

Effect of Inorganic and Biofertilizers on Growth and Yield of Okra *Abelmoschus esculentus* (L.) Moench

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Abstract

A field experiment was conducted in randomized in randomized block design having three replications during summer season of 2007. The experiment was comprised 16 treatments combination of inorganic and bio-fertilizers. The treatment combination T₈ (75% N + 75% P+K+ 25% *Azotobacter* + 25% PSB) exhibited maximum value for all characters like fruit yield, number of fruits per fruit, average fruit weight, number of seeds per fruit, 100 seeds weight, fruit length, fruit width, number of node per plant, number of primary branches per plant and plant height, and it had also registered minimum days for flowering and bear fruit at lower internode. The second best treatment combination was T₁₁ (75% N + 50% P+K+ 25% *Azotobacter* + 50% PSB) followed by T₅ (100% N + 75% P+K+ 25% PSB).

Key words : Okra, Inorganic, Biofertilizer, Growth, Yield.

Among vegetables okra or lady's finger *Abelmoschus esculentus* (L.) Moench is one of the most widely grown vegetables from tropical to sub-tropical and warmer parts of temperate zone of the country. It is widely cultivated as summer and rainy season crop in North India and winter crop in Gujrat, Andhra Pradesh, Karnataka and Tamil Nadu. It fails to grow in high hills which experience low temperature. Generally yield of okra in rainy season crop is quit high as compared to summer season crop. During the period of growth and development, mineral nutrients have vital role for operating the normal physiological functions for higher economic yield. Balanced nutrient supply is one of the key factors for normal growth of the plant. Nitrogen and phosphorus along with potassium are primary and major nutrients which are primary and major nutrients which are required in large quantities for healthy growth of the plant. Among biofertilizers, *Azotobacter* is the group of bacteria found in loose association with the root system of many crop plants. It is a type of non-symbiotic, heterotrophic, aerobic nitrogen fixing bacteria, can substitute part of inorganic fertilizers. *Azotobacter* inoculation saves nitrogenous fertilizers by 10—20% (1). It fixes about 25 to 30 kg/h atmospheric nitrogen in the root region of many vegetables, spices and condiments (2). Vegetable

yield increase by 2 to 45% had been obtained by inoculation of seeds of the crops with *Azotobacter* (3). It has been observed that highest response may be obtained by application of moderate dose of nitrogen. Shende et al. (4) observed enhanced seed germination by *Azotobacter* inoculation in rice and cotton. This is partly due to ability of *Azotobacter* to produce growth promoting and antifungal antibiotic substances (5).

Methods

The field trial was conducted during summer season of 2007 at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (UP) India. The experiment was comprised of 16 treatments combination viz., T₁-N + P + K (100 : 60 : 50) (100% RFD) control, T₂-75% N+P+K+25% *Azotobacter*, T₃-50% N + P + K + 50% *Azotobacter*, T₄-25% N + P + K + 75% *Azotobacter*, T₅-100% N + 75% P + K + 25% PSB, T₆-100% N + 50% P + K + 50% PSB, T₇-100% N + 25% P + K + 75% PSB, T₈-75% N + 75% P + K + 25% *Azotobacter* + 25% P SB, T₉-50% N + 50% P + K + 50% *Azotobacter* + 50% PSB, T₁₀-25% N + 25% P + K + 75% *Azotobacter* + 75% PSB, T₁₁-75% N + 50% P + K + 25% *Azotobacter* + 50% PSB, T₁₂-50% N

+75% P + K + 50% *Azotobacter* + 25% PSB, T₁₃-25% N + 50% P + K + 75% *Azotobacter* + 50% PSB, T₁₄-25% N + 75% P + K + 75% *Azotobacter* + 25% PSB, T₁₅-75% N + 25% P + K + 25% *Azotobacter* + 75% PSB, and T₁₆-50% N + 25% P + K + 50% *Azotobacter* + 75% PSB with four level of nitrogen, phosphorus and four level of biofertilizers (*Azotobacter* and phosphorus solubilizing bacteria). The trial was laid out in randomized block design having three replications in plot size 5 × 4 m². The cultivar of okra (VRO-6) was grown at the spacing of 45 × 30 cm plant to plant and row to row respectively. Fertilizers were supplied through single super phosphate, muriate of potash and urea. A basal dose of phosphorus and potash along with 50% urea was supplied at the time of field preparation remaining dose of urea (nitrogen) was top dressed after 30 days. *Azotobacter* and phosphorus solubilizing bacteria (PSB) culture was used as soil inoculant (5 kg/ha). Observations were recorded on plant height (cm), number of branches/plant, internodal distance (cm), number of nodes/plant, days to 50% flowering, node at which first flower appears, number of fruits/plant, fruit length (cm), fruit width (cm), average fruit weight (g), yield of green fruits/plant (g), number of seeds/fruit, 100 seed weight (g) and total yield of fruits (q/ha) The data were analyzed statistically following the standard procedure (6).

