treatment

Catalase test

Isolates were tested for catalase activity by adding 3-4 drops of hydrogen peroxide (H_2O_2) on bacterial culture and observed for exclusion of air bubbles.

RESULTS

A total of 59 bacteria were isolated from the rhizosphere soil of wheat growing in salt affected soils of Faizabad, Sultanpur, Gonda, Barabanki, Lucknow, Unnao, Kanpur Dehat and Mathura districts of Uttar Pradesh, India. The number of isolates obtained on different media viz., King's B, nutrient agar and Jensen's medium were 16, 27and 16 respectively.

Table 1: Chemical analysis of soil samples

SN	Name of Districts	pH	EC (ds/m)	ESP (%)	Available nutrients (kg/acre)		
					N	P	K
1	Faizabad (FZD)	9.51	5.0	55	227	10	211
2	Sultanpur (SUT)	8.96	3.5	52	225	15	209
3	Gonda (GND)	893	3.6	47	225	13	210
4	Barabanki (BBK)	8.61	3.5	49	230	18	205
5	Lucknow (LKO)	8.85	3.4	48	227	15	211
6	Unnao (UNO)	8.60	3.3	49	225	16	209
7	Kanpur Dehat (KNP)	8.82	3.5	48	225	13	210
8	Mathur (MTH)	8.73	5.8	44	227	14	210

Table 2: Morphological and cultural characteristic of rhizobacterial test isolates

Biochemical characters	*Pseudomonas spp.*	*Bacillus spp.*	*Azotobacter spp.*
Number of isolates	16	27	16
Grams reaction	-ve	+ve	-ve
Shape	Rods	rod	rods
Pigment	Cream , light to green	Cream	Transparent to light milky most isolates become light brown to black after 10 days of incubation
Colony morphology	Smooth margin, flat to raised	Circular, lobate to serrated margin	Watery mucilaginous with smooth margins
Sucrose	+	+	+
Dextrose	+	+	+
Mannitol	-	+	+
H_2S production	-	-	-
Indole	-	-	-
Methyl red	-	-	-
Vogues Prokauer	-	-	-
Citrate Utilization	+	+	+
Catalase test	+	+	+
Nitrate reduction	+	-	-
Lipid hydrolysis	+	+	+
Casein hydrolysis	+	+	+
Starch	+	+	+
Gelatin hydrolysis	+	-	-

Morphological and biochemical characterization

On the basis of cultural, morphological (Form, Elevation, Margin, Color, Appearance, Texture and Surface), cell morphology (Shape, Gram reaction and Arrangement) and biochemical characteristics a total of 59 bacterial isolates were identified as *Pseudomonas Bacillus* and *Azotobacter* as described in Bergey's manual of determinative bacteriology (Holt *et al.,* 1994). The general characteristics of the isolates were illustrated (Table 2).

Screening for plant growth promoting attributes

Each isolate was screened for the production of ammonia, phosphate solubilization and antifungal activity. Plant growth promoting activities compared in Fig. 3. The percentage of distribution of isolates for PGP activity was found as P-solubilization (16.94%), IAA production (20.33%), ammonia production (30.50%) and antifungal activity (63.00%) against *Alternaria alternate*. (Fig. 1)

Quantitative IAA production

On the basis of multiple plant growth promoting traits, twelve isolates (four from each medium) selected and screened for quantitative production of IAA. The selected isolates produced IAA in range of 63.60μg/mL to 304.6μg/mL. (Fig. 2)

Salt tolerance

The twelve selected isolates screened for salt tolerance at graded concentrations (3% to 10%) of NaCl. All the selected isolates with multiple PGP activity could tolerate NaCl (9%) concentration. Out of 12 isolates, *Pseudomonas* (75%) and *Azotobacter* (100.00% and *Bacillus* (75.00%) were able to tolerate NaCl stress up to 10% as shown in Table 3.

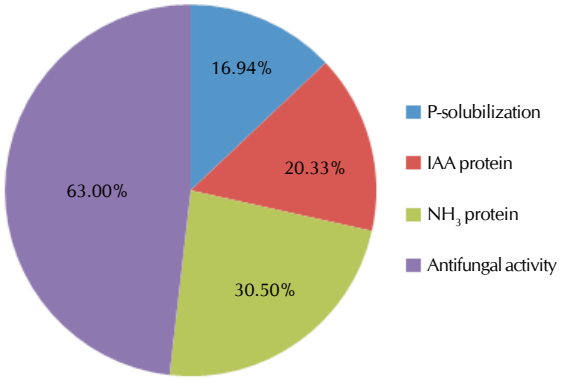
DISCUSSION

The salinity of the soil plays a prominent role in the microbial selection process as environmental stress has been shown to reduce bacterial diversity (Borneman *et al.,* 1996). Wheat is considered to be moderately tolerant to salinity (Mass 1986). IAA production by PGPR isolates is important attribute for improvement of plant growth (Deshwal and Kumar 2013, Kivil *et al.,* 2014). Till date, 80% rhizobacteria have been reported to produce IAA (Loper and Schroth,1986). However, in the present study, out of 59 isolates only 12 isolates (20.33%) shown production of IAA. IAA production was seen maximum by MTH-KB1 strain that is 304.6μg/ml but the lowest by UNO-JM2 that is 63.6μg/ml however, Zahid *et al.,* 2015 showed that isolates had the potential to produce IAA in the range of

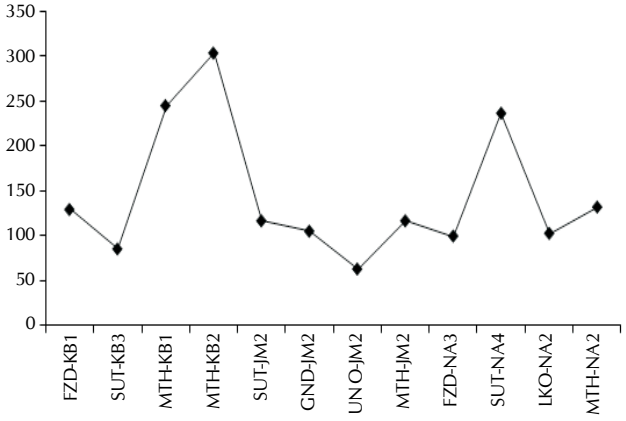
Table 3: Determination of salt tolerance of Rhizobacterialisolates

SN	Isolate Designation	Salt concentration 3% NaCl	4% NaCl	5% NaCl	6% NaCl	7% NaCl	8% NaCl	9% NaCl	10%
1.	FZD-KB1	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ +	+ +	+
2.	SUT-KB3	+ + + +	+ + + +	+ + + +	+ + + +	+ +	+	+ _	
3.	MTH-KB1	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ +	+ +	+
4.	MTH-KB2	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ +	+ +	+
5.	SUT-JM2	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + +	+ +	+
6	GND-JM2	+ + + +	+ + + +	+ + + +	+ + + +	+ +	+	+ +	
7.	UNO-JM2	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + +	+ + +	+ +
8.	MTH-JM2	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + +	+ +	+ +
9.	FZD-NA3	+ + + +	+ + + +	+ + + +	+ + + +	+	+	+ +	
10.	SUT-NA4	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+	+ +	
11.	LKO-NA2	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + +	+ +	
12.	MTH-NA2	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ +	+ +	

- = No growth, + = Poor growth , + + = Medium growth, + + + = High growth, + + + + = Very high growth



Fgiure 1: Percentage distribution of isolated rhizobacterial strains for PGP activities



Fgiure 2: Screening of selected isolates for IAA production after 48 hours of incubation

0.9–5.39μg mL^{-1} and promote plant growth. Ammonia production is also an important PGP trait, out of 59 isolates only 18 isolates (30.5%) shown production of ammonia. The establishment and performance of phosphate solubilizing microorganisms are severely affected by environmental factors, especially under stressful condition (Beneduzi *et al.,* 2008) making it essential to isolate microorganisms from these condition (such as saline-alkali soils) with high efficiency. In the present study, 10 isolates were found to solubilise phosphate. Similar pattern was reported by (Yasmin *et al.,* 2009) who analyzed 15 PGPR isolates for phosphate solubilisation out of which only six were able to solubilise insoluble phosphate. The population and activity of these PGPRs are greatly influenced by the soil conditions. All the selected isolates with multiple PGP activity could tolerate NaCl stress up to 9% and ten isolates (*Azotobacter* 4, *Pseudomonas* 3 and *Bacillus* 3) found tolerant even at 10% NaCl concentration. The screening of 133rhizospheric bacterial strains was done for salt tolerance, out of only 24 strains could grow at 8 % NaCl concentration and no strains was able to grow at 9 % NaCl (Upadhyay *et al.,* 2009) and l *Pseudomonas aeruginosa* and *P. fluorescens* strains showed growth in medium containing 1.5% NaCl and above 1.75% NaCl concentration in medium, the survival number of *Pseudomonas* gradually reduced (Deshwal and Kumar, 2013).

Fifteen strains from wheat rhizosphere screened for in-vitro antifungal activity against multiple plant pathogenic fungi and found effective to antagonism(Sachdev *et al.,* 2009) while in the present study, all 59 isolates were in-vitro screened for antifungal activity against plant pathogenic fungi *Alternaria alternate* and 63% isolates shown antagonistic activity. The inoculation by *R. solani* (without PGPR) showed that all the roots were fully infected (100%) and application of PGPR strains with *R. solani* showed that the PGPR controlled the infection at various degrees in wheat (Fatima *et al.,* 2009).

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COMPARATIVE STUDIES ON EFFECT OF SEED ENHANCEMENT TREATMENTS ON VIGOUR AND FIELD EMERGENCE OF DESI AND KABULI CHICKPEA (*CICER ARIETINUM* L.)

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ABSTRACT
A study was conducted to assess the comparative effect of seed enhancement treatment on seed vigour, abnormal seedling, and field emergence of desi and kabuli type of chickpea (*Cicer arietinum* L.). Desi cultivar Pusa 256, and Kabuli cultivar Pusa1053, each of fresh, 2yrs old and 4 yrs old lots were taken for seed enhancement treatments viz; osmopriming, halopriming, fungicidal, botanical and polymer coating alone and in combination with thiram and neemoil. It was observed that seed treatment with thiram alone or in combination with polymer (PVP or PEM) significantly enhances germination and field performance. The indirect test for seed vigour i.e. Electrical Conductivity (EC) test was also conducted and observed that it was very significantly correlated with first count, vigour index I and II and field emergence. The storage studies under ambient conditions indicated that desi variety maintained satisfactory germination and field performance upto 2 years while kabuli variety suitable for sowing in maximum upto subsequent year stored under ambient condition.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the 3rd largest produced food legume globally after common bean and field pea. It is small herbaceous plant with deep rooted system. There are two type of chickpea; *viz*. desi and kabuli, grown in the world recognized visually by seed coat colour and seed size. The desi types is characterized by small seed size and thick seed coat with pale to dark brown in colour, where as kabuli type is large seed size cream in colour with thick seed coat. Chickpea is grown in more than 50countries with 89.7% production area in Asia alone. India is the largest chickpea producing country accounting for 64% of the global chickpea production (Gaur *et al.,* 2010). It is an important pulse crop in India sharing 29.7 and 38% of the total area and production of total pulses, respectively (Chand *et al*., 2010). Chickpea is good source of dietery protein, carbohydrate, unsaturated fatty acid, ditery fibre, mineral and B-carotene (Jukanti *et al*., 2012). The kabuli type commands a higher price owing to its larger seed size, and the desi type is smaller in size and is relatively cheaper. It is mainly grown in dry or rainfed area, where patchy plant stand often result from failure of crop to emerge quickly and uniformly. The planting value of seed is one of the key factors for proper plant establishment and performance, particularly under moisture stress conditions. Use of quality seed alone has been reported to improve productivity in chickpea from 15-20 percent. Pre-sowing seed treatment including chemical, polymer coating, botanical and priming treatments are known to improve seed performance. Quick and synchronized germination is desirable to set crop successfully in order to compete with weed species and better seed performance. Harris *et al*. (1999) have reported seed priming as one of the important practices which ensures rapid and uniform germination under adverse environmental conditions. Treating the seed before sowing with fungicide prevent fungal invasion particularly in young seedlings. The beneficial effect of thiram treatment is attributed to its role in reducing the fungal infection, control of pre and post mortality (Solenke *et al.,* 1997) on the germinating seeds. The improvement in field emergence and final plant stand due to royalflo is attributed to its thiram base (Shinde, 2009). Seed priming with 2 per cent $CaCl_2$ solution enhanced daily germination index, coefficient of velocity of germination, seed germination, seedling root length, shoot length, Seedling Vigour Index-I, seedling dry weight and Seedling Vigour Index -II of hybrid caster(Jamadar and Chandrashekhar,2015). The seed priming treatments GA_3 (100 ppm) and hydration with water with Bavistin (3.0 g/kg) found effective for improvement in dry matter content of seedling in soybean variety JS-9305 (Agawane and Parhe,

2015). The effects of seed coating with different polymeric formulations in general deteriorate at slower pace as manifest in high germination percentage (Kumar *et al*., 2004). The effect of seed treatment with powdered neem and neem oil formulations suppressed nematode population growth and increased grain yield significantly in chickpea. The study was undertaken to find most appropriate seed enhancement treatment for better field performance and performance of stored seed of desi and kabuli type chickpea under ambient condition.

MATERIALS AND METHODS

Seeds and treatment materials

The seed material for study constituted of four seed lots of two years and four years old of Desi cultivar Pusa 256 and Kabuli cultivar Pusa 1053 each. The two years old seed lots were available from Division of Seed Science and Technology, Indian Agricultural Research Institute, New Delhi and four years old lots were collected from Pulse Laboratories, Indian Agricultural Research Institute, New Delhi. Seeds selected for experiment were bold and free from any damage. The polymer polyvinyl pyrrolidane (PVP) and polyethyl methyl acrylate (PEM) were obtained from Division of Agriculture Chemical, Indian Agricultural Research Institute, New Delhi

Seed treatments

The treatment T_2 *i.e.* Osmo-priming was done by polyethylene glycol (PEG8000) solution containing 25g PEG dissolved in 100ml water. The eight replicate of 50 seeds placed in PEG saturated two layers of filter paper in petri plate for 48 hrs at 20°C. Similarly, treatment T_3 *i.e.* halo-priming was done by taking 2 percent solution of KNO_3 instead of PEG. Primed seeds were rehydrated for next 24 hrs at room temperature before sowing. Fungicidal treatment T_4 and botanical seed treatment T_5 were done with thiram @ 2g per kg of seed and neem oil @ 4ml per kg of seed respectively. The details of seed treatments are given in table 1. For preparation of seed coating formulation 4.0g of each polyvinyl pyrrolidone (PVP) and polyethyl methyl acrylate (PEM) and mixture of 0.10g sodium lauryl sulphate (act as binder) and 0.15g Sodium lingosulfonate (act as surfactant) were added to water and a wet grind was prepared individually for both the polymers. These polymer alone @ 4.0ml per kg and in combination with thiram and neem oil were applied to seed by seed coating machine.

Germination (%)

Eight replicate of 50 seed each variety and each treatments were tested for germination studies as per ISTA method (Ann; 2004). In this method, seed were placed between two layer of wet germination paper which was then rolled and wrapped in wax sheet and placed in germinator in an upright position under 20 ± 1 C and 95 % RH for 8 days. On the day of final count i.e. 8th day, it were evaluated for Normal seedling, Abnormal seedling, Dead and Hard seed.

Abnormal seedling (%)

The entire damaged, decayed and deformed seedlings which were not able to produce normal seedling were counted and considered as abnormal seedling.

Total seedling length (cm)

Ten normal seedlings were taken at random from each replication and shoot and root lengths of each seedling were measured. The mean value was taken for analysis.

Seedling dry weight (mg)

Ten normal seedlings were taken at random from each replication for observing seedling length were dried in hot air oven maintained at 70 ± 1C for 48 hr and cooled in dessicators. The mean value of seedling dry weight was taken for analysis.

Vigour index I and II

The vigour indices were computed by adopting the method of Abdul Baki and Anderson (1973) by using following formula:

Vigour Index I = Germination (%) * Total Seedling Length (cm)

Vigour Index II = Germnation (%) * Seedling Dry Weight (mg)

Field emergence (FE)

Field emergence was estimated by sowing 100 seeds in 4 replications in the field. Observations were recorded on alternate day till 30th day of sowing. The emergence was expressed as percentage of seedling emergence.

Electrical conductively (EC)

Four replicate of 50 seeds were soaked in 250mL of deionized water for 24 hr. Seed leachate was collected and conductivity was measured using Elico Conductivity Bridge. EC of distilled water is taken as control. The above operation was conducted at 200°C temperature.

The conductivity per gram of seed weight for each replicate was calculated after accounting for the background conductivity of original water and average of the four replicates using the following formula;

$$\text{Conductivity } (\mu\text{mhos/cm/g}) = \frac{\text{Conductivity reading - Background reading}}{\text{Weight of replicate (g)}}$$

Statistical analysis

The data from laboratory experiment were collected by adopting complete randomized design (CRD), while data collected from field experiment were through Random block design (RBD) as prescribed by Panse and Sukhatme (1985). The data was analysed using the softwere SPSS10.0.

RESULTS AND DISCUSSION

The experiment was undertaken keeping in view multiple objectives in mind as the main aim was to see the differential pattern of loss in vigour of desi and kabuli chickpea stored under ambient condition and effect of seed enhancement treatment on field performance.

As perusal of germination test data of fresh seed lots presented in Table 2 revealed that both desi and kabuli variety *i.e.* Pusa 256 and Pusa 1053 had more than 90 percent germination. However, it was higher in desi type chickpea. This is largely because desi is basically a semi tropic crop therefore, suiting

Table 1: Details of seed enhancement treatments on chickpea

S.N.	Treatments	Dosage
1	Control	-
2	Osmo-priming	25 % Solution (w/v)
3	Halo-priming	2 % Solution (w/v)
4	Thiram	2.5 g/Kg
5	Neem oil	4 ml/Kg
6	Polymer(PVP)	4ml/Kg
7	Polymer(PVP) + Thiram	4ml/Kg + 2.5 g/Kg
8	Polymer(PVP) + Neem oil	4ml/Kg + 4 ml/Kg
9	Polymer(PEM)	4 ml/Kg
10	Polymer(PEM) + Thiram	4ml/Kg + 2.5 g/Kg
11	Polymer(PEM) + Neem oil	4ml/Kg + 4 ml/Kg

Table 2: Mean table of initial vigour parameters of freshly harvested seed

Type	Variety	Germination (%)	abnormal seedling	Seedling length (cm)
Desi	Pusa 256	95	3	20.4
Kabuli	Pusa1053	92	5	16.9

Table 2: Cont.....

Type	Seedling dry weight(mg)	Vigour indexI	Vigour II index	Field emergence (%)
Desi	528	1937	50203	91
Kabuli	645	1554	59340	87

more to Indian conditions where as kabuli type being a temperate crop. In the two year old seed lot, loss of germination was more in kabuli type. The mean germination of Pusa 256 and Pusa 1053 were 88.3 and 74.5 respectively (Table 3). The same trends of loss in germination were followed in four year old seed lots as presented in Table 4. In the fresh seed lots, because of higher value of most of vigour parameters, the effect of seed enhancement treatment was not significant. But in the two year and four year old seed lots, thiram alone or in combination with polymers improved the germination significantly. The comparative effectiveness of treatment was more pronounced in Kabuli type.

The proportion of abnormal seedling in the fresh seed lot of Kabuli type *Viz*. Pusa 1053 was more than Desi types *Viz*. Pusa 256. On ageing, the rate of increased in number of abnormal seedling was much faster in kabuli lot. It was observed that in the fresh, two year old and four year old lot the number of abnormal seedling were 5, 12 and 14 respectively, where as in desi type it were 3, 5 and 8 respectively. The effects of seed enhancement treatment on number of abnormal seedling across the treatment were not effective very much.

The vigour index I and II decreases very significantly on ageing. This was primarily due to decrease in germination percent. As it had been observed that in two year and four year old seed lot in comparison to fresh lot loss in germination was much higher than seedling length and seedling dry weight. Pooled data revealed that enhancement treatment increases vigour index I and II significantly.

The field emergence data of fresh seed lots revealed that desi variety *viz*. Pusa 256 had more than 90 percent germination.

Table 3: Effect of seed enhancement treatments on the performance of Two year old Desi and Kabuli chickpeas

Treatments	Varieties														
	Pusa 256 (Desi Type)							Pusa 1053 (Kabuli Types)							
	Germination	Abnormal seedling	Seedling Length	Seedling Dry Wt	Vigour Index I	Vigour Index II	Field Emergence	Germination	abnormal seedling	Seedling Length	Seedling Dry Wt	Vigour IndexI	Vigour Index II	Field Emergence
Control	86	5	18.0	510	1548	43860	81	70	12	16.5	640	1155	44800	35
Osmopriming	87	5	18.5	512	1609	44544	82	69	14	16.5	651	1138.5	44919	30
Halopriming	88	6	18.5	511	1628	44968	82	69	13	16.25	648	1121.25	44712	28
Thiram	90	4	19.0	520	1710	46800	89	78	9	17.0	655	1326	51090	48
Neemoil	89	6	18.2	515	1624	45835	83	75	11	16.7	646	1256.25	48450	40
PVP	86	6	18.0	510	1548	43860	80	72	12	16.2	641	1170	46152	39
PVP + Thiram	91	4	19.0	522	1729	47502	88	79	10	17.0	649	1343	51271	46
PVP + Neemoil	89	5	18.5	517	1646	46013	81	78	12	16.7	647	1306.5	50466	42
PEM	87	6	18.0	512	1566	44544	83	74	14	16.4	639	1213.6	47286	41
PEM + Thiram	90	4	19.0	519	1710	46710	88	79	10	16.9	648	1335.1	51192	47
PEM + Neemoil	89	6	18.7	517	1668	46013	84	77	11	16.7	645	1285.9	49665	43
Mean	88.3	5.1	18.5	515	1635.2	45513	83.7	74.5	11.6	16.6	646.2	1241.0	48182	39.9
CD (P=0.05)	3.0	0.2	0.7	NS	56.4	1574.1	2.6	2.3	0.4	NS	NS	38.0	1399.9	1.5
SEM	1.03	0.06	0.25	4.65	19.12	533.58	0.87	0.79	0.14	0.19	10.15	12.88	474.5	0.50
CV	2.02	1.91	2.32	1.56	2.02	2.03	1.80	1.83	2.10	2.02	2.72	1.80	1.71	2.17

Table 4: Effect of seed enhancement treatments on the performance of four year old Desi and Kabuli chickpeas

Treatments	Varieties												
	Pusa 256 (Desi Type)		Pusa 1053 (Kabuli Types)										
	Germination	abnormal seedling	Seedling length	Seedling dry Wt	Vigour index I	Vigour index II	Field Emergence	Germination	abnormal seedling	Seedling length	Seedling Dry wt.	Vigour index I	Vigour index II	Field emergence
Control	81	8	16.5	452	1336	36612	74	65	14	16.0	637	1040	41405	14
Osmopriming	85	9	16.5	492	1406	41820	75	67	17	16.0	650	1075	43550	8
Halopriming	87	8	16.9	471	1474	40977	82	67	15	16.4	640	1102	42880	19
Thiram	87	7	17.2	472	1500	41064	86	65	16	16.7	632	1088	41080	25
Neemoil	84	9	16.2	466	1360	39144	72	62	15	15.7	638	973	39556	10
PVP	83	9	16.1	479	1340	39757	72	60	16	15.6	641	939	38460	17
PVP + Thiram	86	7	16.9	462	1453	39732	84	57	14	16.4	643	934	36651	37
PVP + Neem oil	85	9	16.1	479	1372	40715	82	56	15	16.6	643	932	36008	4
PEM	85	9	16.6	453	1411	38505	82	58	14	16.7	617	968	35786	10
PEM + Thiram	87	8	16.6	453	1448	39411	86	59	17	16.4	631	972	37229	16
PEM + Neem oil	82	8	16.5	446	1357	36572	79	56	17	16.6	631	932	35336	12
Mean	84.7	8.2	16.5	465.9	1405	39482	79.4	61.0	15.4	16.3	636.6	996.2	38903	15.6
CD (P=0.05)	3.3	0.2	0.6	18.5	51.7	1428.0	3.3	1.9	0.6	0.5	NS	31.3	1573.9	0.7
SEM	1.12	0.08	0.22	6.28	17.5	484.06	1.13	0.66	0.22	0.16	6.79	10.60	533.52	0.24
CV	2.30	1.67	2.27	2.33	2.16	2.12	2.47	1.86	2.43	1.73	1.85	1.84	2.38	2.67

However, it was only 87 percent in kabuli variety Pusa 1053. This is largely because of high germination and seedling length in Desi variety. In the two year old seed lot, effect of ageing was more pronounced in kabuli type. The mean field emergence in control of Pusa 256 and Pusa 1053 were 81 and 35 respectively. The difference in comparison to fresh seed lot were much widen at incremental rate in both Desi and kabuli variety. The seed lot with four year of ageing gives only 74 and 14 emerged seedlings in the field for Pusa 256 and Pusa 1053 respectively. It was observed that after enhancement treatment significantly helped in narrowing the gap of field emergence value. The effect of thiram alone or in combination with polymers improved the field emergence very significantly. The comparative effectiveness of treatment was more pronounced in Kabuli type.

The effect of osmo priming and halopriming was not very much significant in increasing field establishment of chickpea. But it was observed that primied seed exhibits greater germination rate and faster and uniform field emergence. The evidence was in agreement with Lin and Sung (2001) and Basra *et al.*, (2005). The was also differential treatment effect observed between desi and kabuli types.The desi type shows better response to treatments in respect of faster and uniform field emergence.

In addition Electrical Conductivity (EC) test was conducted on all the lots of desi and kabuli chickpeas. This test was used to measure the leakage of electrolytes from seed and had be used as vigour test to predict field emergence. This test became an important approach for monitoring large seeded legume seed quality (Hampton, 1995). The mean table of EC indicated as presented in Table 5 revealed that EC value of fresh lots was lower than old seed lots among both desi and kabuli type. The EC value shows lower margin of difference during initial 2yrs of storage as compared to further 2yrs of storage. The differences were more pronounced in kabuli types. Kabuli types were more prone to deterioration in the loss of semi permeability of membrane resulting, thereby in higher leakage of ions in aged seed. Increased membrane permeability resulting in an increased EC of seed leachate has been reported in different crops with ageing (Singh and Dadlani, 2003)

The perusal of correlation data as in Table 6 indicates that field emergence was significantly correlated with first count and germination percentage. However, there is no significant correlation was found between field emergence and seedling length, seedling dry weight and vigour index- I & II.

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Table 5: Mean table of electrical conductivity

Types	Varieties	EC(μmhos/cm/g)		
		Fresh	2 Yrs Old	4 Yrs Old
Desi	Pusa 256	9.27	10.10	11.35
Kabuli	Pusa 1053	16.62	17.45	19.50

Table 6: Correlation matrixes of seed vigour parameters in chickpea

Characters	First count	Germination	Seedling dry weight	Seedling length	Vigour index-I	Vigour index-II	Field emergence	Speed of emergence	Electrical conductivity
First count	1								
Germination	0.631**	1							
Seedling dry weight	0.852**	0.687**	1						
Seedling length	0.744**	0.566*	0.901**	1					
Vigour index-I	0.806**	0.594*	0.925**	0.99**	1				
Vigour index-II	0.774**	0.679**	0.967**	0.867**	0.863**	1			
Field emergence	0.5*	0.48*	0.485	0.383	0.405	0.438	1		
Speed of emergence	0.034	0.241	0.14	0.276	-0.243	-0.115	-0.185	1	
Electrical conductivity	-0.551*	-0.371	-0.636**	-0.771**	-0.740**	-0.633**	-0.501*	-0.122	1

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RESPONSE OF ROOTSTOCKS AND VARIETIES ON GROWTH AND SURVIVAL PERCENTAGE IN EPICOTYL GRAFTING OF MANGO (*MANGIFERA INDICA* L.)

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ABSTRACT
A field trial was conducted at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during 2012 to study the "Response of rootstocks and varieties on growth and survival percentage in epicotyl grafting of mango (*Mangifera indica* L)." The results of experiment revealed that an early initiation of sprouting of mango graft was recorded with Rajapuri rootstock (8.33 days) and Sonpari as a variety (8.41days). Maximum number of graft established and sprouting percentage of graft at 1 month after grafting (MAG) was observed in Rajapuri as a rootstock (9.80) and Amrapali as a variety (10.41). Height of graft was maximum in Rajapuri as a rootstock (27.46, 29.22 and 36.42 cm) and Kesar as a variety (26.97, 28.87 and 35.79 cm) at 2, 4 and 6 MAG respectively. Maximum survival percentage of graft at 6 month after grafting was found in *Deshi* as rootstock (60.88%) and Sonpari as a variety (58.88%). Regarding interaction between rootstock and varieties, Deshi × Alphonso (71.10%), Rajapuri × Sonpari (71.10%) and Deshi × Amrapali (71.10%) were found superior for maximum survival of graft at 6 month after grafting.

INTRODUCTION

Mango (*Mangifera indica* L.), the king of fruit, is grown in India for over 4000 years. India is the largest producer of mango (180.02 lakh MT) occupies about 2.5 million hectares of area. In Gujarat the area under mango is 1.41 lakhs hectares with 10.03 lakh MT production (Anon., 2013).

Regarding varieties of mango, Kesar and Alphonso are the leading commercial varieties of Gujarat and having good export potential. Other varieties like Sonpari, Neelphonso and Amrapali are also gaining popularity among the farmers of this region. Dashehari and Totapuri gave significantly better performance and got popularly in farmers (Singh *et al.,* 2014). So we are selecting these varieties under this investigation. Epicotyl grafting method appears to be the best with respect to fast and mass multiplication and less time consuming for preparation of graft but mortality percentage is higher due to various factors like management, skill of operation, selection of rootstock and scion and climatic conditions. Reddy and Melanta (1989) used Nekkare mango as a rootstock and highest grafts success (90%) was obtained with Dashehari and Totapuri scions. Patil *et al*. (2008) observed that Alphonso grafted on Sindhura showed significantly highest graft success (77.80%) followed by Nekkare.

Generally fresh mango stones extracted from ripe mango fruits of any varieties are used for raising rootstocks. There is possibility of using fresh mango stones of particular variety for raising rootstocks and then these rootstocks are used for grafting of that particular variety. Hence, the present experiment was carried out with the objectives to know the response of mango varieties to epicotyl grafting and to standardize rootstock for epicotyl grafting in commercial mango varieties.

MATERIALS AND METHODS

The trial was conducted at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during 2012.

The experiment was laid out in Completely Randomized Design with factorial concept (FCRD). There was two factors (1) mango rootstocks and (2) mango varieties as scion and repeated thrice. Four mango rootstocks viz., Rajapuri (R_1), Kesar (R_2), Totapuri (R_3) and *Deshi* (R_4) and five mango varieties as a scion Alphonso (V_1), Kesar (V_2), Sonpari (V_3), Neelphonso (V_4) and Amrapali (V_5) were used in this experiment. Fifteen epicotyl grafts were made in each treatment. Regarding methodology, stones of each varieties were collected from R.H.R.S., Navsari, washed with fresh water and treated with carbendazim 10g/ 10 lit of water. After drying, stones were sown in raised bed at 10 × 5 cm spacing in vertical position in the month of June. The healthy vigorous and strong seedlings of 12-15 days old were up rooted along with stone for making epicotyls grafts. Whereas healthy terminal shoots of more than 3 months old with plumps buds were selected as scion from different mango varieties and 12-15 cm long, straight bud woods were used of grafting.

The epicotyl grafting was done by wedge technique of grafting as described by Bhan *et al*. (1969). After making grafts it was planted in polythene bags of 18 × 22 cm size with sufficient drainage holes filled up with mixture of 1:1:1 laterite soil, vermicompost and cocopit as described by Parasana *et al*., 2013. This grafts was kept under poly tunnel for one month and then put under net house. Spray of carbaryl (0.2%) 40 EC (20 ml/10lit.), propiconazol (10 ml/lit.) and drenching of carbendazim (1g/1 lit.) was made for controlling leaf eating catterpiller and fungus.

The data on days taken for first sprouting and sprouting percentage, survival percentage, height and girth of grafts, number of leaves per grafts at two months interval were recorded and subjected to statistical analysis. Number of days counted after preparation of graft to first sprouting, at one month after grafting the number of graft sprouted and its percentage was calculated. Height was measured from the base to the top of graft in centimeters with the help of scale and girth of graft was measured at the centre of joint of grafts in milimeter with the help of vanier caliper at 2, 4 and 6 MAG. The graft survival percentage was calculated at 6 MAG.

RESULTS AND DISCUSSION

The results obtained during study was described with the help of statistical analysis and discuss critically with relevant reference and literature.

Sprouting period and sprouting percentage at one month after epicotyl grafts

Regarding effect of rootstock, early initiation of sprouting of graft (8.33 days) was noted with Rajapuri rootstock (R_1), it was par with Totapuri rootstock (R_3) (8.47 days). *Deshi* rootstock (R_4) took more days for initiation. Rajapuri (R_1) rootstock was also found better with respect to more number of graft established (9.80) and higher sprouting percentage (65.32%) at 1 month of epicotyl grafting (Table 1). It might be due to vigorous growth nature in Rajapuri rootstock. Wide variation in initiation of sprouting and sprouting percentage were observed in different rootstocks due to its heterozygous nature. Singh and Srivastava (1979), Purbiati *et al*. (1993) in mango and Patel *et al*. (2013) in cashew and Madhge *et al*. (2013) in citrus also observed similar results with respect to early sprouting and higher success percentage in their study.

Considering the effect of mango varieties as a scion Sonpari (V_3) had taken minimum days to initiation of sprouting of graft (8.41 days) which was followed by Kesar, Neelphonso and Amrapali. The maximum number of grafts established at one month after grafting and its percentage were reported in Amrapali variety of mango as scion (table-1). Thus present studies confirm the existence of genotypic differences. This type of results were previously noted by Kulwal and Tayde (1988) and Dhakal (1979) and observed wide variation in sprouting percentage with different varieties of mango. An early initiation of sprouting in Langra was noted by Alam *et al*. (2006).

Height of grafts

Among the different rootstock, Rajapuri (R_1) rootstock had maximum height i.e. 27.46cm, 29.22cm and 36.42cm at 2, 4 and 6 month after grafting, respectively. Second best rootstock was Kesar (R_2) in present study (table-2). Various research workers noted variation in height with different rootstocks.

Singh and Singh (1976) with Dashehari seedling, Samaddar and Chakrabarti (1988) with *Mangifera sylvatica* and Chandan *et al*., (2006) with Bappakai rootstock produced maximum height of grafts.

Regarding varieties of mango, maximum height of grafts was recorded with Kesar (V_2) variety (26.97cm, 28.87cm and 35.79cm) followed by Sonpari (V_3) i.e. 26.75cm, 28.75cm and 35.54 cm at 2, 4 and 6 month after grafting, respectively. Least height of graft was noted with Amrapali (V_5) variety *i*.e. 23.74 cm, 25.72 cm and 33.19 cm at 2, 4 and 6 month after grafting, respectively. It may be due to its dwarfing nature of growth. Varietal difference in response to height of grafts in

Table 1: Effect of rootstocks and varieties on days taken for first sprouting, number of grafts establishment and percentage (%) 1 month after grafting

Treatments	Days taken for first sprouting	No. of grafts establishment at 1 month	Percentage (%) at 1 month after grafting
Rootstocks (R)			
R_1- Rajapuri	8.33	9.8	65.32
R_2- Kesar	8.73	8.33	55.55
R_3- Totapuri	8.47	8.73	58.21
R_4- *Deshi*	9.07	8.47	56.44
S.Em. ±	0.12	0.108	2.16
C.D. at 5 %	0.35	0.31	6.19
Varieties (V)			
V_1- Alphonso	9	8.75	58.32
V_2- Kesar	8.5	6.33	42.21
V_3- Sonpari	8.41	9.83	65.55
V_4- Neelphonso	8.59	8.83	58.88
V_5- Amrapali	8.75	10.41	69.44
S.Em. ±	0.13	0.121	2.42
C.D. at 5 %	0.39	0.35	6.92
Interaction R ? V			
S.Em. ±	0.278	0.242	1.61
C.D. at 5 %	0.79	0.692	4.61
C.V. %	5.59	4.75	4.75

Table 2: Effect of rootstocks and mango varieties on height of graft in epicotyl grafting of mango (cm)

Treatments	Height of graft (cm)		
	2 MAG	4 MAG	6 MAG
Rootstocks (R)			
R_1- Rajapuri	27.46	29.22	36.42
R_2- Kesar	25.84	27.62	35.09
R_3- Totapuri	24.59	26.72	33.79
R_4- *Deshi*	25.43	27.38	34.17
S.Em. +	0.439	0.433	0.414
C.D. at 5 %	1.25	1.24	1.18
Varieties (V)			
V_1- Alphonso	25.21	26.79	34.09
V_2- Kesar	26.97	28.87	35.79
V_3- Sonpari	26.75	28.75	35.54
V_4- Neelphonso	25.49	27.56	34.73
V_5- Amrapali	23.74	25.72	33.19
S.Em. +	0.491	0.485	0.414
C.D. at 5 %	1.25	1.24	1.18

Table 3: Effect of rootstocks and mango varieties on girth of graft in epicotyl grafting of mango (mm)

Treatments	Girth of graft (mm)		
	2 MAG	4 MAG	6 MAG
Rootstocks (R)			
R_1- Rajapuri	6.45	6.83	6.99
R_2- Kesar	6.29	6.71	6.82
R_3- Totapuri	6.3	6.64	6.79
R_4- *Deshi*	6.33	6.8	6.92
S.Em. +	0.11	0.113	0.107
C.D. at 5 %	NS	NS	NS
Varieties (V)			
V_1- Alphonso	6.15	6.55	6.67
V_2- Kesar	6.44	6.83	7.01
V_3- Sonpari	6.5	6.89	7.01
V_4- Neelphonso	6.39	6.77	6.88
V_5- Amrapali	6.25	6.69	6.83
S.Em. +	0.123	0.127	0.119
C.D. at 5 %	NS	NS	NS

epicotyl grafting may be due to variations in their genetical make up influencing histological and physiological development within the scion shoots of similar age and growth in different ways. Chakrabarti and Sadhu (1983), Madalageri *et al.*, (1984) Gurudutta *et al.*, (2004) obtained maximum height of grafts in Langra, Dashaheri and Mulgoa, respectively. Various research workers observed varied growth pattern with different varieties of mango. It may be due to their genetical make up using different media and environmental condition. An interaction between different rootstock and varieties of mango were found to be non significant with respect to height of graft at 2, 4 and 6 MAG.

Girth of graft

Girth of graft was unaffected by different mango rootstocks in present study. However, maximum value of girth of graft was noted with Rajapuri rootstock (6.99cm) followed by *Deshi* rootstock (6.92cm) at 6 MAG (table-3). Likewise, there was nonsignificant different in girth of graft with respect to different varieties of mango. However, Sonpari (V_3) and Kesar (V_2) had higher value of girth of graft (7.01cm) at 6 MAG (table-3). Chakrabarti and Sadhu (1983) also reported non-significant differences with three varieties of mango. An interaction between rootstock and varieties of mango were found non-significant with respect to girth of graft at 2, 4 and 6 MAG.

Table 4: Effect of rootstocks and mango varieties on number of leaves per graft in epicotyl grafting of mango

Treatments	Number of leaves per graft		
	2 MAG	4 MAG	6 MAG
Rootstocks (R)			
R_1- Rajapuri	16.06	20.26	25.12
R_2- Kesar	15.4	20.08	25.72
R_3- Totapuri	13.76	20.25	25.73
R_4- *Deshi*	14.24	22.68	28.12
S.Em. +	0.369	0.773	0.433
C.D. at 5 %	1.05	NS	1.23
Varieties (V)			
V_1- Alphonso	14.97	20.31	25.49
V_2- Kesar	15.7	21.1	26.07
V_3- Sonpari	15.63	21.43	26.51
V_4- Neelphonso	14.23	21.45	26.97
V_5- Amrapali	13.8	19.8	25.83
S.Em. +	0.412	0.865	0.484
C.D. at 5 %	1.17	NS	NS

Number of leaves per graft

The number of leaves per graft was significantly affected by different rootstocks of mango at 2 and 6 MAG, at initial stage. Rajapuri rootstock (R_1) had higher number of leaves per graft (16.06) whereas at 6 MAG, *Deshi* rootstock (R_4) was found better with producing higher number of leaves per graft (Table 4). Similar results were not available with Rajapuri and Deshi rootstock, but Chandan *et al*. (2006) note that Bappakai rootstock produce maximum number of leaves per graft.

Regarding varieties of mango, number of leaves per graft was significantly affected with different varieties at 2 MAG. More number of leaves per graft (15.70) was recorded with Kesar (V_2) variety and it was at par with Sonpari (V_3) and Alphonso (V_1). At 4 MAG and 6 MAG, number of leaves was found non-significant in different varieties (table-4). However, Radhamony *et al.*, (1989), Jana (2007) and Patil *et al.*, (2008) also recorded more number of leaves per plant with different varieties of mango in their studies. An interaction effect between rootstock and varieties was found non-significant.

Survival percentage of grafts after 6 month of epicotyl grafting

The data presented in table 5 indicated that the survival percentage of graft after 6 month of epicotyl grafting was significantly affected due to different rootstocks and varieties of mango. The *Deshi* rootstock (R_4) was found better for maximum survival percentage of epicotyl grafting (60.88 %) which was remained at par with R_1 (Rajapuri) and R_2 (Kesar). Where as survival percentage was minimum in Totapuri rootstock (R_3). Oppenheimer (1956) show the high degree of uncertainty when mango grafts prepared out of heterozygous seedling stock. Singh and Srivastva (1979) also reported good success with different rootstocks of mango in Rataul, Mallika and Dashehari varieties of mango. Where as poor success was observed with Chausa.

Among the different varieties, Sonpari (V_3) rank first with higher survival percentage (58.88 %) followed by Amrapali (V_5) in

Table 5: Effect of rootstocks and mango varieties on survival percentage of grafts after 6 months of epicotyl grafting

Treatments			Percentage		
Rootstocks (R)					
R_1- Rajapuri			57.77		
R_2- Kesar			54.21		
R_3- Totapuri			38.21		
R_4- *Deshi*			60.88		
S.Em +			3.12		
C.D. at 5 %			8.93		
Varieties (V)					
V_1- Alphonso			48.88		
V_2- Kesar			48.88		
V_3- Sonpari			58.88		
V_4- Neelphonso			48.88		
V_5- Amrapali			58.32		
S.Em +			3.49		
C.D. at 5 %			9.99		
Interaction R ? V					
	V_1- Alphonso	V_2- Kesar	V_3- Sonpari	V_4- Neelphonso	V_5- Amrapali
R_1- Rajapuri	64.44	57.77	71.1	46.66	48.88
R_2- Kesar	33.33	51.1	55.55	68.88	62.22
R_3- Totapuri	26.66	37.77	46.66	28.88	51.1
R_4- *Deshi*	71.1	48.88	62.22	51.1	71.1
S.Em ±			2.33		
C.D. at 5 %			6.66		
CV %			7.65		

T_{16}- *Deshi* + Alphonso

T_3- Rajapuri + Sonpari

T_{20}- *Deshi* + Amrapali

Figure 1: Growth of grafts at month after grafting under promising treatments

present investigation. Various workers viz., Maiti and Biswas (1980), Singh and Srivastava (1981), Chakrabarti and Sadhu (1983), Kulwal and Tayde (1988), Patil *et al.,* (1991) and Radha and Arvindakishan (1998) recorded different percentage of success with different varieties of mango.

Regarding interaction between rootstock and varieties, Deshi´ Alphonso (71.10%), Rajapuri ´ Sonpari (71.10%) and Deshi Amrapali (71.10%) were found superior for maximum survival of graft at 6 month after grafting. (Table 5 and Fig.1).

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NITROGEN TRANSFORMATION AS AFFECTED BY APPLICATION OF NITROGEN, VERMICOMPOST AND HERBICIDE (*CLODINAFOP PROPARGYL*) IN SANDY SOIL

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ABSTRACT
Application of Nitrogen (N) @ 100 and 200 mg kg^{-1} soil significantly increased the NH_4^+-N and NO_3^--N contents in soil, respectively over control. NH_4^+-N increased from 9.10 to 39.25 and 59.70 mg kg^{-1} soil respectively (14^{th} day) and was the peak observed whereas NO_3^--N contents increased from 11.74 to 86.79 and 104.66 mg kg^{-1} soil respectively (peak value) on the 56^{th} day of incubation. Addition of vermincompost at 1% significantly increased the NH_4^+-N and peak was found on 14^{th} day and the increase was from 15.76 to 58.48 mg kg^{-1} soil. Moreover in case of NO_3^--N contents increase was from9.79 to 65.87 mg kg^{-1} soil (peak value) on the 56^{th} day of incubation. Effect of nitrogen at both the levels (100 and 200 mg kg^{-1}) was not spectacular on NO_2^--N contents in soil except from 3^{rd} to 7^{th} day of incubation where increase was from 0.16 to 2.56 and to 3.23 mg kg^{-1} on 3^{rd} and from 0.17 to 2.05 to 2.74 mg kg^{-1} soil on 7^{rd} day of incubation respectively . However, addition of herbicide in soil significantly decreased the NH_4^+-N, NO_3^--N and NO_2^--N contents at all incubation periods.

INTRODUCTION

Nitrogen is a macronutrient and plays an important role in increasing the agricultural production. Available N includes NH_4^+-N, NO_3^--N and NO_2^--N forms. Mostly total N in soil is bound in organic compounds (95 %), the rest is in inorganic forms, mainly as nitrate and ammonium (NO_3^--N, NH_4^+-N) and content of mineral nitrogen (N_{min}) in the soil is one of the most important factors with a decisive role in high crop yields and a potential risk of environmental pollution. Thus, an accurate prediction of N that is mineralized from soil organic matter and other sources of nitrogen during a growing season would result in a more efficient use of N fertilizer and decrease the potential surface and groundwater contamination (Haney *et al*. 2001).Organic manures could also add substantial amount of N to soil. Among the different wastes utilized, it is evident that the vermicompost from tea waste had high level of nutrients and was able to promote growth and advance the onset of flowering and fruiting in the plant used (Indirabai and Suja Pratha, 2009). Application of vermicompost showed an increased growth of *Abelmoschus esculentus* in terms of height of the plant. It also increased the carbohydrate and protein content. The vermin composting of poultry waste is the best method of disposal and it could be a better alternative to inorganic fertilizers (Tamilselvi and Devi, 2009). Transformation of nitrogen is a complex process brought about by succession of different micro-organisms in the soil which affect the soil fertility, whereas herbicide application may inhibit various processes such as nitrification, denitrification and N fixation (Jolankai *et al*., 2006). Although we are able to appreciate the significance of microorganisms in the soil, we have little information on the importance of microbial diversity in the functioning of soil systems, and most research suggests that the relationships are neither consistent nor direct (Nannipieri *et al*., 2003, Brussaard *et al*., 2004). Microbial diversity in soils is influenced by different factors including anthropogenic activities, and microbial communities are known to respond to organic matter amendments with increased activity and growth, which affects soil processes, including nitrogen (N) mineralization (Fauci and Dick, 1994). With advancement of agricultural technology use of herbicides is now-a-days a common practice to manage weeds to get higher production and profit. Clodinafop propargyl is such a commonly used soil applied herbicide which is used to manage weeds. However, this chemical may alter the balanced soil ecology and result into altered mineralization pattern. The studies on alterations in microbial activities and numbers brought about by pesticides have been undertaken by several authors (Pampulha and Oliveira, 2006, Sebiomo, *et al*., 2011, Cycon and Piotrowska-Seget, 2009, Lo, 2009, Valiolahpor *et al*., 2011). While most of the reports suggest that the application of these chemicals decrease the microbial population (Latha and Gopal, 2010, Newton, *et al*., 2010), some are also in favour of increase in population when these products are applied to soil (Niewiadomska, 2004). However, the information regarding the effect of herbicide on nitrogen transformation in the soil is very scanty. Keeping this in view, the present study was planned to assess the effect of nitrogen

and vermin compost and clodinafop propargyl on nitrogen transformation in soil.

MATERIALS AND METHODS

Study area and soil sampling

An incubation study was conducted under controlled laboratory condition in the Department of Soil Science CCSHAU, Hisar (29º05′ N, 75º38′ E, 222 m elevation) to study the effect of nitrogen and vermin compost and herbicide (clodinafop propargyl) on nitrogen transformation. Bulk surface soil sample (0-15 cm) was collected from village Balsamand, District Hisar. The soil sample was air dried ground and passed through 2 mm sieve. After mixing thoroughly, the soil was used for laboratory studies. The physico-chemical properties of soil are presented in Table 1.

Collection and processing of vermicompost

Vermi compost was collected from Department of Agronomy, CCS HAU, Hisar. It was first air dried at room temperature then ground and passed through 2 mm sieve before use. The nitrogen, phosphorus, potassium and organic carbon content of vermin compost are given in Table 1.

Incubation study

The incubation study was conducted in well controlled laboratory conditions. The treatments comprised of three levels of nitrogen (0, 100 and 200 mg kg^{-1}), two levels of vermin compost (0 and 1 % on dry wt. basis) and two levels of herbicide (0 and 60 g a.i. ha^{-1}). Total 360 wide mouth plastic bottles were used. They were properly washed and dried well before starting the experiment. Thirty gram of air dry soil per bottle was filled. Then vermicompost was added to half the number of bottles and thoroughly mixed with soil. Then solutions of 100 mg kg^{-1} N, 200 mg kg^{-1} N and herbicide were prepared. The soil samples in each bottle were treated with these solutions, making required combination of nitrogen, vermicompost and herbicide and the moisture was maintained at field capacity. After this total weight of each bottle was recorded and mouth of the bottles were closed with cotton. Then these bottles were put into the incubator at 25 ^{0}C. Moisture level was maintained daily by taking the weight of bottles on top pan balance. One set of 36 bottles at each sampling period was analyzed for different nitrogen fractions. After treatment the soil was incubated for 56 days in wide mouth plastic bottles maintaining the soil moisture at field capacity. The soil was analyzed for NH_4^+-N, NO_3^--N and NO_2^--N contents on 0, 3rd, 7th, 14th, 21st, 28th, 35th, 42nd, 49th and 56th days of incubation. Completely randomized design was followed by keeping three replications. For different fractions of nitrogen, soil was extracted with 2 M KCl solution and determined by steam-distillation method (Keeney and Nelson, 1982).

RESULTS AND DISCUSSION

Effect of nitrogen levels at different incubation periods on:

NH_4^+-N

Data (Table 2) indicated that with the application of nitrogen significantly recorded the higher NH_4^+-N contents in soil over control and vermin compost throughout the incubation study. Application of nitrogen @ 100 and 200 mg kg^{-1} significantly increased NH_4^+-N contents upto third day of incubation in the soil and the increase was from 39.25 to 63.52 mg kg^{-1} and from 59.70 to 87.59 mg kg^{-1}, respectively over the zero day of incubation. Thereafter, it starts declining and this trend was observed till the end of incubation. However, at the end of incubation NH_4^+-N contents in soil were 31.22 and 39.62 mg kg^{-1}respectively with the application of nitrogen @ 100 and 200 mg kg^{-1}. So, peak values (63.52 and 87.59 mg kg^{-1}) were observed on the 3rd day of incubation. Hence, from the above results it can be concluded that hydrolysis of added urea might be highest in first 2-3 days and then part of NH_4^+-N started converting into NO_3^--N. N fertilizer application stimulated release of NH_4^+-N from fertilizer nitrogen and favoured the mineralization of vermicompost (Sharma and Mahapatra, 1990). Long-term organic matter applications shifted mineralization towards the labile organic N pool, while mineral N applications stimulated mineralization from the recalcitrant organic N pool. Gross mineralization rates in the vermicompost treatment soil are significantly higher than in control soil (Duhan *et al.*, 2001). Data presented above can be graphically represented as shown in Fig. 1.

NO_3^--N

The data presented in Table 3 revealed that application of nitrogen increased the NO_3^--N content in soil over

Table 1: Physico-chemical properties of soil and vermicompost

Property	Values	Method used
Soil		
Organic carbon (%)	0.15	Walkley and Black Wet oxidation method (Jackson, 1973)
Soil pH	8.10	Glass electrode pH meter (Jackson, 1973)
EC (dS/m at 25 ^{0}C)	0.15	Conductivity bridge meter (Richards, 1954)
Available nitrogen (mg kg^{-1})	54.50	Alkaline per magnate method (Subbiah and Asija, 1956)
NH_4^+-N (mg kg^{-1})	9.10	Steam-distillation method (Keeney and Nelson, 1982).
NO_3^--N (mg kg^{-1})	11.74	Steam-distillation method (Keeney and Nelson, 1982).
NO_2^--N (mg kg^{-1})	0.16	Steam-distillation method (Keeney and Nelson, 1982).
Vermicompost		
Total N (%)	1.30	Colorimetric (Nessler's reagent) method (Lindner, 1944)
Total P (%)	0.52	Vanadomolybdophosphoric yellow color method (Koenig and Johnson, 1942)
Total K (%)	1.22	Using flame photometer (directly)
Organic carbon (%)	15.23	Rapid titration method (Walkley and Black, 1934)

Table 2: Effect of different treatments on the NH_4^+-N contents (mg kg^{-1}) in soil

Treatments	Incubation Days										Mean
	0	3	7	14	21	28	35	42	49	56	
Control	9.10	20.80	33.84	41.24	39.07	36.08	32.26	29.18	21.80	21.72	28.61
N (100 mg kg^{-1})	39.25	63.52	59.41	57.17	43.48	42.98	40.37	36.64	33.28	31.22	44.73
N (200 mg kg^{-1})	59.70	87.59	78.64	75.28	72.48	54.56	47.65	45.23	41.86	39.62	60.26
Vermicompost (1%)	15.76	41.87	49.24	58.48	42.43	40.50	38.51	36.22	31.52	24.70	37.92
Herbicide (60 g a.i. ha^{-1})	8.74	18.55	30.67	38.51	37.09	34.40	30.48	28.61	19.79	17.41	26.43
Mean	26.71	46.47	50.36	54.14	46.91	41.70	37.85	35.18	29.65	26.93	
CD (at 5%)	1.81	4.22	3.96	4.50	3.56	2.95	2.63	2.47	3.44	4.04	

Table 3: Effect of different treatments on the No_3^--N contents (mg kg^{-1}) in soil

Treatments	Incubation Days										Mean
	0	3	7	14	21	28	35	42	49	56	
Control	11.74	14.49	19.51	26.75	32.90	35.57	38.17	39.39	39.62	39.85	29.20
N (100 mg kg^{-1})	14.32	27.40	33.34	62.69	79.47	81.55	83.67	85.48	86.38	86.79	64.11
N (200 mg kg^{-1})	19.56	31.33	46.18	77.73	97.33	99.42	101.54	103.35	104.25	104.66	78.54
Vermicompost (1%)	9.79	25.35	34.69	47.09	58.55	60.63	62.75	64.56	65.46	65.87	49.47
Herbicide (60 g a.i. ha^{-1})	5.41	13.08	16.90	22.93	28.97	29.97	35.33	37.50	37.98	38.23	26.63
Mean	10.96	22.33	30.12	47.44	59.44	61.43	64.29	66.06	66.74	67.08	
CD (at 5%)	1.83	2.11	1.28	1.01	1.24	1.168	1.33	1.23	1.33	1.19	

Table 4: Effect of different treatments on the NO_2^--N contents (mg kg^{-1}) in soil

Treatments	Incubation Days										Mean
	0	3	7	14	21	28	35	42	49	56	
Control	0.16	0.16	0.17	0.17	0.18	0.17	0.17	0.16	0.16	0.16	0.17
N (100 mg kg^{-1})	0.16	2.56	2.05	1.80	1.27	0.85	0.35	0.24	0.18	0.17	0.96
N (200 mg kg^{-1})	0.16	3.23	2.74	2.14	1.51	0.92	0.45	0.25	0.20	0.18	1.18
Vermicompost (1%)	0.16	0.16	0.19	0.46	0.56	0.89	0.38	0.24	0.18	0.17	0.34
Herbicide (60 g a.i. ha^{-1})	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.16	0.15	0.16	0.16
Mean	0.16	1.25	1.06	0.95	0.74	0.60	0.30	0.21	0.17	0.17	
CD (at 5%)	N.S.	0.19	0.16	0.07	0.04	0.04	0.03	N.S.	N.S.	N.S.	

vermicompost alone and control. With the application of nitrogen @ 100 and 200 mg kg^{-1}, NO_3^--N content in soil increased significantly throughout the incubation study and the extent of increase was from 14.32 to 86.79 mg kg^{-1} and from 19.56 to 104.66 mg kg^{-1}, respectively over initial values. However, increase in NO_3^--N contents in the soil were prominent upto 42nd day of incubation and later on contents were almost stable. The increase in NO_3^--N contents in soil might be due to the reason that NH_4^+-N started converting into NO_3^--N and upto the 42nd day of incubation most of the NH_4^+-N converted into NO_3^--N and then NO_3^--N content in soil become almost stable. So, peak values (86.79 and 104.66 mg kg^{-1}) were observed on the 56th day of incubation. Data presented above can be graphically represented as shown in figure 2. The stimulation of gross nitrification after mineral or organic N supply shows that this N transformation is very sensitive to any changes in N supply (Schimel and Bennett, 2004). NO_3^--N concentration start increasing on the 2nd day of incubation with the nitrogen application and this increase in NO_3^--N was continued till last of incubation (Duhan *et al*. 2005).In arable soils, most ammonia oxidation is carried out by autotrophic nitrification (Barraclough and Puri, 1995).

NO_2^--N: Data presented in Table 4 indicated that accumulation of NO_2^--N contents in soil was very low except on third day of incubation. Application of nitrogen @ 100 and 200 mg kg^{-1} were not spectacular with respect to NO_2^--N contents in soil except from third to seventh day of incubation. Application of nitrogen (@ 100 and 200 mg kg^{-1}) increased the NO_2^--N content in soil from 0.16 mg $kg^{-1}$to 2.56 and to 3.23 mg kg^{-1}, 0.17 mg $kg^{-1}$to 2.05 and to 2.74 mg $kg^{-1}$and 0.17 mg $kg^{-1}$to 1.80 and to 2.14 mg kg^{-1}soil on third, seventh and 14th day of incubation, respectively. The peak of NO_2^--N contents in soil (2.56 and 3.23mg kg^{-1}) was observed on third day of incubation. These higher NO_2^--N contents in soil on third day might be intermediate product of NH_4^+-N and NO_3^--N which is completed within in one week. N application increased the potential NO_2^--N contents in the system, regardless of whether it was supplied in mineral or organic form (Table 4). The results of our investigation agreed with previous observations demonstrating that fertilizer addition increased N_2O emissions (Ding *et al*., 2010). Results were also in agreement with those reported by Prasad and Singhania (1989), Sahrawat (1992) and Duhan *et al*. (2001).Data presented above can be graphically represented as shown in Fig. 3.

Effect of vermicompost at different incubation periods on NH_4^+-N

Data presented in the Table 2 indicated that application of vermicompost recorded higher contents of NH_4^+-N contents in soil over control. Application of vermicompost significantly increased NH_4^+-N contents in soil upto 14th day of incubation in the soil and the extent of increase was from 15.76 mg kg^{-1}

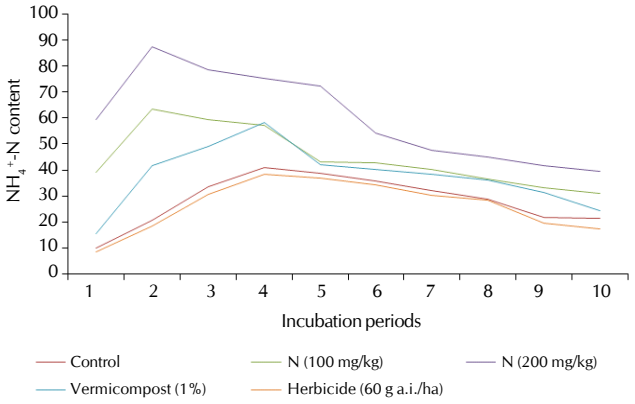

Figure 1: Effect of nitrogen, vermicompost and herbicide on NH_4^+-N content (mg kg^{-1}) of soil

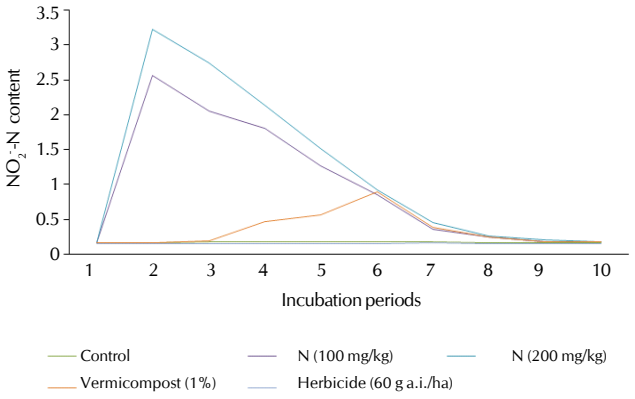

Figure 3: Effect of nitrogen, vermicompost and herbicide on NO_2^--N content (mg kg^{-1}) of soil

to 58.48 mg kg^{-1} over the zero day of incubation. Thereafter, it starts declining and this trend was observed till the end of incubation. However, at the end of incubation contents of NH_4^+-N was 24.70 mg kg^{-1}. So, peak value (58.48 mg kg^{-1}) was observed on the14th day of incubation. Data presented above can be graphically represented as shown in figure 1. This may be due to reason that vermicompost application increased the microbial activity and its mineralization was at peak on the 14th day which increased the NH_4^+-N content in soil. However, amount of release of nitrogen from applied vermicompost varied among the different time periods. This was in agreement with the similar reports of Sharma and Verma (2001). Khankhane and Yadav (2000) also reported similar results. Prasad and Singhania (1989) also reported that organic manure application increased the NH_4^+-N contents in the soil.

NO_3^--N

The data presented in Table 3 revealed that with the application of vermicompost NO_3^--N content in soil increased significantly throughout the incubation study and the extent of increase was from 9.79 to 65.87 mg kg^{-1} over initial value. However, increase in NO_3^--N contents in the soil were prominent upto 42nd day of incubation and later on contents were almost stable. So, peak value (65.87 mg kg^{-1}) was observed on the 56th day of incubation. Data presented above can be graphically represented as shown in Fig. 2. The data suggested

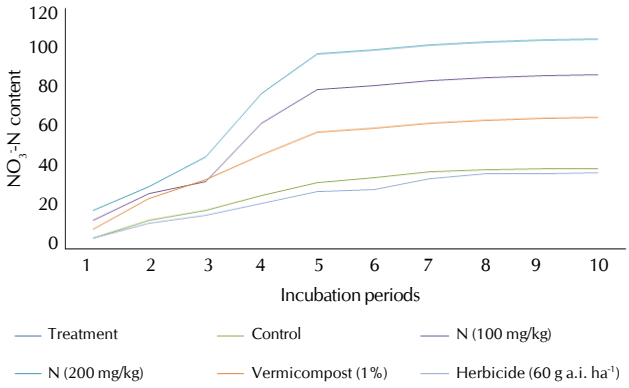

Figure 2: Effect of nitrogen, vermicompost and herbicide on NO_3^--N content (mg kg^{-1}) of soil

that despite the higher input of N by fertilizer nitrogen the accumulation of NO_3^--N content in soil was more with application of vermicompost. This could be because of the much slower release of N from vermicompost resulting in smaller losses of N and building of a higher concentration of NO_3^--N content in soil. Khankhane and Yadav (2000) also reported that vermicompost application increased the NO_3^--Ncontent in soil may be because of presence of more NH_4^+-N content in soil due to mineralization of vermicompost and its oxidation leads to a higher concentration of NO_3^--N content in soil. Prasad and Singhania (1989) and Mukherjee (1998) also reported that the application of vermicompost increased the NO_3^--Nin the soil during incubation.

NO_2^--N

Data presented in Table 4 revealed that the effect of vermicompost on NO_2^--N contents in soil were not spectacular. Although, there was slight increase in NO_2^--N contents in soil on the 14th day of incubation from 0.17 mg $kg^{-1}$to 0.46 mg kg^{-1} and from 0.18 mg $kg^{-1}$to 0.56 mg kg^{-1}on 21st day while on 28th day increase was from 0.17 mg $kg^{-1}$to 0.89 mg kg^{-1} and then decreased till the end of incubation periods and NO_2^--N contents in soil on 56th day of incubation were 0.17 mg kg^{-1}. Data presented above can be graphically represented as shown in figure 3. Vermicompost application increased the NO_2^--N content in soil may be because of presence of more NH_4^+-N content in soil due to mineralization of vermicompost and its oxidation leads to a higher concentration of NO_2^--N content. These results are in contrast to those of Senapati *et al*. (1992) and Duhan *et al*. (2001).

Effect of herbicide (clodinafop propargyl) at different incubation periods on

NH_4^+-N

Data (Table 2) indicated that application of herbicide decreased the NH_4^+-N contents in soil throughout the incubation period over the control (without clodinafop propargyl). NH_4^+-N content was decreased from 10.10 to 8.74mg kg^{-1} at zero day with herbicide application. On the 14th day of incubation, decrease in NH_4^+-N contents of soil with application of herbicide was from 41.24 to 38.51 mg kg^{-1}. Data further revealed that this trend of decrease in NH_4^+-N was observed till the 56th day of incubation study and decrease was from

21.72 to 17.41 mg kg^{-1}. Data presented above can be graphically represented as shown in Fig. 1.The decrease in NH_4^+-N contents in the soil with herbicide application may be due to its adverse effect on micro-organisms responsible for ammonification process which was suppressed and hence NH_4^+-N contents were decreased. These findings were in agreement with results of Kucharski *et al*. (2009) and Parlda *et al*. (2010) who reported that NH_4^+-N decreased with time. Urea treatments contained higher amount of NH_4^+-N as compared to other treatments. Application of pendimethallin caused reduction in NH_4^+-N contents during the initial periods. NO_3^--N content however, increased with time and urea treatments. Pendi methallin application increased the NO_3^--N contents.

NO_3^--N

Data presented in table 3 revealed that application of herbicide also decreased the NO_3^--N content in the soil from 5.74 to 5.41 mg kg^{-1} on zero day of incubation. This trend of decrease in NO_3^--N content in the soil with herbicide application was observed throughout the incubation study. The decrease in NO_3^--N contents in soil with herbicide application may be due to its adverse effect on nitrifying bacteria responsible for nitrification process and hence NO_3^--N contents were decreased. Data presented above can be graphically represented as shown in Fig. 2. These results were in agreement with those reported by Singh and Prasad (1991) reported that application of different pesticides inhibited the nitrification rate in soil. Duhan *et al*. (2005) also reported similar results.

NO_2^--N

Data presented in Table 4 revealed that the effect of herbicide on NO_2^--N contents in soil were not spectacular. Although, there was slight decrease in NO_2^--N contents in soil on the 7th day to 28th of incubation and thereafter, effect of herbicide was found non-significant with respect to NO_2^--N contents in soil. The decrease in NO_2^--N contents in soil with herbicide application may be due to its adverse effect on nitrification process. Similar results were reported by Lucian *et al*. (1998). Data presented above can be graphically represented as shown in Fig. 3.

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SEED SETTING BEHAVIOUR AMONG RESISTANT AND SUSCEPTIBLE GENOTYPES OF GLADIOLUS (*GLADIOLUS XHYBRIDUS* HORT.) FOR FUSARIUM WILT DISEASE

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ABSTRACT
Gladiolus (family Iridaceae) is one of the most important flowering geophytes commercially cultivated for cut flower trade in India and abroad. A total of eight intervarietal cross combinations of resistant and susceptible gladiolus genotypes were made and tested at ICAR-Indian Horticultural Research Institute, Hesaraghatta Lake Post, Bengaluru during 2011-2012 with an objective to find out the potentiality of seed setting in different cross combinations.The cross combination 'IIHRG-12 × Arka Amar' recorded maximum number of seeds per cross (157.33), early capsule maturity (30.33 days) and highest seed germination (96.89%). The genotype 'IIHRG-12' as a female parent in cross combination contributed to higher number of seeds per capsule and per cross. Inclusion of 'IIHRG-12' as male parent also has increased comparatively high number of seeds than any of the cross combinations tested.

INTRODUCTION

Gladiolus, the queen of bulbous ornamentals, is a leading geophyte grown worldwide for cut flower trade and garden displays (Kumar *et al.,* 2015). It occupies a pristine place in the garden for its magnificent inflorescence, wide array of colours, and fascinating varieties of shapes and sizes (Pragya *et al.*, 2010). Gladiolus, the largest genus of the petaloid monocot plant family Iridaceae, is thought to comprise some 255 species (Goldblatt and Manning, 1998). The modern cultivated gladiolus (*Gladiolus* x*hybridus* Hort.) have been developed from 20-25 species which offer a diversity of colours, shapes, and sizes available in few other flowering plants. It is cultivated in almost all countries of the world where spring and summer conditions are favorable (Cantor and Tolety, 2011).

One of the main constraints of gladiolus cultivation is the fusarial wilt disease caused by fungus *Fusarium oxysporum* f. sp. *gladioli*, which causes severe economic losses in production of this cut flower.The pathogen may cause as much as 60–100% damage to gladiolus depending on varietal response (Pathania and Misra, 2000). Improvement of any crop depends on its natural variability which again depends on its reproductive biology. Hybridization, the crossing of one cultivar with another and selection, will probably continue as the most reliable source of new cultivars. The goal of hybridizing is to create superior cultivars by bringing new combinations of genes within chromosomes together through cross pollinations (Hartline, 1996). Considering the economical criteria of the production and commercialization, gladioli flowers must satisfy simultaneously numerous esthetical requirements. The development of desirable varieties with wide genetic base is possible only through sexual propagation in conventional breeding.

The study on the potentiality of seed set in the intervarietal and interspecific crosses is one of the most important pre-requisites for successful breeding program.Extremely low seed set in a few intervarietal crosses, and failure of seed set in some interspecific crosses are apparently realized as major problems in breeding of bulbous flowers including gladiolus (Van Tuyl,1997). In the present study, hybridization in gladiolus was carried out to assess seed setting behaviours of intervarietal crosses aimed at development of new cultivars with resistance to *Fusarium* wilt disease and better quality of spike.

MATERIALS AND METHODS

The experiment was carried out with four gladiolus genotypes i.e. Arka Amar, Arka Aayush, IIHRG-12 and Pink Friendship. A total of eight cross combinations were made such as Arka Amar x IIHRG-12, IIHRG-12 x Arka Amar, Arka Amar x Pink

Friendship, Pink Friendship x Arka Amar, Arka Aayush x IIHRG-12, IIHRG-12 x Arka Aayush, Arka Aayush x Pink Friendship and Pink Friendship x Arka Aayush. Flower colour of all the genotypes was recorded by using RHS colour charts given in Table 1.

Hybridization procedure

Hybridization was done by hand emasculation and hand pollination. The crossing was done between *Fusarium* wilt resistant ('Arka Amar' and 'IIHRG-11') and susceptible ('Pink Friendship' and 'IIHRG-12') genotypes. From each spike three florets were selected. All the anthers were removed carefully with forceps and bagging was done (Misra *et al.,* 2003). Emasculation was done in the afternoon and pollination was done on next day in the morning hours. Flowers were pollinated between 10 a.m. and 11.30 a.m. by gently rubbing dehisced anther against the sticky stigmatic surface. Lower three buds *viz*., B1, B2, B3 were used for hybridization and remaining part of spike was removed as soon as the pollination of third bud was completed. After pollination, the florets were covered with perforated butter papers bags, tied with thread and labelled.

Capsule harvesting and seed extraction

Capsules generally matured in 4-6 weeks after pollination (Misra *et al.,* 2003) depending upon genotypes and weather under Bangalore condition. The spikes that consisted of matured capsules were cut below the first capsule with scissor. Each capsule was separated and kept in small brown paper bags. Before seed extraction, all matured capsules were allowed to dry. Thereafter, each capsule was split longitudinally along the suture and seeds were extracted from individual capsule. Seeds of an individual capsule were kept in perforated butter paper bags. An individual butter paper bag was labelled, indicating pollination date, parentage, harvesting date, and number of seeds. The number of seeds in a pod varies considerably, depending upon the extent of compatibility of the cross.

Sowing of hybrid seeds and aftercare

Before sowing, the seeds were rubbed between two layers of cloth to remove the waxy covering. Seeds were sown in seed pans containing media (cocopeat, sand, soil and FYM @ 3:2:0.5:0.5 v/v). The seeds were sown in 2 cm deep furrows with the individual seeds not closer than 2.5 cm. Before sowing, media was drenched with Bavistin and Captan @ 2g/l each. Seed pans were kept moist by watering with fine rose can. Seeds started germination after 10-15 days of sowing. The observations recorded are days taken for capsule maturity, number of seeds per capsule, number of seeds per cross and seed germination percentage. The experimental design used was RCBD for total number of seeds and maturity, factorial RCBD for number of seeds per capsule and factorial CRD for seed germination percentage. The statistical analysis was carried using SAS-GLM (SAS, 2009) V 9.2 available at Statistics Laboratory, ICAR-IIHR, Bengaluru.

RESULTS AND DISCUSSION

Total number of seeds and days to capsule maturity

On the perusal of data presented in Table 2 indicated highly significant variations for total number of seeds per cross and days taken for capsule maturity among different cross combinations. The total number of seeds per cross varied from 3.33 to 157.33. The cross combination 'Pink Friendship x Arka Amar' (56.67), 'Arka Aayush x IIHRG-12' (49.67), 'Pink Friendship x Arka Aayush' (43.33) and 'Arka Amar x Pink Friendship' (23.33) produced more number of seeds per cross, while, cross combination 'Arka Aayush x Pink Friendship' produced minimum number of seeds per cross (3.33). These findings nearly agree with the results of Dhaduk *et al.* (1987).

The cross combinations recorded significant variations for days taken to capsule maturity (30.33 days to 36.67 days).The cross combination 'Arka Aayush x IIHRG-12' had taken maximum days for capsule maturity (36.67) followed by 'Arka

Table 1: Flower colour of genotypes used for crossing

Genotype	Floret colour (RHS colour chart)
Arka Amar	Red (46.D) having Red (45.B) margin and White (155.B) line on tepals with Yellow (2.C) blotch.
Arka Aayush	Red (41.C) having Red (41.A) margin. Blotch Red (46.B) with Yellow (13.C) border.
IIHRG-12	Purple Violet (82.A) having Purple (77.A) margin with Green White (157.C) line on lower lip.
Pink Friendship	Floret Red (56.A) middle having Red (55.C) margin andGreen White (157.D) blotch.

Table 2: Effect of different cross combination on total number of seeds and days to capsule maturity

Cross combination	Total number of seeds/cross	Days taken for capsule maturity
Arka Amar x IIHRG-12	125.33	31.33
IIHRG-12 x Arka Amar	157.33	30.33
Arka Aayush x IIHRG-12	49.67	36.67
IIHRG-12 x Arka Aayush	152.33	30.67
Arka Amar x Pink Friendship	23.33	30.67
Pink Friendship x Arka Amar	56.67	32.67
Pink Friendship x Arka Aayush	43.33	31.33
Arka Aayush x Pink Friendship	3.33	34.00
SEm ±	9.11	1.06
C.D. @ 5 %	27.65	3.23
CV	20.66	5.72

Table 3: Effect of different cross combination on seed set per capsule

Cross combination (A)	Bud stages (B)			Mean
	B1(First bud)	B2(Second bud)	B3(Third bud)	
Arka Amar x IIHRG-12	50.67	47.33	27.33	41.78
IIHRG-12 x Arka Amar	65.67	61.67	30.00	52.44
Arka Aayush x IIHRG-12	22.00	15.00	12.67	16.55
IIHRG-12 x Arka Aayush	65.67	51.33	35.33	50.78
Arka Amar x Pink Friendship	14.33	7.67	1.33	7.78
Pink Friendship x Arka Amar	41.67	12.00	3.00	18.89
Pink Friendship x Arka Aayush	23.33	17.33	2.67	14.44
Arka Aayush x Pink Friendship	2.67	0.67	0.00	1.11
Mean	35.75	26.63	14.04	-
Grand mean	25.47			
Types of comparisons	CD @ 5%			
A	5.95			
B	3.64			
A x B	10.27			

Table 4: Effect of different cross combination on seed germination (%)

Cross combination (A)	Bud stages (B)			Mean
	B1(First bud)	B2(Second bud)	B3(Third bud)	
Arka Amar x IIHRG-12	88.00	80.00	73.33	80.44
IIHRG-12 x Arka Amar	94.67	97.33	98.67	96.89
Arka Aayush x IIHRG-12	96.00	89.33	88.00	91.11
IIHRG-12 x Arka Aayush	93.33	90.67	93.33	92.44
Mean	93.00	89.33	88.33	
Grand mean	90.22			
Types of comparisons	SEm	SEd	CD @ 5%	CD @ 1%
A	2.1	2.97	6.16	8.37
B	1.81	2.57	-	-
A x B	3.63	5.15	-	-

Aayush x Pink Friendship' (34.00) and 'Pink Friendship x Arka Amar' (32.67). However, cross combination 'IIHRG-12 x Arka Amar' had taken minimum days for capsule maturity (30.33) which was statistically on par with cross combinations 'IIHRG-12 x Arka Aayush' and 'Arka Amar x Pink Friendship'.

Number of seeds per capsule

Interaction between cross combinations and bud stages (first bud, second bud and third bud) on seed setting was found significant (Table 3). Similarly, significant difference was recorded in seed setting in the entire cross combinations and all bud stages. Maximum number of seeds per capsule was recorded in first bud which is followed by second and third bud. In all cross combination, the first bud produced maximum number of seeds. Treatment combination, *viz.*, 'IIHRG-12 x Arka Amar' produced the highest number of seeds in first capsule which differ significantly from the same cross combination in the second and the third capsule.The mean number of seeds per capsule varied from 14.04 to 35.75. Maximum number of seeds were recorded in cross combination 'IIHRG-12 x Arka Amar' (52.44) followed by 'IIHRG-12 x Arka Aayush' (50.78) which were statistically on par. However, minimum number of seeds per capsule was recorded in cross combination 'Arka Aayush x Pink Friendship' (1.11).The number of seeds per capsule per cross varied from 1.11 to 52.44 with mean value of 25.33. Misra *et al*. (2001) also reported wide variations with respect to seeds per capsule. Choudhary *et al*. (2014) also evaluated forty five inter and intraspecific hybrids for seed parameters in cotton.

The genotype 'IIHRG-12' as a female parent in cross combination appeared to have contributed to higher number of seeds per capsule. Even incorporation of this genotype as male parent also seemed to have increased comparatively high number of seeds than any of the cross combinations tested. Thus, genotype 'IIHRG-12' as both female and male parent must have contributed to produce maximum number of seeds per capsule in cross combinations studied. This genotype could have genetic trait to assist in augmenting the number of seeds per capsule. Bhujbal *et al*. (2013) and Chourasia *et al*. (2015) also evaluated genotypes for growth, flowering and corm characters and found highly significant varietal differences indicated the presence of high amount of variability.

Seed germination (%)

Interaction effect of both the factors *viz*., cross combination and bud stages was non-significant (Table 4). Similarly, on par results were obtained for seed germination percentage in all bud stages. The significant variation was recorded in seed germination percentage in all cross combinations. Seed germination in cross combinations varied from 80.44% to 96.89%. The maximum seed germination was recorded in cross combinations 'IIHRG-12 x Arka Amar' (96.89 %), followed by 'IIHRG-12 x Arka Aayush' (92.44 %) and 'Arka Aayush x IIHRG-12' (91.11 %) which were statistically on par.

However, minimum seed germination was recorded in 'Arka Amar x IIHRG-12' (80.44%).

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EFFECT OF SUCROSE AND NUTRIENT ELEMENTS ON FRUITING QUALITY OF KESAR MANGO

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ABSTRACT
A study was carried out to evaluate the effect of sucrose and nutrient elements on fruit quality characteristics of Kesar mango. It was performed during season 2009-2010 at Agriculture Experimental Station, Navsari Agricultural University, Paria, Ta- Pardi and Dist- Valsad. The present experiment was laid out in Randomized Block Design (RBD) with ten treatments and replicated thrice. The treatments are integrated effect of nutrients on trees was found significant on value of TSS (19.00 ^{0}Brix) and ascorbic acid (72.89 mg/100g pulp) content of fruits was noted in treatment T_8- sucrose 10% + boric acid 0.5%., it was followed by treatment T_5- sucrose 5% + boric acid 0.5%., Other quality parameters like reducing sugar, total sugar, acidity, non-reducing sugar *etc.* were not affected by different treatments.

INTRODUCTION

Mango (*Mangiferaindica* L.) is the national fruit of India and rightly known as "king of fruits", owing to its excellent flavour, attractive fragrance, beautiful shades of colour, delicious taste, nutritive value and other desirable characters. The fruit has excellent export potential in both fresh as well as processed forms. India is the major producer of mango in the world with an area of 2.516 million hectares and the annual production of 184.31 lakh tones (Anonymous, 2015). The major mango growing states are Uttar Pradesh, Andhra Pradesh, Bihar, Karnataka, Tamilnadu, Kerala, Maharashtra, Orissa, West Bengal and Gujarat. In Gujarat total area under mango cultivation is about 142.68 thousand ha and production is about 1125.61 thousand tones, while in South Gujarat the total area and production of mango are 66,910 ha and 4,88,810 MT., respectively during year 2011-12 (Anonymous, 2013).

Some nutrients like sucrose, boron and potassium are play a vital role in various enzymatic activities and synthesis of assimilates and hormones. Sucrose has a gives best positive response at fruit quality parameters. According to researchers, only application of major nutrients could not bear out triumphant to generate high quality fruit in mango trees, the application of micronutrients is compulsory as well. Major elements/ macronutrients are quickly taken up and utilized by the tissues of the plants by the catalyzing effect of micronutrients suggested by Phillips 2004. The reasons dispersed for less production due to some genetical, climatical, cultural and hormonal factors responsible for these problems, the scientists have worked for regular cropping through different cultural practices like application of chemical fertilizers. It resulted also in improving the fruit quality parameters *i.e.* total soluble solids, total sugars and coloration (Eliwa, 2003 and Dutta, 2004). These effects may be enthusiastic to the potassium role in increasing tolerance to stresses and improving the formation and accumulation rates of sugars (Saleh and Abd El-Moneim, 2003 and Wahdan, 2011). The increase in the fruit quality by application of micronutrient on guava has also been reported by Gaur *et al*., 2014. To overcome the nutritional problems in mango, the experiment was carried out with respect to find out the suitable nutrient elements on fruit quality of mango cv. Kesar.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Experimental Station, Navsari Agricultural University, Paria, during year 2009-2010.The investigation was conducted on 10 years old mango trees planted at 8 × 8 m apart under square system of planting. In order to assess the effects of various treatments, all the trees were managed with uniform cultural practices as per the standard recommendations with respect to manures and fertilizers, irrigation, plant protection measures *etc.* The experiment was laid out in Randomized Block Design with ten treatments combinations *viz*., T_1-sucrose 5%, T_2- sucrose 10%, T_3- sucrose 5% + potassium citrate 0.2%, T_4- sucrose 5% + potassium citrate 0.3%, T_5- sucrose 5% + boric acid 0.5%, T_6- sucrose 10% + potassium citrate 0.2%, T_7- sucrose 10% + potassium citrate 0.3%, T_8- sucrose 10% + boric acid 0.5%, T_9- control (water spray only), T_{10}- control (without water

spray).The treatments were replicated thrice. Spray was carried once at full bloom stage. However, marketable percentage, total soluble solids (^{0}Brix), pulp:peel ratio, reducing sugar (%), non reducing sugar (%) and total sugars (%), acidity (%), PLW (%) and shelf life (Days) was recorded after ripening of fruits during three days of interval and then finally done the average. The data collected were analyzed statistically as per the procedure (Panse and Sukhatme, 1967) appropriate for Randomized Block Design and the treatment means were compared by means of critical differences at 5 per cent level of probability.

RESULTS AND DISCUSSION

The higher percentage of total soluble solid (19.00°Brix) and ascorbic acid (72.89mg/100g) content were recorded with application of sucrose 10% + boric acid 0.5% (T_8) than control treatment. However, Sanna 2005 reported that application of sucrose 10% + potassium citrate 0.3% at once during at full bloom stage gives best result with respect to quality parameters in Fagri Kalan mango. Singh (2013) reported that boric acid (0.02%) with sorbitol (2.0%) proved to be most effective for enhancing TSS content (18.59°B), total sugar (14.92%) and ascorbic acid (20.32 mg 100 g -1). While, Yadav *et al.* (2013) proved that it was spraying with 0.1 % H_3BO_3 + 0.5 % $ZnSO_4$ at two times *i.e* .during last week of February at after petal fall stage and again at 15 days after the first spraying during observed that foliar spraying of peach trees was the promising treatment for improvement of fruit growth, fruit length and fruit diameter. It might be due to the adequate amount of boron improves the auxin content and it also acts as a catalyst in oxidation-reduction processes in plants. Besides, it also helps in other enzymatic reactions like transformation of carbohydrates, activity of hexokinase and formation of cellulose and change in sugar are considered due to its action on zymohexose (Dutta, 2004) in mango. However, (Sourour, 2000) said that foliar application of boron resulted to increase cell division, cell elongation, sugar metabolism and accumulation of carbohydrates on the fruits so that increase fruits quality. It might be increased chlorophyll content in leaf which is associated with high production of photosythate in plant. Similarly, the combine application of the some nutrient elements at lower level increased total soluble solids and ascorbic acid contents. Foliar spray of micronutrients might have increased rate of photosynthesis, enzymatic activities and translocation of photosynthates leading to improvement in quality parameters in mangoSingh and Maurya (2003), Saraswathy*et al.*(2004) in sapotaBhatt *et al.* (2012) in mango and Jeyabaskaran and Pandey (2008) in banana.The treatment ZnSO4 1% + FeSO4 1% + borax 0.5% significantly favourable effect on fruit quality in terms of TSS, total sugars, reducing sugar and ascorbic acid Nehete *et al.* (2011) and Tulsi Gurjar *et al.* (2015). But, other fruit quality characters like marketable percentage (Table 1) and (Table 2) non-reduc-

Table 1: Influence of various chemicals on Marketable fruit percentage (3 Days interval) of mango fruits cv. Kesar

Treatment	Marketable percentage of mango fruits cv. Kesar.(3 day interval)					
	0	3rd	6th	9th	12th	15th
T_1 : Sucrose 5 %	100	85.4	62.5	37	22.9	19.1
T_2 : Sucrose 10 %	100	87.2	63.8	38	23.3	20
T_3 : Sucrose 5 % + Potassium citrate 0.2 %	100	88.4	64.2	38.6	24.1	21
T_4: Sucrose 5 % + Potassium citrate 0.3 %	100	91.2	66.5	38.9	25	21.7
T_5 : Sucrose 5 % + Boricacid0.5 %	100	99.4	67.8	42.8	26.8	22
T_6 : Sucrose 10 % + Potassium citrate 0.2 %	100	92.1	67	41.2	25.2	21.7
T_7: Sucrose 10 % + Potassium citrate 0.3 %	100	94	67.2	42.1	25.2	21.9
T_8: Sucrose 10 % + Boricacid 0.5 %	100	99.9	67.9	45.5	28.7	24
T_9 : Control (Water spray only)	99.9	85.2	54	35.6	22.8	18.7
T_{10}: Control (Without Water Spray)	99.7	85.1	53.2	35.5	22.5	18.7
S.Em.+	0.10	3.56	3.61	2.11	1.26	1.11
CD. at 5 %	NS	NS	NS	NS	NS	NS

Table 2: Influence of sucrose and nutrient elements on fruit quality of Kesarmango

Treatments	TSS (^{0}Brix)	Pulp: Peel ratio	Reducing Sugar (%)	Non reducing sugar (%)	Total Sugar (%)	Acidity (%)	Ascorbic acid (mg /100g)	PLW (%)	Shelf Life (Days)
T_1 : Sucrose 5 %	17.00	2.97	3.30	9.70	13.0	0.33	67.28	15.70	12.98
T_2 : Sucrose 10 %	17.62	2.94	3.32	9.78	13.10	0.33	67.60	15.66	13.03
T_3 : Sucrose 5 % + Potassium citrate 0.2 %	18.11	2.90	3.38	9.82	13.20	0.32	67.96	15.63	13.20
T_4 : Sucrose 5 % + Potassium citrate 0.3 %	18.22	2.87	3.39	9.84	13.23	0.30	69.33	15.57	13.40
T_5 : Sucrose 5 % + Boricacid 0.5 %	18.77	2.96	3.42	10.12	13.54	0.30	71.22	15.17	13.87
T_6 : Sucrose 10 % + Potassium citrate 0.2 %	18.27	2.88	3.40	9.91	13.33	0.32	70.30	15.53	13.43
T_7 : Sucrose 10 % + Potassium citrate 0.3 %	18.58	2.94	3.40	10.00	13.40	0.31	71.12	15.34	13.73
T_8: Sucrose 10 % + Boricacid0.5 %	19.00	3.00	3.45	10.13	13.58	0.30	72.89	15.12	14.07
T_9 : Control (Water spray)	16.08	2.94	3.43	9.54	12.97	0.32	65.77	16.60	12.16
T_{10}: Control (Without water spray)	15.66	2.92	3.00	8.90	11.90	0.33	64.86	17.20	11.40
S. Em. ±	0.94	1.81	0.13	0.35	0.33	0.01	1.57	0.77	0.52
C D at 5 %	2.20	NS	NS	NS	NS	NS	4.87	NS	NS

ing sugars (%), total sugars (%), reducing sugar (%) and acidity (%),Physiological loss of weight (%) and Shelf life (Days)were not altered significantly by the application of different nutrient elements.

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EFFECT OF NITROGEN, BIO-FERTILIZER AND FARM YARD MANURE ON YIELD AND NUTRIENT UPTAKE IN OAT (*AVENA SATIVA* L.)

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ABSTRACT
An experiment with Four levels of nitrogen (0, 60, 120 and 180 kg/ha), two levels of bio-fertilizer (No bio-fertilizer (B_0) and bio-fertilizer inoculation (B_1)) and two levels FYM (0 and 10 tonnes/ha) was conducted to study the effect of nitrogen, bio-fertilizer and FYM on yield and nutrient uptake of oat (*Avena sativa* L.). Significantly highest seed (54.02 and 51.90 q/ha) and straw (111.17 and 108.82 q/ha) yields, N (85.42 kg/ha), P (24.58 kg/ha) and K (44.61 kg/ha) uptake by seed, N (132.94 kg/ha), P (27.07 kg/ha)and K (105.25 kg/ha) uptake by straw were recorded with application 180 (N_3) and 120 N/ha (N_2) over control (N_0) being remained at par with each other. *Azotobacter* inoculation (B_1) recorded significantly highest seed (48.05q/ha) and straw (105.24 q/ha) yields, highest N (78.69 kg/ha), P (22.66 kg/ha) and K (41.07 kg/ha) uptake by seed, N (127.35 kg/ha) uptake by straw were observed with *Azotobacter* inoculation (B_1) over no inoculation (B_0). FYM application at 10 tonnes/ha (F_1) significantly increased seed (49.97 q/ha) and straw (106.60 q/ha) yields, N (81.63 kg/ha), P (23.65 kg/ha) and K (42.91 kg/ha) uptake by seed and N (129.35 kg/ha), P (26.40 kg/ha)and K (102.98 kg/ha) uptake by straw over control (F_0).

INTRODUCTION

Oat (*Avena sativa* L.) is the most important fodder crop of winter season as it is having high tonnage, good palatability and high nutritive value. Oat is used as green fodder, straw, hay or silage. Oat grain makes a good balanced concentrate in the rations for poultry, cattle, sheep and other animals. Green fodder contains about 10-12 % protein and 30-35 % dry matter and supply abundant quantity of vitamin-A and important minerals like Ca and Fe in addition to energy for the animals. Oat has wider adaptability because of its excellent growth habits, quick regrowth, better yield potential and provides palatable, succulent and nutritious green fodder (Singh *et al*., 1989).

India ranks first among the major livestock holding countries having about 15% livestock population of the world, however, milk production of our country is about 17% (Anonymous 2012-2013). Total livestock population of India is 512 million (2012-13). The present availability of green fodder is about 400 million tonnes projecting a deficit of 63.50 % and that of dry fodder is around 466 million tonnes against the requirnment of 609 million tonnes (Anonymous 2014-15). Fodder and feed are the major inputs in animal production especially in milch animals, which accounts for about 60 to 70 % of total cost of milk production. The milk production can be easily increased by adequate supply of nutritious feed and fodder.

Oat (*Avena sativa* L.) is an important fodder crop and is fast growing and high yielding crop thus requires a large quantity of fertilizers N for enhancing production of quality of herbage (Singh and Dubey, 2007). It is an exhaustive crop considering its nutrient demand and puts heavy nutritional load on soil. Among the major nutrients, nitrogen plays a pivotal role in quantitative as well as qualitative improvement in productivity of fodders. It is an important constituent of protein and chlorophyll which imparts dark green colour to the plants and promotes early vegetative growth. It improves the quality by increasing the protein content of fodder crops and governs to a considerable utilization of potassium, phosphorus and other nutrients. Whereas, split application of nitrogen may further help to reduce its leaching and volatilization losses and improves the efficiency of nitrogenous fertilizers. *Azotobacter chroococcum* is free living heterotropic nitrogen-fixing bacteria which produces a variety of growth promoting substances (Rao, 1975) may play a significant role in integrated N management in fodder oats. FYM is known to play an important role in improving the fertility and productivity of soils through its positive effects on soil physical, chemical and biological properties and balanced plant nutrition (Kumar *et al*., 2011). Balanced fertilizer use along with organic manure like farm yard manure (FYM) is considered as promising agro-technique to sustain yield, increase fertilizer-use efficiency and restore soil fertility. Thus the integrated approach of nutrient supply in oat by chemical fertilizers, FYM along with biofertilizers are gaining importance because this system not

only reduces the use of inorganic fertilizers but is also an environment friendly approach. The demand of green forage is increasing day by day with the introduction of high yielding milch animal. The non availability of quality seeds of improved varieties is a crucial factor in popularization of fodder at vegetative stage, eliminates the opportunity for producing seed which result scarcity of fodder seeds. Therefore, it is essential to develop strategies for high production potential of fodder crop seeds. The paper deals with the effect of nitrogen, bio-fertilizer and FYM and interaction effect of different treatment on growth, yield and quality of oat and nutrient status of soil after harvest of oat.

MATERIALS AND METHODS

The present study was conducted throughout *rabi* season of 2013-14 at the college farm N. M. college of agriculture, Navsari Agricultural University, Navsari, India to study the effect of nitrogen, bio-fertilizer and FYM on yield and nutrient uptake of oat (*Avena sativa* L.). The experiment site was situated at 20°57′ N latitude, 72°54′ E longitude and has an altitude of about 10 metre above the mean sea level. The soil of the experimental field was clayey in texture, low in available nitrogen (216.5 kg/ha), medium in available phosphorus (34.22 kg/ha) and high in available potassium (361.0 kg/ha). The soil was slightly alkaline (pH 7.7) in reaction with normal electrical conductivity (0.34 dS/m) and organic carbon (0.46 %). The experiment was laid out in factorial randomized block design with three replications and 16 treatment combinations *viz.,* Four levels of nitrogen (0, 60, 120 and 180 kg/ha), two levels of bio-fertilizer (No bio-fertilizer (B_0) and bio-fertilizer inoculation (B_1)) (*Azotobacter* as seed treatment) and two levels FYM (0 (F_0) and 10 tonnes/ha (F_1)). The required quantity of seed for experimental area @ 100 kg/ha was worked out.

RESULTS AND DISCUSSION

Effect on yield

Seed and straw yields of oat progressively enhanced due to increasing levels of nitrogen significantly. Application of 120 kg/ha (N_2) and 180 kg N/ha (N_3) recorded significantly highest seed yield (51.90 and 54.02 q/ha, respectively) and straw yield (108.82 and 111.17 q/ha, respectively) (Table 1) over other treatments being remained at par with each other. The better effect of nitrogen levels might be attributed to rapid expansion of dark green foliage, which could intercept and utilize more incident light energy in the production of carbohydrates through the process of photosynthesis. Increased seed and straw yields may be attributed to the improvement in growth attributes due to N application. The results were in agreement with those of Chouhan *et al*. (2015), Joon *et al*. (1993), Sharma *et al*. (2001), Patel and Rajagopal (2002) as well as Devi *et al*. (2014) in oat. Inoculation of seed with *Azotobacter chrococcum* (B_1) registered significantly highest seed (48.06 q/ha) and straw (105.24 q/ha) over control (B_0). The highest yield under bacterial strain inoculation might be due to build up of their higher population in soil at different growth stages *viz*., sowing, tillering and flowering which in turn helped in fixation of more atmospheric nitrogen over non-inoculated treatments. The increase in seed and straw yields was attributed remarkable improvement in almost all parameters of yield under bio-fertilizers treatments. These findings are in conformity with the results of Agarwal *et al*. (2002), Deva, S. (2015), Sheoran *et al*. (2002), Singh and Dubey (2007), Sharma (2009), Patel *et al*. (2010) as well as Devi *et al*. (2014) in oat. Plants under the influence of 10 tonnes/ha farm yard manure (F_1) significantly attained highest seed (48.72 q/ha) and straw (105.21 q/ha) yields over control (F_0). This might be due to significant and progressive effect of FYM application on yield attributes *viz.,* number of grains per panicle, panicle length, seed weight per plant and test weight. The marked increase in seed and straw yields due to beneficial effect of FYM on various yield attributes. The results are in consonance with those reported by Devi *et al*. (2014) in oat.

