Bangladesh J. Bot. **53**(4): 1021-1025, 2024 (December) DOI: https://doi.org/10.3329/bjb.v53i4.78569

INFLUENCE OF RHIZOBACTERIA AND ORGANIC MANURES ON YIELD OF OKRA (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH)

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Keywords: Growth, Manures, Okra, Rhizobacteria, Yield

Abstract

The investigation revealed that different growth and yield parameters *viz*., minimum days to first flowering, earliest first flowering node, minimum days to first fruit harvest and maximum plant height, average fruit weight, fruit length, fruit breadth, fruit yield per plant, fruit yield per plot and harvest duration were recorded in treatment combination of FYM + Vermicompost + Jeevamrit + *Pseudomonas fluorescens*. Therefore, supply of plant nutrients through organic sources like vermicompost, FYM, jeevamrit and *Pseudomonas fluorescens* enhance plant growth and development, increase soil nutrient status and maintain sustainable crop production.

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is a popular vegetable grown as an annual crop in tropical and subtropical regions of the world and is believed to be originated in Tropical Africa. Okra is a rich source of iodine, other vital minerals and vitamins (A, B and C) (Pradhan 2017).

Heavy use of chemical inputs in agriculture results into various problems like soil salinity, heavy metal accumulation, water eutrophication and accumulation of nitrate. It also causes air pollution by nitrogen oxides (NO, N_2O, NO_2) emission through heavy fertilization (Savci 2012). The use of organic inputs is an eco-friendly practice where locally available inputs are used to improve soil health. Farmyard manure is an important source of N, P and K and its addition to the soil increases the available P and exchangeable K, Ca and Mg content (Anim *et al*. 2006). Plant growth promoting rhizobacteria resides in the rhizosphere of plants, increase growth by direct and indirect mechanisms like nitrogen fixation, solubilization of nutrients (P, K, Zn etc.) and siderophore production (Alkaff and Hassan 2003). Plant growth regulators like IAA, gibberellic acid, and cytokinins are produced by plant growth promoting rhizobacteria and they amend the root structure; therefore, pro-up plant development (Kloepper 2003).

Materials and Methods

The experiment was conducted at the Experimental Farm of the Department of Vegetable Science, College of Horticulture & Forestry, Neri, Hamirpur, HP during July, 2021 to October, 2021. The Experiment comprised of 18 treatments viz., T_0 [Control], T_1 [FYM (50 q/ha) + Vermicompost (25 q/ha)], T_2 [Beejamrit + Jeevamrit], T_3 [Cow urine + Jeevamrit], T_4 [FYM (50 q/ha) + Vermicompost (25 q/ha) + Jeevamrit], T_5 [FYM (50 q/ha) + Vermicompost (25 q/ha) + Beejamrit + Jeevamrit], T_6 [FYM (50 q/ha) + Vermicompost (25 q/ha) + Cow urine + Jeevamrit],

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T_7 [FYM (50 q/ha) + Vermicompost (25 q/ha) + *Pseudomonas lactis*], T_8 [FYM (50 q/ha) + Vermicompost (25 q/ha) + *P. fluorescens*], T_9 [Jeevamrit + *P. lactis*], T_{10} [Jeevamrit + *P. fluorescens*], T_{11} [FYM (100 q/ha) + Jeevamrit + *P. lactis*], T_{12} [FYM (100 q/ha) + Jeevamrit + *P. fluorescens*], T_{13} [Vermicompost (50 q/ha) + Jeevamrit + *P. lactis*], T_{14} [Vermicompost (50 q/ha) + Jeevamrit + *P. fluorescens*], T_{15} [FYM (50 q/ha) + Vermicompost (25 q/ha) + Jeevamrit + *P. lactis*], T_{16} [FYM (50 q/ha) + Vermicompost (25 q/ha) + Jeevamrit + *P. fluorescens*] and T_{17} [Recommended dose of fertilizer (78N:50P:54K kg/ha)].

Punjab-8 variety of okra was used for study. Experiment was laid out in randomized complete block design with three replications in a plot size of 1.80 x 1.0 m at a spacing of 60 cm x 20 cm accommodating 15 plants in each plot. The organic manures *viz*., were applied at the time of field preparation as per the treatments in the respective plots. Recommended dose of Nitrogen, Phosphorus and Potassium (78:50:54 kg/ha) were applied in the form of urea (170 kg/ha), SSP (315 kg/ha) and MOP (90 kg/ha) in respective treatments before sowing of seed. Half dose of N along with the full doses of P and K were applied as basal dose. Remaining half in two split equal doses, first at time of sowing and second one month after application of first dose. Treatment of seeds with cow urine and beejamrit, seeds were soaked overnight @ 10% solution of cow urine and @ 10 % solution of beejamrit as per treatments and planted on next day. For the treatment with plant growth promoting rhizobacteria, seeds were soaked in water overnight and dried under shade and thereafter, these seeds were coated with *P. fluorescens* and *P. lactis* culture @ 8 g/kg as per treatments and planted in the field. Mean values of data were subjected to analysis of variance as described by Gomez and Gomez (1984) for randomized complete block design.