Results and Discussion

Nitrogen application significantly increased the growth and yield of okra plant in term of plant height, internodal distance, number of branches, number of nodes/plant, number of fruits/plant, fruit length, fruit width, average fruit weight, number of seeds/fruit, seed weight, yield of green fruit/plant and total green fruit yield but decrease the commencement of 50% flowering (days after sowing) and node at which first flower appears which is desirable for early production of produce (Table 1). The maximum plant height, number of branches per plant, number of nodes/plant and internodal distance was recorded with 75 kg/ha dose of nitrogen. Increased plant growth in okra with increasing nitrogen levels were also supported by the findings of Ahmad et al. (7).

The nitrogen application also increased the fruit yield parameter namely length of fruit, fruit width,

average weight of fruits. The yield per plant and yield per hectare have markedly affected by application of 75 kg N/ha. It might be due to the fact that nitrogen when applied in the optimum dose had maintained and improved the health and accumulation of more food material which in time had been utilized for the development of fruits in more efficient manner. These results are in conformity with the finding of Naidu et al. (8). Phosphorus is the second most important nutrient next to nitrogen. Usually its deficiency is the most important factor which is responsible for poor yield of okra. Phosphorus application significantly increased number of nodes/plant, stimulation of root development and that in the yield and quality of fruits. The maximum plant height, number of branches/plant, internodal length and number of nodes/plant recorded with 45kg/h dose of phosphorus. Increased plant growths in okra with increasing phosphorus in certain levels were also supported by Prabu et al. (9). The availability and optimum supply of nutrients to plants favorably influenced the number of branches, number of nodes/plant, flowering and profit formation which ultimately increased the number of fruit/plant, seeds fruit and test weight, similar results were also reported by Shanker et al. (10).

Biofertilizer play a major role in modifying the various characters related to growth in okra. *Azotobacter* the maximum plant height, number of branches/plant and number of nodes plant obtained when plants were inoculated with *Azotobacter* whereas minimum growth character were observed in controlled conditions. Similar, findings were also reported by Wange et al. (11). The *Azotobacter* influenced significantly all yield attributes over control. The increased yield may be due to better root proliferation, more uptakes of nutrient and water, higher number of leaves and more photosynthesis and enhance food accumulation. Results are in conformity with the finding of Bhadur and Manohar (12). In addition to phosphate solubilization, these microbes can mineralize organic phosphorus into a soluble form. These reactions take place in the rhizosphere and because the microorganisms render more P into soil solubilization than is required for their own growth and metabolism, the surplus is available for plant to absorb. In the present study, since the available P₂O₅ status of experimental field was low (27.20 kg/h) and P was applied in the readily available

form, the PSB might have helped in reducing the fixation by its chelating effect and also solubilized the available form leading to better growth attributes. The results obtained in present investigation are in line with the finding of Naidu et al. (8) and Prabu et al. (9).

In the present study, since the available P was low, PSB might helped in reducing P fixation by its effect and also solubilized the unavailable form of P leading to more uptake of nutrient as reflected in better yield attributes viz., number of fruit/plant fruit length, fruit width and test weight. This is further supported by Prabu et al. (13) and Nawalkar et al. (14).

Biofertilizers in conjunction with nitrogen and phosphorus levels significantly increased the growth of okra plant. In terms of plant height, number of branches/plant, internodal distance and number of nodes/plant. It is also observed from the present investigation that inoculation of *Azotobacter* and PSB resulted in significantly better plant growth when compared with control. Similar results were also reported by Singh and Khan (15). Increased vegetative growth may be attributed due to the increased biological nitrogen and phosphorus fixation, better organic nitrogen and phosphorus utilization, better development of root system and possible synthesis

Table 1. Effect of inorganic and biofertilizers on yield and yield attributes of okra.

Treatments	Plant height (cm)	Number of primary branches/plant	Inter-nodal distance (cm)	Number of nodes/plant	Days to 50% flowering	Node at which first flower appears	Number of fruits/plant
N + P + K (100 : 60 : 50)	54.26	1.53	3.56	15.02	44.00	4.33	16.90
75% N + P + K + 25% <i>Azotobacter</i>	54.80	1.90	3.76	15.86	45.00	4.33	17.33
50% N + P + K + 50% <i>Azotobacter</i>	55.53	1.50	3.59	15.14	44.00	4.00	16.37
25% N + P + K + 75% <i>Azotobacter</i>	56.22	1.90	3.45	15.66	45.00	5.00	16.90
100% N+ 75% P + K + 25% PSB	62.03	2.10	3.89	16.51	43.33	4.00	18.80
100% N + 50% P + K+ 50% PSB	57.19	1.93	3.55	15.86	43.67	4.33	17.27
100% N + 25% P + K+ 75% PSB	57.27	1.63	3.74	15.24	45.33	4.00	17.17
75% N + 75% P + K +25% <i>Azotobacter</i> + 25% PSB	66.88	2.63	4.00	18.15	41.67	3.33	20.90
50% N + 50% P +K + 50% <i>Azotobacter</i> + 50% PSB	61.10	1.93	3.87	15.39	48.00	4.67	18.00
25% N + 25% P + K +75% <i>Azotobacter</i> + 75% PSB	57.23	1.60	3.59	15.66	42.00	5.33	16.33
75% N + 50% P + K +25% <i>Azotobacter</i> + 50% PSB	62.87	2.17	3.93	16.78	42.00	3.67	19.23
50% N + 75% P + K + 50% <i>Azotobacter</i> + 25% PSB	55.93	1.63	3.46	14.73	43.33	4.33	17.33
25% N+ 50% P + K + 75% <i>Azotobacter</i> + 50% PSB	54.33	1.77	3.55	15.64	45.00	4.67	16.33
25% N + 75% P + K + 75% <i>Azotobacter</i> + 25% PSB	55.33	1.77	3.51	15.27	46.00	4.67	16.91
75% N + 25% P + K + 25% <i>Azotobacter</i> + 75% PSB	56.47	1.73	3.58	14.95	46.33	3.67	16.50
50% N + 25% P + K + 50% <i>Azotobacter</i> + 75% PSB	55.33	1.70	3.59	15.11	45.33	4.33	16.47
SE ±	2.987	0.233	0.135	0.709	0.0657	0.505	1.026
CD at 5%	4.725	0.368	0.214	1.122	1.95	0.798	1.623