Effect on nutrient uptake

There was significant improvement in uptake of N, P and K

Table 1: Effect of nitrogen, biofertilizers and FYM on yield and nutrient uptake in oat (*Avena sativa* L.)

Treatment	Seed yield (q/ha)	Straw yield (q/ha)	Uptake by seed			Uptake by straw		
			N	P	K	N	P	K
Nitrogen levels (kg/ha)								
0	34.95	88.62	1.54	0.46	0.82	1.13	0.24	0.93
60	42.07	98.52	1.55	0.46	0.83	1.16	0.24	0.93
120	51.90	108.82	1.64	0.47	0.86	1.22	0.25	0.97
180	54.02	111.17	1.65	0.47	0.86	1.23	0.25	0.97
S.Em. ±	1.27	3.38	0.02	0.01	0.01	0.02	0.00	0.01
C. D. at 5 %	3.66	9.77	0.06	NS	NS	0.05	NS	NS
Bio-fertilizer								
B_0	43.41	98.32	1.57	0.46	0.84	1.16	0.24	0.94
B_1	48.06	105.24	1.62	0.47	0.85	1.20	0.25	0.96
S.Em. ±	0.90	2.39	0.01	0.00	0.01	0.01	0.00	0.01
C. D. at 5 %	2.59	6.91	0.04	NS	NS	0.03	NS	NS
FYM (t/ha)								
0	41.50	96.96	1.57	0.46	0.83	1.16	0.24	0.94
10	49.97	106.60	1.62	0.47	0.85	1.21	0.25	0.96
S.Em. ±	0.90	2.39	0.01	0.00	0.01	0.01	0.00	0.01
C. D. at 5 %	2.59	6.91	0.04	NS	NS	0.03	NS	NS
Interaction effect	NS	NS	NS	NS	NS	NS	NS	NS
CV %	9.60	11.52	4.55	3.96	4.50	4.57	4.81	4.55

due to nitrogen application. Each increase in nitrogen application significantly influenced N, P and K uptake up to the highest nitrogen levels of 180 kg/ha. Application of 120 kg/ha (N_2) and 180 kg N/ha (N_3) resulted in significantly highest uptake of N, P and K in seed and straw over other treatments being remained at par with each other. Highest N, P and K uptake may be attributed to the beneficial effect of nitrogen sufficiency in the soil solution and higher dry matter yields leading to improved uptake to a sufficiency level. These findings corroborated the result of Sharma (2009) as well as Sarkar and Mallick (2010) in oat. The present study reflected that N, P and K uptake by seed and N uptake by straw (Table 1) were significantly influenced due to bio-fertilizer (*Azotobacter*). The highest N (78.69 kg/ha), P (22.66 kg/ha) and K (41.07 kg/ha) uptake by seed and N (127.35 kg/ha) uptake by straw were recorded under *Azotobacter* inoculation over control. Increased uptake of nutrients with *Azotobacter* inoculation may be combined effect of higher dry matter production and creation of proper environment by bacteria for uptake of various plant nutrients. Moreover, this might be due to favourable effect of *Azotobacter* on growth and yield parameters which accumulated more water along with nutrients and produced more photosynthates leading to increased content in seed and straw. These findings were in accordance with those reported by Sharma and Verma (2005), Patel *et al*. (2008), Devi *et al*. (2010), Patel *et al*. (2010) as well as Jat *et al*. (2013) in oat. P and K content uptake by seed and straw showed non significant results by various bio-fertilizer treatments. Application of farm yard manure 10 tonnes/ha (F_1) markedly influenced nutrient uptake in oat crop. The present study reflected that N, P and K uptake by seed and straw (Table 1) were significantly influenced due to FYM application.The highest N, P and uptake by seed and straw were recorded under FYM application @ 10 tonnes/ha over control treatment (F_0). Moreover, this might be due to addition of FYM improved physical, chemical and biological properties of soil and this leads to improve the root growth and development and thereby uptake of nutrients and water from soil volume resulting in increase content in seed and straw. These findings were in accordance with those reported by Jat *et al*. (2013) in oat.

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APPLICATION FORM

NATIONAL ENVIRONMENTALISTS ASSOCIATION (N.E.A.)

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RESPONSE OF DATE OF SOWING ON YIELD AND YIELD ATTRIBUTES OF SAFFLOWER CULTIVARS

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ABSTRACT
In order to investigate the "Response of Date of Sowing on Yield and Yield Attributes of Safflower Cultivars" an experiment was conducted on a split plot design with 4 replications during the year 2013-14 at Indore (M.P.). The experiment consisted of 9 treatment combinations comprising 3 dates of sowing (1st November, 15th November, 30th November) as main plots and 3 cultivars (A-1, NARI-6, NARI-57) as subplots. The result showed that sowing of safflower on 1st November recorded significantly higher Yield and Yield attributing characters viz.; number of capitula/plant (26.21), weight of capitula (78.60 g plant^{-1}), number of seeds capitula^{-1} (22.21), 100 seed weight (6.20 g), higher seed yield (1701 kg ha^{-1}), straw yield (5683 kg ha^{-1}) and biological yield (7384 kg ha^{-1}) as compared to 15th November and 30th November respectively. Among the cultivars of safflower, A-1 had significantly higher yield and yield attributing characters viz., capitula/plant (27.21), weight of capitula (96.72 g plant^{-1}), and 100 seed weight (6.55 g), higher seed yield (1700 kg ha^{-1}), straw yield (5535 kg ha^{-1}) and biological yield (7235 kg ha^{-1}) over NARI-57 and NARI-6. From the study it can be concluded that combination of cultivar A-1 sown in 1st November performed best among all other treatment combinations.

INTRODUCTION

Safflower [*Carthamus tinctorius* (L.) Moench] is a very useful oilseed crop for rainfed or dryland areas. Generally it is known as *Kusum or Kardi*. Safflower is a member of the family Compositae and originally grown for the flowers that were used in making red and yellow dyes. In India the crop has traditionally been grown in the 'Rabi' or winter dry season. In Madhya Pradesh safflower average production is too low. In order to reduce deficiency in oil production and the level of oil and oilseed imported, oilseed crop production areas and oil yield should be increased or Alternative oil crops should be introduced (Nikabadi and Soleimani 2008). Safflower has a promising future as a salinity and drought resistant crop that has both spring and autumn types.

Planting date is very important in agricultural production management decisions, especially at region having environmental restrictions such as sooner or later coldness or serves (Emami *et al*., 2011). Cultivar selection is also a key management component in any cropping system even more critical in sowing date for crop production (Soleymani *et al*., 2011). All the varieties may not be suitable for timely as well as the late sowing. The differences in production of timely sown and late sown crops may be attributed to the unfavourable temperature prevailing at different growth stages, such as low temperature at the time of germination which may delay crop emergence. Low temperature may also slow down the growth and development of the crop, resulting in the accumulation of insufficient biomass and shortening of crop duration (Sooraj Chandra *et al*. 2015).

The field and quality properties of safflower are largely determined by ecological factors and cultivation techniques. It was reported that the sowing date and cultivars of safflower vary depending on ecological conditions (Daltalab *et al.,* 2013). Therefore, in order to obtain safflower with high yield and quality, it is essential to determine the suitable growth conditions and cultivation techniques. So the aim of this study was to evaluate the "Response of Date of Sowing on Yield and Yield Attributes of Safflower Cultivars".

MATERIALS AND METHODS

To evaluate the "Response of Date of Sowing on Yield and Yield Attributes of Safflower Cultivars" an experiment was conducted during the year 2013-14 at Field No. 4 under All India Coordinated Research Project on safflower, at RVSKVV, College of Agriculture, Indore (M.P.). A set of 9 treatment combinations comprising 3 dates of sowing (1st November, 15th November, 30th November) as main plots and 3 cultivars (A-1, NARI-6, NARI-57) as subplots laid out in split plot design with 4 replication.

The soil of experimental field was a typical medium black soil (vertisol), soil pH 8.2, EC (0.432 dsm^{-1}), low in organic (0.36 %), medium in available Nitrogen (235 kg ha^{-1}) and available phosphorus (14.9 kg ha^{-1}) but high in available potash (411 kg ha^{-1}). For ensuring good germination, healthy and good quality seeds were used with 20 kg ha^{-1} With Planting geometry (R × P) 45 x 20 cm. The recommended dose of fertilizer (60 N + 40 P_2O_5 + 20 K_2O kg/ha) was applied in safflower. Full dose of P_2O_5, K_2O and half dose of N were applied at the time

of sowing in the furrow below the seed. Remaining half dose of N was applied at stage of crop at 45 DAS. Soil moisture was not sufficient for crop growth so one uniform irrigation was given to the crop at 50 DAS. Harvest operation done manually.

Studied attributes that selected using 5 plants randomized in each plot included yield (seed yield, straw yield and biological yield) and Yield attributing characters such as number of capitula/plant, weight of capitula, number of seeds/capitula and 100 seed weight was calculated. The data was analyzed by the method of "Analysis of Variance" as described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Number of capitula plant^{-1}

Number of capitula per plant is important yield contributing character to judge the seed yield of safflower crop. The data on average number of capitula plant^{-1} were analyzed statistically**.** Data presented in Table 4, revealed that dates of sowing showed a significant variation on number of capitula plant^{-1}. The maximum capitula plant^{-1} (26.21) was recorded with 1st November sown crop, which was significantly superior over 15th November and 30th November sown crop. Similar result was found by Emami *et al*. (2011).

The maximum capitula plant^{-1} (27.21) was recorded in cultivar A-1 followed by NARI-57 (24.46) and minimum capitula was recorded in cultivar NARI-6 (19.25). These findings confirm those of (Anonymous 2012). The data revealed that combinations of sowing dates and safflower cultivar did not differ significantly for number of capitula plant^{-1} (Table 2).

Weight of capitula (g plant^{-1})

The data in Table 4, showed that the maximum weight of capitula plant^{-1} (78.60 g) was observed in the 1st November sown crop and minimum weight of capitula (58.83 g) was found at 30th November crop. Odivi *et al*. (2013) reported that delay in sowing resulted generally decrease in the yield attributes. Increase in different yield attributing characters in 1st November sowing might be due to more availability of favorable environmental condition at the vegetative and reproductive phase of the crop and might be due to better uptake of nutrients and translocation of photosynthates during the reproductive phase of the crop, thus increasing the size and weight of seeds.

A perusal of data indicated that the maximum weight of capitula (96.72 g) was recorded with A-1. Whereas minimum weight of capitula (52.48 g plant^{-1}) was found with safflower cultivar NARI-6. The data presented in Table 6, revealed that maximum weight of capitula plant^{-1} was given by cultivar A-1 (100.95 g) sown on 30th November as compared to other treatment combinations.

Number of seeds capitula^{-1}

As per Table 4, the highest number of seeds capitula^{-1} (22.21) was obtained by the 1st November sown crop. It was significantly superior over other sowing dates followed by 15th November sowing.

Among the cultivars of safflower, the highest number of seeds per capitula (21.92) was obtained under the NARI-6, which was significantly superior over NARI-57 and A-1. The variation in these yield attributing parameters of the cultivars might be related to inherent differences and high vigour in these cultivars.

The mean pertaining to number of seeds capitula^{-1} in different treatment combinations were subjected to statistically

analyzed, which revealed that there was no significant difference between combination of sowing dates and safflower cultivar (Table 2). These findings confirm those of Daltalab *et al*. (2013).

100 Seed weight (g)

Table 1 : Site conditions of experimental localities

Experimental site	Latitude	Longitude	Height above mean sea level (m)	Average annual precipitation sum (mm)	Soil texture
Indore, (M.P.)	22°43'N	75°56'E	555.7	46.8	Silty loam

Table 1: Cont.....

Available Nitrogen content (kg ha^{-1})	Available phosphorus content (kg ha^{-1})	Available potash content (kg ha^{-1})	OC (%)	EC (dsm^{-1})	Soil pH
235	14.9	411	0.36	0.432	8.2

Table 2: Analysis of variance for experimental characterstics

S.O.V.	df	Number of capitula plant^{-1}	Weight of capitula(g plant^{-1}	Number of seeds capitula^{-1}	100 seed weight (g)
Replication	3	0.42	67.35	0.24	0.03
Date of sowing (S)	2	88.72*	1173.39*	22.90*	3.07*
Error (a)	6	2.74	48.70	0.55	0.03
Cultivar (C)	2	196.05*	7039.08*	15.75*	9.30*
Interaction (S×C)	4	2.10	627.43*	0.24	0.14*
Error (b)	18	1.34	19.52	0.37	0.03
Total	35	* significant at 5 % level			

Table 3: Analysis of variance for experimental characterstics

S.O.V.	df	Seedyield(kgha^{-1})	Straw yield(kg ha^{-1})	Biological yield(kg ha^{-1})
Replication	3	1233.75	10957.28	15365.82
Date of sowing (S)	2	1320972.09*	6211730.06*	13254722.53*
Error (a)	6	1608.83	28288.69	22331.60
Cultivar (C)	2	1383230.16*	3850552.73*	9780615.76*
Interaction (S×C)	4	62974.75*	239467.74*	201222.88*
Error (b)	18	840.81	14329.43	14946.08
Total	35	* significant at 5 % level		

Table 4 :Mean comparision for experimental characterstics

Treatments		Number of capitula plant^{-1}	Weight of capitula (g plant^{-1})	Number of seeds capitula^{-1}	100 seed weight (g)
Dates of sowing	1 November	26.21	78.60	22.21	6.20
	15 November	23.92	69.27	20.25	5.49
	30 November	20.79	58.83	19.54	5.22
	SEm	0.48	2.01	0.21	0.05
	CD at 5 %	1.65	6.97	0.74	0.18
Cultivars	A-1	27.21	96.72	19.67	6.55
	NARI-6	19.25	52.48	21.92	4.80
	NARI-57	24.46	57.51	20.42	5.56
	SEm	0.33	1.28	0.18	0.05
	CD at 5 %	0.99	3.79	0.52	0.15

Table 5 : Mean comparision for experimental characterstics

Treatments		Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Dates of sowing	1 November	1701	5683	7384
	15 November	1314	4787	6101
	30 November	1041	4260	5301
	SEm	11.58	48.55	43.14
	CD at 5 %	40.07	168.02	149.28
Cultivars	A-1	1700	5535	7235
	NARI-6	1022	4429	5451
	NARI-57	1333	4767	6099
	SEm	8.37	34.56	35.29
	CD at 5 %	24.87	102.67	104.86

Table 6: Mean comparision of Interaction effects

Treatments	Number of capitula plant^{-1}	Weight of capitula (g plant^{-1})	Number of seeds capitula^{-1}	100 seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
S1C1	29.88	95.66	21.00	7.11	1941	6566	8507
S1C2	21.63	66.93	23.75	5.24	1505	4988	6493
S1C3	27.13	73.21	21.88	6.25	1656	5496	7153
S2C1	27.13	93.54	19.38	6.57	1766	5408	7174
S2C2	19.13	49.30	21.25	4.58	842	4279	5122
S2C3	25.50	64.98	20.13	5.31	1333	4674	6007
S3C1	24.63	100.95	18.63	5.98	1394	4630	6024
S3C2	17.00	41.21	20.75	4.57	719	4021	4740
S3C3	20.75	34.34	19.25	5.12	1009	4130	5139

Note : S1 - 1 November, S2 - 15 November, S3 - 30 November, C1 - A-1, C2 - NARI-6, C3 - NARI-57

The data (Table 4), showed maximum 100 Seed weight (6.20 g) was obtained under the 1st November sowing followed by 15th November sowing date. The cultivar A-1 registered the highest 100 Seed weight (6.55 g) which was significantly superior over cultivar NARI-6 and NARI-57. The analysis of data revealed that cultivar A-1 gave the maximum 100 seed weight (7.11 g) in 1st November sown crop as compared to other treatment combinations. (Table 6). Similar results were reported by Ali Reza Badri *et al.* (2011).

Seed yield (kg ha^{-1})

Seed yield is the most economical character for evaluating the superiority of the treatment over the other. This increase in yield might be due to more yield attributes viz.; number of capitula plant^{-1}, weight of capitula plant^{-1} (g), number of seeds capitula^{-1}and 100 seed weight. The results are in close

association with findings of Emami *et al*. (2011). The data presented in Table 5, indicated that dates of sowing brought about significant variation in seed yield. The highest seed yield (1701 kg ha^{-1}) was obtained under 1st November sown crop, which was significantly higher over 15th November and 30th November sown crop. Similar result was noted by Odivi *et al*. (2013).

Among the cultivars maximum seed yield (1700 kg ha^{-1}) was recorded with A-1, Similar results were reported by Muralidharudu *et al*., 1989, Hulihalli *et al*., 1997, which was significantly higher over NARI-57 and NARI-57 also recoded significantly higher seed yield as compared to NARI-6 cultivar. (Table 5) Such close association of seed yield with different yield components was also observed by Mohankumar *et al*. (2005) and Anonymous (2012).

Among interaction of dates of sowing and cultivars of safflower, the data presented in Table - 6, indicated that cultivar A-1 recorded the highest seed yield (1941 kg ha^{-1}) with 1st November sown crop, which was followed by cultivar A-1 sown under 15th November (1766 kg ha^{-1}). All the cultivars performed significantly poorer seed yield on 30th November sowing over both the early dates. Planting season and cultivars and its interaction had significant effect on seed and biological yield. The findings are in close confirmity with Sheykhlou *et al*. (2012).

Straw yield (kg ha^{-1})

The data showed in Table 5, indicated that the highest straw yield (5683 kg ha^{-1}) was obtained under 1st November sown crop which was superior over 15th November and 30th November sown crop. In case of straw yield the cultivar A-1 was found superior over other cultivars due to taller plant. Cultivar A-1 registered highest straw yield (5535 kg ha^{-1}) over NARI-57 and NARI-6 during the investigation. The positive effect of date of sowing on straw and biological yield may be due to the pronounced growth during early stages of crop. It resulted that higher plant height and dry matter accumulation and ultimately tended in realization of higher straw and biological yields.

Among interaction of sowing dates and cultivars of safflower, the data presented in Table 6, indicated that cultivar A-1 recorded the highest straw yield (6566 kg ha^{-1}) under 1st November sown crop, which was followed by cultivar NARI-57 sown on 1st November (5496 kg ha^{-1}). On 30th November sowing all the cultivars performed significantly poorer over both the early dates. In case of straw yield cultivar A-1 with 1st November sowing was found superior over other combinations. This may due to taller plant. Similar result was found by Sheykhlou *et al*. (2012).

Biological yield (kg ha^{-1})

Table 5, indicated that the highest biological yield (7384 kg ha^{-1}) was obtained under 1st November sown crop which was superior over 15th November and 15th November sown crop also gave significantly highest biological yield over 30th November sown crop. Heidari Zadeh (2004) reported that postponing the sowing date in addition to temperature increase in developmental stages of germination to flowering which shortening this period cause to yield component production period encounter with high temperature and reduced the total plant dry weight although number of heads per plant, 100 seeds weight and seed yield more affected by it in comparison to biomass yield. The cultivar A-1 registered significantly higher biological yield (7235 kg ha^{-1}) over NARI-57 and NARI-57 also gave significantly highest biological yield over NARI-6 during the investigation.

Among interaction of dates of sowing and cultivars of safflower, the data presented in Table - 6, indicated that cultivar A-1 recorded the highest biological yield (8507 kg ha^{-1}) with 1st November sown crop, which was followed by cultivar A-1 sown on 15th November (7174 kg ha^{-1}). All the cultivars performed significantly poorer biological yield on 30th November sowing over both the early dates. Planting season and cultivars and its interaction had significant effect on seed and biological yield. The findings are in close confirmity with Sheykhlou *et al*. (2012).

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INFLUENCE OF SEED SOURCE VARIATION ON FRUIT AND SEED PARAMETERS IN *SYZYGIUM CUMINI* SKEELS.

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ABSTRACT
In order to identify the seed source variation on fruit and seed parameters in jamun (*Syzygium cumini* Skeels) were evaluated during 2013, 2014 and 2015 spring season. Maximum fruit length (27.48 mm), fruit diameter (19.73 mm), fruit test weight (108.17 g) respectively recorded in Telhara seed source. Maximum seed length (22.14 mm) was recorded in Telhara seed source. Maximum Seed diameter (11.64 mm) and seed weight (46.90 g) recorded in Barshitakli seed source however; least seed length (14.69 mm), seed weight and seed diameter was recorded in Akot seed source (27.17 g), (9.12mm) respectively. Seed sources are suitable for further perpetuation for commercial and breeding zones may be set up in these environmentally heterogeneous areas and the best genotypes may be selected from them.

INTRODUCTION

Variations can be successfully utilized for adaptability of a species e.g. drought resistance or selection of a suitable genotype for growth or fruit quality *etc.* (Sundaram *et al*., 2003). The fruit yielding trees not only provide food, fuel, fodder, timber and /or conserve soil, but also provide rich source of nutrition, medicines and cosmetics. Among several wild fruits, *Syzygium cumini* Skeels is one that has been valued in Ayurvedic and Unani system of medicine for possessing variety of therapeutic properties (Kirtikar and Basu, 1975). High anthropogenic disturbances recorded wherever naturally distributed *Syzygium cumini* (Pawar *et al.*, 2012).

Jamun (*Syzygium cumini* Skeels) is used mainly for food and the sticks of jamun used as tooth sticks (Tripti Bouri *et al*.,2013). The wood is used to install motors in the wells. Being a fast-growing tree, it provides excellent firewood and charcoal to the rural (Chaudhary and Mukhopadhyay, 2012). The leaves are used as fodder and also food for tassar silkworms in India. The leaf distillates yield an essential oil which is used as fragrance in soaps and is blended with other chemicals to make inexpensive perfumes. *Syzygium cumini* flowers are rich in nectar and are useful in the apiculture for their yield of high quality honey (Patel *et al.,* 2010). Fruits are used as a relief for colic, while the wood yields a sulphate pulp that has medicinal uses (Chaudhary and Mukhopadhyay, 2012). The variations are important source for a tree breeder to improve a species. Therefore, variability studies are a prerequisite for improvement of a species.

MATERIALS AND METHODS

The present investigation entitled "Studies on Provenance variability in fruit characters of jamun (Syzygium cumini skeels)" was carried out in the Department of Forestry, Dr.P.D.K.V, Akola. During the year 2013, 2014 and 2015. The extensive survey was undertaken across eight different localities that spread over different provenances of Akola District, Maharashtra. Based on fruit availability at different time, viz. Balapur, Murthizapur, Patur, Akot, Barshitakli, Telhara, Akola (E) Akola (W) fruits were collected from the wide altitudinal range (274 to 425 m) with in their natural distribution to carry out the present investigation. The observations were recorded on shape, colour, and weight, size of fruit and seed of jamun, physiological composition of fruit viz. pulp content (%), seed (%), pulp- seed ratio, the trial was laid out in randomized block design with three replication. The data was analysed statistically as per method given by Panse and Sukhatme

$$\text{Germination percent} \quad \frac{\text{Number of seeds Germinated}}{\text{Number of seeds sown}} \quad 100$$

$$\text{Peak value of germination} \quad \frac{\text{Total germination percent}}{\text{Total number of days}}$$

$$\text{Mean daily germination} \quad \frac{\text{Final germination percent}}{\text{The number of days that took higest Germination}}$$

GV = PV X MDG
Where, PV - Peak Value of Germination
MDG - Mean Daily Germination

RESULTS AND DISCUSSION

Fruit length showed significant variation among the different seed sources. It varied from 19.13 to 27.48 mm. Significantly

higher fruit length was recorded from Telhara(21.26 mm) followed by Akola (E) (27.15 mm) as compared to the other seed sources. The lower seed length was recorded in the seeds collected from Akot (14.69 mm). Maximum fruit diameter and higher fruit test weight were recorded in fruits collected from Telhara (19.73) mm and (108.17) g, respectively, followed by Akola (E) (18.22 mm and 107.87 g, respectively). The fruit parameters are the main important ones for elevation (Srimathi *et al.*, 2001). The fruit traits from Telhara seed source were found superior over the other followed by Akola (E) and Akola (W) seed source and least was observed in Balapur seed source. The fruit from lower altitudinal source were found superior over high altitudinal area probably due to more favourable environmental factors. Similar results were reported by Jamaludheen *et al*. (1995) in *Lagestromia speciosa* and Kallaje (2000) in *Garcinia indicia* Choicy. Higher seed test weight was recorded in Barshitakli (46.90 g) and least seed weight was recorded in Akot seed source (27.17 g). Similarly, higher seed diameter was recorded in Barshitakli (11.64 mm) seed source and seed length (22.14 mm) was recorded in Telhara seed source. Lower seed length and diameter was recorded in the seed collected from Akot (14.69 and 9.12 mm, respectively. It is evident from the data that the highest germination of (88.23) per cent, peak value of germination of 1.95, germination value of 5.08 and mean daily germination of 2.60 was recorded in Telhara seed source. The test weight can be used as a useful parameter for seed source selection. The seed traits and germination characteristics delineated consistent differences among seed sources and this might reflect the true genetic variation. The analyses of the above observations revealed perceptible inter source differences with respect to the seed and germination attributes. These inter source differences establish the existence of genetic variation which can be further exploited to improve nursery production of *S. cumini*. The germination percentage in Telhara seed source recorded was highest and Akot seed source recorded the least (Table 1). This variation in germination may be due to seed size. Heavy and large seed contains more food reserves for the growing embryos, which help in germination by providing more energy than smaller ones; similar results were also reported by Sudhir Kumar (2003) in *Jatropha curcas*. Magnitude of improvement in germination through seed size

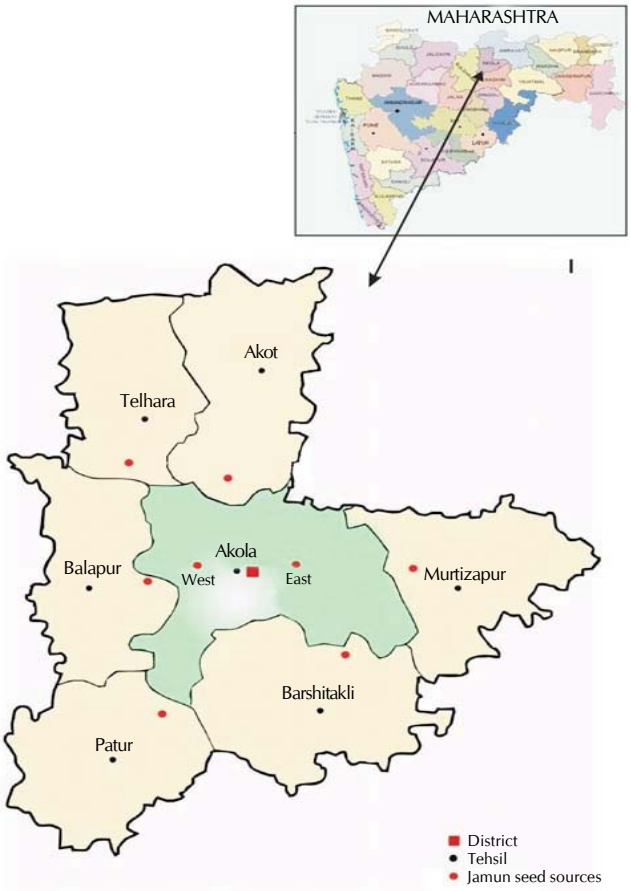

Figure 1: Map of Jamun seed sources in Akola District of Maharstra state

manipulation depends upon the amount of genetic variability and heritability of the traits. However, seed sources with higher seed weight are expected to give higher germination percentage. Hence, it is observed from the results that Telhara and Barshitakli seed sources were found superior with respect to per cent germination, whereas Akot seed source was least in this respect. The peak value of germination (PV) was highest in Telhara seed source followed by Barshitakli and Akola (E).

Table 1: Influence of seed source variation on fruit and seed parameters in *Syzygium cumini*

Treatment / Seed sources	Fruit Length (mm)	Fruit Diameter (mm)	Fruit test weight (g)	Seed length (mm)	Seed diameter (mm)	Seed Test weight (g)	Percent germination	Mean daily germination	Peak value of germination	Germination value
Balapur	19.13	13.49	66.87	15.67	10.41	27.51	80.39 (2.59)	2.31	1.76	4.23
Murthizapur	24.15	17.61	97.79	19.59	10.82	33.49	82.68 (1.41)	2.4	1.8	4.29
Pathur	22.82	16.47	84.5	18.65	9.87	30.66	82.62 (1.46)	2.35	1.78	4.25
Akot	21.18	15.12	74.84	14.69	9.12	27.17	79.41 (1.69)	2.24	1.74	4.19
Barshitakli	23.56	16.96	96.3	21.11	11.64	46.9	86.07 (2.04)	2.57	1.89	4.69
Telhara	27.48	19.73	108.17	22.14	11.37	43.96	88.23 (1.69)	2.6	1.95	5.08
Akola (E)	27.15	18.22	107.87	21.02	11.27	37.95	85.68 (1.46)	2.5	1.85	4.45
Akola (W)	26.91	17.91	98.34	19.97	10.97	34.46	84.68 (1.80)	2.45	1.82	4.31
Mean	24.05	16.94	91.83	19.1	10.68	35.26	83.72	2.43	1.82	4.44
SEm±	0.65	0.5	1	1.37	0.39	1.23	1.74	0.15	0.04	0.33
CD@0.05	1.96	1.53	3.03	4.16	1.19	3.73	5.25	0.45	0.14	1.01

Figures- in parenthesis are arc sin transformed values.

Whereas least peak value of germination was recorded in Akot seed source. This variation in PV may be due to the fact that there is genetic differences exist between the seed sources collected from different locations and moreover seed with high moisture content germinate immediately than with low moisture. This study is in line with Devgiri *et al*. (1998) in *Dalbergia sissoo* and Jayashankar *et al*. (1999) in *Tectona grandis*. The mean germination value was highest in Telhara seed source followed by Barshitakli and Akola (E) seed source. The least germination value was recorded in Akot seed source. The variation in all germination derived parameters may be due to fact that the external and internal seed morphological features are affected to a great extent by the stresses of the habitat and forces operating for perpetuation of the species. This variation in seed traits may be due to fact that this species grown over a wide range of rainfall, temperature and soil type and thus it was found that seed sources with higher seed length and width possessed higher seed weight. Good and viable seeds are always having higher sinks (Srimathi *et al*., 2001). Hence, seed weight can be used as one of the useful criteria for early selection of superior provenances. Thus, seed germination and weight are the two important traits considered for early selection of seed sources and improving seed production. Similar findings were reported by Srivastava (1995) in *Bahunia variegate* and Khalil (1986) in *Picea glauca*. Hence, it is evident from the data that seed sources from Telhara, Barshitakli, and Akola (E) l were found to be superior for fruit and seed traits and they excelled other seed sources

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EFFECT OF PRIMARY NUTRIENT AND ZINC ON NUTRIENT UPTAKE AND YIELD ATTRIBUTES OF MAIZE (*ZEA MAYS* L.)

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ABSTRACT

Field experiments were conducted in factorial design with three replications involving 9 treatment combination (three primary nutrient levels: 0, 50 and 100% RDF and zinc levels: 0, 10, and 20 kg/ha) to evaluate the effect of primary nutrient and zinc application on nutrient uptake, growth and yield attribute of maize (Zea mays L.). Results revealed that treatment combination P_2M_2 (@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1}) significantly enhanced the growth and yield attribute, primary nutrient and zinc uptake, over their respective counter treatments. The highest dry weight in P_2M_2 (360.00 g) and the minimum was recorded in control of (307.33 g). Maximum grain yield (5.95 t ha^{-1}) and stover yield of (13.10 t ha^{-1}) was recorded in P_2M_2 followed by P_1M_1. The highest N, P_2O_5, K and $ZnSO_4$- uptake by grain (67.54, 10.73, 21.97 Kg ha^{-1} and 49.67 mg kg ha^{-1}) and stover (43.29, 4.83, 59.319 Kg $ha^{-1}$and 89.41 mg kg ha^{-1}) was recorded in the treatment combination i.e 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1}. Treatment P_2M_2 was found to be the best.

INTRODUCTION

India with its vast population is confronted with food problem, where millions of people lack a wholes some diet face the increasing food requirement, decreasing of the availability of land per capita. The per capita land has decreased from 1.37 to 0.15 by the year 1999 inspite of increase in cultivated area of the country due to rehabilitation and better management (Behera and Sharma, 2007). World production of maize during 1995 amounted to 514.51 million tonnes with a yielding capacity of 3736 kg ha^{-1}, accounting for 63.93 % of the coarse grains and 27.1 percent of the total cereal production respectively. World production of maize during 2006-07 amounted to 686.75 million tonnes. Maize has the potential to supply large amounts of energy- rich forage for animal diets, and its fodder can safely be fed at all stages of growth without any danger of oxalic prussic acid (Jha *et al*., 2015).

In India it occupies an area of about 6.4 million ha with a production of 11.5 million tones and a productivity of 1.7 tonnes hectare. It is cultivated in diverse production environments, ranging from the temperate hill zones of Himachal Pradesh to the semi – arid deserts of Rajasthan. Uttar Pradesh stand first occupying 1396.6 thousand hectare and producing 1061.3 thousand tones (Economic Survey 2000-2001 and Ministry of Agriculture). Uttar Pradesh production of maize is 9 % out of 100 % percent world productions. Production of maize in Allahabad during 2005-06 amounted to 185 million tonnes. (Karvy comtrade limited, 2007).

Nitrogen is a component of protein and nucleic acids and when nitrogen is sub-optimal, growth is reduced (Singh *et al*., 2013). The recovery of applied nitrogen is low. Particularly in rainy season, the split application of nitrogen usually enhances its recovery and utilization. Demand of plants for nitrogen is more than any other nutrients but deficiencies is noticed at every stage of growth, especially at. Tasseling and silking stage, may lead to virtual crop failure. The nitrogen utilization pattern is found to be increased from seedling to knee- high stage and reach peak at tasseling stage when the plants remove nearly 4-5 Kg N ha^{-1} per day. It is interesting to note that the response of applied nitrogen is highest in poor fertility conditions than the normal ones. Therefore, split application of the same is needed. Best result are achieved when nitrogen applied in three split, *viz* ½th at sowing stage, ¼th at Knee stage (35-40 DAS) and remaining 1/4th at tessling stage. Fertiliser placement below the seed and side dressing of nitrogen at second and third application gives best results. Under ideal fertility management, it is reported than new plant types yield 15-25 Kg grain per kg of applied nitrogen. The crop is grown under rain fed or partially irrigated condition. During rainy season

nitrogen loss through leaching becomes very obvious from the field.Phosphorus is one of the essential nutrient elements required by plants. Recommended dose of phosphorus in maize crop 60 kg ha^{-1} (Shekhawat *et al*. 2012). Phosphorus is helps in root formation, cell division and stimulates growth. Phosphorus make plants more drought and resistant. Increase protein and mineral contents in plant. Increase the ratio of grain to straw in cereals and thus increases the yield of grain. Phosphorus deficiencies show that growth is stunted, leaves become smaller in size, delay maturity and in maize leaves and stem become purple. Phosphorus available forms of nutrients in soil HPO_4^-. Potassium is one of the three major essential nutrient elements required by plants. Potassium is essential in all process needed to sustain plant life. The functions of potassium in the plant are numerous and complex. Potassium is expressed in terms of K_2O .Recommended dose of potassium in maize crop 40 kg ha^{-1} (Ibragimov, 1990). Potassium is absorbed by plants in the ionic form K^+. Generally in plant nutrition and for composition of fertilizers, potassium is expressed in terms of K_2O. Potassium is essential in nearly all processes needed to sustain plant life.

Zinc is secondary essential nutrient for plants and applied for Zn deficiency. Recommended dose of zinc in maize crop 20 kg ha^{-1} (Nayyar *et al*., 2001). In field crops are widespread all over the world because of increased Zn demands of intensive cropping system and adoption of high–yielding cultivars with relatively greater Zn demand. Zn –deficient areas are enhance production of crops on soils that contain low levels of Zn, increased use of high analysis fertilizers containing low amounts of Zn, decrease use of animal manures, compost, and crop residues, and involvement of natural and anthropogenic factors that limit adequate plant nutrient availability and create nutrient imbalances (Fageria *et al*., 2002). One study has found Zn deficiency in nearly 47% soil samples collected from agriculture crop fields (Singh, 1988). Keeping these facts in mind, the present investigation was attempted to study the effect of primary nutrient and zinc on nutrient uptake and yield attributes of maize (*Zea mays* L.).

MATERIALS AND METHODS

Climate and weather conditions

Sam Higgin bottom Institute of Agriculture, Technology and Sciences, Allahabad is situated at 25.57º North latitude and 81.5º East longitudes and a height of 98 m above mean sea level. This tract enjoys a semi arid, sub-tropical climate with extreme of temperature during summer (May-June) and the winter (Dec.-Jan.) are severe with minimum temperature of 3ºC and in summer the temperature often goes to 48ºC accompanied with hot and desiccating winds.

Experimental details

The experiment was laid out in 3 x 3 factorial designs with three replication in Maize as test crop during the Kharif season (mid June-mid November) of the year 2011 and 2012 in sandy loam soil (Sand 60.80%, Silt 24.10% and Clay 15.10%). Recommended Dose of Fertilizer (RDF) for N, P, K and Zn was 120 kg ha^{-1}, P_2O_5 60 kg ha^{-1}, K_2O 40 kg ha^{-1} and $ZnSO_4$ –20 kg ha^{-1}, respectively for maize.

Levels of primary nutrient (P)

Details of treatments and their combinations

Treatment	Combination	Description
T_0	P_0M_0	Control
T_1	P_0M_1	[@ 0 kg N ha^{-1} + 0 Kg P_2O_5 ha^{-1} + 0 Kg K_2O ha^{-1} + @ 10 Kg $ZnSO_4$ ha^{-1}]
T_2	P_0M_2	[@ 0 kg N ha^{-1} +0 Kg P_2O_5 ha^{-1} + 0 Kg K_2O ha^{-1} + (@ 20 Kg $ZnSO_4$ ha^{-1}]
T_3	P_1M_0	[@ 60 kg N ha^{-1} +30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1} + @ 0 Kg $ZnSO_4$ ha^{-1}]
T_4	P_1M_1	[@ 60 kg N ha^{-1} +30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1} + @ 10 Kg $ZnSO_4$ ha^{-1}]
T_5	P_1M_2	[@ 60 kg N ha^{-1} +30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1}]
T_6	P_2M_0	[@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1}+ @ 0 Kg $ZnSO_4$ ha^{-1}]
T_7	P_2M_1	[@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 10 Kg $ZnSO_4$ ha^{-1}]
T_8	P_2M_2	[@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1}]

P0 = control

P1 = 50% RDF, N, P and K [(@ 60 kg N ha^{-1} +30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1})]

P2 = 100% RDF, N, P and K. [(@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1}

Levels of micronutrient (M)

M0 = Control

M1 = 50% RDF, $ZnSO_4$ [(@ 10 Kg $ZnSO_4$ ha^{-1})]

M2 = 100% RDF, $ZnSO_4$ [(@ 20 Kg $ZnSO_4$ ha^{-1})]

[Source: Urea (N), Single Super Phosphate (P_2O_5), Murate of Potash (K_2O), Zinc Sulphate]

Observation recorded in crop

During pre-harvest observation of plant height (cm), number of leaves per plant, stem diameter (cm), dry weight of the plant (g), no. of cobs per plant, at 30, 60 and 90 DAS were taken. Similarly, during Post-harvest, observation of length of cob (cm), no. of grains per cob (g), weight of cob (g), seed Index (1000), grain yield (Kg ha^{-1}), stover yield (kg ha^{-1}) were taken.

Soil observations

Post- harvest soil sample were taken to the plough layer (0-15cm depth) of each plot for determination of its chemical by using standard procedure i.e available N by Subbiah and Asija (1956), available phosphorous by Olsen *et al*. (1954), available potassium by Jackson (1973) and available Zn by Lindsay & Norvell, (1978).

Statistical analysis

The data will be recorded during the course of investigation were subjected to statistical analysis by 'analysis of variance technique' (Fisher, 1950) for drawing conclusion. The significant differences between the means were tested against the critical difference at 5% level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth attributes

There was a significant increase in plant height at 100% RDF of macronutrient level over 50 % RDF of macronutrient and

Table 1: Effect of different level of phosphorous and zinc on growth parameters of maize (2 year pool data)

Treatment	Plant height (cm)			No. of leaves per plant			Stem diameter (cm)			Dry weight (g)		
	30 (DAS)	60 (DAS)	90 (DAS)	30 (DAS)	60 (DAS)	90 (DAS)	30 (DAS)	60 (DAS)	90 (DAS)	30 (DAS)	60 (DAS)	90 (DAS)
T_0	61.0	90.7	132.0	4.9	7.4	8.8	0.93	1.9	2.7	1.1	30.0	175.7
T_1	81.7	132.2	148.3	6.1	8.3	8.3	0.99	2.2	2.9	1.2	31.2	200.0
T_2	75.9	141.8	151.6	5.9	9.0	8.3	1.45	2.35	2.92	1.3	31.2	209.7
T_3	65.7	148.2	153.3	6.3	8.7	8.2	1.45	2.3	2.94	1.4	32.5	210.5
T_4	83.8	154.8	162.7	7.2	9.4	10.0	1.73	2.65	3.78	1.6	39.8	234.3
T_5	74.0	141.6	147.3	6.3	9.0	8.2	1.77	2.6	3.75	1.5	35.3	228.0
T_6	67.3	143.4	153.0	5.9	8.8	7.6	1.75	2.76	3.15	1.4	36.2	231.3
T_7	70.7	146.0	153.0	5.9	8.9	8.4	1.82	2.85	3.84	1.5	36.7	227.3
T_8	103.1	157.4	172.3	8.3	10.8	10.2	1.84	3.01	3.88	1.7	42.2	237.7
S. Em. (±)	0.31	0.54	2.71	0.09	0.13	0.11	0.054	0.057	0.045	0.271	0.569	2.802
C.D. at 5%	0.662	1.148	5.741	0.194	0.266	0.236	0.113	0.121	0.096	NS	1.207	5.940

Table 2: Effect of different levels of phosphorous and zinc levels on yield attributes of maize (2 year pool data)

Treatment	No. of cobsper plant	Length of cob (cm)	Weight of cob (g)	No. of grains per cob
T_0	1.00	15.5	67.3	279.16
T_1	1.00	17.13	88.33	373.83
T_2	1.00	17.83	86.5	382.50
T_3	1.50	18.28	81.66	386.33
T_4	1.83	20.93	102.8	482.66
T_5	1.66	20.75	97.52	472.00
T_6	1.66	19.8	98.8	454.00
T_7	1.50	20.5	92.68	463.00
T_8	2.00	21.75	105.26	485.33
S. Em. (±)	0.180	1.343	0.2	3.143
C.D at 5%	NS	NS	0.585	6.663

Table 3: Effect of different levels of phosphorous and zinc on grain yield of maize (2 year pool data)

Levels of (P)	Levels of (M)			Mean (M)
	M_0	M_1	M_2	
P_0	2.76	3.23	3.65	3.21
P_1	4.83	5.80	5.75	5.46
P_2	4.90	5.70	5.95	5.52
Mean (P)	4.16	4.91	5.12	
	S. Em. (±)	C.D. at 5%		
Macronutrient (P)	0.038	0.081		
Micronutrient $ZnSO_4$ (M)	0.038	0.081		
Interaction (P x M)	0.066	0.140		

Table 4: Effect of different levels of phosphorous and zinc on Stover yield of maize (2 year pool data)

Levels of (P)	Levels of (M)			Mean (M)
	M_0	M_1	M_2	
P_0	8.28	9.76	9.97	9.34
P_1	10.45	12.23	11.75	11.48
P_2	11.95	11.50	13.10	12.18
Mean (P)	10.23	11.16	11.61	
	S. Em. (±)	C.D. at 5%		
Macronutrient (P)	0.081	0.172		
Micronutrient $ZnSO_4$ (M)	0.081	0.172		
Interaction (P x M)	0.140	0.298		

control. At 90 DAS, treatment P_2M_2 (T_8) had maximum plant height of (172.3cm) greater than the control (132.0cm) (Table 1). The increase in number of leaves per plant between control and different level of N P K & Zn were significant at all the successive stage of growth. Among three levels of N P K & Zn, T_8 increased the number of leaves per plant followed by T_4 and showed significant increase over control at 90 DAS. At 90 DAS the maximum stem diameter was (3.88cm) in treatment combination of P_2M_2 followed by (3.84cm) in treatment combination of P_2M_1, respectively and the minimum of (2.70 cm) was found in control. The highest dry weight in T_8 (360.00 g) followed by (355.50 g) in T_4 and the minimum was recorded

Table 5: Effect of different levels of phosphorous and zinc uptake of maize crop (2 year pool data)

Treatment	N-uptake Kg ha^{-1}		K-uptake Kg ha^{-1}		P_2O_5-uptake Kg ha^{-1}		$ZnSO_4$ uptake mg ha^{-1}	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_0	39.85	25.54	11.60	31.32	4.5	2.03	40.63	73.13
T_1	38.21	24.49	14.77	39.879	6.25	2.91	50.00	90.00
T_2	50.60	32.44	17.70	47.79	7.10	3.20	45.33	81.59
T_3	54.60	35.00	12.82	34.614	4.90	2.23	48.00	86.40
T_4	59.45	38.11	18.68	50.436	8.80	3.95	44.67	80.41
T_5	51.66	33.12	15.97	43.119	8.07	3.67	41.67	75.01
T_6	47.70	30.58	15.53	41.931	6.00	2.70	48.00	86.40
T_7	48.80	31.28	13.72	37.044	5.77	2.63	43.33	77.99
T_8	67.54	43.29	21.97	59.319	10.73	4.83	49.67	89.41
S. Em. (±)	0.430	0.394	0.083	0.41	0.035	0.029	0.276	1.16
C.D. at 5%	0.912	0.826	0.175	0.869	0.075	0.061	0.585	2.45

in control of (307.33 g). Sharma *et al*. (1991) from his field experiment conducted at IARI, New Delhi, on sandy loam soil, reported a significant increase in the plant height and number of leaves plant^{-1}, with each successive increase in the level of fertilizers used. From Panthnagar, Shivay and Singh (2000) and Shivay *et al*. (2002) reported increase in plant height and dry matter accumulation in maize with the application of 120 kg N ha^{-1}. Similar findings were reported by Kapur and Rana (1980), Stromberger *et al*. (1994) and Dhingra *et al*. (1991) who supports the findings of the present investigation.

Yield attributes

The significantly maximum number of cobs per plant was (2.00) in treatment T_8 followed by (1.83) in treatment combination T_4 as reported by Sangoi (1990) (Table 2). The crop showed significant increasing trend in length of cob with each levels of N P K and Zn over the control. The maximum length was (21.75) in treatment T_8 followed by (20.93 cm) in treatment T_4 and minimum length was (15.5) in control. The increased length of cob was due to increasing levels of N P K and Zn. There was a significant difference in weight of cob when the plots were treated with difference levels of N P K and Zn. The maximum weight of cob (105.26 g) was recorded in treatment combination of P_2M_2 followed by P_1M_1 over the control. The effect of different levels of N P K and Zn on number of grains per cob was statistically significant and found higher in T_8 (485.33) and minimum in T_0 i.e 279.16. Verma and Singh (1976) from Agra and Dhillon *et al*. (1987) from Ludhiana reported increase in yield attributing characters with increase rate of N application up to 120 kg ha^{-1} on sandy loam soils.

Yield

There was a significant difference in grain yield when the plots were treated with different levels of N P K and Zn i.e maximum yield (5.95 t ha^{-1}) was recorded in P_2M_2 followed by P_1M_1 over the control (2.76) (Table 3). From a field study conducted during winter seasons on sandy loam soils of Hissar, Nandal and Agarwal (1991) reported a linear response of maize to nitrogen application. These results were supported by the findings of Mishra (1993) and Gill *et al*. (1994).

The maximum Stover yield of (13.10 t ha^{-1}) was recorded in P_2M_2 treatment followed by P_1M_1 (12.23 t ha^{-1}) whereas minimum of (8.28 t ha^{-1}) was found in P_0M_0 (control) (Table 4). Padmaja *et al*. (1991) reported that the grain and stover yields were increased significantly with increase in the level of N from 0 to 150 kg ha^{-1} on clay soils of Bapatla during rabi season. Similar findings were reported by Gaur (1991), Oleson *et al*. (1994) and Stromberger *et al*. (1994).

Nutrient uptake

From the table 5 it may be seen that interaction between different N P K and Zn was significant. The highest N- uptake by grain (67.54 Kg ha^{-1}) and stover (43.29 Kg ha^{-1}) was recorded in the treatment combination of N P K and Zn @ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1} followed by (59.45Kg ha-1 in grain and 38.11 Kg ha^{-1})in the treatment combination of N P K and Zn @ 60 kg N ha^{-1} + 30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1} + @ 10 Kg $ZnSO_4$ ha^{-1} respectively and the minimum of (39.85 Kg ha^{-1}) was found in control. Munaswamy et al (1989) reported that uptake of N at harvest was significantly increased with increasing N levels up to 120 kg N ha^{-1}. Similar findings was observed by Burns and Ebelhar (2006).

The highest P_2O_5 and K uptake by grain (10.73, 21.97 Kg ha^{-1}) and stover (4.83, 59.319 Kg ha^{-1}) by was recorded in T_8 treatment (P_2M_2) followed by 8.80 Kg ha^{-1} and 18.68 Kg ha^{-1} in T_4 (P_1M_1) and minimum in control (4.57, 11.60Kg ha^{-1}) respectively. Ananthi *et al*. (2010) from their study at Coimbatore on sandy loam soils during kharif season reported that uptake of P increased with increase in phosphorus from 75 to 100 kg P_2O_5 ha^{-1}.

The highest $ZnSO_4$- uptake by grain (49.67 mg kg ha^{-1}) and stover (89.41 mg kg ha^{-1}) was recorded in treatment P_2M_2 followed by 44.67 mg kg ha^{-1} in the treatment P_1M_1 and minimum in control (4.63 mg kg ha^{-1}). Similar findings were reported by Uribelarrea *et al*. (2004) and Abunyewaa and Quareshie (2004) who observed that application of Zn at higher levels increased grain yield.

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EFFICACY OF CHLORIMURON ALONE AND IN MIXTURE WITH QUIZALOFOP-P-ETHYL AGAINST WEEDS IN SOYBEAN [*GLYCINE MAX* (L.) MERRILL]

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ABSTRACT
A field experiment was conducted during *Kharif* season of 2008 at Livestock Farm, JNKVV, Jabalpur to study the efficacy of chlorimuron alone and in mixture with quizalofop-p-ethyl against weeds in soybean (*Glycine max* (L.) Merill). The field was mainly infested with monocot weeds like *Echinocola colona*, *Dinebra retroflexa* and *Cyperus iria*. Dicot weeds *Alternanthera philoxeroides* and *Eclipta alba* were less dominant in soybean ecosystem. The efficacy of chlorimuron alone as post-emergence was poor when applied @ 6g/ha in reducing weed density and dry weight which was improved slightly with increase the herbicide dose to 9 and 12 g/ha. Among the herbicides combinations, application of chlorimuron + quizalofop-p-ethyl + vit-o-vit @ 9 + 75 + 750 g/ha was most effective in reducing weed growth and it gave highest weed control efficiency (53.51 and 80.52%), crop biomass (591.99 g/m^2) than that of application of chlorimuron @ 6,9 and 12 g/ha and its mixture with quizalofop-p-ethyl @ 50 g/ha and imazethapyr @75g/ha. The significantly highest yield attributing characters were obtained under combined application of chlorimuron + quizalofop-p-ethyl + vit-o-vit @ 9 + 75 + 750 g/ha over rest of the treatments. Treatment of hand weeding twice at 20 and 40 DAS check the weed growth and recorded significantly highest seed yield (1.62t/ha) which were at par with the combined application of chlorimuron + quizalofop-p-ethyl + vit-o-vit @ 9 + 75 + 750 g/ha.

INTRODUCTION

Soybean (*Glycine max*), is an important oil-yielding rainy season (*Kharif*) crop having multiple uses. It has revolutionized the rural economy and has improved socio-economic status of the farmers. Soybean has emerged as a potential crop for changing the ecological position of the farmers in India particularly in Madhya Pradesh. Although ecological condition of the state are congenial for soybean condition but the yield is substantially low, despite of best management practices. The poor weed management practices deprive the crop of its major requirement of nutrients, soil-moisture, sunlight and space which results poor crop growth and yield.

Soybean crop grows slowly during the initial period, which results into vigorous growth and proliferation of weeds. In *kharif* season, the weed competition is one of the most important causes of low yield, which estimated to be 31-84% (Kachroo *et al.,* 2003). Thus, intense weed completion is one of the main constraints for increasing soybean productivity. The weed, if not controlled during critical period of weed crop competition, there may be reduction in the yield of soybean from 58-85% depending upon type and weed intensity (Singh and Singh 1987, Kolhe *et al.,*1998).Hand weeding is traditional and effective method of weed control, but untimely and continuous rains as well as unavailability of labour during peak period of demand are the main limitations of manual weeding. Therefore, there is a need for alternative methods of reducing the weed load during early crop growth period of soybean *i.e.* first 30-45 DAS (Chhokar *et al.,* 1995). Several herbicides *viz,*. fluchoralin, pendimethalin, metalochlor, alachlor and trifluralin *etc.* are presently being used for controlling, weeds associated with soybean, but these herbicides were found not much effective to control many broad leaved weeds existing in soybean. Recently, some of the post-emergence herbicides have been found effective in controlling weeds in soybean (Khope *et al.,* 2011). Therefore, it is imperative, to evaluate the efficacy of suitable early post-emergence herbicide, which could be able to control the dominating weeds in soybean field. According to Chauhan *et al*. (2013) and Dixit *et al.* (2003) chlorimuron may be effective post-emergence herbicide for controlling both sedges and broad leaved weeds in soybean but it is not tested under agroclimatic condition of Jabalpur. Hence, the present investigation was carried out to assess the efficacy of chlorimuron alone and its mixture with quizalofop-p–ethyl against weeds in soybean.

MATERIALS AND METHODS

A field experiment was conducted at the Livestock Farm, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh during rainy season 2008 to evaluate efficacy of chlorimuron alone and in mixture with quizalofop-p-ethyl against weeds in soybean *[Glycine max* (L.) Merrill]. The experimental soil was clay in texture having pH 7.3, electrical conductivity 0.32 ds/m and organic carbon content 0.63 per

cent and analyzing low in available nitrogen (246 kg/ha), medium in available phosphorus (16 kg/ha) and high in potassium (298 kg/ha). The experiment was laid down in randomized block design replicated thrice with ten weed control treatments comprised of, T_1 – Chlorimuron 6 g/ha, T_2 – Chlorimuron 9 g/ha, T_3 – Chlorimuron 12 g/ha, T_4 – Chlorimuron + Quizalofop-p-ethyl (6 + 50 g/ha), T_5 – Chlorimuron + Quizalofop-p-ethyl(9 + 50 g/ha), T_6 – Chlorimuron + Quizalofop-p-ethyl (12 + 50 g/ha), T_7 – Chlorimuron + Quizalofop-p-ethyl + Vit-o-vit (9 + 75 + 750 g/ha), T_8 – Imazethapyr (75 g/ha), T_9 – Weedy check, T_{10} – Hand weeding (20 and 40 DAS). All herbicides alone and in combination were applied at 14 Days after sowing (DAS) in 500 liters of water per ha with knapsack sprayer using flat fan nozzle. Before sowing, seed was treated with Thiram 2.5 g/kg of seed followed by inoculation with *Rhizobium japonicum* culture at 5 g/kg of seed. Soybean variety 'JS-9305' was sown @ 80 kg/ha on 15 July with a row spacing of 45 cm during the year 2008. Full dose of major plant nutrients (20 kg N + 80 kg P_2O_5 + 20 kg K_2O/ha) was applied as basal application through urea, SSP and muriate of potash atthe time of sowing. The whole quantities of all the fertilizers were applied manually at the time of sowing in the furrows about 3 cm below the seed. The species wise weed population was recorded by the least-count quadrat (0.25 m × 0.25 m) method at 40 DAS whereas the weed biomass was recorded at harvest and weed control efficiency was calculated accordingly. While observations on grain yield and yield attributing parameters *viz*., pods/plant, seeds/pod, seed index and harvest index was recorded at harvest. The data of weed density and weed dry weight were subjected to square root transformation $\sqrt{X + 0.5}$ before statistical analysis.

Weed control efficiency (WCE)

Weed control efficiency measures the efficiency of any weed control treatment in comparison to no weeding treatment (Mallikarjun *et al.,* 2014). Mathematically, it could be expressed as below:

$$\text{WCE (\%)} = \frac{\text{DWC—DWT}}{\text{DWC}} \times 100$$

Where,

WCE = Weed control efficiency(%)

DWC = Dry weight of weeds in unweeded plots (g/0.25m^{-2})

DWT = Dry weight of weeds in treated plots (g/0.25m^{-2})

Leaf area index (LAI)

It expresses the total leaf area accumulated by the plants per unit of the ground area in which the crop is grown as explained in the following equation. This observation was taken at 60 DAS as per following formula given by Watson (1952).

$$\text{Leaf area index} = \frac{\text{Total leaf area of crop}}{\text{Total ground area under the crop}}$$

Harvest index

It is the ratio of economic yield to the biological yield. It was determined with the help of following formula and expressed in percentage as follows.

$$\text{Harvest index} = \frac{\text{Economic yield (seed yield)}}{\text{Biological yield (seed and stover yield)}} \times 100$$

RESULTS AND DISCUSSION

Effect on weed flora

Predominant weed species observed in the experimental field consisted of both grassy weeds viz. C*yperus iria*, *Dinebra retroflexa* and *Echinocoloa colona* and broad leaved weeds viz. *Eclipta alba* and *Alternanthera philexeroides*. Among the grassy weeds *Echinocoloa colona* (23.5 and 24.2%) was most dominant weed followed by *Dinebra retroflexa* (22.4 and 22.2%) and *Cyperus iria* (19.4 and 18.5%) at 40 DAS and harvest respectively. While dicot weeds like *Alternanthera philexeroides* (21.9 and 23.4%) and *Eclipta alba* (12.8 and 11.7%) were less dominant in soybean (Fig 1). The predominance of grassy weeds has been reported by (Bhan and Kewat, 2003 and Kumar *et al.,* 2014). In weedy check treatment the total weed population was significantly higher than all the herbicidal treatments (chlorimuron, mixture with quizalofop-p-ethyl and imazethapyr) including weed free treatments. The weed menace was the minimum under weed free treatment.

Among the chlorimuron treatments, activity of chlorimuron as lowest dose at the rate of 6 g/ha as post-emergence caused marginal reduction of broad leaf weeds but applied with higher dose (12 g/ha) reduction of broad leaf weeds was more pronounced. Among herbicidal treatments, chlorimuron + quizalofop-p-ethyl + vit-o-vit @ 9 + 75 + 750 g/ha was most effective to reduced monocot and dicot weeds. (Kushwaha and Vyas, 2005 and Pandey *et al*., 2007). Weedy check had the highest weed biomass and it had reduced significantly when weeds were controlled either by the use of herbicides or hand weeding twice at (20 and 40 DAS) at 40 DAS and harvest, respectively. (Table 1,2). The lowest weed biomass was recorded under weed free treatment closely followed by T_7- chlorimuron + quizalofop-p-ethyl + vit-o-vit @ (9 + 75 + 750g/ha) and chlorimuron + quizalofop-p-ethyl (12 + 50 g/ha). Application of chlorimuron at the rate of 6, 9 and 12 g/ha with quizalofop-p-ethyl @ 50 g/ha found significant to reduced the weed biomass than application of chlorimuron alone at the rate of 6, 9 and 12 g/ha without quizalofop-p-ethyl. On the other hands, imazethpyr @ 75 g/ha caused more reduction in weed biomass of monocot weeds. These results were conformity with Jadhav (2013). Hand weeding twice at 20 and 40 DAS reduced the weed flora and weed biomass to the maximum extent over herbicidal treatments due to the elimination of all sort of weeds. Similar views were also enclosed by Pal *et al*. (2013).

The (WCE) weed control efficiency of different weed control treatments over weedy check was highest under hand weeding twice at (20 and 40 DAS) (Table 2). Among herbicidal treatments application of chlorimuron + quizalfop-p-ethyl + vit-o-vit @ 9 + 75 + 750 g/ha recorded highest weed control efficiency of (53.51 and 80.42%) which was followed by the imazethapyr (51.03 and 79.03%) at 40 DAS and harvest,

Table1: Species wise density of dominant weeds/m² at 40 DAS and harvest as influenced by different treatments

Treatments	Rate (g/ha)	Weed density(m^{-2}) *Echinochloa colona*		*Dinebra retroflexa*		*Cyperus iria*		*Alternenthera philoxaroides*		*Eclipta alba*	
		40DAS	Harvest	40DAS	Harvest	40DAS	Harvest	40DAS	Harvest	40DAS	Harvest
T_1 – Chlorimuron	6	5.05 (22.66)*	5.07 (25.33)	5.08 (25.33)	5.46 (29.33)	3.28 (18.66)	2.80 (5.33)	4.78 (25.33)	3.48 (13.33)	4.36 (8.33)	0.70 (0.00)
T_2 – Chlorimuron	9	4.80 (18.66)	4.81 (21.33)	4.33 (18.33)	4.70 (21.66)	2.82 (10.66)	2.19 (4.00)	4.22 (17.33)	3.11 (6.66)	2.68 (3.66)	0.70 (0.00)
T_3 – Chlorimuron	12	4.25 (25.33)	4.66 (22.66)	3.71 (13.33)	4.14 (16.66)	2.41(5.33)	2.12 (1.33)	3.89 (9.33)	2.67 (9.33)	2.41 (5.33)	0.70 (0.00)
T_4 – Chlorimuron + Quizalofop-p-ethyl	6 + 50	3.23 (10.66)	2.78 (6.66)	2.31 (9.33)	1.99 (2.66)	1.58 (2.66)	0.7 (0.00)	3.71 (13.33)	1.88 (2.66)	2.08 (2.66)	0.70 (0.00)
T_5 – Chlorimuron + Quizalofop-p-ethyl	9 + 50	2.76 (2.66)	2.67 (6.66)	2.12 (9.33)	1.26 (2.66)	1.42 (2.66)	0.7 (0.00)	3.11 (6.66)	1.57 (2.66)	2.03 (2.66)	0.70 (0.00)
T_6 – Chlorimuron + Quizalofop-p-ethyl	12 + 50	2.63 (4.35)	2.17 (5.68)	1.77 (6.66)	1.17 (0.0)	1.17 (3.66)	0.7 (0.00)	2.51 (4.0)	1.17 (2.66)	1.67 (3.66)	0.70 (0.00)
T_7 – Chlorimuron + Quizalofop-p-ethyl + Vit-o-vit	9 + 75 + 750	2.22 (2.66)	1.99 (2.63)	1.33 (3.42)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	2.12 (5.33)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
T_8 – Imazethapyr	75	2.64 (4.34)	2.58 (4.21)	1.92 (2.66)	1.20 (2.66)	1.28 (3.66)	0.7 (0.00)	2.67 (14.66)	1.38 (2.66)	1.89 (3.66)	1.87 (3.01)
T_9-Weedy check	-	6.46 (41.33)	6.76 (45.33)	5.92 (34.66)	6.54 (42.33)	5.81 (34.66)	4.32 (33.33)	5.21 (26.66)	6.62 (43.33)	5.11 (25.66)	5.27 (27.33)
T_{10} – Hand weeding	20 and 40 DAS	1.22 (1.01)	1.22 (1.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
SEm±		0.32	0.21	0.17	0.43	0.28	0.43	0.26	0.11	0.28	0.43
CD at 5%		0.98	0.64	0.52	1.29	0.85	0.66	0.78	0.33	0.85	1.29

Data subjected to $\sqrt{x} + 0.5$ transformation and figure in parenthesis are the original value; DAS: Days after sowing

Table 2: Influence of herbicides on the weed dry weight (g/m²) and weed control efficiency (%) at 40 DAS and harvest in soybean.

Treatments	Rate (g/ha)	Weed dry Weight(g/m^2) *Echinochloa colona*		*Dinebra retroflexa*		*Cyperus iria*		*Alternenthera philoxaroides*		*Eclipta alba*		WCE(%)	
		40DAS	Harvest	40DAS	Harvest	40DAS	Harvest	40DAS	Harvest	40DAS	Harvest	40 DAS	Harvest
T_1 – Chlorimuron	6	3.89 (12.80)*	4.42 (16.80)	2.88 (5.73)	4.06 (16.01)	3.43 (9.73)	3.99 (15.46)	4.73 (10.4)	3.96 (15.06)	3.44 (11.33)	0.70 (0.00)	28.91	44.56
T_2 – Chlorimuron	9	3.80 (14.66)	4.37 (18.40)	2.32 (6.93)	4.04 (13.09)	3.38 (11.33)	3.94 (15.06)	3.29 6.93)	3.94 (12.93)	3.23 (9.46)	0.70 (0.00)	33.64	48.43
T_3 – Chlorimuron	12	3.73 (14.02)	4.14 (17.33)	1.95 (6.93)	3.98 (13.34)	3.19 (10.93)	3.86 (14.40)	3.21 (6.93)	3.79 (12.26)	3.00 (8.33)	0.70 (0.00)	33.98	47.74
T_4 – Chlorimuron + Quizalofop-p-ethyl	6 + 50	3.64 (12.53)	3.92 (18.66)	1.85 (9.86)	3.80 (15.89)	3.04 (8.80)	0.70 (0.00)	2.72 (5.73)	3.67 (15.2)	2.93 (8.13)	0.70 (0.00)	35.71	7.72
T_5 – Chlorimuron + Quizalofop-p-ethyl	9 + 50	3.60 (13.46)	3.25 (19.06)	1.66 (10.4)	3.72 (15.01)	2.89 (7.86)	0.70 (0.00)	2.52 (5.73)	3.66 (14.26)	2.86 (7.73)	0.70 (0.00)	35.91	59.13
T_6 – Chlorimuron + Quizalofop-p-ethyl	12 + 50	3.45 (11.73)	1.49 (3.35)	1.34 (6.53)	3.53 (13.58)	2.33 (6.13)	0.70 (0.00)	2.52 (10.4)	3.49 (13.06)	3.23 (9.46)	0.70 (0.00)	37.23	77.07
T_7 – Chlorimuron + Quizalofop-p-ethyl + Vit-o-vit	9 + 75 + 750	3.32 (10.53)	1.31 (3.12)	1.23 (4.93)	0.70 (0.00)	0.7 (0.00)	0.70 (0.00)	2.35(4.93)	0.7 (0.00)	0.7 (0.00)	0.70 (0.00)	53.51	80.42
T_8 – Imazethapyr	75	3.49 (11.40)	1.49 (2.93)	1.61 (5.06)	3.69 (12.45)	2.57 (5.46)	0.70 (0.00)	2.48 (9.86)	3.50(11.73)	2.79 (7.33)	0.70 (0.00)	51.03	79.03
T_9 – Weedy check	-	5.23 (24.66)	5.86 (33.86)	3.12 (11.06)	4.49 (19.68)	3.52 (11.46)	4.49 (19.73)	4.93 (11.46)	4.73 (18.66)	3.51 (11.86)	4.88 (23.46)	0	0
T_{10} – Hand weeding	20 and 40DAS	1.13 (1.27)	1.21 (1.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	98.19	100
SEm±		0.38	0.29	0.11	0.05	0.18	0.47	0.05	0.03	0.33	0.01		
CD at 5%		1.14	0.88	0.34	0.17	0.55	0.41	0.14	0.11	0.98	0.03		

Data subjected to $\sqrt{x} + 0.5$ transformation and figure in parenthesis are the original value; DAS: Days after sowing

Table 3: Influence of herbicides on growth and yield attributes

Treatments	Rate (g/ha)	Branches /plant (90 DAS)	LAI (60 DAS)	Crop biomass (g/m^2)	Pods/ plant	Seeds/ pod	Seed index (g/ha)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
T_1 – Chlorimuron	6	3.10	7.42	420.29	12.06	2.44	9.36	1.22	3.05	26.68
T_2 – Chlorimuron	9	3.44	7.45	454.33	12.99	2.55	9.39	1.23	3.09	26.67
T_3 – Chlorimuron	12	3.66	7.49	462.42	14.88	2.55	9.57	1.28	3.20	26.68
T_4 – Chlorimuron + Quizalofop-p-ethyl	6 + 50	3.70	7.50	492.29	15.21	2.66	9.65	1.33	3.34	26.68
T_5 – Chlorimuron + Quizalofop-p-ethyl	9 + 50	3.77	7.53	506.61	16.18	2.66	9.84	1.37	3.43	26.67
T_6 – Chlorimuron + Quizalofop-p-ethyl	12 + 50	4.30	7.59	548.80	18.14	2.88	10.63	1.39	3.92	26.67
T_7 – Chlorimuron + Quizalofop-p-ethyl + Vit-o-vit	9 + 75 + 750	4.55	7.79	591.99	20.17	2.92	11.71	1.57	4.07	26.66
T_8 – Imazethapyr	75	4.10	7.56	512.80	16.82	2.88	10.12	1.38	3.47	26.70
T_9 – Weedy check	-	2.33	7.32	315.87	11.06	1.66	9.26	1.07	2.67	24.68
T_{10} – Hand weeding	20 and 40 DAS	4.66	7.81	609.94	21.44	3.10	11.73	1.62	4.25	26.67
SEm ±		0.19	0.07	14.20	0.27	0.15	0.08	0.042	0.18	-
CD at 5%		0.58	0.20	42.19	0.81	0.46	0.25	0.12	0.54	-

DAS: Days after sowing, LAI: Leaf area index

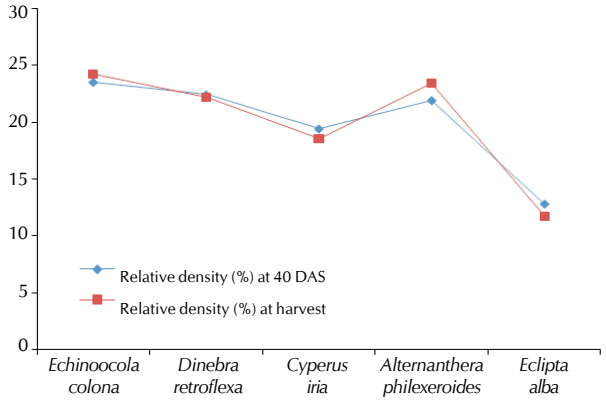

Figure 1: Relative density of weed flora in experimental field at 40 DAS and harvest

respectively. Because both treatments curbed the growth of both type weeds and resulted in the lowest weed biomass which may be reason for higher WCE. The weed control efficiency under chlorimuron at the rate of 6g/ha was lesser than that of different other treatments due to non lethal concentration at the site of action could be reason for poor activity of chlorimuron. Similar finding were also reported by Upadhyay *et al*. (2012).It is mainly because chlorimuron is a selective, systemic sulfonyl urea herbicide absorbed through both roots and foliage. It translocates throughout the plants and inhibits the acetoacetate synthase (ALS). Whereas quizalofop-p-ethyl is a selective, systemic phenoxy herbicide absorbed form the leaf surface and inhibits acetyl CoA synthase (ACCasse). It moving through both xylem and phloem and accumulated in merismetic tissues. Both of these herbicides when applied in combination, the effects on weeds are more lethal than their application alone.

Effect on crop biomass and LAI

Hand weeding twice at 20 and 40 DAS gave significantly higher crop biomass and LAI (Table 3) as compared to the other treatments and it was at par with combined application of chlorimuron + quizalofop-p-ethyl + vit-o-vit @ 9 + 75 + 750g/ha as post- emergence. Application of chlorimuron + quizalofop-p-ethyl (12 + 50 g/ha) and imazethapyr (75 g/ha) was comparable with chlorimuron + quizalofop-p-ethyl + vit-o-vit (9 + 75 + 750 g/ha) and significantly superior over weedy check in respect to crop biomass and LAI. The higher crop biomass is might be due to better weed control by herbicidal mixture. Whereas lower rate of chlorimuron (6 g/ha) applied as post-emergence were ineffective in curbing the weed menace and there by produced inferior crop biomass.

Effect on yield attributes and yield

Yield attributes traits *viz*. pods per plant, seeds per pod, seed index (100 seed weight) were also remarkably superior under hand weeding twice at 20 and 40 DAS as compared to weedy check (Table 3). Both seed and straw yield were significantly higher under all the treatments receiving weed control measure than weedy check plots. Maximum seed yield of soybean was recorded under hand weeding twice at 20 and 40 DAS and proved superior over all the treatments due to elimination of weeds from inter and intra row spaces besides better aeration

due to manipulation of surface soil and thus, more space, water, light and nutrients were available for the growth and development. Pal *et al*. (2013) also reported hand weeding as an effective method for weed control for achieving maximum yield of soybean.

Among chlorimuron treatments, application of chlorimuron + quizalofop-p-ethyl + vit-o-vit @ 9 + 75 + 750g/ha was superior and at par to chlorimuron + quizalofop-p-ethyl (12 + 50g/ha) and imazethapyr (75g/ha) in respect to pods/plant, seed and strover yield due to effectively control of monocot and dicot weeds. These results were in conformity to findings of Kothawale *et al*. (2007), Shete *et al*.(2008). Application of chlorimuron + quizalofop-p-ethyl (12 + 50 g/ha) produced better pods/plant, seed and strover yield as compared to lowest doses of chlorimuron + quizalofop-p-ethyl (6 + 50 g/ha and 9 + 50 g/ha) because of low competitional stress and better yield attributes. Application of lower rates of chlorimuron @ (6 and 9 g/ha) were ineffective in controlling weed menace thereby produced lower yield attributes leads to poor seed yield. The seed yield was lowest in the plots receiving no weed control (weedy check) due to severe competitional stress right from crop establishment up to the end of the critical period of crop growth, leading to poor growth parameters and yield attributing traits and minimum seed yield.

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EVALUATION OF SCHEDULE AND THRESHOLD BASED INSECTICIDAL APPLICATION STRATEGIES ON CONCENTRATION AND ACTIVE INGREDIENT AGAINST SUCKING PESTS INFESTING OKRA

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ABSTRACT
In order to evaluate insecticidal applications strategies along with different doses of thiamethoxam 25 WG and dimethoate 30 EC for the control of sucking pests *i.e.* jassid, aphid and whitefly infesting okra (*Abelmoschus esculentus* Moench), present investigations were conducted at Anand Agricultural University, Anand during during summer and *kharif,* 2012. In comparison to dimethoate 30 EC, thiamethoxam 25 WG on concentration base (0.0125%) applied on schedule base (first spray on appearance of the pests and subsequently five sprays at ten days interval) found effective by recording lowest sucking pests population. The higher fruit yield of okra, economics and Net Insecticidal Cost Benefit Ratio (NICBR) was also recorded in the said treatment.

INTRODUCTION

Among the vegetables, okra or *Bhendi*, *Abelmoschus esculentus* (L.) Moench belonging to the family Malvaceae is an important seasonal fruit vegetable (Varmudy, 2001). Okra is considered as heat loving plant and grown in *kharif* and summer seasons. Being hardy and short duration crop, it is profitability cultivated in summer when other vegetables are not available in the market. In Gujarat, it is grown almost throughout the year. Besides India, it is grown for its immature green non fibrous edible fruits in many tropical and subtropical parts of the world which contains rich source of vitamins, minerals and fibers (Singh, 1970). As high as 72 species of insects have been recorded on okra (Rao and Rajendran, 2003). Its production is badly affected due to heavy attack of sucking pest's *viz*., *Aphis gossypii* Glover, *Amrasca biguttula biguttula* Ishida and *Bemisia tabaci* Gennadius. The pest's damage was observed up to 37.18 and 69.91 per cent in okra production during monsoon and summer seasons, respectively (Mote, 1977). Normally, the insecticides are recommended on the basis of concentration or active ingredient, both of which can be applied either on schedule base or need base. However, which application strategy out of four *viz*., application of insecticides on concentration and need base, application of insecticides on concentration and schedule base, application of insecticides on active ingredient and need base and application of insecticides on active ingredient and schedule base is the effective for the management of insect pests required to be investigated. Scanty information is available on evaluation of different application strategies. Therefore, the present study was carried out at B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during summer and *kharif*, 2012.

MATERIALS AND METHODS

In order to identify a suitable spray application strategy, experiments were laid out in a Split Plot Design with four replications having plot size of 3.6 × 4.2 m during the period of two consecutive seasons; summer and *kharif,* 2012 at College Agronomy Farm, B. A. College of Agriculture, AAU, Anand. Okra variety Gujarat Okra-2 (GO-2) was sown at 45 x 30 cm using recommended agronomical practices except plant protection. Details of insecticides and spray schedules are given in Table 1.

Method of application

Methodology for Schedule based application of insecticides

First spray application of respective insecticides with their respective doses was applied on initiation of pests and subsequent five sprays at 10 days interval. The foliar application of respective insecticides was carried out with the

help of knapsack sprayer at the pressure of 3.5 kg/cm^2 to the extent of slight runoff at vegetative stage.

Methodology for Threshold based applications of insecticides

In case of need (ETL) based applications, the spray applications of respective insecticides with their respective doses were given as and when any of sucking pests reach or cross the ETL (5 insects/leaf).

For recording the population of sucking pests, five plants were selected randomly in each plot. The observations were recorded at 5 days interval after germination till the maturity of the crop. For recording the population of pests, three leaves (each from top, middle and lower canopy of the plant) were selected randomly on each of selected plants. Periodical pickings were made and yield of okra fruits was summed up for further statistical analysis.

Insecticidal Cost Benefit Ratio (ICBR) of the different insecticidal treatments was worked out on the basis of prevailing market price of insecticidal formulations and labour charges for spray applications. Gross realization of a treatment was worked out by considering the yield and its market price. Net realization was worked out by deducting the gross realization in control from gross realization in insecticidal treatment. Net profit of treatment was worked out by deducting the total cost of plant protection from net realization. Insecticidal Cost Benefit Ratio (ICBR) was calculated by dividing the net realization over control with total cost of plant protection. Finally, net ICBR (NICBR) for each treatment was calculated by deducting one from gross ICBR. The data obtained during experiment were analyzed statistically (Steel and Torrie, 1980) and tabulated parameter-wise.

RESULTS AND DISCUSSION

Efficacy of insecticides on population of jassid, *A. biguttula biguttula*

Thiamethoxam 25 WG (I_1) found significantly superior (1.58 / leaf) than dimethoate 30 EC (I_2) by recording the lower jassid population (Table 3). There was significant impact on jassid population when insecticides applied on concentration (D_1) (1.70 jassids/leaf) than a.i./ha (D_2). Schedule based spray application strategy (S_1) was proved more effective and recorded lower (1.13 /leaf) jassid population than the need (ETLs) based (S_2). Thiamethoxam 25 WG when sprayed either on concentration based (I_1D_1) or on g a.i./ha based (I_1D_1) found equally effective, irrespective of application strategies. The extent of jassid population was up to 1.00 per leaf in plots treated on concentration (%) base (D_1) after following schedule based application strategy (S_1D_1). Schedule based application strategy was performed better (1.00 jassids/leaf) with the application of thiamethoxam 25 WG (S_1I_1). Both the application strategies were equally effective when follow either on concentration (%) or on g a.i./ha, irrespective of insecticides. In general, thiamethoxam 25 WG @ 0.0125% ($S_1I_1D_1$) recorded significantly lower jassid population (0.86 /leaf) when applied on the schedule based spray application strategy. The information available on the higher efficacy of the thiamethoxam 25 WG on concentration (%) based against jassid in okra is meagre. Sinha and Sharma (2008) reported foliar spray of thiamethoxam @ 20 g a.i./ha at 15 days interval effectively reduced the jassid population in okra. Sinha *et al*. (2007) concluded that foliar application of thiamethoxam @ 20 g a.i./ha at fortnightly interval was found effective in managing the leaf hopper population. Sinha and Sharma (2007) pointed out that foliar spray of thiamethoxam @ 25 g a.i./ha at 50 days after sowing found effective in managing leaf hopper population in okra. Bhalala *et al*. (2006) reported that foliar applications of thiamethoxam 25 WG at fortnightly interval at two higher doses (50 and 37.5 g a.i./ha) showed higher effectiveness against sucking pests in okra. Thiamethoxam 25 and 50 g a.i. /ha gave significant control of jassid in okra when sprayed at an interval of 15 days (Mishra and Senapati, 2003). As per the report of Subhadra *et al*. (2002), thiamethoxam @ 25 g a.i./ha proved as most effective insecticide against okra leaf hopper when sprayed at an interval of 15 days. Pathan *et al*. (2010) reported need based (ETL) spray of thiamethoxam 25 WG @ 0.0125% was effective and protected the okra crop against sucking pests.

Efficacy of insecticides on population of aphid, *A. gossypii*

The data presented in Table 4 revealed the superiority of thiamethoxam 25 WG (I_1) with lowest (1.72 /leaf) aphid population over dimethoate 30 EC (I_2). There was no any significant impact on aphid population when insecticides applied on concentration (D_1) or on g a.i./ha (D_2). Schedule based application strategy (S_1) recorded lower (1.22 /leaf) aphid population than the need based (S_2) in okra. The impact was reported negligible on the population of aphid when insecticides were applied either on concentration base (D_1) or on g a.i./ha based (D_2). Thiamethoxam 25 WG on schedule based application strategy (S_1I_1) was found more effective and recorded lower (1.05 /leaf) aphid population. Whereas, dimethoate 30 EC when followed either on any of the one application strategy (S_1I_2 or S_2I_2) was found less effective and fail to provide the adequate protection to okra crop against aphid. The interaction S x D *i.e.* application strategy (S_1 or S_2) with either of the two doses *i.e.* D_1 or D_2 was found equally effective in providing protection to the okra crop against aphid. Insecticide with any one of the two doses with schedule or need based application strategy was equally effective and provided adequate protection to okra crop against aphid. The information generated from this particular investigation could not be discussed in the light of earlier findings due to the lack of appropriate reports. Bhalala *et al*. (2006) reported that foliar applications of thiamethoxam 25 WG at fortnightly interval at two higher doses (50 and 37.5 g a.i./ha) showed higher effectiveness. Mishra (2002) also mentioned that thiamethoxam at @ 25 g a.i. /ha when sprayed on 40 and 60 days after sowing effectively managed the aphid incidence in

Table 1: Details of insecticides and spray schedules

Insecticides (I)	Doses (D) Concentration (%)(D_1)	g a.i./ha (D_2)
Thiamethoxam 25 WG (I_1)	0.0125	50
Dimethoate 30 EC (I_2)	0.03	150
Spray schedules (S)		

Schedule based (S_1): First spray application of insecticides was given at initiation of pests and subsequent five sprays were given at 10 days interval. Need (ETLs) based (S_2): Sprays were carried out as and when any one of sucking pests reach or cross the ETL (5 insects/ leaf).

Table 2: Impact of insecticidal applications on incidence of sucking pests in okra (Pooled: summer and *kharif*, 2012)

Treatments 1	No. of jassids/leaf 2	No. of aphid/leaf 3	No. of whiteflies/leaf 4	Yield(q/ha) 5
$S_1 I_1 D_1$	0.86a	0.93a	0.62a	79.83a
$S_2 I_1 D_1$	2.09d	2.14db	1.62c	64.90bcd
$S_1 I_1 D_2$	1.15b	1.16a	0.93b	71.31b
$S_2 I_1 D_2$	2.21d	2.66bc	1.89cd	62.41cd
$S_1 I_2 D_1$	1.14b	1.29a	0.95b	67.20bc
$S_2 I_2 D_1$	2.69e	2.65bc	1.97d	59.40de
$S_1 I_2 D_2$	1.37c	1.47a	1.02b	66.13bcd
$S_2 I_2 D_2$	2.93f	2.86c	2.09d	53.28e
Control (CS_1)	4.62g	4.58d	3.07e	31.41g
Control (CS_2)	4.59g	4.57d	3.09e	32.56f

ANOVA	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)
Treatment (T)	0.07	0.21	0.20	0.64	0.09	0.29	2.57	7.28
Season (Se)	0.07	NS	0.10	NS	0.04	NS	1.82	NS
T x Se	0.11	NS	0.14	NS	0.06	NS	1.28	NS
I x Se	0.05	NS	0.07	NS	0.03	NS	1.28	NS
D x Se	0.05	NS	0.07	NS	0.03	NS	1.28	NS
S x Se	0.05	NS	0.07	NS	0.03	NS	1.28	NS
I x D x Se	0.07	NS	0.10	NS	0.04	NS	1.82	NS
S x I x Se	0.07	NS	0.10	NS	0.04	NS	1.82	NS
S x D x Se	0.07	NS	0.10	NS	0.04	NS	1.82	NS
S x I x D x Se	0.11	NS	0.14	NS	0.06	NS	2.57	NS
Bet. control	0.07	NS	0.10	NS	0.04	NS	2.57	NS
Se x Bet. control	0.11	NS	0.14	NS	0.06	NS	1.82	NS
Control vs Rest	0.17	0.51	0.38	1.09	0.15	0.44	2.03	6.03
Se x Control vs Rest	0.11	NS	0.14	NS	0.06	NS	1.82	NS
C. V. %	8.94		11.09		8.88		8.73	

Notes: **1.** Treatment mean with letter(s) in common are not significant at 5 % level of significance within column; **2.**I_1: Insecticide Thiamethoxam 25 WG; I_2: Insecticide Dimethoate 30 EC; S_1: Schedule based sprays; S_2: ETL based sprays; D_1: concentration (%); D_2: g a. i./ ha; NS: Not significant at 5% level; CS_1: control for schedule based sprays; CS_2: control for ETLs based sprays; Se: Seasons.

Table 3: Impact of spray applications of insecticides on jassid, *A. biguttula biguttula* in okra (Pooled: summer and *kharif*, 2012)

Treatments 1		No. of jassids/ leaf 2	 3	 4	 5	 6	 7
Main" Sub plot		I_1	I_2	Mean (S x D)	Mean (S)	Mean (I)	Mean (D)
S_1	D_1	0.86	1.14	1.00	1.13	I_1 = 1.58	D_1 = 1.70
	D_2	1.15	1.37	1.26			
Mean	S_1 x I	1.00s	1.26t			-	-
S_2	D_1	2.09	2.69	2.39	2.48	I_2 =2.03	D_2 = 1.92
	D_2	2.21	2.93	2.57			
Mean	S_2 x I	2.15u	2.81v	-	-	-	-
Mean (I x D)	D_1	1.48	1.92	-	-	-	-
	D_2	1.68	2.15	-			
ANOVA							
	S x I x D	S x I	I x D	S x D	S	I	D
S. Em. +	0.07	0.05	0.05	0.05	0.04	0.04	0.04
C. D. at 5 %	NS	0.15	NS	NS	0.11	0.11	0.11
C. V. (%)	8.94						

Notes: 1. Treatment means with letter(s) in common are not significant at 5 % level of significance; 2. Sprays (S) S_1: Schedule based spray; S_2: ETLs based spray; Insecticides (I): I_1: Thiamethoxam 25 WG; I_2: Dimethoate 30 EC; Doses (D): D_1: concentration (%); D_2: g a. i./ ha; NS: Not significant at 5% level.

okra. Need (ETL) based spray of thiamethoxam 25 WG @ 0.0125% was found more effective and protected the okra crop against sucking pests (Pathan *et al*., 2010).

Efficacy of insecticides on population of whitefly, *B. tabaci*

Thiamethoxam 25 WG (I_1) was found significantly superior (1.26 whiteflies/leaf) over dimethoate 30 EC (I_2), irrespective of their application strategies and doses (Table 5). Insecticides when sprayed on concentration (%) (D_1) was found better (1.29 whiteflies/leaf) compared to g a.i./ha (D_2). Need (ETLs) based (S_2) application strategy was less effective compared to schedule based (0.89 /leaf) application strategy (S_1). Thiamethoxam 25 WG when follow on concentration based (I_1D_1) was found more effective and recorded 1.26 whiteflies/ leaf. The same insecticide *i.e.* thiamethoxam 25 WG also reduced the whitefly population (1.29 /leaf) significantly when applied on schedule based application strategy (S_1I_1), irrespective of its dose. Schedule based application strategy

Table 4: Impact of spray applications of insecticides on aphid, *A. gossypii* in okra (Pooled: summer and *kharif*, 2012)

Treatments		No. of aphids/ leaf					
1		2	3	4	5	6	7
Main″ Sub plot		I1	I2	Mean (S x D)	Mean (S)	Mean (I)	Mean (D)
S1	D1	0.93	1.29	1.11	1.22	I1 = 1.72	D1 = 1.75
	D2	1.16	1.47	1.31			
Mean	S1 x I	1.05s	1.38t			-	-
S2	D1	2.14	2.65	2.40	2.58	I2 =2.07	D2 = 2.04
	D2	2.66	2.86	2.76			
Mean	S2 x I	2.40u	2.76v	-	-	-	-
Mean (I x D)	D1	1.54	1.97	-	-	-	-
	D2	1.91	2.17	-			
ANOVA							
	S x I x D	S x I	I x D	S x D	S	I	D
S. Em. +	0.10	0.07	0.07	0.07	0.05	0.05	0.05
C. D. at 5 %	NS	0.21	NS	NS	0.14	0.14	NS
C. V. (%)	11.09						

Notes:1. Treatment means with letter(s) in common are not significant at 5 % level of significance; **2.** Sprays (S) S_1: Schedule based spray; S_2: ETLs based spray; Insecticides (I): I_1: Thiamethoxam 25 WG; I_2: Dimethoate 30 EC; Doses (D): D_1: concentration (%); D_2: g a. i./ ha; NS: Not significant at 5% level.

Table 5: Impact of spray applications of insecticides on whitefly, *B. tabaci* in okra (Pooled: summer and *kharif*, 2012)

Treatments		No. of whiteflies/ leaf					
1		2	3	4	5	6	7
Main″ Sub plot		I_1	I_2	Mean (S x D)	Mean (S)	Mean (I)	Mean (D)
S_1	D_1	0.62	0.95	0.79o	0.89	I_1 = 1.27	D_1 = 1.29
	D_2	0.93	1.02	0.98p			
Mean	S_1 x I	0.78s	0.99t			-	-
S_2	D_1	1.62	1.97	1.80q	1.95	I_2 =1.48	D_2 = 1.49
	D_2	1.89	2.09	1.99r			
Mean	S_2 x I	1.76u	2.03v	-	-	-	-
Mean (I x D)	D_1	1.12w	1.46x	-	-	-	-
	D_2	1.41x	1.56x	-			
ANOVA							
	S x I x D	S x I	I x D	S x D	S	I	D
S. Em. +	0.04	0.06	0.06	0.06	0.03	0.03	0.03
C. D. at 5 %	NS	0.16	0.16	0.16	0.09	0.09	0.09
C. V. (%)	8.88						

Notes:1. Treatment means with letter(s) in common are not significant at 5 % level of significance. **2.**Sprays (S) S_1: Schedule based spray; S_2: ETLs based spray; Insecticides (I): I_1: Thiamethoxam 25 WG; I_2: Dimethoate 30 EC; Doses (D): D_1: concentration (%); D_2: g a. i./ ha; NS: Not significant at 5% level.

Table 6: Impact of spray applications of insecticides with their doses on okra fruit yield (Pooled: summer and *kharif*, 2012)

Treatments		Fruit yield (q/ha)					
1		2	3	4	5	6	7
Main″ Sub plot		I_1	I_2	Mean (S x D)	Mean (S)	Mean (I)	Mean (D)
S_1	D_1	79.83a	67.20bc	73.52o	71.12	I_1 = 69.61	D_1 = 67.83
	D_2	71.31b	66.13bcd	68.72p			
Mean	S_1 x I	75.57s	66.67t			-	-
S_2	D_1	64.90bcd	59.40de	62.15q	60.00	I_2 =61.50	D_2 = 63.28
	D_2	62.41cd	53.28e	57.85r			
Mean	S_2 x I	63.66t	56.34u	-	-	-	-
Mean (I x D)	D_1	72.37w	63.30x	-	-	-	-
	D_2	66.86x	59.71y	-			
ANOVA							
	S x I x D	S x I	I x D	S x D	S	I	D
S. Em. +	2.57	1.28	1.28	1.28	0.91	0.91	0.91
C. D. at 5 %	7.28	3.59	3.59	3.59	2.57	2.57	2.57
C. V. (%)	8.73						

Notes:1. Treatment means with letter(s) in common are not significant at 5 % level of significance.**2.**Sprays (S) S_1: Schedule based spray; S_2: ETLs based spray; Insecticides (I): I_1: Thiamethoxam 25 WG; I_2: Dimethoate 30 EC; Doses (D): D_1: concentration (%); D_2: g a. i./ ha.

performed well by recording the lowest *i.e.* 0.79 whitefly/leaf when it follow on the concentration base (S_1D_1), irrespective of the insecticides. Any one of the application strategy (S) *i.e.* schedule based (S_1) or ETLs based (S_1) along with either one of

Table 7: Economics of insecticidal treatments for the control of sucking pests in okra

Treatments	Insecticides	Conc. (%) or g a. i./ha	Qty. of insecticides for sprays (l/ha or kg/ha)	Cost of insecticides (`/liter or kg)	Total cost of plant protection (`/ha)	Yield (q/ha)	Gross realization (`/ha)	Net realization over control (`/ha)	Net profit (`/ha)	ICBR	NICBR
	1	2	3	4	5	6	7	8	9	10	11
S1 I1 D1	Thiamethoxam 25 WG	0.0125%	1.50	3580	7410	79.83	119745	71760	64350	1 : 9.68	1 : 8.68
S2 I1 D1	Thiamethoxam 25 WG	0.0125%	0.75	3580	3705	64.90	97350	49365	45660	1 : 13.32	1 : 12.32
S1 I1 D2	Thiamethoxam 25 WG	50	1.20	3580	6336	71.31	106965	58980	52644	1 : 9.30	1 : 8.30
S2 I1 D2	Thiamethoxam 25 WG	50	0.70	3580	3696	62.41	93615	45630	41934	1 : 12.34	1 : 11.34
S1 I2 D1	Dimethoate 30 EC	0.03%	3.00	330	3030	67.20	100800	52815	49785	1 : 17.43	1 : 16.43
S2 I2 D1	Dimethoate 30 EC	0.03%	1.75	330	1767	59.40	89100	41115	39348	1 : 23.26	1 : 22.26
S1 I2 D2	Dimethoate 30 EC	150	3.00	330	3030	66.13	99195	51210	48180	1 : 16.90	1 : 15.90
S2 I2 D2	Dimethoate 30 EC	150	2.00	330	2020	53.28	79920	31935	29915	1 : 15.80	1 : 14.80
Controls (CS1& CS2)	Controls	-	-	-	-	31.99	47985	-	-	-	-

Skilled labour charges: 170 `/day/spray Number of labours required : 2 per spray Market price of okra fruits: 15 `/kg

the insecticides *i.e.* thiamethoxam 25 WG (I_1) or dimethoate 30 EC (I_2) with concentration based (%) (D_1) or g a.i./ha based (D_1) were equally effective in reducing the whitefly population in okra (Table 5). However, thiamethoxam 25 WG @ 0.0125% ($S_1I_1D_1$) recorded lower population of whitefly (0.62 /leaf) when sprayed on schedule based application strategy. The information available on the higher efficacy of the thiamethoxam 25 WG on concentration (%) based against whitefly in okra is meagre. While scanning the literatures, Bhalala *et al*. (2006) reported higher effectiveness of foliar applications of thiamethoxam 25 WG at fortnightly interval at two higher doses (50 and 37.5 g a.i./ha) against sucking insect pests in okra.

