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RESEARCH PAPER

Effect of biofertilizers and inorganic fertilizers on vegetative growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract : The present experiment was conducted at Horticultural Research Farm, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow (U.P) during 2012-13. The experiment was conducted in a Randomized Block Design with ten treatments replicated thrice. The treatments include different biofertilizers (*Azospirillum, Azotobacter* and PSB) with inorganic fertilizers (N,P,K). The results showed that application of PSB along with *Azotobacter* and full dose of nitrogen, potash and half dose of phosphorus resulted significantly vigorous growth and also increased yield of okra.

Key Words : Biofertilizers, Inorganic fertilizer, Growth, Yield

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INTRODUCTION

Okra [*Abelmoschus esculents* (L.) Moench] is an important vegetable crop in India and is most popular vegetable around the world in respect of area, production and availability. Okra is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds. Okra has multiple uses, the extract from its stem is used for cleaning cane juice in preparation of jaggery. The dry seeds of okra contain 14-23 per cent edible oil and 21-25 per cent protein (Thamburaj and Singh, 2005). The seed cake is also used as an animal feed. In many countries, the ripe seeds of okra are used as substitute of coffee particularly in Turkey. The dry fruit shell and stem containing crude fibre is suitable for use in manufacture of paper and card board. Adding of biofertilizers along with fertilizers increased crop growth and yield of okra (Verma *et al*., 1997). The main aim of conducting work on this crop was to produce organic crop chemicals to improve the crop in terms of higher pod yield, free from conspicious hairs, dark green coloured pod and then medium long, 4-5 ridges pods, suitable for processing, disease and pest resistance, tollrance to abiotic stressess. Use of biofertilizers to meet the nutrient requirement of crop would be an inevitable practice in the years to come for sustainable agriculture. Since, biofertilizers containing live and latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or celluloiytic micro-organism are used to soil or seed or seedling treatment with the objective to augment the availability and access of nutrient to the plants. Heavy use of chemical fertilizers turning the soil sick accompanied by hazardous residual effect and is posing great threat to man and animal and overall agricultural ecology. The main aim of the investigation is to minimize the use of chemical fertilizers and promote biofertilizers to improve the crop growth

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and yield (Shankaranarayaan *et al.*, 1995; Bahadur and Manohar, 2001). Bisaria and Sham (1979) concluded that environmental factors have great influence on growth and yield of crops.

MATERIAL AND METHODS

The experiment was carried out at the Horticultural Research Farm (Pragya Vatika), Department of Applied Plant Science (Horticulture), School for Bio-Sciences and Biotechnology, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.) during the winter season of 2012-2013. Experimental soil was sandy loam and slightly alkaline in nature (pH 8.2), EC- 0.35 dSm^{-1} and low in organic carbon (0.15%). It was low in soluble nitrogen (114.50 kg/ha), available phosphorus (42.50 kg/ha) and high in potassium (194.40 kg/ha). The experiment was laid out in a Randomized Block Design replicated thrice with ten treatments *i.e.* T_0- Recommended dose of fertilizers (RDF), T_1- *Azospirillum* + 50% N + 100% P and K, T_2 -*Azospirillum* + 75% N + 100% P and K, T_3- *Azotobacter* + 50% N + P and K, T_4- *Azotobacter* + 75% N + 100% P and K, T_5- PSB + 50% P + 100% N K, T_6- PSB + 75% P + 100% N K, T_7-50% PSB + 50% *Azotobacter* + 50% P + 100%N K, T_8-50% PSB + 50% *Azpspirillum* + 100% RDF, T_9-50% *Azospirillum* +50% PSB + 50% NK. The field was thoroughly prepared and the full doses of phosphorus and potassium in the form of diammonium phosphate (DAP) and muriate of potash (MOP) were applied at the time of sowing. Two seeds per hill were sown with a spacing of 45 × 20 cm. Nitrogen in the form of urea was applied in three equal split doses *i.e.* 1/3[rd] dose at the time of sowing and remaining in two equal split doses at 30 and 60 days after sowing (DAS). Before sowing the seed were treated with *Azotobacter* and *Azospirillum* inoculants. The biofertilizer solutions were prepared in warm water with addition of jaggery (5 g in 50 ml water) and made sticky paste. The seeds were treated for half an hour and then dried in shade for 30 minutes and then sown in the experimental plot immediately. At the time of sowing PSB @ 20 kg/ha mixed with 30 kg well rotten FYM was applied as per treatment. The chemical fertilizers were applied 21 days after application of biofertilizers as per treatment combination. The observations regarding the growth attributing characters and yield attributing characters were recorded from five representative plants from each plot. Fresh weight of okra fruits was calculated from all the pickings. The data were analyzed using analysis of variance (ANOVA) under Randomized Block Design following the procedure as stated by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Data from Table 1 revealed that there was significant difference in plant height among the various treatments at different stages of crop growth. The data obtained at 30 DAS, the maximum height (14.37 cm) of plant was noted under the treatment T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100% N & K) followed by T_8 (50% PSB + 50% *Azpspirillum* + 100%RDF) and minimum plant height (8.55 cm) was recorded under control T_3 (*Azotobacter* + 50% N + P and K).