Table 1. Continued.

Treatments	Fruit length (cm)	Fruit width (cm)	Average fruit weight (g)	Fruit yield/plant (g)	Number of seeds/fruit	100 seeds weight (g)	Total fruit yield (q/ha)
N + P + K (100 : 60 : 50)	11.59	1.65	14.10	245.41	56.00	5.50	161.75
75% N + P + K+ 25% <i>Azotobacter</i>	12.49	1.77	14.46	254.24	56.67	5.78	178.78
50% N + P + K + 50% <i>Azotobacter</i>	11.77	1.73	14.15	131.32	54.00	5.75	176.65
25% N + P + K + 75% <i>Azotobacter</i>	11.06	1.60	13.59	252.37	51.00	5.64	169.62
100% N + 75% P + K+ 25% PSB	13.01	1.84	14.90	288.88	62.33	5.94	184.61
100% N + 50% P + K + 50% P.S.B.	11.69	1.74	14.30	257.41	61.33	5.74	176.21
100% N + 25% P + K + 75% PSB	11.07	1.71	13.93	229.58	57.00	5.80	160.71
75% N+ 75% P + K + 25% <i>Azotobacter</i> + 25% PSB	13.42	2.41	15.65	300.58	68.67	6.10	215.74
50% N + 50% P + K + 50% <i>Azotobacter</i> + 50% PSB	12.85	1.73	14.53	256.68	61.33	5.79	184.20
25% N + 25% P + K +75% <i>Azotobacter</i> + 75% PSB	11.32	1.62	13.52	227.34	59.67	5.62	159.14
75% N + 50% P + K +25% <i>Azotobacter</i> + 50% PSB	13.23	1.85	14.92	289.78	64.67	5.84	193.02
50% N + 75% P + K+ 50% <i>Azotobacter</i> + 25% PSB	11.70	1.74	14.15	228.30	58.00	5.82	175.85
25% N + 50% P + K+ 75% <i>Azotobacter</i> + 50% PSB	10.53	1.55	13.17	219.33	55.00	5.57	153.32
25% N + 75% P + K +75% <i>Azotobacter</i> + 25% PSB	11.71	1.62	13.19	244.09	54.67	5.39	159.72
75% N + 25% P + K + 25% <i>Azotobacter</i> + 75% PSB	12.77	1.71	14.18	233.59	57.67	5.65	163.51
50% N + 25% P + K + 50% <i>Azotobacter</i> + 75% PSB	11.45	1.68	13.43	229.92	59.33	5.57	160.97
SE ±	0.638	0.104	0.450	18.072	3.719	0.095	12.371
CD at 5%	1.009	0.165	0.712	28.586	5.882	0.277	19.568

of plant growth hormones like IAA, GA₃ and cytokinins. The inoculation of *Azotobacter* and PSB along with nitrogen and phosphorus fertilizers had given marked increased in the yield of okra. The maximum yield was recorded by the plant received 75 kg N/h and 45 kg P₂O₅/kg with application of 1.25 kg *Azotobacter*/ha + 1.25 kg PSB/h.

The interaction of *Azotobacter*, PSB, nitrogen and phosphorus significantly influenced yield attributes like number of fruit/plant, width of fruits (cm) and length of fruits (cm), number of days for first flower initiation, fruit weight/plant. The maximum value for all characters was recorded with treatment combination T₈ (75%N + 75% P + K + 25% *Azotobacter*

+ 25% PSB) along with minimum days for flowering and bear fruit at lower internode. The second best treatment combination was T₁₁ (75% N + 50% P + K + 25% *Azotobacter* + 50% PSB) followed by T₅ (100% N + 75% P + K + 25% PSB). Similar findings had also been reported by Nawalkar et al. (14).

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