Fruit Yield

All the insecticidal treatments were found significantly superior over the controls by recording considerably higher fruit yield of the okra. The highest (69.61 q/ha) fruit yield of okra was recorded from thiamethoxam 25 WG (I_1) treated plots (Table 6). Concentration based (D_1) application of insecticides was more effective and recorded higher fruit yield (67.83 q/ha) than of g a.i./ha (D_2). Thiamethoxam 25 WG when applied on concentration (0.0125%) based (I_1D_1) protected the crop significantly with higher (72.37 q/ha) okra fruit yield with any of the strategies. While comparing the two application strategies, schedule based (S_1) showed super performance (71.12 q/ha fruit yield) over need based (S_2). Irrespective of insecticides, schedule based strategy with concentration based dose (S_1D_1) provided higher yield (73.52 q/ha). The schedule based application of thiamethoxam 25 WG (S_1I_1) recorded significantly higher (75.57 q/ha) fruit yield. Among the various combinations (S x I x D), the okra plots with schedule based application of thiamethoxam 25 WG @ 0.0125% ($S_1I_1D_1$) recorded significantly the highest okra fruit yield (79.83 q/ha) followed by the same insecticides and application strategy on g a.i./ha *i.e.* $S_1I_1D_2$ (71.31 q/ha). Misra and Senapati (2003) reported that thiamethoxam 25 WG @ 25-50 g a.i./ha increased the marketable fruit yield of okra compared to conventional insecticides. In the present investigation, thiamethoxam 25 WG @ 0.0125% on schedule based proved as most effective.

Insecticidal cost benefit ratio (ICBR)

The Insecticidal Cost Benefit Ratio (ICBR) for different treatments was also calculated and presented in Table 7. Thiamethoxam 25 WG @ 0.0125% on schedule based application ($S_1I_1D_1$) recorded the highest net realization (71760 '/ha) followed by the need based application of the same insecticide *i.e.* thiamethoxam 25 WG @ 50 g a.i./ha (58980 '/ ha). The chronological order of various insecticidal treatments on the basis of Net Insecticidal Cost Benefit Ratio (NICBR) given in brackets after each treatment was: $S_2I_2D_1$ (22.26) > $S_1I_2D_1$ (16.43) > $S_1I_2D_2$ (15.90) > $S_2I_2D_2$ (14.80) > $S_2I_1D_1$ (12.32) > $S_1I_1D_2$ (11.34) > $S_1I_1D_1$ (8.68) > $S_1I_1D_2$ (8.30). Looking to the NICBR, dimethoate 30 EC @ 0.03% on need based application was the most economical as it gave maximum return.

In nutshell, thiamethoxam 25 WG @ 0.0125% on schedule based spray *i.e.* first spray on appearance of sucking pests and subsequently five sprays at ten days interval can be recommended for the effective and economical management of sucking pests in okra.

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EFFECT OF WEED MANAGEMENT ON WEEDS, GROWTH AND YIELD OF SUMMER GREENGRAM (*VIGNA RADIATA* L.)

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ABSTRACT
A field experiment was conducted at College farm, Navsari Agricultural University, Navsari (Gujarat) during summer season of the year 2014 to study the "Weed management study in summer green gram (*Vigna radiata* L.) under south Gujarat condition" Among the different herbicidal weed management treatments, Pendi methalin @ 1.0 kg ha^{-1} PE (T_4) recorded lowest weed population of monocot, dicot and sedge at 25, 50 and at harvest of crop, which resulted in lowest dry weight of weed (435 kg ha^{-1}), highest weed control efficiency (79.59 %) as well as lower weed index (7.55 %). Weed free treatment (T_1) registered significantly higher number of branches per plant at harvest (8.88), yield and yield attributing characters viz., number of pods per plant^{-1}(20.73) followed by T_9 (8.85 and 20.40), T_8 (8.79 and 19.73) and T_4 (8.17 and 18.40), respectively. The significantly higher seeds and stover yield (1378 and 1627 kg ha^{-1}, respectively) were recorded in weed free treatment. Effective weed control in green gram can be achieved by hand hoeing at 20 and 30 DAS during crop growth period with an alternative is application of pendi methalin 1.0 kg ha^{-1} PE.

INTRODUCTION

Among the pulses, green gram (*Vigna radiata* L.) is one of the most important and extensively cultivated crop in India, Which is cultivated in arid and semi arid region. Green gram is locally known as "*moong*". It contains about 25 % protein, 1.3 % fat, 3.5% mineral, 4.1 % fiber and 56.7 % carbohydrate. In spite of the importance of this crop in our daily diet average productivity of this crop is very low in India as well as in the Gujarat. The low production of this crop is mainly due to crop-weed competition and other reasons.

Weed management is an important key factor for enhancing the productivity of green gram, as weeds compete for nutrient, water, light and space with crop plants during early growth period. Moreover, besides low yield of crop, they increase production cost, harbor insect-pest and diseases, decreasing quality of farm produce and reduce land value of the different factors known for reduction in crop production, among them weed stand first (Subramainian *et al*., 1993). Weeds spread easily, because of their enormous seed production and once established are not easily eradicated. Life cycle of most of them coincide with that of crop they invade, thus ensuring mixing of their seed with those of the crops (Mahroof *et al*. 2009). Depending on weed type and crop weed competition it reduces crop yield up to 96.5 % (Verma *et al*., 2015), Whereas the loss of mung bean yield due to weeds ranges from 65.4 to 79.0 % (Dungarwal *et al*. 2003). The magnitude of losses largely depends upon the composition of weed flora, period of weed-crop competition and its intensity. Weeds emerge with the summer sown crops and create severe competition unless controlled timely and effectively. Inter-row cultivation is not sufficient and intra-row hand weeding is necessary under most conditions. Therefore, there is an urgent need to move from costly manual-mechanical weed control to an integrated weed control. In the more developed agricultural systems, herbicides have already replaced mechanical weed control. Unavailability of labours at the time of weeding resulting in sever field infestation, which make mechanical weeding ineffective, tedious and costly. Under such circumstances, chemical control of weeds may be the viable and cost effective alternative for this crop. Effective herbicide at appropriate rate may prove as an effective weed control method and replace conventional methods of weed control. So, if weed growth is minimize during the period of crop weed competition, crop yield will be equivalent to that of weed free crop. Therefore, it is an essential to control weeds by any means during crop weed competition. This paper deals with the objective of to study different weed flora, effect of different weed control practices on growth and yield and efficacy of different herbicide for controlling weeds in green gram.

MATERIALS AND METHODS

A field experiment was carried out during summer season of 2014. The experiment was laid out in randomized block design with three replications and ten treatments (Table-1) comprising of weed management practices. The soil of the experimental field was clayey in texture and showed low, medium and high rating for available nitrogen (226.86 kg ha^{-1}) (Kjeldahl method), phosphorus (30.26 kg ha^{-1}) (Olesen's method) and

potassium (384.25 kg ha^{-1}) (Flame photometric method), respectively. The soil was found slightly alkaline (pH 7.8) (Potentiometric method) with normal electric conductivity. The seed of green gram Meha variety was sown on 4th February, 2014 at a row spacing of 30 × 10 cm using seed rate of 20 kg ha^{-1} and fertilized with 20-40-00 N-P_2O_5-K_2O. Pre and post-emergence herbicide spray was done using 500 liters of water per hectare as per treatments. For making Sorgaab, sorghum plant herbage was harvested at maturity. After sun drying it was chaffed into 2-3 cm pieces. This chaffed material was soaked in water in a ratio of 1:10 (w/v) for 24 hr at room temperature (34ºC ± 2) and filtered to collect sorgaab. Sorgaab was used as a spray material (Cheema *et al*., 2000). The crop was grown with recommended package of practices for South Gujarat Heavy Rainfall Agro-climatic Zone and was harvested on 3rd May 2014.

RESULTS AND DISCUSSION

Effect on weed population, dry weight of weed, WCE and WI

Different types of weed flora were observed in experimental field during summer season of 2014. The most common weed species observed on experimental plot were *Echinochloa crusgalli* L., *Cyperus rotundus* L., *Cynodon dactylon* L., *Digera arvensis Forsk., Digitaria sanguinalist* L., *Convolvulus arvensis* L., *Eclipta alba* L., *Amaranthus viridis* L., *Alternanthera pungens, Physalis minima* L., *Trianthema portulacastrum, Sorghum halepense* L., *Vernonia cinerea* L., *Euphorbia hirta* L., *Abutilon theophrasti*. These similar work done by Chhodavadia *et al*. (2014).

All weed management treatment significantly reduce the population of weeds as compare to weedy check (T_{10}). Among the different treatment tried (Table 1), treatment T_1 (weed free) recorded significantly lowest number of monocot, dicot and sedge per m^2 compared to rest of the treatments at 25, 50 DAS and at harvest, which was at par with T_9, T_8 and T_4 in case of monocot, dicot and sedge at 25 DAS, 50 DAS and at harvest of crop. The highest number of monocot, dicot and sedge were recorded under un weeded treatment (T_{10}). The remarkable reduction in weed population at different stages might be due to effective weed control in respective treatments either manual or herbicidal control or both. These finding are confirmed with those reported by Raj *et al*. (2010).

Among the different treatments (Table 1), significantly the highest dry weight of total weeds was recorded under weedy check treatment (T_{10}). However, it was found that, among the different weed management treatments, treatment T_9 in which, hand weeding was done at 20 and 30 DAS, recorded significantly minimum dry weight of weed at harvest, which was at par with hand hoeing was done at 20 and 30 DAS (T_8) treatment and pre-emergence application of pendi methalin 1.0 kg ha^{-1} (T_4). Minimum weed dry weight in different weed management treatment with weed free condition might be due to effective weed control obtained under hand hoeing, hand weeding and pre-emergence application herbicides at initial and early crop growth stage, which resulted into the lowest weed counts and finally reduced the total dry weight of weeds at harvest, ultimately the rapid growth of green gram crop, dense crop canopy might be suppressed weed growth as indicated by plant height and more number of branches

Table 1: Effect of different weed management practices on population, dry weight of weed, weed control efficiency and weed index of greengram (*Vignaradiata* L.)

Tr. No.	Treatments	Weed population per m^2								Dry weight of weeds (kg ha^{-1})	WCE (%)	WI (%)
		Monocot			Dicot			Sedges				
		25 DAS	50 DAS	At hartvest	25 DAS	50 DAS	At hartvest	25 DAS	50 DAS	At hartvest		
T_1	Weed free	-	-	-	-	-	-	-	-	-	100	-
T_2	Sorgaab conc.@10 lit ha^{-1}(1:10 ratio) at 20 and 30 DAS	6.00(35.10)	7.08(49.07)	6.63(43.10)	7.66(57.86)	9.75(94.15)	9.07(81.30)	6.86(46.09)	7.87(60.99)	7.44(54.45)	1794	15.81	19.59
T_3	Sorgaab conc.@10 lit ha^{-1}(2:10 ratio) at 20 and 30 DAS	5.84(33.15)	6.71(44.20)	6.27(38.37)	7.35(53.12)	9.32(85.90)	8.92(78.62)	6.57(42.20)	7.53(56.02)	7.15(50.17)	1680	21.11	18.58
T_4	Pendimethalin 1.0 kg ha^{-1} PE	4.02(15.24)	3.75(13.09)	3.58(11.97)	4.66(20.91)	4.44(19.72)	3.86(14.07)	4.96(23.64)	4.73(21.48)	4.46(18.91)	435	79.59	7.55
T_5	Quizalofop-P-ethyl 0.075 kg ha^{-1}PoE, 20 DAS	5.07(24.74)	4.06(15.46)	3.91(14.33)	8.23(66.91)	9.60(91.44)	9.67(92.86)	5.73(31.93)	5.10(26.56)	4.65(20.73)	1108	48.01	9.29
T_6	Pendimethalin 0.5 kg ha^{-1} PE + T_2	5.58(30.16)	6.42(40.28)	5.93(34.16)	7.12(49.80)	8.51(71.53)	8.40(69.65)	6.38(39.73)	7.05(48.73)	6.51(41.53)	1359	36.22	18.36
T_7	Pendimethalin 0.5 kg ha^{-1} PE + T_3	5.38(28.02)	6.19(37.33)	5.53(29.62)	6.57(42.20)	7.88(61.23)	7.74(58.90)	6.26(38.34)	6.45(40.77)	5.87(33.49)	1189	44.20	17.85
T_8	Hand hoeing at 20 and 30 DAS	3.63(12.26)	3.49(11.21)	3.29(9.87)	4.01(15.25)	3.86(14.02)	3.54(11.76)	4.73(21.40)	4.55(19.76)	4.37(18.20)	381	82.12	3.48
T_9	Hand weeding at 20 and 30 DAS	3.59(12.01)	3.34(10.21)	3.09(8.60)	4.00(15.22)	3.62(12.18)	3.38(10.57)	4.46(19.12)	4.45(18.97)	4.18(16.58)	329	84.56	3.27
T_{10}	Weedy check	6.33(39.14)	7.53(55.89)	6.93(47.10)	8.56(72.28)	10.11(101.29)	9.32(86.13)	7.14(50.05)	8.49(71.13)	7.68(58.16)	2131	-	33.24
	S.Em. ±	0.17	0.16	0.19	0.27	0.29	0.25	0.19	0.23	0.17	85.10	-	-
	C. D. at 0.05 %	0.51	0.46	0.55	0.82	0.87	0.76	0.56	0.69	0.50	252.86	-	-

Table 2: Effect of different weed management practices on growth and yield of greengram (*Vigna radiata* L)

Tr. No	Treatments at harvest	Plant height branches (cm)	No. of /plant per plant	No. of pods yield	Seed yield (kg ha^{-1})	Stover (kg ha^{-1})
T_1	Weed free	49.80	8.88	20.73	1378	1627
T_2	Sorgaab conc.@10 lit ha^{-1} (1:10 ratio) at 20 and 30 DAS	40.96	7.16	14.83	1108	1246
T_3	Sorgaab conc.@10 lit ha^{-1}(2:10 ratio) at 20 and 30 DAS	42.01	7.42	15.10	1122	1263
T_4	Pendimethalin 1.0 kg ha^{-1} PE	45.58	8.17	18.40	1274	1385
T_5	Quizalofop-P-ethyl 0.075 kg ha^{-1}PoE, 20 DAS	44.06	8.00	17.90	1250	1378
T_6	Pendimethalin 0.5 kg ha^{-1} PE + T_2	42.12	7.43	15.83	1125	1319
T_7	Pendimethalin 0.5 kg ha^{-1} PE + T_3	43.96	7.60	16.97	1132	1320
T_8	Hand hoeing at 20 and 30 DAS	47.04	8.79	19.73	1330	1515
T_9	Hand weeding at 20 and 30 DAS	48.80	8.85	20.40	1333	1557
T_{10}	Weedy check	51.04	5.05	13.67	920	1100
	S.Em. ±	2.13	0.39	1.29	75.52	100.84
	C. D. at 0.05 %	6.33	1.15	3.83	224	300

per plant, which did not allow weeds to grow vigorously due to smothering effect. These result confirm the finding of Rajib *et al*. (2014). Various weed management treatment showed better weed control efficiency. The highest weed control efficiency at harvest was recorded under weed free treatment (T_1) followed by treatments T_9 (84.56 %), T_8 (82.12 %) and T_4 (79.59 %). The higher weed control efficiency recorded under weed management treatments might be due to periodical removal of weeds by hand weeding, hand hoeing or herbicidal control resulted in remarkable reduction in weed population and ultimately less dry weight of weeds. These is in agreement with the findings of Malliswari *et al*. (2008).

Looking to the weed index, which is the indicator of losses in seed yield due to presence of weeds, Weed free treatment (T_1) is considered as base for calculating weed index, was followed by treatment T_9 (3.27 %), T_8 (3.48 %), T_4 (7.55 %) and T_5 (9.29 %). This might be due to effective weed control achieved under these weed management treatments, which resulted in reduction of weeds biomass ultimately, achieving higher weed control efficiency. The finding on weed dry weight, WCE and WI are colloborule the result of Sultan and Baigh (2013) and Chhodavadia *et al*. (2014) in green gram.

Effect on crop

Growth attributes

The plant height was significantly more (51.04 cm) with lowest number of branches per plant (5.05), in un weeded control, which might be due to severe competition by weeds for moisture and nutrients; consequently the plant growth was affected. However, in the treatment T_1 the plant height was 49.80 cm with highest number of branches (8.88), which was at par with treatments T_9, T_8 and T_4. The results are in agreement with the finding of Raj *et al*. (2012) and Chhodavadia *et al*. (2013).

Seed yield and yield attributes

The highest value of number of pod per plant (20.73) was recorded with the weed free treatment (T_1) followed by treatment T_9, T_8, T_4 and T_5. Similar effect was also reported by Khot *et al*. (2012). Weed free treatment (T_1) recorded significantly higher seed yield (1378 kg ha^{-1}), which was remain at par with treatments T_9, T_8, T_4 and T_5 and significantly superior over weedy check (T_{10}). The per cent increase in seed yield under treatment T_1 to the tune of 49.7 % over weedy check, while 3.4 %, 3.6 %, 8.2 % and 10.2 % over T_9, T_8, T_4 and T_5 respectively. The significantly higher stover yield (1627kg ha^{-1}) was recorded under weed free treatment (T_1), which was at par with T_9, T_8, T_4 and T_5. The increase in seed and stover yield mainly due to maintenance of weed free environment, especially during critical growth stages of crop, reduce crop weed competition helped in better growth and development of green gram crop resulting in higher seed and stover yield. The yield loss study also shows that reduced weed population initially by pre-emergence herbicide followed by weed control around 25 to 30 DAS either by post emergence herbicide or hand weeding and hand hoeing have less reduction in yield. This result indicated that appreciable increase in seed yield and decrease total dry weight of weeds were recorded under these treatments are also responsible for better seed and stover yield of green gram. These findings are accordance with the finding those of Chhodavadia *et al*. (2014). Based on results of the field experimentation, it seems quite logical to conclude that profitable, potential production and effective weed control in green gram can be achieved by hand hoeing at 20 and 30 DAS during crop growth period. Whereas labours are not easily available, another alternative is application of pendi methalin 1.0 kg ha^{-1} PE was also equally effective for profitable green gram production.

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ROLE OF AUXIN AND DATES OF PLANTING ON GROWTH OF CUTTING RAISED PLANTLETS OF PHALSA (*GREWIA ASIATICA* L.)

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ABSTRACT
The results of the present investigation which was conducted under irrigated conditions at Research Farm, Division of Fruit Science, Faculty of Agriculture, Udheywalla, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu with the objective to find out optimum concentration of growth regulators and suitable planting time for the Phalsa (*Grewia asiatica* L.) by the means of vegetative propagation through cuttings revealed that phalsa cuttings treated with IBA 300 ppm and planted on 30th July showed highest growth and shoot development characters. Per cent survival (63.66 %) was highest in cuttings planted on 30 thy July, while mean number of leaves (18.74), leaf area (3.76 cm^2) and chlorophyll content (39.76%) were found to be highest when the cuttings were treated with IBA 300 ppm. Also, fresh and dry weight per leaf (3.59 g and 2.68 g, respectively) and partitioning coefficient of leaves (20.98%) showed its superiority when the planting was done on 30th July indicating the most appropriate time for obtaining maximum success from phalsa cuttings.

INTRODUCTION

Reproduction of fruit tree species by shoot cutting is very useful for multiplication of species and for developing true to type plants. Due to high medicinal value and economic importance of phalsa, its cultivation could not only play a major role to uplift the socio-economic status of people, its propagation via stem cuttings would also help in the conservation of this rare and endangered species. Over the years, in agriculture, horticulture and forestry for multiplying elite plants selected from natural populations vegetative propagation is extensively used (Hartmann *et al*., 1990). Vegetative propagation via stem cuttings offers true-to-type plants and availability of superior individuals in a short period of time for large scale commercial plantation. In vegetative propa-gation, the formation of adventitious roots is an essential step and its absence leads to losses (de Klerk *et al*., 1999). Although, phalsa cuttings can strike roots, but rooting is not much appreciable and successful. Hence, growth regulators like auxins are to be used to improve its rooting ability. There exists a lot of contradiction with regard to optimum concentration and period of auxin treatment. The work done on this aspect is very limited in India. Keeping these points in view the present study was conducted to find out the optimum concentration of growth regulators and suitable planting season for rapid multiplication of phalsa cuttings.

MATERIALS AND METHODS

Experiment was conducted under irrigated conditions at Research Farm, Division of Fruit Science, Faculty of Agriculture, Udheywalla, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during 2013-14. The experimental field is situated at an elevation of 300 m above mean sea level and lies at 32° 43" North latitude and 74°54" East longitude. The texture of experimental soil was sandy loam soil with pH of 7.5. The available soil nitrogen, phosphorous and potassium were 237.21, 16.23 and 153.25 kg/ha, respectively with 0.46% organic carbon. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications. The treatments included application of plant growth regulators –Naphthalene acetic acid (NAA) and Indole butyric acid (IBA) in six different concentrations viz: T_1: IBA 150 ppm, T_2: IBA 300 ppm , T_3: IBA 450 ppm , T_4: NAA 150 ppm, T_5: NAA 300 ppm T_6: NAA 450 ppm and T_7: Control along with different dates of planting *viz*., D_1: 15th July, 2013, D_2: 30th July, 2013, D_3: 15th August, 2013 and D_4: 30th August, 2013. Hardwood cuttings of phalsa were collected from ten years old, uniformly growing phalsa plants. From the selected branches, 20 cm long cuttings having 4 to 5 nodes with diameter of 1.0-1.2 cm were taken. Stock solutions of 150, 300, and 450 ppm each of IBA and NAA were prepared separately by dissolving 150, 300, and 450 mg of each chemical in 1000 ml water for respective stock solutions (Padma *et al*., 2015). The basal 1.5-2.0 cm portion of the cuttings was dipped in growth regulator formulation of different concentrations for 24 hours. Cuttings were treated with bavistin (0.2%) to prevent fungal infection and immediately planted at an angle of 45° in well pulverized field bed at a depth of 4.5-5.0 cm. During the entire course of study, all the phalsa cuttings were given uniform cultural operations. The experimental results were statistically analysed as per the methods outlined by Panse and Sukhatme (2000) by adopting Fishers analysis of

variance techniques. The data related to survival percentage and rooting percentage were transformed into square root transformation before analysis (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

Growth Parameters

The data on the effect of plant growth regulators and planting dates on different growth attributes *viz*., per cent survival, number of days taken to sprout, number of leaves, total leaf area (cm^2) and chlorophyll content (%) are given in Table 1. Significant differences in all the growth parameters were recorded due to different planting dates, 30th July planting showed maximum mean survival percentage (63.66 per cent), number of days taken to sprout (15.65 days). Earliness in sprouting, due to timely planting, the increase in number of sprouts and sprout length may be due to better utilization of stored carbohydrates, nitrogen and other factors with the help of growth regulators (Sinha *et al*., 2014). Phalsa cuttings treated with IBA 300 ppm showed 58.17 per cent mean survival of the cuttings, whereas the lowest mean survival of cuttings (40.54 per cent) was observed under control. Cuttings treated with IBA 300 ppm took minimum numbers of days to sprout (16.08 days). Ram *et al*. (2005) also reported that hardwood cuttings of pomegranate treated with IBA and PHB showed significantly higher percentage of survival as compared to control.

The maximum mean number of leaves per cutting (15.29) and total leaf area of 3.68 cm^2 were recorded in phalsa cuttings planted on 30th July. Similar results were observed by (Chandramouli, 2001) who reported that plant growth regulator treatments increase number of leaves per cutting in *Bursera penicilliata*. The number of green leaves is most important growth character that has direct impact on total leaf area. Since, number of green leaf was significantly influenced by variation in dosages of plant growth regulators and consequently the total leaf area also showed variation. As far as use plant growth regulator, maximum mean number of leaves per cutting was recorded in phalsa cuttings treated with IBA 300 ppm (18.74) also total leaf area of 3.76 cm^2 was recorded under same treatment. Similar findings has been reported by Kepinski and Leyser (2005) who found that increase in number of leaves

Table 1: Effect of plant growth regulators and planting dates on growth characters of phalsa cv. Purple Round

Treatment Details	Per cent Survival	Number of days taken to sprout	Mean number of leaves	Total leaf area (cm^2)	Chlorophyll content (%)
T_1: IBA 150 ppm	51.00 (6.99)*	16.71	14.64	2.98	34.20
T_2: IBA 300 ppm	58.17 (7.44)	16.08	18.74	3.76	39.76
T_3: IBA 450 ppm	45.53 (6.56)	17.90	16.26	3.19	31.41
T_4: NAA 150 ppm	48.88 (7.14)	17.26	12.28	2.90	33.21
T_5: NAA 300 ppm	55.43 (7.67)	16.63	17.15	3.17	38.62
T_6: NAA 450 ppm	43.07 (6.75)	18.40	15.46	3.09	30.10
T_7: Control	40.54 (6.36)	19.46	10.68	2.35	26.61
S.E. ± (m)	0.03	0.16	0.13	0.03	0.30
C.D. $_{(p=0.05)}$	0.09	0.44	0.39	0.09	0.85
15th July, 2013 (D_1)	57.77 (7.67)	16.55	15.13	3.29	35.82
30th July, 2013 (D_2)	63.66 (8.01)	15.65	15.29	3.68	34.79
15th August, 2013 (D_3)	43.79 (6.68)	17.77	14.96	2.66	30.84
30th August, 2013 (D_4)	30.56 (5.58)	20.00	14.74	2.63	32.22
S.E. ± (m)	0.05	0.24	0.21	0.05	0.46
C.D. $_{(p=0.05)}$	0.13	0.68	0.59	0.13	1.30

* Data transformed to "$\times + 1$. Figure in parentheses indicate transformed values

Table 2: Effect of plant growth regulators and planting dates on shoot characters of phalsa cv. Purple Round

Treatment Details	Fresh weight per leaf (g)	Dry weight per leaf (g)	Partitioning coefficient of leaves (%)	Length of longest sprout (cm)	Shoot diameter (mm)
T_1: IBA 150 ppm	3.52	2.18	22.58	13.89	5.85
T_2: IBA 300 ppm	4.65	3.26	25.33	15.13	6.41
T_3: IBA 450 ppm	2.96	2.62	20.39	13.48	6.10
T_4: NAA 150 ppm	3.38	2.52	20.43	13.38	5.77
T_5: NAA 300 ppm	4.48	2.35	20.92	14.66	6.20
T_6: NAA 450 ppm	2.35	2.25	20.80	12.97	5.97
T_7: Control	2.01	1.80	22.71	12.13	5.55
S.E. ± (m)	0.03	0.04	0.42	0.12	0.06
C.D. $_{(p=0.05)}$	0.08	0.11	1.19	0.35	0.16
15th July, 2013 (D_1)	3.31	2.27	21.34	15.06	6.16
30th July, 2013 (D_2)	3.59	2.68	20.98	16.93	6.83
15th August, 2013 (D_3)	3.17	2.49	22.52	12.87	5.79
30th August, 2013 (D_4)	2.99	2.38	22.68	9.79	5.14
S.E. ± (m)	0.04	0.06	0. 63	0.19	0.08
C.D. $_{(p=0.05)}$	0.13	0.17	1.81	0.53	0.24

was due to the auxin treatment which increased development of primary shoots and their number.

Different planting dates significantly affected the mean fresh and dry weight per leaf recording maximum mean fresh weight per leaf (3.65 g) and mean dry weight per leaf (2.59 g) in cuttings planted on 30th July. The environmental factors, bright sunshine hours, air and soil temperatures, rainfall and relative humidity under optimum condition in monsoon (July and August) have improved the regeneration of shoots and increase in leaves number and weight (Geiss *et al*., 2009). The effect of auxins activated shoot growth which might have resulted in elongation of stems and leaves through cell division accounting in higher mass as a result of which treatment of cuttings with IBA 300 ppm recorded maximum mean fresh and dry weight per leaf of 4.65 g and 3.26 g, respectively. Similar results were also reported by Dadhich *et al*. (2014).

The highest concentration of partitioned photosynthate was recorded in cuttings planted on 30th August (23.65 per cent) which was at par with other planting dates. Among growth regulators treatment, highest partitioning coefficient of 26.33 per cent was recorded in cuttings treated with IBA 300 ppm. IAA inhibits leaf drop and delayed leaf abscission may increase the partitioning of photo assimilate towards the leaves (Taiz and Zeiger, 1998). Highest chlorophyll content in leaves (42.03 per cent) was found in cuttings planted on 15th August. Wong *et al*. (1995) reported that chlorophyll content was found to increase in hormones treated plots as compared to control.

Shoot Parmeters

The data pertaining to fresh weight per leaf (g), dry weight per leaf (g), partitioning coefficient of leaves (%), length of longest sprout (cm) and shoot diameter (mm) shown in Table 2 revealed that the length of longest sprout per cutting was markedly influenced by plant growth regulators and planting dates. Cuttings planted on 30th July recorded maximum mean longest sprout per cutting (16.93 cm) and treatment of cuttings with IBA 300 ppm recorded maximum mean length of sprout per cutting (15.13 cm) The differences in shoot length may be due to better growth of grafts during July which can be correlated to higher cell activity and early sprouting which are responsible for higher number of leaves and shoot length, thus synthesize more food material and photosynthates hence increased the height of scion shoot.

Similar results were obtained by Mellerowicz *et al*. (2001) as they postulated that the application of the hormones have shown to affect cell division in the vascular cambium, cell expansion and control of differentiation into different types of cambial results in success as well as extension of growth of shoots in the woody dicot stem. Maximum mean shoot diameter (6.83 mm) was recorded under 30th July planting which was significantly higher as compared to other planting dates, treatment of cuttings with IBA 300 ppm resulted in maximum mean shoot diameter (6.41 mm), which was also significantly higher as compared to all other plant growth regulator treatments. The timely planting of cuttings resulted in better root establishment leading to higher number of leaves which in turn gathered more biomass in shoot Singh *et al*. (2003).The results emanating during the present investigation concluded that phalsa cuttings treated with IBA 300 ppm and planted on 30th July showed maximum growth and shoot development characters for establishment of phalsa plants in the field and their commercial propagation.

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EFFECT OF SPACING AND NITROGEN ON FLORAL AND VASE LIFE PARAMETER OF GLADIOLUS (*GLADIOLUS GRANDIFLORUS* L.) CV. AMERICAN BEAUTY

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ABSTRACT
An experiment conducted on effect of spacing and nitrogen on floral and vase life parameter of gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty. The treatments comprised of three levels of spacing (40 x 15 cm, 40 x 20 cm and 40 x 25 cm) and four levels of nitrogen (150, 200, 250 and 300 kg ha^{-1}) in a randomized block design with factorial concept and replicated thrice. The results revealed that wider spacing 40 x 25 cm and fertilized with 250 kg N ha^{-1} recorded best spike quality and maximum post- harvest life of gladiolus spike characters *viz*., number of florets per spike, spike fresh weight (g), floret diameter (cm), rachis length (cm), flowering span (days), *in-situ* spike longevity (days) and vase life (days).

INTRODUCTION

Gladiolus grandiflorus, generally called "sword lily" due to foliage shape belong to family Iridaceae and originated from South Africa, is a prominent bulbous cut flower plant. (Sharma *et al.,* 2013). Gladiolus is known as queen of the bulbous plants, which is valued for its beautiful flower spikes. Its cultivation is getting popular for its beautiful flowering spikes due to more vase life as a cut-flower. Its magnificent inflorescence with variety of colors and number of pretty florets has made it attractive for diversified use in the garden. It is an important cut-flower in both domestic and international market. Optimum plant spacing is an important practice for providing better light interception, moisture, nutrients which are vital for successful crop production and quality. Plant spacing affects yield, quality of spikes and corms production. Many researchers conducted various experiment related to plant spacing and found that wider spaces can produced higher number of corm and cormels. Whereas, had observed that plant spacing had non-significant effects on spike length, floret size, number of florets $spike^{-1}$ or the size of corms produced. However, number of spikes plus corms and cormels produced $plot^{-1}$ was affected by plant spacing. The best commercial quality of gladiolus was obtained at a planting density of 25 plants m^{-1}. This objective can be achieved through balanced and judicious application of plant nutrients and adopting proper spacing for plant growth.

Nutrient status of the plants can be a pointer to the response of plant to the fertilization and internal content of the nutrients determine the fertilizer requirements. Nitrogen applied as fertilizer is the main source used to meet the N requirements of plant growth. (Polara *et al*., 2014). The nutrients such as nitrogen play a major role in the growth and development of plants. Nitrogen as an essential macro element that improves the chemical and biological properties of soil and thereby stimulates the production of higher yield in plants. It should be emphasized that to increase plant quality and productivity nutrients need to be available from the soil during a plant's growth period. Nitrogen fertilizer is one of the important factors in canopy formation that its deficiency leads to a decrease of photosynthesis. Nitrogen and phosphorous are essential macro elements for growth but potassium has effect on quality parameter.

MATERIALS AND METHODS

The experiment was conducted during winter season of 2014-2015 at the Fruit Research Station, Jambuvadi Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. Which is located at 21° 30' 6.4296'' N latitude and 70° 26' 58.2504'' E longitude and at an altitude of 61 m above mean sea level. The 'Junagadh region' is included in the 'West-Coast-

Kathiawar Peninsula' of Gujarat state and under the South Saurashtra Agro Climatic Zone –VII of Gujarat state. The medium to shallow black soils of this region is classified as Verticustochrepts. Soil properties of the experimental field are EC- 0.20 dSm^{-1} pH-7.85, available N- 237.8 kg^{-1}, P- 30.30, 237.8 kg^{-1}, K- 284 $kg^{-1}$and The experiment was conducted in a factorial randomized block design involving three levels of spacing *i.e.* S_1 (40 x 15 cm), S_2 (40 x 20 cm) and S_3 (40 x 25 cm) and four levels of nitrogen doses *viz*. N_1 (150 kg ha^{-1}) N_2 (200 kg ha^{-1}), N_3 (250 kg ha^{-1}) and N_4 (300 kg ha^{-1}). Thus total 12 treatment combinations were included with three replications. Gladiolus corms have uniform size (3.5-4.0 cm) were selected and treated with Bavistin 0.1 percent solution for 20 minutes, a day before planting and allowed to dry overnight under shade.

The half-dose of nitrogen along with full dose of phosphorus and potassium was given in the form of basal dose which was thoroughly mixed in experimental plots before planting. Remaining half-dose of nitrogen applied at 30 days after planting in the form of top dressing. The various observations on floral and vase life parameters were recorded on five plants randomly selected from net plot area and tagged. The data collected for all the characters studied were subjected to statistical analysis by adopting 'Analysis of Variance' (ANOVA) technique for factorial randomized block design as suggested by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Effect of spacing and nitrogen on floral parameter

The data represented (Table 1) on number of florets per spike was significantly influenced by different level of spacing and the maximum number of florets per spike (9.30) was recorded when plant spacing 40 x 25 cm, respectively. While, minimum number florets per spike (7.30) was observed in 40 x 15 cm spacing, respectively. The closest spacing resulted in poorest performance on size and number of florets as reported by Singh and Bijimol, (2003). It might be due to less competition among the plants for nutrient and light and wider spacing specifically required for development of proper number of florets. These results are in agreement with Ahmed *et al*. (2012), in gladiolus, Khalaj *et al*. (2012), Khalaj and Edrisi (2012) in tuberose and Pavagadhi *et al*. (2014) in candytuft.

The application of different level of nitrogen had significant effect on number of florets per spike. The data presented in Table 1 revealed that significantly the highest number of florets per spike (9.36) was recorded in 250 kg N ha^{-1}, respectively which was at par with 200 kg N ha^{-1} and minimum number of florets per spike (7.73) was observed in 150 kg N ha^{-1}. The similar result found that the spray of higher concentration urea produced maximum number of florets per spike in gladiolus. Similar results founded Kumar *et al*. (2003) in China aster, Lehri *et al*. (2011), Singh and Bijimol (2003) and Singh and Bijimol (2000) in gladiolus.

The floret diameter as influenced by different level of spacing. Significantly the maximum floret diameter (9.69 cm) was noticed in 40 x 25 cm spacing. Which was at par with 40 x 20 cm spacing. While, minimum floret diameter (8.22 cm) was observed in 40 x 15 cm spacing. Wider spacing was mainly due to less competition among the plants for nutrient and light. Similar results were also recorded by Ramachandrudu and Tangam (2007), Dogra *et al*. (2012) in gladiolus, Pavagadhi *et al*. (2014) in candytuft, Dhatt and Kumar (2007) in *Coreopsis lanceolata* and Karuppaiah and Krishna (2005) in French marigold.

The diameter of floret was significantly influenced by nitrogen application of different levels. However, highest floret diameter (9.86 cm) was observed when plant treated with 250 kg N ha^{-1} which was found statistically at par with 200 and 300 kg N ha^{-1} and the minimum floret diameter (8.22 cm) was noted in 150 kg N ha^{-1}. The positive role of nitrogen might be due to its effect on the uptake of other nutrient. The application of N enhanced the rate of utilization of P and K by gladiolus plant and K improve the quality of flower. The present findings are in accordance to the earlier observations made by other workers in gladiolus plant. Chanda *et al*. (2000), Singh and Bijimol (2000), Singh and Bijimol (2003) and Verma *et al*. (2012).

Table 1: Effect of spacing and nitrogen on floral parameters in gladiolus cv. 'American Beauty'.

Treatments	Florets per spike	Spike fresh weight (g)	Floret Diameter (cm)	Rachis Length (cm)	Flowering span (days)	*In- situ* spike longevity (days)
Factor - Spacing (S)						
S_1 (40 x 15 cm)	7.30	44.28	8.22	33.03	19.30	10.03
S_2 (40 x 20 cm)	8.65	46.32	8.96	35.28	19.98	11.55
S_3 (40 x 25 cm)	9.30	50.19	9.69	36.92	21.75	12.17
S.Em.±	0.23	1.25	0.26	0.83	0.53	0.30
C.D. at 5%	0.69	3.67	0.76	2.42	1.56	0.87
Factor – Nitrogen (N)						
N_1 (150 Kg ha^{-1})	7.73	44.74	8.22	33.54	19.44	10.33
N_2 (200 Kg ha^{-1})	8.93	47.04	9.12	35.83	20.13	11.69
N_3 (250 Kg ha^{-1})	9.36	50.58	9.86	37.27	22.07	12.24
N_4 (300 Kg ha^{-1})	7.64	45.37	9.05	33.65	19.73	10.73
S.Em.±	0.27	1.45	0.30	0.95	0.62	0.34
C.D. at 5%	0.79	4.24	0.88	2.80	1.80	1.00
Interaction (S x N)						
S.Em.±	0.46	2.5	0.51	1.6	1.06	0.59
C.D. at 5%	NS	NS	NS	NS	NS	NS
C.V. %	9.65	9.24	10.11	8.16	9.07	9.09

Table 1: Effect of spacing and nitrogen on vase life (days) in gladiolus cv. 'American Beauty'

Treatments	Spike vase life (days)
Factor – Spacing (S)	
S_1 (40 x 15 cm)	10.10
S_2 (40 x 20 cm)	11.38
S_3 (40 x 25 cm)	12.13
S.Em.±	0.31
C.D. at 5%	0.90
Factor – Nitrogen (N)	
N_1 (150 Kg ha^{-1})	10.31
N_2 (200 Kg ha^{-1})	11.47
N_3 (250 Kg ha^{-1})	12.20
N_4 (300 Kg ha^{-1})	10.84
S.Em.±	0.35
C.D. at 5%	1.04
Interaction (S x N)	
S.Em.±	0.61
C.D. at 5%	NS
C.V. %	9.49

Although fresh weight of spikes was significantly influenced by different levels of spacing and the maximum fresh weight of spikes (50.19g) was recorded when plant planted with 40 x 25 cm spacing, respectively. While, minimum fresh weight of spikes (44.28g) was observed in 40 x 15 cm spacing, respectively. The production of spikes have more florets and more carbohydrates accumulation in sink may probably be due to less competition between plants for water, mineral nutrient and light. Present finding are in conformity Ramachandrudu and Tangam (2007) in gladiolus, Khalaj *et al*. (2012) in tuberose and Pavagadhi *et al*. (2014) in candytuft.

Moreover, application of different levels of nitrogen had significant effect on fresh weight of spikes. The data presented in Table 1 revealed that significantly the maximum fresh weight of spikes (50.58g) was recorded in 250 kg N ha^{-1}, respectively. Which was statistically at par with 200 kg N ha^{-1} and the minimum fresh weight of spikes (44.74g) was observed in 150 kg N ha^{-1}. This increase in spike fresh weight might be due to greater uptake of nutrients into the plant system which involved in cell division, cell elongation as well as protein synthesis which ultimately enhanced the spike length and more accumulation of carbohydrates in sink from source.

The rachis length as influenced by different level of spacing. Significantly the maximum rachis length (36.92 cm) was noticed in 40 x 25 cm spacing which was statistically at par with 40 x 20 cm spacing. While, the minimum rachis length (33.03 cm) was observed in 40 x 15 cm spacing. This might be due to the fact that the closer spacing hampered intercultural operations and as such more competition arises among the plants for nutrients, air, and light. As a result, plant becomes weaker, thinner and consequently affects the floral parameters. These results are in agreement with the findings of Dogra *et al*. (2012), Bhat *et al*. (2010) and Ahmed *et al*. (2010), Khalaj *et al*. (1999), Singh and Singh (2000) in gladiolus.

It is evident from the data (Table 1) revealed that the rachis length was significantly influenced by nitrogen application of different level. The maximum rachis length (37.27 cm) was observed when plant treated with 250 kg N ha^{-1} which was statistically at par with 200 kg N ha^{-1} and the minimum rachis length (33.54 cm) was noted in 150 kg N ha^{-1}. This increase in rachis length might be due to greater uptake of nutrients into the plant system which involved in cell division, cell elongation as well as protein synthesis which ultimately enhanced the rachis length and quality parameters. The similar results found by Kumar *et al*. (2003) in China aster and Lehri *et al*. (2011) in gladiolus.

The variations in flowering span due to different treatments were found significant. The maximum flowering span (21.75 days) was noted in spacing 40 x 25 cm. While minimum flowering span (19.30 days) observed in spacing 40 x 15 cm. and in case of nitrogen flowering span significantly influenced was noticed when nitrogen applied 250 kg ha^{-1} (22.07 days) and minimum flowering span (19.44 days) was observed in 150 kg N ha^{-1}. Chanda *et al*. (2000) reported that increase the doses of nitrogen resulted delayed the emergence of spike and nitrogen promotes vegetative growth in gladiolus.

In-situ spike longevity was significantly influenced different levels in spacing. Significantly the maximum spike longevity (12.17 days) was obtained in 40 x 25 cm which was statistically at par with spacing at 40 x 20 cm and the minimum spike longevity (10.03 days) was observed in 40 x 15 cm spacing. These results are in agreement with the findings of Singh and Bijimol (2003) observed that the spike harvested from the wider spacing absorbed maximum water during vase life of cut gladioli and the widest spacing recorded highest vase life as compared to closest spacing. Tuberose vase life increased with increasing plant spacing in tuberose Mane *et al*. (2006).

In-situ spike longevity was significant differences observed due to applications of different levels of nitrogen. The maximum spike longevity (12.24 days) was recorded in 250 kg N ha^{-1} which was at par with 200 kg N ha^{-1} and the minimum spike longevity (10.33 days) was observed at 150 kg N ha^{-1}. Singh and Bijimol (2003) observed that the nitrogen is essential constituent of various proteins and take active part in various metabolic processes which might have some role in augmenting the *in-situ* longevity of cut gladioli.

Vase life parameters

The data indicated (Table-2) on spike vase life of spike was significantly influenced by different levels of spacing. Significantly the maximum spike vase life (12.13 days) was obtained in 40 x 25 cm and the minimum spike vase life (10.10 days) was observed in 40 x 15 cm spacing, which was statistically at par with 40 x 20 cm spacing.

This positive response of wider spacing resulted more vegetative growth and quality cut spike production might be due to availability of more area per plant for absorption of nutrients and moisture, no shading effect which ultimate increased the rate of net photosynthesis and translocation of assimilates to the storage organs. The carbohydrate reserves in the flower and spike probably maintains pool of dry matter and repairable substance, especially in petals, thus promoting respiration and extending longevity in gladiolus. These results are in agreement with the findings of Singh and Bijimol (2003) observed that the spike harvested from the wider spacing absorbed maximum water during vase life of cut gladioli and the widest spacing recorded highest vase life as compared to closest spacing. Tuberose vase life increased with increasing

plant spacing in tuberose Mane *et al*. (2006).

Significantly the maximum spike vase life (12.20 days) was recorded 250 kg N ha^{-1} which was statistically at par with 200 kg N ha^{-1} and the minimum spike vase life (10.31 days) was observed at 150 kg N ha^{-1} respectively. The maximum spike vase life there were significant differences observed due to applications of different level of nitrogen Singh and Bijimol (2003) observed that the nitrogen is essential constituent of various proteins and take active part in various metabolic processes which might have some role in augmenting the vase life of cut gladioli.

Interaction effect

The interaction effect for floral and spike vase life parameters were found non-significant.

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STUDIES ON FLORAL BIOLOGY AND BREEDING BEHAVIOUR OF SWEET ORANGE [*CITRUS SINENSIS* (L.) OSBECK.]

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ABSTRACT
In sweet orange flowering takes place only once in year *i.e.* February–March under North Indian conditions. The duration of floral bud development was 19-23 days in different cultivars and Jaffa was earliest to start flowering. The duration of flowering was 20-23 days in the cultivars. These cultivars came to full bloom in first week of March. Two type of inflorescence were observed *i.e.* leafy and leafless. The flowers were born on current season's growth in the axils of leaves either solitary or in cymes. Flower structure observed in sweet orange with five sepals, five petals and twenty stamens with superior ovary. The maximum opening of flowers and dehiscence of anthers took place in morning hours (10.00 A.M. to 12.00 noon) in all the cultivars. Stigma became receptive just after anthesis and remained receptive till 72 hours for pollination in all the cultivars. The maximum receptivity was recorded on the day of anthesis. The highest fruit set was recorded in cultivar Jaffa under open pollination (32.84%) followed by self-pollination (29.81%). From the results obtained, it showed that sweet orange cv. Jaffa followed by Pineapple proved to be best with respect to flowering and fruit set.

INTRODUCTION

Citrus is a commercially important fruit crop of India and grown across country with a production of 7.46 million tons from an area of 0.84 million hectares (Mistry *et al.,* 2012). Sweet orange has been reported to be originated in Southern China and, it was introduced to India during thirteenth century (Swingle, 1943; Webber, 1948). It is the second largest citrus fruit, cultivated in tropical and subtropical regions of the country. In India sweet orange is mainly cultivated in Andhra Pradesh, Maharashtra, Karnataka, Punjab, Rajasthan and Haryana on 0.15 million ha with a production of 1.31 million tonnes. Andhra Pradesh is the leading sweet orange producing state sharing 49 per cent of total production (Mistry *et al.,* 2012).

The intensity of flowering is influenced greatly by the period of growth cessation, and the amount of preceding bloom or crop. In North Indian conditions, where the temperature goes down substantially during winter months, major bloom of almost all citrus species occurs during early spring (February-March) when the atmospheric temperature starts rising after the cold winter and soil moisture conditions are suitable (Hayes, 1970). In South India, where there is no well-defined winter, the flowering season is longer and not very distinct. It is very common to get two crops, occasionally three also, in many citrus types grown in South India. The flowering can however, be regulated by withholding soil moisture or through fruit thinning by chemicals and adjustment of fruit harvesting (Naik,1963).

In addition, the knowledge of floral morphology, biology and fruit set are essential pre-requisite for initiating any breeding programme. Besides, such information would also be useful in taxonomical studies (Randhawa *et al.,* 1961). The floral biology in plants is also useful for understanding the mechanism of self-incompatibility and pollen sterility, which have major role in fruit breeding and fruit productivity. Flowering is a key process in citriculture and its evaluation is often difficult due to the canopy structure and field sampling. It also helps to fruit grower in selecting suitable cultivars which have higher yield potential and to adjust cultural operation in relation to flowering and fruiting (Ribeiro *et al.,* 2008).Although some data are available regards the floral biology of sweet orange but there is need of these studies in present changing climatic condition and to know the impact and response of fruit trees to these. Thus, with a view to provide up to date information regarding the floral biology of the sweet orange, the present investigations were undertaken to study the floral biology and breeding behavior of sweet orange (*citrus sinensis* (L.) Osbeck.) under Hisar condition.

MATERIALS AND METHODS

The experiment was carried out at the Orchard of Department of Horticulture, CCS Haryana Agricultural University, Hisar during 2013-14 growing season. Observations were recorded on floral bud development, time of flowering, duration of flowering, floral morphology, time of anthesis, dehiscence of anthers, stigma receptivity, and fruit set on four sweet orange cvs. Pineapple, Blood Red, Jaffa and Mosambi and analysis was worked out by Randomized Block Design with four treatment and five replications.

The aspects of floral biology like stages of flower bud development, season and duration of flowering, fruiting habit, floral morphology, sex ratio, anthesis, anther dehiscence, receptivity of stigma and fruit set were studied. For these studies, sufficient number fruiting shoots/inflorescence was selected at random. The observations were recorded from January to May 2013. The flower bud development was studied in seven different stages and average number of days required for completion of each stage was recorded. The dates of opening of first flower bud, till last date of blooming were recorded as season and duration of flowering. The emergence of flower buds/ inflorescence was noted as terminal, axillary or both (mixed) and with or without leaves and type of inflorescence as cymose, pair or solitary. The number of staminate and hermaphrodite flowers was recorded to work out sex ratio. The time of anthesis and anther dehiscence were studied at two-hour intervals commencing from 08.00 AM to 06.00 PM. The receptivity of stigma was studied by visual observation and by artificial pollination of flower at one day before anthesis, on the day of anthesis, one and two days after anthesis respectively and judged by the setting of fruits. To find out mode of pollination studies like fruit set observed by open (natural) pollination and selfing through bagging and percent of fruit setting recorded in both the mode of pollination.The overall significance of difference among the treatments was tested, using critical differences (C.D.) at 5% level of significance. The results were statistically analyzed with the help of a windows based computer package OPSTAT (Sheoran, 2004).

RESULTS AND DISCUSSION

Flower Bud Development

The flower bud development from emergence to bud burst, grouped in to seven different stages, had been described morphologically in Fig. 1.which required 19.8 (Jaffa) to 23.2 (Mosambi) days for its completion (Table 1). The days required for full bud development from the initiation of buds was between 19.8 days in Jaffa which is significantly lower than other cultivars 'Pineapple' and 'Blood Red' are at par with each other (20.8 days) and Mosambi took 23.2 days which is significantly higher than other cultivars. Rajput and Haribabu(1985) reported similar results under north Indian condition in sweet orange.

Stage- I to II

In the first stage buds just emerged, they are in the leaf axil or terminal end and fully covered with calyx. These were roundish, tiny and completely covered by calyx lobes and green in color. The buds at stage-I took 3.4 days in Jaffa to 4.4 days in Pineapple for reaching stage- II

Stage- II to III

The second stage commenced when the calyx lobes were observed to have just separated at the apex and the corolla tube was discernible. These were also roundish. The bud at stage-II took 3.6 days in Jaffa to 5.4 days in Mosambi for reaching stage- III.

Stage- III to IV

In stage-III, buds are conical to roundish in shape and length of corolla tube and calyx cup are almost equal. The bud at stage-III took 4.4 days in Pineapple to 5.2 days in Mosambi for reaching stage- IV.

Stage- IV to V

When the buds were almost half developed, they were considered to be in the fourth stage of development. The length of corolla is almost double the length of calyx. The buds remained in this stage for 3.4 days in Pineapple to 4.4 days in Mosambi.

Stage- V to VI

In stage-V, buds are usually elliptic ovate in shape, length of corolla tube being approximately three time the calyx cup. The buds remained in this stage for 3 days and this was same

Table 1: Flower bud development stages, time and duration of flowering

Cultivars	Number of days required for passing from one stage to the other						Total number of days	Time of flowering		Duration of flowering (days)
	I to II	II to III	III to IV	IV to V	V to VI	VI to VII		Initiation of flowering	End of flowering	
Pineapple	4.4	4.6	4.4	3.4	3	1	20.8	2nd March	22nd March	20.2
Blood Red	4.2	4.2	4.6	3.8	3	1	20.8	7th March	29th March	21.4
Jaffa	3.4	3.6	4.6	4.2	3	1	19.8	28th Feb.	23rd March	23.5
Mosambi	4.2	5.4	5.2	4.4	3	1	23.2	9th March	31st March	21.4
Average	4.0	4.4	4.7	3.9	3	1	21.1	-	-	21.6
SE(m) ±	-	-	-	-	-	-	0.30	-	-	0.38
CD at 5%	-	-	-	-	-	-	0.94			1.21

Table 2: Time of anthesis and dehiscence of anther in sweet orange cultivars (Flowers opened at two hours interval in percentage)

Cultivar	8 AM – 10 AM		10 AM – 12 PM		12 PM– 2 PM		2 PM – 4 PM		4 PM – 6 PM	
	A	D	A	D	A	D	A	D	A	D
Pineapple	11.04	11.91	42.75	43.13	22.09	24.01	12.20	12.43	09.32	6.48
Blood Red	12.73	11.23	41.25	42.76	21.77	25.25	11.91	13.01	09.34	5.64
Jaffa	10.50	13.63	42.97	44.55	21.59	22.76	12.54	12.69	09.98	4.63
Mosambi	11.47	11.95	42.36	42.44	22.51	24.15	12.59	13.69	07.83	5.52

A- Anthesis, D- Dehiscence of anthers

Table 3: Per cent stigma receptivity through visual and fruit set method

Cultivars	Per cent stigma receptivity based on							
	Visual obs. One day before anthesis	% fruit set	Visual obs. On the of day of anthesis	% fruit set	Visual obs. One day after the anthesis	% fruit set	Visual obs. Two days after anthesis	% fruit set
Pineapple	24.4	25.3	77.7	73.7	44.0	31.6	21.1	14.4
Blood Red	24.4	26.8	81.8	76.8	42.5	32.9	22.7	15.5
Jaffa	26.1	26.1	79.2	75.3	40.7	32.5	22.7	15.5
Mosambi	26.8	26.1	80.0	74.0	42.4	30.3	22.4	15.7
Average	25.4	26.1	79.7	74.9	42.4	31.8	22.2	15.3

Table 4: Fruit set under different modes of pollination (%).

Cultivars	Per cent fruit set under	
	Self pollination	Open pollination
Pineapple	26.38(32.58)	29.03(30.88)
Blood Red	25.94(31.11)	26.73(30.59)
Jaffa	29.81(34.94)	32.84(33.07)
Mosambi	26.39(32.34)	28.66(30.90)
SE(m) ±	0.47	0.33
CD at 5%	1.46	1.05

for all the cultivars.

Stage- VI to VII

In stage-VI, buds usually attain their full size and shape and were fully developed. No further elongation of bud took place. A faint suture appeared at the top of corolla tube and ready to open next day. The buds remained in this stage only for one day in all the cultivars.

Stage- VII

In this stage, flowers are fully open. It was interesting to note that number of days required increases from stage one to stage four and then reduced with the advancement of the season in all the cultivars. The development of a flower bud in citrus is greatly influenced by the prevailing temperature. A low temperature induces many buds to grow out and most of these are floral. As the temperature increases time taken by a bud to develop is reduced (Rajpoot and Haribabu, 1985).

Time and Duration of flowering

The initiation of flowering varied from 28th February in Jaffa to 9th March in Mosambi (Table 1) and same trend was observed in full bloom and end of flowering. The total duration of flowering in sweet orange cultivars varied from 20.2 days to 23.5 days. Sweet orange cultivar Jaffa took maximum number of days (23.5) to complete flowering and minimum days were in cv. Pineapple (20.2). The cultivar Pineapple and Blood Red took equal numbers of days *i.e.* 20.8 days for flowering. However, owing to the diversity in climate in India, citrus species are observed to flower in other season also. Under Hisar condition where there are distinct winter and summer seasons, the sweet orange bloom only once in year *i.e.* in spring (February- March) whereas, Sathgudi orange in South India, flowers during December-April and September-December. In Central and Western India, oranges flower three times *i.e.*June,October and February (Sharma and Hare Krishna, 2014). The flowering season is mainly influenced by climatic conditions especially thetemperature level also observed in mango by Singh *et al.* (2014).

Earlier studies of revealed that variations in flowering seasonality based upon environmental factors and genetic makeup of the cultivars (Nebauer *et al.,* 2006). Citrus flowering that it is a complex process and is influenced by number of interacting factors. Low winter temperature is recognized as an important factor, but the flowering response has not been quantified under variable natural conditions. Results shows that buds at apical positions produced more flowers than buds located far from the apex and crop load reduced flowering by an average of 41.5% compared to no crop load and varied cultivar (Valiente and Albrigo, 2004).

Floral biology

In all cultivars, flower buds were found to be mostly arising from the axils of the leaf and sometimes terminal. Two types of inflorescence were observed *viz*. leafy inflorescence and leafless inflorescence. The mean percentage of leafy inflorescence was higher (81.30%) than the leafless inflorescence (18.40%). Number of flowers per inflorescence varied according to the type of inflorescence *i.e*. leafy inflorescence (20.70) or leafless inflorescence (14.08), similarly two types of inflorescence were reported by Xuehu *et al*. (2009) in Tankan (*Citrus tankan* Hayata). Two types of flowers were observed in sweet orange, *viz*. hermaphrodite (complete) and staminate (incomplete). The former had fully developed pistil, stamens, while in the latter only stamens were developed and the pistils were either rudimentary or partially developed. The mean percentage of hermaphrodite flowers was recorded higher (76.98%) than the staminate flowers (22.93%). The calyx is a cup like structure surrounding the base of the petals. It is green in color. The number of sepals is usually five, which are, united (Gamosepalous). The corolla has usually five petals. They are usually white, they are not united (Polypetalous). The number of anthers in sweet orange found mostly 20. The filaments are more or less united at base into groups of four or five and are free at the apex (Polyadelphous). The superior type of ovary was found in all cultivars of sweet orange. Similar results were reported by Rajput and Haribabu (1985) under North Indian conditions.

Time of anthesis and anther dehiscence

All the varieties were in peak period of flowering during March and five trees of each variety were selected for counting the number of flowers opened in day observations started at 8 AM when practically opening of flowers just started and continued till 6 PM, by which time the anthesis for the day was more or less over. Flower was considered to be anthesized when all the petals were fully opened. It is clear from data (Table 2) that the time of anthesis in all sweet orange cultivar is spread from 8 AM to 6 PM with peak anthesis at 10 AM to 12 noon closely followed by 12 noon to 2 PM, similar pattern of anthesis recorded in local malta of sweet orange (Manju and

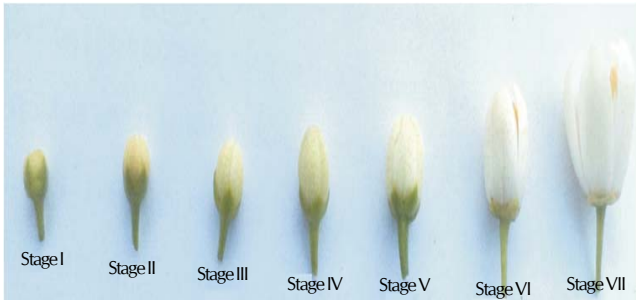

Figure 1: Floral bud development stages in sweet orange cultivars

Rawat, 2010).The rate ofanthesis was retarded during 4 to 6 PM. The dehiscence of anthers started simultaneously with the anthesis. The anthers became pale yellow with powdery mass and a longitudinal slit was formed between the lobes. Mostly in all the cultivars anther dehiscence took place just after anthesis started at 8 AM and continued up to 6 PM. Maximum anther dehiscence (42.44 to 44.55 %) took place between 10 AM to 12 AM. In some citrus varieties, reported the time of anthesis between 9 AM to 12 noon and dehiscence of anthers between 10 to 14hours, thus indicating species and varietal differences in respect of anthesis and anther dehiscence (Rajput and Haribabu, 1985). Similarly,the peak period of dehiscence was observed from 10.00 to 12.00 in *Aloe vera* (Rathod *et al.*, 2014).

Stigma receptivity

Stigma receptivity in Sweet orange cultivars was observed by two methods, which are illustrated in details as follows-

By visual method

on the basis of appearance and color of the stigma appeared to be receptive one day before anthesis and continued up to two day after anthesis. The peak period of anthesis was recorded on the day of anthesis in all the cultivars (Table 3).

By fruit set method

The observation based on actual pollination test showed the similar results like the visual observation (Table 3). All the sweet orange cultivars showed variation in stigma receptivity. The maximum fruit set was obtained when pollination was done on the day of anthesis. The maximum fruit set was obtained when pollination was done on the day of anthesis (73.7 to 76.8%). There after a sharp decline was noticed in the fruit set. Rajput and Haribabu (1985) reported that most receptivity period of stigma was found on the day of anthesis, followed by the day succeeding and preceding the anthesis (Rajput and Haribabu, 1985).

Fruit set (%)

Fruit set was determined by two modes of pollination *i.e.*selfing by bagging and open pollination. In all the sweet orange cultivars higher fruit set was obtained in open pollination than self-pollination. In open pollination, fruit set was recorded maximum (32.84%) in Jaffa and minimum in Blood Red (29.81%), similarly in self-pollination higher fruit set was recorded in Jaffa (26.73%) and low set was in Blood Red (25.94%) (Table 4). It is clear from results that, the percentage of fruit-set was more in open pollination than self-pollination. The observations on fruit set Malta lemon were recorded by RajputandHaribabu(1985) in Delhi condition. They found that fruit set was significantly higher in Malta lemon when the flowers were cross-pollinated. Greater fruit set was observed in the leafy than in the leafless inflorescence, although the variation was not significant (Iqbal and Karacali, 2004).

Values given in parentheses are angular transformed

This suggests a sort of self-incompatibility, which, however, needs further confirmation. Experiment conducted by Saleem *et al*. (2008) shows that Polyamines significantly increased initial fruit set, yield/tree, and production of grade-I fruit. Maximum fruit set (25.89%) was observed on trees sprayed with spermidine followed by spermine (22.73%) and putrescine (15%) compared with control (10.10%).In many commercial citrus species, high fruit load inhibits vegetative growth and floral induction. As a result, trees that had a high fruit load will bear few flowers and fruit the following year, along with abundant vegetative growth and high fruit load impacts the process of flowering (Samach and Smith, 2013).

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EFFECT OF HERBICIDE AND INSECTICIDE COMBINATION AGAINST WEEDS (*CONVOLVULUS ARVENSIS* AND *CELOSIA ARGENTEA*) AND SUCKING PESTS IN SOYBEAN

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ABSTRACT
A field experiment was conducted at Research Farm of IGKV, Raipur during *Kharif* 2013 and 2014 to evaluate the combined effect of herbicide and insecticide against the weed (*Convolvulus arvensis* and *Celosia argentea*),sucking pest (including jassid, aphid and white fly) and yield in soybean. All the herbicidal treatments recorded significantly at par in reducing weed count and weed dry matter. Imazathapyr 10 SL@1.0 l ha^{-1} recorded lowest weed count, weed dry matter and highest weed control efficiency (94.81% and 99.59% in 2013 and 2014 respectively). Rynaxypyre 20 EC @100 ml ha^{-1} recorded lowest pest count (1.18 insect $plant^{-1}$) in 2013 but in 2014, Indoxacarb 14.5 EC @ 300 ml ha^{-1} + Imazathapyr 10 SL @1.0 l ha^{-1} recorded lowest pest incidence (2.12 insect $plant^{-1}$). The highest seed yield (2323 kg ha^{-1}), net income (63655 ¹ /ha) and B:C ratio (3.09) was recorded under Imazathapyr 10 SL@1.0 l ha^{-1} in 2013. Whereas, in 2014, the highest seed yield (2459 kg ha^{-1}) was recorded by indoxacarb 14.5 EC @ 300 ml ha^{-1} + imazathapyr 10 SL @1.0 l ha^{-1} and highest net income (67767 ¹ ha^{-1}) was recorded under indoxacarb 14.5 EC @ 300 ml ha^{-1} + imazathapyr 10 SL @1.0 l ha^{-1} but B : C ratio (3.27) was superior under quinolphos 25 EC @1.5 l ha^{-1} + quizalophop ethyl 5 EC @ 1.0 l ha^{-1}.

INTRODUCTION

Soybean (*Glycine max*) is an important oil seed crop of India with high protein (40-42%) and oil (20-22%).In Chhattisgarh, soybean occupies 0.147 million ha with production of 0.134 million tone and average productivity of 915 kg ha^{-1} (www.sopa.org/REK2014.pdf, 2014).Soybean is very sensitive to early weed infestation. The critical crop weed competition period in soybean was observed at 27 to 40 days after sowing. The uncontrolled weeds at critical period of crop weed competition will reduce the yield of soybean by 58 to 85 per cent depending upon type and intensity of weed infestation (Jha *et al.*, 2014).Of the several factors responsible for poor yield, insect pests infestation is also considered as most important factor. In India, jassid (*Empoasca kerri*), aphid(*Aphis glycines*) and white fly (*Bemisia tabaci*) is considered as major sucking pest with about 20.47 per cent yield loss (Joshi and Patel, 2010).Hand weeding through hoeing is a common practice of weed controlin soybean(Jha *et al.*, 2014), however, due to non-availability of labour or continuous rains often prevents timely weed control. Under such situations, application of herbicides offers an alternate and equally effective method of weed control. Post-emergence herbicides provides the farmers to have a wide choice of application time from 10-30 days after sowing. Fewnewer post-emergence herbicides like imazethapyr, etc are found to control both broadleaved and grassy weed (Meena *et al.*, 2011) and mixed application of these herbicides with insecticide might be effective to weed as well as pest control in soybean crop.In the present study, an attempt was made to evaluate the bio-efficacy of broad spectrum insecticide along with herbicide against soybean weeds and pests.

MATERIALS AND METHODS

A field experiment was conducted to evaluate the efficacy of herbicide and insecticide against weeds and pest of soybean at Instructional cum Research Farm, Indira Gandhi KrishiVishwavidyalaya, Raipur (C.G.) during *kharif* 2013 and 2014. The experiment was laid out in Randomized Block Design (RBD) with four replication and twelve treatments which included rynaxypyre 20 EC @100 ml ha^{-1} ,indoxacarb 14.5 EC @ 300 ml ha^{-1} , quinolphos 25 EC @1.5 l ha^{-1} , imazathapyr 10 SL @1.0 l ha^{-1}, quizalophop ethyl 5 EC @ 1.0 l ha^{-1} as alone and with combination of herbicide and insecticide and Untreated Check. All the treatments were applied at 20 DAS (Day after sowing) as a tank mix at time of spraying. Soybean variety JS-335 was sown with spacing of 30 X 7 cm and seed rate of 65 kg ha^{-1} was used. The weed study in each plot was made at random from two selected spots and for this purpose quadrate (0.25 m^2) was used. Counting of weeds was done according to species and total population of weeds was also worked out and finally oven-dried at 60°C for 48 hours.The weed control efficiency was calculated on the basis of reduction in dry matter production of weeds in treated plots in comparison with weedy check and expressed in percentage

as suggested by (Mani *et al.,* 1973). Observation on sucking pest jassid (*Empoasca kerri*), aphid (*Aphis glycines*) and white fly (*Bemisia tabaci*) were taken by counting the number of pest (nymph/adult) from 3 leaves plant^{-1} (upper, lower and middle leaf) from 10 plants. Yield and yield attributes were recorded at harvest. The economics of soybean crop production pertaining to each of the treatment has been worked out in terms of cost of cultivation. Gross return (Rs. ha^{-1}) was obtained by converting the harvest into monetary terms at the prevailing market rate during the course of studies for every treatment. Net return (Rs. ha^{-1}) was obtained by deducting cost of cultivation from gross return.

The data on number of pests, weeds and weed dry matter were subjected to square root transformation $\sqrt{X + 0.5}$ before statistical analysis.

RESULTS AND DISCUSSION

Effects on pests

Incidence of sucking pest (jassid, aphid and white fly) were significantly reduced by different insecticidal treatments in 2013 but it was increases some extent in 2014 (Table 1). The incidence of pest population were recorded at 15 day after treatment and at flowering stage. The lowest number of pest population (1.18 insect plant^{-1}) was recorded under rynaxypyre 20 EC @100 ml ha^{-1} at 15 day after treatment and at flowering stage it was found non significant pest count during 2013. Whereas, during 2014, quizalophop ethyl 5 EC @ 1.0 l ha^{-1}recorded the lowest pest incidence (1.22 insect plant^{-1}) at 15 day after treatment, this was might be because of naturally unfavorable conditions for pest under this treatment. However at flowering stage, indoxacarb 14.5 EC @ 300 ml ha^{-1} + imazathapyr 10 SL @1.0 l ha^{-1}recorded lowest pest incidence (2.12insect plant^{-1}). The highest pest population was observed under the non insecticidal treatments. Similar trends were also recorded by Gupta (2008) and Joshi and Patel (2010).

Effects on weed

The different herbicidal treatment significantly reduces the weed count and weed dry matter of *Convolvulus arvensis* and *Celosia argentea*as compared to non herbicidal treatments and Untreated Check during both the year of experiment at 30 Day after treatment(Table 2). The lowest weed intensity(0.7 m^{-2}) and dry matter (0.7 g m^{-2}) of *Convolvulus arvensis* was recorded under the different herbicidal treatment of Imazathapyr 10 SL @ 1.0 l ha^{-1} and quizalophop ethyl 5 EC @ 1.0 l ha^{-1}, similar trend was also noticed by Khedkar *et al*. (2009) and Goud *et al*. (2013). However the highest weed intensity (2.12 m^{-2}) was recorded under quinolphos 25 EC @1.5 l ha^{-1} and Untreated Check and dry matter (2.26 g m^{-2}) under Untreated Check which was at par with indoxacarb 14.5 EC @ 300 ml ha^{-1} in first year of experiment whereas in the second year the highest weed intensity (1.51 m^{-2}) and dry matter (1.82 g m^{-2}) was recorded under Untreated Check showing at par result with indoxacarb 14.5 EC @ 300 ml ha^{-1} and quinolphos 25 EC @1.5 l ha^{-1}.

Imazathapyr 10 SL @ 1.0 l ha^{-1} and quizalophop ethyl 5 EC@ 1.0 l ha^{-1} treatments recorded the lowest weed count (0.7 m^{-2}) and weed dry matter (0.7 g m^{-2}) of *Celosia argentea* in both the year of experiment. Similar results were recorded by Kushwah and Vyas, (2005). Whereas the highest weed count and weed biomass were recorded under the non herbicidal treatment.Imazathapyr 10 SL @1.0 l ha^{-1}recorded highest weed control efficiency of 94.81% and 99.59% in 2013 and 2014, respectively. The results are conforming the observations by Khedkar *et al*. (2009)and Kushwah and Vyas, (2005).

Effects on yield

All herbicidal treatment significantly increased the yield and yield component like seed yield, number of pods plant^{-1} and seed index in soybean (Table 3). Number of pods plant^{-1} (61.65 and 72.25 pods plant^{-1} in 2013 and 2014, respectively) was recorded highest under rynaxypyre 20 EC @100 ml ha^{-1} + quizalophop ethyl 5 EC @ 1.0 l ha^{-1} during both the year of experiment. The seed index was found non significant in 2013 but in 2014 it was significantly higher (11.71 g) under rynaxypyre 20 EC @100 ml ha^{-1} + imazathapyr 10 SL @1.0 l ha^{-1}. Imazathapyr 10 SL @1.0 l ha^{-1} recorded highest seed yield (2323 kgha^{-1}) in 2013 but in 2014, indoxacarb 14.5 EC @ 300 ml ha^{-1} + imazathapyr 10 SL @1.0 l ha^{-1} recorded

Table 1: Effect of herbicide and insecticide on sucking pest in soybean

Treatments	Sucking pests (insect plant^{-1})			
	2013		2014	
	15 DAT	At Flowering	15 DAT	At Flowering
Rynaxypyre 20 EC @ 100 ml/ha	1.18(0.90)	0.95(0.40)	1.41(1.50)	2.91(8.00)
Indoxacarb 14.5 EC @ 300 ml/ha	1.76(2.60)	0.95(0.40)	1.50(1.75)	2.91(8.00)
Quinolphos 25 EC @ 1.5 l/ha	1.82(2.80)	0.89(0.30)	1.32(1.25)	2.54(6.00)
Imazathapyr 10 SL @ 1.0 l/ha	1.64(2.20)	1.00(0.50)	1.32(1.25)	3.27(10.25)
Quizalophop ethyl 5 EC @1.5 l/ha	1.82(2.80)	1.00(0.50)	1.22(1.00)	3.27(10.25)
Rynaxypyre 20 EC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	1.76(2.60)	1.00(0.50)	1.32(1.25)	3.08(9.00)
Rynaxypyre 20 EC @ 100 ml/l +Quizalophop ethyl 5 EC @ 1.0 l/ha	1.82(2.80)	0.95(0.40)	1.41(1.50)	2.95(8.25)
Indoxacarb 14.5 EC @ 300 ml/ha +Imazathapyr 10 SL @ 1.0 l/ha	1.84(2.90)	0.95(0.40)	1.58(2.00)	2.12(4.00)
Indoxacarb 14.5 EC @ 300 ml/ha+Quizalophop ethyl 5 EC @ 1.0 l/ha	1.45(1.60)	1.00(0.50)	1.41(1.50)	2.29(4.75)
Quinolphos 25 EC @ 1.5 l/ha +Imazathapyr 10 SL 1.0 l/ha	1.87(3.00)	1.00(0.50)	1.58(2.00)	2.34(5.00)
Quinolphos 25 EC @ 1.5 l/ha +Quizalophop ethyl 5 EC @ 1.0 l/ha	1.73(2.50)	0.95(0.40)	1.50(1.75)	2.50(5.75)
Untreated check	1.76(2.60)	1.10(0.70)	2.00(3.50)	3.12(9.25)
SEm (±)	0.05	0.03	0.04	0.09
CD (P=0.05)	0.16	NS	0.13	0.26

Note:-Figures in the parentheses are original values; data were transformed through $\sqrt{x+0.5}$ which are given in bold,Sucking pest including jassid, aphid and white fly.(DAT = Day after treatment)

Table 2: Effect of herbicide and insecticide on weed count, weed dry matter and WCE in soybean

Treatments	Convolvulus arvensis (No/m²) at 30 DAT		(g m⁻²) at 30 DAT		Celosia argentea (No/m²) at 30 DAT		(g m⁻²) at 30 DAT		Total weed control efficiency (%)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Rynaxypyre 20 EC @ 100 ml/ha	1.58 (2.0)	1.37 (1.4)	1.73(2.50)	1.67 (2.3)	1.22 (1.0)	1.87 (3.0)	3.84(14.26)	2.20 (4.35)	13.74	-4.44
Indoxacarb 14.5 EC @ 300 ml/ha	1.87(3.0)	1.44 (1.6)	2.21(0.23)	1.79 (2.7)	1.58 (2.0)	1.79 (2.7)	3.72 (13.35)	1.95 (3.29)	13.52	-6.44
Quinolphos 25 EC @ 1.5 l/ha	2.12(4.0)	1.48 (1.7)	0.91(0.33)	1.73 (2.5)	2.12(4.0)	1.84 (2.9)	3.77 (13.75)	2.21 (4.41)	0.33	4.07
Imazathapyr 10 SL @ 1.0 l/ha	0.7(0.0)	0.7 (0.0)	0.7(0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0)	0.7(0.0)	94.81	99.59
Quizalophop ethyl 5 EC @1.5 l/ha	0.7(0.0)	0.7 (0.0)	0.7(0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0)	0.7(0.0)	78.58	93.97
Rynaxypyre 20 EC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	0.7(0.0)	0.7 (0.0)	0.7(0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0)	0.7(0.0)	89.79	97.09
Rynaxypyre 20 EC @ 100 ml/l + Quizalophop ethyl 5 EC @ 1.0 l/ha	0.7(0.0)	0.7 (0.0)	0.7(0)	0.7(0.0)	1.58 (2.0)	1.22 (1.0)	2.88(7.79)	0.80 (0.15)	71.40	97.93
Indoxacarb 14.5 EC @ 300 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	1.58(2.0)	0.7 (0.0)	1.73(2.51)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0)	0.7(0.0)	94.11	95.15
Indoxacarb 14.5 EC @ 300 ml/ha + Quizalophop ethyl 5 EC @ 1.0 l/ha	0.7(0.0)	0.7 (0.0)	0.7(0)	0.7(0.0)	0.7(0.0)	1.22 (1.0)	0.7(0)	0.78 (0.11)	81.60	95.15
Quinolphos 25 EC @ 1.5 l/ha + \Imazathapyr 10 SL 1.0 l/ha	0.7(0.0)	0.7 (0.0)	0.7(0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0)	0.7(0.0)	89.58	96.88
Quinolphos 25 EC @ 1.5 l/ha + Quizalophop ethyl 5 EC @ 1.0 l/ha	0.7(0.0)	0.7 (0.0)	0.7(0)	0.7(0.0)	0.7(0.0)	1.22 (1.0)	0.7(0)	0.76 (0.08)	84.57	92.61
Untreated check	2.12(4.0)	1.51 (1.8)	2.26(4.60)	1.82 (2.8)	2.12(4.0)	1.87 (3.0)	3.76(13.62)	2.26 (4.62)	-	-
SEm (±)	0.03	0.03	0.04	0.03	0.04	0.03	0.04	0.04	-	-
CD (P = 0.05)	0.10	0.09	0.11	0.10	0.12	0.10	0.12	0.13	-	-

Note:-Figures in the parentheses are original values; data were transformed through $\sqrt{x+0.5}$ which are given in bold, (DAT = Day after treatment)

Table 3: Effect of herbicide and insecticide on pods number, seed index, seed yield and economics in soybean

Treatments	Pods (No/plant)		Seed index (g/100 seeds)		Seed yield(kg/ha)		Net income (Rs. /ha)		B:C ratio	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Rynaxypyre 20 EC @ 100 ml/ha	45.40	50.00	10.99	10.64	1550	1615	36828	39124	1.88	1.97
Indoxacarb 14.5 EC @ 300 ml/ha	46.93	55.06	10.67	10.67	1513	1594	35785	38502	1.86	1.98
Quinolphos 25 EC @ 1.5 l/ha	47.93	56.41	11.29	10.81	1548	1650	37540	40909	1.99	2.14
Imazathapyr 10 SL @ 1.0 l/ha	61.40	70.16	11.36	11.21	2323	2364	63655	64781	3.09	3.11
Quizalophop ethyl 5 EC @1.5 l/ha	60.83	71.25	11.78	11.61	2201	2412	60026	67019	3.05	3.36
Rynaxypyre 20 EC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	59.68	66.25	11.76	11.71	2205	2281	57938	59997	2.63	2.70
Rynaxypyre 20 EC @ 100 ml/l + Quizalophop ethyl 5 EC @ 1.0 l/ha	61.65	72.25	11.13	11.33	2247	2394	60387	65206	2.86	3.06
Indoxacarb 14.5 EC @ 300 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	58.48	71.50	11.56	11.46	2049	2459	52726	66767	2.44	3.06
Indoxacarb 14.5 EC @ 300 ml/ha + Quizalophop ethyl 5 EC @ 1.0 l/ha	52.53	68.75	11.31	11.34	2030	2304	52833	61713	2.55	2.95
Quinolphos 25 EC @ 1.5 l/ha + Imazathapyr 10 SL 1.0 l/ha	56.45	69.25	11.63	11.42	2254	2447	60524	66794	2.85	3.11
Quinolphos 25 EC @ 1.5 l/ha + Quizalophop ethyl 5 EC @ 1.0 l/ha	55.48	71.75	11.02	11.32	2255	2434	61417	67289	3.02	3.27
Untreated check	36.58	47.56	11.04	10.81	1521	1558	37270	38664	2.08	2.13
SEm (±)	1.42	2.71	0.36	0.22	138	71	-	--	-	
CD (P = 0.05)	3.99	7.6	NS	0.62	381	195	-	--	-	

Note:-Figures in the parentheses are original values; data were transformed through $\sqrt{x+0.5}$ which are given in bold, (DAT = Day after treatment)

highest seed yield (2459 kgha^{-1}),which was found at par with all the herbicidal treatment. The higher seed yield under this treatment were might be due to better efficacy of herbicide at initial stage of crop growth providing weed free environment to the crop. Similar results was also reported byVenkatesha *et al*. (2008), Goud *et al*. (2013)and Sangeetha *et al*. (2013).

Economics

Imazathapyr 10 SL @1.0 l ha^{-1} recorded highest net income (63655 ¹ ha^{-1}) and B : C ratio (3.09)in 2013 but in 2014,highest net income (67767 ¹ ha^{-1})was recorded under indoxacarb 14.5 EC @ 300 ml ha^{-1} + imazathapyr 10 SL @1.0 l ha^{-1} and B: C ratio (3.27)under Quinolphos 25 EC @1.5 l ha^{-1} + Quizalophop ethyl 5 EC @ 1.0 l ha^{-1}(Table 3). Similar results were also found by Amaregouda *et al*. (2013) and Jha *et al*. (2014).

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BIO-CHEMICAL EVALUATION OF MANGO (*MANGIFERA INDICA* L.) CV. KESAR AT DIFFERENT LOCATIONS IN SAURASHTRA REGION (GUJARAT)

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ABSTRACT

The present investigation entitled "Bio-chemical evaluation of mango (*Mangiferaindica*L.) cv. Kesar at Saurashtra region" was carried out at Department of Horticulture and Food Testing Laboratory, College of Agriculture, Junagadh Agricultural University, Junagadh during the year 2013-14. Nine different locations from Saurashtra region were selected for this experiment *viz.*, Una, Mendarda, Bheshan, Junagadh (Sakkarbaug), Talala, Vanthali, Dhari, Aadityana and Ghogha. The harvested sample fruits from different locations were cleaned, ripened at room temperature in paper boxes, than used for further bio-chemical evaluation. The experiment was conducted in Completely Randomized Design.In the experiment,comparatively highest results were found formost of biochemical parameters in fever of treatment L_5 (Talala)*viz.*,total sugar content (117.78 mg/g), non-reducing sugar content(87.33 mg/g), lowest acidity (0.21 %), lowest ascorbic acid content (42.46 mg/100g pulp) Whereas in treatment L_1 (Una) higher reducing sugar content (26.85 mg/g) was found. The myth has been proven to be real from this scientific study. From the conducted experiment over nine different locations, it can be concluded that the Talala is more congenial for mango cv. Kesar or it can be truly say that mango orchards located at/near Talala region produces better quality fruits as compared to others.

INTRODUCTION

The mango (*Mangifera indica* L.) (2n = 2x = 40) is one of the choicest fruit of tropical and sub-tropical region of the world, especially in Asia. Its population and importance can easily be realized by the fact that it is often referred as "King of Fruits in the Tropical World" (Singh, 1960). Mango is popular due to its excellent flavour, delicious taste, delicate fragrance, attractive colour and nutritive value which make at rank among the best fruits of world.

Kesar is the most popular cultivar grown around Gujarat state. Kesar is characterized by its golden color with green overtones. The fruit is slightly smaller compared to the Alphanso variety. The fruits are medium to large sized (250-325 g per fruit), oblong in shape with an attractive light apricot-yellow color. The taste is very good and sugar/acid blend is excellent. The cultivar is free from spongy tissue disorder and malformation. Tree bears excellent quality fruits with saffron coloured pulp when ripe and delicious. Excellent for table purpose fruits, medium sized with fiber-less stone. The 'Kesar' fruit has 18 to 22 percent T.S.S., 0.25 to o.29 per cent acidity and 10.5 to 12.0 per cent total sugars with storability of 15 to 20 days (Singh, 1960 and Chovatia, 1995).

Gir Kesar mango is cultivated in the area of Junagadh district particularly Gir territory including Gir Sanctuary and National park and other adjoining tehsils like Dhari and Khambha of Amreli district near to Gir territory. Junagadh district lies between 20°44′ North to 21°40′ North latitude and 69°40′ East to 71°50′ East longitude. Whereas Amreli district lies between 20°45′ East to 22°25′ East longitude and 70°30′ North to 71°75′ North latitude(*Geographical Indications Journal-2011*).

Ample information on the effect of climatic and soil conditions on quality of mango fruit is available elsewhere. A very little work has been done on the mango crop cv. Kesar in Gujarat in general and in Saurashtra in particular to study the adaptability of mango cv. Kesar into different locations. In view of above a field study on the effect of location on the quality of mango fruits cv. Kesar was under taken during period of May-July of year 2014 (Summer and *Kharif* season) taking nine Kesar mango producing tehsils of Saurashtra as Una, Mendarda, Bheshan, Junagadh, Talala, Vanthali, Dhari, Aadityana and Ghogha.

MATERIALS AND METHODS

An investigation was carried out to find out "Bio-chemical evaluation of mango (*Mangifera indica* L.) cv. Kesar at Saurashtra region". Nine different locations from Saurashtra region were selected for this experiment. The selection of locations was based on popularity at local markets and production pocket of this cultivar. Mango orchards, selected

as locations were ranged from 18 to 26 years. Treatments can be described as: L_1 (Una), L_2 (Mendarda), L_3 (Bheshan), L_4 (Sakkarbaug, Junagadh), L_5 (Talala), L_6 (Vanthali), L_7 (Dhari), L_8 (Aadityana) and L_9(Ghogha). The collected sample of about 10kg fruits from each location were further replicated into three different replications. The statistical analysis was done using Completely Randomized Design, described by Panse and Sukhatme (1967).The biochemicals analyzed were; total sugar (Rangana, 1986), reducing and non-reducing sugar (Sadasivam and Manickam, 1999), TSS (hand refrectometer), acidity (Rangana, 1986), ascorbic acid (Rangana, 1986) and total carotenoids (Sadasivam and Manickam, 1999).

RESULTS

Different climatic conditions and soil conditions have deep impact on development of various biochemical properties of cv. Kesar, they are described as below.

Total sugar

The Table 1 clearly shows that total sugar content (117.78 mg/g) was significantly highest in fruits of treatment L_5 (Talala), which remained at par with treatments L_1 (115.45 mg/g), L_2 (113.17 mg/g) and L_9 (113.10 mg/g). Whereas the lowest total sugar content (102.18 mg/g) was recorded in treatment L_3 (Bheshan).

Reducing sugar

The data (Table 1) indicated the reducing sugar of fruits significantly influenced by different locations. Among the different locations treatment L_1 (Una) had significantly resulted the higher reducing sugar content in ripe fruits (26.85 mg/g). The treatment L_5 (25.85 mg/g) was remained at par with treatment L_1. Whereas treatment L_6 (22.66 mg/g) had recorded lowest reducing sugar content.

Non-reducing sugar

The data on non-reducing sugar are presented in Table 1. Results recorded that significantly the highest non-reducing sugar content was found in treatment L_5 (87.33 mg/g), remained statistically at par with treatment L_2, L_9, L_1 and L_8 having values of 84.86, 84.21, 84.17 and 82.30 mg/g, respectively. Whereas minimum non-reducing sugar content (74.76 mg/g) was noted in treatment L_7.

Total soluble solids

The perusal of data from Table 1 revealed that the highest content of total soluble solids in fruits was recorded in fruits of treatment L_5 with value of 21.75 % which was also found at par with treatment T_1 (20.66 %), whereas lowest total soluble solids (18.26 %) was recorded in treatment L_3.

Acidity

The data regarding acidity content of ripe fruit of Kesar mango are furnished in Table 1. The acidity of ripen fruits significantly affected by different treatments *i.e.* locations of Saurashtra region. The treatments L_1 and L_5 were showed lowest acidity (0.21 %) of fruits, than remained treatments. Whereas highest acidity (0.28 %) was found in treatments L_4 and L_7.

Ascorbic acid content

Significantly the lowest ascorbic acid content (42.46 mg/100g pulp) was registered in treatment L_5 (Talala). Treatments L_1 (43.20 mg/100g pulp), L_6 (43.28 mg/100g pulp) and L_8 (43.77 mg/100g pulp) were remained at par with treatment L_5 for ascorbic acid content. Whereas maximum ascorbic acid content (46.36 mg/100g pulp) was found in fruits of treatment L_7 (Table 1).

Total carotenoids content

The data pertaining to the total carotenoids content are tabulated in Table 1. It clearly indicates that significantly highest total carotenoids content (10.80 mg/100g of pulp) was observed in treatment L_5 (Talala), which was at par with treatment L_1 (10.11 mg/100g of pulp) and the lowest total carotenoids content was found in treatment L_4 (9.24 mg/100g of pulp).

DISCUSSION

The result shown in Table (Table 1) indicates the values for bio-chemical characters of fruit. The significant higher values were obtained for total sugar content (117.78 and 115.45 mg/g), T.S.S. (21.75 and 20.66%) and total carotenoids (10.80 and 10.11 mg/100g of pulp)in treatments L_5 and L_1, respectively. The reducing sugars were significantly higher in treatments L_1 and L_5 in value of 26.85 and 25.85mg/g, whereas significantly a higher non-reducing sugar (87.33 mg/g) was noted in L_5.The lowest significant acidity (0.21 %) was noted in treatments $L_5$and L_1.Significantly the lowest ascorbic acid content (42.46 mg/100g pulp) was recorded in treatment L_5. Whereas Treatments L_1 (43.20 mg/100g pulp), L_6 (43.28 mg/

Table 1: Bio-chemical variation in mango cv. Kesar found at different locations

Treatments	Total sugar (mg/g)	Reducing sugar (mg/g)	Non-reducing sugar (mg/g)	Total soluble solids (%)	Acidity (%)	Ascorbic acid (mg/100g pulp)	Total carotenoids (mg/100g pulp)
L_1	115.45	26.85	84.17	20.66	0.21	43.20	10.11
L_2	113.17	23.84	84.86	19.20	0.23	45.70	9.39
L_3	102.18	23.11	75.11	18.26	0.26	45.67	9.79
L_4	102.36	23.60	74.82	19.12	0.28	46.02	9.24
L_5	117.78	25.85	87.33	21.75	0.21	42.46	10.80
L_6	104.17	22.66	77.43	19.62	0.25	43.28	9.55
L_7	103.01	24.31	74.76	18.56	0.28	46.36	9.29
L_8	109.37	22.73	82.30	19.02	0.23	43.77	9.64
L_9	113.10	24.45	84.21	18.82	0.27	44.17	9.63
S. Em. $\pm$	1.67	0.52	1.76	0.43	0.01	0.84	0.24
C.D. at 5 %	4.95	1.54	5.25	1.28	0.016	2.49	0.73
C.V. %	2.65	3.71	3.8	3.84	3.66	3.26	4.38

100g pulp) and L_8 (43.77 mg/100g pulp) remained at par with treatment L_5.

Thus it can be said that significantly the better quality of ripe fruits were recorded in treatments L_5(Talala) in comparison to other locations.

Effect of climatic conditions on quality of fruits

In the present study, Kesar fruits of Talala were found to be superior with respect to bio-chemical characters as compare to other locations. The comparatively higher maximum temperature was recorded in Talala and Una locations as compare to other locations of present study as well as lower fruit quality was observed at those locations which having relatively lower maximum temperature during the period from flowering to fruit maturity (January to June) (Dudhat, 1997). These findings are in agreement with findings of Dudhat (1997) in mango, Singh (1960) and Mosqueda *et al*. (1993) in mango, Cooper *et al*. (1963) in citrus, Condit (1950) in fig, and Sulladmath and Rao (1979) in sapota.

The effect of temperature for increasing fruit quality may be explained with reason that the metabolism and composition of fruit are affected by temperature and ultimately release of sugars by hydrolysis of starch. Soule and Hatton (1955) put forth theory that, ascorbic acid is respiratory substance and likely to be respired and utilized. The rise in T.S.S. could be due to the accumulation of sugars as a consequence of starch hydrolysis (Leley *et al.,* 1943).

The variations observed in quality of fruit were also due to atmospheric relative humidity. The comparatively lower humidity was noted in Talala and Una locations as compare to other locations of Saurashtra region like Junagadh, Vanthali and Dhariand it was observed that the locations having high relative humidity were lower in quality (Dudhat, 1997). These findings are in close conformity with those obtained by Dudhat (1997) in mango, Singh (1960) in mango, Cooper *et al*. (1963) in citrus fruit and Condit (1950) in Fig.

The unfavourable effect of relative humidity for fruit characters may be due to the reason that when relative humidity is high, ultimately process of photosynthesis decreases, causing adverse effects on starch formation, thereby reduces the growth and development of fruit and also the fruit quality (Pantastico, 1975).

Effect of soil conditions on quality of fruit

The significant variations observed in quality of fruit were due to soil characteristics.

Soil texture has a deep impact on yield and quality on fruit crops. Dudhat (1997) noted lower percentage of total send (17.90 and 19.57%) and significantly higher percentage of silt (47.19 and 38.20%) in soils of Talala and Una localities as compare to other locations.

In the present study, Talala and Una were found with better Kesar fruit quality, because of soil texture of silty clay loam or silty clay as explained by Dudhat (1997). These findings are in confirmation with observations of EL-Tomi (1953), Carlton (1948) and Iyengar (1954) in mango.

The results indicated that variation in quality of fruits was due to variation in soil nutrients content. Dudhat (1997) observed significantly higher levels of available nitrogen, available phosphorus, available potassium, organic carbon, magnesium, and iron content at Talala and Una locations as compare to other locations. Sharma (2013) noted enriched FYMcondition of soil has deep impact on fruit quality parameters *viz.,* total sugar (%), reducing and non-reducing sugar (%) and TSS (%).

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EFFECT OF NPK LEVELS AND BIO-ORGANICS ON YIELD AND NUTRIENT REMOVAL BY BASMATI RICE CV. HUBR 10-9

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ABSTRACT
A field experiment conducted during rainy season of 2014 at Varanasi to study the effect of NPK levels and bio-organics on basmati rice cv. HUBR 10-9. Results revealed that increasing NPK levels up to 100% RDF (120-60-60 kg ha^{-1}) significantly improved yield attributes, grain yield (52.28 q ha^{-1}) and straw yield(78.19 q ha^{-1}) as well as NPK removal by grain (75.52, 19.12 & 17.33 kg ha^{-1}) and straw (53.31, 7.58 & 118.67kg ha^{-1}). Combined application of FYM + BGA + PSB proved significantly superior resulted increase in grain yield (4.70 & 10.62%) and straw yield (5.02 & 10.96%) over FYM + BGA and FYM alone. Variety HUBR 10-9 shown higher grain and straw yield potential due to NPK application @100% RDF (120-60-60 kg ha^{-1}) combined with FYM + BGA + PSB. Hence, study suggests no saving of fertilizer NPK possible even after integration of bio-organics to the earlier recommended NPK dose.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for more than 65 per cent of the people and provides livelihood security to 70 per cent of Indian population (Kulkarni *et al.*, 2015). Presently, rice is grown in an area of 43.9 million hectare with a total production of 106.5 million tonnes and average productivity of 24.24 q ha^{-1} (Anonymous, 2014). By the year 2020, India has to produce 170-180 million tonnes of rice with an average productivity of 40.30 q ha^{-1} to continue with the present level of self- sufficiency (Mishra *et al.*, 2006).

Applying inorganic fertilizers even in balanced amount cannot sustain soil fertility and crop productivity under diversified continuous cropping / mono cropping as a result agriculture is now facing lot of stresses (Kundu *et al.*, 2010). Improvement in nutrient use efficiency and their by stabilizing yield and farmer's income are the issues of prime concern.Such issues may be addressed efficiently by adopting integrated nutrient management which emphasizes judicious use of inorganic and bio-organic sources of nutrients to increase the productivity in a sustainable manner.

Farmyard manure is easily available, cheap, proven source of nutrition and has been traditionally used by farmers. Application of cyano bacterial inoculants could be the cheapest and easiest way to increase rice yield because of their capacity to fix atmospheric nitrogen in wetland rice. Among various organic sources, FYM and use of blue green algae (BGA) in wetland rice are the common practices (Begum *et al.*, 2009). Phosphorus solubilising bacteria (PSB) solubilise the fixed soil phosphorus and increase the efficiency of applied phosphate resulting in higher rice yield (Gull *et al.,* 2004).

Basmati rice cultivation is popular mainly in the 13 districts of North Western Uttar Pradesh and a comprehensive study indicated that non-traditional basmati varieties have higher productivity and profitability thus area under non-traditional basmati rice is increasing. The productivity of non-traditional basmati varieties ranged between 3.5-4.0 tonne ha^{-1} compared to the traditional basmati cultivars which ranged between 2-3 tonne ha^{-1} (Singh *et al.*, 2006). Attempts have been made to develop medium maturity scented (HUR-105, 2009) as well as basmati rice varieties (HUBR 2-1, 2005; HUBR 10-9, 2013) under irrigated conditions with considerably high productivity and wider adaptability to diverse agro-eco regions. The average productivity of the recently released basmati cultivar (HUBR 10-9) is highest among the basmati group (6-6.5 tonne ha^{-1}). Thus, it is hypothesized that to exploit the production potential of new basmati variety there is an urgent need to find out and readjust the integrated nutrient management practice for Varanasi region. The objective of the present study was to compare the effect of NPK levels in conjunction with bio-organics on yield attributes, yield and removal of primary nutrients by basmati rice cv. HUBR 10-9 under eastern Uttar Pradesh conditions.