At 45 DAS, the maximum height of plant was noted under the treatment T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100% N & K) followed by T_8 (50% PSB + 50% *Azpspirillum* + 100%RDF) and minimum plant height was recorded under control T_0 (19 cm).

Similarly, the maximum height of plant (60.50 cm) was recorded under the treatment T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100% N & K) followed by T_8 (50% PSB + 50% *Azpspirillum* + 100%RDF) at 60 DAS. The minimum plant

Table 1 : Effect of different treatment combinations of chemical fertilizers along with biofertilizers in okra

Treatments	Height of plant (cm)			Number of leaves per plant			Basal diameter of stem (cm)		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_0- Recommended dose of fertilizers (RDF)	10.25	19.00	40.00	4.00	7.75	13.00	0.36	0.85	1.34
T_1- *Azospirillum* + 50% N + 100% P & K	10.90	25.25	55.75	5.52	10.25	31.25	0.36	1.19	1.35
T_2 -*Azospirillum* + 75% N + 100%P & K	12.47	28.75	45.75	5.53	11.25	24.25	0.46	1.13	1.37
T_3- *Azotobacter* + 50% N +100% P & K	8.55	19.87	52.50	4.00	7.80	29.50	0.57	1.08	1.39
T_4- *Azotobacter* + 75% N + 100%P & K	11.47	24.62	45.50	5.51	9.75	30.25	0.34	1.10	1.37
T_5- PSB + 50% P + 100% N K	11.10	21.00	47.25	6.25	11.75	24.25	0.42	1.00	1.33
T_6- PSB + 75% P + 100% N K	11.30	24.50	41.50	5.00	10.00	27.00	0.36	1.17	1.38
T_7-50% PSB+50% *Azotobacter* + 50% P + 100% N K	14.37	33.50	60.50	8.00	9.55	39.25	0.56	1.24	1.39
T_8-50% PSB + 50% *Azpspirillum* + 100%RDF	13.82	30.00	53.75	5.10	9.50	18.50	0.38	1.07	1.38
T_9-50% *Azospirillum*+50% PSB + 50% NK	10.10	29.10	56.75	4.50	10.25	28.50	0.48	1.15	1.36
S.E. ±	0.529	0.834	1.490	0.237	0.488	0.804	0.032	0.058	0.014
C.D. (P=0.05)	1.573	2.427	4.427	0.703	1.450	2.388	0.100	0.169	0.030

height was recorded under control T_0 (40 cm) followed by T_6 (PSB + 75% P + 100%N K) which were statistically at par. Similar finding was also reported by Manivannan and Singh (2004) that the maximum plant height was recorded with *Azospirillum.* This might be due to the fact that *Azospirillum* is the source of symbiotic nitrogen fixing bacteria and PSB solubilises phosphorus and helps in plant growth by increasing the biological activity of desired microorganism in rhizosphere.

Table 1 also showed that the effects of various treatments on the number of leaves per plant were significantly varied at 30, 60 and 90 DAS. The maximum number of leaves per plant was observed under the treatment of T_7 at 30 and 60 DAS while treatment T_5 (PSB + 50% P + 100%N K) showed maximum number of leaves at 45 DAS. The result corroborated with the finding of Kachari and Korla (2009).

It was observed from Table 1 that there was continuous increase in the diameter of okra stem and it is clear that the stem diameter was significantly affected by various treatments at different periods after sowing *i.e.* at 30, 45 and 60 DAS. Maximum stem diameter (0.57cm) at 30 DAS was recorded under the T_3 treatment (*Azotobacter* + 50% N + 100% P & K) followed by T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100% N & K) and were at par. Maximum stem diameter (1.24 cm) at 45 DAS was recorded under T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100%N K) and (1.19 cm) under T_1 treatment. At 60 DAS treatment T_3 (*Azotobacter* + 50% N + 100% P and K) and T_7(50% PSB + 50% *Azotobacter* + 50% P + 100%N K) showed the maximum stem diameter (1.39 cm) and was significantly superior over other treatments as well as control. Minimum diameter (1.340 cm) was recorded under treatment T_0 (recommended dose of NPK through chemical fertilizers) at 60 DAS.