Results and Discussion

The analysis of variance revealed that there were significant differences between treatments for all of the horticultural traits. Minimum (44.33) days to first flowering were observed in treatment T_{16} which was found statistically at par with treatment $T_{12,}$ T_{15} and T_8 observing 45.33 days, 45.67 days and 46.33 days to first flowering, respectively (Table 1). The increased production of auxin and growth substances by humic acid at early phase of growth would have caused early induction of flowering. These results are similar with the findings of (Divya 2010). Treatment T_{16} recorded earliest (3.66) first flowering node which was found statistically at par with treatment T_{15} and T_{14} recording first flowering node values of 3.83 and 4.06, respectively (Table 1). Earliness is due to continuous supply of nutrients and growth promoting substances which ultimately led to enhanced flowering as stated by (Divya 2010). Treatment T_{16} recorded minimum number of days (48.33 days) for first fruit harvest which was found statistically at par with treatment T_{12} recording 50.33 days to first fruit harvest (Table 1). Combined application of bioinoculants and organic inputs might have resulted in pronounced nitrogen and phosphorus uptake which helped in the development of reproductive parts, stimulated early fruiting and harvesting in accordance with the findings of (Alkaff and Hassan 2003). Among all the treatments, T_{16} recorded maximum (259.08 cm) plant height, which was statistically at par with treatment T_8 and T_{14} recording plant height of 244.68 cm and 243.67 cm, respectively (Table 1). Synthesis of phytohormones like gibberellins, cytokinins and indole acetic acid by plant growth promoting rhizobacteria led to increased plant height. These results are similar with the findings of (Gyaneshwar *et al*. 2002). Maximum (27.03) number of nodes per plant recorded in treatment T_{15} which was found statistically at par with treatment T_{12}, T_8, T_{10}, T_{16}, T_{17}, T_9, T_{11} and T_{14} recording 26.80, 26.66, 26.13, 26.06, 25.80, 25.40, 25.13 and 25.06 number of nodes per plant, respectively (Table 1). This is due to better availability and uptake of plant nutrients, resulting in better photosynthesis and protein synthesis as reported by (Gyaneshwar *et al*. 2002). Maximum (19.40 g)

Table 1. Influence of plant growth promoting rhizobacteria and organic manures on yield in okra.

Treatment code	Days to first flowering	First flowering node	Days to first fruit harvest	Plant height (cm)	Number of nodes per plant	Average fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Number of fruits per plant	Fruit yield per plant (kg)	Fruit yield per plot (kg)	Harvest duration (days)
T_0	50.33	6.07	55.33	184.65	19.60	15.47	11.68	1.53	12.16	0.20	1.06	48.67
T_1	47.67	5.53	53.67	241.46	23.00	15.77	13.62	1.69	14.83	0.22	1.83	51.33
T_2	47.67	4.86	55.33	206.16	21.93	16.14	13.14	1.81	18.00	0.29	1.80	50.33
T_3	50.33	5.26	55.33	188.64	21.20	16.27	12.72	1.82	14.83	0.20	1.74	48.67
T_4	48.67	5.53	52.33	194.73	23.93	15.84	13.28	1.65	13.50	0.24	1.72	52.67
T_5	48.33	5.86	53.33	186.66	23.66	15.59	13.21	1.88	12.83	0.25	1.83	50.67
T_6	49.67	5.53	52.33	204.47	22.13	16.14	13.02	1.92	15.50	0.25	1.76	52.00
T_7	47.67	5.20	53.67	201.08	22.99	16.51	12.83	1.89	15.00	0.26	1.89	50.33
T_8	46.33	5.06	53.33	244.68	26.66	16.71	13.47	1.91	16.94	0.27	1.99	50.67
T_9	48.67	5.73	52.33	206.21	25.40	17.22	12.98	1.75	18.10	0.30	1.82	51.67
T_{10}	47.33	4.46	50.67	213.48	26.13	16.29	13.87	1.84	18.10	0.32	1.83	53.33
T_{11}	47.33	5.10	53.67	236.55	25.13	17.72	13.72	1.90	17.77	0.31	1.90	50.33
T_{12}	45.33	5.03	50.33	240.03	26.80	18.60	13.93	2.02	19.66	0.36	2.19	53.67
T_{13}	47.67	5.06	52.67	236.20	23.40	17.14	13.28	1.88	16.05	0.26	2.04	51.67
T_{14}	47.33	4.06	51.67	243.67	25.06	17.59	13.85	1.93	17.44	0.31	2.20	52.33
T_{15}	45.67	3.83	51.33	232.00	27.03	16.96	15.12	1.99	19.44	0.33	2.69	51.67
T_{16}	44.33	3.66	48.33	259.08	26.06	19.40	15.58	2.14	19.33	0.37	2.74	55.67
T_{17}	48.00	4.80	53.00	225.14	25.80	18.48	13.60	1.75	18.33	0.34	2.01	51.00
Mean	47.68	5.03	52.70	219.16	24.21	16.88	13.49	1.85	16.54	0.28	1.94	51.48
$CD_{(0.05)}$	2.40	0.64	2.33	16.35	2.44	1.01	1.12	0.13	1.28	0.01	0.42	2.99
SE(m)	0.83	0.22	0.80	5.66	0.84	0.65	0.41	0.04	0.44	0.003	0.14	1.03
C.V.	3.02	7.65	2.65	4.47	6.05	6.70	5.33	4.44	4.67	2.11	12.52	3.49