MATERIALS AND METHODS

The field experiment was carried out during rainy season of

2014 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to compare the effect of NPK levels in conjunction with bio-organics on yield attributes, yield and removal of primary nutrients by basmati rice cv. HUBR 10-9 under eastern Uttar Pradesh conditions. Soil samples (0-15 cm depth) were collected from experimental site and analysed for mechanical and physico-chemical properties. The soil was sandy clay loam in texture, neutral in reaction pH 7.52, low in organic carbon 0.41% (Jackson, 1973), low in available nitrogen 213.07 kg ha^{-1} (Subbiah and Asija, 1956), medium in available phosphorus 25.60 kg ha^{-1} (Olsen *et al*., 1954) and potassium 156.80 kg ha^{-1}(Jackson, 1973). Factorial experiment was laid out in randomized complete block design involving four NPK levels *i.e.* control , 50% RDF , 75% RDF and 100% RDF and three bio-organic sources *viz*. FYM, FYM + BGA and FYM + BGA + PSB with a total of twelve treatment combinations replicated thrice. Recommended dose of fertilizer (RDF) for Varanasi region N-P_2O_5-K_2O (120-60-60 kg ha^{-1}) used to calculate various NPK levels. Half of the nitrogen and full dose of phosphorus and potassium applied basally and the remaining half nitrogen was applied in two equal splits at active tillering and panicle initiation stages as per treatments to their respective plots. Fertilizer sources used for NPK were urea (46% N), di-ammonium phosphate (18% N and 46% P_2O_5) and muriate of potash (60% K_2O). Four week old seedlings of recently recommended Basmati cultivar HUBR 10-9 were transplanted on the puddled field during third week of July keeping two seedlings hill^{-1} at a spacing of 20 cm × 15 cm. Well decomposed FYM was applied uniformly @ 5 tonne ha^{-1} two days prior to transplanting in all the experimental plots. Blue green algae was applied @ 10 kg ha^{-1} 10 days after transplanting in the respective treatments. The liquid PSB culture (*Bacillus polymyxa*) obtained from the Department of Soil Science and Agricultural Chemistry, BHU was used for seedling treatment. Before transplanting, inoculants suspension prepared with water in ratio of 1:10 and seedling roots were dipped in solution for about 30 minutes under shade and transplanted immediately to their respective plots. Throughout the crop period, experimental crop received 757.9 mm rainfall and about ± 5 cm water level was continuously maintained till flowering then after field was kept under saturated condition. Recommended agronomic practices were followed to raise the experimental crop. The N content in grain and straw was analysed by micro Kjeldahl method. Phosphorus was determined by Vanado molybdo phosphoric acid yellow colour method and potassium by Flame photometer (Jackson, 1973). Nutrient removal by grain and straw for individual treatment was calculated by multiplying grain and straw yield with respective nutrient content. The data recorded were analyzed following standard statistical analysis of variance procedure as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Yield attributes and yield

Increasing NPK levels significantly increased panicle length, panicle weight, number of filled spikelets panicle^{-1} and straw yield up to 75% RDF. Further increment in NPK level (100% RDF) though increased the values but remained at par with 75% RDF. Increase in the levels of NPK up to 75% RDF significantly reduced the number of unfilled spikeletspanicle^{-1}. Further increase in NPK level (100 % RDF) though reduced the number of unfilled spikelets panicle^{-1} but could not reach to the level of significance. Highest number of unfilled spikelets panicle^{-1} was noted with the control treatment. Rice grain yield increased significantly with each increment in the NPK level up to the highest level of 100% RDF which registered maximum grain yield (52.28 q ha^{-1}). Continuous supply of nutrients in balanced amount throughout the growth period augmented production of sufficient photosynthates and their effective translocation from source to sink resulted in better yield attributes, grain and straw yield. Similar findings were also reported by Singh *et al*. (2014) and Srivastava *et al*. (2014).

Various bio-organics significantly affected length and weight of panicle, number of filled spikelets panicle^{-1}, number of unfilled spikelets panicle^{-1}, grain and straw yield. The maximum value for these parameters except number of unfilled spikelets

Table 1: Effect of NPK levels and bio-organics on yield attributes and yields of rice

Treatments	Panicle length (cm)	Panicle weight (g)	Number of filled spikelets panicle^{-1}	Number of unfilled spike lets panicle^{-1}	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
NPK levels (% RDF)						
0	21.94	2.57	101.71	32.81	39.67	59.50
50	22.98	2.99	128.64	25.72	47.44	71.17
75	23.72	3.23	138.98	22.64	50.03	76.02
100	24.29	3.36	144.29	21.73	52.28	79.19
SEm±	0.23	0.06	1.98	0.51	0.75	1.13
CD (*P*=0.05)	0.69	0.20	5.83	1.52	2.22	3.32
Bio-organics						
FYM	22.57	2.81	121.02	26.47	44.92	67.72
FYM + BGA	23.21	3.04	129.55	25.70	47.46	71.55
FYM + BGA + PSB	23.91	3.26	134.64	25.00	49.69	75.14
SEm±	0.20	0.05	1.72	0.45	0.65	0.98
CD (*P*=0.05)	0.60	0.17	5.05	1.32	1.92	2.88
Interaction	NS	NS	NS	NS	NS	NS

RDF: N-P_2O_5-K_2O (120-60-60 kg ha^{-1}), FYM (Farmyard manure) @ 5 tonne ha^{-1}, BGA (Blue Green Algae), PSB (Phosphate Solubilising Bacteria)

Table 2: Effect of NPK levels and bio-organics on nutrient removal by rice grain and straw

Treatments	Nitrogen removal (kg ha^{-1})		Phosphorus removal (kg ha^{-1})		Potassium removal (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
NPK levels (% RDF)						
0	44.79	28.35	12.47	3.14	10.55	71.92
50	62.73	42.49	16.75	5.62	14.23	99.10
75	70.33	49.01	18.09	6.86	16.03	111.60
100	75.52	53.31	19.12	7.58	17.33	118.67
SEm±	1.12	1.03	0.28	0.11	0.32	2.00
CD (P=0.05)	3.29	3.03	0.82	0.32	0.95	5.87
Bio-organics						
FYM	58.04	37.92	15.52	5.12	13.33	92.44
FYM + BGA	63.51	43.50	16.65	5.81	14.55	100.50
FYM + BGA + PSB	68.48	48.45	17.65	6.46	15.72	108.03
SEm±	0.97	0.89	0.24	0.09	0.28	1.73
CD (P=0.05)	2.85	2.62	0.71	0.28	0.82	5.09
Interaction	NS	NS	NS	NS	NS	NS

RDF: N-P_2O_5-K_2O (120-60-60 kg ha^{-1}), FYM (Farmyard manure) @ 5 tonne ha^{-1}, BGA (Blue Green Algae), PSB (Phosphate Solubilising Bacteria)

panicle^{-1} was found associated with combined use of FYM + BGA + PSB which was significantly higher than the application of FYM + BGA and sole application of FYM. Combined use of FYM + BGA + PSB also resulted in lowest number of unfilled spikelets panicle^{-1} observed significantly lower than application of FYM alone only but statistically at par with application of FYM + BGA. Application of FYM alone and FYM + BGA observed comparable in respect of unfilled spikelets panicle^{-1}. Yield enhancement due to combined application of FYM + BGA + PSB may not be solely due to balanced nutrient supply, N fixation or phosphate solubilisation, but also because of several other factors such as release of growth promoting substances, control of plant pathogens and proliferation of beneficial organisms in the rhizosphere. Increased values of yield attributes, grain and straw yield may be ascribed to combined application of bio-organics which might enhance soil microbial population resulting better root proliferation, nutrients availability and their uptake, ultimately led to the better dry matter production and its distribution in the crop. The result substantiates the findings of Quyen and Sharma (2003), Singh *et al*. (2013) and Meena *et al*. (2015).

NPK removal

Increasing NPK levels resulted significant increase in NPK removal by grain and straw. Maximum NPK removal by grain and straw was recorded with 100% RDF while the minimum removal was noticed with the control treatment. The increase in the uptake of nutrients with increasing dose of NPK seems because of greater availability of these nutrients and prolific root system developed due to balanced application of nutrients, resulting better absorption of nutrients (Brar *et al*., 1995). Result supports the findings of Murali and Setty (2001) and Srivastava *et al*. (2014). Among bio-organics, combined use of FYM + BGA + PSB removed higher N, P and K by grain and straw. Removal of NPK observed minimum by grain and straw with FYM alone and increased significantly with addition of each bio-organic source (BGA and PSB) and reached to its maximum with use of FYM + BGA + PSB. Farmyard manure helped in the proliferation of BGA and PSB and supplied considerable N and P from its own and also through the process of N fixation and P solubilisation. Hence, increased nutrients availability in soil led to better uptake by crop. Bhat *et al*. (2005) and Kumar *et al*. (2010) also reported similar results.

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INFLUENCE OF VACUUM PACKAGING AND STORAGE TEMPERATURE ON POSTHARVEST SHELF-LIFE AND QUALITY OF MINIMALLY PROCESSED JACKFRUIT BULBS

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ABSTRACT
The study on influence of vacuum packaging in minimally processed jackfruit bulbs of five different clones were carried out with and without vacuum packaging in polypropylene (300 gauge) and stored in refrigeration (3-5^{0}C) and deep freeze (-12^{0}C). There was no detectable total loss in weight (0.18% to 0.45%) in samples under two storage conditions. Vacuum packed samples under deep freeze condition had higher retention of ascorbic acid content of 7.82, 8.37, 8.64, 8.16 and 8.40 mg/100 g for clone1, clone 2, clone 3, clone 4 and clone 5, respectively (ranged from 7.90 to 8.70 mg/100g before packaging) over conventional storage (3-5^{0}C).TSS was found at acceptable levels (ranging from 24.2^{0}B to 27^{0}B)in samples under deep freeze conditions with vacuum packaging after four weeks of storage over samples under refrigerated conventional packaging (TSS of 26.01 ^{0}B to 28^{0}B) atsecond week of storage itself. The rate of decrease in titrable acidity was slower under deep freeze conditionwith vacuum packaging (0.35% to 0.44%). Higher sensory scores were recorded in vacuum packaged samples under deep freeze as they sustained the quality and fresh-like parameters of jackfruit bulbs. Thus deep freeze storage retarded deteriorative changes and enhanced the shelf-life of jackfruit bulbs.

INTRODUCTION

Jackfruit is a nutritious fruit, rich in vitamins A, B and C, potassium, calcium, iron, proteins and carbohydrates. The value of its versatility is enhanced by its availability during the monsoon period, when the supply of other fruits and vegetables is small (Singh, 1986). It is therefore commonly referred to as the poor man's fruit (Samaddar, 1985; Jagtap *et al*., 2010). There are peak seasons during which the fruit mainly rots away in the gardens or in the markets due to its perishable nature. Post-harvest losses of fruits in Indiais reported to be as high as 30% (Verma and Joshi, 2001) with loss of potential income and nourishment. Since the edible fleshy pericarp amounts to only 35% of the whole fruit, which is often prone to flavor loss, tissue softening, cut-surface browning and post-harvest decay (Narasimham, 1990), it is desirable to develop suitable processing and storage protocols for the pitted and pre-cut bulbs. Jackfruit bulbs in pre-cut form can provide convenience for consumers and an appropriatepost-harvest technology for shelf-life extension may facilitate its transportation from production site to remote location.Storage of fresh-cut or minimally processed fruits and vegetables along with low temperature storage conditions have gained rapid popularity due to growing consumer preference towards ready-to eat and quality produce for convenience (Shah and Nath, 2006).

The safety and effectiveness of minimal processing depends on the use of novel preservation technologies (Ohlsson and Bengtsson, 2002).There is need to diversify utilization and reduce losses through appropriate processing into a variety of convenient and relatively shelf-stable and acceptable products like minimally processed jackfruit bulbs.Changing lifestyles dictate the need for food that offers convenience to the consumer in a myriad of ways such as minimizing preparation time while also offering high quality through an extended shelf-life (Blakistone, 1999). As a result, consumers are increasingly demanding convenient, ready-to-use and ready-to-eat fruits with a fresh-like quality, containing only natural ingredients (Lund, 1989; Rocha and Morais, 2007). In response to these needs, one of the most important recent developments in the food industry has been the development of minimal processing technologies designed to limit the impact of processing on the nutritional and sensory quality and to preserve food without the use of synthetic additives. The increasing demand for these minimally processed products represents a challenge for researchers and processers to make them shelf-stable and safe. All food producers and processors have an obligation to produce food that is both safe and of high quality.There is need to reduce losses through appropriate processing into a variety of convenient and relatively shelf-stable and acceptable products like minimally processed jackfruit bulbs. The safety and effectiveness of minimal processing depends on the use of novel preservation technologies (Ohlsson and Bengtsson, 2002).

In view of the above factors, an investigation was undertaken to study the influence of vacuum packaging in enhancing the

post harvest shelf-life and quality of minimally processed jackfruit bulbs of five different clones.

MATERIALS AND METHODS

To study the influence of vacuum packaging on shelf-life and quality of minimally processed jackfruit bulbs, fresh, well matured, uniformly sized and good quality ripened jackfruits from five different elite clones were procured from in and around Doddaballapur taluk, Bangalore Rural District, Karnataka State and used for the study. Bulbs (deseeded) were packed in polypropylene (PP) packages of 300 gauge with and without vacuum packaged with 70% vacuum and stored in refrigeration (3-5ºC) and deep freeze (-12ºC) temperatures for a period of 2 weeks and 4 weeks, respectively. The details of the experimental treatments are as shown below.

Vacuum packaging was done in polypropylene bags of 300 gauge using a laboratory model vacuum packaging machine (Reepack- RV 50, Italy). The bulbs were packed at 70% vacuum and thermally sealed. Observations pertaining to pH, titrable acidity, total soluble solids (TSS), ascorbic acid and sensory evaluation scores were taken at weekly intervals during the course of the storage of the minimally processed and packaged jackfruit bulbs. The procedures followed in taking these observations are detailed below.

Total loss in weight

The total loss in weight of the minimally processed jackfruit bulbs inside the package was determined by weighing on a digital electronic balance DS-450 (Essae-Teraoka Ltd., India) at periodic intervals during the storage period (Mandhare, 2008). The difference in sample weight expressed as percentage, was computed from the first day of storage to the subsequent week.

Ascorbic acid content

The ascorbic acid content of jackfruit bulbs was determined by 2, 6-dichlorophenol indophenol visual titration method.A 2 to 5 g of pulp of minimally processed jackfruit bulbs was taken in a 100 ml volumetric flask and thoroughly mixed with 50 ml of 4 percent oxalic acid. The mixture was filtered through a thin cloth and the filtrate volume made up to 100 ml using 4 percent oxalic acid. A 10 ml of filtered sample and 5 ml of 4% oxalic acid were taken in a conical flask and titrated against the 2, 6 dichlorophenol indophenol dye solution in a burette. The end point was light pink colour that persisted for 5-10 seconds.

$$\text{Ascorbic acid, mg/100g} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Volume taken for titration} \times \text{Weight of pulp sample}} \times 100$$

pH and TSS

Juice extracted from 100 g of sample of minimally processed jackfruit bulbs of each treatment was used to determine the pH and TSS. The pH was estimated using a litmus paper. TSS was assessed with a hand refractometer (Erma Optical Works Ltd., Tokyo, Japan).

Titratable acidity

The titratable acidity of jackfruit bulb samples was determined by the visual titration method. A 10 g sample of pulp was taken in a 100 ml beaker and a little quantity of distilled water was added to it. The mixture was then gently boiled in a water bath for 1 hour with occasional stirring and frequently replacing water which was lost due to evaporation. After cooling, the mixture was transferred to 100 ml volumetric flask and the volume made up with distilled water. This was then filtered through Whatman No. 4 filter paper and the filtrate was used for analysis.A 10 ml of filtrate was taken in a conical flask and titrated against 0.1N NaOH solution in a burette using 1 or 2 drops of phenolphthalein indicator. Formation of pink colour was reckoned at the end point of titration. The titration was repeated till consistent titre values were obtained.

$$\text{Titratable acidity (\%)} = \frac{\text{Titre value} \times \text{N of NaOH} \times \text{Volume made up} \times \text{Equivalent weight of citric acid}}{\text{Aliquot taken for titration} \times \text{weight of sample} \times 1000} \text{ X } 100$$

Sensory Evaluation

The criteria used to judge the appearance were freshness, aroma, flavour, sweetness, bitterness, cut surface browning, discoloration and marketability, etc. The products were scored for appearance, texture and shelf life on a numerical scoring method. The nine point "Hedonic scale" was employed.

Statistical analysis

The experimental data was subjected to analysis of variance (ANOVA) using the SAS system at 5% level of significance.

RESULTS AND DISCUSSION

The results on influence of vacuum packaging in enhancing the post harvest shelf-life and quality of minimally processed jackfruit bulbs of five different clones are presented below.

Total loss in weight

There was no detectable total loss in weight in the samples of all five clones under deep freeze storage and refrigeration storage (Under refrigeration storage temperature, the control samples recorded total loss in weight of 0.37%, 0.30%, 0.18%, 0.45% and 0.20% in PP bags of clone 1, clone 2, clone 3, clone 4 and clone 5, respectively during second week) (Table 1). In contrast to present result, study on litchi storage showed that PLW (Physiological Loss in Weight) of fruits increased with the increase in duration of storage irrespective of treatments (Monica *et al*., 2013). Packaging of products modifies the atmosphere (O_2 and CO_2 levels) inside the package to levels required to alleviate respiratory activity and also maintains a high humidity environment inside the package. As the product tissues are still alive, moisture is lost due to respiration resulting in total loss in weight (Naglaa, 2010).

Ascorbic acid

The rate of decline in ascorbic acid content was slower (non significant difference) under deep freeze storage than under refrigeration storage. The ascorbic acid content of five different clones varied from 7.90 mg/100g (clone 1) to 8.70 mg/100g (clone 3) before packaging. The ascorbic acid content retention under refrigeration storage was 7.75 (clone 1), 8.36 (clone 2), 8.56 (clone 3), 8.05 (clone 4) and 8.25 mg/100 g

Table 1: Influence of vacuum packaging on total loss in weight of minimally processed jackfruit bulbs of five different clones under different storage conditions

Clone	Vacuum %	Total loss in weight (%) Storage period (weeks) Refrigeration storage(3-5°C)			Deep freeze storage(-12°C)				
		0	1	2	0	1	2	3	4
Clone 1	control	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
	70%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clone 2	control	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
	70%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clone 3	control	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00
	70%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clone 4	control	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00
	70%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clone 5	control	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
	70%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S.Em±	-	-	-	-	-	-	-	-	
CD @ 5%		NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Influence of vacuum packaging on the ascorbic acid content (mg/100g) of minimally processed jackfruit bulbs of different clones under different storage conditions

Clone	Vacuum %	Ascorbic acid content (mg/100g) Storage period (weeks) Refrigeration storage (3-5°C)			Deep freeze storage (-12°C)				
		0	1	2	0	1	2	3	4
Clone 1	Control	7.90	7.85	7.75	7.90	7.86	7.78	7.60	7.58
	70%	7.90	7.88	7.80	7.90	7.88	7.86	7.86	7.82
Clone 2	Control	8.50	8.40	8.36	8.50	8.42	8.35	8.30	8.28
	70%	8.50	8.48	8.44	8.50	8.50	8.41	8.38	8.37
Clone 3	Control	8.70	8.61	8.56	8.70	8.63	8.58	8.54	8.50
	70%	8.70	8.68	8.60	8.70	8.69	8.66	8.64	8.64
Clone 4	Control	8.20	8.14	8.05	8.20	8.15	7.92	7.88	7.87
	70%	8.20	8.18	8.14	8.20	8.20	8.18	8.16	8.16
Clone 5	Control	8.50	8.38	8.25	8.50	8.40	8.32	8.28	8.26
	70%	8.50	8.45	8.44	8.50	8.47	8.46	8.42	8.40
S.Em±		-	-	-	-	-	-	-	-
CD @ 5%		NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Influence of vacuum packaging on TSS (°B) of minimally processed jackfruit bulbs of five different clones under different storage conditions

Clone	Vacuum %	TSS (°B) Storage period (weeks) Refrigeration storage (3-5°C)			Deep freeze storage (-12°C)				
		0	1	2	0	1	2	3	4
Clone 1	control	26.20	27.30	28.00	26.20	27.40	28.20	28.36	28.40
	70%	26.20	26.80	27.00	26.20	26.40	26.60	26.70	27.00
Clone 2	control	25.50	26.90	27.20	25.50	26.40	26.50	26.80	26.80
	70%	25.50	25.70	26.10	25.50	25.60	25.80	26.00	26.20
Clone 3	control	25.00	26.60	26.80	25.00	26.70	26.90	27.00	27.20
	70%	25.00	26.10	26.80	25.00	26.30	26.50	26.80	26.80
Clone 4	control	22.50	25.60	26.01	22.50	25.78	25.82	25.91	25.95
	70%	22.50	23.01	24.50	22.50	23.01	23.45	23.50	24.22
Clone 5	control	23.50	26.50	26.58	23.50	26.01	27.12	27.42	27.47
	70%	23.50	25.52	25.63	23.50	25.01	25.22	25.47	25.58
SEm ±	-	-	-	-	-	-	-	-	
CD @5%		NS	NS	NS	NS	NS	NS	NS	NS

(clone 5) during second week under conventional packaging. Under deep freeze condition, ascorbic acid retention was found to be 7.82, 8.37, 8.64, 8.16 and 8.40 mg/100 g for clone1, clone 2, clone 3, clone 4 and clone 5, respectively under vacuum packaging (Table 2). Vitamin C is probably the most unstable vitamin and it is readily oxidized by many non-enzymatic processes. Although frozen storage temperatures between -18 and -28°C result in satisfactory vitamin C retention

Table 4: Influence of vacuum packaging on titratable acidity (%) of minimally processed jackfruit bulbs of five different clones under different storage conditions

Clone no.	Vacuum %	Titratable acidity (%) Storage period (weeks) Refrigeration storage (3-5°c)			Deep freeze storage (-12 °C)				
		0	1	2	0	1	2	3	4
Clone 1	Control	0.52	0.45	0.40	0.52	0.50	0.46	0.40	0.38
	70%	0.52	0.48	0.44	0.52	0.50	0.48	0.48	0.46
Clone 2	Control	0.56	0.48	0.38	0.56	0.53	0.48	0.44	0.40
	70%	0.56	0.54	0.46	0.56	0.52	0.50	0.48	0.44
Clone 3	Control	0.48	0.42	0.35	0.48	0.45	0.42	0.38	0.34
	70%	0.48	0.44	0.36	0.48	0.46	0.44	0.42	0.38
Clone 4	Control	0.58	0.46	0.39	0.58	0.52	0.49	0.42	0.38
	70%	0.58	0.50	0.46	0.58	0.53	0.50	0.47	0.44
Clone 5	Control	0.50	0.40	0.32	0.50	0.47	0.45	0.35	0.32
	70%	0.50	0.44	0.36	0.50	0.48	0.43	0.38	0.35
SEm±	-	-	-	-	-	-	-	-	
CD @ 5%		NS	NS	NS	NS	NS	NS	NS	NS

Table 5: Influence of vacuum packaging on pH of minimally processed jackfruit bulbs of five different clones under different storage conditions

Clone no.	Vacuum %	pH Storage period (weeks) Refrigeration storage (3-5°C)			Deep freeze storage (-12°C)				
		0	1	2	0	1	2	3	4
Clone 1	Control	5.40	5.38	5.53	5.40	5.36	5.46	5.50	5.52
	70%	5.40	4.35	4.60	5.40	4.39	4.56	4.59	4.61
Clone 2	Control	5.30	5.27	5.42	5.30	5.28	5.37	5.40	5.42
	70%	5.30	4.23	4.50	5.30	4.26	4.48	4.49	4.52
Clone 3	Control	5.40	5.36	5.51	5.40	5.34	5.42	5.48	5.50
	70%	5.40	4.37	4.63	5.40	4.39	4.55	4.60	4.61
Clone 4	Control	5.22	5.00	5.28	5.22	5.17	5.28	5.36	5.48
	70%	5.22	4.20	4.49	5.22	4.16	4.38	4.40	4.43
Clone 5	Control	5.80	5.68	5.70	5.80	5.77	5.86	5.88	5.93
	70%	5.80	4.80	4.98	5.80	4.79	4.91	4.93	5.03
SEm±	-	-	-	-	0.020	0.020	0.019	0.019	
CD @ 5%	NS	NS	NS	NS	0.034	0.034	0.034	0.033	

Table 6: Influence of vacuum packaging on the overall acceptability scores of minimally processed jackfruit bulbs of different clones under different storage conditions

Clone no.	Vacuum %	Overall acceptability scores Storage period (weeks) Refrigeration storage (3-5°c)			Deep freeze storage (-12 °C)				
		0	1	2	0	1	2	3	4
Clone 1	Control	9.00	7.70	7.50	9.00	8.80	8.60	8.40	8.30
	70%	9.00	8.50	8.40	9.00	9.00	8.90	8.80	8.70
Clone 2	Control	9.00	7.50	7.30	9.00	8.80	8.60	8.30	8.10
	70%	9.00	8.50	7.90	9.00	8.90	8.80	8.70	8.50
Clone 3	Control	8.80	7.60	7.30	8.80	8.70	8.50	8.30	8.20
	70%	8.80	8.40	8.20	8.80	9.00	8.80	8.70	8.60
Clone 4	Control	8.50	7.60	7.40	8.50	8.80	8.60	8.30	8.10
	70%	8.50	8.50	8.10	8.50	8.90	8.80	8.70	8.50
Clone 5	Control	8.50	8.40	8.20	8.50	8.30	8.50	8.30	7.90
	70%	8.50	8.50	8.40	8.50	8.40	8.70	8.60	8.50
Upper score: 10									

levels in fruits during storage, at temperatures above 10° C, it is easily oxidized and will be drastically reduced in a short period of time (Lozano, 2006). Ascorbic acid has an important role as a phytochemical, due to its functionality as an antioxidant besides its vitamin C activity (Saxena *et al.,* 2008).

Total soluble solids (TSS) and titrable acidity (TA)

The TSS of fresh jackfruit ripe bulbs among five different clones varied from 22.5° B to 26.2° B for clone 4 and clone 1 respectively. The rate of increase in TSS was much slower under vacuum packaging with deep freeze (ranging from

24.22 °B for clone 4 to 27 °B for clone 4) during fourth week of storage than that observed under the conventional packaging technique under refrigeration (ranging from 26.01 °B for clone 4 to 28ºB for clone 4) during second week of storage(Table 3). Samples with vacuum packaging at 70% was credited for the increase in titrable acidity of the samples against the control. At the end of the fourth week of the deep freeze storage, the control samples in PP packaging recorded the titrable acidity values in between 0.32% (clone 5) and 0.40% (clone 2), while the samples with vacuum packaging in PP bags had the values in between 0.35% (clone 5)and 0.44% (clone 2). Under refrigeration, vacuum packaged samples had the values ranging from 0.36% (clone 5) to 0.46% (clone 4 and 2) after two weeks of storage while the control had values in between 0.32% and 0.40% for clone 5 and clone, respectively (Table 4). The rate of decrease in titrable acidity was slower under deep freeze storage, indicating the influence of storage temperature in the ripening process.

The faster the rate of increase in TSS, the faster the ripening process and therefore the senescence. The increase in TSS with the advancement of storage period might be due to conversion of reserved starch and other polysaccharides into soluble form of sugar (Gohlani and Bisen, 2012). Vacuum packaging delayed the occurrence of ripening and as such, senescence in minimally processed jackfruit bulbs. Ripening index (RI), which is the ratio of TSS/acidity was observed to increase in the minimally processed jackfruit bulbs during storage. The increase in RI could be due to the degradation of available starch during storage into simple sugars (Saxena *et al*., 2008) which might be the reason for the decreased acidity and increased sweetness of the minimally processed jackfruit bulbs as observed during sensory evaluation. Lower values of ripening index are preferred as they are indicative of a longer shelf-life and better flavour of the fruit. As the ripening process is influenced by temperature and amount of O_2 in the package headspace, the rate of increase in ripening index was higher under refrigeration storage and conventional packaging technique compared to deep freeze storage temperature and vacuum packaging technique.

pH

The samples with vacuum packaging had significantly ($p < 0.05$) lower pH values than the control samples under both refrigeration and deep freeze storage. During the course of storage, there was an increase in the pH values of the control samples in PP packages. Significant changes in pH was observed among the clones during first to fourth week of storage between packaging in deep freeze condition. No significant ($p < 0.05$) differences were observed among clones between vacuum packaging under refrigeration condition (Table 5). Spoilage of fresh-cut fruits caused by specific moulds and yeasts which utilize organic acids, could have led to further reduced acidity and increased pH (Corbo *et al.,* 2010). This indicated the positive influence of vacuum packaging in controlling the rise in pH of the minimally processed jackfruit bulbs. There were no significant changes in pH among five clones under vacuum packaging.

Sensory evaluation

Samples under vacuum packaging under deep freeze conditions had higher sensory scores compared to samples under conventional packaging techniques as these samples maintained freshness in terms of colour, flavour and appearance (Tables 6). Sensory attributes of pre-cut jackfruit bulbs showed better preference by the judges for the samples kept under vacuum packaging due to better maintenance on colour, flavor and texture compared to conventional packaging.The samples under refrigeration in PP packages (without vacuum) had the lower acceptability scores, which may be the result of anaerobic fermentation (Saxena *et al*., 2008).

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH PARAMETERS OF BIRD OF PARADISE [*STRELITZIA REGINAE* (L.)]

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ABSTRACT
A research to know the effect of Integrated Nutrient Management (INM) on growth parameters of Bird of Paradise [*Strelitzia reginae* (L.)]" was conducted at Horticulture Research Station (HRS), University of Agricultural Sciences, GKVK, Bangalore during 2010-2012. One-year-old Bird-of-Paradise plants were supplied with different combinations of organic and inorganic nutrient sources. Spacing of 1.5m X 1.5m was maintained and laid out in Factorial Randomized Complete Block Design with three replications. Among the growth parameters, significantly highest plant height (117.72 cm), maximum leaf length (36.96cm), leaf width (16.14cm), number of leaves (75.77), number of suckers (13.88) and plant spread (9787 cm^2) were recorded in plants receiving 80 per cent RDF through fertigation plus organic source of nutrients like Vermicompost (300g) along with different biofertilizers such as Azotobacter, PSB and KMB (T_{11}), whereas least observations were recorded (73.93 cm, 29.68cm, 10.94cm, 34.33, 5.22 and 3361.67cm^2 respectively) in plants received 100 per cent RDF as normal fertilizers through soil application (T_1). These results clearly indicate the beneficial effect over the conventional method of nutrition management and also suggest that combined application of inorganic fertilizers, biofertilizers and vermicompost was superior over their individual application for better plant growth and development.

INTRODUCTION

Bird-of-Paradise is indigenous to South Africa and is an evergreen perennial, herbaceous, underexploited cut flower plant, grown in the regions having moderate subtropical climate. The brilliant colours and unusual appearance of the flowers have made it exceptionally popular as cut flower. India has been identified as one of the major forces in the world floriculture scenario. Bird of parasdise are grown commercially in India in places having tropical climate in Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra and Kerala. In Karnataka in and around Bangalore and the entire part of transitional belt seems to be very ideal for cultivation of most of the flowers on account of favourable climate, soil and other factors (UASB, package of practice, 2010). In order to exploit its continuous quality supply and to give some of the improved management practices to the farming community the present study was taken.

Increased flower production, quality of flowers and perfection in the form of plants are the important objectives to be reckoned in commercial flower production. It is impossible to meet the nutrient requirement of the crops, exclusively through the organic farming. In view of the above, there is an increasing awareness about alternative agricultural system in the present decade, known variably as biological/organic/ecological/ regenerative/biodynamic/low external input sustainable agriculture (LEISA) and farmers are showing an inclination to revert back to traditional farming with the least usage of synthetic chemicals (Vanilarasu and Balakrishnamurthy 2014.) Under these circumstances, integrated soil fertility management practices involving judicious combination of organic manures, biofertilizers and chemical fertilizers seems to be a feasible option for sustained Horticulture on a commercial and profitable scale. In addition, they are eco-friendly, easily available and cost effective. Therefore, emphasis is now focused on the use of organic manures such as compost, vermicompost, farm yard manures and biofertilizers like *Azotobacter*, *Azospirillium* and phosphate solubilizing bacteria (PSB), potash mobilising bacteria (KMB). The vermicompost serves as an organic manure, since it is a source of nutrients, such as nitrogen, phosphate, potassium, humic acids and micronutrients. Aryamba (2014) observed that use of organic and inorganic combinations was found to be significantly superior in morphological characters such as plant height, plant spread, number of leaves per plant, number of shoots, flower canopy

height, leaf area, leaf area ratio and leaf area index in Heliconia. Mridubhashini Patanwar *et al.,* (2014) also observed increased vegetative growth parameters in chrysanthemum when

nutrients were supplied in combination with organic and inorganic nutrient sources.

Biofertilizers or more appropriately called 'microbial inoculants' are the preparations containing live or latent cells of efficient strains of microorganisms. These may be biological nitrogen fixers, P-solubilizing, mineralization of nitrogen and transformation of several elements like sulphur and iron into available forms. These biofertilizers benefit agricultural production by supplying nutrients. In line with above advantages, Rajadurai *et al. (*2000) observed increased growth in respect of plant height (144.50 cm) number of leaves (156.20) and laterals per plant (28.30) was observed in pot culture experiments with the application of NPK (45:45:37.5 mg/kg) along with combination of *Azospirillum* and VAM in marigold.

In order to exploit advantages of integrated nutrient management a study was carried out using different organic and inorganic nutrient sources with the objectives to know the influence of organic manures and biofertilizers with graded levels of inorganic fertilizers on growth parameters of *Strelitzia reginae*.

MATERIALS AND METHODS

The experiment was conducted on one-year-old bird-of-paradise plants and was laid out in RCBD design with 12 treatments and 3 replications during 2010-2012 at Horticulture Research Station (HRS), Division of Horticulture, University of Agricultural Sciences, GKVK, Bangalore-560 065. The experimental station is located between the latitude of $12^0.58'$ N and longitude of $77^0.35'$ E at an altitude of 930 meters above MSL. The maximum and minimum temperature of the station during the experiment period was 33.5^0C and 13.6^0C respectively. The plants were planted at the spacing of 1.5m X 1.5m (UASB, package of practice, 2010); from the plot 180 well-developed plants were selected for the experiment. Irrigation was given through drip irrigation system daily for one hour with a discharge of 12 liter per hour depending on soil moisture conditions. In all the treatments the specified percentage of the recommended dose was provided at fortnight intervals. The recommended quantity of nutrients (according to UASB, package of practice, 2010, RDF is 16:11:6 g NPK/ plant/month) were calculated (100%- 18g:30g:12g-MAP:UREA:SOP, 80%- 14.4g:24g:9.6g-MAP:UREA:SOP, 60%- 10.8g:18g:7.2g-MAP:UREA:SOP) and dissolved in the tank containing irrigation water and supplied through ventury system (once in 15 days). Organic sources of nutrients like Biofertilizers (such as *azotobacter*, phosphate solubilizing bacteria (PSB- *Bacillus megaterium*) and potash mobilising bacteria (KMB- *Frateuria aurantia*) @ 2g/plant), Vermicompost (150g, 300g and 450g/plant) and Farm Yard Manure (5kg/ plant) were calculated and applied once in six months in a trench made by digging around the plant in a circular manner, later covered with top soil. Same method of application of biofertilizers were practiced by Chandrikapure *et al*. (1999) in African marigold and Shivalingappa (1998) in tuberose.

The entire plot was kept weed free by hand weeding as and when required. The soil was raked at least once in six months, without disturbing the root system for better aeration. Observations such as Plant height (cm) (bimonthly), Number of leaves per plant (bimonthly), Leaf length (cm) (bimonthly), Leaf width (cm) (bimonthly), Plant Spread (cm^2) (bimonthly) and Number of suckers produced / plant / year were recorded. The above observations were included in confirmation with earlier reports of Siraj Ali (1998), Jainag (2011) in Bird of Paradise.

RESULTS AND DISCUSSION

In general, the growth of Bird of paradise was better when inorganic fertilizers were supplemented with the Vermicompost, FYM and biofertilizers compared to solitary application of either organic manure or biofertilizers along with inorganic fertilizers.

Significantly highest plant height (117.72cm), leaf length (36.96cm) and leaf width (16.14cm) at 16^{th} month after

Table 5: Effect of integrated nutrient management on growth parameters of Bird of paradise (16 MAIT)

Treatments	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Number of leaves	Number of suckers	Plant spread (cm^2)
T_1: 100% RDF (NF, Soil application)	73.93	29.68	10.94	34.33	5.22	3361.67
T_2: 100% RDF (WSF) + Vc (150g)	97.19	35.51	14.59	72.00	11.77	9726.00
T_3: 80% RDF (WSF) + Vc (300g)	83.33	35.78	12.49	40.22	10.22	8825.55
T_4: 60% RDF (WSF) + Vc (450g)	78.55	31.71	11.41	38.11	7.55	5094.00
T_5: 80% RDF (WSF) + Vc (300g) + *Azotobacter*	89.33	33.04	11.80	44.66	9.22	8543.11
T_6: 60% RDF (WSF) + Vc (450g) + *Azotobacter*	80.57	32.93	11.50	43.00	8.11	8217.11
T_7: 80% RDF (WSF) + Vc (300g) + PSB	84.02	34.07	12.01	49.43	10.22	8593.22
T_8: 60% RDF (WSF) + Vc (450g) PSB	81.27	32.57	11.48	42.87	8.89	7980.22
T_9: 80% RDF (WSF) + Vc (300g)+ KMB	97.17	35.16	14.28	68.89	11.89	8923.78
T_{10}: 60% RDF (WSF) + Vc (450g) + KMB	91.31	33.04	11.87	54.11	10.66	8571.55
T_{11}: 80% RDF (WSF) + Vc (300g) + *Azotobacter* +PSB+ KMB	117.72	36.96	16.14	75.77	13.88	9787.11
T_{12}: 60% RDF (WSF) + Vc (450g) + *Azotobacter* +PSB+ KMB	93.89	35.02	12.57	68.78	11.55	9680.00
F-test	*	*	*	*	*	*
S. Em±	1.67	0.30	0.17	0.85	0.26	96.55
CD@5%	4.92	0.89	0.50	2.51	0.75	283.19

* Significant at 5%, NS – Non Significant; MAIT-Months After Imposing the Treatment , Vc- Vermicompost, PSB- Phosphorus Solubalising Bacteria; KMB- Potassium Mobilizing Bacteria, WSF-Water soluble fertilizers, RDF-Recommended Dose of fertilizers

imposing the treatment were recorded in treatment receiving 80 per cent RDF (WSF) + Vc (300g) + Azotobacter + PSB + KMB (T_{11}) followed by (T_2) 100 per cent RDF (WSF) + Vc (150g) (97.19cm, 29.68cm and 10.94cm respectively) at 16th month after treatment imposition) (Table.1). Increased observations in treatment T_{11} might be due to the supplementation of balanced nutrition for crop growth. Combined application of bio fertilizers (*Azatobacter*, *Bacillus megaterium* (PSB) and *Frateuria aurantia* (KMB)), organic manures and water soluble fertilizers through drip irrigation, might have helped in progressive mineralization of nutrients which in turn was available constantly throughout the crop growth. Higher availability of nitrogen favours apical dominance and maintains proper rate of cell division, which inturn leads to increased rate of meristamatic activity resulting in better plant growth parameters. Apart from the role of nitrogen, vermicompost might have helped to increase the plant height, leaf length and leaf width as vermicompost is a rich source of readily available macronutrients and chelated form of micronutrients such as Fe and Zn (Mamta bohra and Ajit Kumar,2014). And also it serves as source of organic matter and food for heterotrophic rhizosphere microflora which inturn enhances the microbial activity, which might have augmented the plant growth. This is in confirmation with earlier reports of Siraj Ali (1998) in Bird of Paradise, Shivalingappa (1998) in tuberose Chandrikapure *et al*. (1999) in African marigold, Jainag (2011) in Bird of Paradise, Ravindra *et al.,* (2013) in China aster and

Different treatments significantly influenced the number of leaves, number of suckers and spread of plant at 16th month after imposition of treatment. Maximum results (75.77, 13.88 and 9787.11cm^2) were recorded in T_{11} throughout the period of crop growth which was on par with T_9 and T_2, while T_1 had least observations (34.33, 5.22 and 3361.67cm^2) on above said growth parameters of plant at 16 month after imposition of treatment. There was increase in plant spread with higher levels of RDF. However, the higher plant spread was recorded in T_{11} with 80 percent recommended dose of fertilizers and further increased and decreased levels of fertigation had no beneficial effects. Similarly the spread was maximum when biofertilizers were applied along with water soluble fertilizers compared to use of biofertilizers alone.

The increased number of suckers per plant may be due to continuous supply and uptake of nutrients with higher moisture content, conversion of non available nutrients to available forms by biofertilizers during different growth stages which stimulate more cell elongation and cell division lead to more number of leaves. Leaves are the main photosynthetic apparatus in plants, synthesizing various metabolites required for plant growth and development. Nitrogen being a constituent of chlorophyll might have increased the leaf area (Sindhu and Gupta, 1993) there by more synthesis of carbohydrates, which are utilized in building up of new cells then finally leads to more sucker production. These results are in agreement with that of Krishna *et al*. (1999) in Carnation and Pansuriya (2015) in gladiolus. Role of KMB is also very important in mineralization of available potassium in soil which in turn helps in easy absorption and helps in forming carbohydrates and translocating the starch resulting in improved plant growth reported by Singh *et al*. (2008) in lilium. Increased plant spread might be due to availability of more nutrients from water soluble form at higher levels of fertigation, improved soil moisture maintenance when irrigated through drip irrigation, use of biofertilizers and vermicompost at different intervals throughout the crop growth period which could have induced plants to produce more number of suckers and which in turn increased wider plant spread. These results are in confirmation with the works of Ravindra *et al.,* (2013) in China aster, Renukaradhya (2006) in carnation and Ranjan and Srivastava and Mansee Govil (2007) in gladiolus.

Results have clearly showed that the application of recommended nitrogen, phosphorous and potassium can be saved when applied through watersoluble form with microbial inoculation of *Azatobacter,* PSB and KMB besides obtaining higher Bird of paradise growth. Therefore, it may be concluded that the use of *Azatobacter,* PSB, KMB and vermicompost along with 80 per cent recommended nitrogen, phosphorous and potassium helped in realizing better plant growth, in the economic production of Bird of paradise [*Strelitzia reginae* (L.)]" under open field condition and also suggest that combined application of inorganic fertilizers, biofertilizers and vermicompost was superior over their individual application for better plant growth and development.

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VARIABILITY STUDIES IN SPROUTING BROCCOLI HYBRIDS (*BRASSICA OLERACEA* L. VAR. *ITALICA* PLENCK) UNDER MID HILLS OF NORTH-WESTREN HIMALAYAS

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ABSTRACT

Significant differences were observed among genotypes in sprouting broccoli suggesting sufficient genetic variability for yield and other yield related characters. The highest estimates of phenotypic coefficient of variation and genotypic coefficient of variation were observed for number of spears per plant (42.85 % and 83.93 %) followed by weight of spears per plant (40.46 % and 35.31 %) and terminal head weight per pant (33.60 % and 31.96 %). High heritability coupled with high genetic advance was observed for characters viz., terminal head weight per plant (90.46 % and 62. 61 %), marketable yield per plant (89.44 % and 56.51 %), number of spears per plant (82.56% and 72.86 %), harvest index (77.03 % and 35.35 %) and weight of spears per plant (76.17 % and 63.50 %). These high estimates suggest substantial variability for the characters thereby ensuring ample scope for improvement of these characters through direct selection. On the basis of genetic divergence, sixteen genotypes were grouped into three clusters. Altar and Indica were found to be the most diverse genotypes and offer promise as a breeding stock to be used in hybridization for obtaining transgressive segregants for further exploitation in broccoli improvement programme.

INTRODUCTION

Broccoli (*Brassica oleracea* L. var. *italica* Plenck) a member of family Brassicacea is one of the nutritious cole crop. It is known for its taste, flavor, nutritive and medicinal properties (Tiwari, 2010). Broccoli and other cole crop like cauliflower contain the compound namely, glucoraphanin, which can be processed into an anti-cancer compound sulphoraphane (Aires *et al*., 2006 and Kushwaha *et al*., 2013). Broccoli is a cool season vegetable and its off season cultivation fetches lucrative remuneration to the growers during summer season in hills when it cannot be grown in plains due to prevailing high temperature. These days broccoli is highly preferred on an account of its nutrition and the crop is being sold at higher prices in comparison to other cole crops *viz*., cabbage, cauliflower, knol-khol, kale and brussel sprouts. Furthermore, hill farmers with small land holdings are benefited with sprouting type of broccoli as two to three harvestings can be taken.The improvement in any crop is proportional to the magnitude of the genetic variability present in the germplasm (Dhankar and Dhankar, 2002 and Yadav *et al*., 2014). Information on the extent of genetic variability available for yield and its component characters along with heritability and genetic advance would be of immense importance to the breeders as the success of selection of any crop improvement programme is determined by these specific genetic parameters. D^2 analysis will help the breeders in grouping of genotypes in different clusters and to identify genotypically diverse and desirable genotypes. High yield, earliness, compact and medium size head with maximum number of lateral heads (spears) are the main criteria which are being taken into consideration for genetic improvement of broccoli. Hence, an attempt was made with specific objectives to examine the genetic parameters of variability to identify major characters for achieving higher yield.

MATERIALS AND METHODS

The present investigation was conducted at the Experimental Farm of the Department of Vegetable Science and Floriculture, CSK HPKV, Palampur, in two environments viz., environment I (*Rabi*, 2010-2011) and environment II (*Rabi*, 2011-2012). The experimental material comprised of 16 genotypes of sprouting broccoli. There were 16 plants in each plot having 4.5 m^2 area planted at 60 cm distance between and 45 cm with in row in a Randomized Complete Block Design, with three replications. Observation were recorded on five randomly selected competitive plants per replication for fourteen characters viz., days to first harvest, marketable yield per plant, terminal head weight per plant, gross weight per plant, number of spears per plant, head size index, plant frame, leaf size with leaf stalk, leaf size without leaf stalk, plant height up to longest leaf, plant height up to head, stalk length, weight of spears per plant and harvest index. The data regarding above mentioned characters were averaged and subjected to analysis of variance (Panse and Sukhatme, 1985). The phenotypic

coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were calculated as per Burton and De Vane (1953). Heritability (broad sense) and genetic advance as per cent of mean were computed by following the methods of Burton and De Vane (1953) and Johnson *et al*. (1955), respectively. To determine the genetic diversity Mahalonobis' D^2 analysis was done and genotypes were grouped in various clusters following Tocher's method as suggested by Rao (1952).

RESULTS AND DISCUSSION

Analysis of variance indicated significant differences among all the genotypes for all characters in environment I and environment II (Table 1). This indicates sufficient genetic variability in the genetic stock under study. Pooled analysis of variance over the environment revealed the presence of g×e interactions for characters namely, days to first harvest, number of spears per plant, leaf size without leaf stalk, weight of spears per and harvest index (Table 2).The presence of g×e interactions has greatly influenced the variation due to genotypes to the extent that genotypic differences recorded in individual environment have vanished for these characters.

The knowledge of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) is helpful in predicting the amount of variation present in the given genetic stock which in turn helps in formulating an efficient breeding programme. The high estimates of phenotypic and genotypic coefficients of variation were observed for number of spears per plant followed by weight of spears per plant and terminal head weight per pant. Similar findings were also reported by Kalia and Shakuntla (2002). Marketable yield per plant recorded higher magnitude of phenotypic coefficient of variation. These high estimates suggest substantial variability for the characters thereby ensuring ample scope for improvement of these characters through selection.

Moderate PCV and GCV were recorded for leaf size without leaf stalk, harvest index, head size index, leaf size with leaf stalk, plant frame, gross weight per plant and plant height up to head. These moderate estimates suggested that direct selection for these characters should be considered cautiously, whereas days to first harvest showed low PCV and GCV suggesting thereby that the genotypes possessed less variability for this character. Similar findings were also reported by Kalia and Shakuntla (2002).

The information on heritability estimates is helpful in studying the inheritance of quantitative characters as well as for planning breeding programmes (Ulaganathan and Nirmalakumari, 2014). High heritability was noticed for terminal head weight per plant followed by marketable yield per plant, number of spears per plant, harvest index, weight of spears per plants, days to first harvest, leaf size with leaf stalk, stalk length and gross weight per plant. These findings are in agreement with Kalia and Shakuntla (2002), Khattra *et al*.,(1997), Kanwar and Korla (2002) and Jindal and Thakur (2004).

High heritability for these characters indicate that large proportion of phenotypic variance is attributed to genotypic variance and therefore, reliable selection could be made for these characters on the basis of phenotypic expression. Moderate heritability was shown by plant frame, plant height

Table 1 : Analysis of variance for different characters of broccoli in environment I (2010-11) and environment II (2011-12)

Sr. No.	Characters	Source	Mean Sum of Squares					
			Replication		Genotypes		Error	
			Environment I	Environment II	Environment I	Environment II	Environment I	Environment II
		d.f.	2		15		30	
1	Days to first harvest		27.9	299.01	158.80*	425.29*	13.23	26.88
2	Marketable yield/plant (g)		159.39	914.02	28177.00*	24685.72*	874.41	1016.73
3	Terminal head weight/plant (g)		370.08	820.89	31661.15*	24453.78*	704.17	941.22
4	Gross weight/plant (g)		10368.75	62659.39	38818.88*	66957.72*	7075.97	9876.19
5	Number of spears/plant		0.23	0.7	14.88*	13.59*	0.28	0.38
6	Head size index (cm^2)		1291.72	2069	3502.73*	3874.38*	908.68	1041.42
7	Plant frame (cm^2)		18396.72	2550174	950545.94*	1002219.17*	213727.3	216443.1
8	Leaf size with leaf stalk (cm^2)		985.86	8621.71	37588.85*	29117.77*	2969.44	4596.57
9	Leaf size without leaf stalk (cm^2)		293.9	15917.26	8535.83*	28594.18*	1340.35	1966.1
10	Plant height up to longest leaf (cm)		78.28	599.99	39.84*	52.70*	11.93	14.43
11	Plant height up to head (cm)		12.41	32.63	46.66*	41.75*	8.69	15.92
12	Stalk length (cm)		0.03	0.02	0.20*	0.15*	0.02	0.02
13	Weight of spears/plant (g)		347.41	260.94	4889.01*	4382.15*	200.34	271.55
14	Harvest index (%)		7.39	16.09	206.65*	123.44*	13.57	11.34

*Significantat p≤0.05

Table 2: Analysis of variance for different characters of broccoli in pooled over the environments

Sr. No.	Characters	Mean Sum of Squares Source	Genotypes	Environments	Genotype × (g×e) Environment	Pooled error
		d.f.	15	1	15	60
1	Days to first harvest		494.95*	743.70*	89.15*	20.05
2	Marketable yield/plant (g)		51660.71*	1971.09	1202.02	945.57
3	Terminal head weight/plant (g)		54682.17*	1759.59	1432.77	822.7
4	Gross weight/plant (g)		94587.86*	240500.26*	11188.74	8476.08
5	Number of spears/plant		25.48*	7.36	3.00*	0.33
6	Head size index (cm^2)		6085.89*	590.19	1291.18	975.05
7	Plant frame (cm^2)		1709313.49*	1847728.22*	243451.6	215085.2
8	Leaf size with leaf stalk(cm^2)		60778.59*	154496.50*	5928.03	3783
9	Leaf size without leaf stalk(cm^2)		22846.53	59946.51	14283.49*	1653.22
10	Plant height up to longest leaf (cm)		74.11*	537.65*	18.43	13.18
11	Plant height up to head (cm)		74.74*	484.38*	13.67	12.95
12	Stalk length (cm)		0.31	0.006	0.37	6.02
13	Weight of spears/plant (g)		8186.72*	6147.20*	1084.43*	235.94
14	Harvest index (%)		308.84*	106.70*	23.25*	12.46

*Significant at $p \leq 0.05$

Table 3: Estimates of different parameters of variability for various characters of broccoli

Sr. No.	Characters	Range	Mean	PCV (%)	GCV (%)	ECV (%)	h^2_{bs} (%)	GA (%)
1	Days to first harvest	93.46-129.00	109.32	9.62	8.01	5.32	69.4	13.76
2	Marketable yield/plant (g)	140.66-541.33	316.76	30.67	29.01	9.96	89.44	56.51
3	Terminal head weight/plant (g)	99.00-525.50	296.11	33.6	31.96	10.38	90.46	62.61
4	Gross weight/plant (g)	680.66-1121.16	858.05	17.23	13.49	10.73	61.26	21.75
5	Number of spears/plant	1.41-9.96	5.2	42.85	38.93	17.89	82.56	72.86
6	Head size index (cm^2)	131.17-257.38	225.56	19.22	12.85	14.28	44.76	17.72
7	Plant frame (cm^2)	2777.66-4837.22	3820.28	17.92	13.03	12.29	52.92	19.53
8	Leaf size with leaf stalk (cm^2)	476.67-798.39	624.19	18.71	15.55	10.39	69.12	26.64
9	Leaf size without leaf stalk (cm^2)	297.10-449.83	367.04	22.67	14.81	17.16	42.67	19.93
10	Plant height up to longest leaf (cm)	44.23-53.61	49.18	10	6.42	7.67	41.22	8.49
11	Plant height up to head (cm)	27.36-42.96	31.56	15.17	10.19	11.24	45.15	14.11
12	Stalk length (cm)	2.10-3.21	2.49	10.89	8.86	6.34	66.11	14.84
13	Weight of spears/plant (g)	20.83-156.66	101.96	40.46	35.31	19.75	76.17	63.5
14	Harvest index (%)	19.54-49.23	35.59	22.41	19.67	10.74	77.03	35.35

Table 4: Clustering pattern of 16 genotypes of broccoli

Cluster Number	Number of genotypes	Genotypes
I	14	Packman, PalamHaritika, CBH-1, BR-60, PalamSamridhi, Pluto, Supreme, BR-70, Green Magic, Kendi, Fiesta, Lucky, Tiltest, Green Beauty
II	1	Altar
III	1	Indica

up to head, head size index, leaf size without leaf stalk and plant height up to longest leaf. The genetic advance expressed as per cent of mean varied from 8.49% to 72.86% for plant height up to longest leaf and number of spears per plant, respectively.

High estimates of genetic advance were observed for number of spears per plant, weight of spears per plant, terminal head weight per plant, marketable yield per plant and harvest index. Moderate genetic advance was recorded by leaf size with leaf stalk, gross weight per plant, leaf size without leaf stalk, plant frame, head size index, stalk length, plant height up to head and days to first harvest, whereas expected genetic advance was found to be low for plant height up to longest leaf.

The estimates of heritability act as a predictive instrument in exercising the reliability of phenotypic values. Therefore, it helps the breeders to make selection for a particular character when heritability is high. The genetic advance is a useful indicator of the progress that can be expected as a result of exercising selection on the pertinent population. Heritability along with genetic advance is more useful than the heritability alone in predicting the resultant effect of selecting best genotype as it suggests the presence of additive gene effects. High heritability associated with high genetic advance were observed for terminal head weight per plant, marketable yield per plant, number of spears per plant, harvest index and weight of spears per plant. This view was also reported by Kalia and Shakuntla (2002). The results indicated that most likely the heritability is due to additive gene effects and direct selection could be effective for these characters. High heritability along

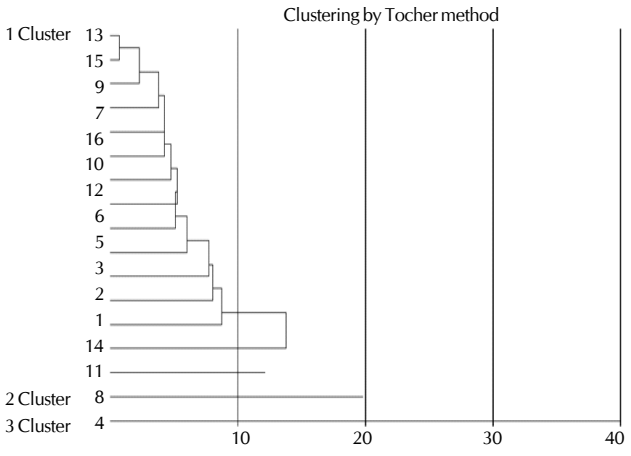

Figure 1: Dendrogram showing grouping of 16 broccoli genotypes generated using D^2 cluster analysis

with moderate genetic advance were observed for days to first harvest, stalk length and leaf size without leaf stalk. The results revealed the presence of additive and non-additive gene action, providing scope for improvement of these characters through hybridization and selection. Similar findings have also been reported by Dhatt and Garg (2008) and Kanwar and Korla (2002). In case of gross weight per plant, plant height up to head, plant frame and head size index moderate heritability was associated with moderate genetic advance. These estimates indicated the role of dominance and epistasis. Moderate heritability along with low genetic advance for plant height up to longest leaf may be attributed to non-additive gene action and epistasis.

The multivariate analysis revealed considerable genetic diversity present in all the genotypes. Sixteen genotypes of broccoli were grouped into three clusters when studied under Tocher's method of D^2 analysis (Table 4). Maximum genotypes were placed in cluster I, which comprised of 14 genotypes with 87.50% contribution and remaining two clusters namely, cluster II and cluster III were monogenotypic *i.e.* containing only one genotype. The cluster pattern revealed that the genotypes of same geographical distribution fall into different clusters which indicated that clustering pattern and geographical distribution were independent of each other. The maximum intra-cluster difference was recorded in cluster I (1.68). The maximum inter-cluster genetic divergence was recorded between cluster II and III (8.96) suggesting wide diversity among genotypes of the two clusters due to different genetic constitution. The results of cluster analysis can contribute directly for development of classification scheme and also for identification of diverse pattern of hybridization. On the basis of dendrogram (Figure 1), it is clear that the genotypes 'Altar' and 'Indica' were most diverse genotypes and offer promise as a breeding stock to be used in hybridization for obtaining transgressive segregants for further exploitation in broccoli improvement programme.

The results indicated the presence of adequate genetic variability within the germplasm evaluated for the improvement of marketable yield and other related characters. The genetic variation observed suggests that a positive response to direct selection is possible for all the characters studied. Multivariate analysis revealed considerable genetic diversity in all the sixteen genotypes studied.

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MORPHOLOGICAL, YIELD AND SOIL QUALITY STUDIES OF FRENCH BEAN (*PHASEOLUS VULGARIS* L.) AS INFLUENCED BY INTEGRATING VARIOUS ORGANIC AND INORGANIC FERTILIZERS

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Vermi compost
Organic
Biofertilizers
Yield

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ABSTRACT
A field experiment was carried out at Research Farm, Faculty of Agriculture, Wadura, SKUAST-Kashmir (J&K) during *Kharif*, 2012 to study the effect of integrated nutrient management on morphology, yield and soil quality of French bean under temperate conditions. The experiment consisted of twelve treatment combinations and was laid out in Randomized Block Design with three replications. The results revealed that the application of 125% RDF recorded highest seed yield (1386.67 kg/ha), plant height (35.98 cm), primary branches (5.20), secondary branches (5.00), leaf area index (2.67), total dry weight (29.40 g), days to 50% flowering (37.5 days) but showed no significant difference with treatment involving substitution of 50% RDF through 25% FYM + 25%VC + biofertilizer (1.5 ton FYM/ha + 0.55 ton VC/ha + 20 g biofertilizer/kg seed). However, maximum available NPK (346.33, 33.83 and 268.25 kg/ha N, P_2O_5 and K_2O, respectively) were recorded with VC (2.2 ton/ha) which was significantly higher than the treatments receiving only inorganic fertilizers. Further, the conjugative use of inorganic fertilizers and organic manure along with biofertilizers improved available NPK in soil as compared to other treatments. Thus, integrated resource management improved crop yield, morphological attributers and the soil fertility.

INTRODUCTION

French bean (*Phaseolus vulgaris*) is non-traditional legume and highly relished pulse crop of North India with a yield potential of 18-20 q/ha. It is an important crop grown both for tender pods and dry seeds, which form the rich source of crude protein (21.25 %), fat (1.7%) and carbohydrates (70%). Besides, it contains 0.16 mg iron, 1.76 mg calcium and 3.43 mg zinc per 100 g of edible part (Kaur and Mehta, 1994). It is a temperate region crop, and is mainly confined to northern foot hills of Jammu and Kashmir, Himachal Pradesh and Utter Pradesh as a *Kharif* crop and in some parts of Maharashtra, Andhra Pradesh, Western and Eastern ghats and Northern eastern plain zone. It is characteristically shy of nitrogen fixation and require larger amount of nitrogen. It is well documented that the higher level of nitrogen application not only seems to be uneconomic, but also endanger the basic production system (Kumar *et al.,* 2006). Further, high use of the chemical fertilizers not only puts a heavy financial burden to the growers but gradually decreases the partial productivity. Excess and imbalanced use of nutrients has caused nutrient mining from the soil, deteriorated crop productivity and ultimately soil health. Replenishment of these nutrients through organics and in combination with organics and inorganics has a direct impact on soil health and crop productivity (Sharma *et al.,* 2013). Organic sources of the plant nutrients have been reported to improve growth, yield attributes, yield and soil fertility status. Inadequate use of the organic manures has rendered Indian soils deficient in macro and micro nutrients (Acharya and Mandal, 2002). In commercial agriculture, the use of chemical fertilizers cannot be ruled out completely. However, there is a need for integrated application from alternate sources to supply nutrients for sustaining the desired crop productivity (Dar *et al.,* 2014). The integration of organic and inorganic sources of plant nutrients has proved superior to individual components with respect to growth, yield and quality of pulses (Ghosh *et al,* 2014; Datt *et al.*, 2013). Keeping this in view, an experiment was carried out to improve yield and soil fertility of French bean with integrated nutrient management under temperate conditions.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* 2012 at Research Farm of the Department of Agronomy, Faculty of Agriculture, Wadura, Sopore, SKUAST-Kashmir located at 34º 172 N and 72º332 E at an altitude of 1524 m above MSL, to study the effect of integrated nutrient management on morphology, yield and soil fertility of French bean. The soil (0-15 cm) of experimental site was well drained silty clay loam in texture with pH 7.4, high in organic carbon (0.86%), medium in available N (317.4 kg/ha), available P (19.2 kg/ha) and available K (248.5 kg/ha). The experiment was laid out in

a randomized block design having 12 treatments (Table 1), comprising different combinations of inorganic fertilizers, organic manure and biofertilizers *viz*, 75% RDF (T_2), 100% RDF (T_3), 125% RDF (T_4), FYM (T_5), VC (T_6), Bio-fertilizer viz., *Rh* + PSB (T_7), 50% FYM + 50% VC + Bio-fertilizer (T_8), 50% RDF + 50% FYM (T_9), 50% RDF + 50% VC (T_{10}), 50% RDF + Bio-fertilizers (T_{11}), 50% RDF + 25% FYM + 25% VC + Bio-fertilizer (T_{12}), besides an absolute control *i.e.*, T_1 (no organic, inorganic and bio-fertilizer applied) and was replicated thrice. Recommended doses of NPK fertilizers (100% as per soil test) applied to French bean were N:P_2O_5:K_2O @ 30:50:30 kg/ha). The 100% NPK was applied as basal at the time of sowing. The recommended dose of *Rhizobium* (20 g/kg seed) or PSB as per treatment was first mixed in clean water to make thick slurry and seed was then inoculated as per treatments with the biofertilizer. Organic manures (farm yard manure and vermicompost) were incorporated according to the treatments at the time of field preparation and mixed thoroughly. French bean (Selection-3) was sown @ 80 kg/ha at 20 × 5 cm spacing during second fortnight of April and harvested in the first fortnight of July. All other agronomic practices were followed as per standard recommendations. The grain and straw yield of French bean were recorded and soil samples (0–15 cm) were collected from each plot after harvest of crop. These samples were analyzed for pH (1:2.5 soil: water suspension), organic carbon by rapid titration method (Walkley and Black, 1936), available N was estimated by alkaline permanganate method (Subbiah and Asija, 1956), available P by Olsen's method (Olsen *et al*, 1954), available K by ammonium acetate extraction method (Jackson, 1967). Crop growth rate (CGR) was calculated by using the standard formula:

$$\text{CGR (g dm}^{-2}\text{ day}^{-1}) = \frac{(W2 - W1)}{(t2 - t1)} \frac{1}{A}$$

The data were analyzed as per the standard procedure for Analysis of Variance (ANOVA) as described by Gomez and Gomez, (1984). The significance of treatments were tested by 'F' test (Variance ratio). Standard error of mean (SEm ±) was computed in all cases. The difference in the treatment mean was tested by using critical difference (CD) at 5% level of probability.

RESULTS AND DISCUSSION

The data presented in Table 2 revealed that seed yield in all the treatments differ significantly from control. Maximum seed yield (1386.67 kg/ha) was recorded with 125% RDF (T_4) showing 159.19% increase over control while minimum seed yield (535.00 kg/ha) was recorded with control (T_1) where no fertilizer or biofertilizer was applied. However, no statistical difference was found between seed yield (1386.67 kg/ha) with 125% RDF (T_4) and seed yield (1272.00 kg/ha) with 50% RDF + 25% FYM + 25% VC + biofertilizer (T_{12}). Treatments 100% RDF (T_3), 50% RDF +50% VC (T_{10}), 50% RDF + 50% FYM (T_9) and 50% RDF + biofertilizers (T_{11}) were at par with each other. In case of stover yield, maximum stover yield (1249.00 kg/ha) was recorded with 100% RDF (T_3), showing 83.59 per cent increase over control, but remained statistically at par with stover yield (1235.00 kg/ha) with 50% RDF + 25% FYM 25% VC + biofertilizer (T_{12}) and stover yield (1224.00 kg/ha) with 125% RDF (T_4). All the treatments recorded significantly higher stover yield over control (680.33 kg/ha). Similar results were also reported by Gupta *et al*, (1996) and Abd El-Mawgoud *et al*, (2005). The higher seed and stover yield associated with higher inorganic fertilization might be due to higher availability of NPK to crop. Further, higher seed and stover yield by application of inorganic fertilizers in combination with organic manures may be due to its greater availability and uptake of macro and micro nutrients resulting in higher photosynthesis, tissue differentiation, translocation of assimilates etc. leading to higher seed and stover yield (Sen *et al.*, 2002).

Although, the germination percentage proved to be non-significant (Table 2). The data on days to 50% flowering showed that higher days (37.5 days) were taken with 125% RDF (T_4) to 50% flowering among all other treatments. This might have been due to more supply of N in case of 125% RDF (T_4) which resulted in an increase in vegetative growth of plants causing a significant delay in flowering. Increased growth with increase in fertilizers is in agreement with the findings of Band *et al*, (2007) and Arya *et al*, (1999). The data on CGR revealed a significant increase in CGR between 20-40 days after sowing (DAS) and 40-60 DAS and decrease between 60 DAS-Harvest, irrespective of the treatments (except T_1). Application of 125% RDF (T_4) showed highest (0.424 g dm^{-2} day^{-1}) CGR and minimum (0.295 g dm^{-2} day^{-1}) with control (T_1) and but remained significantly at par with 25% FYM + 25% VC + Bio-fertilizer (T_{12}), 100% RDF (T_3), and 50% RDF + 50% VC (T_{10}). However between 40-60 DAS maximum (0.587 g dm^{-2} day^{-1}) and minimum (0.184 g dm^{-2} day^{-1}) CGR were recorded with 100% RDF (T_3) and control (T_1), respectively. Between 60 DAS to harvest, maximum (0.370 g dm^{-2} day^{-1}) CGR was recorded with 125% RDF (T_4) which was statistically similar with 100% RDF (T_3) while minimum (0.050 g dm^{-2} day^{-1}) CGR was recorded with control (T_1). The increase in CGR might have been due to significantly higher total dry weight by the application of higher fertilization. These results are in conformity with Shubashree *et al*, (2011) and Nawalgatti *et al*, (2009).

The results presented in Table 3 revealed that the various morphological parameters showed significant variation with application of organic and inorganic fertilizers in combination. The morphological parameters increased with increasing level of RDF. Application of 125% RDF significantly recorded higher morphological attributes *viz*, plant height (35.98 cm), primary branches (5.20), secondary branches (5.00), leaf area index (2.67) and total dry weight (29.40 g) followed by treatment involving substitution of 50% NPK through 25% FYM + 25% VC + biofertilizer (1.5 ton FYM/ha + 0.55 ton VC/ha + 20 g biofertilizer/kg seed) than other treatments involving inorganic fertilization alone or in combination with organic manures and were significantly superior over control (T_1). The minimum morphological attributes *viz*, plant height (26.05 cm), primary branches (3.07), secondary branches (3.40), leaf area index (0.40) and total dry weight (12.83 g) were recorded in control. 125% RDF (T_4) recorded 38.1%, 69.38%, 47.06%, 5.67% and129.15% increase in plant height, primary branches, secondary branches, leaf area index and total dry weight, respectively, over control. Similar findings were also reported by Jagdale *et al*. (2005).The higher valves might be due to

Table 1: Various organic and inorganic treatment combinations

Abbreviation used	Treatment details	
T_1	Control	No organic, inorganic or Biofertilizer applied
T_2	75% RDF	22.5 N: 37.5 P_2O_5:22.5 K_2O kg/ha
T_3	100%RDF	30 N: 50 P_2O_5: 30 K_2O kg/ha
T_4	125% RDF	37.5 N: 62.5 P_2O_5: 37.5 K2O kg/ha
T_5	FYM	6 ton/ha
T_6	Vermicompost	2.2 ton/ha
T_7	Biofertilizers (Rhizobia+PSB)	20 g/kg seed
T_8	50% FYM+ 50%VC + Biofertilizers)	3 ton/ha + 1.1 ton/ha + 20 g/kg seed
T_9	50% RDF + 50% FYM	15 N: 25 P_2O_5: 15 K_2O kg/ha + 3 ton/ha
T_{10}	50% RDF + 50% VC	15 N: 25 P_2O_5 :15 K_2O kg/ha + 1.1 kg/ha
T_{11}	50%RDF+Biofertilizer	15 N: 25 P_2O_5:15 K_2O kg/ha + 20 g/kg seed
T_{12}	50%RDF + 25% FYM + 25%VC + biofertilizer	15 N: 25 P_2O_5: 15 K_2O kg/ha +1.5 ton/ha + 0.55 ton ton/ha + 20 g/kg seed

Table 2: Germination%, days to 50 % flowering, relative growth rate, seed and stover yield as influenced by organic and inorganic fertilizers

Treatments	Germination (%)	Days to 50% flowering	Relative growth rate Days after sowing 20-40	40-60	60-harvest	Seed yield (Kg ha^{-1})	Strover yield (kg ha^{-1})
T_1	81.00	34.5	0.295	0.184	0.050	535.00	680.33
T_2	84.00	35.3	0.333	0.481	0.255	890.00	841.33
T_3	82.67	36.4	0.400	0.587	0.326	1190.00	1249.00
T_4	85.82	37.5	0.424	0.564	0.370	1386.67	1224.00
T_5	85.55	32.6	0.355	0.546	0.171	977.00	928.00
T_6	85.00	31.0	0.360	0.547	0.180	1002.00	949.00
T_7	88.44	30.3	0.344	0.543	0.206	952.00	883.67
T_8	87.50	33.0	0.334	0.510	0.222	912.00	920.00
T_9	86.00	35.3	0.387	0.529	0.210	1052.00	985.00
T_{10}	86.44	35.0	0.399	0.522	0.165	1113.00	1035.33
T_{11}	88.50	35.3	0.365	0.552	0.200	1045.00	973.00
T_{12}	88.00	34.3	0.404	0.582	0.213	1272.00	1235.00
SEm±	1.88	1.4	0.009	0.028	0.036	51.49	32.23
CD (p = 0.05)	NS	4.1	0.026	0.084	0.107	152.00	95.15

Table 3: Influence of organic and inorganic fertilizers on different parameters of French bean (*Phaseolus vulgaris* L.)

Treatments	Plant height	Primary branches	Secondary branches	Leaf area index (LAI)	Total dry weight(g)
T_1	26.05	3.07	3.40	0.40	12.83
T_2	29.65	3.80	3.80	0.47	23.60
T_3	33.23	4.80	4.60	2.36	28.51
T_4	35.98	5.20	5.00	2.67	29.40
T_5	31.13	4.07	4.00	1.69	23.68
T_6	32.13	4.20	4.07	1.72	24.00
T_7	30.90	4.00	4.00	0.91	24.13
T_8	30.80	3.80	3.80	1.07	23.57
T_9	33.03	4.60	4.40	1.82	24.80
T_{10}	33.20	4.60	4.60	2.00	24.00
T_{11}	32.30	4.40	4.40	1.84	24.60
T_{12}	34.33	5.00	4.80	2.47	26.27
SEm±	0.96	0.14	0.09	0.18	0.51
CD (p = 0.05)	2.83	0.41	0.26	0.52	1.50

higher levels of NPK which might results in increase in activity of photosynthesis and enzymes, cell division which ultimately leads to increase in growth attributes. Similar findings were also reported by Veeresh, (2003). Organic manures acting as slow release of nutrients and this could reduce the nutrient losses resulting in higher nutrient use efficiency (Becker *et al*, 1994).

Post-harvest soil analysis

The data (Table 4) on soil pH and organic carbon indicated that there was no significant difference between treatments. Numerically lowest pH (7.30) was recorded with 125% RDF (T_4) and lowest organic carbon with control (T_1) and highest soil pH (7.81) and organic carbon with 50% FYM + 50%VC + Bio-fertilizer (T_8). This might have been due to shorter

Table 4: Post harvest data as influenced by organic and inorganic fertilizers

Treatments	Soil pH	Organic Carbon(%)	Available Nx Carbon(%)	Available P (kg ha^{-1})	Available K(kg ha^{-1})
T_1	7.37	0.844	299.67	14.20	246.00
T_2	7.33	0.8.52	317.87	18.60	252.00
T_3	7.32	0.859	315.00	16.50	254.30
T_4	7.30	0.860	341.00	26.80	264.40
T_5	7.51	0.871	355.00	30.83	267.00
T_6	7.60	0.872	364.33	33.83	268.25
T_7	7.38	0.870	346.00	28.43	267.00
T_8	7.81	0.874	338.00	23.50	262.40
T_9	7.41	0.867	336.00	19.80	265.10
T_{10}	7.44	0.868	339.50	24.30	266.40
T_{11}	7.40	0.866	344.00	20.90	266.70
T_{12}	7.46	0.869	327.07	27.63	254.33
SEm ±	0.19	0.069	2.09	0.75	0.90
CD (p = 0.05)	NS	NS	6.17	2.23	2.66
Initial	7.43	0.860	317.43	19.22	248.57

duration of the crop (78 days) which might have been insufficient for the treatments to cause any significant changes in soil pH and organic carbon. Maximum available N (364.33 kg/ha), available P (33.83 kg/ha) and available K (268.25 kg/ha) were recorded with VC (T_6), showing 21.58%, 138.23% and 9.04% increase over control, respectively and lowest available N (299.67 kg/ha), available P (14.20 kg/ha) and available K (246.00 kg/ha) was recorded with control. However, in case of available K, VC (T_6) remained statistically at par with FYM (T_5), Bio-fertilizer viz., Rh + PSB (T_7), 50% RDF + 50% VC (T_{10}) and 50% RDF + Bio-fertilizers (T_{11}). The increase in available NPK by application of vermi compost has also been reported by Prabha *et al*. (2007), Azarmi *et al*. (2008) and Ekinci and Dursu (2009). It might be due to fact that the application of nitrogen in presence of organic manures helps the mineralization by minimizing C/N ratio. These results are in agreement with Datt *et al*. (2013). Increase in N might also be due to N fixing with *Rhizobium* inoculation (Abd El-fatah and Arisha, 2000), available P by PSB inoculation due to release of organic acids which mobilize phosphorus into available form (Manjunath *et al*. (2006) and available K may be due to direct addition of K to the available K pool of the soils besides the reduction of K fixation due to interaction of organic matter with clay (Bhardwaj and Omanwar, 1994). Naik *et al*. (2014) also reported improvement in nutrient status of soils through application of organics. Therefore,from the study it is concluded that in context of sustainable agriculture, growth, yield and soil quality may be improved by integrated use of organic and inorganic sources of nutrient under temperate conditions of Kashmir, and the nutrient management of French bean may involve substitution of 50% RDF through 25% FYM (1.5 ton FYM/ha) + 25%VC (0.55 ton VC/ha) + biofertilizer (20 g biofertilizer/kg seed).

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EFFECT OF SEED TREATMENT ON SEED QUALITY ENHANCEMENT IN CORIANDER

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ABSTRACT

An experiment was conducted with 40 seed samples of coriander collected from farmers field at Seed Technology Research, NSP (Crop), Orissa University of Agriculture and Technology, Bhubaneswar to study the quality status in comparision to TL seeds with respect to germination, field emergence and seed health. Germination of seed ranged from 36 to 51 % and almost all the seeds had germination % below the minimum prescribed standardof 65 %. The farmers seeds were found to be less vigorous having seedling length SVI-I (659.3 to 1048.6) and seedling dry weight (SVI-II) as 75.2 to 120.2 as compared to TL seed with 1064.4 and 151.4 respectively. Among seed treating chemicals, Carbendazim recorded maximum germination (72%) , field emergence (61%) and yield (90.5g green plant/m^2), SVI-I (1366) and SVI-II (144) . Seed treatment with biocontrol agents revealed that *Trichoderma vidide* (8g/kg seed) gave highest germination %(71%), field emergence (65%)and yield (90.5 g/m^2), SVI-I(1583),SVI-II (142) and found most effective in enhancing speed of germination (upto 5.32), minimum bacterial infection (18%). Based on the above study, it can be concluded that seed treatment with fungicide Carbendazim @ 3g/Kg is the most effective in enhancing quality of seeds saved by the farmers. But owing to so many problems in view of ecosystem and environment, seed treatment with *Trichoderma viride* @ 8g/Kg seed is found most effective in managing seed infection, seed quality and higher yield

INTRODUCTION

Coriander (*Coriandrum sativum* L.) which belongs to family Apiaceae (Umbelliferae) is an important spice and condiment used as common flavouring substance in Indian curries. It is quite popular for its peculiar sweet fragrance in leaves and fruits and is recognized well as good source of vitamins and minerals (Hnamte *et al.,* 2013). Coriander crop is widely cultivated in Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Rajasthan, Karnataka and Uttar Pradesh almost in every season. It is popularly grown in the hilly regions of south India in rainy season and mostly in winter season in Odisha. In India eighty per cent farmers use their own saved seeds for sowing. Seed is the basic input for crop production and availability of quality seed is the key to get quality produce adequately. In absence of adequate supply of quality seeds at planting time farmers save their own seed from previous crop. Good quality seed acts as a catalyst for realizing the potential of all other inputs in any crop. There are many factors that can narrow down the gap between potential and farm level yield. Among them, use of quality seed is the most important one (Ahmad, 2001), as quality seeds ensure better germination as well as better yield. But if the seed is of inferior quality then crop failure is unavoidable. To the farmers for satisfactory crop production, a high quality seed is not only desirable but also satisfactorily required. Various fungal and bacterial pathogens are associated with seed which play important role in reducing seed quality, plant stand and crop yield in field (Sahu and Kar, 2009). The advantage of seed treatment in reducing the germination time and improving emergence uniformity is well established under laboratory conditions (Chavan *et al.*, 2014). However, no information is available in literature on the health and other quality status of coriander seeds saved and used by farmers in the country. The combined use of bio-control agents and chemical pesticides has attracted much attention as a way to obtain synergistic or additive effects in the control of pathogens (Maurya *et al.*, 2008).But owing to so many problems in view of ecosystem and environment, a rapid shift has been made from synthetic products to bio products, which are eco friendly and beneficial. Keeping these aspects in view, the present study was also carried out to find out the effect of various bio-agents on seed quality by minimizing the incidence of seed borne diseases. Treatment of seed with beneficial micro-organisms including fungi and bacteria (species of *Trichoderma, Pseudomonas, Bacillus, Rhizobia* etc.) ameliorates a wide variety of biotic, abiotic, and physiological stresses to seed and seedlings (Mastouri *et al.,* 2010). In the present study an attempt has been made to evaluate the quality status of farmers' saved coriander seed and to explore the possibility of increasing the seed quality by minimizing the incidence of seed borne pathogens

MATERIALS AND METHODS

An experiment was conducted with fourty coriander seed samples collected from the farmers' of different districts of Odisha for two years (2013 & 2014) at Seed Technology Research, NSP (crops), O.U.A.T., Bhubaneswar. About 100g

seeds were collected in sealed polythene bags from each location. A truthfully levelled seed (TLS) of Century Seeds Pvt. Ltd was procured from local market for comparison. Immediately after collection, the samples were tested for moisture content, physical purity, germination (ISTA, 1993 and Pramila *et al.,* 2013), seedling vigour index as SVI-1 and SVI-II basing on seedling length and seedling dry weight, respectively (Abdul-Baki and Anderson, 1973), field emergence and seed health following standard moist blotter method. The results were compared with the minimum seed standard prescribed for the crop (Trivedi and Gunasekaran, 2013). Standard germination test was carried out in plastic box (10x15x6 cm) containing moist pleated paper.The plastic boxes were incubated at 25ºC alternating temperatures with 12 h light/darkness regime and illumination provided by white fluorescent tubes. Seedlings were evaluated at 7 and 21 days days after sowing and the mean normal seedlings, fresh seeds and dead seeds were calculated (ISTA, 1999). The seed lot showing the higher seed vigour index is considered to be more vigorous .The formula for calculating SVI-I and SVI-II as described by (Abdul-Baki and Anderson, 1973) were :

Seedling Vigor index I = Germination% × Seedling length

Seedling Vigor index II = Germination% × Seedling dry weight

As the seed quality deteriorates due to the pathogen association with seeds, a further study was carried out to improve the seed health by using the chemical fungicides as seed treatment. The experiment was laid out in Completely Randomized Design with eight treatments in four replications. Coriander seeds we treated with fungicides viz., T_1- Thiram @3g/kg seed, T_2- Captan @3g/ kg seed, T_3-Carbendazim @1g/ kg seed, T_4- Mancozeb @2.5g/kg seed, T_5- Copper oxychloride @2g/kg seed, T_6- Hexaconazole @2ml/kg seed, T_7- Propiconazole @1ml/ kg seed and T_8- untreated control. Seeds were treated with respective fungicides alongwith untreated control, put in the moisture chamber and incubated at 25 ± 2^{o}C with 12 hours alternate light and dark condition for seven days. Observation was taken on total percentage of bacterial and fungal growth on seeds for each treatment. Seeds were also tested for germination, field emergence, seedling vigour of the treated seeds following standard methods and observations were recorded after twenty one days.

As green plants of coriander are consumed raw hence maximum care should be taken to avoid the chemical fungicides which adversely impact human health and nonchemical methods of disease management should be emphasized. Hence, an experiment was also undertaken for evaluating biocontrol agents as seed treatments, viz. T_1- *Trichoderma viride* (6g/kg seed), T_2- *Trichoderma viride* (8g/ kg seed), T_3- *Pseudomonas fluorescens* (10g/kg seed), T_4- *Pseudomonas flurorescens* (12g/kg seed) and T_5- untreated control in enhancing seed quality parameters like germination percentage, field emergence, vigour under lab condition. Observation on incidence of bacterial and fungal infection on seed were also recorded after 7 days of incubation.

RESULTS AND DISCUSSION

Evaluation of seed quality is an integral part of seed improvement programme. In most of the cases, performance of the seed relates to its ability to germinate and produce a healthy vigorous plant. The quality attributes of farmers' seed samples (Table 1) indicated that the seed moisture content of the seed ranged from 8.1 to 10.7 percent and 15% of the samples had higher seed moisture content than the prescribed limit of 10 percent. Germination of the seed ranged from 36 to 51% and all most all seed samples had germination percentage below the minimum prescribed standard of 65%. The lower germination in the farmers' saved seed may be due to improper post harvest management including storage and pathogens associated with seeds. On the other hand, the TLS collected from the local market conformed to the seed standards for germination and seed moister content. Although seed quality is governed by genetic make-up, commonly the quality of seeds may deteriorate in subsequent stages like harvesting, threshing, processing and storage period. Retention of seed germination always forms the important consideration in agricultural practices.Besides germination, the seed quality was also evaluated on seed vigour calculated on the basis of seedling length (SVI-I) and seedling dry weight (SVI-II). Although there is no specific standard for this trait, the quality of farmers' seed samples was evaluated in comparison to the TLS. It was found that the farmers' seeds, were less vigorous having SVI-I (659.3 to 1048.6) and SVI-II (75.2 to 120.2) as compared with 1064.4 and 151.4, respectively of TLS. Field emergence percentages of majority of the farmers' seeds were also extremely low (30 to 45%) as compared to that of TLS(70%).

As regards the health status of the seed samples, the extent of bacterial infection in the farmers' seeds ranged from 25to 46% and the fungal infection was 18 to 27%. It is quite higher in comparison to the 18% and 15% in bacterial and fungal infection in TLS.

Many authors have reported that not only in coriander crop but in many cereal crops farmers own saved seed were below the certification standards. This is in confirmation with the observation of Huda (1990) who reported that 61.2% of farmers' wheat seed and 49.3% of rice seed samples had germination percentage below standards. Presence of bacterial pathogens like *Pseudomonas, Xanthomonas* and *Erwinia* and fungal pathogens like *Aspergillus niger* and *A. flavus* have been reported in coriander seeds (Garbagnoli and Irigoyen,1998). The results therefore indicated that the farmers' saved seeds are inferior in quality considering different quality parameters. This is in confirmation with the observations reported by a number of workers in a number of crops (Vig *et al.,* 2001). Seed treatment with Carbendazim recorded maximum germination, Field emergence and yield which were 72%, 61% and 90.5g green plants/m2 respectively (Table 2). The second best treatment was Captan @3g/kg and Mancozeb @3g/kg had 69% germination whereas Mancozeb had the maximum field emergence 62%. Rajib *et al.* (1996) had also reported that Carbendazim had better effect for reducing the disease incidence of *Fusarium solani* and increasing the seed yield.The fungicidal treatment with proper dosage and treatment methods were found to preserve the quality of seeds by their well known antifungal effect (Prasanna, 1994). Seed treatments provide an economical crop input that is applied directly on the seed using highly effective

Table 1: Physiological and Health quality status of coriander seeds at farmers' level

District	No. of samples collected	Moisture content %	Germination % (mean & range)	SVI – I	SVI -II	Field emergency %(mean & range)	Bacterial infection % (mean & range)	Fungal infection %(mean & range)
Cuttack	7	(8.1-10.0)	42 (36-48)	930.5	75.2	37(33-40)	36.8(32-46)	21.7(18-26)
Khurda	6	(9.8-10.7)	42(39-46)	659.3	77.4	34(30-36)	31(27-35)	21(18-24)
Puri	5	(8.4-9.2)	46(40-49)	830.6	92.3	37(32-43)	33(26-40)	22(19-26)
Jagatsingpur	5	(8.8-9.4)	43(40-50)	782.2	91.0	31(37-40)	32.8(30-36)	22(18-24)
Kendrapada	4	(8.8-9.4)	44(41-48)	714.0	95.2	36(30-41)	32.5(29-37)	21.5(19-27)
Deogarh	5	(8.1-9.3)	44(40-48)	950.7	141.5	37(34-40)	32(25-42)	22.8(20-27)
Koraput	4	(8.0-8.6)	49(47-51)	1048.6	97.2	39(37-42)	33(29-37)	22.5(19-27)
Kalahandi	4	(8.9-10.2)	47(46-48)	915.2	120.2	30(36-39)	30(29-32)	22.5(20-25)
TLS	1	9.4	73	1064.4	151.4	70	18	15
IMSCS limits	-	10.0	65	-	-	-	-	-

Table 2: Effect of chemical seed treatment on seed microflora and seed quality parameters

Treatments	Germination	Field (%)	Speed of emergence (%)	SVI-I germination	SVI- II	Bacterial Infection(%)	Fungal Infection (%)	Green Plant Yield (g/m^2)
Thiram@3g/kg	66(54.34)	57(49.02)	7.0	1089.0	92.4	(25.77)	(20.23)	84.7
Captan@3g/kg	69(56.17)	59(50.19)	6.5	1317.9	93.9	(27.93)	(16.35)	70.5
Carbendazim@1g/kg	72(58.05)	61(51.36)	6.0	1366.4	144.6	(25.06)	(16.29)	90.5
Mancozeb@2.5g/kg	69(56.17)	62(51.94)	5.5	1346.4	110.4	(25.06)	(21.95)	88.2
Copper oxychloride @2.0g/kg	67(54.94)	59(50.19)	6.6	1214.8	87.1	(30.65)	(22.78)	70.7
Hexaconazole@2ml/kg	57(49.02)	53(46.72)	4.6	1037.4	96.9	(29.27)	(22.77)	65.7
Propiconazole@1ml/kg	61(51.36)	54(47.29)	5.3	677.1	54.9	(29.26)	(23.55)	58.2
Control	50(45.00)	50(45.00)	4.4	655.0	45.0	(31.91)	(25.06)	60.5
SE(m)±	0.52	0.52	0.06	14.98	1.27	1.13	0.83	2.49
CD	1.54	1.54	0.19	43.72	3.73	3.31	2.45	7.28

*Figure in parenthesis are angular transformed values

Table 3: Effect of seed treatment with bicontrol agents on seed quality parameters.

Treatments	Germination (%)	Field emergence (%)	Speed of germination	SVI-I	SVI-II	Bacterial infection(%)	Fungal infection	Green plant yield (%)(g/m^2)
Trichoderma viride @ 6g/kg	62(51.94)	61(51.35)	5.15	1302	117.8	26.52	21.94	80.5
Trichoderma viride @ 8g/kg	71(57.42)	65(53.73)	5.32	1583.3	142	25.06	20.22	90.5
Pseudomonas fluorescens @10 g/kg	59(50.18)	55(47.87)	4.65	949.9	88.5	27.95	21.06	84.25
Pseudomonas fluorescens @ 12g/kg	64(53.13)	62(51.94)	4.75	1107.2	108.8	27.96	18.38	74.25
Control	50(45)	50(45)	4.5	655	45	31.91	25.03	59.75
SE(m)±	0.49	0.58	0.06	14.54	1.3	0.9	0.96	0.73
CD	2.89	4.17	0.18	43.83	3.93	9.99	11.37	2.2

*Figure in parenthesis are angular transformed values

technology. Moreover, other crop protection techniques are now being replaced with seed treatments by virtue of their residual systemic efficacy (Schwinn, 1994). Considering seedling vigour index as an important quality attribute seed treatment with Carbendazim recorded maximum SVI-I (1366) and SVI-II (144) followed by seed treatment with Mancozeb having SVI-I and SVI-II as 1346 and 110 respectively. To keep the uniformity in the plant growth, the seed treatment with Thiram was found effective as it had recorded the maximum speed of germination as 7.0. Seed treatment with Carbendazim and Mancozeb recorded the minimum bacterial infection of 25% and similarly seed treatment with carbendazim and captan had also recorded to have minimum fungal infection of 16%. Champawat and Pathak, 1991 have also stated that seed treatment with Carbendazim increased yield by lowering the bacterial and fungal infection of seeds. As the seed treatment with Carbendazim minimizes the fungal and bacterial infection in the coriander seed, the germination and field emergence increased.Research efforts in alternative methods to chemical crop protection are currently being addressed worldwide especially with regards to food safety and environmental sustainability (Nicholas and Groot, 2013). Seed treatment with biocontrol agents also resulted in significant improvement in seed quality. Among all the biocontrol agents *Trichoderma*

Viride (8g/kg seed) gave highest germination, field emergence and yield which were 71%, 65% and 90. 5g green plant/m^2, respectively (Table 3).

Seeds are considered as basic input and output in agriculture. Whereas, the productions and timely supply of quality seeds to the farmers are most crucial and challenges the technology. Therefore, production of quality seed and maintenance of high germination is of utmost significance in the seed program. The results indicated that there was significant difference among the seed treatment with bio-agents at different doses. Seed treatment with *T.viride* @8g/kg recorded maximum SVI-I and SVI-II as 1583 and 142, respectively. *T. viride* @8g/kg seed was found to be most effective in increasing the speed of germination upto 5.32. Seed treatment with T.viride @8g/kg recorded the minimum bacterial infection (18%) where as *P.fluorescence* @12g/kg have recorded the lowest fungal infection (10%). Bio agents such as *T.viride* and *P.fluorescence* are able to suppress the pathogenic expression especially (Azcon,1989).Increased aerobic activity of micro organism increases the release of CO_2which in turn inhibits the growth of pathogen and helps to build up the seed health. These micro-organisms also release some enzymes which help to improve the seed health status and check infection by pathogenic fungi (Anonymous, 2002). Based on the above study, it can be concluded that seed treatment with chemical fungicide carbendazim@3g/kg is found most effective in increasing the quality of seed saved by the farmers. But owing to so many problems in view of ecosystem and environment, seed treatment with *Trichoderma viride* @ 8g/Kg seed is found most effective in managing seed infection, seed quality and higher green plant yield. In this way, seed enhancements technology plays a significant role in improvising the seed performance of coriander. Use of bio-pesticides for sustainable production in an eco-friendly manner is an essential component. Hence the bio-agents and fungicide combinations would be incorporated in the integrated management of disease incidence under field conditions in future in coriander Seed treatment must be an initial step of raising a farmers crop and has a pivotal role in sustainable crop production which cannot be ignored.

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INTEGRATED WEED MANAGEMENT IN PIGEONPEA (*CAJANUS CAJAN* L.) UNDER RAINFED CONDITIONS OF KARNATAKA

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ABSTRACT
A field investigation was carried out during rainy seasons of 2010, 2011 and 2012 at Agricultural Research Station, Gulbarga (Karnataka) to evaluate the effect of pre and post emergent herbicides on weeds and productivity of pigeonpea. The pooled data of three years indicated that, pre emergence application of pendimethalin @ 0.75 kg a.i ha^{-1} – one hand weeding at 50 DAS recorded significantly higher weed control efficiency (97.4%) similar to that of weed free plot (97.4%) and was on par with hand weeding twice at 25 and 50 DAS (94.2%) at 70 DAS. Application of imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS - paraquat @ 0.40 kg a.i. ha^{-1} at 6 weeks after sowing recorded significantly higher seed yield (1475 kg ha^{-1}), more number of pods per plant (165.7), pod weight (68.39 g $plant^{-1}$) and 100 seed weight (9.82 g) as compared to other treatments. Significantly lower seed yield (971 kg ha^{-1}) and yield parameters were recorded in weedy check treatment because of higher weed incidence and their competition throughout the growth period of pigeonpea.It can be concluded that, imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS - paraquat @ 0.40 kg a.i. ha^{-1} at 6 WAS can be effectively used for controlling weeds and in obtaining optimum seed yield of pigeonpea.

INTRODUCTION

Pigeonpea (*Cajanus cajan* L.) is the second important pulse crop of India only after chickpea. It is cultivated over an area of 3.90 m.ha with a total production of 2.89 m.t and productivity of 741 kg ha^{-1} (FAOSTAT, 2013). Pigeonpea is an important pulse crop of Karnataka state, having 5.80 lakh ha area, 2.60 lakh tones production and 448 kg ha^{-1} productivity. The low productivity of pigeonpea is due to an array of biotic and abiotic factors. One of the major constraints in pigeonpea production is weed infestation. Weeds compete with crop for light, moisture and nutrients, with early season competition being the most critical. In Karnataka, pigeonpea is mainly grown during rainy season. Due to its slow initial growth, wider spacing and continuous rains in monsoon season, severe infestation of weeds cause maximum damage to pigeonpea (Channappagoudar and Biradar, 2007). Unchecked weeds have been reported to cause a considerable yield reduction which in case of pigeonpea could be 32-65 percent (Vaishya and Khan, 1989, Kundra and Brar, 1990, Kandasamy, 1999, Guriqbal Singh and Sekhon, 2013). The critical period of crop weed competition is during the first eight weeks after sowing (Guriqbal Singh and Sekhon, 2013). Therefore it is imperative to control weeds at proper time with suitable methods to get high yield in pigeonpea. At present weeds are controlled by hand weeding twice at 25 and 45 days after sowing and hoeing. However, due to continuous rains during monsoon season it becomes difficult for manual weeding at right time. Furthermore, non availability of labour and increasing labour charges and being time consuming it was felt to find out suitable weed control methods involving herbicides. Pre emergent herbicides may helps in checking weed growth during this period. Pendimethalin, as pre emergence has been found very effective in controlling weeds and increasing yield (Reddy *et al.*, 2007 and Guriqbal Singh and Sekhon, 2013). The pre emergence herbicides are effective only for about intitial 30 days and thereafter weeds may threat pigeonpea crop. Therefore integrated use of pendimethalin with hand weeding or inter cultivation may help in effective control of weeds in pigeonpea. Sometimes due to unavoidable circumstances, it is not possible to spray pre emergent herbicides and later on it becomes very difficult to control the weeds manually. Under such circumstances, the best possible means to control new flush of weeds are through use of post emergence herbicides (Guriqbal Singh and Sekhon, 2013). Integrated weed management provides effective weed management in pigeonpea (Reddy *et al.* 2007, Sukhadia *et al.,* 2000 and Tomar *et al.,* 2004), groundnut (Basavaraj Kumbar *et al.,* 2014), greengram (Chhodavadia *et al.*, 2014) and blackgram (Rajib Das *et al.,* 2014). Therefore, the present investigation was undertaken with the objective to find out suitable integrated weed control measure in pigeonpea.