Data from Table 2 revealed that the effects of various treatments on the number of flower per plant at every stage of growth were finding significant at 30, 45 and 60 DAS. It was seen that the maximum number of flower (2.00) per plant was observed under the treatment T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100%N K) of followed by (1.80) treatment T_8 (50% PSB + 50% *Azpspirillum* + 100% RDF) was statistically at par and superior over all other treatments and control which showed minimum (0.80) number of flower per plant. Application of treatment combination *i.e.* PSB + *Azotobacter* + NK 50% + 50% + 50% of each (T_7) also showed maximum number of flower at 45 and 60 DAS (10.11 and 20.94, respectively).

It was also seen that the treatment effect due to T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100%N K) on the number of fruit per plant was better as compared to other treatments at every stage of growth. T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100%N K) showed maximum number of fruits per plant *i.e.* 2.25, 8.50 and 18.25 at 30, 45 and 60 DAS.

However, there was no specific trend in other treatments at every stage of growth. It was observed that treatment T_2 (*Azospirillum* + 75% N + 100% P & K) had maximum number of fruit per plat at 30 DAS whereas, T_5 (PSB + 50% P + 100%N K) showed the maximum fruit at 45 DAS after T_7. Similarly, treatment T_8 (50% PSB + 50% *Azpspirillum* + 100% RDF) showed maximum number of fruits per plat at 60 DAS after T_7.

Table 1 showed that the maximum weight of fruit (78.31g) was observed under the treatment T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100%N K) followed by (77.61g) treatment T_2 (*Azospirillum* + 75% N + 100% P and K) and minimum weight of fruit (54.10g) was recorded under control treatment T_0 (recommended dose of NPK). Bahadur and Manohar (2001) also found the similar result while experimenting on effect of biofertilizers on okra. Bashan *et al.*

Table 2 : Effect of different treatment combinations of chemical fertilizers along with biofertilizers on fruiting of okra

Treatments	No. of flower per plant			No. of fruits per plant			Fruit weight (g)	Fruit yield per ha. (q)
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS		
T_0- Recommended dose of fertilizers(RDF)	0.75	6.15	10.04	0.75	9.15	9.24	54.10	80.85
T_1- *Azospirillum* + 50 %N + 100% P & K	1.25	7.75	10.97	1.00	6.75	8.78	68.02	76.48
T_2 -*Azospirillum* + 75% N + 100%P & K	1.75	7.88	11.67	2.05	7.58	9.37	77.61	83.70
T_3- *Azotobacter* + 50% N + 100%P & K	1.58	7.98	12.27	1.50	7.01	10.21	53.35	89.92
T_4- *Azotobacter* + 75% N + 100%P & K	1.25	8.24	17.74	1.75	6.67	12.47	69.41	129.40
T_5- PSB + 50% P + 100%N K	0.80	9.75	13.12	1.80	7.75	11.37	60.25	120.88
T_6- PSB + 75% P + 100%N K	1.50	6.78	12.68	0.90	6.80	11.68	57.80	100.44
T_7-50% PSB + 50% *Azotobacter* + 50% P + 100%N K	2.00	10.11	20.94	2.25	8.50	18.25	78.31	178.96
T_8-50% PSB + 50% *Azpspirillum* + 100%RDF	1.80	8.50	13.07	1.90	7.45	12.65	73.18	135.03
T_9-50% *Azospirillum* +50% PSB + 50% NK	1.60	7.62	12.69	1.95	6.67	10.78	74.29	103.81
S.E. ±	0.071	0.850	2.271	0.101	0.872	0.847	1.272	11.671
C.D. (P=0.05)	1.573	2.427	6.427	0.290	1.830	1.780	3.780	24.538

(1989) also reported that inoculation of *Azospirillum* resulted in an increase in plant yield in tomato.

It was observed that the fruit yield (178.86 q/ha) was found maximum under treatment T_7 (50% PSB + 50% *Azotobacter* + 50% P + 100%N K) followed by T_8 (135.03 q/ ha) and the minimum yield was recorded in the plants under treatment T_1 (*Azospirillum* + 50 %N + 100% P & K) (Table 2). Bambal *et al.* (1968) reported that application of *Azotobacter* + *Azospirillum* increased yield of cauliflower.

On the basis of present investigation it can be concluded that the application of 50% PSB + 50% *Azotobacter* + 50% P + 100% N and K proved to be the best for improving vegetative growth and yield of okra under Lucknow sub-tropical condition.

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