fruit weight was recorded in treatment T_{16} which was found statistically at par with treatment T_{12} and T_{17} observing average fruit weight of 18.60 g and 18.48 g, respectively (Table 1). The partitioning of photosynthates to the growing pods having more demand for assimilates lead to higher fruit weight as reported by Sreenivas *et al*. (2000) and Sivagamasundari and Gandhi (2017).

The maximum (15.58 cm) fruit length was observed in treatment T_{16} which was statistically at par with treatment T_{15} recording fruit length of 15.12 cm (Table 1). *Pseudomonas fluorescens* might be attributed to the accumulation of assimilates leading to increased fruit size due to continuous supply of nutrients. These findings are in close confirmity with the results obtained by Kachari and Gogoi (2020) and Pravisya *et al*. (2021). Maximum (2.14 cm) fruit breadth was recorded in treatment T_{16} which was statistically at par with treatment T_{12} recording fruit breadth of 2.02 cm (Table 1). Increased rate of photosynthesis and production of growth promoting substances have positive effect on the physiological activity of the plants which increase fruit breadth. The reported findings were consistent with Kloepper (2003) and Pravisya *et al.* (2021). Maximum (19.66) number of fruits per plant were recorded in treatment T_{12} which was statistically at par with treatment T_{15} and T_{16} recording 19.44 and 19.33 number of fruits per plant, respectively (Table 1). It might be attributed to bio-fertilizers support for nutrition elements to the plant, contents of bacterial chelates that stimulates cell division which ultimately increase number of fruits as reported by Pravisya *et al*. (2021). The maximum (0.37 kg) fruit yield per plant was recorded in treatment T_{16} which was statistically at par with treatment T_{12} recording fruit yield of 0.36 kg (Table 1). FYM decomposition increased dissolution of nutrients which are easily imbibed by the plants and availability of nutrients helps the plant to bear more number of flowers and ultimately increased fruit load per plant. These findings are similar with the findings of Kachari and Gogoi (2020) and Haas *et al*. (2000). Maximum (2.74 kg) fruit yield per plot was recorded in treatment T_{16} which was statistically at par with treatment T_{15} recording 2.69 kg fruit yield per plot (Table 1). The increased yield due to the secondary metabolites of *Pseudomonas fluorescens*, which are mostly involved in the induction of resistance and promoting plant growth and yield as reported by Van *et al*. (1998). Maximum (55.67 days) harvest duration was recorded in treatment T_{16} which was statistically at par with treatment T_{12} and T_{10} recording harvest duration of 53.67 days and 53.33 days, respectively (Table 1).

Treatment T_{16} was found superior for most of growth and yield parameters followed by treatment T_{10}, T_{14} and T_{17}. Hence, it can be concluded that, application of organic manures *viz.*, FYM, vermicompost and jeevamrit along with *Pseudomonas fluorescens* enhances the growth and yield characters and also improves the soil available nutrients.

Acknowledgements

The authors would like to express their heartfelt appreciation to Department of Vegetable Science, College of Horticulture and Forestry, Neri, Hamirpur for providing necessary laboratory facility and support for carrying out the study.

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(Manuscript received on 20 February, 2024; revised on 16 December, 2024)