MATERIALS AND METHODS

Field experiment was conducted during *kharif* seasons of 2010, 2011 and 2012 at Agricultural Research Station,

Gulbarga, Karnataka, India. The soil (pH 8.80) of the experimental field was clay loam in texture, low in organic carbon (0.50%), available nitrogen (180 kg ha^{-1}), medium in available phosphorus (25 kg ha^{-1}) and high in available potassium (350 kg ha^{-1}). The experiment was laidout in randomized complete block design comprising ten treatment combinations viz., Weedy check (T_1), Hand weeding twice at 25 and 50 DAS (T_2), Pendimethalin @ 0.75 Kg a.i. ha^{-1} as pre-emergence (T_3), Pendimethalin @ 0.75 Kg a.i. ha^{-1} - one hand weeding at 50 DAS (T_4), Imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS (T_5), Pendimethalin @ 0.75 Kg a.i. ha^{-1} - Post emergent spray of paraquat at 0.40 Kg a.i. ha^{-1} at 6 WAS (T_6), Imazethapyr @ 75 g a.i. ha^{-1} (20 DAS) + Paraquat at 0.40 Kg a.i. ha^{-1} at 6 WAS (T_7), Pendimethalin @ 0.75 Kg a.i. ha^{-1} - Post emergent spray of paraquat at 0.40 Kg a.i. ha^{-1} at 8 WAS (T_8), Imazethapyr @ 75 g a.i. ha^{-1} (20 DAS) - Paraquat at 0.40 Kg a.i. ha^{-1} at 8 WAS (T_9), Weed free check (T_{10}) with three replications. The pigeonpea variety ICP-8863 (160-175 days) was sown at 90 cm x 30 cm during first week of July and harvested during last week of December during all the three years of experimentation. The recommended fertilizer dose (25:50:0 kg/ha as N: P_2O_5 and K_2O) was applied at the time of sowing through urea and single super phosphate. The crop was raised under rainfed conditions with recommended package of practices for the zone. The pre-emergent herbicide i.e., pendimethalin was sprayed on the same day of sowing and post emergence herbicides *i. e.,* imazethapyr and paraquat were sprayed in between the crop rows (directed sprays) as per the treatments using 500 litres of water per hectare. The knapsack sprayer with flat fan nozzle and hood was used for spraying post emergence herbicides (paraquat).

Observations on weeds

Weed dry weight

The weed dry weight was recorded at 30, 50 and 70 DAS using an iron quadrate of 1 m^2 size. The weed samples were first dried under sun and then in hot air oven at 70° C for four days for recording the dry matter. The data was analyzed after subjecting the original data to square root transformation ("X + 1).

Weed control efficiency (WCE)

Weed control efficiency (WCE) was calculated by the following method as per the procedure given by Main et al. (2010).

$$WCE\ (\%) = \frac{\text{WCC - WCI}}{\text{WCC}} \text{ X } 100$$

Where,

WCC = Dry weight of weeds in unweeded control plot

WCT = Dry weight of weeds in treated plot

Weed control efficiency (WCE) was calculated at 30, 50 and 70 days after sowing.

Observations and analysis of data

Regarding agronomic characters, ten competitive plants were randomly selected from each plot and observations were recorded for growth and yield attributes. Whereas, seed yield obtained from the net plot area was recorded and expressed in kg ha^{-1}. The data were statistically analyzed as per the procedure given by Gomez and Gomez (2010) for randomized block design.

RESULTS AND DISCUSSION

Weed Flora

The season witnessed diversified weed flora in the experimental plot that could compete with crops for growth resources and bring reduction in the yield. The dominant weed flora found during all the three years of experimentation consisted of broad leaved weeds such as *Euphorbia hirta, Digera arvensis, Commelina benghalensis, Amaranthes viridis, Celosia argentia, Trianthema portulacastrum, phylanthus niruri, boerhavia diffusa, Cassia spp.,* grassy weeds such as *Cyperus rotundus, Cyanodan dactylon, Eleusine aegyptiacum* etc. Analysis of spectrum of weed flora revealed that broad leaved weeds are more problematic, constituting 80% and 20% by grassy weeds.

Weed dry matter

The results of the experiments showed that, dry matter of weeds in weedy check was maximum because of higher weed intensity and higher dry weight due to its dominance in utilizing the growth resources like sunlight, nutrients, moisture, CO_2 etc., Weed free check recorded significantly lower weed dry weight at all the stages of pigeonpea. These results are in close conformity with those reported by Dhonde *et al*.(2009), Sukhadia *et al.* (2000) *and Venkat Rao et al.* (2015). Among the herbicide treatments, pre emergence application of pendimethalin @ 0.75 kg a.i. ha^{-1} – post emergent spray of paraquat @ 0.40 kg a.i. ha^{-1} at 6 WAS was found significantly superior for controlling weeds in pigeonpea which recorded lowest weed dry weight at all the growth stages (4.2 g, 2.0 g and 1.5 g, respectively at 30, 50 and 70 DAS). The next best treatment which recorded lower weed dry weight were imazethapyr @ 75 g a.i. ha^{-1} (20 DAS) – paraquat @ 0.40 kg a.i. ha^{-1} at 8 WAS, pendimethalin @ 0.75 kg a.i. ha^{-1} – post emergent spray of paraquat @ 0.40 kg a.i. ha^{-1} at 8 WAS and imazethapyr @ 75 g a.i. ha^{-1} (20 DAS) – paraquat @ 0.40 kg a.i. ha^{-1} at 6 WAS. This might be due to the action of different pre and post emergent herbicides used in pigeonpea by their different mode of action on weeds i.e. primary mode of action of pendimethalin is to inhibit microtubule formation in cells of susceptible monocot and dicot weeds which are an important part of the cell division process. As a result of restricted cell division, growth of the emerging weed seedling is prevented. Post emergence application of imazethapyr is responsible for inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS) in broad leaf weeds which caused destruction of these weeds at 3-4 leaf stage. Similar results have been reported by Guriqbal Singh and Sekhon (2007).

Weed control efficiency (WCE)

Significantly lower weed control efficiency was recorded in weedy check and maximum in weed free check (99.4, 100 and 97.4% respectively at 30, 50 and 70 DAS). Among the weed control treatments, application of pendimethalin @ 0.75 kg a.i. ha^{-1} – post emergent spray of paraquat @ 0.40 kg a.i. ha^{-1} at 6 WAS recorded highest weed control efficiency (97.4%) at 70 DAS, followed by imazethapyr @ 75 g a.i. ha^{-1} (20 DAS) – paraquat @ 0.40 kg a.i. ha^{-1} at 8 WAS (84.9%), pendimethalin @ 0.75 kg a.i. ha^{-1} – post emergent spray of paraquat @ 0.40

Table 1: Growth parameters of Pigeonpea as influenced by Integrated Weed Management (IWM) practices

Sl.No.	Treatments	Plant height (cm)				Number of primary branches plant^{-1}				Total dry matter g plant^{-1}at harvest			
		2010	2011	2012	Pooled	2010	2011	2012	Pooled	2010	2011	2012	
Pooled													
1	Weedy check	136	124	140	133	7.5	6.8	8.1	7.5	118.8	122.6	129.1	123.5
2	Hand weeding twice at 25 and 50 DAS	176	162	182	173	10.8	10.1	10.2	10.4	147.2	149.9	155.7	150.9
3	Pendimethalin @ 0.75 Kg a.i.ha^{-1} as pre-emergence	152	139	156	149	8.1	9.2	8.8	8.7	129.7	132.5	140.4	134.2
4	Pendimethalin @ 0.75 Kg a.i.ha^{-1} - one hand weeding at 50 DAS	189	174	195	186	11.6	10.9	11.1	11.2	161.5	162.2	165.4	163.0
5	Imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS	169	155	174	166	9.3	9.8	9.2	9.4	135.1	139.1	145.2	139.8
6	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i ha^{-1} at 6 WAS	178	164	184	175	11.1	10.5	10.4	10.7	157.9	159.9	161.6	159.8
7	Imazethapyr @ 75 g a.i./ha (20 DAS) - Paraquat at 0.40 Kg a.i.ha^{-1} at 6 WAS	206	189	212	202	12.8	12.1	14.2	13.0	178.4	180.2	182.9	180.5
8	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i.ha^{-1} at 8 WAS	173	159	178	170	10.2	10	9.8	10.0	139.7	145.8	150.7	145.4
9	Imazethapyr @ 75 g a.i./ha (20 DAS) - Paraquat at 0.40 Kg a.i. ha^{-1} at 8 WAS	202	185	208	199	12.3	11.8	13.6	12.6	163.9	166.4	170.2	166.8
10	Weed free plot	208	191	215	205	14.5	12.9	16.8	14.7	195.7	198.8	210.7	201.7
	S.Em.±	8	7	7	6.5	0.40	0.38	0.43	0.35	8.1	8.7	7.7	8.0
	CD at 5%	23	22	20	19.0	1.19	1.14	1.27	1.08	24.2	26.1	22.9	23.8

Table 2: Yield parameters of Pigeonpea as influenced by Integrated Weed Management (IWM) practices

Sl.No.	Treatments	No. of pods plant^{-1}				Pod weight g plant^{-1}				100 seed weight (g)			
		2010	2011	2012	Pooled	2010	2011	2012	Pooled	2010	2011	2012	Pooled
1	Weedy check	68.5	72.9	80.4	73.9	27.88	30.91	32.75	30.51	8.11	8.53	8.24	8.29
2	Hand weeding twice at 25 and 50 DAS	138.9	144.8	154.8	146.2	56.54	61.39	63.06	60.33	9.43	9.33	9.31	9.36
3	Pendimethalin @ 0.75 Kg a.i.ha^{-1} as pre-emergence	125.8	129.6	138.4	131.3	51.21	54.94	56.38	54.18	9.08	9.11	9.11	9.10
4	Pendimethalin @ 0.75 Kg a.i.ha^{-1} - one hand weeding at 50 DAS	147.2	151.8	165.4	154.8	59.92	64.35	67.38	63.88	9.67	9.58	9.48	9.58
5	Imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS	129.1	131.2	145.2	135.2	52.55	55.62	59.15	55.77	9.22	9.18	9.18	9.19
6	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i ha^{-1} at 6 WAS	144.1	147.1	160.3	150.5	58.65	62.36	65.30	62.11	9.55	9.44	9.37	9.45
7	Imazethapyr @ 75 g a.i./ha (20 DAS) - Paraquat at 0.40 Kg a.i.ha^{-1} at 6 WAS	157.2	161.8	178.2	165.7	63.99	68.59	72.59	68.39	9.81	9.77	9.89	9.82
8	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i.ha^{-1} at 8 WAS	133.4	139.4	149.5	140.8	54.30	59.10	60.90	58.10	9.30	9.21	9.22	9.24
9	Imazethapyr @ 75 g a.i./ha (20 DAS) - Paraquat at 0.40 Kg a.i. ha^{-1} at 8 WAS	152.4	157.4	172.8	160.9	62.03	66.73	70.39	66.38	9.72	9.75	9.53	9.67
10	Weed free plot	168.8	175.2	187.5	177.2	68.71	74.28	76.38	73.12	9.97	9.84	10.18	10.00
	S.Em±	6.7	6.9	7.5	6.5	2.7	3.2	3.6	2.8	0.18	0.22	0.21	0.19
	CD at 5%	19.9	20.5	22.3	18.4	8.0	10.1	11.2	8.5	0.55	0.63	0.62	0.56

Table 3: Seed yield (kg ha^{-1}) as influenced by IWM in pigeonpea (pooled)

Sl.No.	Treatments	Seed yield (kg ha^{-1}) 2010	2011	2012	Pooled
1	Weedy check	1080	745	1088	971
2	Hand weeding twice at 25 and 50 DAS	1405	969	1416	1263
3	Pendimethalin @ 0.75 Kg a.i.ha^{-1} as pre-emergence	1209	834	1219	1087
4	Pendimethalin @ 0.75 Kg a.i.ha^{-1} - one hand weeding at 50 DAS	1510	1041	1522	1358
5	Imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS	1345	928	1356	1210
6	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i ha^{-1} at 6 WAS	1420	979	1431	1277
7	Imazethapyr @ 75 g a.i./ha (20 DAS) - Paraquat at 0.40 Kg a.i.ha^{-1} at 6 WAS	1640	1131	1654	1475
8	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i.ha^{-1} at 8 WAS	1380	952	1392	1241
9	Imazethapyr @ 75 g a.i./ha (20 DAS) - Paraquat at 0.40 Kg a.i. ha^{-1} at 8 WAS	1610	1110	1622	1447
10	Weed free plot	1660	1145	1673	1493
	S.Em. ±	90	62	69	61
	C.D.at 5%	268	185	205	181

Table 4: Effect of different weed management practices on Weed dry weight (g plant^{-1}) in pigeonpea

Sl.No.	Treatments	Weed dry weight (g plant^{-1}) 2010			2011			2012			Pooled		
		30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS
1	Weedy check	41.2 (39.9)	84.3 (66.7)	99.2 (84.9)	44.0 (41.6)	22.1 (28.0)	21.4 (27.6)	41.3 (40.0)	55.1 (47.9)	65.4 (54.0)	42.2 (40.5)	53.8 (47.2)	69.7 (51.9)
2	Hand weeding twice at 25 and 50 DAS	1.6 (7.3)	0.2 (2.6)	2.9 (9.8)	0.8 (5.1)	0.6 (4.4)	1.9 (7.9)	1.8 (7.7)	1.2 (6.3)	3.7 (11.1)	1.4 (6.8)	0.7 (4.7)	2.8 (9.7)
3	Pendimethalin @ 0.75 Kg a.i.ha^{-1} as pre-emergence	21.2 (27.4)	29.7 (33.0)	41.5 (40.1)	36.3 (37.0)	17.2 (24.5)	16.3 (23.8)	26.2 (30.8)	21.5 (27.6)	30.1 (33.3)	27.9 (31.9)	22.8 (28.5)	29.3 (32.8)
4	Pendimethalin @ 0.75 Kg a.i.ha^{-1} - one hand weeding at 50 DAS	16.8 (24.2)	0.0 (0.0)	6.2 (14.4)	27.0 (31.3)	0.0 (0.00)	18.0 (25.1)	19.8 (26.4)	1.0 (5.7)	14.2 (22.1)	21.2 (27.4)	0.3 (3.3)	12.8 (21.0)
5	Imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS	22.5 (28.3)	18.9 (25.8)	12.5 (20.7)	30.2 (33.3)	13.3 (21.4)	7.1 (15.5)	23.7 (29.1)	15.8 (23.4)	10.4 (18.8)	25.5 (30.3)	16.0 (23.6)	10.0 (18.4)
6	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i ha^{-1} at 6 WAS	4.5 (12.2)	2.6 (9.3)	1.7 (7.5)	3.3 (10.5)	1.1 (6.0)	0.6 (4.4)	4.7 (12.5)	2.3 (8.7)	2.2 (8.5)	4.2 (11.8)	2.0 (8.1)	1.5 (7.0)
7	Imazethapyr @ 75 g a.i./ha (20 DAS) - Paraquat at 0. 40 Kg a.i.ha^{-1} at 6 WAS	13.5 (21.6)	17.3 (24.6)	7.2 (15.6)	36.2 (37.0)	16.7 (24.1)	10.0 (18.4)	23.8 (29.2)	16.7 (24.1)	9.4 (17.9)	24.5 (29.7)	16.9 (24.3)	8.9 (17.3)
8	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i.ha^{-1} at 8 WAS	19.3 (26.1)	3.9 (11.4)	8.5 (17.0)	22.0 (28.0)	10.0 (18.4)	5.5 (13.6)	22.9 (28.6)	8.1 (16.5)	8.4 (16.8)	21.4 (27.6)	7.3 (15.7)	7.5 (15.9)
9	Imazethapyr @ 75 g a.i./ha (20 DAS) - Paraquat at 0.40 Kg a.i. ha^{-1} at 8 WAS	11.8 (20.1)	7.5 (15.9)	5.8 (13.9)	27.3 (31.5)	10.8 (19.2)	6.1 (14.3)	17.6 (24.8)	10.1 (18.5)	7.1 (15.5)	18.9 (25.8)	9.5 (17.9)	6.3 (14.6)
10	Weed free plot	0.0 (0.0)	0.0 (0.00)	1.2 (5.3)	0.0 (0.0)	0.0 (0.00)	0.8 (5.1)	0.8 (5.1)	0.0 (0.00)	1.8 (7.7)	0.3 (3.0)	0.0 (0.0)	1.3 (6.5)
	S.Em ±	1.8	1.9	2.1	2.3	1.4	1.3	1.9	1.8	2.0	1.8	1.5	1.7
	CD at 5%	5.4	5.8	6.3	7.0	4.3	4.0	5.6	5.4	5.8	5.4	4.3	5.0

* Figures in the parenthesis are transformed values

Table 5: Effect of different weed management practices on weed control efficiency (WCE) in pigeon pea.

Sl.No.	Treatments	Weed Control Efficiency (%)									
		2010			2011			2012			
		30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS	Pooled
											30 DAS 50 DAS 70 DAS
1	Weedy check	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 0.0 0.0
2	Hand weeding twice at 25 and 50 DAS	96.1	99.8	97.1	98.2	97.3	91.1	95.6	97.8	94.3	96.6 98.3 94.2
3	Pendimethalin @ 0.75 Kg a.i.ha^{-1} as pre-emergence	48.5	64.8	58.2	17.5	22.2	23.8	36.6	61.0	54.0	34.2 49.3 45.3
4	Pendimethalin @ 0.75 Kg a.i.ha^{-1} - one hand weeding at 50 DAS	59.2	100.0	93.8	38.6	100.0	15.9	52.1	98.2	78.3	50.0 99.4 62.6
5	Imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS	45.4	77.6	87.4	31.4	39.8	66.8	42.6	71.3	84.1	39.8 62.9 79.4
6	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i ha^{-1} at 6 WAS	89.1	96.9	98.3	92.5	95.0	97.2	88.6	95.8	96.6	90.1 95.9 97.4
7	Imazethapyr @ 75 g a.i/ha (20 DAS) - Paraquat at 0.40 Kg a.i.ha^{-1} at 6 WAS	67.2	79.5	92.7	17.7	24.4	53.3	42.4	69.7	85.6	42.4 57.9 77.2
8	Pendimethalin @ 0.75 Kg a.i./ha - Post emergent spray of paraquat at 0.40 Kg a.i.ha^{-1} at 8 WAS	53.2	95.4	91.4	50.0	54.8	74.3	44.6	85.3	87.2	49.2 78.5 84.3
9	Imazethapyr @ 75 g a.i./ha (20 DAS) - Paraquat at 0.40 Kg a.i. ha^{-1} at 8 WAS	71.4	91.1	94.2	38.0	51.1	71.5	57.4	81.7	89.1	55.6 74.6 84.9
10	Weed free plot	100.0	100.0	98.8	100.0	100.0	96.3	98.1	100.0	97.2	99.4 100.0 97.4
	S.Em±	3.2	4.7	4.2	2.7	2.1	2.7	3.2	3.7	3.6	3.1 3.3 3.8
	CD at 5%	9.7	14.0	12.6	8.1	6.4	8.0	9.7	10.8	10.8	9.3 9.7 11.4

kg a.i. ha^{-1} at 8 WAS (84.3%) and imazethapyr @ 75 g a.i ha^{-1} at 20 DAS (79.4%). These results are also in conformity with the findings of Rajput and Pandey (1994) and Sharma *et al*. (2014).

Effect of weeds on growth, yield and yield attributing characters of pigeonpea

Different weed control treatments were found to be significantly affected various growth and yield attributing characters in pigeonpea over control treatment. Taller plants, more number of branches, highest plant dry matter, more number of pods per plant, higher pod weight and test weight were observed in weed free check. Among the herbicide treatments, imazethapyr @ 75 g a.i ha^{-1} (20 DAS) - paraquat at 0.40 Kg a.i ha^{-1} at 6 WAS recorded higher growth and yield attributes as compared to rest of the weed management practices. This might be due to effect of different herbicides that controlled the weeds and reduced the competition of crop with weeds for growth resources like space, air, sunlight, moisture and nutrients.

Progressive and significantly higher number of pods per plant, pod weight per plant, test weight and grain yield of pigeonpea were obtained with different weed control measures over weedy check. The weed free treatment recorded the highest number of pods per plant (177.2), test weight (10.0 g) and grain yield (1493 kg ha^{-1}) than weedy check (73.9, 8.29 g and 971 kg ha^{-1}, respectively). The lower grain yield and yield parameters in weedy check was mainly due to emergence of weeds since beginning of crop that resulted in intense competition with crop plants for nutrients, moisture and sunlight. However, among the set of IWM treatments, the maximum grain yield was recorded under IWM treatments viz., imazethapyr @ 75 g a.i ha^{-1} (20 DAS) – paraquat @ 0.40 kg a.i ha^{-1} at 6 WAS (1475 kg ha^{-1}), imazethapyr @ 75 g a.i ha^{-1} (20 DAS) – paraquat @ 0.40 kg a.i ha^{-1} at 8 WAS (1447 kg ha^{-1}) and pendimethalin @ 0.75 kg a.i ha^{-1} – one hand weeding at 50 DAS (1358 kg ha^{-1}) and differences between these three treatment combinations were statistically at par with each other as well as with weed free plot. Higher grain yields in these treatments may be due to effective weed control as reflected in lower weed dry weight, higher weed control efficiency, better plant growth and yield attributes. These findings are in concurrence with those of Dhonde *et al*. (2009) and Venkat Rao *et al*. (2015).

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EFFECT OF MINERAL NUTRIENTS AND GROWTH REGULATORS ON MANAGEMENT OF FRUIT DROP AND IMPROVEMENT OF FRUIT QUALITY IN KINNOW MANDARIN

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ABSTRACT
The present investigation on the effect of the foliar application of micronutrients and growth regulators on management of fruit drop concomitant with improvement of fruit quality in Kinnow mandarin was carried out at Punjab Agricultural University, Ludhiana during 2012-2013. Minimum fruit drop percent and maximum fruit retention per cent were recorded with the foliar application of $MgSO_4$ (0.6%). A significant increase in yield due to reduction in per cent fruit drop when compared to control has been recorded with the application of KNO_3 + 2,4-D (2.5 + 20μg/ml). The maximum fruit weight (232g/fruit), size (6.51x7.44cm), TSS:Acid ratio (15.0), Vitamin C (50.46 mg/100 ml juice), juice per cent (54.66%), flavonoids (24.96 mg/g equivalent); and a minimum rag per cent (20.26%) were recorded with the application of KNO_3 + 2,4-D (2.5 + 20μg/ml). Thus the synergistic effect of KNO_3 + 2,4-D (2.5% and 20μg/ml) improves fruit yield and quality in Kinnow mandarin by reducing the fruit drop.

INTRODUCTION

Citrus is one of the major economically important fruit crops in the world and is grown in developed and developing countries, constitutive of one of the main sources of vitamin C. In India, citrus is grown in an area of 106400 hectares with an annual production of 994500 MT (Anonymous, 2013-14). The major citrus variety grown in Punjab in India is Kinnow mandarin which occupies an area 48000 hactares with an annual production of 1036832 MT (Anonymous, 2013-14). Fruit drop in citrus, especially in Kinnow mandarin is a serious problem confronting the Kinnow growers. The phenomenon of fruit drop is effected by several physiological and environmental factors viz. malnutrition, high temperature, humidity, diseases and pests (Razi *et al.*, 2011; Ashraf *et al.*, 2012). Citrus trees produce very large number of flowers, however less than 1-2% of flowers produce harvestable yield (Nishikawa, 2013). Early reproductive processes in citrus are strongly affected by plant growth regulators indicating that the regulatory mechanism controlling set and abscission of ovaries and fruitlets possesses a pivotal hormonal component (Talon *et al.*, 1990). The balance between specific plant growth regulators at the abscission zone controls cell separation processes and eventually fruit drop (Brown, 1997).

The plant growth regulators have been exploited for the control of fruit drop and improvement of fruit quality in Kinnow mandarin. Reports indicate that 2,4-D could improve TSS, TSS : Acidity ratio, total sugars and ascorbic acid along with an increase in fruit retention and fruit yield per plant (Jain *et al.*, 2014). In another study, foliar application of GA_3 has been reported to increase yield by reducing the per cent fruit drop (Ullah *et al.*, 2014). The nutrient deficiency disturbs the production of plant growth regulators which ultimately control size, color and premature fruit drop. Different workers have suggested that application of suitable combination of plant growth regulators and macro and micro-nutrients for the control of excessive fruit drop and improvement of the yield and quality of citrus fruits (Doberman and Fairhurst, 2000; Saleem *et al.*, 2005). The nutrients are being exploited for their applications in other fruit crops also (Gaur *et al.*, 2014; Gurjar *et al.*, 2015). The present investigation has been under taken with the hypothesis that an effective supplement of nutrients and plant growth regulators may be necessary to produce high quality citrus fruits and control excessive citrus fruit drop. Therefore, the objective of the present study was to curtail the excessive fruit drop and enhance fruit yield and quality of Kinnow mandarin with the application of optimum dose plant growth regulators, nutrients and their combinations at an appropriate stage of growth.

MATERIALS AND METHODS

Location

The present investigations were made on eight year old Kinnow trees growing in the New Orchard of Department of Fruit Science, Punjab Agricultural University Ludhiana. Thirty Six trees which were uniform in size & vigour and given

cultural practices as per Package of Practices recommended by Punjab Agricultural University, Ludhiana were selected for the present study.

Treatments

The treatments (Twelve) were applied as foliar application and the concentration of plant growth regulators, nutrients and the time of application is as per Table 1. The experimental design was Randomized complete Block Design with single tree as an experimental unit replicated three times.

Periodical fruit drop

The experimental trees were visited regularly to observe periodical fruit drop. The dropped fruits were collected and counted at fortnightly interval beginning with May and continued up to end of December.

Fruit drop (%)

The fruit drop per cent was computed at the time of harvest. Per cent fruit drop was calculated by recording the total number of dropped fruits at each stage and the total number of fruits on the tree at the time of harvest by employing the following standardized formula :

$$\text{percent fruit drop} = \frac{\text{Number of fruits droped}}{\text{Number of fruits on the tree (dropped + total fruit no. at harvest)}} \times 100$$

Physical and Biochemical attributes of the fruits

At the time of harvest, ten fruits were picked randomly from each experimental tree. These fruits were brought to the laboratory of Department of Botany for quantificati on of quality attributes. The fruits were washed and allowed to dry at room temperature. The fruit weight, fruit size, peel weight and peel thickness were recorded with electronic balance and vernier caliper. The fruit juice was extracted with a juice extractor and weighed. The fruit juice quality parameters, viz., juice per cent,total soluble solids, titratable acidity, TSS : Acid ratio, vitamin C, and flavonoids were estimated by following standard methods (Malik and Singh,1982; AOAC,1990).

Statistical analysis

For the comparison of treatments, Randomized Block Design has been applied.

The data has been analyzed statistically by using ANOVA.

RESULTS

Fruit drop and Fruit retention

The data on the effect of the various treatments on fruit drop and fruit retention is presented in Fig 1, and the data revealing decrease in fruit drop and increase in fruit retention by the treatments is presented in Table 3. The data on periodical fruit drop and the impact of different treatments on the periodical fruit drop is presented in Table 2.

In general, the maximum fruit drop in control plants was recorded during the month of May (69.53%) followed by June (21.26%) as is evident from Table 2. The same pattern of fruit drop has been observed among all the other treatments. The total number of fruits dropped in control trees were recorded to be (~ 559 fruits/tree) and the minimum (~ 423 fruits/tree) were recorded with $MgSO_4$ (0.6%). The foliar application of KNO_3 + 2,4-D (2.5% + 20 µg/ml) resulted in reduction in number of fruit drop (~ 522 fruits/tree) as compared to control.

The minimum fruit drop (37.78%) was recorded with $MnSO_4$ (0.3%) followed by 2,4-D (38.61% fruit drop). Corresponding to this, maximum fruit retention (62.21%) was recorded with $MnSO_4$ (0.3%), closely followed by 2,4-D (61.38% fruit retention) (Fig.1).

The maximum increase in fruit retention as compared to control was recorded with $MnSO_4$ (16.51 %). The combination of KNO_3 + 2,4 D (2.5 % and 20 µg/ml) resulted in 10.86 % increase in fruit retention as compared to control as is evident from Table 3.

Fruit yield

The influence of different treatments on the fruit yield has been recorded on the basis of fruit number per tree as well as fruit weight per tree (Fig. 2). The fruit yield (kg/per tree) recorded a significant increase with the foliar application of all the treatment when compared to control. The increase in fruit yield based on fruit weight recorded a significant increase due to significant increase in fruit size with the foliar application of the treatments. The maximum fruit yield (239.02 kg/tree) was recorded with the foliar application of $MnSO_4$ + $ZnSO_4$ (0.1% each).

Fruit weight

The data on the effect of different treatments on fruit weight is represented in Table 4. There was significant increase in fruit

Table 1: Concentrations and time of application of nutrients and growth regulators

S.No.	Treatments	Concentration	Time of Application
T1	$FeSO_4$	0.3 (%)	Mid-April,Mid-June,Mid-September
T2	$MnSO_4$	0.3 (%)	Mid-April, Mid-June,Mid-September
T3	$ZnSO_4$	0.3 (%)	Mid-April, Mid-June,Mid-September
T4	$CaSO_4$	0.6 (%)	Mid-April, Mid-June,Mid-September
T5	$MgSO_4$	0.6 (%)	Mid-April, Mid-June,Mid-September
T6	$FeSO_4 + MnSO_4 + ZnSO_4$	0.3 + 0.3 + 0.3(%)	Mid-April, Mid-June,Mid-September
T7	$MnSO_4 + ZnSO_4$	0.1 % + 0.1 %	Mid –April and Mid – August
T8	KNO_3 + 2,4 – Dichlorophenoxy acetic acid	5 % + 20 µg/ml	Sixty days after full bloom
T9	KNO_3 + 2,4 – Dichlorophenoxy acetic acid	2.5 % + 20 µg/ml	Sixty days after full bloom
T10	2,4 – Dichlorophenoxy acetic acid	20 µg/ml	End-March, End April, Mid-August, Mid-September
T11	Gibberellic acid	20 µg/ml	End-March, End April, Mid-August, Mid-September
T12	Control	Water spray	-

Table 2: Effect of nutrients and plant growth regulators on the periodical fruit drop (Total fruits dropped/tree)

Treatment	Conentration	May IFN	May IIFN	June IFN	June IIFN	July IFN	July IIFN	Aug IFN	Aug IIFN	Sept. IFN	Sept. IIFN	Oct. IFN	Oct. IIFN	Nov IFN	Dec IIFN	IFN	Total I
$FeSO_4$	0.3 (%)	175.00	110.66	80.00	30.00	25.33	12.66	10.00	0.33	1.66	1.33	2.00	1.33	2.00	2.66	1.00	445.96 = 446.00
$MnSO_4$	0.3 (%)	179.33	90.00	56.00	17.33	9.00	4.00	9.33	0.33	0.33	0.00	0.66	0.00	0.33	0.33	0.00	366.96 = 367.00
$ZnSO_4$	0.3 (%)	284.00	116.33	91.33	48.66	27.00	14.00	9.33	0.33	1.00	0.66	1.33	0.33	0.66	0.66	1.33	596.95 = 596.95
$CaSO_4$	0.6 (%)	228.66	160.00	53.66	21.66	18.33	8.66	9.33	0.33	1.00	0.00	0.66	0.33	0.33	0.33	0.66	503.94 = 503.94
$MgSO_4$	0.6 (%)	250.00	157.00	104.33	57.00	15.00	6.00	10.33	0.33	1.66	0.00	1.00	0.00	0.33	1.00	0.33	422.98 = 423.00
$FeSO_4 + MnSO_4 + ZnSO_4$	0.3 + 0.3 + 0.3 (%)	212.33	110.66	73.33	35.33	24.00	8.00	9.66	0.33	1.00	0.33	1.00	0.33	0.33	0.33	0.00	444.96 = 445.00
$MnSO_4 + ZnSO_4$	0.1 + 0.1(%)	257.33	141.66	82.66	54.33	25.33	8.66	9.66	0.33	0.33	0.00	1.00	0.00	0.00	0.00	0.33	581.62 = 581.62
KNO_3 + 2,4 – D	5 % + 20µg/ml	199.00	135.66	65.66	32.66	12.66	5.00	9.00	0.66	0.66	0.33	0.33	0.33	0.00	0.33	0.33	462.28 = 463.00
KNO_3 + 2,4 – D	2.5 % + 20 µg/ml	210.00	163.33	82.33	33.33	12.00	6.00	8.66	0.00	1.33	0.33	1.00	0.00	1.66	0.66	0.66	521.62 = 521.62
2,4 – D	20 µg/ml	190.00	144.00	64.00	36.33	14.33	7.66	9.33	0.00	0.66	0.00	0.33	0.00	0.00	0.00	0.33	466.97 = 467.00
GA_3	20 µg/ml	262.66	168.33	66.33	30.33	8.33	3.33	8.66	0.00	0.00	0.33	0.33	0.00	0.66	0.00	0.00	545.29 = 546.00
Control	Water spray	*247.00	*141.66	**71.33	**47.33	20.66	10.00	17.33	1.00	0.33	0.33	0.33	0.33	0.66	0.00	0.33	558.62 = 558.62
CD(P = 0.05)		62.62	NS	26.68	NS	12.25	NS	4.21	NS	0.68	NS	NS	NS	NS	0.76	NS	51.15

*May = 69.53% drop **June = 21.26% drop

weight with the application of all the treatments as compared to control. But, a decrease in fruit weight was recorded with $ZnSO_4$ (0.3 %), $CaSO_4$ (0.6%) and $MgSO_4$ (0.6%) as compared to control. In the present study, the fruit weight was maximum (232.0 g/fruit) with KNO_3 + 2,4-D (2.5% + 20μg/ml) and this is 14.28 % increase over control.

Fruit size

The fruit length ranged between 5.80 to 6.53 cm and fruit breadth ranged between 5.61 to 7.44 cm with different treatments (Table 4). The maximum fruit length (6.53 cm) was recorded in the fruits treated with GA_3 (20μg/ml) followed by 6.51 cm by KNO_3 + 2,4-D (2.5% + 20µg/ml). The fruit breadth was maximum (7.44 cm) with foliar application of KNO_3 + 2,4-D (2.5% + 20μg/ml). However, the foliar application of all the nutrients and plant growth regulators recorded significant increase in fruit length and fruit breadth as compared with control (except for fruit breadth in $FeSO_4$ and $MnSO_4 + ZnSO_4$).

Peel characters

There was variation in peel thickness (mm) and peel per cent with foliar application of nutrients and plant growth regulators (Table 4). The minimum peel per cent (19.73) and peel thickness (1.60 mm) were recorded from the fruits which were given foliar application of $MnSO_4$ (0.3%).

Juice and Rag content

The changes recorded in juice per cent and rag per cent with the foliar application of nutrients and plant growth regulators are represented in Table 4. A significant increase in juice per cent has been recorded with the foliar application of $ZnSO_4$ (0.3%), $CaSO_4$ (0.6%), $MgSO_4$ (0.6%), combination of $FeSO_4$ + $MnSO_4$ + $ZnSO_4$ (0.3% each), GA_3 (20µg/ml), 2,4-D (20µg/ml) and combination of two doses of KNO_3 (2.5 + 5%) with 2,4-D (20µg/ml). The maximum juice (54.66%) was recorded from the fruits of the tree which were given foliar application of KNO_3 + 2,4-D (2.5% + 20µg/ml). This treatment is closely followed by 2,4-D (20µg/ml) with 53.83% juice recovery. The rag per cent decreased significantly in almost all the treatments (except 0.3% $MnSO_4$) as compared to control. The minimum rag percentage (20.26) was recorded from the fruits which were given KNO_3 (2.5%) + 2,4-D (20µg/ml).

Acidity, TSS, TSS: acid ratio, reducing sugars

The acidity percent decreased, whereas the TSS per cent and reducing sugars increased with the foliar application of all the treatments, but, TSS recorded decrease with $MnSO_4$ + $ZnSO_4$ (0.1% each). Corresponding to high TSS and low acidity with the foliar application of nutrients and plant growth regulators, there was an increase in TSS: Acid ratio with all the treatments (Table 5). The reduction in acidity with the foliar applications of treatments was non significant, however minimum acidity (0.70%) was recorded in the juice of the fruits which were picked from the trees which are given foliar application of KNO_3 (2.5%) + 2,4-D (20μg/ml) followed by (0.3%) $MnSO_4$ (0.77% Acidity). A significant maximum (11.30 %) TSS was recorded in the juice of fruits that were picked from the trees that were sprayed with GA_3 (20μg/ml).

DISCUSSION

A significant increase in reducing sugar was observed with

Table 3: The effect of nutrients and plant growth regulators on the percent decrease of fruit drop and percent increase of fruit retention in Kinnow mandarin

Treatments	Concentration	Decrease in fruit drop over control (%)	Increase in fruit retention over control (%)
$FeSO_4$	0.3 (%)	11.69	10.81
$MnSO_4$	0.3 (%)	23.37	16.51
$ZnSO_4$	0.3 (%)	14.80	12.90
$CaSO_4$	0.6 (%)	8.62	7.52
$MgSO_4$	0.6 (%)	9.41	5.09
$FeSO_4 + MnSO_4 + ZnSO_4$	0.3 +0.3+0.3 (%)	16.94	14.79
$MnSO_4 + ZnSO_4$	0.1 + 0.1(%)	11.60	10.11
KNO_3 + 2,4 – Dichlorophenoxy acetic acid	5 % + 20 µg/ml	16.73	14.17
KNO_3 + 2,4 – Dichlorophenoxy acetic acid	2.5 % + 20 µg/ml	12.46	10.86
2,4 – Dichlorophenoxy acetic acid	20 µg/ml	17.16	14.96
Gibberellic acid	20 µg/ml	12.80	11.18
Control	Water spray	-	-

Table 4: Effect of different treatments on Physical attributes of fruits of Kinnow mandarin

Treatments	Concentration	Fruit weight (g/Fruit)	Fruit length (cm)	Fruit breadth (cm)	Peel thick ness (mm)	Peel percent (%)	Juice percent (%)	Rag percent (%)
$FeSO_4$	0.3 (%)	213.3	6.13	5.61	1.70	21.36	45.63	32.96
$MnSO_4$	0.3 (%)	221.7	6.24	6.10	1.60	19.73	44.90	38.70
$ZnSO_4$	0.3 (%)	200.0	6.20	6.40	2.10	22.76	51.13	26.10
$CaSO_4$	0.6 (%)	186.1	6.25	7.30	2.16	21.09	48.96	29.93
$MgSO_4$	0.6 (%)	173.4	6.44	6.30	2.00	24.73	49.50	25.63
$FeSO_4 + MnSO_4 + ZnSO_4$	0.3 +0.3+ 0.3 (%)	213.3	6.35	7.25	2.26	25.73	50.53	23.60
$MnSO_4 + ZnSO_4$	0.1 + 0.1(%)	221.8	5.80	5.95	2.40	21.00	45.50	33.50
KNO_3 + 2,4 – Dich lorophenoxy acetic acid	5 % + 20µg/ml	230.0	6.28	6.28	2.46	22.10	50.40	28.40
KNO_3 + 2,4 – Dich lorophenoxy acetic acid	2.5 % + 20 µg/ml	232.0	6.51	7.44	2.73	24.90	54.66	20.26
2,4 – Dichlorophenoxy acetic acid	20 µg/ml	225.0	6.50	7.35	2.66	23.56	53.83	22.56
Gibberellic acid	20 µg/ml	231.8	6.53	7.19	2.40	25.63	52.59	21.63
Control	Water spray	203.3	5.40	5.60	1.93	19.83	43.16	37.00
CD(P = 0.05)	_	09.30	0.36	0.47	0.46	2.52	2.82	4.15

Table 5: Effect of different treatments on quality attributes of Kinnow fruit juice

Treatments	Concentration	Acidity (%)	TSS (%)	TSS: acid ratio	Acid reducing sugars (%)	Vitamin C (mg/100ml)	Flavonoids (mg/g equivalent)
$FeSO_4$	0.3 (%)	0.84	10.80	12.85	1.73	25.90	22.66
$MnSO_4$	0.3 (%)	0.77	10.13	13.15	2.31	25.20	23.96
$ZnSO_4$	0.3 (%)	0.80	10.06	13.25	2.36	36.73	25.23
$CaSO_4$	0.6 (%)	0.98	11.00	11.20	2.54	30.56	23.10
$MgSO_4$	0.6 (%)	0.98	10.60	10.80	2.25	35.60	23.70
$FeSO_4 + MnSO_4 + ZnSO_4$	0.3 +0.3+0.3 (%)	0.82	10.40	12.60	2.24	35.00	23.13
$MnSO_4 + ZnSO_4$	0.1 + 0.1(%)	0.87	8.80	10.10	3.00	32.10	22.80
KNO_3+2,4– Dichloro phenoxy acetic acid	5 % + 20 µg/ml	0.85	10.46	12.30	1.63	41.96	25.40
KNO_3+2,4– Dichloro phenoxy acetic acid	2.5 % + 20 µg/ml	0.70	10.50	15.00	2.61	50.46	24.96
2,4– Dichlorophe noxy acetic acid	20 µg/ml	0.83	9.60	11.50	3.07	48.76	24.23
Gibberellic acid	20 µg/ml	0.94	11.30	12.00	2.85	50.20	24.80
Control	Water spray	0.99	9.40	9.50	1.56	30.43	22.50
CD(P = 0.05)	_	NS	1.19	1.04	0.49	4.10	1.18

Table of Fig. 1: Effect of nutrients and plant growth regulators on the fruit drop and fruit retention in Kinnow mandarin

Treatments	Concentration	Fruit drop (%)	Fruit retention (%)
$FeSO_4$	0.3 (%)	41.16	58.83
$MnSO_4$	0.3 (%)	37.78	62.21
$ZnSO_4$	0.3 (%)	39.71	60.28
$CaSO_4$	0.6 (%)	42.59	57.41
$MgSO_4$	0.6 (%)	42.22	53.11
$FeSO_4 + MnSO_4 + ZnSO_4$	0.3 + 0.3 + 0.3 (%)	38.71	61.29
$MnSO_4 + ZnSO_4$	0.1 + 0.1(%)	41.20	58.79
KNO_3 + 2,4 – Dichlorophe noxy acetic acid	5 % + 20µg/ml	38.81	60.96
KNO_3 + 2,4 – Dichlorophe noxy acetic acid	2.5 % + 20 µg/ml	40.80	59.19
2,4 – Dichlorophenoxy acetic acid	20 µg/ml	38.61	61.38
Gibberellic acid	20 µg/ml	40.64	59.36
Control	Water spray	46.61	53.39
CD(P = 0.05)	_	2.75	2.83

Table of fig. 2: Effect of nutrients and plant growth regulators on the total fruits and fruit yield in Kinnow mandarin

Treatments	Concentrations	Total fruit (No.)	Fruit yield(kg/tree)
$FeSO_4$	0.3 (%)	691.00	160.74
$MnSO_4$	0.3 (%)	630.00	188.84
$ZnSO_4$	0.3 (%)	844.33	204.69
$CaSO_4$	0.6 (%)	641.33	119.92
$MgSO_4$	0.6 (%)	831.33	168.38
$FeSO_4 + MnSO_4 + ZnSO_4$	0.3 + 0.3 + 0.3 (%)	756.33	161.81
$MnSO_4 + ZnSO_4$	0.1 + 0.1(%)	838.33	239.02
KNO_3 + 2,4 – Dichlorophe noxy acetic acid	5 % + 20 µg/ml	727.33	189.84
KNO_3 + 2,4 – Dichlorophe noxy acetic acid	2.5 % + 20 µg/ml	748.00	173.88
2,4 – Dichlorophenoxy acetic acid	20 µg/ml	726.33	150.22
Gibberellic acid	20 µg/ml	776.33	179.36
Control	Water spray	628.00	109.06
CD(P = 0.05)	_	152.13	39.74

most of the treatments, the maximum reducing sugar (3.07%) was recorded in the juice of fruits that were picked from the trees which were given foliar application of 2,4-D (20μg/ml). The maximum TSS: Acid ratio (15.0) was recorded with the foliar application of KNO_3 (2.5%) + 2,4-D (20μg/ml), whereas minimum TSS: Acid ratio (10.1) was recorded $MnSO_4$(0.1%) + $ZnSO_4$(0.1%). In the present investigation, the high TSS: Acid ratio (15.0) and high reducing sugar (3.07%) with the application of KNO_3 + 2,4-D (0.5% + 20 μg/ml) and 2,4-D (20μg/ml) respectively suggests these treatments, as good for improvement of TSS :Acid ratio of fruit juice.

Flavonoids and vitamin C

In the present investigation, maximum Vitamin C (50.46 mg/ml juice) was recorded in the fruits which were picked from the trees sprayed with KNO_3 (2.5%) + 2,4-D (20μg/ml) (Table 5). This increase in Vitamin C is at par with GA_3 (20μg/ml). However, there was a decrease in Vitamin C content with the foliar application of $FeSO_4$ (0.3%) and $MnSO_4$ (0.3 %).

All the treatments recorded an increase in the content of flavonoids as compared to control and eight among the twelve treatments recorded a significant increase. The maximum content of flavonoids (25.40 mg/g equivalent) was recorded from juice of fruit picked from the trees treated with KNO_3 (0.5%) + 2,4-D (20μg/ml).

The application of plant growth regulators for reduction of fruit drop and improvement of fruit quality in citrus has been an instrument for the researchers (Kaur *et al*., 2007; Saleem *et al*.,2008, Jain *et al*., 2015). The maximum fruit drop during the current investigation was recorded during the months of May followed by June and the rest of the drop was distributed in the other months. The maximum fruit drop observed during May and June followed by August for Kinnow mandarin is reported earlier by Kaur *et al*. (2000). Fruit retention depends upon the overall health of the tree and the fruit drop could be due to some nutritional as well as physiological problems. The fruit drop could also be due to low activity or limited supply of auxin to the developing fruits as reported by Lima and Davies (1984) in Navel orange. The findings in the present study have revealed an increase in fruit retention with the foliar application of nutrients and plant growth regulators. Earlier reports on increase in fruit yield by enhancing the fruit retention and reduction of fruit drop in citrus support the present investigation (Srivastava and Singh, 2006). The combination of KNO_3 + 2,4 D (2.5 % and 20 µg/ml) which resulted in 10.86 % increase in fruit retention as compared to

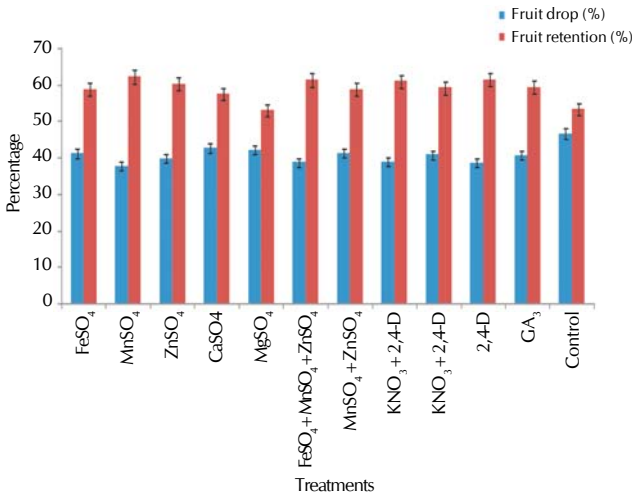

Figure 1: The effect of nutrients and plant growth regulators on fruit drop and fruit retention in Kinnow mandarin.

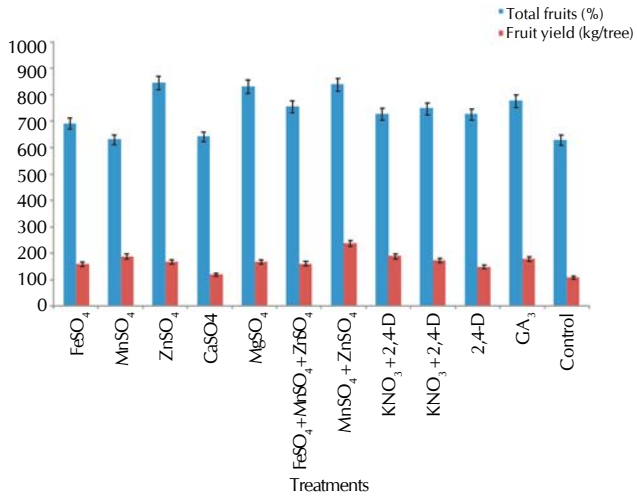

Figure 2: The effect of nutrients and plant growth regulators on total fruit (Number) and fruit yield (Kg/tree) of Kinnow mandarin

control is close to $MnSO_4$ (0.3 %) which resulted in maximum fruit retention (16.51 % increase over control) as is evident from Table 3. The combination of nutrients and plant growth regulators have been tried earlier for the control of fruit drop in citrus (Modise *et al.*, 2009) and increase in fruit retention. Corresponding to higher fruit retention, the nutrients and plant growth regulators mediated an increase in the fruit yield (Fig 2). The increase in fruit yield based on fruit weight recorded a significant increase due to significant increase in fruit size with the foliar application of the treatments. Similar increase in yield and reduction of fruit drop with the application of Zn (75μg/ml), Fe (75μg/ml) and Mn (50 μg/ml) alone or in combination has earlier been reported by Khurshid *et al.* (2008).

There was significant increase in fruit weight (Table 4) with the application of almost of all the treatments. Jain *et al.* (2014) reported increase in fruit weight with the application of 2,4-D in Nagpur mandarin. Increase in fruit weight with 2,4-D (20μg/ml) has also been reported by Singh and Gupta (1972) in sweet orange. In the present study, the fruit weight was maximum with KNO_3 + 2,4-D (2.5% + 20μg/ml) which is 14.28 % increase over control. The increased fruit weight is attributed to increase in fruit size with this treatment. The sink strength has been reported to increase by auxin treatment by Agusti *et al.* (1996). The application of KNO_3, 2,4-D and Gibberellic acid have been reported to improve the fruit growth in Nagpur mandarin by Huchche (2005).

The foliar application of all the nutrients and plant growth regulators recorded significant increase in fruit length and fruit breadth as compared with control (except for fruit breadth in $FeSO_4$ and $MnSO_4$ + $ZnSO_4$). Chundawat and Randhawa (1972) also reported increase in fruit size in Saharanpura grapefruit in response to plant growth regulators. Increase in fruit size in sweet lime has also been observed by Kumar *et al.* (1975) with the foliar application of GA_3 (250-100 μg/ml). Gibberellins activate cell division and cell enlargement processes in vegetative organs and thus are associated with growth (Talon and Zeevart, 1992).

In the present study, the peel thickness and peel per cent have been recorded to increase with the treatments there by adding to the overall fruit weight. The peel thickness is effected by many factors and it may vary in different situations. Chundawat and Randhawat (1972) reported increase in peel thickness in Saharanpur species of fruit with the foliar application of GA_3 and 2,4-D.

The changes recorded in juice per cent and rag per cent with the foliar application of micronutrients and plant growth regulators which are represented in Table 4 reveal a significant increase in juice per cent and decrease in rag percent as compared to control. Jain *et al.* (2014) in their experiment on Nagpur mandarin, reported maximum juice recovery with the spray of GA_3 (100µg/ml) followed by 2,4-D (30μg/ml). 2,4-D application has also been reported to increase juice percentage in Kinnow (Singh and Mishra, 1986).

The acidity percent decreased, whereas the TSS per cent and reducing sugars increased with the foliar application of all the treatments but, TSS recorded decrease with $MnSO_4$ + $ZnSO_4$ (0.1% each). Corresponding to high TSS and low acidity with the foliar application of nutrients and plant growth regulators, there was an increase in TSS: Acid ratio with all the treatments (Table 5). The maximum TSS: Acid ratio (15.0) was recorded with the foliar application of KNO_3 (2.5%) + 2,4-D (20μg/ml). Similar increase in TSS, reducing sugars and decrease in acidity has been observed by Kaur *et al.* (2000) in Kinnow mandarin. An increase in TSS of citrus juice has been reported by Ashraf *et al.* (2012) with Zn and K. A high TSS: Acid ratio is necessary for good juice quality. The citrus juice factories also prefer the juice with high TSS: acid ratio. In the present investigation, the high TSS: acid ratio (15.0) and high reducing sugar (3.07%) with the application of KNO_3 + 2,4-D (0.5% + 20 μg/ml) and 2,4-D (20μg/ml) respectively suggests these treatments, as good for improvement of TSS :Acid ratio of fruit juice. Ashraf *et al.* (2012) suggested the application of Zn + K to attain high TSS: acid ratio of fruit juice. The maximum Vitamin C has also been recorded in the fruits which were picked from the trees sprayed with KNO_3 (2.5%) + 2,4-D (20 μg/ml) Table 5. All the treatments recorded an increase in the content of flavonoids as compared to control.

A positive correlation between Vitamin C and total soluble solids in the juice of Valencia orange has been reported as early as 1951 by Sites and Reitz (1951). In the present investigation also a very high TSS: Acid ratio (15.0) with KNO_3(2.5%) + 2,4-D(20µg/ml) along with high Vitamin C (50.46mg/100ml) has been observed. Potassium and auxins as foliar spray have been suggested for the improvement of Vitamin C of Kinnow juice by Ashraf *et al*. (2012) and Kaur *et al*. (2000) respectively. Due to foliar application of plant growth regulators and micronutrients, Singh and Mishra (1986) observed an increase ascorbic acid content in Kinnow mandarin. Chundawat and Randhawa (1972 and 1973) reported that 2,4-D, 2,4,5-T and CIPA increased the vitamin C content as compared to control in grapefruit. Chundawat *et al*. (1975) and Daulta *et al*.(1986) also found similar improvement in Kinnow fruits in the vitamin C content.

It may thus be concluded that the foliar application of KNO_3 (2.5%) + 2,4-D (20µg/ml) on Kinnow mandarin trees had a positive effect on the fruit quality and yield by reducing fruit drop.

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EFFECT OF PHOSPHORUS AND SULPHUR APPLICATIONS ON GROWTH, YIELD AND QUALITY OF TOMATO IN CALCAREOUS SOIL

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ABSTRACT
The present study was conducted to examine the effect of phosphorus and sulphur applications on growth, yield and quality of tomato in medium black calcareous clay loam soil. Phosphorus (P) was tested at rates of 312.5, 250, 187.5, 125 and 0 kg ha^{-1} in combination with sulphur (S) applied at rates of 2.5, 1.5, 0.5 and 0 percent equivalent to calcium carbonate content in calcareous soil. Increased rate of P and S applications enhanced the tomato growth recording maximum height (86.53 cm), internode length (7.54 cm), branches per plant (9.75) and flowers per cluster (7.49) in treatment receiving $P_{312.5}$ + $S_{2.5.}$ However, highest fruit setting rate (69.37%), number of fruits per cluster (4.94), fruits per plant (41.17), fruit weight (77.60 g) and fruit diameter (5.17cm) was obtained with application of P_{250} + $S_{2.5}$. Hence, application of 250 kg/ha Phosphorus along with 2.5 per cent S equivalent to $CaCO_3$ content in calcareous soil was found ideal for tomato, that resulted in maximum fruit yield (3.19 kg $plant^{-1}$) and better fruit quality *viz*., total soluble solids (4.71°Bx), ascorbic acid (17.43 mg $100g^{-1}$) and â-carotene (3.61 mg 100 g^{-1}) content.

INTRODUCTION

Tomato is one of the popular and most consumed vegetables in the world and is treated as 'protective food' as it is a good source of mineral nutrients *viz.,* potassium, calcium and iron, vitamins *viz.,* A, B and C and antioxidants *viz.,* lycopene, carotene, organic acids and phenols (Giovanelli and Paradiso, 2002). Its quality and productivity depends on supple mentation of nutrients through soil fertilizers, amendments and organic manure as it has good response to nutrient application (Malash *et al.,* 2008) and semi-tolerant to soil salinity (Modaish *et al.,* 1989). Hence, integrated approach of fertilizer scheduling and organic manures application was found beneficial under arid condition (Singh *et al*., 2013) that usually possess high calcium carbonate content in soil.

Amongst the essential nutrient elements, phosphorus is the most important major nutrient, because of its significant role in chemical and biochemical metabolism. It has critical role in energy transfer metabolism, as structural component of cell membranes and nucleic acids and for root growth and development (Tisdale *et al*., 2007). Generally, soluble P fertilizers are applied to manage P fertility in calcareous soils. But, their efficiency is very low (Aulakh *et al.,* 2007), because of its rapid adsorption in large amounts on $CaCO_3$ and its precipitation with Ca as insoluble compounds *viz*., di-calcium phosphate, octa-calcium phosphate, tri-calcium phosphates and ultimately hydroxy-apatites. This will gradually decrease P solubility in soil and consequent availability to plants (Tunesi *et al.,* 1999; Leytem and Mikkelsen, 2005). Acidification of calcareous soil through application of soil amendments, containing sulphur compounds helps in release of fixed P through bio-chemical reactions and desorption processes (Soaud *et al*., 2011). Besides, sulphur has significant role as secondary essential nutrient in synthesis of proteins and vitamins and as co-factor for many enzymes (Kertesz and Mirleau, 2004). But, acidification of entire calcareous soil requires higher quantity of sulphur which is an impractical approach to adopt.

Hence, the present study is conducted with an objective to ascertain the quantity of sulphur required for effective transformation of applied and native phosphorus, there by its effect on growth, yield and quality of tomato in calcareous soil.

MATERIALS AND METHODS

Experimental site and weather data

A field experiment was conducted from July to December 2013 at Regional Horticultural Research and Extension Centre (RHREC), University of Horticultural Sciences, Bagalkot, situated in the Northern Dry Zone (Zone - 3) of Karnataka, India. The experimental site was located at 75°42' East longitude and 16°10' North latitude at an altitude of 542m above mean sea level. The initial chemical properties of experimental soil are shown in Table 1. The total rainfall of 230.1 mm was received during crop growth period. The

mean relative humidity of morning and evening were 79 per cent and 56.5 per cent respectively and minimum and maximum air temperatures were 29.76ºC and 18.05ºC, during crop growth period.

Crop management

Tomato hybrid '*Arka Ananya*' released by Indian Institute of Horticultural Research (IIHR), Hesaraghatta, Bangalore, India were raised in a seedbed and 30 days old, uniform, healthy seedlings were transplanted at spacing of 45 cm X 90 cm. The intercultural operations *viz*., gap filling, weeding, staking, irrigation *etc*., were carried out as per standard management practice (Anon, 2013).

Experimental design and treatments

The experiment was conducted in a factorial randomized block design (Clarke and Kempson, 1997) with two factors and replicated three times. The treatments comprised of five different levels of P applied at the rate 312.5, 250, 187.5, 125 and 0 kg ha^{-1}as factor-1 and four different levels of sulphur applied at the rate of 2.5, 1.5, 0.5 and 0 per cent equivalent to calcium carbonate ($CaCO_3$) as factor-2.

Application of fertilizers

All treatments received uniform application of organic manure (38 t ha^{-1}) fifteen days before transplanting. Full dose of potassium (250 kg ha^{-1}) and phosphorus, as per treatment requirement, were applied using muriate of potash and di-ammonium phosphate at the time of transplanting. The nitrogen (250 kg ha^{-1}) was applied in two equal splits at the time of transplanting and 30 days after transplanting using di-ammonium phosphate and urea. Amount of sulphur required to neutralize $CaCO_3$ content as per the treatment requirement was calculated on weight/weight basis using the following relationship and supplied using sulphonite (90% S) at the time of transplanting (Prasad, 1970).

$$\frac{1 \text{ meq } CaCO_3}{100 \text{ g soil}} \quad \frac{1 \text{meq } S^{o}}{100 \text{ g soil}}$$

Data Collection

The growth and yield parameters were recorded from five randomly selected plants from each plot by avoiding the border effect for higher precision. The parameters such as plant height, internodal length and number of branches per plant, flowers per cluster were determined at full bloom stage, fruits per cluster was recorded at breaker stage and per cent fruit setting rate was calculated using the ratio of the number of fruits to the number of flowers per cluster (Hazra *et al*., 2011) as following,

$$FSR\% \quad \frac{\text{Number of fruitts}}{\text{Number of flowers}} \quad 100$$

Ripened fruits were harvested in four pickings starting from 70 to 100 days after planting, counted and weighed to record fruits per plant, fruit weight (g) and fruit yield (kg $plant^{-1}$). The broadest fruit diameter (horizontal axis) was measured using vernier callipers and expressed in centimetre.

Biochemical analysis

Fully ripened representative tomato fruits from second picking were blended using stainless steel mixer to determine quality parameters. Total soluble solids (TSS) was measured by hand refractometer and expressed in °Brix (0-32 degree brix). Ascorbic acid was determined using 2, 6- dichlorophenol indophenol dye method (Thimmaiah, 1999) and β-carotene content was estimated by calorimetric method using acetone, sodium sulphate and petroleum ether and colour intensity was measured using UV-Visible spectrophotometer at 452 nm (AOAC, 2004). The data were statistically analysed using Fisher's method of analysis of variance (Sunderaraj *et al*., 1972).

RESULTS AND DISCUSSION

Initial soil properties

The soil of the area under investigation was moderately

Table 1: Initial chemical properties of experimental soil

Soil chemical properties	Value
Soil pH (1:2.5)	8.67
Electrical conductivity (dS m^{-1}) (1:2.5)	1.02
Organic carbon (%)	0.47
CEC (cmol (p^+) kg^{-1})	34.80
Available N (kg ha^{-1})	298.30
Available P_2O_5 (kg ha^{-1})	33.45
Available K_2O (kg ha^{-1})	384.80
Exchangeable Ca (cmol (p^+) kg^{-1})	26.84
Exchangeable Mg (cmol (p^+) kg^{-1})	4.91
Available S (mg kg^{-1})	15.66
DTPA- Zn (mg kg^{-1})	0.89
DTPA- Fe (mg kg^{-1})	4.74
DTPA- Mn (mg kg^{-1})	3.84
DTPA- Cu (mg kg^{-1})	1.56
Acid soluble $CaCO_3$ (%)	6.50

Table 2: Growth parameters of tomato as influenced by different levels of phosphorus and sulphur application in calcareous soil

Treatments	Plant height (cm)	Internodal length (cm)	Number of branches $plant^{-1}$
$P_{312.5}+S_{2.5}$	86.53	7.54	9.75
$P_{312.5}+S_{1.5}$	85.99	7.39	9.63
$P_{312.5}+S_{0.5}$	85.2	7.25	8.22
$P_{312.5}+S_{0}$	79.08	6.98	7.68
$P_{250}+S_{2.5}$	86.07	7.49	9.53
$P_{250}+S_{1.5}$	83.67	7.38	8.36
$P_{250}+S_{0.5}$	81.03	7.24	7.78
$P_{250}+S_{0}$	78.47	6.97	7.38
$P_{187.5}+S_{2.5}$	83.42	7.28	9.5
$P_{187.5}+S_{1.5}$	82.01	7.18	8.26
$P_{187.5}+S_{0.5}$	78.12	7.1	7.48
$P_{187.5}+S_{0}$	77.44	6.74	7.25
$P_{125}+S_{2.5}$	79.59	7.25	8.67
$P_{125}+S_{1.5}$	80	7.14	8.11
$P_{125}+S_{0.5}$	77.2	7	6.96
$P_{125}+S_{0}$	75.33	6.7	6.68
$P_{0}+S_{2.5}$	77.68	6.53	7.31
$P_{0}+S_{1.5}$	77.6	6.48	7.15
$P_{0}+S_{0.5}$	73.67	6.44	6.8
$P_{0}+S_{0}$	64.78	6.14	6.44
S Em ±P	0.55	0.012	0.091
S	0.49	0.011	0.081
PXS	1.11	0.024	0.182
CD@5%P	1.58	0.035	0.26
S	1.41	0.031	0.232
PXS	3.17	0.070	0.52

Table 3: Effect of phosphorus and sulphur application on yield parameters and yield of tomato in calcareous

Treatments	Flowers cluster^{-1}	FSR%	Fruits cluster^{-1}	Fruits plant^{-1}	Fruit diameter	Fruit weight	Fruit yield (kg plant^{-1})
$P_{312.5}+S_{2.5}$	7.49	58.69	4.39	36.69	5.06	68.8	2.64
$P_{312.5}+S_{1.5}$	6.91	64.46	4.46	38.33	5.08	72.3	2.73
$P_{312.5}+S_{0.5}$	6.78	66.02	4.48	39.23	5.09	74.3	2.84
$P_{312.5}+S_{0}$	6.04	61.37	3.71	31.2	4.68	65.3	2.04
$P_{250}+S_{2.5}$	7.12	69.37	4.94	41.17	5.17	77.6	3.19
$P_{250}+S_{1.5}$	6.36	68.66	4.37	34.25	5.1	76.4	2.93
$P_{250}+S_{0.5}$	6.1	67.85	4.08	31.24	4.83	74.6	2.33
$P_{250}+S_{0}$	6.02	60.4	3.64	29.38	4.61	64.2	1.89
$P_{187.5}+S_{2.5}$	7.08	61.8	4.38	34.68	5.08	75.8	2.63
$P_{187.5}+S_{1.5}$	6.76	58.8	3.92	30.82	4.93	70.4	2.17
$P_{187.5}+S_{0.5}$	5.97	58.73	3.51	29.69	4.81	59.3	1.76
$P_{187.5}+S_{0}$	5.78	58.54	3.38	28.89	4.62	56.3	1.64
$P_{125}+S_{2.5}$	6.74	59.56	4.02	30.13	4.97	60.4	1.82
$P_{125}+S_{1.5}$	5.95	57.23	3.41	27.36	4.82	57.3	1.57
$P_{125}+S_{0.5}$	5.68	57.34	3.26	25.81	4.78	53.6	1.38
$P_{125}+S_{0}$	5.64	56.91	3.21	26.93	4.6	54.21	1.46
$P_{0}+S_{2.5}$	5.4	57.84	3.12	24.94	4.78	53.2	1.33
$P_{0}+S_{1.5}$	5.38	57.83	3.11	24.64	4.78	51.8	1.28
$P_{0}+S_{0.5}$	5.34	57.41	3.07	24.56	4.63	51.2	1.26
$P_{0}+S_{0}$	5.35	56.76	3.03	24.16	4.58	50.8	1.2
S. Em ±P	0.074	0.532	0.055	0.59	0.021	1.1	0.03
S	0.066	0.476	0.049	0.53	0.019	0.99	0.03
PXS	0.148	1.065	0.111	1.18	0.043	2.21	0.07
CD@5%P	0.212	1.522	0.159	1.69	0.062	3.16	0.09
S	0.19	1.362	0.142	1.51	0.056	2.82	0.08
PXS	0.425	3.045	0.318	3.38	0.125	6.31	0.19

calcareous in nature (Table 1) with 6.5% total calcium carbonate equivalent (Day, 1983). The accumulation of $CaCO_3$ in these soils might be due to semi-arid climatic conditions and drainage problems of the area (Dhir *et al.,* 1979). Based on soil test data, the soil sample was found to contain low in organic carbon (0.47%) due to poor vegetation and high rate of organic matter decomposition under hyper-thermic temperature regime which leads to high oxidising conditions (Kameriya, 1995). Soil possessed alkaline pH (8.67) with EC of 1.02 dS m^{-1}. Relative high pH of the soil is due to high base saturation of soils (Kumar *et al.,* 1997). The major nutrients N, P_2O_5 and K_2O (298.3, 33.45 and 384.8 kg ha^{-1} respectively) were medium in availability. The soil CEC was 34.8 c mol (p$^+$) kg^{-1}, of which exchangeable Ca and Mg occupied 26.84 and 4.91 c mol (p$^+$) kg^{-1} respectively. Available sulphur was 15.66 mg kg^{-1} and DTPA extractable iron, zinc, manganese and copper were 4.74, 0.89, 3.84 and 1.56 mg kg^{-1} respectively.

Effect of phosphorus and sulfur application on growth of tomato in calcareous soil

Application of different rates of P and S significantly influenced the growth parameters of tomato in calcareous soil (Table 2). Application of S at 2.5 per cent equivalent to $CaCO_3$ content along with P at 312.5 kg ha^{-1} recorded highest plant height (86.53 cm), internodal length (7.54 cm) and number of branches (9.75) which was on par with the treatment receiving P_{250} and $P_{187.5}$. Application of only P without S from 0 to 312.5 kg ha^{-1} enhanced plant height from 64.78 to 79.08 cm. Similarly, increasing S rate without P improved plant height to 77.68 cm with $S_{2.5}$ as compared to 73.67 cm with $S_{0.5}$. The results are in conformity with the works De-groot *et al*., (2002) and Nawaz *et al*. (2012). They reported enhanced tomato height with application of P and S. Phosphorus helps in better root growth and to overcome transplantation shock. The application of S solubilize native $CaCO_3$ and to enhance P availability in calcareous soil, thus, getting the advantage of P application (Rongzhong *et al.,* 2011). Besides, S being an essential element helps in plant growth and development through synthesis of proteins and chlorophyll (Orman and Kaplan, 2011).

Internodal length is manifestation of plant nutrient uptake and hormonal impact. However, better nutrient availability and uptake is crucial for stem elongation (Yadav *et al*., 2004 and Colpan *et al.,* 2013). In the present study maximum intermodal length was recorded in $P_{312.5}$ + $S_{2.5}$ (86.53 cm). Number of branches with the application of $P_{312.5}$ + $S_{2.5}$ (9.75) was on par with $P_{312.5}$ + $S_{1.5}$ (9.63) and P_{250} + $S_{2.5}$ (9.53) and P_{125} + $S_{2.5}$ (9.75). Optimum number of branches is essential for obtaining higher productivity. Too many branches may overshadow each other and may decrease cluster number and fruit setting rate, whilst, too less number will have negative impact on tomato yield (Haque *et al*., 2011).

Effect of phosphorus and sulfur application on yield and yield parameters of tomato in calcareous soil

Number of flowers per cluster was high with application of P_{325} + $S_{2.5}$ (7.49) but, its fruit setting rate was less (58.69%) resulting in decreased number of fruits per cluster (4.39) and fruits per plant (36.69) compared to P_{250} + $S_{2.5}$. Application of P_{250} + $S_{2.5}$ was found optimum for better flowers (7.12) and fruits per cluster (4.94), fruits per plant (41.17), fruit setting rate (69.37%) and fruit diameter (5.17 cm). This was followed by $P_{312.5}$ + $S_{0.5}$ and P_{250} + $S_{1.5}$ which recorded on par flowers per cluster (6.78 and 6.36 respectively), fruits per cluster (4.48

Table 4: Effect of different levels of phosphorus and sulphur application on Quality of tomato fruits in calcareous soil.

Treatments	TSS	Ascorbic acid	Beta carotene
$P_{312.5}+S_{2.5}$	4.67	16.89	3.48
$P_{312.5}+S_{1.5}$	4.69	16.93	3.51
$P_{312.5}+S_{0.5}$	4.7	17.08	3.54
$P_{312.5}+S_{0}$	4.19	14.39	2.99
$P_{250}+S_{2.5}$	4.71	17.43	3.61
$P_{250}+S_{1.5}$	4.69	17.18	3.21
$P_{250}+S_{0.5}$	4.33	16.34	2.81
$P_{250}+S_{0}$	4.11	14.15	2.65
$P_{187.5}+S_{2.5}$	4.57	16.68	3.05
$P_{187.5}+S_{1.5}$	4.48	15.16	2.75
$P_{187.5}+S_{0.5}$	4.34	15.13	2.58
$P_{187.5}+S_{0}$	4.09	14.02	2.55
$P_{125}+S_{2.5}$	4.43	16.28	2.98
$P_{125}+S_{1.5}$	4.35	15.12	2.71
$P_{125}+S_{0.5}$	4.17	14.73	2.45
$P_{125}+S_{0}$	3.92	13.68	2.5
$P_{0}+S_{2.5}$	4.13	14.58	2.81
$P_{0}+S_{1.5}$	4.07	14.36	2.45
$P_{0}+S_{0.5}$	3.86	12.89	2.42
$P_{0}+S_{0}$	3.83	12.21	2.38
S. Em $\pm$P	0.064	0.157	0.047
S	0.057	0.141	0.042
PXS	0.128	0.314	0.094
CD@5%P	0.183	0.449	0.134
S	0.163	0.402	0.12
PXS	0.365	0.899	0.269

and 4.37 respectively), fruit setting rate (66.02 and 68.66 per cent respectively) and fruit diameter (5.09 and 5.10 cm respectively). The results are in conformity with Damse *et al*. (2014). Phosphorus is known to positively influence male functional parts *viz*., pollen production per flower, pollen grain size and pollen P concentration (Lau and Stephenson, 1994 and Jennifer *et al*., 2002) which enhances total flower production, fruit setting rate, fruit number and fruit weight in tomato.

Tomato fruit weight was highest with P_{250} + $S_{2.5}$ (77.60 g) which was significantly decreased at $P_{312.5}$ + $S_{0.5}$ (68.80 g). Similarly, highest fruit yield of 3.19 kg plant^{-1} was recorded with application of P_{250} + $S_{2.5}$ followed by application of P_{250} + $S_{1.5}$ (2.93 kg plant^{-1}) and $P_{312.5}$ + $S_{0.5}$ (2.84 kg plant^{-1}). Increased rate of P application without S significantly enhanced fruit yield while increased S application without P marginally enhanced fruit yield. Lowest yield of 1.20 kg plant^{-1} (20.57 t ha^{-1}) was obtained with P_0 + S_0. Fruit yield is the manifestation of plant growth and yield parameters. Application of P_{250} + $S_{1.5}$ showed optimum plant growth, flowers and fruits per cluster, fruit setting rate, number of fruits per plant, fruit weight and diameter. This might have resulted in the production of maximum marketable fruits among all other treatments. Similar observations of enhanced tomato yield with the application of optimum P was reported by De-Groot *et al*. (2002), Adebooye *et al*. (2006) and Nawaz *et al*. (2012) and enhanced yield with S was reported by Khorsandi (1994).

Effect of phosphorus and sulfur application on quality of tomato in calcareous soil

Fruit quality parameters *viz*., TSS, ascorbic acid and β-carotene content in tomato varied significantly with different levels of P and S application in calcareous soil. Increasing rates of S application had positive impact on fruit quality parameters with P rates up to P_{250}. Application of P at 312.5 kg ha^{-1} decreased the quality of tomato fruits. Poor fruit quality was noticed with P_0 + S_0 recording lowest TSS (3.83°Bx), ascorbic acid (12.21 mg 100 g^{-1}) and β-carotene (2.38 mg 100 g-1). Application of P_{250} + $S_{2.5}$ recorded highest TSS (4.71°Bx), ascorbic acid (17.43 mg 100 g^{-1}) and β-carotene (3.61 mg 100 g^{-1}). The result signifies the role of optimum nutrient requirement (Pal *et al*., 2015) for obtaining quality tomato fruits. Winsor and Long (1968) reported, enhanced TSS, ascorbic acid and β-carotene content of tomato with combined application of P and S. But, a high rate of P is known to reduce these parameters. Further, Winsor (1966) stated that, high level of P increased proportion of unevenly ripened fruits and hollow fruits which declined the amounts of TSS, ascorbic acid and β-carotene content in tomato fruits.

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EFFECT OF FOLIAR APPLICATION OF MICRONUTRIENTS ON GROWTH AND FLOWERING OF ROSE CV. TOP SECRET UNDER POLYHOUSE CONDITION

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ABSTRACT
An experiment was carried out to study the effect of foliar application of micronutrients on growth and flowering of rose cv. Top Secret under polyhouse condition at green house complex, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during the year 2013-2014. The experiment was laid out with eighteen treatment combinations with spraying of $ZnSO_4$ (0, 0.2 and 0.4 %) and $FeSO_4$ (0, 0.2 and 0.4 %) at 15 and 30 days interval. The results indicated that the vegetative growth in term of plant height (60.00 cm), number of leaves per stalk (6.78) and leaf area (44.53 cm^2) were found significantly superior in foliar application of 0.4 % $FeSO_4$ followed by 0.4 % $ZnSO_4$. The flowering attributes like days taken to flower bud initiation (17.60 days) and days taken to opening of flower bud (19.46 days) was found minimum in foliar application of 0.2 % $ZnSO_4$. Foliar spray of 0.4 % $ZnSO_4$ increased the flower quality parameters like stalk length (56.23 cm), stalk girth (8.88 mm), length of bud (36.2 mm), diameter of flower (9.11 cm), fresh weight of flower stalk (15.81 g), number of petals per flower (34.5), weight of petals per flower (8.66 g) and vase life (9.47 days). The production of flower respectively, number of flower per plant (30.1 and 30.2) and number of flower per square meter (165.7 and 166.5) increased with the foliar spray of 0.4 % $ZnSO_4$ and 0.4 % $FeSO_4$.

INTRODUCTION

Rose is one of the most beautiful creations of nature and is universally acclaimed as "Queen of flowers". It belongs to the family '*Rosaceae*' and genus *Rosa*. Successful production of good quality cut roses, micronutrients plays a vital role for production of quality flowers, increase the yield by involving in oxidation reduction process, photosynthesis and energy transfer. Foliar application of micronutrient was increased physiological activity and productive process in rose (Bhattacharjee, 1993). Zinc is an important for the formation and activity of chlorophyll and in the functioning of several enzymes and the growth hormone auxin. Plant needs iron (F_2) to produce chlorophyll and to activate several enzymes including those involved in the oxidation/ reduction processes of photosynthesis and respiration. Various experiments have been conducted earlier on foliar spray of micro-nutrients in different flower crops (e.g. in rose, Younis *et al*., 2013), in fruit crops (e.g. in mango, Gurjar *et al*., 2015) and vegetables (e.g. in okra, Dalal and Nandkar, 2010) and shown significant response to improve yield of different crops. Thus, present study was conducted to study the effect of micronutrients on growth and production of rose by foliar application.

MATERIALS AND METHODS

The present investigation was carried out at the Greenhouse Complex, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari- 396 450, Gujarat, during the year 2013-2014. The bed size of bottom width 100 cm, top width 90 cm, height 45 cm, path 50 cm and spacing 30 x 30 cm. The experiment was laid out in Randomized Block Design with Factorial Concept (FRBD) with eighteen treatments combinations *viz*. T_1- $S_1Z_0F_0$, T_2- $S_1Z_0F_1$, T_3- $S_1Z_0F_2$, T_4- $S_1Z_1F_0$, T_5- $S_1Z_1F_1$, T_6- $S_1Z_1F_2$, T_7- $S_1Z_2F_0$, T_8- $S_1Z_2F_1$, T_9- $S_1Z_2F_2$, T_{10}- $S_2Z_0F_0$, T_{11}- $S_2Z_0F_1$, T_{12}- $S_2Z_0F_2$, T_{13}- $S_2Z_1F_0$, T_{14}- $S_2Z_1F_1$, T_{15}- $S_2Z_1F_2$, T_{16}- $S_2Z_2F_0$, T_{17}- $S_2Z_2F_1$ and T_{18}- $S_2Z_2F_2$ involving two levels of micronutrients ($ZnSO_4$ 0.2 and 0.4 % and $FeSO_4$ 0.2 and 0.4 %) and its spray interval (S_1 and S2)along with control. The treatments were replicated thrice.

The budded plants of rose cv. Top Secret were used for planting in raised beds under polyhouse conditions. The micronutrients were applied as per proposed treatments at 15 and 30 days interval regularly throught foliar spary. Data regarding different growth parameters as plant height (cm), stalk length (cm) and leaf area (cm^2) were taken by measuring tap and digital leaf area meter respectively. Length of bud (mm) and flower diameter (cm) were measured by digital vanier caliper. Fresh weight of flower stalk (g) was taken by digital weighing balance and at the end vase life of flower was counted in days.

Statistical analysis

The experimental data pertaining to all the characters studied

were subjected to statistical analysis of variance technique as described by Panse and Sukhatme (1967). The method of analysis of variance for factorial randomized block design (FRBD) was used. The test of significance among treatments was worked out by 'F' test. The critical difference at five per cent level of probability was worked out wherever the treatment effect were significant to compare mean of two treatments.

RESULTS AND DISCUSSION

Effect of spray interval on growth, flowering and flower production

A perusal of data regarding plant height, number of leaves per stalk, leaf area, days taken to flower bud initiation and opening of flower bud, flower stalk length, stalk girth, length of bud, diameter of flower, fresh weight of flower stlak, number of petals per flower, weight of petals per flower, vase life, number of flower per plant and number of flower per square meter as influenced by spray interval was found non significant.

Effect of $ZnSO_4$ on growth, flowering and flower production

It is evident from the data revealed that application of zinc sulphate at different concentration (0, 0.2 and 0.4 %) show better results on growth, flowering ang leaf nutrient content in rose. Plant height (59.80 cm), number of leaves per stalk (6.58) and leaf area (44.28 cm^2) were found significantly maximum in plants treated with 0.4 % $ZnSO_4$ (Z_2). Maximum plant height due to higher concentration of zinc might be its role in synthesis of proteins. Micronutrients involving in leaves and shoots of plants by oxidation – reduction process and photosynthesis process (Jagtap *et al.,* 2012) in rose. Khosa *et al.,* 2011, reported that due to spraying of micronutrient solution the food prepared by leaves and maximum leaf area provides more food to body of the plant to kept gerbera plant health.

The improvement of flowering attributes were observed by foliar application of 0.4 % $ZnSO_4$ (Z_2) recorded minimum days taken to flower bud initiation (17.60 days) and opening of flower bud (19.46 days). Foliar application of micro nutrients minimized the days for number of flower bud initiation and opening of flower bud in gerbera (Khosa *et al.,* 2011). Flowering quality parameters like flower stalk length (56.23 cm), stalk girth (8.88 mm), length of bud (36.2 mm), diameter of flower (9.11 cm) and fresh weight of flower stalk (15.81 g) was found significantly maximum in 0.4 % $ZnSO_4$ (Z_2). A good amount of leaves coupled with conducive root environment which would have led to proper nutrient uptake in the substrates may resulted in grater accumulation of food matter leading to increase in flower quality (Younis *et al.,* 2013) in rose. Significantly maximum number of petals per flower (34.5), weight of petals per flower (8.66 g) and vase life (9.47 days) was found in plants treated with 0.4 % $ZnSO_4$ (Z_2). Khoshgoftarmanesh *et*

Table 1: Effect of foliar application of micronutrients and their combination on vegetative growth parameters and flowering attributes in rose cv. Top Secret under polyhouse condition

Treatments	Plant height (cm)	Number of leaves per stalk	Leaf area (cm^2)	Days taken to flower bud initiation	Days taken to opening of flower bud	Stalk length (cm)	Stalk girth (mm)
S- Interval of spray							
S_1- At 15 days interval	58.20	6.31	43.23	18.03	19.84	54.44	8.27
S_2- At 30 days interval	59.50	6.53	43.96	18.67	20.63	55.03	8.40
S.Em. ±	0.49	0.07	0.30	0.14	0.14	0.32	0.06
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS
Different concentration of Zinc (Zn)							
Z_0- 0 % $ZnSO_4$	57.60	6.23	42.39	19.27	21.11	53.41	7.77
Z_1- 0.2 % $ZnSO_4$	59.20	6.46	44.11	18.18	20.14	54.56	8.35
Z_2- 0.4 % $ZnSO_4$	59.80	6.58	44.28	17.60	19.46	56.23	8.88
S.Em. ±	0.60	0.09	0.37	0.18	0.17	0.39	0.08
C.D. at 5 %	1.72	0.28	1.00	0.52	0.50	1.14	0.23
Different concentration of Iron (Fe)							
F_0- 0 % $FeSO_4$	57.50	6.05	42.37	19.28	21.18	53.30	8.00
F_1- 0.2 % $FeSO_4$	59.10	6.45	43.87	18.05	19.85	54.90	8.30
F_2- 0.4 % $FeSO_4$	60.00	6.78	44.53	17.72	19.68	56.01	8.71
S.Em. ±	0.60	0.09	0.37	0.18	0.17	0.39	0.08
C.D. at 5 %	1.72	0.28	1.00	0.52	0.50	1.14	0.23
Interaction Effect of S x Z							
S.Em. ±	0.85	0.13	0.53	0.25	0.25	0.56	0.11
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS
Interaction Effect of S x F							
S.Em. ±	0.85	0.13	0.53	0.25	0.25	0.56	0.11
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS
Interaction Effect of Z x F							
S.Em. ±	1.04	0.16	0.65	0.31	0.30	0.68	0.14
C.D. at 5 %	NS	NS	NS	NS	NS	1.97	0.40
Interaction effect (S x Z x F)							
S.Em. ±	1.47	0.23	0.92	0.44	0.43	0.97	0.20
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS
CV %	4.33	6.44	3.68	4.23	3.71	3.07	4.18

Table 2: Effect of foliar application of micronutrients and their combination on flower quality and production of flower in rose cv. Top Secret under polyhouse condition

Treatment	Length of bud (mm)	Diameter of flower (cm)	Fresh weight of flower stalk (g)	Number of petals per flower	Weight of petals per flower (g)	Vase life (days)	Number of flower per plant	Number of flower per square meter
S- Interval of spray								
S_1- At 15 days interval	35.1	8.62	14.94	33.0	8.47	8.38	29.0	159.7
S_2- At 30 days interval	36.0	8.82	15.40	33.3	8.59	8.71	29.7	163.4
S.Em.±	0.18	0.09	0.16	0.26	0.04	0.11	0.32	1.75
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
Z- $ZnSO_4$ and its interval								
Z_0- 0 % $ZnSO_4$	34.9	8.10	14.72	31.2	8.38	7.54	28.0	154.3
Z_1- 0.2 % $ZnSO_4$	35.8	8.97	15.31	33.9	8.59	8.62	29.9	164.4
Z_2- 0.4 % $ZnSO_4$	36.2	9.11	15.81	34.5	8.66	9.47	30.1	165.7
S.Em.±	0.22	0.11	0.20	0.32	0.05	0.14	0.39	2.15
C.D. at 5 %	0.65	0.31	0.57	0.93	0.15	0.41	1.12	6.19
F- $FeSO_4$ and its interval								
F_0- 0 % $FeSO_4$	34.8	8.36	14.56	31.9	8.45	7.84	27.9	153.5
F_1- 0.2 % $FeSO_4$	35.7	8.86	15.14	33.0	8.48	8.61	29.9	164.7
F_2- 0.4 % $FeSO_4$	36.0	8.96	15.48	34.3	8.61	9.18	30.2	166.5
S.Em.±	0.22	0.11	0.20	0.32	0.05	0.14	0.39	2.15
C.D. at 5 %	0.65	0.31	0.57	0.93	0.15	0.41	1.12	6.19
Interaction Effect of S x Z								
S.Em.±	0.32	0.15	0.28	0.45	0.07	0.20	0.55	3.04
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
Interaction Effect of S x F								
S.Em.±	0.32	0.15	0.28	0.45	0.07	0.20	0.55	3.04
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
Interaction Effect of Z x F								
S.Em.±	0.39	0.19	0.34	0.56	0.09	0.24	0.68	3.73
C.D. at 5 %	1.13	0.55	NS	1.61	0.26	0.71	1.95	10.7
Interaction effect (S x Z x F)								
S.Em.±	0.56	0.27	0.49	0.79	0.112	0.38	0.96	5.27
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
CV %	2.72	5.37	5.60	4.14	2.61	7.08	5.67	5.65

al., 2008, also showed that genotypic difference and enough micro-nutrient contribution were two solution factors in successful development of rose. Micronutrient application is key factor which play a dominant role in successful production of best quality cut roses and increased vase life of flower. Maximum number of flower per plant (30.1) and number of flower per square meter (165.7) was found in foliar application of 0.4 % $ZnSO_4$ (Z_2).

Effect of $FeSO_4$ on growth, flowering and flower production

Application of micronutrients has remarkable effect on the growth and fowering parameters in rose. The plants treated with 0.4 % $FeSO_4$ (F_2) was found significantly maximum plant height (60.00 cm), number of leaves per stalk (6.78) and leaf area (44.53 cm^2). Iron plays a vital role in production of vegetative growth and ultimately encourages the plant height in rose (Jagtap *et al.,* 2012). Khosa *et al.,* 2011, reported that due to spraying of micronutrient solution the food prepared by leaves and maximum leaf area provides more food to body of the plant to kept gerbera plant health. These results are in accordance with those reported by Bashir *et al*. (2013) in gerbera and Munikrishnappa *et al*. (2002) in tuberose.

It is evident from the data revealed that minimum days taken to flower bud initiation (17.72 days) and opening of flower bud (19.68 days) was recorded in foliar application of 0.4 % $FeSO_4$ (F_2). Flowering parameters like flower stalk length (56.01 cm), stalk girth (8.71 mm), length of bud (36.0 mm), diameter of flower (8.96 cm), fresh weight of flower stalk (15.48 g) was recorded significantly maximum in plants treated with 0.4 % $FeSO_4$ (F_2). Bhattacharjee, 1993 in rose reported that micronutrient plays an important role involving in photosynthesis; break down of IAA, auxin and protein synthesis. Bud length and fresh weight of flower stalk was maximum in fertilization, raise in the length of pollen tubes, cell division, growth, development and process of respiration in plants (Khosa *et al*., 2011) in gerbera. The data revealed that significantly maximum number of petals per flower (34.3), weight of petals per flower (8.61 g) and vase life (9.18 days) was found in same treatment. Vase life was considerably maximum in proper application of micronutrients supported the flowers in the vase for the extended vase life in orchid (Ganga *et al*., 2009). Significantly maximum number of flower per plant (30.2) and number of flower per square meter (166.5) was found in plant treated with 0.4 % $FeSO_4$ (F_2).

Interaction effect of S x Z, S x F, Z x F and S x Z x F

The data showed that interaction effect of different micronutrients was found non significant different growth parameters and days taken to flower bud initiation and opening of flower bud was found non significant as influenced by interaction effect of micronutrients. The data pertaining to flower stalk length, stalk girth, bud length, diameter of flower, number

of petals per flower, weight of petals per flower, vase life of flower, number of flower per plant nd number of flower per square meter was found non significant with respect to interaction effect of micronutrients.

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YIELD, QUALITY, NUTRIENT UPTAKE, SOIL FERTILITY AND WEED DRY WEIGHT AS INFLUENCED BY CASTOR (*RICINUS COMMUNIS* L.) INTERCROPPED WITH MUNGBEAN (*VIGNA RADIATA* L.) UNDER DIFFERENT ROW RATIOS AND SPACING DURING *RABI* SEASON

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ABSTRACT
Experiment was conducted during *rabi* season of 2012-13 to study the response of castor (*Ricinus communis* L.) and mungbean (*Vigna radiata* L.) intercropping under different row spacing. The highest castor yield (2072 kg/ha) was found with sole castor (150 cm x 60 cm) while significantly higher stalk yield of castor (3545 kg/ha) was found with castor (120 cm x 60 cm) + mungbean (1:2). The highest oil content (45.26%) and oil yield (934 kg/ha) of castor was recorded with treatment T_3- sole castor (180 cm x 60 cm), whereas highest seed yield (1023 kg/ha), stover yield (2614 kg/ha) and protein content (23.15%) of mungbean were recorded with T_4- sole mungbean (40 cm x 10 cm). Whereas, higher available N and P_2O_5 in soil after harvest were observed with sole mungbean (40 cm x 10 cm). However significantly higher N uptake (56.43 kg/ha), P uptake (11.42 kg/ha) and K uptake (52.03 kg/ha) was observed with treatments T_2- sole castor (150 cm x 60 cm). Treatment T_4- sole mungbean (40 cm x 10 cm) recorded significantly lowest weed dry weight (2.90 g/m^2) but did not differ significantly with treatment T_5- castor (120 cm x 60 cm) + mungbean (1:2). Hence, intercropping of castor with mungbean in 1:2 ratio is recommended.

INTRODUCTION

Castor (*Ricinus communis* L.) is the most primitive non-edible oilseed crop, belongs to family *Euphorbiaceae*. This is one of the most suitable oil seed crop which can be used to fulfill the ever increasing demand of industrial oil. The castor oil is different from other vegetable oils in the sense that it does not freeze upto -18ºC temperature. It is, therefore, considered to be the best lubricating agent particularly for both high speed engines and aeroplanes. Castor oil is also used in the manufacture of dyes, detergents, plaster of paris, soaps, costumes, polishes, greases, rubber, wetting agents, etc. It is also used as bactericides and fungicides. The demand of castor oil both, inside and outside the country has grown with the advancement of industrialization all over the world. Castor cake provides excellent organic manure with 4.5 per cent N, 2.6 per cent phosphorus and 1.0 per cent potash, 22.37 per cent protein and 45-46 per cent carbohydrates. On an average (last 3 years), India has nearly 1.02 million ha under castor cultivation with a total production of 1.57 million tonnes and productivity of 1560 kg/ha (Anon., 2012).

Green gram or mungbean (*Vigna radiata* L.), a protein rich (25%) staple food, is one of the most important pulse crops in India cultivated since ancient times. It is particularly rich in Leucine, Phenylalanine, Lysine, Valine, Isoleucine, etc. In addition to being an important source of human food and animal feed, mungbean also plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen.

Intercropping has been recognized as a potentially beneficial system of crop production which can provide sustained yield advantages compared to sole cropping. To take the advantages of different rooting depths, duration, nutrient and water requirement of the crops and better utilization of all the resources, the concept of intercropping has been introduced in primitive agriculture. In the present situation, increasing agricultural production through extensive agriculture has limited scope due to limited availability of cultivable area. An area of 143.8 million ha out of 329 million of geographical area is at present under cultivation and further expansion of cultivable area is extremely difficult.

Under these circumstances, to meet the requirement of food grains for ever increasing population, the only option open is through time and space utilization in agriculture (Sankaran and Rangaswamy, 1990). Intercropping has been recognized as a potentially beneficial system of crop production and evidences indicate that intercropping can provide substantial yield advantage compared with pure cropping (Willey, 1979). Intercropping plays an important role in the food-production system of developing countries where small farms and labour-

intensive operation predominant, greater yield stability over different seasons and increasing yield or monetary returns and improved yields for subsequent crops are common advantages of intercropping. Recent evidence suggests that there are substantial advantages of legumes intercropping, which are achieved not by means of costly inputs but by the simple expedient of growing crops together in an appropriate geometry (Khan and Khaliq, 2004). Though intercropping of castor (*Ricinus communis* L.) and Mungbean [*Vigna radiata* (L.)] are the most dominant *rabi* season intercropping system of castor growing regions of India viz., Gujarat (Patel *et al.,* 2009). Therefore, the present study was undertaken to find out the effect of intercropping treatments with different row ratios on growth and yield efficiency of castor and mungbean.

MATERIALS AND METHODS

The experiment was carried out at Pulses and Castor Research Station (South Gujarat Heavy Rainfall Zone, AES-III), Navsari Agricultural University, Navsari during rabi season of 2012-13. The soil of the experimental field is classified under the order Inceptisols comprising member of fine Montmorillonitic, isohyperthemic, family of verticustrochrepts and soil series Jalalpur by the soil survey officer, Navsari, Department of Agriculture, Gujarat state (Desai and Patel, 1970) having moderate drainage capacity and good water holding capacity. The soil of experimental field was low in organic carbon (0.45%), low in available N (234.52 kg/ha), medium in available phosphorus (31.80 kg/ha) and high in available potassium (374 kg/ha). The soil was slightly alkaline in reaction with a pH of 7.8 and EC of 0.36 dS/m.

The experiment was laid out in randomized block design (RBD) with 8 treatments allocation in each replication and was replicated thrice. The experimental treatments comprise T_1- sole castor (120 cm x 60 cm), T_2- sole castor (150 cm x 60 cm), T_3- sole castor (180 cm x 60 cm), T_4- sole mungbean (40 cm x 10 cm), T_5- castor (120 cm x 60 cm) + mungbean (1:2), T_6- castor (150 cm x 60 cm) + mungbean (1:2), T_7- castor (180 cm x 60 cm) + mungbean(1:2) and T_8- castor (180 cm x 60 cm) + mungbean (1:3). The crops were sown on 27Oct. 2012 using 'GCH-7' castor and 'CO-4'mungbean. The recommended fertilizer does of 120:25:00 kg N:P:K ha^{-1} for castor and 20:40:00 kg N:P:K ha^{-1} for mungbean was applied through urea and SSP. In intercropping combinations seed rate and fertilizers were adjusted according to the number of row arrangement. The other agronomic practices were followed as per recommendation.

The seed yield of castor and mungbean was recorded in kilogram per net plot and converted into kilogram per hectare. Oil content of castor seeds was determined by using Nuclear Magnetic Resonance (NMR) instrument as per the method suggested by Tiwari *et al*. (1974). Oil yield in kg per hectare was calculated by using the following formula.

$$\text{Oil yield (kg/ha)} \quad \frac{\text{Oil content of the seed (\%)} \quad \text{Seed yield (kg/ha)}}{100}$$

The protein content in mungbean seeds was determined by multiplying nitrogen percentage with factor 6.25 (Bhuiya and Chowdhary, 1974). Protein yield (kg/ha) was calculated by using following formula:

$$\text{Protein yield (kg/ha)} \quad \frac{\text{Protein content (\%) in seed} \quad \text{Seed yield (kg/ha)}}{100}$$

Soil samples (0-30 cm depth) were taken from four spots in each net plot and composited samples were prepared plot-wise. These samples were dried, grinded and then sieved through 2 mm size sieve for determination of available N, P_2O_5 and K_2O by the following standard methods prescribed in Table 1.

The weed samples were collected at harvest of mungbean from one meter square area. These samples were sun dried and finally dried in the electrical oven at 65º C for 24 hours. The dry weight of weeds was recorded with laboratory balance when samples attained a constant weight as g per square meter.The data were analyzed as per standard statistical procedure (RBD) suggested by Gomez and Gomez (1984). As the data on weed population and dry weight of weed showed much variation, they were subjected to square root transformation ($\sqrt{X+1}$) and then statistically analyzed by the standard method as described by Steel and Torrie (1960).

RESULTS AND DISCUSSION

The different intercropping system had significant influenced the yields and quality of castor and mungbean (Table 1). The highest yield of castor (2072 kg/ha) was recorded with the treatment T_2- sole castor (150 cm x 60 cm) but found non-significant with rest of the treatments. Treatment T_5- castor (120 cm x 60 cm) + mungbean (1:2) recorded significantly highest stalk yield of castor but remained statistically at par with treatment T_1- sole castor (120 cm x 60 cm). The highest oil content (45.26%) and oil yield (934 kg/ha) of castor was recorded with treatment T_3- sole castor (180 cm x 60 cm).Significantly higher seed yield and stover yield as well as protein content and protein yield of mungbean were recorded with treatment T_4- sole mungbean (40 cm x 10 cm). However, with respect to protein content in mungbean seeds treatment T_4- sole mungbean (40 cm x 10 cm) did not differ significantly with treatments T_6- castor (150 cm x 60 cm) + mungbean (1:2) and T_7- castor (180 cm x 60 cm) + mungbean (1:2).The increase in yield of castor per plant might be due to wider spacing had better nutrition to individual plant which enhanced crop growth and development with more food storage which increased translocation of stored food for sink development. The yield attributes and mungbean yield on unit area basis were reduced when it was grown as intercrop in association with castor. This may probably due to mungbean and castor when grown together, they compete for common environmental resources and thus growth is reduced

Table 1: Methods of estimation of available N, P_2O_5 and K_2O from soil

Particular	Method of analysis
Available Nitrogen (kg/ha)	Alkaline $KMnO_4$ method (Subbaiah and Asija,1956)
Available P_2O_5 (kg/ha)	Olsen's method (Olsen *et al*., 1954)
Available K_2O (kg/ha)	Flame photometric method (Jackson, 1973)

Table 2: Effect of different intercropping systems on yield and quality of castor and mungbean

Treatment	Castor				Mungbean			
	Castor yield (kg/ha)	Stalk yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Seed yield (kg/ha)	Stover yield (kg/ha)	Protein content (%)	Protein yield (kg/ha)
T_1	2033	3350	44.90	911	-	-	-	-
T_2	2072	2975	45.16	931	-	-	-	-
T_3	2054	2648	45.26	934	-	-	-	-
T_4	-	-	-	-	1023	2614	23.15	236.66
T_5	1931	3547	43.85	847	211	539	21.46	45.31
T_6	1867	3017	44.13	824	250	639	22.52	56.29
T_7	1841	2762	44.32	815	222	747	22.73	50.49
T_8	1797	2696	44.04	791	259	789	21.84	56.78
S. Em. ±	128	157	1.04	56	30.00	64.00	0.31	6.58
C.D. (p=0.05)	NS	484	NS	NS	97.85	209.30	1.02	21.47

T_1- sole castor (120 cm x 60 cm), T_2- sole castor (150 cm x 60 cm), T_3- sole castor (180 cm x 60 cm), T_4- sole mungbean (40 cm x 10 cm), T_5- castor (120 cm x 60 cm) + mungbean (1:2), T_6- castor (150 cm x 60 cm) + mungbean (1:2), T_7- castor (180 cm x 60 cm) + mungbean(1:2) and T_8- castor (180 cm x 60 cm) + mungbean (1:3).

Table 3: Effect of different intercropping systems on Nutrient status of soil after harvest and nutrient uptake by castor and mungbean

Treatment	Nutrient Status of soil after Harvest			Nutrient uptake by Castor			Dry weight of weeds (g/m^2) at harvest
	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	N uptake (Kg /ha)	P uptake (Kg /ha)	K uptake (Kg /ha)	
T_1	237.90	29.90	401.30	55.93	11.42	45.65	3.54(11.61)
T_2	249.97	34.00	403.83	56.43	11.28	43.74	3.75(13.08)
T_3	260.73	40.50	405.33	55.02	10.55	41.51	4.07(15.59)
T_4	265.50	42.40	406.60	-	-	-	2.90(7.39)
T_5	246.53	34.63	401.87	53.10	10.77	52.03	3.18(9.18)
T_6	256.83	37.90	404.30	51.66	9.99	46.05	3.33(10.06)
T_7	265.00	39.43	406.07	49.15	9.10	41.15	3.68(12.53)
T_8	270.23	40.50	408.70	49.42	9.05	40.16	3.38(10.42)
S. Em. ±	6.32	1.19	9.94	1.68	0.33	2.08	0.12
C.D. (p=0.05)	19.16	3.62	NS	5.17	1.03	6.41	0.35

*Data in parenthesis indicate actual value and those outside are transformed values; T_1- sole castor (120 cm x 60 cm), T_2- sole castor (150 cm x 60 cm), T_3- sole castor (180 cm x 60 cm), T_4- sole mungbean (40 cm x 10 cm), T_5- castor (120 cm x 60 cm) + mungbean (1:2), T_6- castor (150 cm x 60 cm) + mungbean (1:2), T_7- castor (180 cm x 60 cm) + mungbean(1:2) and T_8- castor (180 cm x 60 cm) + mungbean (1:3).

reflecting in yield reduction. The results are in conformity with those of reported by Manukonda and Shaik, (2007); Rani, (2008); Sardana *et al*. (2008); Patel *et al*. (2009) and Ghilotia *et al*. (2015).

Different intercropping systems also influenced nutrient status of soil, nutrient uptake by castor and dry weight of weeds (Table 3). Treatment T_4- sole mungbean (40 cm x 10 cm) recorded significantly higher available N (265.50 kg/ha) and P_2O_5 (42.40 kg/ha) in soil after the harvesting of crop but, in case of available N treatment T_4 did not differ significantly with all the left over treatments except treatment T_1- sole castor (120 cm x 60 cm, while in case of available P_2O_5 treatment T_4- sole mungbean (40 cm x 10 cm) found statistically at par with treatment T_3- sole castor (180 cm x 60 cm) only. Treatment T_8- castor (180 cm x 60 cm) + mungbean (1:3) recorded highest available K_2O (408.70 kg/ha) in soil after harvest and originate statistically non-significant.Improvement in N status could be attributed to nitrogen fixation ability of the legume crops while improved P_2O_5 might be ascribed to the development of P_2O_5 solubilizing organisms in root zone of legume. Similar results were also observed by Bishnoi and Singh (1986) in Pigeonpea.

Significantly higher N uptake (56.43 kg/ha) by castor crop was recorded with treatment T_2- sole castor (150 cm x 60 cm) and found at par with treatments T_1- sole castor (120 cm x 60 cm), T_3- sole castor (180 cm x 60 cm), T_5- castor (120 cm x 60 cm) + mungbean (1:2) and T6. Significantly higher P uptake (11.42 kg/ha) by castor crop was observed in treatment T_1- sole castor (120 cm x 60 cm,) but did not differ with treatments T_2- sole castor (150 cm x 60 cm), T_3- sole castor (180 cm x 60 cm) and T_5- castor (120 cm x 60 cm) + mungbean (1:2). Treatment T_5- castor (120 cm x 60 cm) + mungbean (1:2) recorded significantly higher K uptake (52.03 kg/ha) and remained statistically at par with treatment T_1- sole castor (120 cm x 60 cm) and T_5- castor (120 cm x 60 cm) + mungbean (1:2). Treatment T_4- sole mungbean (40 cm x 10 cm) recorded significantly lowest weed dry weight (2.90 g/m2) although it remained at par with treatment T_5- castor (120 cm x 60 cm) + mungbean (1:2). This might be due to mungbean is a smoother crop which grow fast in the initial stage and utilize more resources viz., light, water, space and nutrient and finely reduce the weed population and dry weight of weeds.The results corroborate with the findings of Prasad and Verma (1986), Singh and Singh (1988) Gupta and Rathore (1993), Patel *et al*. (2009) and Singh (2009).

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EFFECT OF SIMULATED TRANSPORTATION ON PHYSICO-CHEMICAL PROPERTIES OF BER CV. UMRAN

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ABSTRACT
The work was undertaken to evaluate the effect of simulated transportation by providing different levels of vibration and time duration on physico-chemical properties of ber fruits cv. Umran during transportation and storage under ambient storage conditions. The total soluble solids, TSS: acid ratio and organoleptic rating first increased and then decreased with increase in duration of storage. The TSS, TSS: acid ratio and ascorbic acid content decreased with increased intensity and duration of vibration. The acidity of the fruits first decreased and then increased with increase in period of storage. Based upon above parameters among various levels of simulation vibration and duration of vibration, fruits without simulation vibration were best in maintaining their physico-chemical attributes whereas the simulation vibration given to the fruits up to 50 rpm for 3 and 6 hours were found effective for maintaining their organoleptic acceptability.

INTRODUCTION

The ber (*Ziziphus mauritiana* Lamk.) known as "poor man's fruit" is an important fruit crop of semi-arid regions, belongs to the family Rhamnaceae. It occupied nearly 26.31 thousand hectares of area and contributed production of 289.41 thousand MT in India during the year 2012-13 (Tiwari *et al.*, 2013).Ber is not being marketed to any far extent places where it is not grown. This is because of the absence of proper post-harvest handling technology including transportation and storage. In particular, it has been reported that the basic mechanisms involved in the fresh fruit damage are impact and vibrations experienced by the individual items of the fruit as the vehicles traverse abrupt changes in road profiles (Jones *et al.*, 1991; Olorunda and Tung, 1995; Singh and Singh, 1992).The vibrations due to transportation are influenced by road roughness, distance, traveling speed, packaging and some characteristics of the truck such as suspension and the number of axles (Vursavus and Ozguven, 2004).

Cuts, vibrations, abrasion, compression, and impacts are the main causes of mechanical damages to produce during handling and transportation. Compression damage occurs when fruits are over loaded and usually the weight of the load is supported by the product than the container in most of the fruit handling systems. Vibration damage is prominent in vehicles fitted with steel leaf-spring-suspension systems (Vigneault *et al.*, 2009). During the transportation process the vehicles transmit vibrations and jerks that cause damage to the fruits. Therefore, during long distance transportation there is needed to standardize the speed of the vehicles so that the shelf life of the fruits can be increased. In the present studies, attempts were made to know the impact of transportation on physico-chemical properties of ber by providing simulated transportation at different frequency levels for different time durations and on that basis the frequency of vibrations were standardized.

MATERIALS AND METHODS

The experiment was carried out in the post-harvest technology laboratory of Department of Horticulture, CCS Haryana Agricultural University, Hisar. Laboratory vibration tester powered with 3HP electric motor was used to provide simulation vibration with required time as per treatments. The frequency and time of which were adjusted by the frequency and time adjusting knobs respectively, as per requirement. The ber fruits of cultivar Umran were selected after harvesting and packed in nylon netted bags. Approx. 4kg fruits were packed in each of the nylon netted bags and were subjected to simulation vibration at three levels *i.e.* 50,100 and 200 rpm for 3 and 6 hour durations. The physico-chemical parameters were recorded at alternate days up to 8th day of storage after simulation vibration and fruits were stored at ambient temperature (26 ± 3^{o}C). A control (without any simulated vibration *i.e.* 0 rpm) was also taken for comparing with simulated vibration treated fruits. The seven treatments were replicated four times following the complete randomized design (CRD) and data recorded analyzed accordingly.

The TSS of the representative fruit juice was determined by using hand refractometer. The titratable acidity and ascorbic acid content was determined as per the method given by AOAC (1990). Organoleptic test of fruits was made by using nine

points hedonic rating test by a panel of five judges on the basis of colour, flavour, texture and taste.

RESULTS AND DISCUSSION

Total soluble solids (%)

The TSS content of the fruits decreased significantly with increased intensity of vibration (Table 1.1). It was observed maximum (13.60 %) in the fruits without simulation vibration followed by the fruits simulated at vibration of 50 rpm (13.31 %) and minimum TSS (12.97 %) was recorded in the fruits simulated at vibration of 200 rpm. TSS content of the fruits decreased after transportation. Similar results were reported by Lal and Fageria (2004) and Yadav *et al*. (2005).With increased duration of vibration, there was significant decrease in TSS content of the fruits. Maximum (13.32 %) TSS content was observed in the fruits exposed to simulation vibration for 3 hours, while minimum TSS (13.25 %) was observed in fruits given simulation vibration for 6 hours. The data depicted in the Table 1.2 indicated that the TSS content first increased and then decreased. The increase in TSS during storage might be due to conversion of reserved starch and other

Table 1.1: Effect of simulation transportation (duration of vibration and simulation vibration) on total soluble solids (%) of ber cv. Umran during storage at ambient temperature

SimulationPeriod(Hours)	Simulation vibration (rpm)				Mean
	0	50	100	200	
3	13.60	13.34	13.27	13.07	13.32
6	13.60	13.29	13.25	12.86	13.25
Mean	13.60	13.31	13.26	12.97	

C.D at 5 % H = 0.05 S = 0.07 H x S = 0.10

Table 1.2: Effect of simulation transportation (duration of vibration and days of storage) on total soluble solids (%) of ber cv. Umran during storage at ambient temperature

SimulationPeriod(Hours)	Days of storage					Mean
	0	2	4	6	8	
3	13.20	13.56	13.66	13.26	12.90	13.32
6	13.20	13.71	13.65	13.04	12.64	13.25
Mean	13.20	13.64	13.66	13.16	12.77	

C.D at 5 % H = 0.05 D = 0.08 H x D = 0.11

Table 1.3: Effect of simulation transportation (simulation vibration and days of storage) on total soluble solids (%) of ber cv. Umran during storage at ambient temperature

SimulationVibration (rpm)	Days of storage					Mean
	0	2	4	6	8	
0	13.20	13.38	13.70	14.05	13.68	13.60
50	13.20	13.60	13.80	13.20	12.75	13.31
100	13.20	13.68	13.94	12.96	12.53	13.26
200	13.20	13.90	13.19	12.41	12.13	12.97
Mean	13.20	13.64	13.66	13.16	12.77	

C.D at 5 % S = 0.07 D = 0.08 S x D = 0.16

Table 1.4: Effect of simulation transportation (duration of vibration, simulation vibration and days of storage) on total soluble solids (%) of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
Days	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	13.20	13.20	13.20	13.20	13.20	13.20	13.20	13.20
2	13.38	13.53	13.60	13.75	13.38	13.68	13.75	14.04
4	13.70	13.75	13.85	13.35	13.70	13.85	14.03	13.03
6	14.05	13.35	13.05	12.63	14.05	13.05	12.88	12.20
8	13.68	12.85	12.65	12.43	13.68	12.65	12.40	11.83

C.D at 5 % H = 0.05 S = 0.07 D = 0.08 H x S x D = 0.23

polysaccharides to soluble form of sugar (Gohlani and Bisen). It was also observed in ber by Bhardwaj *et.al.,* 1999 and Lal *et al.*, 2002. Further decrease in TSS might be due to fermentation of sugars during storage of fruits. It could be attributed to the utilization of TSS in respiration (Bhaviskar *et al.,* 1995 and Wasker *et al.,* 1999). Maximum TSS content (13.66 %) was observed on the 4th day of storage while, it was minimum (12.77 %) on 8th day of storage. The interaction given in the Table 1.4 indicated that the maximum TSS content (14.05 %) was observed in the fruits without simulation

Table 2.1: Effect of simulation transportation (duration of vibration and simulation vibration) on acidity (%) of ber cv. Umran during storage at ambient temperature.

Simulation Period (Hours)	Simulation vibration (rpm)				Mean
	0	50	100	200	
3	0.20	0.19	0.19	0.20	0.19
6	0.20	0.21	0.22	0.22	0.21
Mean	0.20	0.20	0.20	0.21	

C.D at 5 % H = NS S = NS H x S = NS

Table 2.2: Effect of simulation transportation (duration of vibration and days of storage) on acidity (%) of ber cv. Umran during storage at ambient temperature

Simulationperiod	Days of storage					Mean
	0	2	4	6	8	
3	0.24	0.20	0.17	0.16	0.20	0.19
6	0.24	0.22	0.19	0.19	0.22	0.21
Mean	0.24	0.21	0.18	0.17	0.21	

C.D at 5 % H = NS D = 0.01 H x D = NS

Table 2.3:Effect of simulation transportation (simulation vibration and days of storage) on acidity (%) of ber cv. Umran during storage at ambient temperature

Simulationvibration	Days of storage					Mean
	0	2	4	6	8	
0	0.24	0.22	0.19	0.15	0.17	0.20
50	0.24	0.22	0.19	0.15	0.20	0.20
100	0.24	0.21	0.18	0.17	0.22	0.20
200	0.24	0.19	0.16	0.22	0.25	0.21
Mean	0.24	0.21	0.18	0.17	0.21	

C.D at 5 % S = NS D = 0.01 S x D = NS

Table 2.4:Effect of simulation transportation (duration of vibration, simulation vibration and days of storage) on acidity (%) of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2	0.22	0.21	0.20	0.18	0.22	0.23	0.22	0.21
4	0.19	0.18	0.17	0.15	0.19	0.20	0.19	0.17
6	0.15	0.14	0.13	0.20	0.15	0.16	0.21	0.23
8	0.17	0.19	0.21	0.24	0.17	0.21	0.23	0.27

C.D at 5 % H = NS S = NS D = 0.01 H x S x D = NS

Table 3.1: Effect of simulation transportation (duration of vibration and simulation vibration) on TSS: acid ratio of ber cv. Umran during storage at ambient temperature

Simulation Period (Hours)	Simulation vibration (rpm)				Mean
	0	50	100	200	
3	72.50	72.67	73.78	66.92	71.47
6	72.51	65.44	61.77	59.54	64.81
Mean	72.50	69.05	67.78	63.23	

Table 3.2: Effect of simulation transportation (duration of vibration and days of storage) on TSS: acid ratioof ber cv. Umran during storage at ambient temperature

SimulationPeriod (Hours)	Days of storage					Mean
	0	2	4	6	8	
3	55.00	67.48	80.62	88.91	65.33	71.47
6	55.00	62.95	73.67	73.13	59.32	64.81
Mean	55.00	65.22	77.14	81.02	62.32	

Table 3.3: Effect of simulation transportation (simulation vibration and days of storage) on TSS: acid ratio of ber cv. Umran during storage at ambient temperature

Simulation Vibration (rpm)	Days of storage 0	2	4	6	8	Mean
0	55.00	60.31	73.50	93.87	79.85	72.50
50	55.00	63.13	73.83	88.71	64.58	69.05
100	55.00	65.37	78.05	83.93	56.54	67.78
200	55.00	72.05	83.20	57.56	48.32	63.23
Mean	55.00	65.22	77.14	81.02	62.32	

Table 3.4: Effect of simulation transportation (duration of vibration, simulation vibration and days of storage) on TSS: acid ratio of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00
2	60.31	66.00	68.09	75.52	60.31	60.27	62.65	68.58
4	73.50	78.89	80.88	89.21	73.50	68.77	75.22	77.19
6	93.87	93.94	105.38	62.44	93.87	83.48	62.47	52.69
8	79.85	69.51	59.55	52.41	79.85	59.66	53.53	44.24

Table 4.1: Effect of simulation transportation (duration of vibration and simulation vibration) on ascorbic acid content (mg/100 g) of ber cv. Umran during storage at ambient temperature

Simulation Period (Hours)	Simulation vibration (rpm) 0	50	100	200	Mean
3	69.28	68.52	67.19	64.72	67.43
6	69.28	67.29	65.41	61.38	65.84
Mean	69.28	67.90	66.30	63.05	

C.D at 5 % H = 0.31 S = 0.44 H x S = 0.62

Table 4.2: Effect of simulation transportation (duration of vibration and days of storage) on ascorbic acid content (mg/100 g) of ber cv. Umran during storage at ambient temperature

SimulationPeriod (Hours)	Days of storage 0	2	4	6	8	Mean
3	76.63	72.85	67.09	63.14	57.41	67.43
6	75.15	72.05	65.90	60.64	55.45	65.84
Mean	75.89	72.45	66.50	61.89	56.43	

C.D at 5 % H = 0.31 D = 0.49 H x D = 0.69

Table 4.3: Effect of simulation transportation (simulation vibration and days of storage) on ascorbic acid content (mg/100g) of ber cv. Umran during storage at ambient temperature

SimulationVibration (rpm)	Days of storage 0	2	4	6	8	Mean
0	79.23	72.58	69.08	65.40	60.09	69.28
50	77.46	73.17	68.00	62.32	58.57	67.90
100	75.09	72.02	66.84	62.13	55.43	66.30
200	71.78	72.02	62.06	57.71	51.65	63.05
Mean	75.89	72.45	66.50	61.89	56.43	

C.D at 5 % S = 0.44 D = 0.49 S x D = 0.98

vibration while minimum TSS (11.83 %) was observed on the 8th day in the fruits simulated at vibration of 200 rpm for 6 hours.

Acidity (%)

The acidity content of the ber fruits in cv. Umran did not differed significantly with increased intensity of vibration and duration of vibration (Table 2.1). The acidity content of the fruits first decreased and then increased (Table 2.2). The decrease in acidity might be due increased rate of respiration (Kapse *et al.*, 1977) or could be due to conversion of acids into salts and sugars by invertase enzyme (Hawker, 1968). The increase in acidity might be due to water loss from the fruits during storage (Hifney and Abdel, 1977). Acidity of the fruits first decreased up to 6th day and then it increased up to 8th day of storage. Minimum acidity (0.17%) was recorded in the fruits on 6th day which is at par with the 4th day of storage, while it was maximum (0.24%) on zero day. The acidity

Table 4.4: Effect of simulation transportation (duration of vibration, simulation vibration and days of storage) on ascorbic acid content (mg/ 100 g) of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	79.23	78.14	76.05	73.11	79.23	76.77	74.13	70.46
2	72.58	73.35	72.65	72.83	72.58	73.00	71.40	71.22
4	69.08	68.71	67.18	63.38	69.08	67.29	66.50	60.75
6	65.40	62.77	63.58	60.82	65.40	61.88	60.68	54.61
8	60.09	59.61	56.51	53.46	60.09	57.52	54.35	49.84

C.D at 5 % H = 0.31 S = 0.44 D = 0.49 H x S x D = NS

Table 5.1: Effect of simulation transportation (duration of vibration and simulation vibration) on organoleptic quality of ber cv. Umran during storage at ambient temperature

Simulation Period (Hours)	Simulation vibration (rpm)				Mean
	0	50	100	200	
3	7.2	6.9	6.0	5.1	6.3
6	7.2	6.6	5.4	4.5	5.9
Mean	7.2	6.8	5.7	4.8	

Table 5.2: Effect of simulation transportation (duration of vibration and days of storage) on organoleptic quality of ber cv. Umran during storage at ambient temperature

SimulationPeriod (Hours)	Days of storage					Mean
	0	2	4	6	8	
3	7.4	7.8	6.8	5.5	3.8	6.3
6	7.4	7.7	6.4	5.0	3.0	5.9
Mean	7.4	7.8	6.6	5.2	3.4	

Table 5.3: Effect of simulation transportation (simulation vibration and days of storage) on organoleptic quality of ber cv. Umran during storage at ambient temperature

Simulation Vibration (rpm)	Days of storage					Mean
	0	2	4	6	8	
0	7.4	8.1	8.5	6.8	5.0	7.2
50	7.4	7.8	8.1	6.3	4.2	6.8
100	7.4	7.7	5.6	4.8	2.8	5.7
200	7.4	7.6	4.3	3.0	1.6	4.8
Mean	7.4	7.8	6.6	5.2	3.4	

Table 5.4: Effect of simulation transportation (vibration and days of storage) on organoleptic quality of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
2	8.1	7.9	7.8	7.7	8.1	7.7	7.6	7.5
4	8.5	8.2	6.0	4.5	8.5	8.0	5.2	4.0
6	6.8	6.5	5.2	3.6	6.8	6.1	4.5	2.4
8	5.0	4.5	3.5	2.2	5.0	3.8	2.1	1.1

decreased after transportation of the fruits. This decline in acidity after transportation and during storage might be due to rapid utilization of organic acids in the energy production and alcoholic fermentation. The results are in close agreement with Bisen *et al*. (2014).The interaction of duration of vibration, simulation vibration intensity and days of storage was found non-significant (Table 2.4).

TSS: acid ratio

The TSS to acid ratio decreased with increase intensity of vibration (Table 3.1). Maximum TSS: acid ratio (72.50) was recorded in the fruits without simulation vibration followed by the fruits simulated at vibration of 50 rpm (69.05). The ratio was observed minimum (63.23) in the fruits simulated at vibration of 200 rpm. It also decreased with increased duration

of vibration. Maximum ratio (71.47) was found in the fruits given simulation vibration for 3 hours, while the minimum ratio (64.81) was found in the fruits rendered to simulation vibration for 6 hour. The TSS: acid ratio increased then it decreased (Table 3.2). Initial increase in TSS: acid ratio might be due to the fact that there was continuous increase in TSS and decrease in acidity of the fruits which resulted in increased TSS-acid ratio. At later stages decline in TSS: acid ratio might be due to continuous decrease in TSS and increase in acidity of the fruits. Similar findings were reported by Kaur *et. al.* (2013) in pear. It increased up to 6th day of storage and there after it decreased. The maximum TSS: acid ratio (81.02) was recorded in the fruits on 6th day of storage, while it was minimum (55.00) on zero day of storage. The interaction given in the Table 3.4 indicated that the maximum TSS: acid ratio (105.38) was observed in the fruits that simulated at 100 rpm for 3 hours on 6th day, whereas minimum ratio (44.24) was found in the fruits that were given simulation at vibration of 200 rpm for 6 hours on 8th day of storage.

Ascorbic acid content (mg/100 g)

The data given in the Table 4.1 indicated that there was significant decrease in ascorbic acid content of the fruits with increased intensity of vibration. Maximum of ascorbic acid content (69.28 mg/100g) was observed in the fruits without simulation vibration followed by the fruits simulated at vibration of 50 rpm (67.90 mg/100g). The minimum ascorbic acid content (63.05 mg/100g) was observed in fruits simulated at vibration of 200 rpm. With increase in the duration of vibration there was decrease in ascorbic acid content of the fruits. Maximum ascorbic acid (67.43 mg/100g) was retained in the fruits given simulation vibration for 3 hours. It was found minimum (65.84 mg/100g) in the fruits employed simulation vibration for 6 hours. Further, there was significant decrease in the ascorbic acid content with storage (Table.4.2). This could be due to the oxidation and irreversible conversion of ascorbic acid to dehydro-ascorbic acid in the presence of enzyme ascorbinase. Similar results were also found by Yadav *et al.* (2005) in ber and Das and Dash (1967) in mosambi fruits. The maximum ascorbic acid content retention (75.89 mg/100g) was observed on the zero day followed by 2nd day (72.45 mg/100g) and minimum (56.43 mg/100g) was observed on the 8th day. The interaction (Table 4.4) of duration of vibration, simulation vibration and days of storage showed no significant effect on the ascorbic acid content of the fruits.

Organoleptic rating

Organoleptic rating differed with increased period of storage. The rating decreased with increased intensity of vibration (Table 5.1). Maximum oraganoleptic rating (7.2) was attained by the fruits without simulation followed by the fruits simulated at 50 rpm (6.8). The fruits simulated at vibration of 200 rpm were rated minimum (4.8). Organoleptic rating also decreased with increased duration of vibration. Maximum rating (6.3) was observed in the fruits which were given simulation vibration for 3 hours while minimum rating (5.9) was observed in the fruits given simulation vibration for 6 hours. The data indicated in the Table 5.2 indicated that the organoleptic rating first increased then decreased with increased period of storage. The initial increase in organoleptic rating may be due to ripening of the fruits from green mature stage to optimum state, improvement in texture, TSS, TSS: acid ratio and total sugars. At later stages, reduction in organoleptic rating could be attributed to over ripening, loss of texture and decrease in biochemical attributes like TSS and total sugars. The results are in close agreement with Yadav *et al.* (2005) in ber. Organoleptic rating was maximum (7.8) on 2nd day and it was minimum on 8th day of storage (3.4). The interaction given in the Table 5.4 indicated that the maximum organoleptic rating (8.5) was observed on 4th day in the fruits without simulation while minimum rating (1.1) was noted on the 8th day in the fruits simulated at vibration of 200 rpm for 6 hours

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EFFECT OF WEED MANAGEMENT PRACTICES ON GROWTH AND YIELD OF PIGEONPEA [*CAJANUS CAJAN* (L.) MILLSP.]

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ABSTRACT
A field experiment was conducted during *kharif*, 2014 at Agriculture Research Station, Almel to evalvate the optimum dosage and efficacy of new molecules of herbicides used alone or in combination with cultural methods for better management of weeds in pigeon pea. Ten treatments were replicated thrice in Randomized Complete Block Design (RCBD). Significantly higher seed and stalk yield of pigeon pea was recorded in the treatment which received application of pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* imazethapyr + imaza mox 70% WG (POE) @ 70 g a.i. ha^{-1} and one inter cultivation at 60 DAS (19.31 and 44.42 q ha^{-1}, respectively). Growth parameters viz., plant height (143. 93 cm), number of primary branches (14.50), total dry matter (136.74 g $plant^{-1}$) and yield parameters like number of pods per plant (128.43 $plant^{-1}$) and 100 seed weight (12.60 g) of pigeonpea were also increased significantly with application of pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i. ha^{-1} and one intercultivation at 60 DAS as compared to weedy check. Combination of pre and post emergence herbicides along with manual/mechanical method of weed control has resulted in significant increase in growth and yield of pigeonpea.

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of the important pulse crops in the world and widely grown throughout the tropics in Africa, America, Australia, Hawaii, West Indies, Srilanka and China. Pigeonpea is commonly known as red gram, *tur* or *arhar* and it is the fifth prominent legume crop in the world and second in India after chickpea occupying 14.5 per cent of area and 15.5 per cent of total pulse production (Mishra *et al*., 2011). In India, it occupies an area of 3.90 m ha with a production of 3.38 m t and average productivity of 871 kg per ha which is far below the world's average productivity (1049 kg ha^{-1}). In Karnataka, it occupies an area of 0.66 m ha with a production of 0.63 m t and average productivity is 950 kg per ha (Anon., 2013).

Pigeonpea is grown during *kharif* season after the onset of monsoon. Sole pigeonpea gets heavily infested with weeds due to wider row and plant to plant spacing; these weeds compete with pigeonpea for growth factors like nutrients, moisture and gave shelter to insect pests. The yield loss in sole pigeonpea due to weeds was 32 to 90 % (Talnikar *et al*., 2008). The critical period of crop weed competition is during the first eight weeks after sowing. Therefore, it is imperative to manage weeds at proper time with suitable methods to obtain maximum grain yield. Weeding by mechanical methods is very common and sometimes these methods becomes very difficult to accomplish because of frequent rains coupled with non-availability of labours in time. Under such conditions, use of herbicides to control the weeds is only the best option to reduce the losses caused by weeds (Manu, 2013). In many advanced countries, herbicide usage for control of weeds in crop lands has been proved successful and is now gaining importance in Indian agriculture. With this background the present study was undertaken to give an efficient weed management package to the pigeonpea growing farmers in order to achieve better yields under rain fed conditions.

MATERIALS AND METHODS

A field experiment to find out the optimum dosage and efficacy of different herbicides used alone or in combination with cultural methods for better management of weeds in pigeonpea during *kharif*, 2014 at Agriculture Research Station, Almel. The soil of experiment site is medium deep black soil having pH 7.90 with low in available nitrogen (154.00 Kg ha^{-1}), medium in available phosphorous (24.00 Kg ha^{-1}) and potassium (287 Kg ha^{-1}) status.

The treatments comprised of Pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* two inter cultivations (30 and 60 DAS), Pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) imazethapyr 10% SL @ 100 g a.i. ha^{-1} (POE) and one inter cultivation at 60 DAS, Pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i. ha^{-1} and one inter cultivation at 60 DAS, Oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* two inter cultivations (30 and 60 DAS), Oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* imazethapyr 10% SL @ 100 g a.i. ha^{-1} (POE) and one inter cultivation at 60 DAS, Oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i. ha^{-1} and one inter cultivation at 60 DAS, RPP (Pendimethalin 30% E.C @ 1.0 kg a.i ha^{-1} (PE) + one inter cultivation at 25 DAS), Farmers practice (One hand weeding at 25 DAS and two inter

cultivations at 45 and 60 DAS), weed free and weedy check treatments replicated thrice under Randomized Complete Block Design (RCBD). The required amount of herbicides for the experimentation was calculated by using the following formula.

$$F = \frac{R \times 100 \times A}{\text{Purity } \% \times 10{,}000}$$

Where,

F = Formulated product required in kg or litre ha^{-1}.

R = Dose in a.i. kg ha^{-1} to be sprayed (recommended rate).

A = Area to be sprayed (m^2).

The calculated amount of herbicide was sprayed to each treatment using knapsack sprayer with flat fan nozzle WFS 72 with a spray volume of 750 litres of water per ha. The pre-emergence herbicides *viz*., pendimethalin and oxyfluorfen were sprayed uniformly one day after sowing of the crop. The post emergence herbicides *viz*., imazethapyr and imazethapyr + imazamox (combi product) were applied uniformly when weeds were at 3-4 leaf stage as per the treatment. Hand weeding was carried out on bunds side and paths whenever the weeds emerged in order to keep the experimental site clean. Hand weeding and inter cultivation was done as per the treatment requirement. The data on growth parameters, dry matter production and its distribution were recorded from 5 randomly selected plants at 30, 60, 90 and 120 days after sowing. Other biometric observations (yield and yield parameters) are taken as per the standard procedure. The crop was sown on 14th July 2014 and harvested on 20th December 2014.

RESULTS AND DISCUSSION

Effect on growth parameters

Weed free and weedy check treatments recorded significantly higher and lower growth parameters viz., plant height, number of primary branches and total dry matter production. Among different weed management treatments, application of pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i. ha^{-1} and one inter cultivation at 60 DAS recorded significantly higher plant height (13. 93 cm), number of primary branches (14.50) and total dry matter production (136.74 g $plant^{-1}$) and it was on par with treatment which received farmers practice (One hand weeding at 25 DAS and two inter cultivations at 45 and 60 DAS) (141.33 cm, 11.93 and 117.49 g $plant^{-1}$, respectively) and application of oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i. ha^{-1} and one inter cultivation at 60 DAS (141.07 cm, 12.07 and 127.59 g $plant^{-1}$, respectively) (Table 1). Increase in growth parameters was due to the reduced weed infestation in early stage of crop and resulted in less competition between crop and weed for growth factors. All these have to be enabled the crop to draw more nutrients and moisture during pre-flowering stage finally leading to more primary branches per plant (Basavraj Kumbar *et al*. 2014). More number of leaves per plant has higher photosynthetic area, accumulates more dry matter in plant parts and resulted in higher total dry matter content. This is in line with the findings of Yadav and Singh (2009).

Effect on yield and yield parameters

Weed free and weedy check treatments recorded significantly higher and lower yield & yield attributing parameters. Among different weed management treatments, significantly higher seed and stalk yield was recorded in treatment which received application of pendimethalin 38.7% C.S @ 1.0 kg a.i ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i ha^{-1} and one inter cultivation at 60 DAS (19.31 and 44.42 q ha^{-1}, respectively) (Table 2). Significantly higher seed and stalk yield in these treatments were attributed due to application of herbicides controlled the weeds in early growth stages of crop and followed by inter cultivation at 60 DAS efficiently controlled post emergent weeds in later stages and it has created

Table 1: Effect of different weed management practices on growth parameters of pigeonpea

Treatment	Plant height at 120 DAS (cm)	No. of primary branches at 90 DAS	Total dry matter production (g) at 120 DAS
T_1:Pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* two intercultivations (30 and 60 DAS)	131.30	10.40	96.31
T_2:Pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* imazethapyr 10% SL @ 100 g a.i ha^{-1} (POE) and one intercultivation at 60 DAS	132.50	11.07	98.82
T_3:Pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i ha^{-1} and one inter cultivation at 60 DAS	143.93	14.50	136.74
T_4: Oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* two inter cultivations (30 and 60 DAS)	129.07	10.30	88.78
T_5: Oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* imazethapyr 10% SL @ 100 g a.i. ha^{-1}(POE) and one inter cultivation at 60 DAS	138.87	11.60	107.95
T_6: Oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i ha^{-1} and one inter cultivation at 60 DAS	141.07	12.07	127.59
T_7: RPP (Pendimethalin 30% E.C @ 1.0 kg a.i ha^{-1} (PE) + one inter cultivation at 25 DAS)	125.77	9.80	76.07
T_8: Farmers practice (One hand weeding at 25 DAS and two inter cultivations at 45 and 60 DAS)	141.23	11.93	117.49
T_9: Weed free check	150.63	15.07	158.57
T_{10}: Weedy check (Control)	98.20	7.33	63.73
S.Em ±	3.48	0.93	8.55
C.D.at 5%	10.17	2.71	24.97

*DAS = days after sowing, PE = pre emergence, POE = post emergence, *fb* = followed by

Table 2: Effect of different weed management practices on yield and yield parameters of pigeonpea

Treatment	No. of pods plant^{-1}	100 seed weight (g)	Seed yield (q ha$^{-1)}$	Stalk yield (q ha^{-1})
T_1:Pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* two intercultivations (30 and 60 DAS)	101.40	11.80	15.61	36.74
T_2:Pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* imazethapyr 10% SL @ 100 g a.i.ha^{-1} (POE) and one intercultivation at 60 DAS	110.57	11.80	16.85	39.58
T_3:Pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i. ha^{-1} and one intercultivation at 60 DAS	128.43	12.60	19.31	44.42
T_4: Oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* two intercultivations (30 and 60 DAS)	91.13	11.43	12.08	29.52
T_5: Oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* imazethapyr 10% SL @ 100 g a.i. ha^{-1} (POE) and one intercultivation at 60 DAS	115.67	11.93	15.12	37.47
T_6: Oxyfluorfen 23.5% E.C @ 125 g a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i. ha^{-1} and one intercultivation at 60 DAS	123.73	12.30	17.98	42.58
T_7: RPP (Pendimethalin 30% E.C @ 1.0 kg a.i ha^{-1} (PE) + one intercultivation at 25 DAS)	87.80	10.97	11.52	28.25
T_8: Farmers practice (One hand weeding at 25 DAS and two intercultivations at 45 and 60 DAS)	121.40	12.33	17.80	41.18
T_9: Weed free check	137.33	12.60	20.94	48.45
T_{10}: Weedy check (Control)	60.27	9.40	6.50	16.19
S.Em ±	8.47	0.46	1.37	1.78
C.D.at 5%	24.73	1.34	4.01	5.21

*DAS = days after sowing, PE = pre emergence, POE = post emergence, *fb* = followed by

a congenial conditions for crop to come up well under weed free situation and resulted in higher yield. This was evidenced from the findings of (Channappagoudar and Biradar, 2007 and Vyas *et al.,* 2003). Higher nutrient uptake by crop due to selective nature of herbicide during early growth stage of the crop minimized the crop-weed competition (Basavraj Kumbar *et al.,* 2014). Thus crop plants might have used available resources effectively throughout the crop growth stages resulting in higher seed and stalk yield. Results obtained in this study are in conformity with findings of Poonia and Pithia (2013).Yield parameters like number of pods per plant and 100 seed weight were significantly higher in treatment which received application of pendimethalin 38.7% C.S @ 1.0 kg a.i. ha^{-1} (PE) *fb* imazethapyr + imazamox 70% WG (POE) @ 70 g a.i. ha^{-1} and one inter cultivation at 60 DAS (128.43 plant^{-1}and 12.60 g, respectively). It was due to higher primary branches having more flowers per plant and resulted in more pod formation per plant. This also confirms the earlier findings of Nagaraju and Mohankumar (2009). The higher 100 seed weight is due to more seed size as evidenced by better utilization of resources by the crop, because of weed suppression (Chauhan *et al.,* 1999). The findings are in line with the results of Veeresh Hatti *et al*. (2014). Pigeonpea yields can be increased significantly to the tune of 30 per cent more by adopting this combination of cultural method with pre and post emergent herbicides application at right periods of crop growth.

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QUALITY IMPROVEMENT IN PLUM THROUGH CPPU AND POTASSIUM IN THE NORTH WEST PLAINS OF INDIA

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ABSTRACT
Fruit size, weight, colour, TSS, acidity, TSS/acid ratio and total sugars is important components for the fruit quality of plum. By improving these parameters we can improve the quality of fruits. Foliar spray of CPPU (2.5 ppm and 5.0 ppm) and potassium salts (KNO_3 and K_2SO_4) at 1 per cent and 2 per cent were done at 7 DAFB and 14 DAFB on 12 year old plum plants. In this experiment we noted that all the CPPU treatments significantly increased fruit size and fruit weight whereas KNO_3 treatments improved colour, TSS, acidity, TSS/acid ratio and total sugars which contributed in the fruit quality of plum cv. Satluj Purple. According to this experiment we find the conclusion that fruit weight and size was maximum under CPPU 5.0 ppm 7 DAFB (36.13 g and 3.54 cm and 3.32 cm) length and breadth respectively and other quality parameters was maximum in KNO_3 2% 7 DAFB and is the best treatment in TSS (12.48%), tss/acid ratio (18.35%), total sugars (7.52%), acidity (0.68%) and fruit colour (16.80 and 7.21) a and b value respectively.

INTRODUCTION

Plum (*Prunus domestica* L.) is relatives of the peach, nectarine, plum and almond is considered as one of the most popular fruit found in Himalayan region of Darjeeling and Sikkim. Traditionally plums are growing in Darjeeling and Sikkim and mostly produced plums are used for fresh consumption, but very small quantities are processed into juices (Sherpa *et al.,* 2014). Plants like (*Prunus ferrugineum*) containing high total phenol and flavonoid contents can be considered as a medicinal source for the treatment and prevention of many free radical related diseases (Chanda *et al.,* 2013).

The cultivated plum belongs to two species, viz., *Prunus domestica* L. (European plum) and *Prunus salicina* L. (Japanese plum). The European plums require high chilling, have deep purple/blue skin, yellow flesh, oval/round shape and are free/ clingstone whereas Japanese plums require low chilling, have light to deep red skin, red to yellow flesh and are semi free/ clingstone. Most of the plum cultivars are self unfruitful and require cross-pollination. Satluj purple is the only plum variety which is recommended for planting in the sub-tropics of north India. It is self unfruitful and requires Kala Amritsari as a pollinizer. Fruit size is an important component of fruit quality in plum. Pruning of fruiting wood, thinning of flowers and fruits are generally used to reduce the crop load on the tree and increase fruit size and quality. Foliar application of certain bio-regulators and chemicals like CPPU and potassium salts is another practice which is gaining popularity for increasing fruit size and improving the quality of fruits in temperate fruit plants. Havlin *et al*. (2007) reported that the increased in quality (TSS and colour) with foliar application of K is related with role of potassium in translocation of sugars from leaves to fruits. Shirzadeh and Kazemi (2011) reported that increase in TSS content with foliar application of potassium in apple. Karim and Neven (2012) concluded that GA_3 combined with potassium sulphate had a significant effect on TSS and it was observed in 'Nova' tangerines. Pathak and Mitra (2010) found lowest amount of fruit acidity (0.31%), highest Brix/acid ratio (64.01%) and highest ascorbic acid content (49.67 mg 100 g/ aril) with the application of 600 g potassium in litchi. These results are also same as that of our results like potassium increases the TSS, colour, TSS/acid ratio and decrease acidity and CPPU increased fruit size and fruit weight by causing cell division and cell elongation in fruits. So there is a need to check the effect of potassium and CPPU on the quality of plum fruits because there is very less of few studies done on the effect of CPPU and potassium under different doses and time of application. To improve the prospects of plum cultivar in the state, it is essential to produce the marketable size fruits of good colour and quality. Keeping this view, the present studies were conducted to improve the quality of plum through the use of CPPU and potassium and related to this experiment.

Our objectives of this experiment are-

To optimize the ideal time and dose of CPPU and potassium in plum.

To determine the effect of CPPU and potassium on the fruit quality of plum.

MATERIALS AND METHODS

The present studies were conducted at PAU Farm Orchard, Ladhowal during the year 2014. The orchard soil was deep,

well drained and loamy sand. All the trees received recommended doses of fertilizers (FYM 36 kg, Urea 360 g, SSP 570 g and MOP 360 g) and other cultural practices along with plant protection measures during the course of this study. Foliar sprays of CPPU (N-(2-chloro-4-pyridyl)-N'-phenylurea) @ 2.5 ppm and 5.0 ppm and potassium salts (KNO_3 and K_2SO_4) at 1 per cent and 2 per cent were done at 7 days after full bloom and 14 days after full bloom on 12 year old plum trees. Hand thinning was done during second week of March before pit hardening stage keeping 5-8 cm distance between fruits. Observations were recorded regarding physiochemical characteristics of plum fruits determined by using standard procedure (AOAC 1985).

Fruit weight (g)

The weight of 10 randomly selected fruits was recorded in grams and mean weight per fruit for each treatment as worked out.

Fruit size (cm)

Length and diameter across the cheeks of ten randomly selected mature fruits were taken with the help of weighing balance and means are worked out.

Fruit colour

The fruit colour was recorded with the help of colour difference meter (Model: Mini Scan XE Plus, Made: Hunter lab, USA) and expressed as a, b Hunter Colour values (Hunter 1975).

Total soluble solids (%)

Freshly extracted and thoroughly strained juice of ten fruits were taken out for determining TSS. The readings were recorded with the help of Bausch and Lamb hand refracto meter (0-32 per cent).

Titratable acidity (%)

Two ml of strained juice was diluted to 20 ml distilled water and then titrated against 0.1 N NaOH using phenolphthalein as an indicator. The appearance of pink coloured marked the end point. The acidity was expressed in terms of anhydrous malic acid by using following formulae:

$$\text{Acidity}(\%) = \frac{0.0067 \times \text{Volume of NaOH used}}{\text{Volume of juice taken}} \times 100$$

TSS/ Acid ratio

TSS/acid ratio was calculated by dividing the value of TSS with that of corresponding titratable acidity.

Total sugars (%)

10 gm of meshed pulp was taken in a 100 ml beaker and volume was made upto the mark with distilled water. 1 g of lead acetate was added for precipitation and allowed to stand for one and half hour. Then 1 g potassium oxalate was added to remove excess of lead and solution was filtered.

25 ml of the above filtered content were pipetted out in a 100 ml flask and to this, 25 ml distilled water and 5 ml HCL (60% by volume) was added and left for overnight at room temperature for acid hydrolysis. The flasks were heated on a water bath in such a way that the temperature rose to 68°C in 10 minutes flasks. Flasks were kept at 68°C for another 5 minutes. A piece of litmus paper was put into the flask and sugars were neutralized with 10 per cent NaOH in the initial stages and 0.1 N NaOH near the neutralization point. Fehling solution A and Fehling solution B were taken in another volumetric flasks and placed on the hot plate. Then titration with neutralized solution containing sugar was done using methylene blue as an indicator. The end point was recorded with the appearance of brick red colour. Total sugar was expressed in percentage by using following formulae:

$$\text{Total sugar}\% = \frac{\text{Fehling Factor (0.05)}}{\text{Volume of filtrate used}} \times \frac{\text{Dilution made}}{\text{Weight of sample used}} \times \frac{\text{Final volume made}}{\text{Volume of filtrate taken}} \times 100$$

RESULTS AND DISCUSSION

Fruit weight and size

The data presented in Table 1 reveals that fruit weight and size of all the treatments were significantly higher than control in the present investigations. Maximum fruit weight (36.13 g) and size (3.54 cm length and 3.32 cm breadth) was recorded in CPPU 5.0 ppm applied 7 DAFB and it was statistically at par with all the CPPU treatments used in the present studies. KNO_3

Table 1: Effect of CPPU and potassium on physical parameters of plum cv. Satluj Purple.

Treatments	Fruit weight(g)	Fruit size(cm) length	breadth	Fruit colour a	b
CPPU 2.5 ppm 7 DAFB	35.80	3.53	3.32	9.39	13.80
CPPU 5.0 ppm 7 DAFB	36.13	3.54	3.32	9.33	13.83
CPPU 2.5 ppm 14 DAFB	35.10	3.42	3.23	9.17	14.04
CPPU 5.0 ppm 14 DAFB	36.04	3.44	3.24	9.05	14.48
KNO_3 1% 7 DAFB	33.27	3.35	3.13	16.40	7.70
KNO_3 2% 7 DAFB	34.05	3.37	3.12	16.80	7.21
KNO_3 1% 14 DAFB	32.26	3.03	2.94	15.20	8.12
KNO_3 2% 14 DAFB	33.78	3.12	3.01	15.64	7.74
K_2SO_4 1% 7 DAFB	31.59	2.97	2.93	14.34	8.76
K_2SO_4 2% 7 DAFB	31.70	3.01	2.94	13.07	9.75
K_2SO_4 1% 14 DAFB	31.21	2.91	2.90	13.74	9.43
K_2SO_4 2% 14 DAFB	31.12	2.90	2.86	14.38	8.38
Hand thinning	33.00	3.23	3.04	13.58	9.65
Control	29.47	2.76	2.66	10.03	12.65
CD at 5 %	1.33	0.14	0.13	1.94	1.60

Table 2: Effect of CPPU and potassium on chemical parameters of plum cv. Satluj Purple

Treatments	TSS (%)	ACIDITY (%)	TSS/ACID RATIO (%)	TOTAL SUGARS (%)
CPPU 2.5 ppm 7 DAFB	9.88	0.73	13.53	5.76
CPPU 5.0 ppm 7 DAFB	9.75	0.75	13.00	5.63
CPPU 2.5 ppm 14 DAFB	9.57	0.74	12.93	5.33
CPPU 5.0 ppm 14 DAFB	9.27	0.75	12.36	5.23
KNO_3 1% 7 DAFB	12.45	0.68	18.30	7.45
KNO_3 2% 7 DAFB	12.48	0.68	18.35	7.52
KNO_3 1% 14 DAFB	12.17	0.68	17.89	7.26
KNO_3 2% 14 DAFB	12.30	0.67	18.35	7.37
K_2SO_4 1% 7 DAFB	11.30	0.70	16.14	6.49
K_2SO_4 2% 7 DAFB	11.90	0.72	16.52	6.72
K_2SO_4 1% 14 DAFB	11.00	0.72	15.71	6.20
K_2SO_4 2% 14 DAFB	11.07	0.71	15.59	6.42
Hand thinning	11.00	0.71	15.49	6.18
Control	10.03	0.75	13.19	5.87
CD at 5 %	0.64	0.02	1.19	0.45

and hand thinning treatments also recorded higher fruit weight and size than the K_2SO_4 treatments and control. Minimum fruit weight (29.47 g) and size (2.76 cm length and 2.66 cm breadth) was found in control. These results are in accordance with those reported by Caixi *et al*. (2007) and Kim *et al*. (2006) who found that CPPU was effective in enhancing fruit weight in pear and kiwifruit, respectively by stimulating cell division and cell expansion. Kittiwatsopon and Karintanyakit (2014b) also found that 5 ppm CPPU applied seven days before flowering or 10 ppm CPPU applied seven days after full bloom increased berry size in grape cv. Perlette. Serri and Hepp (2011) revealed that there was an increase in berry size with the application of CPPU in 'High Bush' Blueberries.

Fruit colour

Colour values 'a' and 'b' represent the intensity of red and green colour of fruits, respectively. The maximum 'a' value (16.80) was recorded in the fruits treated with 2% KNO_3 applied 7 DAFB and it was statistically at par with fruits of 1% KNO_3 applied 7 DAFB (16.40) and KNO_3 1% and 2% applied 14 DAFB (15.20 and 15.64). The 'a' values of all the KNO_3 treatments were significantly higher than the 'a' values of all other treatments. The 'a' values of K_2SO_4 and hand thinning treatment were also statistically at par and significantly higher than CPPU treated and control fruits. Minimum 'a' value was recorded in CPPU treated fruits. The 'b' value was found to be maximum in CPPU treatments and it was significantly higher than all other treatments but statistically at par with control. Minimum 'b' values were recorded in KNO_3 treatments followed by K_2SO_4 treatments. The examination of data reveals that maximum intensity of red colour was noted in KNO_3 treatments and minimum in CPPU treatments whereas maximum intensity of green colour was found in CPPU treatments and minimum in KNO_3 treatments. The potassium spray positively affected the peel colour development in plum and more anthocyanin accumulation whereas inverse effect was observed with CPPU applications. The change in fruit colour depends upon the degradation of chlorophyll content and accumulation of colouring pigments like anthocyanins and carotenoids. Thakur *et al*. (2006) reported that berry colour was improved in Perlette grape by K_2SO_4 sprays. Peppi *et al*. (2008) found that clusters treated with CPPU in combination with ABA (300 or 600 mg/l at verasion) had higher anthocyanin content and better fruit colour than clusters treated only with CPPU in grape berries.

TSS, acidity and TSS/acid ratio

The data on these aspects are presented in Table 2. The data shows that treatments had a significant effect on TSS and acid content of plum fruits. Highest TSS (12.48 %) and lowest acidity (0.67%) was recorded when KNO_3 2 % was applied 7 DAFB closely followed by KNO_3 1 % applied 7 DAFB and KNO_3 1 % and 2% applied 14 DAFB. K_2SO_4 and hand thinning treatments also recorded higher TSS and lower acidity than CPPU and control. Lowest TSS and highest acid content was found in CPPU treated fruits. The TSS/acid ratio was also found to be maximum in KNO_3 treatments followed by K_2SO_4 and hand thinning and minimum in CPPU treatments. The reduction in TSS with CPPU treatments has also been reported in grapes by Reynolds *et al* (1992) and in kiwi fruit by Kim *et al* (2006). Less TSS recorded in CPPU treatments could be due to the reason that large size fruits might have exerted a diluting effect on TSS or caused a competition for carbohydrates among fruits. The maximum increase in TSS with KNO_3 and K_2SO_4 might be due to translocation of carbohydrates as a result of maintenance of assimilating power of leaves over a longer period. Increase in TSS could also be due to higher level of applied potassium as potash is helpful in the synthesis of large amounts of the carbohydrates, which increase the sweetness of the fruits. Kittiwatsopon and Karintanyakit (2014b) reported that 5 ppm CPPU applied seven days before flowering or 10 ppm CPPU applied seven days after full bloom increased acidity in grape cv. Perlette. Gill *et al* . (2012) reported that reduction in the acidity under potassium treatment might be owing to increased TSS of the fruits in pear cv. Patharnakh. Yadav *et al*. (2013) reported that the effect of the potassium compounds on TSS and ascorbic acid was significant with 2% K_2SO_4 as compared to other potassium compounds in ber cv. 'Banarasi Karaka'. Pathak and Mitra (2010) found lowest amount of fruit acidity (0.31%), highest Brix/acid ratio (64.01%) and highest ascorbic acid content (49.67 mg 100 g/aril) with the application of 600 g potassium in litchi

Total sugars

The data presented in Table 2 further shows that KNO_3, K_2SO_4

and hand thinning treatment significantly increased total sugars over control in plum. The KNO_3 2% applied 7 DAFB recorded maximum total sugar (7.52%) closely followed by KNO_3 2% applied 14 DAFB (7.37%) and KNO_3 1% applied 7 DAFB and 14 DAFB (7.45% and 7.26%, respectively). The next best treatment was found to be K_2SO_4 1% and 2% applied 7 DAFB. Minimum total sugars were recorded in CPPU treatments and control. Kim *et al*. (2006) reported that CPPU has tendency to delay fruit maturity and degradation of starch in the fruits. The reduction in sugar content in grapes due to CPPU application has been reported by Reynolds *et al*. (1992).The increase in total sugars by KNO_3 and K_2SO_4 might be due to translocation of carbohydrates as a result of maintenance of assimilating power of leaves over a longer period resulting in increased availability of sugars to fruits. These results are in conformity with the findings of Singh and Singh (1981) who reported that foliar spray of KNO_3 (1%) increased total sugars in 'Dancy' tangerines. Soliman and Osman (2003) reported that N + K (1.5 + 1.5) kg/palm gave the highest TSS% and total sugars content in date palm cv. 'Samany'. Kim *et al*. (2006) reported that total sugars increased by application of CPPU (1 mg/l and 5mg/l) in 'Hardy' kiwifruit.

From the present investigation, it is concluded that CPPU treatments increased fruit weight and size whereas, KNO_3 treatments improved fruit quality of Plum cv. Satluj Purple.

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EFECT OF SEASONAL VARIATIONS AND WEATHER PARAMETERS ON YIELD, QUALITY AND DISEASE INCIDENCE IN GUAVA CULTIVARS UNDER RAINFED CONDITIONS OF JAMMU REGION

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ABSTRACT

The six cultivars under the study were *Allahabad Safeda*, *Lucknow-49*, *Apple Colour*, *Hybrid 1 and Hybrid 2 and Banarsi Surkha*. *Lucknow-49* cultivar proved to be most successful variety with the highest fruit yield (78 and 114 kg tree^{-1}) followed by cv. *Allahabad Safeda* (61 and 88 kg tree^{-1}) in rainy and winter season, respectively. *Apple colour* cv. recorded lowest (24 kg tree^{-1}) fruit yield during rainy season however cv. *Hybrid-2* observed the lowest fruit yield (43 kg tree^{-1}) in winter season. Total soluble solids, total sugars and vitamin C were higher in winter season (14.5 %, 4.82 % and 221 mg 100 g^{-1}) than rainy season crop (10.6 %, 3.33 % and 157 mg 100 g^{-1}), respectively. The minimum disease incidence was recorded in cv. *Lucknow-49* (17.7 & 8.0 %) followed by *Allahabad Safeda* (21.0 & 11.9 %) at harvest in rainy and winter season, respectively. Maximum and minimum temperature, relative humidity (evening) and evaporation were negatively related in rainy season, whereas rainfall was positively related with disease intensity. Hence, it is concluded that winter season guava was more quantitative, qualitative and disease resistant as compared to rainy season crop under rainfed conditions.

INTRODUCTION

Guava (*Psidium guajava* L.) is a champion fruit belonging to family *Myrtaceae* and originated in tropical south America. It is one of the leading fruit crops in India due to wide adaptability to varying soil and climatic conditions (Sharma *et al*., 2013). Guava has earned the popularity of 'poor man's apple' due to low fetching price available in plenty to every person during the season. It is no inferior to apple for its nutritive values. It is pleasant, sweet and refreshingly, acidic in flavour and emits sweet aroma. It is an excellent source of vitamin-C and pectin (Dhaliwal and Singla, 2002; Mahour *et al*., 2012). It is considered to be one of the exquisite, nutritionally valuable and remunerative crops. Its cultivation is getting popularity due to increasing international trade, better nutritional contents and processing of its value added products (Sharma *et al*., 2013a).

The major growing areas of guava fruit in India are in Uttar Pradesh, Bihar, Madhya Pradesh, Gujarat and Maharashtra states. However, in Jammu and Kashmir state, it is mainly grown in the areas of Jammu, Kathua, Samba, Reasi, Udhampur, Rajouri, Poonch and Ramban districts. The total area under guava fruit in J&K State is 2478.6 ha with an annual production of 5100.9 MTs and a productivity of 2.06 MT/ha (Anonymous, 2015).

Guava has an important place among the tropical fruits but grown widely in sub-tropical regions also. Guava bears flowers and fruits more than once in a year (Dubey *et al*., 2009; Aulakh, 2004). In most of the commercial cultivars, presence of large number of hard seeds, wilt and fruit fly seems to be the major factors responsible for restricting its cultivation (Sharma *et al*., 2011). It has been observed that seasonal variations and different weather parameters generally affect the quality and quantity of guava cultivars especially under rainfed conditions. The study of seasonal variations in guava fruit characters and quality is required to evaluate commercial guava growing season and better performed cultivars. A study in that direction will provide ample opportunity to researchers to understand the different guava cultivars. Therefore, keeping the above point of view in mind, a study entitled, "Effect of Seasonal Variations and Weather Parameters on Yield, Quality and Disease Incidence in Guava cultivars under Rainfed Conditions of Jammu Region" was undertaken, with the following objectives:

To study the effect of seasonal variations and weather parameters in different guava cultivars on yield, quality and disease incidence.

MATERIALS AND METHODS

The present study entitled, "Effect of Seasonal Variations and Weather Parameters on Yield, Quality and Disease Incidence in Guava cultivars under Rainfed Conditions of Jammu Region" was conducted at Rainfed Research Sub-Station for Sub-Tropical Fruits (RRSS), Raya, SKUAST-Jammu on 15 years old trees of guava during rainy and winter seasons of 2010-11 and 2011-12. The treatments consist of six guava cultivars namely; T_1: *Allahabad Safeda*, T_2: *Lucknow-49*, T_3: *Apple Colour*, T_4: *Hybrid 1*, T_5: Hybrid *2 and* T_6: *Banarsi Surkha* and the experiment was laid out in randomized block design (RBD) with four replications.

During both the fruiting seasons (rainy and winter) ten fruits were taken randomly at commercial maturity and analyzed for yield and quality attributes.

Fruit-weight was measured by using digital balance (Indosaw805CH). Fruit length and fruit diameter was determined by digital Vernier Calliper (Mitutoyo) whereas; fruit yield data was recorded at the time of each picking. Titratable acidity was determined by using the standard procedures of Rangana (1977). Ascorbic acid was determined by using 2, 6-dichlorophenol indophenol dye (Ruck, 1969). Total soluble solids (TSS), reducing and total sugars were determined as per standard procedures given by A.O.A.C (1994). The data obtained was statistically analysed (Gomez and Gomez, 1984). The correlation analysis study was done by using SPSS16 software.

For disease incidence, in each variety three trees were selected randomly and in each tree fifty fruits were taken by stratified random sampling at fruit setting, full size of fruit and at harvest stages. The per cent disease was calculated by using the following formula:

$$\text{Per cent diseaseincidence} = \frac{\text{No. of infected fruits}}{\text{Total no. of fruits observed}} \times 100$$

RESULTS AND DISCUSSION

Fruit size and yield

The data on fruit size like length and breadth was significantly more in cultivar *Lucknow 49* in rainy and winter season, which was immediately followed by cultivar *Allahabad Safeda*. However, the values obtained for length and breadth of guava fruit were higher in winter season as compared to the rainy season. Fruit weight (g) and fruit yield (kg tree^{-1}) was recorded higher during winter season crop in all the six cultivars of guava as compared to rainy season crop. The difference in average fruit weight might be due to varietal characteristics and agro-climatic conditions in which they are growing. There was a gradual increase in fruit size and weight during winter season over rainy season. This information was also supported by Singh *et al*. 2002 and Jana *et al*. 2009 under hilly region.

Statistically highest guava fruit yield was recorded in cv. *Lucknow 49* (78 & 114 kg tree^{-1}) which was followed by cv. *Allahabad Safeda* (61 & 88 kg tree^{-1}) in rainy and winter season, respectively. Whereas, the minimum fruit yield of guava was recorded in cv. *Apple colour* (24 kg tree^{-1}) in rainy season and cv. *Hybrid 2* (43 kg tree^{-1}) in winter season in both the years under study (Table 1). The fruit which set during August and mature during winter season attained more size and weight than harvested during rainy seasons. The probable cause may be that the winter season fruit-set occurred during August-September when plenty of food material is available in comparison to fruit set in April month. Apart from food

Table 1: Effect of seasonal variations on yield and fruit characteristics of different cultivars of guava

	Fruit size (cm)											
	Rainy Season						Winter Season					
Cultivars	Length			Breadth			Length			Breadth		
	2010	2011	Mean	2010	2011	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
Allahabad Safeda	5.5	5.9	5.7	6.9	6.5	6.7	7.4	7	7.2	7.5	7.3	7.4
Lucknow-49	6.3	6.7	6.5	7	6.8	6.9	7.6	7.2	7.4	7.9	7.5	7.7
Apple Colour	3.5	3.9	3.7	4.7	4.3	4.5	5.5	5.1	5.3	6.4	6	6.2
Hybrid 1	4.7	4.9	4.8	5.8	5.4	5.6	6.4	6	6.2	6.9	6.5	6.7
Hybrid 2	4.9	5.1	5	6	5.6	5.8	6.5	6.1	6.3	7.2	6.8	7
Banarsi Surkha	4.5	4.7	4.6	5.8	5.4	5.6	5.8	5.4	5.6	6.6	6.2	6.4
Mean	4.9	5.2	5.1	6	5.7	5.9	6.5	6.1	6.3	7.1	6.7	6.9
Range	3.5-6.3	3.9-6.7	3.7-6.5	4.7-7.0	4.3-6.8	4.5-6.9	5.5-7.6	5.1-7.2	5.3-7.4	6.4-7.9	6.0-7.5	6.2-7.7
CD (5 %)	0.08	0.1	0.06	0.64	0.63	0.41	0.07	0.1	0.06	0.64	0.09	0.33

	Fruit Weight (g)						Fruit Yield (kg tree^{-1})					
	Rainy Season			Winter Season			Rainy Season			Winter Season		
Cultivars	2010	2011	Mean	2010-11	2011-12	Mean	2010	2011	Mean	2010	2011	Mean
Allahabad Safeda	128.4	149.3	138.9	175.6	155.3	165.5	56	66	61	94	82	88
Lucknow-49	148.2	157.8	153	204.5	189.7	197.1	74	82	78	118	110	114
Apple Colour	51.2	59	55.1	131.2	110	120.6	22	26	24	62	50	56
Hybrid 1	74.4	98.8	86.6	142.6	133.8	138.2	38	46	42	48	54	51
Hybrid 2	68.2	81.8	75	135.1	107.6	121.4	31	37	34	45	41	43
Banarsi Surkha	63	75.6	69.3	139	121.2	130.1	26	30	28	73	65	69
Mean	88.9	103.7	96.3	154.7	136.3	145.5	41	48	45	73	67	70
Range	51.2-148.2	59.0-157.8	55.1-153.0	131.2-204.5	110.0-189.7	120.6-197.1	22-74	26-82	24-78	45-118	41-110	43-114
CD (5 %)	6.4	5.7	7.3	9.5	8.2	14.3	6.1	2.8	3.4	5.1	4.7	3.6

Table 2: Effect of seasonal variation on quality parameters of different cultivars of guava

	TSS (⁰ Brix)						Acidity (%)					
	Rainy			Winter			Rainy			Winter		
Cultivars	2010	2011	Mean	2010-11	2011-12	Mean	2010	2011	Mean	2010-11	2011-12	Mean
Allahabad Safeda	9	7	8	14	10	12	0.5	0.56	0.53	0.29	0.35	0.32
Lucknow-49	14	10	12	18	14	16	0.61	0.65	0.63	0.4	0.46	0.43
Apple Colour	12	8	10	14	12	13	0.39	0.43	0.41	0.28	0.34	0.31
Hybrid 1	13	11	12	16	14	15	0.46	0.52	0.49	0.42	0.48	0.45
Hybrid 2	10	8	9	18	12	15	0.32	0.38	0.35	0.24	0.28	0.26
Banarsi Surkha	14	12	13	17	15	16	0.41	0.47	0.44	0.34	0.38	0.36
Mean	12	9.3	10.6	16.2	12.8	14.5	0.45	0.5	0.48	0.33	0.38	0.36
Range	9-14	11-Jul	8-13	14-18	15-Oct	16-Dec	0.32-0.61	0.38-0.65	0.35-0.63	0.24-0.42	0.28-0.48	0.26-0.45
CD (5 %)	2.5	3.4	1.3	2.9	2	3.3	0.06	0.07	0.04	0.07	0.05	0.04

	Vitamin C (mg 100 g^{-1} pulp)						Reducing sugars						Total sugars (%)					
	Rainy			Winter			Rainy			Winter			Rainy			Winter		
Cultivars	2010	2011	Mean	2010-11	2011-12	Mean	2010	2011	Mean	2010-11	2011-12	Mean	2010	2011	Mean	2010-11	2011-12	Mean
Allahabad Safeda	157	175	166	226	240	233	1.98	2.08	2.03	3.72	4.02	3.87	2.82	3.06	2.94	4.14	4.26	4.2
Lucknow-49	178	200	189	238	268	253	2.56	2.76	2.66	4.56	4.8	4.68	3.56	3.88	3.72	5.36	5.64	5.5
Apple Colour	142	160	151	202	220	211	2.06	2.34	2.2	3.84	4.16	4	2.96	3.12	3.04	4.28	4.42	4.35
Hybrid 1	136	168	152	217	235	226	2	2.28	2.14	3.8	4.1	3.95	3.42	3.7	3.56	5.28	5.56	5.42
Hybrid 2	128	150	139	187	205	196	2.26	2.52	2.39	4.46	4.62	4.54	3.01	3.19	3.1	4.06	4.2	4.13
Banarsi Surkha	136	156	146	192	218	205	2.34	2.54	2.44	4.52	4.68	4.6	3.5	3.76	3.63	5.16	5.42	5.29
Mean	146	168	157	210	231	221	2.2	2.42	2.31	4.15	4.4	4.28	3.21	3.45	3.33	4.71	4.92	4.82
Range	128-178	150-200	137-189	187-238	205-268	196-2531	1.98-2.56	2.08-2.76	2.03-2.66	3.72-4.56	4.02-4.80	3.87-4.68	2.82-3.56	3.06-3.88	2.94-3.72	4.06-5.36	4.20-5.64	4.13-5.50
CD (5 %)	5.5	8.6	10.3	15.5	39.1	23.8	0.28	0.46	0.17	0.22	0.24	0.22	0.32	0.26	0.29	0.19	0.35	0.17

Table 3: Correlation between fruit yield and size with quality parameters of different cultivars of guava fruit during rainy season under rainfed conditions

	Fruit Length	Fruit Breadth	Fruit Weight	Fruit Yield	TSS	Acidity	Vitamin-C	Reducing Sugars	Total Sugars
Fruit Length	1	.898**	.938**	.947**	-.148	.777**	.724**	.429	.352
Fruit Breadth	.898**	1	.838**	.825**	.023	.604*	.434	.138	.134
Fruit Weight	.938**	.838**	1	.984**	-.239	.883**	.827**	.255	.233
Fruit Yield	.947**	.825**	.984**	1	-.165	.899**	.839**	.317	.305
TSS	-.148	.023	-.239	-.165	1	-.007	-.257	.127	.474
Acidity	.777**	.604*	.883**	.899**	-.007	1	.914**	.340	.515
Vitamin- C	.724**	.434	.827**	.839**	-.257	.914**	1	.518	.462
Reducing Sugars	.429	.138	.255	.317	.127	.340	.518	1	.699*
Total Sugars	.352	.134	.233	.305	.474	.515	.462	.699	1

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

Table 4: Correlation between fruit yield and size with quality parameters of different cultivars of guava fruit during winter season under rainfed conditions

	Fruit Length	Fruit Breadth	Fruit Weight	Fruit Yield	TSS	Acidity	Vitamin-C	Reducing Sugars	Total Sugars
Fruit Length	1	.984**	.921**	.725**	.161	.166	.525	.008	.052
Fruit Breadth	.984**	1	.915**	.707*	.251	.071	.427	.090	.011
Fruit Weight	.921**	.915**	1	.902**	.253	.313	.620*	.134	.276
Fruit Yield	.725**	.707*	.902**	1	.144	.345	.668*	.200	.340
TSS	.161	.251	.253	.144	1	.012	-.333	.258	.348
Acidity	.166	.071	.313	.345	.012	1	.732**	.131	.892**
Vitamin- C	.525	.427	.620*	.668*	-.333	.732**	1	.101	.486
Reducing Sugars	.008	.090	.134	.200	.258	.131	.101	1	.385
Total Sugars	.052	.011	.276	.340	.348	.892**	.486	.385	1

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

materials, climatic factors such as temperature and humidity prevailing during winter season are also favourable for development of fruits. The results are more or less coinciding with the findings given of Aulakh and Kamboj, 1996 and Jana *et al*. 2014. The fruit yield of *Lucknow-49* cultivar was more than *Allahabad safeda* cultivar under Punjab conditions (Aulakh, 2004).

Quality parameters

Besides productivity, fruit quality is another concern in assessing the performance of guava cultivars under rainy and winter seasons. Fruit quality characteristics values like total soluble solids (TSS), vitamin C, reducing sugars and total sugars were found superior during winter season as compared to the rainy season except the values obtained for quality parameter acidity where the values were higher in rainy season as compared to the winter season for all the six cultivars in both

Table 5: Correlation coefficients between disease intensity and weather parameters at different stages in guava crop during rainy and winter seasons

Parameters	Rainy season				Winter season			
	P_1	P_2	P_3	P_4	P_1	P_2	P_3	P_4
Max.Temperature (°C)	-0.27	-0.52	-0.36	-0.51**	-0.24	0.24	-0.58*	-0.81**
Min. Temperature (°C)	-0.31	-0.26	0.38	-0.83**	-0.10	-0.06	-0.46	-0.66**
RH m (%)	0.73**	-0.07	-0.07	-0.06	0.34	-0.14	0.47	0.71**
RH e (%)	0.69*	-0.48	-0.34	-0.42*	0.11	0.14	0.09	0.44**
Evaporation (mm)	-0.74**	0.43	-0.29	-0.72**	-0.23	0.18	-0.33	-0.30
Rainfall (mm)	0.11	0.03	0.18	0.42*	0.04	0.18	0.40	0.37*

P_1- Fruit setting stage, P_2- Full size of fruit, P_3- At time harvesting of fruit, P_4- whole season

Table 6: Prediction of acidity and vitamin C of guava fruit during rainy season under rainfed conditions of Jammu region

S. No.	Acidity Equation	R^2	Vitamin-C Equation	R^2 (mg 100 g^{-1} pulp)
1	$Y = 0.083X_1 + 0.049$	0.61	$Y_1 = 16.33X_1 + 74.28$	0.54
2	$Y = 0.072X_2 + 0.050$	0.37	$Y_1 = 10.80X_2 + 93.62$	0.19
3	$Y = 0.002X_3 + 0.249$	0.8	$Y_1 = 0.451\ X_3 + 112.9$	0.7
4	$Y = 0.004X_4 + 0.264$	0.85	$Y_1 = 0.897X_4 + 116.1$	0.74
	Y= Acidity of fruit (%)			Y_1= Vitamin-C in fruit (mg/100 g pulp)
	X_1= Fruit length (cm)			X_1= Fruit length (cm)
	X_2= Fruit breadth (cm)			X_2= Fruit breadth (cm)
	X_3= Fruit weight (g)			X_3= Fruit weight (g)
	X_4= Fruit yield (kg)			X_4= Fruit yield (kg)

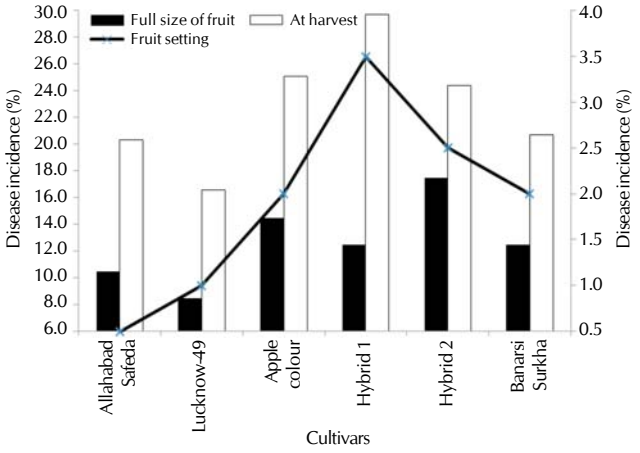

Figure 1: Disease incidence in different cultivars of guava fruit during rainy season of 2010

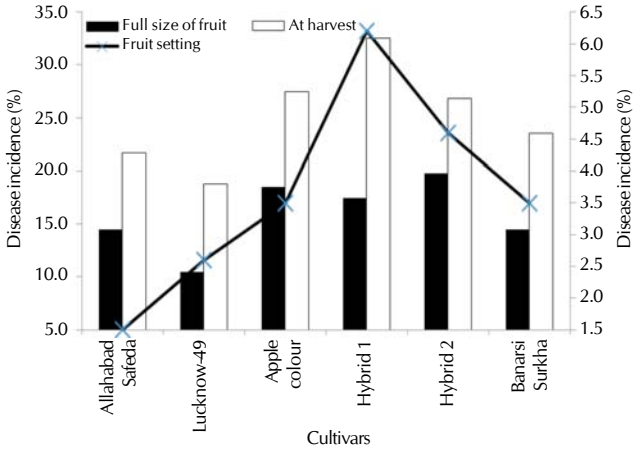

Figure 2: Disease incidence in different cultivars of guava fruit during rainy season of 2011

the years under study. Aulakh, 2004, Sidhu *et al*. (1996) also found superior fruit quality characteristics during winter season as compared to rainy season fruits.

Statistically superior values of TSS was found in cv. *Banarsi Surkha* (13°Brix) during rainy season and was followed by cv. *Lucknow 49* (12°Brix). However, during winter season the maximum value of TSS was shared by cvs. *Lucknow 49* and *Banarsi Surkha* (16°Brix). The similar results were also recorded by Aulakh, 2004. The maximum values of quality parameter like acidity (%) was recorded in cv. *Lucknow 49* (0.63%) which was immediately followed by cv. *Allahabad Safeda* (0.53%) and the minimum value of acidity (0.35%) was recorded in cv. *Hybrid 2* during the rainy season. In winter season, statistically higher values of quality parameter acidity were observed in cv. *Hybrid 1* (0.45%); which was immediately followed by cv. *Lucknow 49* (0.43%) and the minimum values were again recorded in cv. *Hybrid 2* (0.26%).

The vitamin-C values were higher in winter season fruit as compared to rainy season crop. However, statistically significant values of vitamin C content were found with cv. *Lucknow 49* in rainy as well as winter season and were followed by cv. *Allahabad Safeda* in both the years under study. Rainy season fruit contains less vitamin-C, TSS and sugar. This might be due to cloudy weather and presence of relatively more moisture in soil which must have moved in to the fruit and diluted the organic metabolites particularly sugars. The results corroborate the findings of Jana *et al*. (2014).

The values of quality parameters like reducing and total sugars were significantly superior in cv. *Lucknow 49* and were followed by cv. *Banarsi Surkha* in rainy and winter season

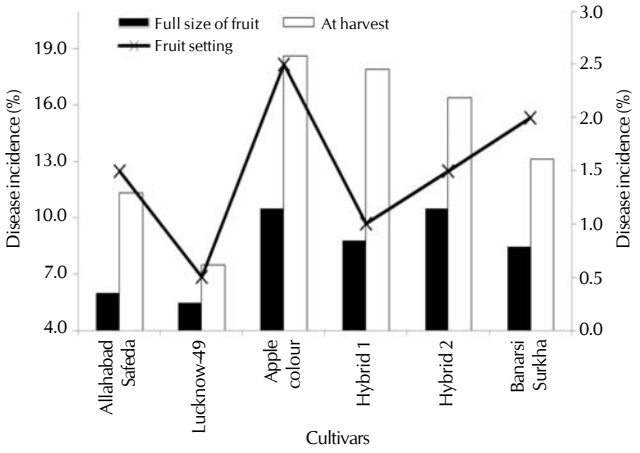

Figure 3: Disease incidence in different cultivars of guava fruit during winter season of 2010-11

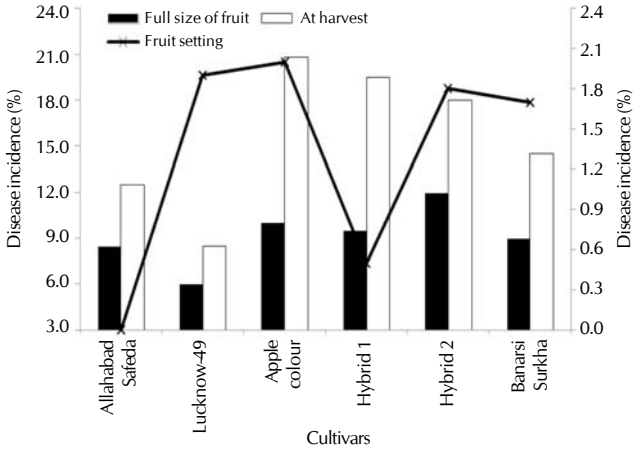

Figure 4: Disease incidence in different cultivars of guava fruit during winter season of 2011-12

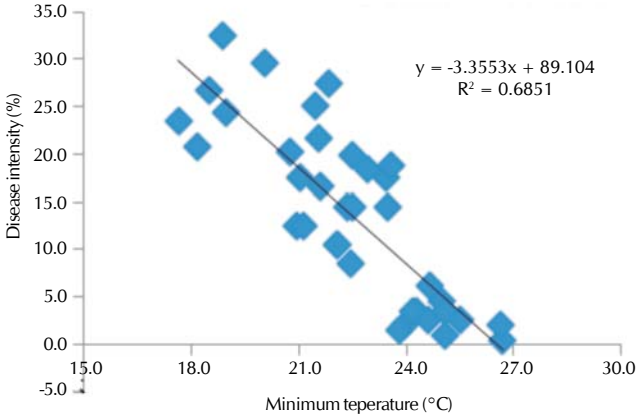

Figure 5: Relationship of disease intensity in guava fruit and minimum temperature during rainy season

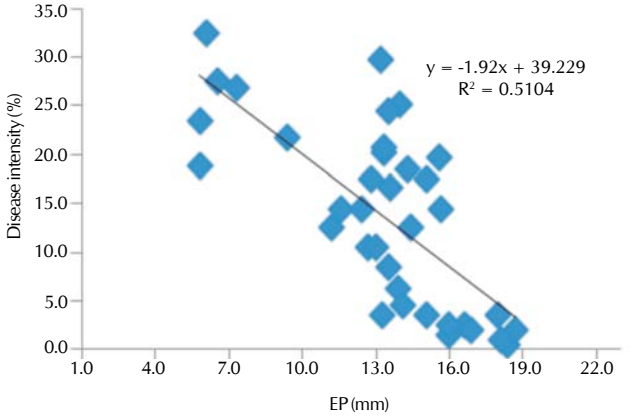

Figure 6: Relationship of disease intensity in guava fruit and evaporation during rainy season

crops in the years 2010-11 and 2011-12. Overall, fruit quality characteristics were found superior during winter seasons as compared to the rainy seasons (Table 2). Similar results were also reported by Sidhu *et al.*, 1996 and Singh *et al.*, 1976. The overall superiority of *Lucknow-49* and *Allahabad safeda* might be due to genetic make-up which got favourable microclimate in sub-tropical region of Jammu to express its characteristics.

Correlation study

It is evident from the correlation study that length and breadth of the fruit decided the fruit weight and finally yield of guava fruit crop during both the seasons. Acidity in guava fruit is highly correlated with length, breadth, fruit weight and yield during rainy season; whereas it was not correlated during winter season. Fruit weight and fruit yield per plant was highly correlated (0.01) with vitamin C during rainy season, but was less correlated (0.05) during winter season. Length of fruit during rainy season was also significantly correlated with vitamin C; whereas no significant relationship was observed during winter season. Acidity was significantly differed with vitamin C and yield and yield attributes of guava fruit crop during rainy season. Acidity was highly significantly correlated with vitamin C and total sugars during winter season (Table 3 and 4).

The disease intensity at fruit setting, full size of fruit and harvesting stages was less correlated as compared to whole season. The morning and evening relative humidity (RH m & RH e) was positively correlated while evaporation was negatively correlated with disease intensity at fruit setting stage of guava during rainy season. But in case of rainy season the maximum and minimum temperature, evening relative humidity (RH e) and evaporation were negatively related, whereas rainfall was positively related with disease intensity. In winter season, maximum temperature at the time of harvesting was found negatively correlated. In whole season the disease intensity were negatively related with maximum and minimum temperature, while relative humidity morning and evening and rainfall were positively correlated (Table 5).

Guava fruit yield during rainy season have higher values of vitamin C and acidic, as compared to winter season fruit. The acidity and vitamin C during rainy season can be determined with the help of yield and other parameters of guava fruit crop. The acidity in guava fruit varied with fruit weight and yield with an accuracy of 80 and 85 per cent, respectively; however, in case of vitamin C with an accuracy of 70 and 74 per cent, respectively. The length of guava fruit also influenced acidity

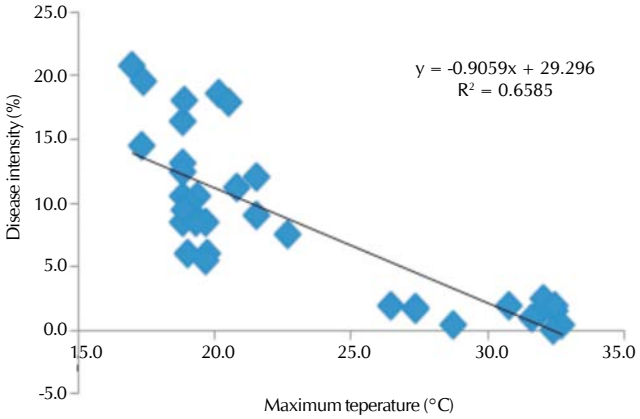

Figure 7: Relationship of disease intensity in guava fruit and maximum temperature during winter season

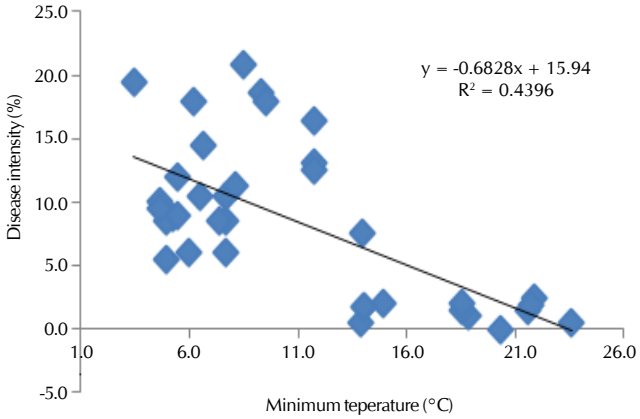

Figure 8: Relationship of disease intensity in guava fruit and minimum temperature during winter season

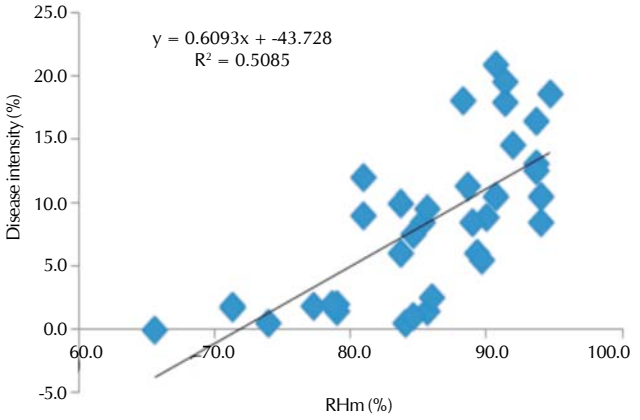

Figure 9: Relationship of disease intensity in guava fruit and relative humidity (morning) during winter season

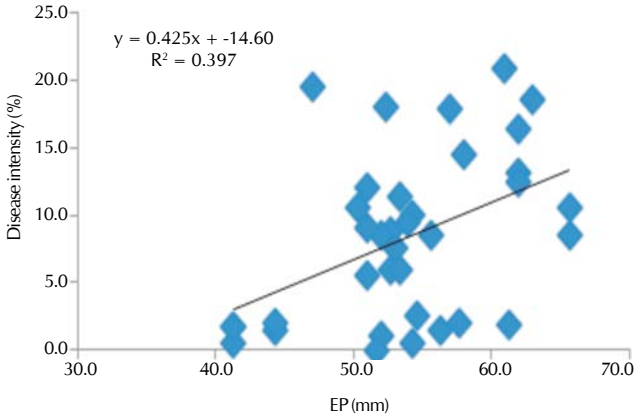

Figure 10: Relationship of disease intensity in guava fruit and evaporation during winter season

and vitamin C of the fruit during rainy season in rainfed areas of sub tropical conditions of Jammu region (Table 6).

Disease incidence

The incidence of disease was more during rainy season as compared to winter season at stages fruit setting, full size of fruit and at harvest in all the cultivars of guava fruit. However, percentage of disease incidence was more at harvest as compared to the other two stages in all the cultivars under both the seasons. The minimum incidence of diseases was recorded in cv. *Lucknow 49* followed by cv. *Allahabad Safeda* and cv. *Banarsi Surkha* during both the rainy and winter season. The maximum incidence of diseases was recorded in cv. *Hybrid 1* and cv. *Apple Colour* during both seasons (Fig. 1, 2, 3 & 4). Higher incidence of diseases during rainy season as compared to the winter season crop may be due to extreme temperature and more relative humidity which are favourable for incidence of different diseases. Pandey *et al*. (1997) also found the similar results.

In rainy season, disease intensity was negatively related with minimum temperature and evaporation in guava fruit. Disease intensity decreased with an increase in minimum temperature (ºC) and evaporation (mm) and is explained with accuracy of 69 and 51 %, respectively (Fig 5 & 6). The disease intensity was negatively related with maximum and minimum temperature during winter season. With an increase of 0.91ºC and 0.68ºC of maximum and minimum temperature; disease intensity decreased per percentage with accuracy of 66 and 44 %, respectively (Fig 7 & 8). An increase in morning relative humidity at the rate of about 0.61 per cent enhanced the disease intensity by 1 % with a regression coefficient of 0.51. The evaporation rate also influenced the occurrence of disease intensity with the rate of 0.40 mm/per cent (Fig 9 and 10).

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EFFECT OF STRAW MULCH AND ANTI-TRANSPIRANTS ON YIELD AND QUALITY OF SOYBEAN (*GLYCINE MAX* L. MERRIL)

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ABSTRACT
A field experiment was conducted for three consecutive years during *kharif* season to assess the effect of straw mulch and anti-transpirants on growth, yield and quality of soybean. Straw mulch application @ 5 tons ha^{-1} resulted in significantly higher N, P and K content in grain, seed protein content, seed, stover and biological yield and harvest index. Foliar application of Glycerol 5% as anti-transpirant resulted in significantly higher seed yield and harvest index but for N, P and K content in seed, protein content and available N and K in soil anti-trans pirants did not show significant difference. All the treatments in which mulch was included proved to be superior. The highest seed yield (2347 kg ha^{-1}), stover yield (2736 kg ha^{-1}) and biological yield (5083.6 kg ha^{-1}) was recorded in M_1A_3 [mulch + Sodium carbonate (Na_2CO_3) 5%]. However, the highest harvest index was observed in M_1A_2 [mulch + Glycerol 5%] (47.51 %). M_1A_1 [mulch + Magnesium carbonate ($MgCO_3$) 5%] gave the highest N content and highest protein content in seeds. Available N and P in soil was recorded to be the highest in M_1A_2 [mulch + Glycerol 5%] with 283 kg $ha^{-1}$and M_1A_0 [mulch + control] 17.27 kg ha^{-1}.

INTRODUCTION

The wonder crop soybean (*Glycine max*, L. Merril) is a leguminous crop and belongs to family leguminoaceae with sub family papillionaceae. It is also called "Golden Bean" of the 20th century because of its nutritive value and regarded a substitute or compliment of protein. It is now the world's leading oilseed crop, cultivated in an estimated global area of 108.75 million ha with a production reaching 268 million tonnes and productivity of 2.5 tonnes ha^{-1} in 2012-13 (Anonymous, 2013). In India, it is grown in a projected area of 10.69 million ha with estimated production and productivity of 12.67 million tonnes and 1185 kg ha^{-1}(Anonymous, 2013). In Nagaland, the estimated area under soybean production is 24670 ha with total production of 30880 metric tonnes (Anonymous, 2013). It is a potential crop of the region and is grown primarily as a pulse crop as well as intercrop with maize, ragi, arhar etc.

The major factor for low yield of soybean is less plant population due to low germination rate. To obtain high yields there is a need to improve plant stand through higher emergence. Straw mulch lowers the maximum soil temperature (Singh and Kler, 1990), raises the minimum soil temperature (Kitoh and Yoshida, 1996) in the seed zone and keep the soil moist (Munn, 1992) resulting enhanced rate and final count of seedling emergence (Singh and Jolly, 2008). Apart from straw mulches, mulching with farm yard manure may also improve emergence in some crops (Chaudhari and Das, 1980).In soybean crop, the yield was recorded to be higher by 1.0 q $acre^{-1}$ by opting mulching as compared to normal sowing (Maan and Mandeep Singh, 2009) Climate change and erratic rainfall also affect the yield of soybean. Proper moisture control at flowering stage is the critical stage for soybean yield. At the time of flowering under moisture stress condition certain chemicals effectively reduces the water loss and improve the yield. Anti-transpirants affect stomatal movement influence the guard cells around the stomatal pores and reduces loss of water vapour but not intake of CO_2 (Sivadjian, 1967). The most efficient and desirable anti-trans pirants are those that especially close stomata to transpiration but produce no phytotoxic effects to plants (Gale and Hagan, 1966). Considering the beneficial effect of mulching and no information in regard to the effect of anti-trans pirants on yield and quality of soybean in North East region of India the present investigation was undertaken to study the effect of straw mulch and anti-tran spirants on growth, yield and quality of soybean (*Glycine max* L. Merril).

MATERIALS AND METHODS

A field experiment was carried out during *kharif* season of 2012, 2013 and 2014 in the experimental farm of Department of Agricultural Chemistry and Soil Science, SASRD, Medziphema to study the "Effect of anti-tran spirants and mulches on the yield and quality of soybean (*Glycine max*, L. Merril)".The soil samples were collected from experimental site, processed and physic-chemical properties of soil were measured with prescribed standard procedure (Jackson,

1973). The soil of experimental field was sandy loam and well drained, having low available N (227.21 kg ha^{-1}), medium available P (17.8 kg ha^{-1}), and low available K (175.6 kg ha^{-1}). Soil organic carbon content was also low (0.72%) with soil pH of 4.6.The treatments consisted of two mulches treatments *viz.,* M_0 [control (no mulch)] and M_1 (straw mulch @ 5 tons ha^{-1} after sowing) and four anti-transpirants *viz.*, Magnesium carbonate ($MgCO_3$) 5%, Glycerol 5%, Sodium carbonate (Na_2CO_3) 5% and KNO_3 1%, with a control (water supply). The experiment was conducted in Factorial Randomized Block Design with three equal blocks and each block was divided into ten equal plots of 2.5m × 2.5m size, consisting of 30 plots in total. Soybean variety RKS-18 @ 65 kg ha^{-1} were treated with Malathion powder @ 12 g $plot^{-1}$ for controlling termites, ants and worms and sown on 23rd June, 2012, 26th June 2013 and 2nd July 2014. Straw mulch @ 5 tons $ha^{-1}$was applied to the plots randomly at the time of sowing and spraying of anti-trans pirants was done 15 days after flowering. Crop was harvested at physiological maturity, threshed and plot-wise seed and stover yields in kg ha^{-1}were recorded. Final seed samples were taken from each plot for analysis of N, P, K by modified kjeldhal method as described by Black (1965), vanado-molybdate yellow colour method as outlined by Jackson (1973)and flame photometry as described by Chapman and Pratt (1961) respectively. Seed protein content (%) was estimated by multiplying per cent N content in seed with the factor 6.25. Composite soil samples were collected plot wise after harvesting and available N, P, K were analysed as per the method described by Jackson (1973). The experiment data recorded during the course of investigation for each parameter were analysed statistically as per standard method prescribed by Cochran and Cox, 1957

RESULTS AND DISCUSSION

Effect of straw mulch, anti-transpirants and their interaction on yield and harvest index

Two mulch treatments *viz.*, M_0 [control (no mulch)] and M_1 (straw mulch @ 5 tons ha^{-1} after sowing) were tested in the experimental plot. Significant increase in seed yield (2139.46 kg ha^{-1}), biological yield (4730.53kg ha^{-1}) and harvest index (45.27%) attributes was observed with mulch application as compared to no mulch (1791.93 kg ha^{-1}, 4227.93 kg $ha^{-1}$and 42.38% respectively), while for stover yield (2591.06kg ha^{-1}) there was no significant increase although the mulch treatment recorded higher value. Higher value of growth, yield attributes and pod yield was observed with slash grass mulch by Sah *et al.* (2015) in cowpea while Kumar *et al.* (2015) summarized that use of bio- fertilizer along with mulching proved useful in increasing growth and yield attributes of potato crop significantly compared to control.

Significant variations inseed yield and harvest index were observed with different anti-transpirant applications *viz.,*Magnesium carbonate ($MgCO_3$) 5%, Glycerol 5%, Sodium carbonate (Na_2CO_3) 5% and KNO_3 1%, and control (water supply). Stover yield and biological yield did not vary significantly although an increase over control was observed on anti-transpirant application. The maximum seed yield (2100.33) and harvest index (45.28%) was recorded on application of A_2 [Glycerol 5%], whereas, maximum stover yield (2588.00) and maximum biological yield (4636.83) was recorded on application of A_1 [Magnesium carbonate ($MgCO_3$) 5%]. These findings are in conformity with Dalvi *et al.*, (1991) who reported significant differences on seed yield and harvest index due to anti-transpirants.

The interaction effects of mulches and anti-transpirantswith respect to seed yield,biological yield and harvest index were found to be significant. However, interaction effect for stover yield was not significant. The highest seed yield(2347kg ha^{-1}), stover yield (2736kg ha^{-1}) and biological yield (5083.6kg ha^{-1})was associated with treatment combination M_1A_3[mulch + Sodium carbonate (Na_2CO_3) 5%]. Treatment combination M_1A_2 [mulch + Glycerol 5%] recorded the highest harvest index (47.51 %). This finding is in agreement with Brahma *et al.* (2007) who reported that growth and yield attributing characters differed significantly due to the application of straw mulch and anti-transpirants.

Effect of straw mulch, anti-transpirants and their interaction on N, P, K and protein content of seed

The N, P and K content estimated in seeds of soybean were significantly influenced by mulching treatment. M_1 (straw mulch @ 5 tons ha^{-1}) recorded higher N, P and K content in seeds as compared to control(no mulch). Shah *et al.* (2015) also reported higher NPK content in wheat grains that were given mulch treatment @ 5 t ha^{-1} combined with 20 kg ha^{-1}N and 20 kg ha^{-1} P 30 days before sowing.

Protein content due to mulching was also found to be

Table 1: Effect of straw mulch and anti-transpirants on biological yield (kg ha^{-1}), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) of soybean. (Pooled)

Treatment	Biological yield (kg/ha)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
Mulches (M)M_0	4227.93	1791.93	2436.00	42.38
M_1	4730.52	2139.46	2591.06	45.22
SEm ±	101.97	30.63	74.69	0.43
CD (P = 0.05)	366.28	110.02	NS	1.55
Anti-transpirants (A)A_0	4111.83	1703.83	2408.00	41.43
A_1	4636.83	2048.83	2588.00	44.18
A_2	4628.33	2100.33	2528.00	45.37
A_3	4589.66	2026.50	2563.16	44.15
A_4	4429.50	1949.00	2480.50	44.00
SEm ±	161.22	48.43	118.09	0.68
CD (p = 0.05)	NS	173.97	NS	2.45

Table 2: Interaction effect of straw mulch and anti-transpirants on biological yield (kg ha^{-1}), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%). (Pooled)

Treatment	Biological yield (kg/ha)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
M_1A_1	4916.00	2261.00	2655.00	45.91
M_1A_2	4679.00	2223.00	2456.00	47.51
M_1A_3	5083.66	2347.00	2736.00	46.16
M_1A_4	4455.66	1960.66	2495.00	44.01
M_1A_0	4518.33	1905.66	2612.66	42.17
M_0A_1	4357.66	1836.66	2521.00	42.14
M_0A_2	4577.66	1977.66	2600.00	43.20
M_0A_3	4095.66	1706.00	2389.66	41.65
M_0A_4	4403.33	1937.33	2466.00	44.00
M_0A_0	3705.33	1502.00	2203.33	40.53
SEm ±	228.01	68.49	167.01	0.96
CD (p = 0.05)	819.04	246.03	NS	3.47

Table 3: Effect of straw mulch and anti-transpirants on N, P and K content (mg g^{-1} seed) and protein content (%) of soybean. (Pooled)

Treatment	N	P	K	Protein content (%)
Mulches (M)M_0	5.52	0.34	1.22	34.54
M_1	6.36	0.42	1.30	39.76
SEm ±	0.07	0.01	0.01	0.46
CD (P = 0.05)	0.26	0.03	0.04	1.67
Anti-transpirants (A)A_0	5.78	0.35	1.25	36.16
A_1	5.95	0.41	1.31	37.22
A_2	5.97	0.39	1.29	37.34
A_3	6.03	0.39	1.27	37.73
A_4	5.96	0.38	1.21	37.30
SEm ±	0.11	0.01	0.02	0.73
CD (p = 0.05)	NS	NS	NS	NS

Table 4: Interaction effect of straw mulch and anti-transpirants on N, P and K content (mg g^{-1} seed) and protein content (%) in soybean.(Pooled)

Treatment	N	P	K	Protein content (%)
M_1A_1	6.49	0.45	1.35	40.56
M_1A_2	6.25	0.45	1.34	39.06
M_1A_3	6.35	0.41	1.30	39.70
M_1A_4	6.35	0.41	1.22	39.70
M_1A_0	6.36	0.39	1.32	39.77
M_0A_1	5.42	0.37	1.26	33.89
M_0A_2	5.70	0.33	1.24	35.62
M_0A_3	5.72	0.36	1.24	35.76
M_0A_4	5.58	0.35	1.20	34.89
M_0A_0	5.21	0.32	1.18	32.56
SEm ±	0.16	0.02	0.02	1.04
CD (p = 0.05)	0.59	NS	NS	3.73

Table 5: Effect of straw mulch and anti-transpirants on available N, P and K at harvest in soil.(Pooled)

Treatment	Available nutrient in soil at harvest (kg ha^{-1})		
	N	P	K
Mulches (M)M_0	251.29	11.61	175.27
M_1	271.54	15.52	176.34
SEm ±	3.60	0.46	4.26
CD (P = 0.05)	12.93	1.65	NS
Anti-transpirants (A)A_0	259.48	15.22	181.32
A_1	259.36	12.08	178.19
A_2	263.58	12.84	175.68
A_3	258.35	13.69	177.32
A_4	263.00	14.01	161.53
SEm ±	5.57	0.72	6.60
CD (p = 0.05)	NS	2.61	NS

Table 6: Interaction effect of straw mulch and anti-transpirants on available N, P and K at harvest in soil.(Pooled)

Treatment	Available nutrient in soil at harvest (kg ha^{-1})		
	N	P	K
M_1A_1	271.11	13.23	174.98
M_1A_2	283.00	15.83	175.90
M_1A_3	267.51	15.12	179.19
M_1A_4	274.14	16.17	170.54
M_1A_0	261.96	17.27	181.11
M_0A_1	247.61	10.94	181.40
M_0A_2	244.15	9.84	175.45
M_0A_3	249.19	12.27	175.45
M_0A_4	251.85	11.85	152.53
M_0A_0	257.00	13.18	181.54
SEm ±	7.88	1.02	9.33
CD (p = 0.05)	28.30	3.69	NS

significantly higher (39.76%) than control (34.54%). Non-significant variations in N, P and K content in seeds were observed with different anti-transpirant applications. Similarly, protein content also did not vary significantly due to anti-trans pirant treatment.The interaction effects of mulches and anti-trans pirants on protein content was found significant. The interaction M_1A_1[mulch + Magnesium carbonate ($MgCO_3$) 5%] gave the highest protein content (40.56%). Mulch and anti-transpirant interaction for seed nutrient content showed significant variation for N content in seeds whereas, P and K contents varied non significantly among treatment combinations. The highest N content was observed in M_1A_1[mulch + Magnesium carbonate ($MgCO_3$) 5%] treatment.

Effect of straw mulch, anti-transpirants and their interaction on available soil nutrient status

The highest available nitrogen (271.54 kg ha^{-1}) was recorded from M_1 (straw mulch @ 5 tons ha^{-1}). Results showed that higher amounts of nutrients were left in the soil following crop harvest in the case of application of mulches. This might have been due to the supply of nutrients by the microbial decomposition of plant residues placed on soil surface and also due to the multiplication of N_2-fixing bacteria and algae on the plant residues that act as a source of nitrogen supply. Similar results were observed by Harper and Lynch, (1984). Correspondingly, the highest available phosphorus (15.52 kg ha^{-1}) and potassium (176.34 kg ha^{-1}) was recorded from M_1 (straw mulch @ 5 tons ha^{-1}), although increase in potassium content as compared to control was non significant. These findings on phosphorus and potassium were in agreement with the findings of Sonsteby *et al*., (2004) who reported that application of straw mulch significantly increased the available phosphorus and potassium in the soil.

There were non significant differences for available nutrients in soil due to anti-transpirant application, except for phosphorus. The highest value for phosphorus (15.22 kg ha^{-1}) and potassium (181.32 kg ha^{-1}) was associated with control treatment A_0 (water supply). Results showed that application of anti-trans pirants did not prove to be superior over control for P and K.

The interaction effects of mulches and anti-transpirants on soil nutrient status was found to be significant for nitrogen and phosphorus and non-significant for potassium. The highest available N (283 kg ha^{-1}) and P (17.27 kg ha^{-1}) was associated with M_1A_2 [mulch + Glycerol 5%] and M_1A_0 [mulch + control (water supply)], respectively

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EFFECT OF NUTRIENT MANAGEMENT ON GROWTH, YIELD AND QUALITY OF SUMMER MUNGBEAN (*VIGNA RADIATA* L.)

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ABSTRACT
A field experiment was conducted during summer season of 2012 at Muzaffarpur. Result revealed that Growth attributes were significantly higher found under application of 100 % RDF, 50% RDF + 2 % urea spray at 40 DAS. HW at 25 DAS and pendimethalin @ 1.0 kg ai ha^{-1} increased all the growth and yield attributes. Highest grain yield obtained under 100% RDF 12.60 q ha^{-1}. HW at 25 DAS recorded max. grain yield 13.50 q ha^{-1} being at par with PE pendimethalin @ 1 kg ai ha^{-1} 12.67 q ha^{-1}. Thus it can be concluded that application of 100% RDF and HW at 25 DAS proved to be better nutrient and weed management practice over other practices.

INTRODUCTION

Mungbean (*Vigna radiata* L. wilczek) is an important pulse crop of India having an excellent source of high quality protein**.** It not only plays an important role in human diet but also in improving the soil fertility by fixing the atmospheric nitrogen (Athernadeem *et al*., 2004). Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses (Anjum *et al*., 2006). Besides this, summer mungbean has special importance in intensive crop production due to its short growing period as it can be grown as a catch crop in rice-wheat cropping system. It is not only ideal for catch cropping, inter cropping and multiple cropping system but also serve as excellent cover crop to protect the soil against erosion. It is mainly utilized in making dal, curries, soup, sweets and snacks. During sprouting, there is an increase in thiamine, niacin and ascorbic acid concentration. The food values of mungbean lie in its high and easily digestible protein. The mungbean seeds contain approximately 25-28% protein, 1.0-1.5% oil, 3.5-4.5% fiber, 4.5-5.5% ash and 62-65% carbohydrates on dry weight basis.

The management of fertilizers is one of the most important factors that greatly affect the growth, development and yield of mung bean (Asaduzzaman *et al*., 2008). Nitrogen and phosphorus are both integral components of virtually all the biochemical compounds that make plant life possible. N and P are essential elements in their structural, biochemical and physiological roles contributing to crop growth (Sinclair and Vadez, 2002). Nitrogen is an important major nutrient element for plant. For legumes, it is more useful because it is the main component of amino acids as well as proteins. Adequate supply of nitrogen is essential for normal growth and yield (Mozumder *et al*., 2003). Without N it is not possible to synthesize the necessary proteins, enzymes, DNA and RNA required in virtually all plant cells for their initial development, sustained growth and functioning to support other tissues of the plant. So, deficiencies in reduced N necessarily results in less biochemical machinery to catalyze plant metabolism and to generate new cells. Consequently, nitrogen deficiencies result in decreased crop leaf area, photosynthetic assimilation and seed growth (Sinclair and Vadez, 2002).Phosphate nutrition is the basic need of legumes. In view of fact that added phosphorus get fixed in the soil, the phosphorus deficiency accounts for the major limiting factor for the growth of the legumes (Sharma *et al*., 2003). Among the soil nutrient elements, P is the second most essential nutrient after the nitrogen. Many studies have shown that application of phosphorous fertilizers generally has great impact on crop yields because its deficiency limits the response of plants to other nutrient (Akinrinde and Adigun, 2005). Phosphorus is an essential component of cell structures, mainly as nucleic acids and phospholipids (Sinclair and Vadez, 2002). It is especially critical in establishing the enzymatic machinery in energy storage and transfer, which in many cases involves membrane processes. Not surprisingly, P deficiency results in a loss in cell integrity. The bonding properties of P also make it crucial for metabolic processes that are nucleotide-based, *e.g.*, ADP, NAD and NADP, because of its unique energy-transfer properties. A general consequence of P deficiency is a decrease in the energy charge of cells (Sinclair and Vadez, 2002). Though, potassium is rarely applied to pulse crops because of high potassium content in the soil, its application

regulates the utilization of other nutrients in the plant system (Thiyagarajan *et al., 2003*). Therefore, superimposition of K at different level of phosphate besides a starter dose of N may improve yield in mungbean (*vigna radiata* L., Wilczek). Sulphur is an important secondary nutrient which helps in plant growth and metabolism especially by improving activities of proteolytic enzymes and is also required for nitrogen fixation by leguminous plants. Foliar fertilization is gaining importance in plant nutrition these days. The foliar applied nutrients are more effective as compared to soil applied nutrients. Because of higher uptake efficiency, foliar supply of nutrient can increase photosynthetic efficiency by delaying the leaf senescence. The present study deals with effect of nutrient levels and weed management on growth, yield and quality of mungbean.

MATERIALS AND METHODS

A field experiment was conduct at Tirhut College of Agriculture Farm, Dholi (Muzaffarpur), a campus of Rajendra Agricultural University, pusa (Samastipur), Bihar during summer 2012 to study the effect of weed management in summer mungbean. Dholi, Pusa (Altitude of 52.18 meter above mean sea level and lies at 25º.39'N latitude and 85^0.40'E longitude) is located semi-arid, sub-tropical climate with moderate rainfall, hot dry summer and cold winter. The soil of the experimental plot was alluvial and calcareous in nature, having pH 7.4, low in organic carbon (0.45%), low in available nitrogen and medium phosphorus and potassium content.

The treatment included all the possible 20 combinations four nutrient levels with main plot 100 % RDF (10-15-17-20 kg NPK, 50% RDF + 2.0% Urea spray at 40 DAS, 2% Urea spray 20 at DAS + 40 and No fertilizer and sub plot five weed management treatments. Pendimethalin @ 1.0 kg ai/ha (PE) Imazethapyr @ 50g ai/ha (20 DAS) Chlorimuron ethyl @ 4g ai/ha (PPI), Hand weeding at 25 DAS and Weedy cheek were tested in a split plot design with three replication and net plot size was 4×1.8 m. The crop was shown on 18 march, 2012 in row spacing of 30 cm using a recommended seed rate of 25 kg/ha of variety HUM-16.Chlorimuron ethyl, pendimethalin and Imazethapyr were applied as pre plant incorporation (PPI), pre-emergence and post emergence (20 DAS). The spraying was done with flat fan nozzle. Weed As per treatment, one hand weeding was done at 25 days after sowing with the help of khurpi. No weeding was done in rest of the plot. Data on weed count, weed dry matter and weed control efficiency at 20, 40 DAS and at harvest and weed index at count at harvest, using a quadrate 50×50 cm. Data on plant growth was recorded 20 and 40 DAS and at harvest and data on yield, yield attributed and economics were recorded at harvest. Plant sample was analyzed for nutrient uptake at harvest. The data were analyzed and treatments having a significant F valve, critical difference (CD) value were calculated at 5% probability level.

RESULTS AND DISCUSSION

Crop growth and development in mungbean was measured in terms of plant height, number of trifoliate leaves/plant, leaf area index and dry matter accumulation at an interval of 20 days starting from 20 days after sowing.

Plant height (cm)

Nutrient levels did not influence the plant height at 20 DAS but significant variation was observed at 40 DAS and at harvest. Maximum plant height was observed under 100 % RDF (32.52 cm) which was significantly superior to 2 % urea spray at 20 and 40 DAS (27.54 cm) and no fertilizer (28.54 cm) but was at par with 50 % RDF + 2 % urea spray at 40 DAS (31.91 cm) at harvest. This increase in plant height might be due to greater uptake of nutrients which helps in producing more protoplasm

Table 1: Growth parameters as affected by different treatments at 20 and 40 DAS

Treatments	Plant height (cm)		Number of trifoliate leaves/plant		Leaf area index		Dry matter of plant (g/plant)	
	40 DAS	at harvest	40 DAS	at harvest	40 DAS	At harvest	40 DAS	At harvest
RDF(10:15:17:20 kg NPKS/ha)	15.40	32.52	5.71	8.39	1.33	2.77	2.62	9.32
50 % RDF + 2.0 % Urea spray at 40	15.34	31.91	5.61	8.24	1.27	2.69	2.56	9.16
2 % Urea spray at 20 DAS + 40	13.50	28.54	5.19	7.41	1.07	2.28	2.22	8.2
Control (no fertilizer)	13.17	27.54	5.07	7.10	1.01	2.14	2.09	7.7
S.Em.±	0.30	0.97	0.13	0.19	0.04	0.08	0.07	0.19
C.D.(p=0.05)	1.05	0.83	0.48	0.65	0.15	0.27	0.25	0.67

Table 2: yield attributed and yield parameters as affected by different treatments

Treatments	Pods/ Plant (No.)	seeds/ pod (No.)	Grain Yield weight (g/plant)	Test (g)	Grain yield (q/ha)	Straw yield harvest (q/ha) index
RDF(10:15:17:20 kg NPKS/ha)	9.83	4.58	43.55	12.60	21.66	36.77
50 % RDF + 2.0 % Urea spray at 40DAS	9.43	4.30	42.39	12.12	21	36.51
2 % Urea spray at 20 DAS + 40 DAS	9.20	3.90	39.69	10.70	19.87	35.58
Control (no fertilizer)	9.07	3.76	39.30	9.17	17.18	34.8
S.Em.±	0.38	0.11	0.70	0.24	0.63	0.75
C.D.(p=0.05)3.38	0.38	0.39	2.43	0.83	2.19	NS

Table 3: Available nutrient in post harvest soil as influenced by different treatments

Treatments	Available nutrient in soil (kg/ha) at harvest			
	N	P	K	S
RDF(10:15:17:20 kg NPKS/ha)	199.72	17.94	129.24	31.42
50 % RDF + 2.0 % Urea spray at 40 DAS	197.78	17.39	126.87	29.81
2 % Urea spray at 20 DAS + 40 DAS	194.04	14.41	118.14	25.73
Control (no fertilizer)	193.17	13.89	117.01	25.15
S.Em.±	1.22	0.48	1.45	0.49
C.D.(p=0.05)	4.23	1.66	5.03	1.73
Initial	182.5	16.63	122.25	26.7

Table 4: Protein content (%) as affected by different treatments

Treatments	Protein content in grain
Nutrient levels	
F_1- RDF (10:15:17:20 kg NPKS/ha)	23.01
F_2- 50 % RDF+2.0 % Urea spray at 40 DAS	22.56
F_3- 2 % Urea spray at 20 DAS + 40 DAS	22.43
F_4 - Control (no fertilizer)	21.75
S.Em.±	0.22
C.D.(P=0.05)	0.77

and thereby enhancing rapid cell division and elongation which was exhibited in from of increase in height at recommended dose of fertilizer. Similar results were also reported due to application of 100 % RDF by Choudhary and Yadav (2011) and Sharma *et al*. (2000).

Number of trifoliate leaves plant^{-1}

Number of trifoliate leaves/plant is one of the important growth attributes because it determines leaf area index and consequently the photosynthetic efficiency of the plant. The higher number of trifoliate leaves/plant was obtained with 100 % RDF at all the stages of crop growth. However, the differences were significant only at later two stages *i*.e. at 40 DAS and at harvest but was not significant at initial stage of 20 DAS. Plots receiving 2 % urea spray at 20 DAS + 40 DAS and no fertilizer recorded the lowest number of green trifoliate leaves at almost all the stages of crop growth. It is known that nitrogen being the constituent of chlorophyll, delay leaf senescence and thereby keeps the plant green for longer period. Increasing nitrogen supply allows the leaves to remain green for longer period and in many cases increases the growing season and delays the maturity. Thus the reasons for higher number of green trifoliate leaves with application of fertilizer particulars N are clearly obvious. Lesser number of green trifoliate leaves/ plant was associated with 2 % urea spray at 20 and 40 DAS and no fertilizer was apparently due to low supply of nitrogen from the soil to plant. Finding of Yakadri *et al*. (2002) support the result of this character. As known fertilizer application in grain legumes has been found to be more conducive towards their vegetative growth which stimulated the branching efficiency consequently resulting in higher number of trifoliate leaves/plant. However, the degree of effect of applied fertiliser depends on the available soil nutrient and N fixation efficiency of the plant itself.

Leaf area index

Leaf area index did not differ significantly due to different nutrient levels at 20 DAS but significant variation was observed at 40 DAS and at harvest. Maximum leaf area index was noticed with 100 % RDF at all the stages of crop growth. Increase in leaf area index was due to favourable synthesis of growth favouring constituents in plant system due to better supply of nitrogen which resulted in enlargement of leaf area. Devlin (1971) also pointed out that nitrogen was essential constituent of protein. Thus, low nitrogen availability must cause a decrease in protein synthesis which consequently decreased cell size and especially cell division. A decrease in leaf epidermal cell size due to lack of nitrogen ultimately reduce the size of leaves. Hegde and Shrinivas (1989) also observed a higher leaf area index with increasing rate of fertilizer.

Dry matter production plant^{-1}

Dry matter accumulation/plant differed significantly due to different nutrient levels at all the stages of crop growth. Higher dry matter accumulation/plant was obtained under 100 % RDF (9.32) followed in descending order by 50 % RDF + 2 % urea spray at 40 DAS (9.16), 2 % urea spray at 20 + 40 DAS (8.20) and no fertilizer (7.70) at harvest. The photosynthetic activities of the plants are well reflected in their dry matter accumulation. An increased production of dry matter indicates the better utilization of nutrients along with better harvest of solar energy. In present investigation, nutrient application increased the rate of photosynthetic process which finally resulted in increased dry matter production by the plant at each stage of growth. Increased plant height, more number of trifoliate leaves and higher leaf area index due to application of nutrients might have resulted in increase in dry matter accumulation/plant. Increase in dry matter accumulation per meter row length due to higher nutrient level was also reported by Dean and Clark (1960). The results are also in close conformity with the findings of Choudhary and Yadav (2011).

Yield attributes and yield

Yield of a crop is the final expression of overall performance of crop *i*.e. pre and post harvest characters. These characters as known are influenced and consequently modified by various management factors in the mungbean crop. The yield/ plant depends on the number of pods/plant, pod weight/plant, pod length, number of grains/pod and test weight. In the present investigation, nutrient application favourably influenced all the yield attributing characters except number of grains/pod. Higher values of all the yield attributes was observed with the application of 100 % recommended dose of fertilizer and minimum was associated with 2 % urea spray at 20 DAS and 40 DAS and no fertilizer. Thus through the pathways of enhanced photosynthetic efficiency in the post-

anthesis growth of the crop, nutrient application under optimum soil moisture favourably influenced the yield contributing characters. These finding are in complete agreement with the results of many worker Sharma *et al*. (2000) and Sultana *et al*. (2009).

Pulses have special affinity for P and it is perhaps the most common factor limiting pulses production. Varieties efficient in using phosphorus appear to be also efficient in using soil nitrogen. However, responses to potassium are rarely reported and North Bihar soils are usually adequately supplied with potassium. In the present experiment, hence, both 100 % RDF and 50 % RDF + 2 % urea spray at 40 DAS maintained its superiority over 2 % urea spray at 20 and 40 DAS and no fertilizer (control), in respect of the expression of yield attributing characters like number of pods/plant, number of grains/pod, grain yield/plant and test weight of munbean. Consequently a significant increase in yield of grain was observed with application 100 % RDF (12.60 q/ha) and 50% RDF + 2 % urea spray at 40 DAS (12.12 q/ha), which was at par each other and both of them were significantly superior to 2 % urea spray at 20 and 40 DAS (10.70 q/ha) and no fertilizer (9.17 q/ha). These results are in agreement with finding of Kumar *et al*. (2003) and Sheoran *et al*. (2008)

Like grain yield, straw yield was also the outcome of growth and yield attributes like plant height, leaf area index, dry matter accumulation and other characters. In the present investigation all the growth and developmental characters were found to have been favourably influenced by nutrient levels in mungbean. The highest straw yield (21.66 q/ha) was recorded under 100 % RDF which was significantly superior over 2 % urea spray at 20 and 40 DAS (19.37 q/ha) and no fertilizer (17.18 q/ha) but was at par with 50 % RDF + 2% urea spray at 40 DAS (21.07 q/ha). This may be attributed the beneficial effect of nutrients on the vegetative growth of plant. It is known that nitrogen is an important constituent of protoplasm levels. Higher nutrient level *i. e.* 100 % RDF and 50 % RDF + 2 % urea spray at 40 DAS helped in cell multiplication and its elongation and thus resulted in significantly better growth of the plant with improvement in plant height, number of trifoliate leaves, leaf area index and dry matter accumulation and other characters. All these cumulatively increased the straw yield.

In the present investigation nutrient levels failed to cause any significant variation in the harvest index of mungbean. Though, higher harvest index was obtained with higher nutrient levels. Improved harvest index is an indication of increased physiological efficiency of the plant to metabolize the photosynthate for grain development.

Quality parameters

Significant increase in protein content of mungbean was recorded under the treatment containing 100 % RDF than no fertiliser but was at par with 50 % RDF + 2 % urea spray at 40 DAS. The increase in protein content could be assigned to increased uptake of nitrogen with increase in its application which was in turn transferred from the non grain to grain portion. Higher nitrogen content is directly responsible for higher protein content because it is a primary component of amino acids which constitutes the basis of protein. Similar results were also reported Verma *et al*. (1976), Yadav *et al*. (2002) and Chesti *et al*. (2012).

Available nitrogen was influenced significantly under different nutrient levels and weed management practices. Higher value of available nitrogen was noticed under F_1 (199.72 kg/ha) which was at par with F_2 (197.78 kg/ha) and both of them were significantly superior to F_3 (194.04 kg/ha) and F_4 (193.17 kg/ha).

Available P content in the post-harvest soil was influenced significantly by both nutrient and weed management practices. Among the nutrient levels, F_1 (17.94 kg/ha)proved significantly superior F_3 (14.41kg/ha) and F_4 (13.89 kg/ha) but was at par with F_2 (17.49 kg/ha).

The different nutrient levels significantly affected the available K content in post harvest soil. Higher available K was recorded in F_1 (129.24 kg/ha) which was significantly superior over F_3 (118.14 kg/ha) and F_4 (117.01 kg/ha) but was at par with F_2 (126.87 kg/ha).

Significant difference in available S was observed due to different nutrient levels. Maximum available S was recorded under F_1 (31.42 kg/ha) being at par with F_2 (29.81 kg/ha) and both of them were significantly superior over F_3 (25.73 kg/ha) and F_4 (25.15 kg/ha).

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DRYING CHARACTERISTICS OF DIFFERENT CORIANDER (*CORIANDRUM SATIVUM* L.) VARIETIES

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ABSTRACT
A lab experiment was conducted to know the effect of drying on colour and sensory characteristics of different varieties of coriander herbage during 2012-13 at department of plantation, spices, medicinal and aromatic crops, Kittur Rani Channamma College of Horticulture, Arabhavi (Karnataka). The experiment was laid out in completely randomized design with three replications and thirteen treatments. Studies on the drying characteristics of different coriander varieties revealed that the maximum drying ratio and rehydration ratio were recorded in Rcr-480 (5.42) & DWD-3 (4.23) respectively. The variety RCr-446 was only towards the lightness (58.07). The mean values of *L** decreased from fresh herbage (40.09) to dried herbage (36.67). The mean values for redness (*a**) decreased from (-7.57) to (-2.26). The *b** value was towards the yellowness for both fresh and dried herbage. The highest score for flavor and aroma was observed in DWD-3 (7.97) and highest score for colour (8.00) and overall acceptability (7.77) was observed in RCr-435.

INTRODUCTION

Green leafy coriander herb is an abundant source of minerals and vitamins and adds colour, flavour and aroma to the daily diet. In India fresh coriander is available from December to March. Coriander green foliage is highly perishable in nature and has short shelf life. In summer months the availability of coriander foliage is scarce. When there is a glut in the market the herbage is wasted due to lack of proper post harvest handling and preservation techniques. The fresh green coriander (herbage) if properly dried, packed and stored may help in increasing its availability during lean periods at a lower price (Preetinder *et al*., 2006).

Drying is one of the oldest method of preservation of foods. In addition to increasing variety in the diet, dried products create easy transportation, possibility of storage at ambient conditions and occupying less storage space. Further, dehydrated produce can be rehydrated before use to near fresh quality.

Dehydration is the process of removing water from a product under controlled conditions of airflow, temperature and humidity, which reduces the moisture in the food to such a low level that inhibits the microbial growth leading to decay and spoilage.

Ahmed *et al*. (2001) studied the drying characteristics and product quality of coriander leaves. Rehydration capacity was found to be maximum when the blanched leaves were dried at 45ºC. Agasimani *et al*. (2008) studied the effect of drying on sensory quality of coriander leaves. The results indicated that, the leaves dried at ambient condition retained better organoleptic qualities compared to shade drying. The sun dried samples retained olive green colour while shade dried samples had bright green colour. The leaves dried at 100 and 140ºC turned brown to reddish brown and gave burnt appearance and flavor, while those dried at 40ºC recorded better colour and organoleptic attributes.Limited studies are available in the literature with regard to preservation of greens. The present paper deals with screening of the suitability of coriander varieties for dried herbage

MATERIALS AND METHODS

The experiment was conducted in a Completely Rando mised Design with three replications. The details of the treatments are as follows.

Treatment Details: Varieties

T_1 - CO-1
T_2 - CO-2
T_3 - CO-3
T_4 - CO-4
T_5 - RCr-20
T_6 - RCr-41
T_7 - RCr-435
T_8 - RCr-436
T_9 - RCr-446
T_{10} - RCr-480
T_{11} - RCr-684
T_{12} - RCr-728
T_{13} - DWD-3

Method

One kg each of green coriander herbage per treatment per replication in each variety was harvested at 45 days after sowing and a total of three kg in each variety constitutes three

replications.

Pretreatments

Coriander herbage was pretreated with 0.1 per cent magnesium chloride + 0.1 per cent sodium bicarbonate + 0.2 per cent potassium metabi sulphate in water for 15 minutes before drying.

Drying

The pretreated coriander herbage was dried in tray drier at 55p C for 5 hours uniformly.

Drying ratio

Drying ratio was calculated by dividing fresh weight of herbage by dry weight.

$$\text{Drying ratio} = \frac{\text{Fresh weight}}{\text{Dry weight}}$$

(Ranganna, 1991)

Rehydration ratio

Rehydration ratio is analysed by soaking 2 g dehydrated sample in 50 ml water at 60^{0}C for 20 minutes, excess water was drained and the sample was weighed and rehydration ratio was calculated by the following formula.

$$\text{Rehydration ratio} = \frac{\text{weight of the rehydrated sample}}{\text{weight of the dehydrated sample used for the test}}$$

(Ranganna,1991)

Colour estimation

Colour of the fresh and dried coriander herbage was estimated by using a Lovibond colour meter in terms of *L**(lightness), *a** (red-green) and *b**(blue-yellow).

Sensory evaluation (Score out of 9.00)

Organo leptic evaluation of dried coriander herbage was carried out on a 9 point Hedonic scale using the score card mentioned below by 15 semi trained judges. The organoleptic characters like colour, flavor and aroma and overall acceptability were recorded.

Score card for organoleptic evaluation (Ranganna, 1991)

Colour	Flavour and aroma	Overall Acceptability	Scores
Highly attractive	Excellent	Extremely acceptable	8-9
Very attractive	Very good	Very acceptable	7-8
Moderately attractive	Good	Moderately acceptable	6-7
Slightly attractive	Fair	Slightly acceptable	5-6
Not attractive	Poor	Not acceptable	0-5

RESULTS AND DISCUSSION

Drying ratio

Drying ratio of dried coriander herbage was presented in table 1. Among the 13 varieties evaluated, the drying ratio was ranging between3.49-5.42. The highest drying ratio was recorded in RCr-480 (5.42) as against least in RCr-435 (3.49). The higher drying ratio in the var. RCr-480 could be due to inherent composition of the variety and the drying ratio is directly proportional to the dry matter content and it is a varietal trait.

Rehydration ratio

Rehydration ratio of dried coriander herbage was presented in table 1. Among the 13 different varieties, the highest rehydration ratio was found in DWD-3 (4.23) as against the least in RCr-20 (3.00). The higher rehydration ratio in the var. DWD-3 could be due to the higher capacity of the variety to absorb the moisture and the difference in moisture uptake between the varieties can be attributed to variation in the type of variety, structural components and interactions between the components during dehydration (Rajeswari, 2010).

Colour estimation

Colour estimation of fresh and dried coriander herbage was presented in table 2. In fresh coriander herbage, the mean values of lightness (*L**) revealed that variety RCr-446 was towards the lightness (58.07) compared to all the other varieties. This could be due to the varying levels of pigments and other biochemicals that could impact the colour of the herbage. The composition of the biochemical constituent is highly specific to the inherent quality of the variety.

The mean values of *L** decreased from fresh herbage (40.09) to dried herbage (36.67). This is expected because drying of herbage would leads to loss of moisture and pigments that could probably lead to decrease in the values for Lightness.

Table 1: Drying and rehydration ratio of coriander herbage as influenced by different varieties

Treatments	Varieties	Drying ratio	Rehydration ratio
T_1	CO-1	5.18	3.33
T_2	CO-2	5.00	4.17
T_3	CO-3	4.69	4.17
T_4	CO-4	4.69	4.00
T_5	RCr-20	3.61	3.00
T_6	RCr-41	5.03	3.33
T_7	RCr-435	3.49	3.67
T_8	RCr-436	4.85	4.17
T_9	RCr-446	4.54	3.17
T_{10}	RCr-480	5.42	3.77
T_{11}	RCr-684	4.68	4.00
T_{12}	RCr-728	4.41	4.17
T_{13}	DWD-3	4.85	4.23
	Mean	4.65	3.78
	SEmCD (P = 0.01)	0.190.73	0.140.54

Table 2: Colour (*L* a* b) values of fresh and dried coriander herbage as influenced by different varieties**

Treatments	Varieties	Fresh herbage			Dried herbage		
		*L**	*a**	*b**	*L**	*a**	*b**
T_1	CO-1	38.56	-9.31	25.64	32.94	-1.65	17.56
T_2	CO-2	42.34	-9.82	30.14	33.88	-3.64	19.55
T_3	CO-3	32.71	-5.79	20.85	37.68	-2.44	20.75
T_4	CO-4	34.63	-5.88	21.70	34.71	-0.87	18.38
T_5	RCr-20	41.02	-6.25	28.20	39.26	-4.35	18.13
T_6	RCr-41	32.80	-5.05	21.64	39.57	-5.68	21.42
T_7	RCr-435	38.95	-6.68	21.48	36.30	-0.48	20.11
T_8	RCr-436	41.84	-8.53	20.08	35.49	-0.70	18.63
T_9	RCr-446	58.07	-8.78	39.31	39.57	-1.65	21.46
T_{10}	RCr-480	41.15	-7.85	25.99	34.28	-1.57	16.95
T_{11}	RCr-684	49.65	-9.40	29.13	44.51	-1.17	19.53
T_{12}	RCr-728	31.33	-8.15	21.60	34.74	-4.35	19.78
T_{13}	DWD-3	38.06	-6.88	21.72	33.73	-0.88	17.77
	Mean	40.09	-7.57	25.19	36.67	-2.26	19.23
	SEmCD (P = 0.01)	1.596.24	0.622.43	0.592.30	1.746.85	0.461.88	0.97NS

L* = Lightness; a* = Red-Green ; b* = Blue-Yellow

Table 3: Sensory characteristics of dried coriander herbage as influenced by different varieties

Treatments	Varieties	Colour(score out of 9.00)	Flavour and aroma (score out of 9.00)	Overall Acceptability (score out of 9.00)
T_1	CO-1	6.23	7.17	6.70
T_2	CO-2	7.93	7.37	7.77
T_3	CO-3	6.77	7.57	7.23
T_4	CO-4	6.90	7.23	7.03
T_5	RCr-20	7.57	7.03	7.28
T_6	RCr-41	7.43	6.83	7.13
T_7	RCr-435	8.00	7.54	7.77
T_8	RCr-436	6.53	7.43	6.98
T_9	RCr-446	7.03	6.83	6.93
T_{10}	RCr-480	7.27	7.07	7.18
T_{11}	RCr-684	7.23	7.57	7.37
T_{12}	RCr-728	7.07	7.23	7.18
T_{13}	DWD-3	6.63	7.97	7.27
	Mean	7.12	7.26	7.21
	SEmCD (p = 0.01)	0.040.15	0.030.13	0.030.11

The variations in *L** values of fresh and dried herbage could be due to the varietal effect because individual variety respond differently to drying.

The mean values for redness (*a**) decreased from (-7.57) to (-2.26) indicating changing of colour from dark green to light green. This could be due to loss of chlorophyll during the process of drying leading to loss of green colour. The variations within the variety could be inherent quality of the particular variety showed.

Among the 13 varieties studied it was observed that, the (*b**) value was towards the yellowness for both fresh and dried herbage and there were no significant difference for dried herbage with respect to (*b**) value.

Sensory evaluation

The sensory qualities of products are an important tool for indicating the consumer acceptability. Human preference plays an important role in evaluation of organoleptic character of a product.The data on organoleptic evaluation pertaining to the colour, flavour and aroma and overall acceptability differed significantly and it was presented in Table 3.

The highest score for colour was observed in RCr-435. The highest score for flavour and aroma was observed in DWD-3 and the overall acceptability was recorded in RCr-435 due to its higher score for colour, flavor and aroma. Similar variations among the different varieties with respect to organoleptic characters were reported by several workers (Esturk and Soysal, 2010; Fatima *et al.,* 2001).

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EXTENT OF LOSSES INFLICTED BY APHID COMPLEX AT DIFFERENT LEVELS OF INFESTATION ON WHEAT AND DETERMINATION OF EIL AND ETL

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ABSTRACT
Field experiments were conducted at Experimental Farm of Department of Entomology, CSK HPKV, Palampur, Himachal Pradesh during 2013-14 and 2014-15 to assess the losses caused by aphid complex in wheat. The aphid population at initial infestation levels of 5, 10, 20 and 40 aphids per plant released at CRI stage and peaked during 3rd week of March with the corresponding population of 26.7, 38.5, 38.9 and 38.5 aphids per plant and 25.2, 37.6, 38.1 and 39.0 aphids per plant during 2013-14 and 2014-15, respectively. The highest avoidable losses in grain yield were 28.64 and 26.67 per cent during 2013-14 and 2014-15, respectively. Tillering stage showed higher yield losses and thus proved to be the most susceptible stage. EIL determined for aphids for the infestation initiated at CRI was 32.61 CAD (Cumulative aphid days) and at tillering and panicle emergence stages the corresponding EIL values were 41.55 and 35.77 CAD per plant and the ETL values were 24.46, 31.16 and 26.83 CAD per plant, respectively. On the basis of initial aphid infestation levels, the EIL was 14.93, 7.19 and 6.78 aphids per plant and the ETL values were 11.20, 5.39 and 5.09 aphids per plant at CRI, tillering and panicle emergence.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second most important cereal in India after rice and it covers an area of 30 million hectares with the production of 93.50 million tonnes (Anonymous 2014). In Himachal Pradesh, during 2013-14, it was grown an area of 371.06 thousand hectares with the production of 538.52 thousand tonnes (Anonymous 2014a). Wheat being a premier winter cereal crop in India and is attacked by number of insect pests viz., termites, armyworm, shoot fly, brown wheat mite and cutworms (Dhadwal *et al.,* 2014). More than eleven aphid species infest wheat crop out of them four species viz., *Sitobion avenae* (Fabricius), *S. miscanthi* (Takahashi), *Rhopalosiphum padi* (Linnaeus) and *R. maidis* (Fitch) are reported to be the most predominant (Jarosik *et al.,* 2003). A complex of four species viz., *R. maidis*, *S. miscanthi*, *R. padi* and *S. avenae* was reported to infest wheat crop and losses were estimated to the tune of 3.53-21.05 per cent in Punjab (Deol *et al.,* 1987; Singh and Deol 2003). The aphids are emerging as important pests of wheat in Himachal Pradesh. During 2010-11 and 2011-12, aphid population ranging from 7.75-52.07 aphids per shoot was recorded in the month of March under Palampur conditions of Himachal Pradesh (Sharma *et al.,* 2013). Highest yield of wheat recorded by Meena *et al.* (2013) was 41.2 quintals per hectare. Populations exceeding 50 aphids per ear have been reported to inflict 6.13-27.82 per cent yield losses (Singh *et al.,* 2008). Keeping in view the fact that no systematic work on the extent of losses on wheat has been undertaken in Himachal Pradesh, the studies were undertaken on this aspect and working out ETL and EIL values for the successful management of the pest, the present studies were conducted to assess the losses caused by aphid complex in wheat.

MATERIALS AND METHODS

Stock culture of aphids was maintained in laboratory for the present studies and aphid population levels *i.e.* 5, 10, 20 and 40 were released on 10 marked plants at CRI (Crown Root Initiation), tillering and panicle emergence stages of wheat in separate plots of size of 9 m². Level 'zero' plants were maintained with the spray of dimethoate 30EC (Rogor). Observations on the number of aphids per 10 shoots were recorded at weekly intervals after the release of aphids at their respective levels in the different crop stages. The relationship between cumulative aphid days and yield was worked out for different population levels as per the method used by Jeon *et al*. (2008) and the losses at different infestation levels were worked out. The grain yield was recorded from all the marked plants in different levels of release during different crop growth stages. The per cent avoidable losses were calculated using formula outlined by Atwal and Singh (1990). Economic injury level (EIL) was calculated for three plant growth stages in crop by using following parameters:

EIL = C / (V x I x D x K)

where, C is the cost of management, V is the market value of crop, I is the unit injury per aphid, D is the damage per unit injury and K the control efficacy or proportional reduction in potential injury or damage by management practices as outlined by Pedigo *et al*. (1986) and Pedigo (2002).

RESULTS AND DISCUSSION

Population buildup of aphids in wheat crop during 2013-14

Infestation initiated at CRI stage

In order to study the effect of differential infestation levels of aphids at 5, 10, 20 and 40 aphids per plant on population buildup, released artificially on wheat plants at CRI crop growth stage, and thereafter weekly observations recorded on population buildup of aphids are presented in table 1.At CRI stage, the plants were infested artificially on January 18, 2014 by releasing 5, 10, 20 and 40 aphids per plant. A perusal of data contained in table 1 revealed that one week after initiation of infestation, the population of aphids was 9.50, 15.60, 15.70 and 16.80 aphids/ plant at the corresponding infestation levels of 5, 10, 20 and 40. The number of aphids in plants which were infested with 20 and 40 aphids/ plant decreased because of the crowding at higher levels of infestation and also due to small size of plants, they were not able to hold that much of pest population released at higher levels. Thereafter, the population increased significantly and reached the peak in 3rd week on March, 2014 with a population of 26.70, 38.50, 38.90 and 38.50 aphids per plant at infestation levels of 5, 10, 20 and 40 aphids per plant, respectively. Further, a decline in population was set in and aphid count was zero during first week of May, 2014. The mean population varied significantly at all the initial infestation levels 23.70, 22.40, 21.50 and 14.50 aphids per plant in descending order at 40, 20, 10 and 5 aphids level of infestation.

Infestation initiated at tillering stage

At tillering stage, the plants were infested artificially on Feb 22,

Table 1: Population buildup of aphids released at varying infestation levels at different stages of wheat during 2013-14

Sampling date	Aphids (number/ plant) at indicated levels of initial infestation				
	5	10	20	40	Mean
1. CRI Stage					
18-01-2014	5.00	10.00	20.00	40.00	18.80
25-01-2014	9.50	15.60	15.70	16.50	14.30
01-02-2014	12.50	19.70	18.60	18.60	17.40
08-02-2014	15.10	21.40	20.70	19.20	19.10
15-02-2014	16.20	25.20	24.90	25.00	22.80
22-02-2014	17.50	29.40	28.90	29.70	26.40
01-03-2014	18.90	31.20	33.40	34.60	29.50
08-03-2014	20.20	35.10	36.20	36.40	32.00
15-03-2014	26.70	38.50	38.90	38.50	35.70
22-03-2014	23.40	35.20	36.40	36.70	32.90
29-03-2014	22.10	27.60	28.10	28.40	26.60
05-04-2014	20.50	25.40	26.30	26.20	24.60
12-04-2014	15.20	17.80	18.40	18.50	17.50
19-04-2014	8.60	9.10	9.40	9.50	9.20
26-04-2014	1.20	2.00	2.00	2.10	1.80
03-05-2014	0.00	0.00	0.00	0.00	0.00
Mean	14.50	21.50	22.40	23.70	
CD (p=0.05): A = 0.65, B = 0.32, AB = 1.30					
2. Tillering stage					
22-02-2014	5.00	10.00	20.00	40.00	18.80
01-03-2014	12.60	19.70	28.90	49.20	27.60
08-03-2014	18.90	24.80	32.70	51.60	32.00
15-03-2014	29.60	32.60	39.90	54.90	39.30
22-03-2014	28.20	30.40	37.50	53.10	37.30
29-03-2014	26.40	29.10	35.10	52.20	35.70
05-04-2014	25.20	27.50	31.20	45.70	32.40
12-04-2014	17.20	20.10	22.10	31.60	22.80
19-04-2014	10.80	11.20	12.10	14.20	12.10
26-04-2014	5.40	5.80	6.60	7.10	6.20
03-05-2014	0.00	0.00	0.00	0.00	0.00
Mean	16.30	19.20	24.20	36.30	
CD (p=0.05): A = 0.74, B = 0.44, AB = 1.48					
3. Panicle emergence stage					
05-04-2014	5.00	10.00	20.00	40.00	18.80
12-04-2014	13.70	19.50	27.60	49.90	27.70
19-04-2014	18.50	22.20	30.10	50.50	30.33
26-04-2014	10.20	13.10	17.60	20.10	15.30
03-05-2014	2.10	2.50	3.20	7.10	3.73
Mean	9.90	13.50	19.70	33.52	
CD (p=0.05): A = 0.64, B = 0.58, AB = 1.29					

Table 2: Population buildup of aphids released at varying infestation levels at different stages of wheat during 2014-15

Sampling date	Aphids (number/ plant) at indicated levels of initial infestation				
	5	10	20	40	Mean
1. CRI stage					
10-01-2015	5.00	10.00	20.00	40.00	18.80
17-01-2015	7.20	13.20	13.50	14.60	12.10
24-01-2015	10.60	17.20	17.50	18.10	15.90
31-01-2015	13.70	19.60	20.10	20.50	18.50
07-02-2015	14.80	23.10	23.20	24.10	21.30
14-02-2015	16.90	27.70	27.80	28.20	25.20
21-02-2015	17.80	30.10	30.50	31.10	27.40
28-02-2015	19.90	32.60	32.90	33.20	29.70
07-03-2015	21.20	34.70	35.80	36.30	32.00
14-03-2015	25.20	37.60	38.10	39.00	35.00
21-03-2015	22.10	33.10	34.20	35.30	31.20
28-03-2015	20.20	24.60	25.70	26.60	24.30
04-04-2015	18.40	19.00	20.10	21.20	19.70
11-04-2015	12.50	14.10	14.50	15.00	14.00
18-04-2015	5.20	5.50	5.50	5.70	5.50
25-04-2015	0.90	1.40	1.40	1.50	1.30
02-05-2015	0.00	0.00	0.00	0.00	0.00
Mean	13.60	20.20	21.20	23.00	
CD (p=0.05): A = 0.63, B = 0.30, AB = 1.25					
2. Tillering stage					
14-02-2015	5.00	10.00	20.00	40.00	18.80
21-02-2015	10.60	17.60	26.60	47.50	25.60
28-02-2015	17.80	20.40	30.70	50.10	29.80
07-03-2015	28.70	29.90	35.60	52.70	36.70
14-03-2015	31.20	34.50	37.80	55.50	39.80
21-03-2015	27.10	28.90	31.20	47.60	33.70
28-03-2015	25.20	27.40	29.70	44.50	31.70
04-04-2015	18.90	20.10	23.40	40.10	25.60
11-04-2015	17.20	18.20	20.50	33.50	22.40
18-04-2015	11.50	12.10	12.50	15.70	13.00
25-04-2015	5.10	5.20	5.60	6.10	5.60
02-05-2015	0.00	0.00	0.00	1.20	0.30
Mean	16.53	18.69	22.80	36.21	
CD (p=0.05): A = 0.65, B = 0.37, AB = 1.29					
3. Panicle emergence stage					
11-04-2015	5.00	10.00	20.00	40.00	18.80
18-04-2015	12.80	17.20	25.20	48.20	25.85
25-04-2015	17.20	20.10	28.10	50.00	28.90
02-05-201509-05-2015	6.401.30	6.601.50	8.202.40	20.007.00	10.303.05
Mean	8.54	11.08	16.78	33.04	
CD (p=0.05): A = 0.57, B = 0.51, AB = 1.14					

Table 3: Yield obtained at various infestation levels during 2013-15

Crop growth stages	Yield at varying infestation levels					Mean grain yield (g/ plant)	Mean grain yield (q/ ha)
A. 2013-14	0	5	10	20	40		
CRI	2.74	2.60	2.41	2.37	2.36	2.50	21.66
Tillering	2.55	2.20	2.10	1.93	1.82	2.12	18.37
Panicle emergence	2.95	2.83	2.70	2.42	2.22	2.62	22.71
Mean	2.75	2.54	2.40	2.24	2.13		
B. 2014-15							
CRI	2.86	2.72	2.55	2.54	2.52	2.64	22.88
Tillering	2.70	2.44	2.29	2.08	1.98	2.30	19.93
Panicle emergence	3.00	2.89	2.78	2.54	2.31	2.70	23.40
Mean	2.85	2.68	2.54	2.39	2.27		

CRI = Crown Root Initiation

2014 by releasing 5, 10, 20 and 40 aphids per plant and resulted in population of 18.0, 19.70, 28.90 and 49.20 at infestation level of 5, 10, 20 and 40 aphids on March 1, 2014 (Table 1). The population of aphids resulted in peak population

Table 4: Avoidable losses (%) at indicated levels of infestation and at selected crop growth stages

2013-14	Avoidable losses (%) at indicated levels of infestation and at selected crop growth stages				Mean
	5	10	20	40	
CRI	5.11	12.04	13.50	13.87	11.13
Tillering	13.71	17.65	24.30	28.64	21.08
Panicle emergence	4.03	8.45	17.96	24.73	13.79
Mean	7.62	12.71	18.59	22.41	
2014-15					
CRI	4.92	10.85	11.21	11.90	9.72
Tillering	9.62	15.17	22.95	26.67	18.60
Panicle emergence	3.67	7.33	15.33	23.00	12.33
Mean	6.07	11.12	16.50	20.52	

CRI = Crown Root Initiation

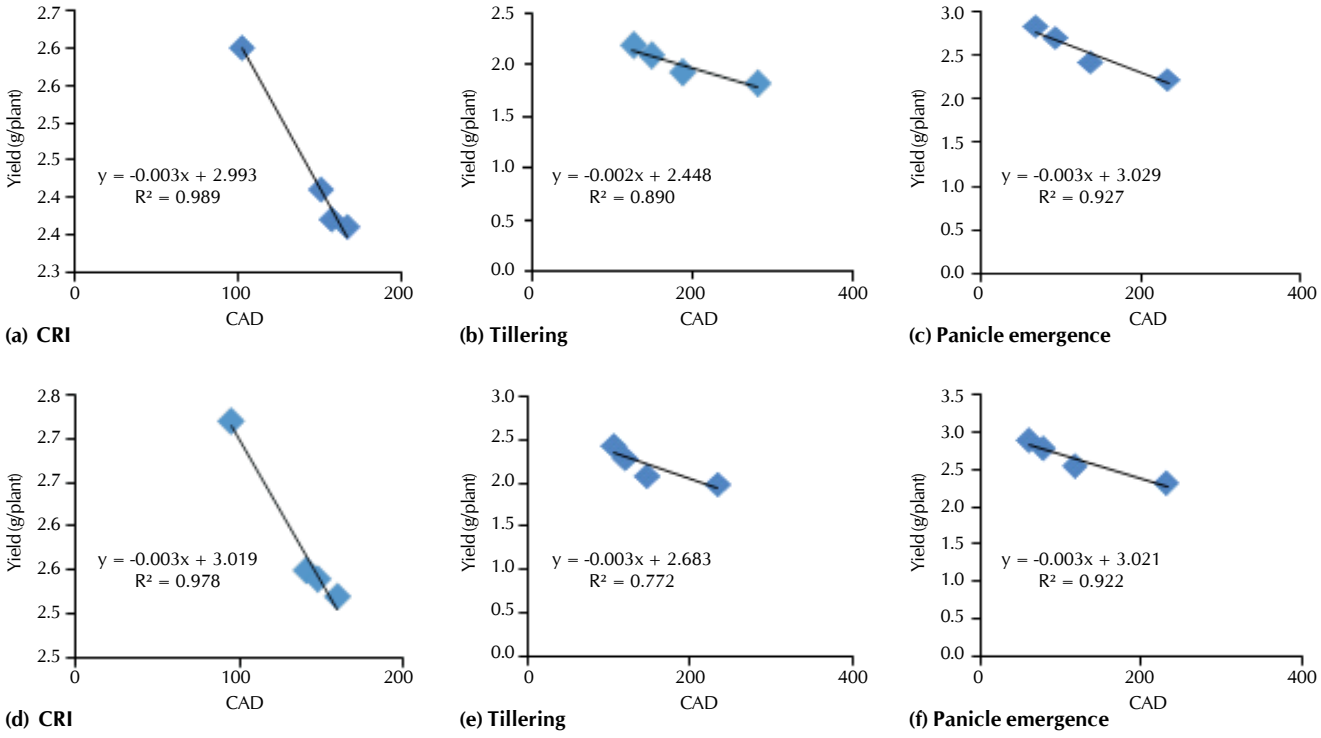

Figure: 1 Relationship between yield and cumulative aphid days (CAD) of levels released at different crop growth stages during 2013-14 (a-c) and 2014-15 (d-f)

of 29.60, 32.60, 39.90 and 54.90 at infestation levels of 5, 10, 20 and 40 aphids during March, 2014. It was evident that the mean population increased steadily upto3rd week of March, 2014 and mean peak activity was during the same period. Thereafter, aphid population experienced a steady decline till the last observation recorded on May, 2014.

Infestation initiated at panicle emergence stage

The plants with 5, 10, 20 and 40 aphids per plant were infested artificially on April 5, 2014 (Table 1) at panicle emergence stage of wheat and the mean aphid population was maximum on April 19, 2014 with 30.33 aphids and being lowest on May 3, 2014 with 3.73 aphids per plant. As evident from the mean aphid population at 5, 10, 20 and 40 the highest population was at level 40 followed by 20, 10 and 5 *i.e.*, 33.52, 19.70, 13.50 and 9.90 aphids per plant, respectively.

Infestation initiated at CRI stage 2014-15

During 2014-15 at CRI stage, the plants were infested artificially on January 10, 2015 by releasing 5, 10, 20 and 40 aphids per plant. A perusal of data contained in table 2 revealed that one week after initiation of infestation, the aphid population reached the level of 7.20, 13.20, 13.50 and 14.60 aphids/ plant at infestation levels of 5, 10, 20 and 40 on Jan 17, 2014 *i.e.*, 7 days after infestation. The number of aphids during 2014-15 also showed similar trend as during 2013-14 in population levels released at 20 and 40 aphids per plant. Whereas the population of aphids decreased after release because the population was crowded at high levels and due to small size of plants they were not able to hold that much of pest population released at 20 and 40 aphids/ plant. As evident from the data (Table 2) the population increased significantly and reached the peak in 2nd week on March, 2015 with the population of 25.20, 37.60, 38.10 and 39.00 aphids per plant

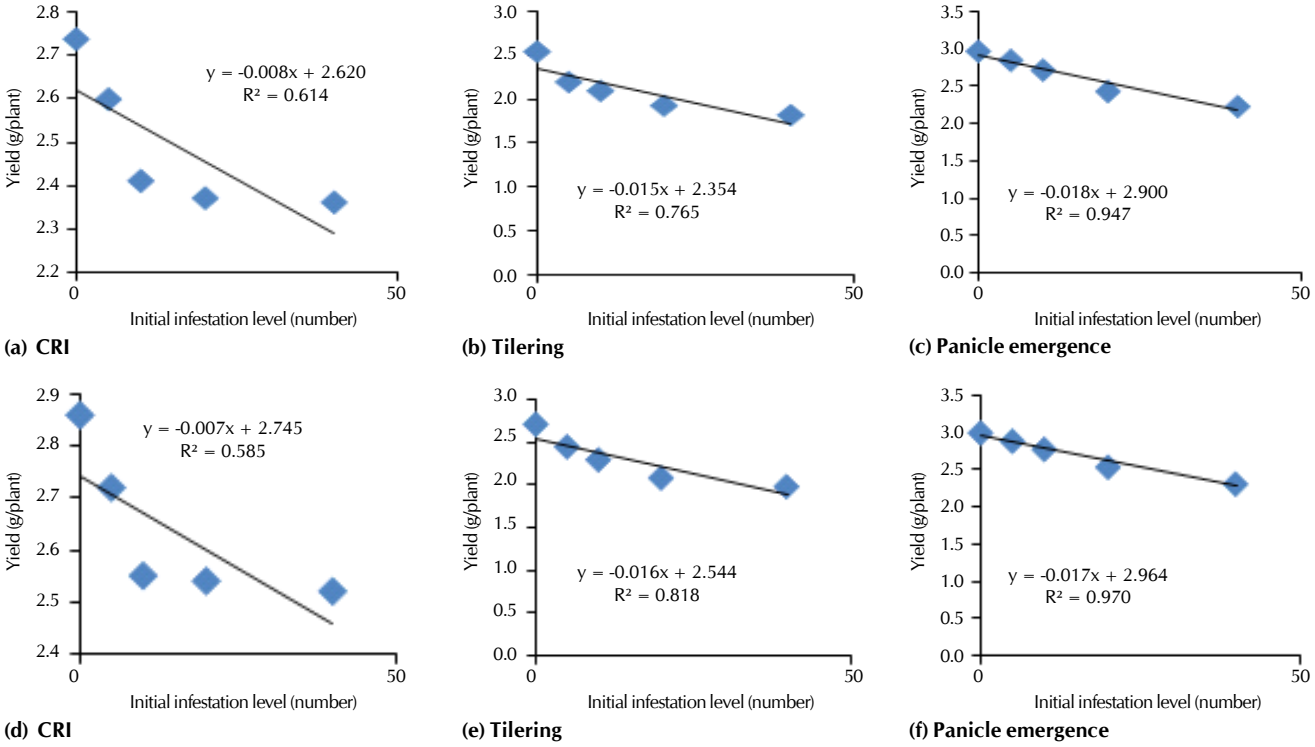

Figure: 2 Relationship between yield and indicated levels of infestation released at different crop growth stages during 2013-14 (a-c) and 2014-15 (d-f)

at corresponding infestation levels of. Thereafter, a decline in population was started and aphid count became zero on May 2, 2015. It was also evident that the mean population varied significantly at all the infestation levels being lowest at 5 aphid level with 13.60 aphids per plant and maximum corresponding to 40 aphids level i.e., 23.00 aphids per plant and mean aphid population at level 10 and 20 was 20.20 and 21.20 aphids per plant, respectively.

Infestation initiated at tillering stage

At tillering stage, the plants were infested artificially on Feb 14, 2015 by releasing 5, 10, 20 and 40 aphids per plant and resulted in population of 10.60, 17.60, 26.60 and 47.50 at infestation level of 5, 10, 20 and 40 aphids on March 8, 2014 (Table 2). The population of aphids resulted in peak population of 31.20, 34.50, 37.80 and 55.50 at infestation levels of 5, 10, 20 and 40 aphids, respectively. It was evident that the peak activity was observed on March 14, 2015. Thereafter, aphid population experienced a steady decline and was zero on May 9, 2015.Similar trend of aphid population was also observed by Sharma *et al*. (2013),they reported that the maximum or the peak population of aphids was recorded during the 3rd week of March under Palampur conditions of Himachal Pradesh. These findings are in close conformity with the findings of present studies. Similar observations on the peak period of aphid population have also been reported from Argentina by Rios and Conde (1986).

Infestation initiated at panicle emergence stage

The plants with 5, 10, 20 and 40 aphids per plant infested artificially on April 11, 2015 (Table 2) at panicle emergence stage of wheat and the mean aphid population was highest on April 25, 2014 with 28.85 aphids and being lowest on May 9, 2014 with 3.05 aphids per plant. As evident from the mean aphid population at 5, 10, 20 and 40 the highest was at level 40 followed by 20, 10 and 5 i.e., 33.04, 16.78, 11.08 and 8.54 aphids per plant, respectively.

Yield obtained

The data of the mean yield at indicated levels of infestation at selected crop growth stages (Table 3) revealed that the mean yield of levels 40 and 20 was 2.13 g/ plant and 2.24 g/ plant, respectively which were at par with each other while the highest yield was obtained in 0 level with 2.75 g/ plant followed by levels 5 and 10 with 2.54 and 2.40 g/ plant, respectively. It was also evident that the mean yield at selected crop growth stages viz., CRI, tillering and panicle emergence was highest at panicle emergence (2.62 g/ plant) followed by CRI and tillering stage with 2.50 and 2.12 g/ plant, respectively. However, data presented in tables 7 and 8 also revealed that the tillering stage was found to be the most susceptible stage of wheat against aphids as population of aphids at this stage was maximum and resulted in reduced yields as compared to other stages of initial infestation levels.

Data presented on table 3 revealed that the mean yield of level 40 was 2.27 g/ plant followed by 20, 10 and 5 levels of infestation was 2.39, 2.54 and 2.68 g/ plant, respectively. Level 0 plants resulted in highest yield 2.85 g/ plant as these plants were free from infestation. It was also evident that the mean yield at selected crop growth stages was highest in panicle emergence *i.e.*, 2.70 while in CRI stage was 2.64 and lowest at

tillering stage with 2.30 g/ plant.

Avoidable per cent losses

The avoidable loss in grain yield during 2013-14 varied from 4.03 to 28.64 per cent in different infestation levels at different crop stages (Table 4). Amongst different crop stages, the mean losses inflicted were highest in tillering stage was (21.08%) followed by panicle emergence and CRI stage with 13.79 and 11.13 per cent, respectively. The mean losses were more at 40 aphid infestation level followed by 20, 10 and 5 aphids with 22.41, 18.59, 12.71 and 7.62 per cent, respectively. During 2014-15 (Table 4) the data revealed that the per cent losses in infestation levels at different crop stages varied between 3.67 and 26.67. The highest mean losses observed in tillering stage were 18.60 per cent and minimum was in CRI stage with 9.72 per cent losses. The infestation initiated at panicle emergence stage registered 12.33 per cent yield losses. However, the mean losses were maximum in 40 level of aphid infestation being 20.52 followed by 20, 10 and 5 levels with 16.50, 11.12 and 6.07 per cent avoidable losses, respectively. The avoidable losses during the present studies varied between 3.67 and 28.64 under different levels of infestation. The yield losses ranging from 7.9 and 34.2 per cent against average aphid population of 1.57 to 2.25 aphids per tiller have also been reported by Akhtar *et al*. (2010) from Pakistan. These variations in the yield losses may be attributed to the different varieties used in experiments. In the studies conducted by Singh *et al*. (2008), it was reported that population of aphids exceeding 50 aphids per ear caused losses ranging between 6.13 and 27.82 per cent whereas 6 to 10 aphids per ear resulted in 6.70 per cent losses and 11 to 25, 26 to 50 and 51 to 100 aphids per ear resulted in 9.28, 11.37 and 15.45 per cent yield losses, respectively which shows that their results were in agreement with our findings where 20 to 50 aphids per ear resulted in 16.50 to 18.59 per cent losses (Table 4). The variations in results of per cent losses may be due to different crop growth stages and various abiotic factors. Ali *et al*. (2011) reported 8.03 per cent loss in variety Sehar-06, minimum on FSD-08 (4.3%) and 5.55 and 6.73 per cent in varieties on Lasani-08 and Inqlab-91, respectively. The variations in per cent losses caused by aphids in comparison to our findings may be due to methods of estimation of losses and differences in response of the varieties to the aphids.

Relationship between aphid population and damage inflicted

The damage inflicted to wheat crop was worked out on the basis of cumulative aphid days (CAD) and initial infestation population levels released at CRI, tillering and panicle emergence stages. The relationships worked out are being presented hereunder.

Cumulative aphid days based

The aphid infestation initiated at CRI stage during 2013-14 resulted in 106.21, 155.49, 157.69 and 158.62 cumulative aphid days (CAD) at initial infestation levels of 5, 10, 20 and 40 aphids, respectively 135.57, 156.49, 191.41 and 279.69 CAD at corresponding levels of aphid infestation when the infestation was initiated at tillering stage. The CAD values were 77.88, 100.28, 137.38 and 223.3 at corresponding levels of infestation when the infestation was initiated at panicle emergence stage. The relationship deduced between grain yield and CAD revealed that per unit increase in CAD resulted in reduction in grain yield to the tune of 0.003, 0.002 and 0.003 g/ plant when the infestation was initiated on CRI, tillering and panicle emergence stages, respectively, (Figure 1a,b,c). However, during 2014-15 the reduction in grain yield was to the tune of 0.003 g/ plant/ CAD at all the stages of initial infestation i.e. CRI, tillering and panicle emergence stages (Fig 1 d,e,f).

Aphid infestation levels based

The linear regression equations worked out between grain yield and aphid infestation levels presented in figure 2 (a,b,c) revealed that a unit aphid infestation initiated at CRI, tilllering and panicle emergence resulted in reduction in yield to the extent of 0.008, 0.015 and 0.018 g per plant, respectively. During 2014-15 the reduction in grain yield was 0.007, 0.016 and 0.017 g per plant at CRI, tillering and panicle emergence stages of wheat (Fig. 2 d,e,f).

Determination of economic injury level

The economic injury levels (EIL) were worked out based on the cumulative aphid days and aphid infestation levels. The parameters used for cost analysis of aphid management by foliar application of dimethoate (Rogor 30EC) on per hectare were application rate, insecticide required per hectare, rate of pesticide, cost of pesticide, cost of pesticide application and labour, total number of plant protection applications in cropping system, total cost of protection per ha (C) Rs 1300, market value of produce (V) Rs 13/ kg, and gain threshold (GT) where GT was comes out to be 100.

Cumulative aphid days based

A perusal of table 5 depicting the EIL determined for aphids in wheat crop for the infestation initiated at CRI stage was 32.61 CAD for dimethoate based aphid management programme. For the infestation initiated at tillering stage, the EIL value was comparatively higher (41.55 CAD) as compared to the infestation initiated at panicle emergence stage (35.77 CAD). The economic threshold level (ETL) at 75 per cent of EIL for the infestation starting CRI stage was established at 24.46 CAD. Whereas, it was 31.16 and 26.83 CAD, respectively for infestation starting at tillering and panicle emergence stages

Aphid infestation levels based

On the basis of initial aphid infestation levels, the EIL was found to be 14.93 for dimethoate based aphid management programme (Table 5), with corresponding ETL value 11.20 aphids per plant for CRI crop growth stage. The EIL values of 7.19 and 6.78 aphids per plant with corresponding ETL values of 5.39 and 5.09 aphids per plant were determined for the infestation initiated at tillering and panicle emergence stages, respectively.

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A REGRESSION MODEL FOR NONDESTRUCTIVE FRUIT VOLUME ESTIMATION IN KARONDA (*CARISSA CARANDUS* L.)

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ABSTRACT
A model relating to karonda (*Carissa carandus*.L.) fruit length and diameter to its volume was derived using the regression analysis. Two year investigation was carried out during 2014 and 2015 under open field conditions to test a whether a model could developed to estimate fruit volume using linear measurements. Regression analysis having FV versus L and D disclosed ten models viz., $FV = -4.52 + 0.5(L+D)^2$, $FV = -18.14 + 5.5(L+D)$, $FV = -48.19 + 37.22D^{0.5}$, $FV = -41.56 + 32.09L^{0.5}$, $FV = 2.07 + 0.15L^2D^2$, $FV = -5.37 + 2.44D^2$, $FV = -3.44 + 1.88L^2$, $FV = -4.55 + 2.18LD$, $FV = -19.62 + 12.02D$ and $FV = -16.08 + 9.99L$ that could be used for estimating the volume of individual karonda fruits. Among these models a regression model having LD as the independent variable (FV = -4.55 +2.18 *LD) provided most accurate ($R^2 = 0.98$), MSE = 0.75) estimate of karonda FV. Validation of the model having LD of fruits from other genotype measured in the 2015 experiment showed that the correlation between calculated and measured area was very high. Therefore, this model can estimate accurately the FV of karonda in many experimental comparisons without the use of any pricey instruments.

INTRODUCTION

The qualitative and quantitative character of fruit is very important in horticultural crops to meet the quality standards, monitoring fruit growth, predicting yield, assessing optimal level of fertilization and irrigation, identification of the cultivars (Demirsoy and Demirsoy, 2007) and also to meet the domestic and International market needs (Wilhelm *et al*., 2005), (Koc , 2007). The size of fruit will determine its market value. Therefore the size of horticultural product is often represented by its weight because it is comparatively easy to measure. However, volume-based sorting and growth monitoring may provide a more efficient method than weight sorting. In addition, the weight of horticultural produce can be estimated from volume if the density of the produce is known (Koc, 2007).

There are many methods to estimate fruit volume in horticultural crops. However, these methods, including water displacement, gas displacement, image processing (Rashidi *et al*., 2009; Koc, 2007; Omid *et al*., 2010; Khojastehnazhand *et al*., 2008), and electronic devices (Jarimopas *et al*., 2005), require the excision of fruits from the plants. It is therefore, not possible make successive measurements of the same fruit. However fruit volume can be measured quickly, accurately and in a non-destructive manner using image analysis with image measurement by using image analysis software. The capture of image by digital camera is rapid, non-destructive and more accurate (Bignami and Rossini 1996), but the processing of images are time consuming, and the facilities required for this method is expensive (Cristofori *et al*., 2007).

Therefore, there is a need to develop simple, inexpensive, rapid, reliable, and non-destructive method for measuring fruit volume in different fruit crops by the horticulturists. The mathematical relationships between fruit volume and dimensions of the fruit (length and diameter) could be clarified, a method using just linear measurements to estimate fruit volume would be more advantageous than many of the methods are mentioned above (Villegas *et al*., 1981; Beerling and Fry, 1990). Various combinations of measurements and various models relating length and diameter to volume have been developed for several fruit and vegetable crops, such as apples (Batjer *et al*., 1957), muskmelon (Currence *et al*., 1944; Jenni *et al*., 1997), pear (Mitchell, 1986; Williams *et al*., 1969; Ortega *et al*., 1998), bell pepper (Ngouajio *et al*., 2003), apricot (Arzani *et al*., 1999), peach (Demirsoy and Demirsoy, 2007), while the information on fruit volume estimation in karonda (*Carissa carandas* L.) is still lacking.

Karonda (*Carissa carandas* L.) is a species of flowering shrub belongs to family Apocynaceae and order Gentianales. Flowers were white, scented and important source of nectar for different butterfly species (Atluri *et al*., 2011). It produces berry-sized fruits and these are commonly used as a condiment in Indian pickles and spices. It is a hardy, drought-tolerant plant that flourishes well in a wide range of soils, in regions with high temperatures and thrives well throughout tropical and sub tropical climate. In India, it grows wild in states of UP, Bihar,

West Bengal, lower, outer and middle Himalayas, Rajasthan, Uttarakhand, Maharashtra and parts of southern India (Malik *et al*., 2010). Therefore, the this study deals with development of different linear regression models for fruit volume prediction and evaluation of the developed linear regression models.

MATERIALS AND METHODS

The present study was performed in a karonda orchard located at Central Horticultural Experiment Station (CHES), Chettalli, Kodagu, Karnataka, India (latitude 12º59'N, longitude 75º84'E, altitude 609m) in a very deep, well drained clay soils with iron gravel horizon. The annual mean temperature was 21.6ºC, with annual rainfall of 1450 mm. Ten karonda accessions (Konkan bold (layered) Vengurla (open pollinated), Konkan bold (open pollinated), Konkan Big, Vengurla Big, Thakurwadi local, Vengurla small, Konkan small (open pollinated), Vengurla big (open pollinated) and Thakurwadi (open pollinated) were used to develop a fruit volume prediction models. These accessions were planted in the year 2006 and maintaining at spacing of 6 x 6m. Fruit sampling was performed in early June when the fruits were fully developed. Fruits were selected randomly from different levels of the shrub canopy ranging from 1 to 3m from the soil level and all around the crown. Thirty fruits were sampled from each accession. Total of 300 karonda fruits (30 fruits per accession) were measured for fruit volume (FV), fruit Length (FL) and fruit diameter (FD) in the preliminary calibration experiment coming from ten accessions.

The weight of fruits was measured with weighing balance (Sartorius, CP324S). The volume of fruit was measured using water displacement method. The dependent variable FV were regressed with different independent variables, including L, D, $L^{0.5}$, $D^{0.5}$, L^2, D^2, L^2D^2, $(L+D)^2$ and product LD in combination of all genotypes.

Mean square error (MSE) and the values of the coefficients (a) and constants (b) were also reported, and the final model was selected based on the combination of the highest coefficient of determination (R^2) and the lowest MSE.

Moreover, using two measurements (*i.e.*, length and diameter) introduced potential problems of co-linearity, resulting in poor precision in the estimates of the corresponding regression coefficients. For detecting the variance inflation factor (VIF) (Marquaridt., 1970) and the tolerance values(T), were also calculated (Gill., 1986).

$$VIF = \frac{1}{(1 - r^2)}$$

$$T = \frac{1}{VIF}$$

Where *r* is the correlation coefficient between length and diameter of fruit. If the VIF value was higher than 10 or if *T* value was smaller than 0.10 then co-linearity may have more than a trival impact on the prediction of the parameters, and consequently one of those should be excluded from the model (Gill., 1986). In order to validate the developed model and to increase practical applicability, a validation experiment was conducted in the summer 2015 on fruit samples of other genotype (Thakuwadi OP) grown at experimental farm of CHES, Chettalli. Total 30 fruits of the local genotype were used to determine fruit length, fruit diameter as well as fruit volume using the best predicted model from the calibration experiment and was compared with actual fruit volume. Moreover, to compare the predicted fruit volume (PFV) and the observed fruit volume (OFV), the season of local genotype growing and graphical procedures (Martin Bland and Altman, 1986) were used. Scatter plots of values for the PFV against the OFV are presented in (Fig. 2). SPSS 16.0 programme was used to evaluate the linear relationship for OFV and PFV of the local genotype.

RESULTS AND DISCUSSION

The models derived through linear regression procedure were simple to use. These models use both fruit diameter and fruit length as input variables. Regression analysis demonstrated a strong relationship ($P < 0.001$) between fruit volume (FV) and fruit length (FL), fruit diameter (FD), the product of length and diameter (LD), the square of the sum of length and diameter $(L+D)^2$, the square of length (L^2) and the square of diameter (D^2) among the selected genotypes (Table 1.).

As a preliminary step to model calibration, the degree of colinearity among L and D was analyzed. The VIF was ranged from 4.3 to 6.0 and T values ranged from 0.12 to 0.19, depending on genotypes respectively. In, all selected

Table 1: Fitted coefficient (b) and constant (a) values of the models used to estimate the karonda fruit volume (FV) of single fruits from length (L) and diameter (D) measurements.

Model Number	Form of model tested	Fitted coefficient and constant[a] aa	b	R^2b	MSE[b]	RMSE
1	FV= a +b $(L+D)^2$	-4.52 (0.33)	0.54 (0.01)	0.98	0.77	0.88
2	FV = a+ b(L+D)	-18.14 (0.81)	5.55 (0.17)	0.96	1.21	1.098
3	FV = a+ b$D^{0.5}$	-48.19 (2.24)	37.22 (1.48)	0.94	1.98	1.41
4	FV = a+b $(L^{0.5})$	-41.56 (2.07)	32.09 (1.33)	0.93	2.14	1.46
5	FV = a+b $(L^2 D^2)$	2.07 (0.21)	0.15 (0.004)	0.97	0.86	0.93
6	FV = a+b (D^2)	-5.37 (0.41)	2.44 (0.07)	0.97	1.01	1.01
7	FV = a+b (L^2)	-3.44 (0.44)	1.88 (0.07)	0.95	1.52	1.23
8	FV = a+b (L D)	-4.55 (0.33)	2.18 (0.05)	0.98	0.75	0.87
9	FV = a+b (D)	-19.62 (0.99)	12.02 (0.42)	0.95	1.56	1.25
10	FV = a+b (L)	-16.08 (0.95)	9.99 (0.38)	0.94	1.84	1.36

[a] standard errors in parenthesis; L and D were in cm; [b] Coefficient of determination (R^2), mean square errors(MSE in cm^2) of the various models are also given. All data were derived from the calibration experiment held by 2014(n = 300fruits)

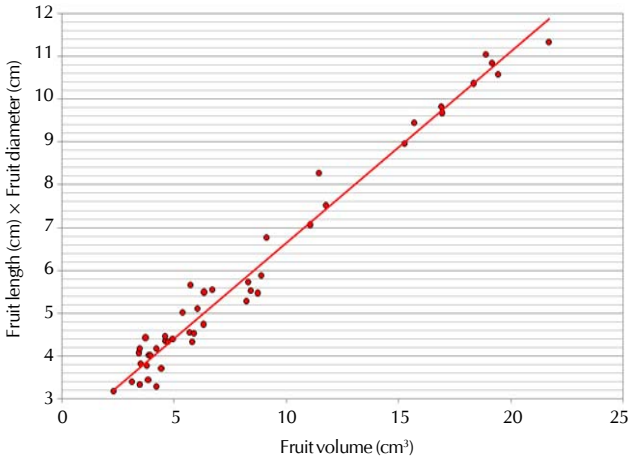

Figure 1: Relation between fruit volume (FV) and fruit length (L) x Fruit diameter (D) of fruits from ten genotypes measured in the calibration experiment (2014). The regression equation is FV = -4.552+2.181*LD

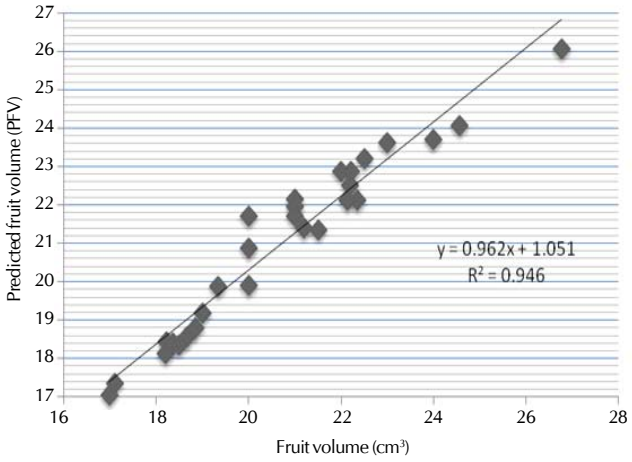

Figure 2: Observed vs. predicted values of fruit volumes of karonda during 2015 (validation experiment) using model number 8 FV = -4.552+2.181*LD. Where FV is individual fruit volume (cm³) and LD is the product of fruit length (cm) X fruit diameter (cm). Solid line represents linear regression lines of Model 8. Dotted lines represent the 1:1 relationship between the measured and calculated values

genotypes, VIF was < 10 and T was > 0.10, showing that the co-linearity between fruit length and diameter can be considered negligible. Therefore both the variables were included in the model (Gill., 1986) to avoid the experimental errors.Similar studies were conducted on some species of fruit trees such as peach (Demirsoy and Demirsoy, 2007), apricot (Arzahi *et al*., 1999), pear (Ortega *et al*., 1998), where the fruit size estimation models were developed using the linear measurement of fruits.

Among, all the models developed, the model number 8 (FV = -4.552+2.181*LD) was selected for its highest R^2 (0.98), smallest MSE (0.75) (Fig. 1). Although model number 1 FV = -4.52+0.543*$(L+D)^2$ had same R^2 (0.98) as model number 8, the preference was give to model number 8, because of its easy calculation and lowest MSE. Except for Model 3, 4 and 10, all models produced a coefficient of determination (R^2) equal to or greater than 0.95 (Table 1).

Comparisons between measured versus calculated fruit volume using model number 8 FV = -4.552+2.181*LD for the validation set derived from 2015 experiment, showed a high degree of correlation and provided quantitative evidence of the validity of volume estimation model (Fig. 2). The results indicated that a high correlation (R^2= 0.946, P<0.0001), between OFV and PFV. Finally, it may be concluded that length-diameter model can provide more precise estimation of karonda fruit volume than those based on single length or diameter measurements. Measuring fruit length and diameter are easy access parameters in the field. Therefore, use of this model would enable researchers to make non-destructive or repeated measurements on the same fruits. This model may be accurately utilized to estimate the fruit volume in karonda shrubs without use of common method of volume measurements like water displacement, gas displacement and expensive instruments, e.g., image processing software or machine vision techniques. To summarize that, it was concluded that the fruit length-diameter model (i.e. Model 8) can provide precise estimation of karonda fruit volume across genotypes and environments. With this model, horticulturists, agronomists and physiologists can estimate fruit volume of karonda accurately.

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EFFECT OF INTEGRATED USE OF FYM AND UREA ON YIELD, NUTRIENT UPTAKE AND PROTEIN CONTENT OF WHEAT (*TRITICUM AESTIVAM* L.)

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ABSTRACT

The present investigation was conducted for one *rabi* seasons during 2013-14 in a clay loam soil at the Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.), India. To study the effect of integrated use of FYM and urea on yield, nutrient uptake and protein content of wheat (*Triticum aestivum L.*) The result revealed that the highest values of grain yield (4744.11 kg ha^{-1}) were obtained from M_1N_2 (SWI at 75% N from urea and 25% N from FYM) which differed significantly over rest of the treatment combinations. However, the maximum nutrient (N,P and K) uptake by wheat in method of sowing and integrated use of FYM and urea respectively in SWI the maximum nutrient uptake by wheat 63.20,15.79,122.63 in integrated use of FYM and urea 74.77, 24.95,142.37 kg ha^{-1} were observed in the treatment receiving at 75% N from urea and 25% N from FYM and also highest protein content in SWI 9.44% and integrated use of FYM and urea 11.05% (100 % N through urea). Thus, integrated use of FYM and urea improve the crop yields, produces quality grain as well as improve the soil fertility.

INTRODUCTION

Cereals are an important dietary protein source throughout the world, because they constitute the main protein and energy supply in most countries. Wheat (*Triticum aestivum L.*) is one of the major cereal crops with a unique protein (gluten), which is consumed by humans and is grown around the world in diverse environments. In India, wheat is second most important food crop, next only to rice, with an area of 29.8 million hectares and production of 93.90 million tons during 2012-13 (Anon., 2013). The average productivity is 2.96 tons ha^{-1}. It occupies 21 per cent of area under food grains and contributes 34 per cent to the total food grain production of the country. The rapid increase in the world population demands parallel increases in food production, particularly of wheat. In India, after the green revolution, intensive agriculture involving exhaustive high-yielding varities of wheat has lead to heavy withdrawal of nutrients from the soil. The imbalanced use of chemical fertilizers by farmers has deteriorated soil health. The integrated use of FYM and urea improving and maintaining soil health for enhancing and sustaining agricultural production. Integrated use of 75% NPK and FYM @ 5 t ha^{-1} or poultry manure @1.5 mg ha^{-1} to rainy season crops and 75% NPK to wheat significantly improved the yield of wheat over application of 100% NPK in both the season (Bandyopadhyay *et al*. 2009). Similarly, a field experiment conducted by Pandey *et al*., (2009) at Pusa exhibited that application of FYM at varying fertility levels produced significantly higher values for yield attributing characters than as well as grain and straw yield than the application of chemical fertilizers alone due to adequate quantities and balanced proportion of plant nutrients supplied to the crop.Adoption of integrated plant nutrient supply and management strategies for enhancing soil quality, input use efficiency and crop productivity is extremely important for food and nutritional security in Indian agriculture (Swarup, 2010).

The effect of integrated use of organic and inorganic fertilizers on the yield of wheat was evaluated by Shah *et al*., (2010) at NIFA, Peshawar. The results showed that integrated use in different proportion increased the plant height, spike length, grain per spike and 1000-grain weight. Maximum grain yield of 3.5 t ha^{-1} was obtained from treatments where 25% N was applied from FYM 25% N from poultry manure or city waste and 50% from mineral source and in treatment where 25% N was applied from FYM, 25% from city waste and 50% from mineral fertilizer. Application of half N from urea with 25% N from either FYM and 25% poultry manure or city waste proved beneficial and reduced 50% fertilizer cost. Nutrients are one of the most important inputs, required by the plants for their growth and yield. The N, P and K are major nutrients and are supplied through fertilizers and manures. Farm yard manure is considered as the promising renewable, nutrient rich source and can be served as a substitute to cut down the cost of fertilizer input and to increase the productivity of wheat in addition to maintain soil productivity, improve the eco-system and ultimately resulting in improved soil-plant-health in a sustainable agricultural eco-system. Keeping this in view, the present investigation was planned to study the impact of

integrated use of FYM and urea on yield, nutrient uptake and protein content of wheat (*Triticum aestivum L.*)

MATERIALS AND METHODS

A field experiment was conducted during rabi season of 2013-14 at Instructional Farm, Indira Gandhi Krishi Vishwa vidyalaya, Raipur located at between 21º16'N latitude and 81°26'E longitude with an altitude of 289.56 m above mean sea level. During the investigation cumulative rainfall was 89.2 mm while mean maximum and minimum temperature of 42.6ºC and 9.6ºC respectively. The soil of experiment site was clay loam (25.41% sand, 22.72% silt, 52.86% clay), with a pH of 7.6, 0.37% organic carbon, low in available nitrogen (188.16 kg ha^{-1}), medium in available phosphorus (19 kg ha^{-1}) and potash (220.11kg ha^{-1}). The experiment using split plot design where the main plot were sowing methods and the sub plot were integrated use of nitrogen. Treatments comprised of three methods of sowing viz. SWI (M_1), line sowing (M_2) and broadcasting (M_3) and six levels of N fertilizers *viz.* ,urea and FYM were combined in a way to supply N at 120 kg ha^{-1} from both sources in 0:0 (N_0), 100:0 (N_1), 75:25 (N_2), 50:50 (N_3), 25:75 (N_4) and 0:100 (N_5) ratios arranged in a split plot design with three replications. The wheat (variety *Ratan*) was planted using a seed rate of 25, 100 and 125 kg ha^{-1} in SWI, line sowing and broadcast methods of sowing, respectively. In case of line sowing seeds were sown at a row spacing of 22 cm apart, while seeds were spread uniformly in broadcast method. The weeds were eliminated from each plot by hand weeding. An intercultural operation was performed in SWI method with the help of hand wheel- hoe in order to facilitate better aeration in the root zone. The required quantity of wheat seeds for different methods, were treated with Bavistin @ 2.5 g/kg of seed before sowing. Standard procedures were adopted for recording the data on various growth and yield parameters.

The grain and straw yield of wheat were recorded and soil samples (0-15cm) were collected from each plot after harvest of wheat. The sample were analyzed for Organic by rapid titration method (Walkley and Black, 1936). Available N was estimated by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus by Olsen¼s method (Olsen *et al.*, 1954), available K by ammonium acetate extraction method (Jaction ,1967) . Data collected were statistically analyzed by using Fisher's analysis of variance technique.

RESULTS AND DISCUSSION

The data on effective tillers m^{-2}, length of ear head (cm), no. of grains ear^{-1} head, weight of grains ear^{-1} head (g), grain yield, straw yield and protein content (%) of wheat at harvest as influenced by different treatments are presented in Table 1.The number of effective tillers in wheat varied significantly due to methods of sowing and integrated use of nitrogen at harvest number of effective tillers were recorded in SWI treatment, being significantly higher (330.17) over other methods of sowing. The broadcast method resulted in lesser number of effective tillers (234.06 m^{-2}) compared to those recorded in SWI and line sowing treatments. Similar trend also found in number of length of ear head (cm), no. of grains ear^{-1} head , no. of grains ear^{-1} head (g). The broadcasting method resulted less effective tillers due to greater intra-specific competition between plant populations than line sown crop. Similarly, the ear length of wheat was also found higher in SWI compared to conventional broadcasting as well as line sowing by Adhikari *et al.* (2013). Similarly Singh *et al.* (2011) who reported marked increase in number of grains per ear of wheat by applying organic manures and mineral fertilizer in combination. Similarly data reported Tanveer *et al.* (2003) and Khan *et al.* (2007) who reported minimum 1000-grain weight for broadcast planted wheat as compared to wheat planted with other planting methods. Similar trend also found in grain yield and straw yield at harvest. Protein content in grain (%) wheat was significantly influenced by methods of sowing and integrated use of nitrogen. The crop planted through SWI had significantly higher (9.44 %) followed by line sowing (8.06 %) and significant difference existed in between these two treatments. The minimum protein content in grain (6.34 %) was recorded in plants sown through broadcasting method.

As regards to integrated use of nitrogen, results showed that application of nitrogen increased effective tillers m^{-2}, significantly over absolute control treatment. Maximum no. of effective tillers of (307.47m^{-2}) at harvest, were observed in treatment where 75 % RDN was applied through urea and 25 % N through farm yard manure (N_2), being significantly superior over rest of the treatment combinations. Similar trend also found in length of ear head (cm), no. of grains ear^{-1} head , no. of grains ear^{-1} head (g), grain yield and straw yield but in non significant variation are also observed in no. of grains ear^{-1} head (g) and protein content in grain due to methods of sowing and integrated use of nitrogen at harvest. The interaction between sowing methods and integrated use of nitrogen on number of effective tillers, length of ear head (cm), no. of grains ear^{-1} head, 1000-seed weight (g), grain yield and straw yield of wheat was found significantly at harvest.

The interaction between sowing method and integrated use of nitrogen had a significant effect on grain yield of wheat (Table 2). The highest values of grain yield (4744.11 kg ha^{-1}) were obtained from M_1N_2 (SWI at 75% N from urea and 25% N from FYM) which differed significantly over rest of the treatment combinations. The lowest values of grain yield (1138.24 kg ha^{-1}) were obtained from M_3N_0 (broadcasting method without N fertilization) which was proved to be significantly lowest compared to other treatment combinations. Therefore, the combination of M_1N_2 is recommended as the treatment that maximizes grain yield of wheat under this study. Similarly, Abbas and Fadul (8) also showed significant interaction of the planting methods and manures for the grain yield. Similar trend also found in number of effective tillers, length of ear head (cm), no. of grains ear^{-1} head , 1000-seed weight (g), straw yield at harvest. . Application of N solely from urea (N_1) gave maximum grain protein content (11.05 %), being significantly superior over other treatment combinations followed by protein content of 9.93 % observed in treatment receiving 75% N from urea and 25% N from FYM (N_2). Absolute control (N_0) devoid of nitrogen addition remained inferior most with respect to protein content in wheat grain. These results are in close conformity with the previous findings of Kumar *et al.* (2013) who found that reduction in nitrogen doses significantly reduced the protein content in

Table 1: No. of Effective Tillers m^{-2}, Length of Ear head (cm), No. of grains Ear^{-1} head, weight of grains Ear-1 head (g), 1000-seed weight (g), Grain yield, Straw yield and protein content (%) of wheat as influenced by effect of integrated use of FYM and urea

Treatment	No. of Effective Tillers m^{-2}	Length of Ear head (cm)	No. of grains Ear^{-1} head	Wt. of (g) grains Ear^{-1} head	1000-seed weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Protein content in grain (%)
Method of sowing								
SWI	320.17	9.83	47	2.84	44.54	3336.04	4456.83	9.44
Line Sowing	262.55	8.66	40.02	2.54	40.05	2450.60	3646.28	8.06
Broadcasting	234.06	8.04	36.66	2.31	37.59	2067.75	3059.90	6.34
SEm ±	2.27	0.12	0.85	0.04	0.84	27.76	47.69	0.28
CD (P=0.05)	8.89	0.48	3.35	0.15	3.28	109.01	187.25	1.13
Nitrogen level								
N_0	198.48	6.73	30.91	1.77	32.57	1581.92	2477.30	3.69
N_1	279.32	9.7	46.09	3.13	44.97	3267.71	4508.38	11.05
N_2	307.47	10.17	50.48	3.57	50.83	3638.96	4926.15	9.93
N_3	260.98	9.27	43.99	2.69	42.33	2786.49	3996.95	9.04
N_4	244.73	8.98	39.35	2.32	39.47	2445.39	3446.21	7.99
N_5	216.57	8.39	36.54	2.12	36.19	1988.31	2971.03	5.98
SEm ±	4.75	0.14	0.68	0.12	0.9	90.931	80.29	0.27
CD (P=0.05)	13.72	0.39	1.97	0.34	2.61	262.62	231.9	0.78
Interaction	24.02	0.69	3.44	NS	4.56	459.72	405.93	NS

Table 2: Grain yield (kg ha^{-1}) of wheat as influenced by interaction between methods of sowing and integrated use of nitrogen

Treatments	M_1 (SWI)	M_2 (Line sowing)	M_3 (Broadcasting)
N_0-RDN (100%N from urea)	2283.07	1324.44	1138.24
N_1-RDN(75% urea + 25% FYM)	4441.83	2984.70	2376.58
N_2- RDN(50% urea + 50% FYM)	4744.11	3579.34	2593.44
N_3- RDN(25% urea + 75% FYM)	3317.86	2812.27	2229.34
N_4- RDN(100 % FYM)	3019.94	2079.77	2236.47
N_5-RDN (100%N from urea)	2209.45	1923.08	1832.41

For comparing means of SEm ± $CD_{5\%}$ M x N at the same level of M 157.50 459.73M x N at the same or different level of N 148.57 471.53

Table 3: N, P, K and organic carbon availability as influenced by integrated use of FYM and urea on wheat

Treatment	Available N Kg ha^{-1}	Available P Kg ha^{-1}	Available K Kg ha^{-1}
Method of sowing			
M_1 (SWI)	237.21	24.88	264.32
M_2 (Line sowing)	237.2	23.65	262.91
M_3 (Broadcasting)	229.56	23.1	262.18
SEm ±	1.48	0.2	2.18
CD (P=0.05)	5.81	0.79	8.58
Integrated use of Nitrogen			
N_0 (Absolute control)	177.78	17.73	182.51
N_1 (100% through Urea)	248.53	22.39	281.68
N_2 (75% Urea + 25% FYM)	253.73	25.53	284.36
N_3 (50% Urea + 50% FYM)	248.51	24.62	278.38
N_4 (25% Urea + 75% FYM)	242.65	25.42	278.35
N_5(100% through FYM)	236.74	27.55	273.54
SEm ±	2.68	0.62	2.22
CD (P=0.05)	7.75	1.81	6.41
Interaction	NS	NS	NS

wheat grain.

Nutrient status of soil after harvest of crop

The data on available N, P, and K of soil kg ha^{-1} after harvesting of crop was analysed and embodied in table 3. The available nitrogen in wheat varied significantly due to methods of sowing and integrated use of nitrogen after harvest of crop available nitrogen were recorded in SWI treatment, being significantly higher (237.21 $kgha^{-1}$) over other methods of sowing. The broadcast method resulted in lesser available nitrogen (229.56 $kgha^{-1}$) compared to those recorded in SWI and line sowing treatments. Similar trend also found in Available P and K kg ha^{-1}. This kind of sowing with proper plant density allows plant to grow in its full potential on account of sufficient aeration, moisture, sunlight and nutrient availability leading to proper root system development resulting in healthier growth and higher yield (Dash and Pal, 2011).

The interaction between sowing method and integrated use of

Table 4: N, P and K uptakes as influenced by integrated use of FYM and urea on wheat

Treatment	Nitrogen uptake kg ha^{-1}			Phosphorus uptake kg ha^{-1}			Potassium uptake kg ha^{-1}		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Method of sowing									
M_1 (SWI)	47.99	15.21	63.20	12.71	3.08	15.79	48.8	73.83	122.63
M_2 (Line sowing)	45.01	14.88	59.89	10.97	2.26	13.23	45.77	69.46	115.23
M_3 (Broadcasting)	43.88	14.25	58.13	9.89	1.54	11.43	35.31	66.65	101.96
SEm±	0.34	0.07	0.41	0.31	0.09	0.4	0.39	0.67	1.06
CD (P=0.05)	1.34	0.27	1.61	1.22	0.36	1.58	1.53	2.64	4.17
Integrated use of Nitrogen									
N_0 (Absolute control)	32.62	10.89	43.51	3.15	0.59	3.74	33.44	50.05	83.49
N_1 (100% through Urea)	49.73	16.57	66.30	14.74	3.34	18.08	46.6	81.33	127.93
N_2 (75% Urea+25% FYM)	55.89	18.88	74.77	20.15	4.8	24.95	51.43	90.94	142.37
N_3 (50% Urea+50% FYM)	47.43	15.44	62.87	13.2	2.37	15.57	44.82	71.90	116.72
N_4 (25% Urea+75% FYM)	45.21	14.01	59.22	9.56	1.58	11.14	42.88	66.47	109.35
N_5(100% through FYM)	42.88	12.88	55.76	6.35	1.09	7.44	40.6	59.19	99.79
SEm±	0.53	0.32	0.85	0.25	0.16	0.41	0.46	1.20	1.66
CD (P=0.05)	1.55	0.93	2.48	0.74	0.46	1.2	1.33	3.46	4.79
Interaction	2.72	1.62	4.34	1.3	0.81	2.11	2.32	6.05	8.37

Table 5: N, P and K uptake (kg ha^{-1}) of wheat as influenced by interaction between methods of sowing and integrated use of nitrogen

Treatment	Nitrogen uptake kg ha^{-1}		Phosphorus uptake kg ha^{-1}		Potassium uptake kg ha^{-1}	
	Grain	Straw	Grain	Straw	Grain	Straw
M_1N_0	37.20	10.37	4.14	0.75	36.75	53.70
M_1N_1	49.85	18.22	17.40	4.25	51.05	86.08
M_1N_2	62.63	21.15	22.37	6.90	56.01	100.99
M_1N_3	47.37	15.70	15.17	2.97	50.89	74.07
M_1N_4	46.26	14.22	10.00	1.90	49.33	66.78
M_1N_5	44.63	11.59	7.20	1.72	48.77	61.34
M_2N_0	31.90	11.69	3.06	0.57	32.95	50.87
M_2N_1	49.41	15.67	13.70	3.36	50.40	82.01
M_2N_2	52.77	18.58	21.39	4.49	53.46	92.89
M_2N_3	47.60	15.82	12.51	2.44	48.51	68.67
M_2N_4	45.06	13.90	9.23	1.70	46.47	63.59
M_2N_5	43.30	13.62	5.94	0.97	42.86	58.74
M_3N_0	28.75	10.61	2.24	0.45	30.64	45.59
M_3N_1	49.94	15.82	13.11	2.40	38.36	75.89
M_3N_2	52.26	16.91	16.68	3.01	44.81	78.93
M_3N_3	47.32	14.81	11.92	1.71	35.06	72.97
M_3N_4	44.32	13.92	9.46	1.13	32.83	69.04
M_3N_5	40.70	13.45	5.92	0.56	30.16	57.49

nitrogen had a significant effect on available N, P and K (Table 3). The higher availability of nitrogen (253.73 kg ha^{-1}) were obtained from N_2 (75% N from urea and 25% N from FYM) which differed significantly over rest of the treatment combinations. The lowest availability of nitrogen (177.78 kg ha^{-1}) were obtained from N_0 (without N fertilization) which was proved to be significantly lowest compared to other treatment combinations. Similar trend also found in Available P and K kgha^{-1}. The available nutrient in soil was non-significant influenced due to method of sowing and integrated use of nitrogen. Increase in available nitrogen in soil due to addition of organics was observed in wheat (Singh *et al*., 2006) .The available P was either maintained or slightly improved due to addition of farm yard manure. The similar result was also found by (Panwar, 2008).

The data on nutrient uptakes of N, P and K (kg ha^{-1}) in grain and straw of wheat at harvest as influenced by different treatments are presented in Table 4. The nutrient uptake in wheat varied significantly due to methods of sowing and integrated use of nitrogen at harvest N uptake by grain and straw were recorded in SWI treatment, being significantly higher (48.1,15.43 and total 63.20 kg ha^{-1}) over other methods of sowing. The broadcast method resulted in lesser nitrogen uptake in grain and straw (44.21, 14.35 and total 58.13 kg ha^{1}) compared to those recorded in SWI and line sowing treatments. Similar trend also found in phosphorus uptake, potassium uptake, the nitrogen uptake by wheat increased with the integrated use of FYM and urea. The higher nutrient uptake with organic manure might be attributed to solubilization of native nutrients, chelation of complex intermediate organic molecules produced during decomposition of added organic manures, their mobilization and accumulation of different nutrients in different plant parts. The results are in agreement with the findings of (Mitra *et al.,* 2010).

Phosphorus uptake by wheat was also influenced by combined application of inorganic fertilizers, organic manure and produced during decomposition of organic resources. Similar

results were also observed by (Mohapatra *et al.,* 2008) in rice–potato (*Solanum tuberosum* L.) cropping system and (Sawarkar *et al.,* 2013) under soybean-wheat cropping sequence in a Vertisol. The increase in grain and straw yield in integrated use of FYM and urea could be due to enhanced nutrient availability which improved nitrogen and other macro- and micro-elements absorption as well as enhancing the production and translocation of the dry matter content from source to sink. Specifically the higher organic matter and available N, P and K (Table 3) provided an improved soil quality leading to improved crop productivity. Soil productivity is closely linked with soil organic matter status as it plays an important role in the improvement of soil structure and organic matter status. Mukhopadhyay *et al*. (2008) and Siavoshi *et al*. (2011).

The interaction between sowing method and integrated use of nitrogen had a significant effect on nutrient uptake of wheat nitrogen grain and straw (Table 2). The highest values nutrient uptake of (55.89, 18.88 and total 74.77 kg ha^{-1}) were obtained from M_1N_2 (SWI at 75% N from urea and 25% N from FYM) which differed significantly over rest of the treatment combinations. The lowest values of grain and straw nitrogen uptake (32.62,10.89and total 43.31 kg ha^{-1}) were obtained from N_0 absolute control which was proved to be significantly lowest compared to other treatment combinations. Therefore, the combination of M_1N_2 is recommended as the treatment that maximizes nutrient uptake of wheat under this study. Similar trend also found in phosphorus and potassium grain and straw uptakes in wheat. similar finding were reported by Kumpawat (2010), Vadgave (2010), Anandan and Natarajan (2012) and Prajapati (2014). Benificial effects of integration of inorganic fertilizers and organic manures along with biofertilizers on nutrient uptake in wheat and sesame crops were also noticed by Sharma *et al*. (2013) and Nayek *et al*. (2014), respectively.

As regards to different treatment combinations interaction between methods of sowing and integrated use of nitrogen (Table 5) the SWI along with 75:25 RDN from urea (M_1N_2) maximum nitrogen uptake in grain and straw (62.62, 21.15 kg ha^{-1}). Among all the treatment combinations, M_3N_0 had the lowest nitrogen uptake in grain and straw (28.75, 10.61 kg ha^{-1}) [1] compared to others. Similar trend also found in phosphorus and potassium grain and straw uptakes of different treatment combinations in wheat. These observations are in accordance with those of Metwally and Khamis (1998) who reported that combination of organic and inorganic N resulted in greater values of apparent net N release than those obtained when each was applied singly. These results are in line with the findings of Shah *et al*. (2006).

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ESTIMATION OF RANK BASED QUOTIENT (RBQ) FOR SWOT ON PRACTICING SOYBEAN PRODUCTION TECHNOLOGIES IN THE NORTHERN TELANGANA ZONE

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ABSTRACT
The present study was conducted on soybean production to estimate theRank Based Quotient (RBQ) for SWOT on practicing soybean production technologies in Adilabad, Nizamabad and Karimnagar districts of Northern Telangana zone of Telangana state. The major RBQ-strengths are less number of irrigations required during the crop period, JS335 is high yielding variety and fixation of the atmospheric nitrogen in to the soil by the soybean crop due to its leguminous nature. The major RBQ-weaknesses JS335 is a semi-dwarf variety and low seed viability, lack of suitable high yielding varieties to the zone other than JS335. Low incidence of pest and diseases in line sowing followed by low cost of plant protection, harvest indices are easy to understand and practice are top three RBQ-opportunities in practicing soybean production technologies. The major RBQ-threats are yield reduction in *rabi* season followed by more soil erosion in red soils due to heavy rains, lack of varieties suitable for *rabi* season.

INTRODUCTION

The opportunity to increase soybean yields is at the fingertips of every soybean farmer in India. It begins with understanding the needs of the soybean, the environment it prefers, adopting the best agronomic practices and stacking technology to optimize yield.Improving soybean production on your farm requires a systematic approach. Make sure you account for the entire production system - from seed selection to soil preparation, to planting and weed and pest control, all the way through harvesting - all in one continuous loop of possible decisions you can make. You must strive to optimize all factors, not just eliminate limitations. Learn to exploit the plant itself.Soybean crop is widely grown in Northern Telangana Zone of Telangana state. Gradually year after year the area and production of the crop is being stretched into different districts of Northern Telangana Zone. So there is a need to know the Strengths, Weaknesses, Opportunities and Threats for Soybean production technologies in Northern Telangana Zone. Based on the SWOT we need to estimate the Rank Based Quotient (RBQ) of Soybean production technologies for the welfare of the farmers living in Northern Telangana Zone. Dalvi *et al*. (2004) found that majority (86.66%) of the respondents faced difficulty in getting improved and hybrid seeds in time followed by shortage of FYM under double cropping (85.83%), 88.33 percent perceived that there was a medium technological gap in use of seed and sowing, 58.33 percent of respondents grouped under medium in terms of usage of fertilizers and 61.66 percent grouped under medium on usage of plant protection measures.Kumar (2004) revealed that the weaknesses in SRI Rice cultivation as perceived by the farmers practicing SRI method of rice cultivation includes more weed problems, more labour required for land leveling and transplanting, low lying area and water logging condition, non availability of rotary weeders, lack of technical support, non availability of sufficient organic manures, poor drainage, poor understanding of concept of SRI, less attention of farmers on cultivation, less possibility of second crop like black gram/ green gram.Ajay Raghu Vamshi *et al*. (2010) indicated that majority (99.00%) of the respondents completely adopted all the recommended land preparation practices followed by use of recommended varieties (73.30%), spacing(70.80%), time of sowing (66.70%) and weed management (65.00%) in soybean crop.Todasam *et al*. (2010) were carried out a field survey to ascertain knowledge of the soybean growers about recommended technologies. The results were found that over half (55.34%) of soybean growers had medium level of knowledge about improved cultivation practices recommended for soybean crop. Lakpathi (2011) indicated that the opportunities felt by the maize seed producers were favorable climate conditions, existence of village tanks and bore wells (92.20%), FYM availability at cheaper and abundantly (87.50%), easy to understand and can practiced by any one (82.30%), availability of marketing information about prices and demand (72.00%), large area for drying (55.70%), Ease of procuring plant protection chemicals around

the mandal (53.70%), south-west monsoon (42.50), for spacing no need of skilled labour (26.50%), supervision and guidance available from the department and private companies (15.80%).Prathyusha (2014) concluded that the majority (87.08%) of the respondents had given first rank to high cost of Bt cotton seed followed by fluctuations in market prices (85.99%), availability of Spurious seed (82.24%), highly dependent on private companies for seed (77.25%), defective government policies. Loan waving only for farmers having 1 to 2ha (62.32%), defective rehabilitation package (39.16%), lack of Bt cotton hybrids released by SAU (27.49%), less minimum support price (26.56%) and availability of illegal seeds sold by unlicensed companies (26.24%).The eruption of sporadic disturbances in soybean production in the zone could not stall the cultivation of crop by the farmers. It is the high time to diagnose and understand the ifs and buts and the intricacies involved in cultivation of soybean crop in the zone. This idea has propelled to take up the present study with objective of estimation of RBQ for SWOT on practicing soybean production technologies in Northern Telangana Zone.

MATERIALS AND METHODS

Descriptive research design was adopted in the present investigation. Adilabad, Nizamabad and Karimnagar districts of Northern Telangana zone of Telangana state was purposively selected for the study as it has highest area under Soybean cultivation. The study was conducted in 24 villages selected from 12 mandals of 3 districts of Northern Telangana Zone of Telangana state, which included 5 respondents from each of the selected village, thus a sample of 120 respondents were selected for the study.Rank Based Quotient (RBQ) for SWOT on Practicing soybean production technologies was calculated for few strengths, weaknesses, opportunities and threats which were chosen based on highest percentage of respondents. The respondents were asked to rank these few chosen strengths, weaknesses, opportunities and threats. These were arranged in an ascending order based on calculated RBQ values.

RESULTS AND DISCUSSION

RBQ strengths

The Table 1 represents that the major strengths on practicing soybean production technologies perceived by the respondents based on RBQ calculated values are- requirement of less (2-3) number of irrigations (1st rank) followed by JS335 is a high yielding variety (2nd rank), Soybean fixes the atmospheric nitrogen into the soil (3rd rank), broadcast sowing facilitate high germination percentage (4th rank), and the least ranked strengths are easy weed control in red soils (9th rank) and easily establishing the crop in red sandy loam soils (10th rank). It is sensed from the Table1 that the major strengths on practicing soybean production technologies are less number of irrigations followed by JS335 a high yielding variety, fixation of atmospheric nitrogen into the soil by the soybean crop, high germination percentage in broadcasting sowing. Usually soybean is considered as a rainfed crop eventually it demands less irrigation water, compared to other varieties of soybean

Table 1RBQ for Strengths on practicing soybean production technologies in Northern Telangana Zone (n = 120)

S. No.	Strengths	Ranks										RBQ	Rank
		I	II	III	IV	V	VI	VII	VIII	IX	X		
1	Requires less (2-3) number of irrigations	82	26	12								95.84	1
2	JS335 is high yielding variety	64	24	18	14							91.5	2
3	Soybean fixes the atmospheric nitrogen into the soil	51	31	23	15							89.84	3
4	High germination percentage in broadcast sowing	47	34	23	16							89.34	4
5	Machines facilitate in complete threshing and winnowing	28	39	33	20							86.25	5
6	Black cotton soils are highly suitable for intercropping (Soybean + Redgram or Soybean + Mango)	32	28	26	22	12						83.83	6
7	Black cotton soils are fertile and helps to conserve soil moisture		52	28	24	16						79.67	7
8	Farmers had the experience in judging the maturity of pods		37	29	23	19	12					75	8
9	Easy weed control in red soils			43	27	24	16	10				66.41	9
10	Red sandy loam soils help to easily establish the crop			35	29	23	19	14				64.34	10

Table 2: RBQ for Weaknesses onpracticing soybean production technologies in Northern Telangana Zone

S. No.	Weaknesses	Ranks I	II	III	IV	V	VI	VII	VIII	IX	X	RBQ	Rank
1	Semi dwarf variety (JS-335) and low seed viability	63	24	19	14							91.34	1
2	Lack of suitable high yielding varieties to the zone other than JS335	51	32	23	14							90	2
3	Practicing recommended spacing is time consuming process in line sowing	32	37	24	27							86.17	3
4	More weed problem in black cotton soils		24	41	36	19						75.84	4
5	Poor fertility status of red soils		22	43	34	21						75.50	5
6	Intra competition is more in broadcasting and hence lanky growth			31	48	25	16					67.84	6
7	No scientific storage mechanism			31	39	33	17					67	7
8	Lack of INM mechanism			31	37	29	23					66.34	8
9	Lack of IPM mechanism				42	35	28	15				58.67	9
10	Often more seed is used due to lack of awareness on optimum spacing						26	39	31	24		35.58	10

(n = 120)

Table 3: RBQ for Opportunities on practicing soybean production technologies in Northern Telangana Zone

S. No.	Opportunities	Ranks I	II	III	IV	V	VI	VII	VIII	IX	X	RBQ	Rank
1	Low incidence of pest and diseases in line sowing	57	26	20	17							90.25	1
2	Low cost of plant protection	24	44	33	19							86.08	2
3	Harvest indices are easy to understand and practice		48	31	27	14						79.41	3
4	Under less rainfall conditions 2-3 irrigations are given with the help of open wells and bore wells which are predominant in the zone		41	36	24	19						78.25	4
5	Less missing of the pods on plant with manual harvesting		31	44	24	21						77.08	5
6	Clean and quality produce is obtained with predominant in the zone			27	39	31	23					65.84	6
7	Abundant sunshine for drying			22	29	42	27					63.84	7
8	Less seed rate due to possibility of wide spacing					40	38	26	16			48.50	8
9	Chance to establish drip irrigation					37	39	26	18			47.90	9

(n = 120)

Table 4: RBQ for Threats on practicing soybean production technologies in Northern Telangana Zone

S. No.	Threats	Ranks I	II	III	IV	V	VI	VII	VIII	IX	X	RBQ	Rank
1	Yield reduction in Rabi season	49	37	21	13							90.17	1
2	More soil erosion in red soils due to heavy rains	26	48	28	18							86.84	2
3	Lack of varieties suitable for *Rabi* season	28	39	29	24							85.91	3
4	Poor seed germination under line sowing	26	35	31	28							84.91	4
5	Lack of suitable bio fertilizers		46	31	29	14						79.08	5
6	Forced to give the produce on agreed price		36	33	28	23						76.84	6
7	Less availability of direct sulphur fertilizers			37	39	25	19					67.84	7
8	Relying only on chemical control measures to control pest and diseases				28	36	31	25				55.58	8

(n = 120)

crop like Co1, Co2, Davis and KHsb2, the variety JS335 gives an average yield of 10-12 q/acre and is highly suitable for Northern Telangana Zone of Andhra Pradesh state, where as the yield of other varieties ranges between 6-8 q/acre in the zone. Soybean crop has a capacity to fix the atmospheric nitrogen into the soil due to its leguminous character of having rhizobium nodules on the roots of the crop, there by enhances the soil fertility. High germination percentage is observed in broadcast sowing as the seed is placed at shallow depth compared to line sowing where in the seed usually placed deeply reducing seed germination.

RBQ weaknesses

It is understood from the Table 2 that the prominent weaknesses on practicing soybean production technologies as perceived by the respondents based on RBQ calculated values are- JS335 is a semi dwarf variety (1st rank) and low seed viability followed by lack of suitable high yielding varieties other than JS335 (2nd rank), line sowing is a time consuming process (3rd rank), more weed problem in black cotton soils(4th

rank) and the least ranked weaknesses are lack of IPM (9th rank) and usage of more seed rate (10th rank).

The major weaknesses on practicing soybean production technologies as observed from the Table 2 are JS335 is a semi dwarf variety and low seed viability, lack of suitable yielding varieties in the zone other than JS335, time consuming process in line sowing and more weed problem in black cotton soils, the farmers face the problems of in comfortable body ergonomics in posture while harvesting the pods from the variety JS335 due to its semi dwarf character , the seed of the soybean crop is highly sensitive to minimum damage caused to the outer layer of the seed there by looses itself viability, the varieties other than JS335 don't have the potential to give yields more than the variety JS335 which is highly suitable to the zone. The sowing of soybean seed under line sowing had good benefits but following the spacing of 30 × 7.5 cm while sowing the seed especially in black cotton soils is a time consuming process. Weeds are the big menace in black cotton soils due to its fertility, retention of moisture and more bulk density.

RBQ opportunities

The opportunities on practicing soybean production technologies as per the Table 3 ranked by respondents based on RBQ values are- low incidence of pest and diseases in line sowing (1st rank) followed by low plant protection cost (2nd rank), understandable and practicable harvest indices (3rd rank), 2-3 irrigations are given under less rainfall conditions (4th rank) and the least ranked opportunities are less seed rate due to possibility of wide spacing (8th rank) and chance to establish drip irrigation (9th rank).

The opportunities on practicing soybean production technologies as highlighted in the table 3 are low spreading of pest and diseases in line sowing, less cost of plant protection, easy understand ability and practicability of harvest indices, giving 2-3 irrigations with the help of open/bore wells under less rainfall conditions. Definite spacing is followed in the line sowing of the soybean seed, the space between lines and rows allows the entry of sunrays and the crop canopy is completely exposed to the sun which arrests the spread of pest and diseases to other plants in the field. Usually soybean crop doesn't invite more pest and diseases which drives the farmers not resort to spray pesticides indiscriminately, this perhaps lead to low cost of plant protection, the harvest indices stipulated to judge the maturity of the pods are user friendly and easy to understand. These harvest indices are turning of pods into black/grey/golden colour, occasionally the zone receives less amount of rainfall, under these circumstances the farmer resort to give 2-3 irrigations with the help of open/ bore wells as these sources of irrigation are predominant in the zone.

RBQ threats

From the Table 4 it was mentioned that the important threats on practicing soybean production technologies perceived by soybean growers based on the RBQ values are- crop yield reduction in *rabi* season (1st rank), more soil erosion in red soils due to heavy rains (2nd rank), lack of suitable varieties for *rabi* season (3rd rank), Poor seed germination under line sowing (4th rank) and the least ranked threats are less availability of direct sulphur fertilizers (7th rank) and relying only on chemical control of pest and diseases (8th rank).

The Table 4 indicate that the prominent threats expressed by the respondents on practicing soybean production technologies are reduction in yield in *rabi* season followed by soil erosion due to heavy rains in red soils, lack of suitable varieties for *rabi* season and poor seed germination in line sowing. The reason for poor yields in *rabi* season could be attributed to non-adaptability of the varieties to the season. Red soils are susceptible for soil erosion due to their loose structure and texture this can be minimized by adopting the soil and water conservation techniques. The non-adoption of these techniques also might have proned these sandy soils to soil erosion. The soybean varieties presently grown during *rabi* are not suitable for the season, there by low yields are realized from these varieties. There is every need to breed the varieties of soybean crop which are highly suitable to *rabi* season of Northern Telangana Zone of Andhra Pradesh state. At present the same varieties grown under kharif season were also being cultivated in *rabi* season but their suitability to the *rabi* season is ill-fated. Soybean seed can't germinate if placed above optimum depth which reflects poor seed germination.

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EFFECT OF GEOMETRY AND FERTILITY LEVELS ON PRODUCTIVITY AND PROFITABILITY OF WINTER MAIZE (*ZEA MAYS* L.)

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ABSTRACT
A field experiment was conducted during the winter seasion of 2013-14 and 2014-15 to find out the optimum plant geometry and fertilizer requirement for winter maize. Treatments comprised 4 geometries (60×20, 50×20, 50×45 and 60×15cm) in main plots with 4 fertilizer levels (150-60-00, 150-60-60, 200-75-75 and 250-90-90 kg N-P_2O_5-K_2O ha^{-1}) in sub-plots were tested in split plot design with three replications. The biometric parameters and yield attributes namely, grains row^{-1}, grains cob^{-1}, shelling %, harvest index, and grain:stover ratio were significantly increased up to geometry of 50×20cm to closer geomtries with fertility level of 200-75-75 kg N-P_2O_5-K_2O ha^{-1} to lower fertility levels. Grain yield (110.68 q ha^{-1}), cob yield (140.67q ha^{-1}), PFP_N (61.23), PFP_p (159), crop productivity (73.78), profitability (830) and B: C ratio (4.16) significantly higher in 50x20cm to 60x20cm. The interaction effect of geometry and fertility in terms of productivity and profitability of winter maize were significantly increased up to geometry of 50x20cm to 60x20cm with 200-75-75 kg N-P_2O_5-K_2O ha^{-1} to lower fertility level. The finding might be concluded with adoption of plant density of 1,00,000 plants ha^{-1} at 50x20cm with 200-75-75 kg N-P_2O_5-K_2O ha^{-1} to winter maize proved to be economical in realizing higher grain yield and productivity.

INTRODUCTION

Wheat crop in winter season has become difficult to adopt by farmers in Southern Rajasthan to reduce yield tremendously due to abruptly shoot up the temperature during reproductive phase (25 Feb. - 15 March) which force the crop to mature before the time and ultimately reduced the grain yield of the crop to enjoy a short growing period. In such situations, maize is rapidly emerging as a favorable option due to its higher productivity and profitability with lesser biotic and abiotic stresses during winter season. Maize is also called 'queen of cereal' as it is grown throughout the year due to its photo-thermo insensitive character and has highest genetic yield potential among the cereals (Singh *et al*, 2013). Yield obtained during winter season is more than double to rainy season due to crop enjoys long duration with mild agro-climatic conditions. Growth and development of a plant is resulted the interaction of two major components viz. Genetic potential of individual and environment (Bhalerao *et al*., 2010). Maize growth and productivity per unit area depends upon the genetic potential of the plant, plant density, and supply of essential nutrients (Mehta *et al*., 2011). The newly released hybrids have, the more yield potential than local varieties because, its plant architecture is modified according to get maximum economic yield through optimum utilization of resources. The growth rate of plants under particular environment can be measured through classical growth analysis. Agronomic practices such as seed rate, plant population and fertilizer management are known to affect the crop environment, which influence the growth and ultimately the yield. Maize is wide-spaced crop, having a slow growth rate in early growing stages, which leads to more loss of water and nutrients through evaporation and a heavy infestation of weeds while, high density is undesirable because it encourage inter plant's completion for resources (Hargilas and Ameta, 2015). The previous evidences indicated that the information of optimum geometry and fertilization to new maize hybrids is lacking at present and will be very useful for exploiting its full potential to boost up the yield level under winter season. One hand the farmer's are used maximum single nutrient as nitrogen through urea and nitrogen and phosphorus through di-ammonium phosphate in imbalance quantity and other hand, crop productivity can be sustained with balance fertilization. Moreover, the response of hybrid maize to plant density and fertilizer requirement varies widely under irrigated condition. Optimum plant geometry is one of the important factors for higher production, by efficient utilization of underground resources and also harvesting as much as solar radiation and in turn better photosynthethates formation (Mehta *et al*, 2011). Keeping the above information in view, the present study was conducted to find out the optimum plant geometry and fertilization for exploring the growth, development and yield potential of winter maize in irrigated condition of Southern Rajasthan.

MATERIALS AND METHODS

Experimental site and meteorological information

A field experiment was conducted in two consecutive winters

of 2013-14 and 2014-15 at Agricultural Research Station (MPUAT), Banswara to study the effect of geometry and fertility levels on productivity and profitability of winter maize (*Zea mays* L.) under irrigated condition of Southern Rajasthan. The experimental site is geographically situated at 23^0 33′ N latitude, 74^0 27′ E longitude and altitude of 220 M above Mean Sea Level. It is covered under humid southern plain agro-climatic zone of Rajasthan, which falls under sub-humid climate with dry, hot summer and mild winters. The average annual rainfall is 862 mm. The soil of experimental field is clay loam in texture, slightly alkaline in reaction with low in available nitrogen (218kg ha^{-1}), medium in available phosphorus (23.4kg ha^{-1}) and high available potassium (478 kg ha^{-1}).

Technical programme

The experiment was laid out in split-plot design with three replications. The maize hybrid Bio-9681 planted in 16 treatment combinations comprising of four plant geometries viz. G_1: 60x20cm (83,333 plants ha^{-1}), G_2: 50x20cm (100,000 plants ha^{-1}), G_3: 45×20cm (1, 11,111plants ha^{-1}), and G_4:60x15cm (1, 11,111plants ha^{-1}) in main-plots and four fertility levels (F_1 :150-60-00, F_2: 150-60-60, F_3: 200-75-75 and F_4: 250-90-90 kg N-P_2O_5-K_2O ha^{-1}) in sub-plots, were evaluated.

Experimental materials used and cultural operations

The sources of N, P_2O_5, and K_2O used as urea, single super phosphate, and murate of potash, respectively. A full dose of P_2O_5 and K_2O and 20% dose of nitrogen applied to the crop as basal at the time of furrow opening through tractor drawn fertilizer drill. The remaining dose of nitrogen was applied in four splits as 25% at V_4 (Four leaf stage), 30% at V_8 (Eight leaf stage), 20% at VT (Tasseling stage) and 5% at GF (Grain filling stage). The crop was sown in first fore night in November of both the years through dibbling of 1-2 seeds $hill^{-1}$ and plant population was maintained by gap filling and subsequent thinning keeping single plant $hill^{-1}$. Two hoeing and weeding were done to keep crop-weed free and conserve soil moisture and uniform plant protection measures were adopted in all treatments.

Experimental design, data collection, and analysis

Regarding agronomic characters, five competitive plants were randomly selected from each plot and observations were recorded for growth attributes, yield attributes, and yield. The data were analyzed as per standard statistical procedure (SPD) suggested by Gomez and Gomez (2010). The estimates of correlation coefficients were worked out using the Mini-Tab program based on a concept developed by Dewey and Lu (1959).

Measurement of growth and development parameters

Plant height (cm)

The plant height of five randomly selected plants was measured from the base of the stem to the base of the topmost unfold leaf. The height of each plant was measured in cm at harvest and mean values of five plants for each plot were determined.

Dry matter accumulation (g $plant^{-1}$)

Periodic dry matter accumulation was determined by randomly selecting two-plant $plot^{-1}$ at 30 days interval.

Crop growth rate (CGR)

GGR (g $plant^{-1}$ day^{-1}) is the increase in dry matter per plant per unit of time. The periodic crop growth rate determined by randomly selecting two plant $plot^{-1}$ at 30 days interval and it was calculated according to the formula given by Radford (1967).

$$CGR \quad \frac{W_2 \quad W_1}{t_2 \quad t_1}$$

Where, CGR = Crop Growth Rate (g day^{-1}), W_2 and W_1: dry matter of plant at the time t_2 and t_1, respectively.

Leaf Area Index (LAI)

The leaf area index was measured at 50% silking stage of the crop by using a leaf area meter. From the leaf area, the leaf area index was calculated according to the formula given by Watson (1947).

$$LAI \quad \frac{\text{Leaf area plant}^{\ 1}}{\text{Land area occupied plant}^{\ 1}}$$

Measurement of yield attributes and yield

Five cobs were selected at random from each plot for measuring grain rows cob^{-1}, grains row^{-1} and total grains cob^{-1}. Test weight was determined by randomly selecting a sample from a pool of harvested seeds from each plot. Number of cobs were measured from each plot and its values converted in unit per hectare. The shelling percentage was calculated by dividing the grain yield by cob yield and multiplying by 100. The harvest index (HI) was calculated by dividing the grain yield by biological yield at harvest and multiplying by 100.

$$\text{Shelling \%} \quad \frac{\text{Grain yield (q ha}^{\ 1})}{\text{Cob yield (q ha}^{\ 1})}$$

$$\text{Harvest index} \quad \frac{\text{Grain yield (q ha}^{\ 1})}{\text{Grain} \quad \text{stover yield (q ha}^{\ 1})} \quad 100$$

Partial factor productivity (PFP)

Partial factor productivity (kg harvest per kg-applied nutrient) computed through formula given by Cassman *et al* (1996) to study the response of fertilizer to produce an economic yield per unit investment of fertilizers.

$$PEP_{N \text{ or } P} \quad \frac{\text{Economic yield (kg ha}^{\ 1})}{\text{Applied nutrient (N or P kg ha}^{\ 1})}$$

Where, PEP_N = Partial factor productivity of nitrogen (kg grain kg^{-1} applied N) and PEP_P = Partial factor productivity of phosphorus (kg grain kg^{-1} applied P)

Statistical analysis

All data collected were analyzed using analysis of variance (ANOVA) followed by protecting Fisher's least-significant difference (LSD) test. The means were separated by the LSD at the $P = 0.05$ level of probability as suggested by Gomez and Gomez (2010).

RESULTS AND DISCUSSION

Growth parameters

Growth parameters *viz* dry matter accumulation (g plant^{-1}), crop growth rate (g day^{-1} plant^{-1}), leaf area index (LAI), plant height (cm) were varied with diffrent plant geometry and fertility levels (table 1). The dry matter accumulation at 30 DAS did not significantly affected to geometry and fertility levels but it significantly influenced at beyond intervals. Dry matter accumulation per plant being the maximum at geometry of 60 × 20cm and 250-90-90 kg N-P_2O_5-K_2O ha^{-1} which was observed statistically at par with geometry of 50 × 20cm at 200-75-75 kg N-P_2O_5-K_2O ha^{-1} but found significantly higher over rest geometry and fertility levels at all intervals. The optimum accumulation of dry matter, followed by adequate partitioning of assimilates to the sink leads to higher grain yield. Increase in nutrient level produced more number of leaves plant^{-1} with more height and LAI resulting in more dry matter accumulation (Sobhana *et al.*, 2012).

The crop growth rate (CGR) of winter maize showed increasing slowly in interval of 0-30DAS and speedly in interval of 30-120 DAS and further increasing in declining trend in interval of 120-150DAS. the maximum CGR value of 2.73, 3.13, and 3.11 in interval of 60-90, 90-120, and 120-150 DAS at geometry of 60x20cm that found at par with 50x20cm and significantly higher over rest geometries. Among, fertility levels, the maximum CGR values of 2.76, 3.18, and 3.17 in interval of 60-90, 90-120, and 120-150 DAS at 250-90-90 kg N-P_2O_5-K_2O ha^{-1}, which observed statistically at par with 200-75-75 kg N-P_2O_5-K_2O ha^{-1} and significantly higher over other fertility levels. This trend might have explained that as the number of plants increased in a given area, the competition between plants for utilization of resources such as water, nutrients, space and sunlight increased. Several studies have shown that CGR decreases progressively as the number of plants increases in a given area because the dry matter accumulation of individual plants is decreased (Hamidi *et al.*, 2010). Pandey *et al*. (2000) and Lakshmi *et al*. (2009) observed that the increasing the value of CGR and RGR with increasing rate of nutrients.

Leaf area index (LAI) of winter maize is lower in an initial growth stage, which progressively increasing with vegetative growth stages. The LAI observed at 50% silking stage crop, which was increase with increasing plant density. The maximum LAI (5.00) recorded with high plant density at 60x15 cm geometry that found at par with plant geometry of 45x20cm and it calculated 5 and 26% significantly higher over plant geometry of 50x20cm and 60x20cm, respectively. Between the fertility levels, the maximum LAI (4.74) observed at 250-90-90 kg N-P_2O_5-K_2O ha^{-1} followed by 200-75-75 kg N-P_2O_5-K_2O ha^{-1} while it was calculated 4.85 and 5.27 %, significantly higher over 150-60-60 and 150-60-00 kg N-P_2O_5-K_2O ha^{-1}, respectively. The increased LAI might be due to increased functional levels and more area occupied by a green canopy per unit area. This indicates that plant population is the main factor influencing the LAI. The efficiency of conversion of intercepted solar radiation into economic maize yields may decrease with high plant density because of mutual shading of the plant. These results are in agreement with the finding of Saberali (2007). The consistent increase in LAI observed with increase fertility levels might be due to the availability of nutrients.

The tallest plants (286cm) observed at wider geometry of 60x20cm that calculated statistically at par with geometry of 50x20cm and found significantly higher over closer geometry. Wider geometry might have increased the root spread, which eventually utilized the resources such as water and nutrient, space and sunlight. Among, the fertility levels, the maximum plant height (285cm) recorded at 250-90-90 kg N-P_2O_5-K_2O ha^{-1} that found statistically at par with 200-75-75 kg N-P_2O_5-K_2O ha^{-1} and calculated significantly superior over lower fertility levels. This study supported by the work of Pandey *et al* (2000) who observed that plant height of maize increased greatly when the seeds planted sparsely and sufficient quantity of nutrients were applied.

Yield attributes and yield

The yield attributes *viz* number of cobs per hectare, number

Table 1: Effect of plant geometry and fertility levels on dry matter accumulation, crop growth rate, leaf area index and plant height (pooled data of two years)

Treatments	Dry matter accumulation (g plant^{-1})					Crop growth rate (g plant^{-1} day^{-1}				LAI at	Plant
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	30-60 DAS	60-90 DAS	90-120 DAS	120-150 DAS	50% silking	height (cm) at harvest
Plant spacing(000 plants ha^{-1})											
G_1:60x20cm (83.33)	3.71	50.78	132.58	226	320	0.157	2.73	3.13	3.11	3.70	286
G_2:50x20cm (100.00)	3.71	50.93	131.42	225	317	0.158	2.68	3.10	3.09	4.75	282
G_3:45x20cm (111.11)	3.71	48.10	126.42	219	310	0.148	2.61	3.08	3.03	4.99	269
G_4:60x15cm (111.11)	3.70	48.93	127.42	220	312	0.151	2.62	3.09	3.07	5.00	270
SEm ±	0.09	0.28	0.51	0.66	1.43	0.026	0.01	0.01	0.04	0.03	1.5
CD (p = 0.05)	0.30	0.98	1.76	2.28	4.95	0.026	0.04	0.09	0.15	0.09	5.1
Fertility levels(N-P_2O_5-K_2O kg ha^{-1})											
F_1:150-60-00	3.60	47.78	124.75	214	302	0.147	2.57	2.98	2.94	4.49	270
F_2:150-60-60	3.60	49.22	127.25	220	311	0.152	2.60	3.08	3.05	4.51	271
F_3:200-75-75	3.71	50.53	132.00	227	321	0.156	2.72	3.15	3.15	4.71	282
F_4:250-90-90	3.92	51.21	133.83	229	324	0.158	2.76	3.18	3.17	4.74	285
SEm ±	0.13	0.19	0.78	0.67	1.88	0.020	0.02	0.04	0.07	0.04	2.6
CD (p = 0.05)	0.37	0.57	2.27	1.95	5.51	0.14	0.08	0.10	0.19	0.15	7.6

Table 2: Effect of plant geometry and fertility levels on yield attributes, grain yield (pooled data of two years)

Treatment	Cobs (000 ha^{-1})	Grain rows cob^{-1}	Grains row^{-1}	Grain cob^{-1}	Test weight (g)	Cob yield (q ha^{-1})	Shelling (%)	Grain yield (q ha^{-1})	Harvest index (HI)	Grain: stover ratio
Plant spacing(000 plants ha^{-1})										
G_1:60x20cm (83.33)	65.41	14.00	42.54	596	250.00	119.33	81.57	97.48	40.79	0.68
G_2:50x20cm (100.00)	78.47	14.00	40.34	565	250.00	140.67	78.65	110.68	38.40	0.62
G_3:45x20cm (111.11)	80.57	14.00	38.60	540	249.00	143.00	78.38	112.02	32.81	0.55
G_4:60x15cm (111.11)	80.61	14.00	38.61	541	249.00	143.08	79.23	113.30	33.02	0.55
SEm ±	0.98		0.81	11.30	0.31	1.12	1.15	2.34	0.48	0.02
CD (p = 0.05)	3.07	NS	2.79	39.10	1.09	3.89	3.98	5.30	1.67	0.05
Fertility levels(N-P_2O_5-K_2O kg ha^{-1})										
F_1:150-60-00	75.21	14.00	37.14	520	249.00	129.58	77.17	99.95	35.13	0.57
F_2:150-60-60	76.41	14.00	39.32	550	249.33	136.17	78.40	106.65	35.54	0.59
F_3:200-75-75	76.63	14.00	41.32	578	249.67	138.92	80.41	111.47	36.87	0.61
F_4:250-90-90	76.79	14.00	42.31	592	250.00	141.42	81.84	115.40	37.47	0.64
SEm ±	0.84		1.71	5.28	0.23	1.35	1.11	1.29	0.58	0.02
CD (p = 0.05)	2.41	NS	1.10	15.42	0.66	3.95	3.24	3.78	1.6	0.03

Table 3: Effect of plant geometry and fertility levels on partial factor productivity (PFP) of nitrogen and phosphorus and crop productivity and profitability (pooled data of two years)

Treatment	PFP_N (kg harvest kg^{-1} N applied)	PFP_p (kg harvest kg^{-1} P applied)	Crop productivity (kg ha^{-1} day^{-1})	Crop profitability (Rs ha^{-1} day-1)	Cost of cultivation (Rs ha^{-1})	Gross return	Net return (Rs ha^{-1})	B:C ratio
Plant spacing(000 plants ha^{-1})								
G_1:60x20cm (83.33)	53.49	139	64.99	712	29595	136470	106876	3.61
G_2:50x20cm (100.00)	61.23	159	73.78	830	30428	154948	124520	4.16
G_3:45x20cm (111.11)	61.98	161	74.68	839	30984	156821	125838	4.05
G_4:60x15cm (111.11)	62.92	163	75.53	851	30984	158614	127631	4.14
SEm ±	0.88	2.30	1.02	14		2143	2143	0.05
CD (p = 0.05)	3.05	7.94	3.54	49		7416	7417	0.17
Fertility levels(N-P_2O_5-K_2O kg ha^{-1})								
F_1:150-60-00	66.63	167	66.63	748	27699	139925	112227	4.01
F_2:150-60-60	71.10	178	71.10	798	29619	149312	119694	4.08
F_3:200-75-75	55.74	149	74.31	831	31431	156056	124626	4.01
F_4:250-90-90	46.16	128	76.93	855	33242	161561	128319	3.86
SEm ±	0.69	1.81	0.86	12		1816	1816	0.03
CD (p = 0.05)	2.01	5.29	2.53	35		5299	5299	0.09

of grain rows per cob, number of grains per row, the number of grains per cob, test weight, cob and grain yield, shelling percentage, harvest index and grain:stover ratio was presented in Table 2.

The number of cobs per hectare significantly influenced to plant densities and fertility levels. Maximum cobs produced at a plant density of 1.11 lac plants ha^{-1}compared to 1.0 lac and 0.83 lac plants ha^{-1}, which might be due to higher plant population in respective plant densities. Similarly, maximum numbers of cobs produced with higher fertility levels of 250-90-90 kg and 200-75-75 kg N-P_2O_5-K_2O ha^{-1} compared to lower fertility doses of 150-60-60 kg and 150-60-00 kg N-P_2O_5-K_2O ha^{-1}. Similar results reported by Sobhna *et al* (2012) who found maximium number of cobs resulted higher plant population with better availability of nutrients in higher fertility levels.

Numbers of grain rows per cob were not significantly influence by plant densities and fertility levels. Whereas, significant influenced on the number of grains per row was noticed with different plant densities. The maximum number of grains row^{-1}(42.54) reported at geometry of 60x20cm, which was found at par with geometry of 50x20cm and significantly superior over closer geometry. Two fertility levels of 250-90-90 kg and 200-75-75 kg N-P_2O_5-K_2O ha^{-1} found at par in number of grains per row, which were significantly superior over lower fertility levels.

Number of grains per cob were decreased with increase plant density. The maximum grains per cob (596) were recorded at geometry of 60x20cm which was statistically at par with geometry of 50x20cm and significantly superior over the rest geometries. Similar, results reported by Abuzar *et al* (2011). The reason might be attributed due to the availability of better resources in low plant density. In high plant density, the number of plants per unit area increased beyond the optimum plant density; there are severe consequences that are ontogeny that result in barrenness (Sangoi, 2001). The number of grains per cob was increased to increase fertility levels. The maximum grains per cob (592) were recorded at 250-90-90 kg N-P_2O_5-K_2O ha^{-1} which found statistically at par with 200-75-75 kg N-P_2O_5-K_2O ha^{-1} and calculated significantly superior over lower

fertility levels. This might be due to better availability of nutrient to plant at high fertility level. Singh *et al* (2000) confirmed that a significant increase in grains at high nutrient level.

The test weight (1000 seeds) was not significantly increased to plant density but it increased with increasing fertility levels. The maximum test weight (250 g) recorded at 250-90-90 kg N-P_2O_5-K_2O ha^{-1} that statistically at par with 200-75-75 kg N-P_2O_5-K_2O ha^{-1} and significantly superior over lower fertility levels. The low grain weight in high plant density probably due to the availability of less photosynthetates for grain development on account of high inter specific competition, which resulted in a low rate of photosynthesis and high rate of respiration as a result of enhanced mutual shading (Zamir *et al*,2011). On the other hand, grain weight increased with increase fertility level might be due better availability of nutrient to plant. Mehta *et al* (2011) has also reported that increasing nutrient supplements led to an increase in leaf area, photosynthesis, cob health, etc. which in turn in the form of healthy seed.

The maximum cob yield (143.08q ha^{-1}) was obtained at geometry of 60x15cm, which was at par with geometry of 50x20cm (140.00q ha^{-1}) and significantly superior over geometry of 60x20cm (119.33q ha^{-1}). However, there was no significant difference in cob yield between 1, 11,111, and 1, 00,000 plant ha^{-1} under 60x15, 45x20 and 50x20cm geometries which might be due to a number of cobs did not increase significantly beyond 1,00,000 plants ha^{-1}. There was a consistent increase in cob yield with the increase in fertility levels. However, the significant influence obtained up to 200-75-75kg N-P_2O_5-K_2O ha^{-1} level.

Shelling percentage, harvest index, and grain:stover ratio showed a similar trend as that maximum observed at geometry of 60x20cm with fertility level of 250-90-90kg N-P_2O_5-K_2O ha^{-1} level, which were recorded statistically at par with geometry of 50x20cm with fertility level of 200-75-75 kg N-P_2O_5-K_2O ha^{-1} and significantly superior over high plant density and lower fertility level. These results might be due to plant shift from vegetative to reproductive phase, higher amount of source transferred to develop better sink size as indicated by higher shelling, harvest index and grain:stover ratio. Similar results reported by Mehta *et al* (2011).

The grain yield, presented as pooled of two years, responded positively to increasing plant density and fertility levels. The maximum grain yield (113.30q ha^{-1}) obtained at geometry of 60x15cm that found statistically at par with geometry of 50x20cm and significantly superior over geometry of 60x20cm. The reason might be resulted of yield attributes due to significant reduction of shelling, harvest index, number of grains per cob, test weight were noticed at high plant density, the number of plants per unit area is increased beyond 1,00,000 plant ha^{-1}, there is severe consequences that are ontogeny that result in barrenness (Sangoi, 2001). Different fertility levels increased the grain yield significantly with the increase in fertility level; a progressive increase in grain yield obtained up to 200-75-75kg N-P_2O_5-K_2O ha^{-1} level (111.67q ha^{-1}) which realized an increase of 10.5 and 4.5% over 150-60-00 and 150-60-60kg N-P_2O_5-K_2O ha^{-1} fertility levels, respectively.

The interaction effect between plant densities and fertilizer levels on yield was found significant (Fig.1). In respected of the plant density, increase rate of fertilizer application increased the grain yield. However, significantly higher grain yield (114.08q ha^{-1}) was obtained at a plant density of 1, 00,000-plant ha^{-1} under 50x20cm geometry with 200-75-75kg N-P_2O_5-K_2O ha^{-1}. It showed at par with a fertility level of 250-90-90kg N-P_2O_5-K_2O ha^{-1}. The difference in grain yields among plant density and fertility treatments was more associated with total plant dry matter and harvesting index.

Table 4: Correlation coefficient studies among grain yield, growth and yield parameters

	Grain yield (q ha^{-1})	Grains cob^{-1}	Shelling %	HI	LAI	CGR	Plant height (cm)
Grain yield	1						
Grains/cob	0.134	1					
Shelling %	0.245	0.902	1				
HI	-0.283	0.875	0.714	1			
LAI	0.805	-0.445	-0.349	-0.754	1		
CGR	0.501	0.793	0.877	0.51	-0.077	1	
Plant height.(cm)	-0.056	0.851	0.64	0.851	-0.459	0.488	1

Correlation coefficient is significant at p = 0.05

Table 5: Correlation coefficient studies among grain yield, crop productivity and profitability, partial factor productivity, B:C ratio, plant density and fertility levels

-	Grain yield q ha^{-1}	Crop productivity (kg ha^{-1} day^{-1})	Crop profitability (Rs ha^{-1} day^{-1})	PFP_N	PFP_P	B:C ratio	Plant density	Fertility levels
Grain yield (q ha^{-1})	1							
Crop productivity (kg ha^{-1} day^{-1})	0.999	1						
Crop profitability (Rs ha^{-1} day^{-1})	0.99	0.99	1					
PFP_N	-0.183	-0.183	-0.086	1				
PFP_P	-0.07	-0.07	0.034	0.995	1			
B:C ratio	0.566	0.565	0.652	0.607	0.683	1		
Plant density	0.686	0.687	0.738	0.339	0.423	0.661	1	
Fertility levels	0.581	0.58	0.492	-0.902	-0.842	-0.267	0	1

The correlation coefficient is significant at p = 0. 05

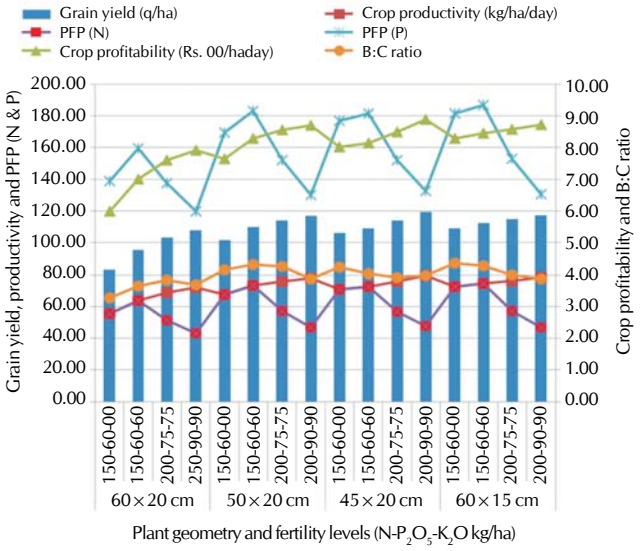

Figure 1: Interaction effect of plant geometry and fertility levels on yield and economics of winter maize

Productivity and profitability

Partial factor productivity of suppied nutrients, crop productivity and profitability and economics at different geometry and fertility levels were presented in Table 3.

The maximum Partial Factor Productivity (PFP) of 62.92 kg grains kg^{-1} of N and 163 kg grains kg^{-1} of P recorded highest at geometry of 60x15cm that found at par with geometry of 50x20cm and these values were calculated significantly higher over geometry of 60x20cm. The PFP of 61.23 kg grains kg^{-1} of N and 159 kg grains kg^{-1} of P at geometry of 50x20cm were 12.64 and 12.58% significantly higher over PFP of 53.49 kg grains kg^{-1} of N and 139 kg grains kg^{-1} of P at geometry of 60x20cm. The PFP values of N and P significantly increased up to significant enhancement in the grain yield.There are indicating the optimum use of N and P at optimum plant population. Between the fertility levels, PFP of 71.10 kg grain kg^{-1} of N and 178 kg grains kg^{-1} of P were highest at 150-60-60 kg N-P_2O_5-K_20 ha^{-1} and further decreasing with increasing dose of nutrients. The minimum PFP was 46.16 kg grains kg^{-1} of N and 128 kg grains kg^{-1} of P recorded at highest dose of 250-90-90 kg N-P_2O_5-K_2O ha^{-1}. Nutrient use efficiency decreased with per unit increase in fertility levels as it is governed by grain yield production, which is decreased per unit of applied nutrients at higher levels where plant-nutrients completion is decreased due to more availability of nutrients in soil (Charak *et al*, 2013).

Crop productivity and profitability significantly increased with increased plant population up to 1,00,000 plants ha^{-1} under geometry of 50x20cm and further, enhancement in productivity and profitability was found non-significant with increase of plant population. The crop productivity (73.78kg $ha^{-1}day^{-1}$) and crop profitability (Rs.830 $ha^{-1}day^{-1}$) recorded at 1, 00,000 plants ha^{-1} which were significantly 11.91 and 14.22% superior over 83,333 plants ha^{-1}, respectively. Between fertility levels, crop productivity (76.93kg ha^{-1} day^{-1}) and crop profitability (Rs 855 $ha^{-1}day^{-1}$) recorded at highest fertility levels of 250-90-90kg N-P_2O_5-K_2O ha^{-1} which found at par with lower fertility level of 200-75-75kg N-P_2O_5-K_2O ha^{-1} and were significantly 7.58 and 13.39% and 6.67 and 12.52% superior over fertility level (F_2) and F_1, respectability. An increased in population and fertility levels that caused the improvement in yield, which are the best indicator of responses to the added fertility doses. The similar responses recorded by Shukla *et al*. (2013).

The influence of plant density and fertility levels in winter maize in terms of economic returns presented in Table 3. The highest gross return (Rs.158614 ha^{-1}), net return (Rs.127631 ha^{-1}) were recorded at plant geometry of 60x15cm which computed statistically at par with 45x20 and 50x20cm and significantly superior over 60x20cm. The highest B: C ratio (4.16) recorded at 50x20cm that was significantly 13.22% higher over 60x20cm geometry. However, it's not found significant with higher plant populations at rest geometry. It is might be due to significant enhancement in yield and yield attributes were recorded at 50x20cm geometry. The results confirmed that closer geometry recorded low net returns (rupees $rupee^{-1}$) because of higher cost of cultivation (Reddy and Gopinath, 2008). The difference in gross and net returns due to different fertility levels found significant. Increasing in fertilizer doses increased gross and net returns progressively. The highest gross returns (Rs. 161561ha^{-1}) and net return (Rs.128319 ha^{-1}) were recorded with the fertility level of 250-90-90 kg N-P_2O_5-K_2O ha^{-1} which was found statistically at par with 200-75-75kg N-P_2O_5-K_2O ha^{-1} and computed significantly superior over lower fertility levels. However, highest B:C ratio (4.08) calculated at 150-60-60kg N-P_2O_5-K_2O ha^{-1} which was found at par with lower and higher level, but significantly superior over 250-90-90 kg N-P_2O_5-K_2O ha^{-1}. This is may be due to same quantum variation in the cost of fertilizer and net return up to a fertility level of 200-75-75kg N-P_2O_5-K_2O ha^{-1} and a further quantity of fertilizer added more amount of cost than return.

Correlation analysis

The results of correlation coefficient among the grain yield and yield and growth parameters were shown in Table 4. Highly significant and positive correlation was observed between grain yield with LAI (r=0.805), CGR (r=0.501), plant density (r=0.686) and fertility levels (r=0.581) and it was recorded non-significant and positive correlation with grains cob^{-1} (r=0.134) and shelling % (r=0.245). However, non-significant and negative correlations observed between grain yield with harvest index (r=-0.283) and plant height (r=-0.056).These finding seems logic because field data showed that increase the grain yield might be due to increasing the plant density with fertility levels. These results are in harmony with those obtained by Sadek *et al.*, (2004). Grains cob^{-1} recorded highly significant and positive correlated with shelling % (r=0.902), HI (R=0.875), CGR (R=0.851), plant height (r=851) and fertility levels (r=0.665) and contrary negative corrected with plant density. Shelling % calculated significant and positive correlated with harvest index (r=0.714), CGR (r=0.877), plant height (r=0.64) and fertility level (r=0.69) and LAI was observed highly significant and positive with plant density (r=0.959) and negatively correlated with CGR (r=-0.077). However, rest factors were found non-significant correlation with each other.

The results of the correlation coefficient among grain yield and profitability and economy traits are shown in Table 5 grain yield was observed significantly and positive correlated with crop productivity (r = 0.999), profitability (0.99), B:C ratio (r = 0.566), plant density (r = 0.686) and fertility levels (r = 0.581). Crop productivity was significant and positive correlated with crop profitability (r = 0. 99), B: C ratio (r = 0. 565), plant density (r = 0. 687) and fertility levels (r = 0. 58). Crop profitability was observed significant and positive correlated with B: C ratio (r = 0. 652) and plant density (r = 0. 738). PFP_N and PFP_P were observed significantly and positively correlated with both together and B: C ratio (r = 0. 607). However, both shown contrary correlated with fertility levels (r = 0. 902 and (r = 0. 842), respectively. B: C ratio was significantly and positively correlated with all factors, but non-significant and negative correlated with fertility levels.

Regression analysis

The results of regression equation between B: C ratio and grain yield, plant density and fertility levels indicated that B: C ratio resulted of positive regression coefficient (0.048) of grain yield, plant density (-0.007) and fertility level (-0.000) with a regression equation ($R^2 = 0.846$) at intercept (1.347) with error (0.128). The trait is the most important to finding economics of the crops.

The findings of the present study are concluding that winter's maize performed well and produced higher growth and yield attributes that lead to achieving more utilization of available resources through better conversion of assimilates into grain yield under optimum geometry of 50x20cm and sufficient availability of nutrients at 200-75-75kg N-P_2O_5-K_2O ha^{-1}. However, the yield attributes and yield increased with increase of plant population and fertility levels, but benefit: cost ratio significantly improved up to 50x20cm plant geometry at 200-75-75 kg N-P_2O_5-K_2O ha^{-1}. Correlation matrix among traits (growth, yield and productivity) showed significantly and positively associated with each other and this further supported by regression analysis and increase in B: C ratio caused an increase in grain yield. Therefore, the plant geometry of 50x20cm and fertility level of 200-75-75 kg N-P_2O_5-K_2O ha^{-1} recommended finding for better productivity and profitability of winter maize under the humid zone of southern Rajasthan.

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MORPHOLOGICAL CHARACTERIZATION OF PROMISING GUAVA (*PSIDIUM GUAJAVA* L.) VARIETIES UNDER SUB-TROPICAL HUMID CONDITIONS OF NORTH INDIA

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ABSTRACT
The morphological studies on the performance of different guava varieties revealed that the tree height was medium (2 to 4 m) in Pant Prabhat, Arka Amulya, Shweta and Thailand.Red coloured young shoots (Anthocyanin colouration) were observed in Allahabad Safeda, Punjab Pink, L-49, Lalit, Shweta, Pear Shaped.A significant variation in leaf length was observed among different guava varieties ranging from 101.89 mm in Lalit to 151.27 mm in Punjab Pink,while, maximum leaf blade width was recorded in the variety L-49 (65.54 mm). Leaf chlorophyll index values ranged from 38.60 to 51.70 with an overall mean value of 42.84 with the maximum chlorophyll index in variety Pear Shaped. First sign of flower bud for winter season crop was noted from 21st to 25th June. In winter season crop, variety Punjab Pink was first to have open flower on 5th July. Maximum mean flower size (47.01 mm) for winter season crop was recorded in L-49. Varieties Hisar Safeda (42 days), 17-16, Lalit, G.Bilas and Pear Shaped (41 days) were found to bear flowers for longer duration.

INTRODUCTION

Guava (*Psidium guajava* L.) is one of the most common and important commercial fruit crops cultivated in both tropical and sub-tropical regions of the world.Guava tree normally produces as many as two crops in a year; which is a unique phenomenon of the tropical and sub-tropical regions. The blooming period varies from 25 to 45 days depending upon the cultivar, season and the region where it is grown. Knowledge of floral morphology, blossom biology, mode of pollination, fruit set and drop is an essential pre-requisite for hybridization and any fruit crop improvement programme. Defined programme may also serve as a guide to the orchardists in selecting the suitable cultivars having promising traits and accordingly to adjust cultural operations in relation to the flowering and fruiting behaviour of the guava trees.The cultivars Sardar and Allahabad Safeda were the most vigorous and produced maximum stock girth, scion girth, tree height and tree volume (Kumar 1998).Under New Delhi conditions, the varieties Chittidar and Red Fleshed were the earliest to start flowering and had the longest flowering period (36-46 days), whereas Apple Colour and Seedless were at the last to come into flowering (27-34 days) (Seghal and Singh 1965). The flowering season was generally longer in autumn (28-46 days) than spring season (27-39 days).Thus, in the present investigation, the growth and flowering characteristics are studied in some promising guava varieties, under sub-tropical conditions.

For a planned breeding programme, aimed at to achieve incremental improvement in the genotypes, the morphological characterization of existing germplasm has special significance. The present study conducted on guava will be of immense help for planning such experiment on guava improvement.

MATERIALS AND METHODS

The characterization for vegetative and flower characters was done in 13 guava varieties(Allahabad Safeda, Punjab Pink, Pant Prabhat, 17-16, L-49, Arka Amulya, Hisar Surkha, Hisar Safeda, Lalit, Shweta, G.Bilas, Thailand and Pear Shaped) at the Fruit Research Farm, Department of Fruit Science, Punjab Agricultural University, Ludhiana. The characters of guava accessions were observed on basis of UPOV (International Union for the Protection of New Varieties of Plants) descriptors (Rodriguez *et al*., 2010). Tree height was recorded on visual basis and the categories were recognized as tall (more than 4 meters), medium (2 to 4 meters) and small (less than 2 meters).The observations for tree foliage for current season´s growth were on visual basis and the categories were recognized as scant, normal and dense.Attitude of branches were made for tree habit on visual basis. The categories recognized were spreading, spreading to drooping and drooping. Colour of young twig was recorded on visual basis and categorized as per descriptors green, red and red colour of twig which shows presence of anthocyanin colouration.

The observations for leaf chlorophyll index were recorded using Minolta SPAD 502, a non-destructive method. Ten fully mature leaves from four directions of each tree were used and

means were worked out. The leaf surface (upper side of the fully developed leaf) was recorded visually for categories namely smooth and medium. Shape of mature leaf was observed on visual basis and expressed as elliptical, lanceolate, oblong and obovate. Leaf base and apex shape of fully developed leaves was categorized as round, obtuse and acute.The leaf length,width, petiole length and flower size of ten randomly selected mature leaves and flowers were measured with the help of digital vernier caliper, Mitutoyo Inc., Japan.Colour of midrib on lower side was observed on visual basis as green or red. Presence or absence of undulation of the margin for fresh leaves was also observed visually.The season of flowering, duration and total numbers of petals per flower were also recorded. The results obtained were subjected to analysis of variance by using RBD design and the treatment means were compared using the least significant difference (LSD) values at a significance level of $p \leq 0.05$ using procedures of the Statistical Analysis System 9.3 (Anonymous, 2011).

RESULTS AND DISCUSSION

Tree height, tree foliage and attitude of branches

The medium (2 to 4m) tree height was observed (Table 1) in Pant Prabhat, Arka Amulya, Shweta and Thailand. Whereas, tall (more than 4 m) tree height was observed in rest of the guava varieties. Varieties also showed variation with respect to tree foliage. Normal tree foliage was observed in Pant Prabhat, Arka Amulya, Lalit and Shweta. Rest of the guava varieties showed dense tree foliage. Dubey *et al* (2000) also recorded marked difference in plant height of different guava germplasm.Among guava varieties, under present study spreading to drooping habit (Table 1) of branches was recorded. Plants in majority of varieties (Allahabad Safeda, Pant Prabhat, 17-16, L-49, Arka Amulya, Hisar Surkha, Hisar Safeda, Lalit, Shweta, G.Bilas and Thailand) exhibited spreading plant habit, while, the guava varieties Punjab Pink and Pear Shaped revealed spreading to drooping plant habit. Singh (2003) while studying the growth and physical characters of seven guava cultivars recorded mean plant spread of 5 m in Behat Coconut and 6.67 m in BarafKhana and Seedless.Similarly, Deshmukh *et al* (2013)also observed under mid-hills of NE India, guava hybrid RCGH 1 showed upright growth habit, whereas hybrid RCGH 4, Allahabad Safeda and Lalit had semi-spreading and L-49 and RCGH 7 possessed drooping growth habit.

Colour of young twig, Anthocyanin colouration and leaf surface

The colour of newly emerging shoot/young twig ranged from green to red in different varieties (Table 1). Red coloured young shoots were observed in Allahabad Safeda, Punjab Pink, L-49, Lalit, Shweta, Pear Shaped and Anthocyanin colouration of young emerging leaves was also present in these varieties. Whereas, green coloured new twigs without anthocyanin colouration were observed in varieties, namely; Pant Prabhat, 17-16, Arka Amulya, Hisar Surkha, G. Bilas, Thailand and Hisar Safeda and most of the varieties showed smooth surfaced leaves,whereas, 17-16 variety had medium rough leaf surface.

Leaf shape

Much variation was observed among different guava varieties for their leaf shape, leaf base and leaf apex as per data recorded in Table 2. Four varietiesviz; L-49, Arka Amulya, Hisar Surkha and Thailand had elliptical leaf shape and all these varieties had obtuse leaf base and leaf apex. Oblong type of leaf shape was recorded in Allahabad Safeda, Pant Prabhat, G.Bilas and Hisar Safeda with round leaf base and obtuse leaf apex. Lanceolate type of leaf shape was observed among varietiesviz; Punjab Pink, 17-16 and Shweta and all these varieties possessed leaves with obtuse leaf base and acute leaf apex. Varieties Lalit and Pear Shaped showed obovate leaf shape along with obtuse leaf base and round leaf apex. Similar kind of variation for leaf shape was also observed by Sharma *et al* (2010) for different guava varieties.

Colour of midrib and undulation of the margin

The green coloured midrib on lower side of leaf was observed (Table 2) among all the varieties expect Hisar Surkha, which showed red coloured midrib on lower leaf surface. Varieties were also categorized on the basis of presence or absence of leaf margin undulation. Undulation of the margin to a medium extent was observed in Allahabad Safeda, Punjab Pink, Pant Prabhat, Lalit, G.Bilas, Thailand and Pear Shaped. For rest of

Table 1: Tree height, tree foliage, attitude of branches,colour of young twig and Anthocyanin colouration of young leaf in different guava varieties

SrNo	Varieties	Tree height	Tree foliage	Attitude of branches	Colour of young twig	Anthocyanin colouration of young leaf
1	Allahabad Safeda	Tall	Dense	Spreading	Red	Present
2	Punjab Pink	Tall	Dense	Spreading to drooping	Red	Present
3	Pant Prabhat	Medium	Normal	Spreading	Green	Absent
4	17-16	Tall	Dense	Spreading	Green	Absent
5	L-49	Tall	Dense	Spreading	Red	Present
6	Arka Amulya	Medium	Normal	Spreading	Green	Absent
7	Hisar Surkha	Tall	Dense	Spreading	Green	Absent
8	Hisar Safeda	Tall	Dense	Spreading	Green	Absent
9	Lalit	Tall	Normal	Spreading	Red	Present
10	Shweta	Medium	Normal	Spreading	Red	Present
11	G.Bilas	Tall	Dense	Spreading	Green	Absent
12	Thailand	Medium	Dense	Spreading	Green	Absent
13	Pear Shaped	Tall	Dense	Spreading to drooping	Red	Present

Table 2: Leaf characteristics (Leaf shape, leaf base shape, leaf apex shape,relief on upper surface of leaf, colour of midrib on lower side and undulation of margin) of different guava varieties

SrNo	Varieties	Leaf shape	Leaf base	Leaf apex	Relief on upper surface of leaf	Colour of midrib on lower side	Undulation of margin
1	Allahabad Safeda	Oblong	Round	Obtuse	Smooth	Green	Present
2	Punjab Pink	Lanceolate	Obtuse	Acute	Smooth	Green	Present
3	Pant Prabhat	Oblong	Round	Obtuse	Smooth	Green	Present
4	17-16	Lanceolate	Obtuse	Acute	Medium	Green	Absent
5	L-49	Elliptical	Obtuse	Obtuse	Smooth	Green	Absent
6	Arka Amulya	Elliptical	Obtuse	Obtuse	Smooth	Green	Absent
7	Hisar Surkha	Elliptical	Obtuse	Obtuse	Smooth	Red	Absent
8	Hisar Safeda	Oblong	Round	Obtuse	Smooth	Green	Absent
9	Lalit	Obovate	Obtuse	Round	Smooth	Green	Present
10	Shweta	Lanceolate	Obtuse	Acute	Smooth	Green	Absent
11	G.Bilas	Oblong	Round	Obtuse	Smooth	Green	Present
12	Thailand	Elliptical	Obtuse	Obtuse	Smooth	Green	Present
13	Pear Shaped	Obovate	Obtuse	Round	Smooth	Green	Present

Table 3: Leaf characteristics (Leaf blade length, leaf blade width, leaf length: width ratio and petiole length) of different guava varieties

SrNo	Varieties	Leaf blade length (mm)	Leaf blade width (mm)	Leaf length : width ratio	Petiole length (mm)
1	Allahabad Safeda	127.93 ± 4.14^{cd}	59.37 ± 2.51^{bc}	2.158 ± 0.054^{defg}	6.76 ± 0.23^{bc}
2	Punjab Pink	151.27 ± 1.75^{a}	65.26 ± 1.85^{a}	2.320 ± 0.039^{cd}	7.32 ± 0.21^{b}
3	Pant Prabhat	132.16 ± 2.84^{c}	63.23 ± 1.26^{ab}	2.091 ± 0.045^{fg}	8.60 ± 0.55^{a}
4	17-16	147.06 ± 2.86^{ab}	49.70 ± 0.74^{ef}	2.959 ± 0.037^{a}	5.63 ± 0.21^{def}
5	L-49	134.71 ± 3.03^{c}	65.54 ± 1.78^{a}	2.056 ± 0.013^{g}	7.38 ± 0.26^{b}
6	Arka Amulya	117.39 ± 2.34^{ef}	52.43 ± 1.57^{def}	2.240 ± 0.026^{cdef}	4.83 ± 0.37^{fg}
7	Hisar Surkha	122.68 ± 1.37^{de}	53.77 ± 1.62^{de}	2.284 ± 0.060^{cde}	5.59 ± 0.45^{def}
8	Hisar Safeda	122.33 ± 2.28^{de}	60.43 ± 0.61^{abc}	2.024 ± 0.018^{g}	4.88 ± 0.11^{efg}
9	Lalit	101.89 ± 2.76^{h}	47.82 ± 2.27^{fg}	2.135 ± 0.045^{efg}	4.36 ± 0.22^{gh}
10	Shweta	113.74 ± 1.14^{fg}	42.70 ± 1.18^{g}	2.666 ± 0.049^{b}	3.86 ± 0.12^{h}
11	G.Bilas	128.97 ± 1.90^{cd}	56.30 ± 2.49^{cd}	2.297 ± 0.070^{cde}	6.06 ± 0.50^{cd}
12	Thailand	107.56 ± 1.42^{gh}	51.87 ± 2.30^{def}	2.079 ± 0.071^{fg}	5.74 ± 0.66^{de}
13	Pear Shaped	143.45 ± 3.16^{b}	60.10 ± 2.27^{abc}	2.397 ± 0.140^{c}	6.28 ± 0.38^{cd}
	S.E. Mean	3.65	2.68	0.087	0.43
	LSD (p ≤0.05)	7.52	5.53	0.179	0.88

Means with the same letter are not significantly different (LSD, p ≤0.05). Each value represents treatment mean ± S.E. Mean (3 replications).

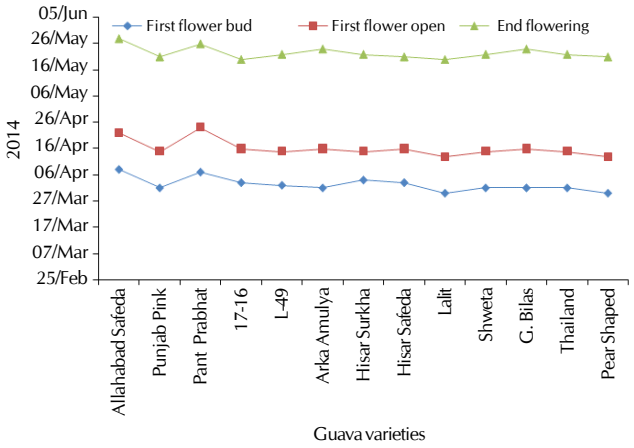


Figure 1: Comparison of flowering season in different guava varieties for rainy season crop

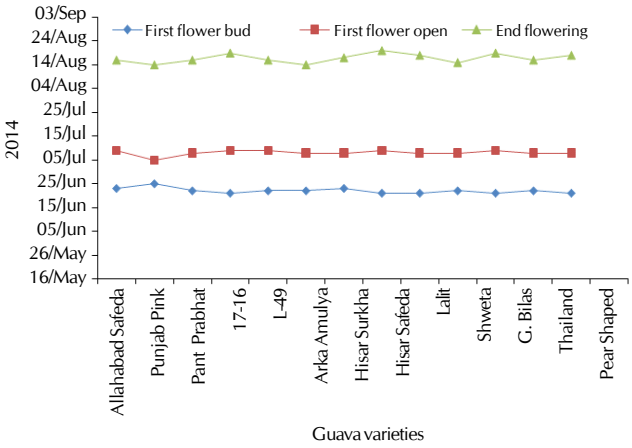


Figure 2: Comparison of flowering season in different guava varieties for winter season crop

the varieties, (17-16, L-49, Arka Amulya, Hisar Surkha, Shweta and Hisar Safeda) undulation of the leaf margin was absent.

Leaf blade length (mm)

A significant variation in leaf length was observed among different guava varieties ranging from 101.89 mm in Lalit to the tune of 151.27 mm in Punjab Pink with 127.01 mm overall average leaf length (Table 3). Maximum leaf blade length was observed in Punjab Pink (151.27 mm) followed by 17-16

Table 4: Leaf chlorophyll index, flower size and number of fully developed petals in different guava varieties for winter season crop (2014).

SrNo	Varieties	Leaf chlorophyll index	Flower size (mm)	Number of fully developed petals
1	Allahabad Safeda	38.89 ± 1.20^{f}	39.84 ± 0.19^{ef}	6 ± 0.00^{de}
2	Punjab Pink	46.70 ± 0.91^{bc}	40.92 ± 0.42^{e}	7 ± 0.00^{c}
3	Pant Prabhat	44.32 ± 0.71^{cd}	39.18 ± 0.42^{f}	6 ± 0.00^{de}
4	17-16	47.92 ± 0.45^{b}	39.75 ± 0.32^{f}	6 ± 0.17^{d}
5	L-49	40.08 ± 1.16^{ef}	47.01 ± 0.26^{a}	8 ± 0.00^{a}
6	Arka Amulya	38.69 ± 0.77^{f}	37.23 ± 0.38^{g}	6 ± 0.17^{d}
7	Hisar Surkha	45.43 ± 0.71^{bc}	43.11 ± 0.33^{d}	7 ± 0.17^{bc}
8	Hisar Safeda	38.60 ± 1.11^{f}	44.37 ± 0.22^{c}	6 ± 0.33^{d}
9	Lalit	40.64 ± 0.47^{ef}	34.90 ± 0.23^{h}	6 ± 0.33^{ef}
10	Shweta	40.48 ± 1.14^{ef}	37.03 ± 0.31^{g}	6 ± 0.17^{def}
11	G.Bilas	41.93 ± 0.96^{de}	45.66 ± 0.43^{b}	8 ± 0.33^{ab}
12	Thailand	41.55 ± 0.48^{e}	39.35 ± 0.42^{f}	6 ± 0.33^{ef}
13	Pear Shaped	51.70 ± 0.74^{a}	37.50 ± 0.75^{g}	5 ± 0.33^{f}
	S.E. Mean	1.28	0.55	0.30
	LSD (p ≤0.05)	2.64	1.13	0.61

Means with the same letter are not significantly different (LSD, p ≤0.05). Each value represents treatment mean ± S.E. Mean (3 replications).

(147.06 mm).Leaf blade length in these varieties was statistically at par among each other. Minimum leaf blade length was observed in Lalit with value 101.89 mm followed by Thailand (107.56 mm). Leaf blade length in Allahabad Safeda (127.93 mm) was statistically at par with G.Bilas (128.97 mm). Likewise, in Pant Prabhat (132.16 mm) of blade length was also statistically at par with L-49 (134.71 mm).

Leaf blade width (mm)

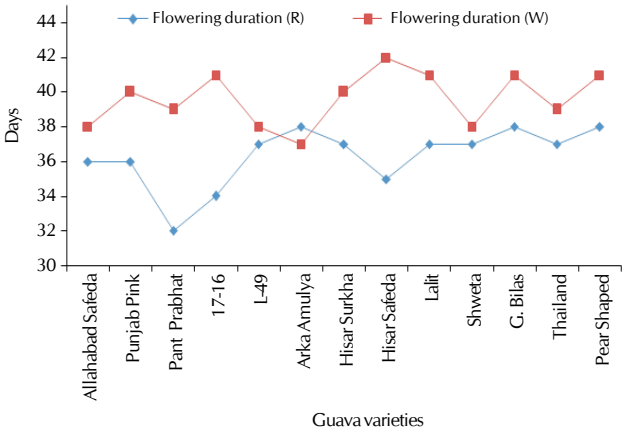
The maximum leaf blade width was recorded in the variety L-49 (65.54 mm) followed by the variety Punjab Pink (65.26 mm) and was statistically at par among each other (Table 3). The leaf blade width in Hisar Safeda (60.43 mm) variety was statistically at par with Pear Shaped (60.10 mm) and Pant Prabhat (63.23 mm). Arka Amulya (52.43 mm) variety was also statistically at par with Thailand (51.87 mm). The minimum leaf blade width (42.70 mm) was found in variety Shweta, which was significantly lower than all the varieties under study and it was followed by the varieties Lalit and 17-16 which recorded 47.82 mm and 49.70 mm leaf blade width, respectively.

Leaf length to width ratio

Length to width ratio of leaf blade was maximum (2.959) in 17-16 and it was significantly higher than all other varieties (Table 3). It was followed by Shweta, Pear Shaped, Punjab Pink and G. Bilas which recorded 2.666, 2.397, 2.320 and 2.297 leaf length to width ratio, respectively. Lower length to width ratio (2.024) was recorded in Hisar Safeda and it was followed by L-49 (2.056), Thailand (2.079) and Pant Prabhat (2.091) which was statistically at par among each other.

Petiole length (mm)

The maximum (8.60 mm) petiole length was recorded (Table 3) in variety Pant Prabhat followed by L-49 (7.38 mm), Punjab Pink (7.32 mm), Allahabad Safeda (6.76 mm) and these varieties had no significant difference among themselves. The shorter inter-node length along with minimum petiole length is responsible for dense foliage in guava variety. Shorter petiole length was recorded in Shweta (3.86 mm), Lalit (4.36 mm) and these varieties had no significant difference among each other but both were significantly different from other varieties. Arka Amulya (4.83 mm) and Hisar Safeda (4.88 mm) varieties were also statistically at par among each other, with respect to petiole length.



R - Rainy season; W - Winter season

Figure 3: Comparison of flowering duration in different guava varieties for rainy and winter season crops

Leaf chlorophyll index

Leaf chlorophyll index ranged from 38.60 to 51.70. Maximum chlorophyll index (51.70) was found in variety Pear Shaped (Table 4) and it was significantly higher than all other varieties. It was followed by 17-16, Punjab Pink, Hisar Surkha and Pant Prabhat which recorded 47.92, 46.70, 45.43 and 44.32 leaf chlorophyll index, respectively. Minimum chlorophyll index was found in varieties Hisar Safeda 38.60 which was statistically at par with Arka Amulya (38.69), Allahabad Safeda (38.89), L-49 (40.08), Shweta (40.48) and Lalit (40.64).

Flower size and no. of fully developed petals

The data revealed that the maximum flower size (45.87 mm) for rainy season crop was recorded in L-49 and this was statistically at par with G.Bilas (44.81 mm) and Hisar Safeda (44.43 mm). Minimum value for the trait was observed to be 33.99 mm in variety Lalit. Data pertaining to flower size for winter season crop is given in Table 4 and it reveals maximum

flower size of 47.01 mm as recorded in L-49, followed by G. Bilas(45.66 mm) and Hisar Safeda (44.37 mm). Least average flower size of 34.90 mm was observed in variety Lalit, followed by Shweta (37.03 mm) and this was observed to be at par with Arka Amulya (37.23 mm) and Pear Shaped (37.50 mm).The number of fully developed petals ranged from a 5 petals as observed in Pear Shaped to maximum 8 petals as observed in L-49 and G. Bilas for rainy season crop and these varieties had no significant difference among them, but both were significantly different from other varieties. Most of the varieties showed 6 fully developed petals in flower for both seasons. Punjab Pink and Hisar Surkha (7 petals) were statistically at par among each other.

Season of flowering

For rainy season crop, the date of appearance of flower bud was observed to start from 30 March during year 2014-15 (Fig. 1). The time of flower bud appearance was observed earliest in variety Lalit and Pear Shaped (30th March, each), followed by Punjab Pink, Arka Amulya, Shweta, G.Bilas and Thailand (1st April, each). While, varieties Allahabad Safeda (8th April) and Pant Prabhat (7th April) were found last to show flower bud. Dates regarding first sign of flower bud for winter season crop are illustrated in Fig. 2 and the data reveal that date of flower bud appearance ranged from 21th June to 25th June. Varieties 17-16, Hisar Safeda, Lalit, G. Bilas and Pear Shaped (21th June, each) were earliest to show the sign of flower bud. Whereas variety Punjab Pink (25th June) was observed to be late for producing flower buds. Not much significant difference for time of flower bud appearance was observed among different varieties for both the seasons during the year and it was also noted that time of flower bud appearance varied for particular variety during the year for summer as well as winter season. This variation may be attributed to environmental influence on this trait. The date of first flower opening during summer season varied from 13th April to 24th April. Varieties namely; Lalit and Pear Shaped (13th April) were earliest to open the flower and Pant Prabhat was last to open flower. For winter season crop, Punjab Pink was first to open flower on 5th July. Varieties Allahabad Safeda, 17-16, L-49, Hisar Safeda, and G.Bilas were last to show flower opening on 9th July. As observed earlier for first sign of flower bud, the date for first flower to open also showed low variation among different guava varieties.The end of flowering was observed on 20th May to 28th May for different guava varieties. Varietiesviz; 17-16 and Lalit (20th May) were first to complete flowering duration. Whereas Allahabad Safeda (28th May) and Pant Prabhat (26th May) were last to end bloom among different guava varieties under investigation. Ending time of bloom varied from 14th August to 20th August for winter season crop. Punjab Pink and Arka Amulya (14th August) were earlier to end flowering, while, Hisar Safeda (20th August), G. Bilas (19th August) and 17-16 (19th August) were found to be late to complete end of flowering.The effect of micronutrients and GA_3 on flowering was observed by Gaur *et al*. (2014). According to Kaur (2004) during rainy season, the end of flowering in different varieties of guava ranged from 29th of May to 9th of June. However, the variety Hisar Surkha was first to end flowering, whereas, Red Fleshed was at the last to end flowering.

Flowering duration

Flowering duration for rainy season crop ranged from 32 to 38 days in year 2014 with varieties Arka Amulya, G. Bilas and Pear Shaped (38 days) having longer flowering duration (Fig. 3). Shorter flowering duration was observed invarietyPant Prabhat (32 days). In winter season crop, flowering duration ranged from 37 to 42 days. Varieties Hisar Safeda (42 days), 17-16 (41 days), Lalit(41 days), G.Bilas(41 days) and Pear Shaped (41 days) were found to bear flowers for longer duration. Shorter flowering duration of 37 days was observed in variety Arka Amulya. A little variation for flowering duration was observed between both the seasons. Ulemale *et al*. (2015) also recorded performance of nine guava genotypes to qualitative and yield attributes in RBD design with three replications of each genotypes. Therefore, it was noticed that existing agro-climate situation with genetic composition of being cultivars influence the retort to meticulous agro-climatic circumstance.

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EFFECT OF SEQUENTIAL APPLICATION OF HERBICIDES ON WEEDS AND PRODUCTIVITY OF SPRING PLANTED SUGARCANE (*SACCHARUM OFFICINARUM* L.)

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ABSTRACT
The study was carried out during the spring seasons of 2011-12 and 2012-13 to the effect of sequential application of herbicides on weeds and productivity of spring planted sugarcane (*Saccharum officinarum* L.). Results showed that the minimum weed density at 90 DAP, weed control efficiency (94.53%) at 90 DAP and weed index were significantly highest with conventional practice (three hoeings) at 30, 60 and 90 DAP. Weight of millable cane, cane yield (135.32 t/ha), green tops yield, trash yield, biological yield and harvest index were found highest under conventional practice (three hoeings) at 30, 60 and 90 days after planting of sugarcane. Among the herbicides, the sequential application of ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP of sugarcane observed as the second best treatment with lower weed density at 90 DAP, weed control efficiency (85.61%) at 90 DAP weed index (8.61%) and cane yield (123.66 t/ha).

INTRODUCTION

Sugarcane is the main source of sugar in India and holds an important agricultural commercial cash crop (Dev *et al.*, 2013) which provides gainful employment to large number of people. India is the second largest among sugarcane (*Saccharum officinarum* L.) producing countries, sharing 20 per cent of the world's sugarcane area. Sugarcane is the most important sugar crop in the world for sugar production which also plays pivotal role in Indian economy by contributing 0.67% of national GDP because of its wider adaptability over varying agro-climatic condition (Dev *et al.*, 2011). It is a chief raw material for Indian sugar industry. Sugarcane occupies an area of about 5.06 million hectares with a production of 334.54 million tonnes of canes. In India, 26.34 million tonnes of sugar produced with a recovery of 10.25%. The productivity of sugarcane in India is low (66.08 t/ha) compared with that in many other sugarcane growing countries namely Egypt (121.14 t/ha) and Colombia (100.42 t/ha). Uttar Pradesh ranks first both in area (2.21 mha) and production (130.51 mt) of sugarcane, contributing 43.68 and 39.01 per cent, respectively at the national level. This gap in the acreage and production is because of poor cane productivity in the state being 59.00 t/ha which is even less than the national average (IISR, 2013).

Productivity of sugarcane in India is low as compared to other sugar growing countries of the world. Various factors such as major acreage under small and marginal holdings, non availability of quality inputs, attack of diseases and insect-pest and occurrence of various inevitable stresses during the crop growth period restrict the crop yield particularly in the sub-tropical region of the country. Negligent attitude of farmers towards weed control is the most important among losses due to various factors in sugarcane. In sugarcane crop, weed infestation is very high due to slow initial growth of crop and wide spacing between the crop rows, frequent and heavy irrigations, application of heavy doses of manures and fertilizers and the warm and humid climate during a large part of the growing season. Weeds are fast growing and multiply at alarming rate. It is well established that plants grown first have an upper hand in utilizing various resources. Therefore, weeds, if allowed to grow unhindered, lead to severe competition for light, space, water, nutrients etc. As a result crop plants are subjected to hardship during their early growth period and heavy yield losses do occurs. Sugarcane, by virtue of its long duration, has a longer critical period of 60 to 120 days for weed competition (Chauhan and Srivastava, 2002). None of the herbicide either pre or post-emergence alone can take care of weeds for such a long period and economical. Identification of new herbicides is vital and urgently needed to reduce the possibility of evolution of resistant biotype of weeds and getting higher sugarcane yield. Hence, proper choice of the weed management system would be viable, effective and economical with the varying intensity of weed species, population and their dominant effect on sugarcane. Identification of new herbicides is vital and urgently needed to reduce the possibility of evolution of resistant biotype of weeds and getting higher sugarcane yield and recovery. The

study was carried out to find out the most suitable herbicide or a combination of herbicides to control weeds in spring planted sugarcane.

MATERIALS AND METHODS

The field experiment was conducted during two consecutive spring seasons of 2011-12 and 2012-13 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India. The physico-chemical properties of soil of the experimental site were sandy clay loam in texture (Typical Ustochrept) with pH 7.64. It was moderately fertile being low in organic carbon (0.36%), available nitrogen (187.00 kg/ha), whereas, available phosphorus (21.03 kg/ha) and potassium (227.00 kg/ha) were medium. The experiment was laid out in randomized complete block design with three replications. Twelve treatment combinations *viz*., T_1-Weedy, T_2-Conventional practice (Three hoeings at 30, 60 & 90 DAP), T_3-Ametryne @ 1.6 kg a.i./ha at 30 DAP, T_4-Ametryne @ 2.0 kg a.i./ha at 30 DAP, T_5-Ametryne @ 2.4 kg a.i./ha at 30 DAP, T_6-Atrazine @ 1.0 kg a.i./ha at 30 DAP, T_7-Ametryne @ 1.6 kg a.i.ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP, T_8-Ametryne @ 2.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP, T_9-Ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP,T_{10}-Atrazine @ 1.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP, T_{11}-Atrazine @ 1.0 kg a.i./ha at 30 DAP *fb* Carfentrazone + Glyphosate @ 1.0 kg a.i./ha at 60 DAP and T_{12}-Carfentrazone + Glyphosate @ 1.0 kg a.i./ha at 60 DAP were allotted to plots. The treatments were allocated randomly to each plot. Urea, diamonium phosphate and muriate of potash were used as a source of nitrogen, phosphorus and potassium. The crop was uniformly fertilized with 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha giving half of the nitrogen and full dose of phosphorus and potassium as basal in furrows. Remaining nitrogen was top dressed in two equal splits at 60 and 90 DAP. Seed canes were taken from healthy crop of CoS 98231, suitable for spring season. Canes were cut in to 3 budded pieces and healthy setts were dipped in 0.25% solution of emisan for 15 minutes to prevent any fungal infection. The treated setts were placed horizontally in 15 cm deep furrows opened at 75 cm distance. Weed control efficiency (%) was calculated at 90 DAP by using the following formula.

$$\text{Weed control efficiency (\%)} \quad \frac{WDM_C \quad WDM_t}{WDM_C} \quad 100$$

Where,

WDM_C = Weed dry matter in control plot

WDM_t = Weed dry weight in treated plot

Weed index, a measure of reduction in crop yield, was computed as using the following formula.

$$\text{Weed index (\%)} \quad \frac{X \quad Y}{X} \quad 100$$

Where,

X = Yield from weed free plots (Three hoeings)

Y = Yield from treated plot

Data for weed components were subjected to square root transformation ($\sqrt{X \quad 0.5}$) for uniformity.

RESULTS AND DISCUSSION

Weed parameters

Critical examination of data on weed density and their weed control efficiency at 90 days after planting and weed index revealed that three hoeings at 30, 60 and 90 DAP (conventional practice) was recorded minimum weed density and highest weed control efficiency (94.53%) at 90 DAP which was significantly superior over rest of the treatments during both the years of experimentation (Table 1). Among the herbicidal treatments, ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_9) recorded minimum weed density and maximum weed control efficiency which was closely followed by ametryne @ 2.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_8), ametryne @ 1.6 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_7) and atrazine @ 1.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_{10}). However, the application of atrazine @ 1.0 kg a.i./ha at 30 DAP *fb* carfen + glypho @ 1.0 kg a.i./ha at 60 DAP (T_{11}) was also at par with ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_9) on weed control efficiency at 90 DAP during experimentation. Weed index, a measure of reduction in yield was recorded the lowest (0.00 %) in three hoeings at 30, 60 and 90 DAP which was significantly lower than rest of the treatments. The second minimum weed index per cent 8.61 was recorded under ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP during investigation. The highest weed index per cent was recorded in weedy plot during the experimentation. The main reason behind this was mainly due to better control of ametryne against grassy weeds plus inhibiting action of 2,4-D against sedges and broad leaf weeds. It might have happened due to effect of sequential application of herbicides which suppressed the weed density. Similar results were obtained by Singh and Lal (2008), Singh *et al*. (2008), Kumar *et al*. (2014), and Siddappa *et al*. (2015). Repeated hoeing (conventional practise) led to continuous decline in total weeds with advancement in crop age. It might have been attributed to better control of weeds after second hoeing. Srivastava *et al*. (2003) also reported that at 30 days interval hoeings were quite effective in controlling total weeds in sugarcane field.

Productivity of sugarcane

The data pertaining to weight of millable cane, cane yield, green tops yield, trash yield and biological yield are presented in Table 1 and 2. A perusal of the data revealed that the highest weight of millable cane, cane yield (135.32 t/ha), green tops yield (19.88 t/ha), trash yield (10.81 t/ha) and biological yield were recorded in crop given three hoeings at 30, 60 and 90 DAP (conventional practice) which was significantly higher than rest of the treatments. The sequential application of ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_9) was next treatment in maximum increasing the weight of millable cane, cane yield, green tops yield, trash yield and biological yield was found at par with ametryne @ 2.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_8), ametryne @ 1.6 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_7) and atrazine @ 1.0 kg a.i./ha at 30 DAP

Table 1: Weed density, weed control efficiency, weed index, weight of millable cane, cane yield and green tops yield as influenced by weed control treatments in sugarcane (pooled data of two years)

Treatment	Dose (kg/ha)	Time (DAP)	Weed density (No./m^2) 90 DAP	Weed control efficiency (%) 90 DAP	Weed index (%)	Weight of millable cane (g/cane)	Cane yield (t/ha)	Green tops yield (t/ha)
Weedy			23.94(572.41)	0.00	51.65	867.82	65.42	14.71
Conventional practice (Three hoeings)		30, 60 & 90	5.67(31.60)	94.53	0.00	1385.86	135.32	19.88
Ametryne	1.6	30	15.42(237.22)	58.59	22.22	1104.46	105.28	16.03
Ametryne	2.0	30	15.11(227.66)	60.28	20.65	1115.42	107.37	16.28
Ametryne	2.4	30	14.85(220.04)	61.61	18.15	1123.00	110.76	16.43
Atrazine	1.0	30	15.73(247.00)	56.88	22.90	1074.89	104.36	16.12
Ametryne *fb* 2,4-D	1.6 fb 1.0	30 fb 60	9.81(95.65)	83.35	12.55	1222.16	118.33	17.62
Ametryne *fb* 2,4-D	2.0 fb 1.0	30 fb 60	9.52(90.22)	84.30	10.80	1240.89	120.69	18.12
Ametryne *fb* 2,4-D	2.4 fb 1.0	30 fb 60	9.12(82.76)	85.61	8.61	1262.24	123.66	18.25
Atrazine *fb* 2,4-D	1.0 fb 1.0	30 fb 60	9.95(98.44)	82.87	13.58	1207.11	116.94	17.25
Atrazine *fb* Carfentrazone + Glyphosate *	1.0 fb 1.0	30 fb 60	10.67(113.40)	80.24	17.32	1132.76	111.87	16.56
Carfentrazone + Glyphosate *	1.0	60	14.17(200.18)	65.07	26.18	1037.12	99.89	15.73
SE m ±	-	-	0.41	2.45	0.56	36.17	3.68	0.53
CD (P = 0.05)	-	-	1.19	7.19	1.64	106.06	10.80	1.54

*Carfentrazone + Glyphosate (Ready mix formulation), Values are subjected to square root transformation ($\sqrt{X \quad 0.5}$), Original data given in parenthesis

Table 2: Trash yield, biological yield and harvest index as influenced by weed control treatments in sugarcane (pooled data of two years)

Treatment	Dose(kg/ha)	Time(DAP)	Trash yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Weedy			8.13	88.25	64.02
Conventional practice (Three hoeings)		30, 60& 90	10.81	166.00	81.54
Ametryne	1.6	30	8.88	130.18	80.89
Ametryne	2.0	30	8.93	132.58	81.01
Ametryne	2.4	30	8.99	136.18	81.35
Atrazine	1.0	30	8.83	129.31	80.72
Ametryne *fb* 2,4-D	1.6 fb 1.0	30 fb 60	9.64	145.59	81.29
Ametryne *fb* 2,4-D	2.0 fb 1.0	30 fb 60	9.79	148.59	81.24
Ametryne *fb* 2,4-D	2.4 fb 1.0	30 fb 60	9.93	151.84	81.47
Atrazine *fb* 2,4-D	1.0 fb 1.0	30 fb 60	9.48	143.67	81.41
Atrazine *fb* Carfentrazone + Glyphosate *	1.0 fb 1.0	30 fb 60	9.05	137.48	81.40
Carfentrazone + Glyphosate *	1.0	60	8.68	124.30	80.38
SE m ±	-	-	0.29	4.35	2.42
CD (P = 0.05)	-	-	0.84	12.77	7.09

*Carfentrazone + Glyphosate (Ready mix formulation)

fb 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_{10}) during both the years. An examination of data further revealed (Table 2) that maximum harvest index (81.54%) was recorded due to three hoeings at 30, 60 and 90 DAP of sugarcane which was statistically at par with rest of the treatments except weedy condition during both the years of investigation. However, minimum harvest index was observed under weedy plot (64.02%) during both the years. Such increase in yield might have been attributed to effective suppression of weeds and improved soil physical condition in these treatments. Increase in yield with conventional practice (three hoeings) at 30, 60 and 90 days after planting had also been reviewed by Agrawal *et al*. (1997), Rana and Singh (2004), Mansuri *et al*. (2014), and Kumar *et al*. (2015).

Conventional practice; three hoeings at 30, 60 and 90 DAP is the most effective weed management practice in respect of suppression density of all types of weeds. This treatment produced lowest weed index with highest weed control efficiency among all weed control measures and yield attributes as well as yield of spring planted sugarcane under the agro-climatic condition of eastern Uttar Pradesh. Nevertheless, ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP may be a viable and choice for farmers in case of non-availability of labour at peak periods of crop-weed competition.

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