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Effect of Different Inorganic Fertlizers and Bio Fertilizers on Growth, Yield and Quality of Okra (*Abelmoschus esculentus L. Moench*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was carried out during March – June 2022 on vegetable research farm Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj. The objective of the experiment was to screen out the best combination of biofertilizer and inorganic manures for growth, yield, and quality of okra and to work out the economics. The design of the experiment was randomized block design (RBD) with three replications. The result shows that T_8 75%N + 100%PK + Azotobacter + Azospirillum + PSB was found superior in terms of plant height (9.30cm in 20 days, 30.23cm in 40 days, 43.58cm in 60 days), plant spread (19.94cm^2 in 20 days, 34.64 cm^2 in 40 days, 60.74 cm^2 in 60 days), days to first flowering (33.98 days), days to 50% flowering (42.43days), days to fruit setting (46.95 days), days to first fruit picking (48.68 days), fruit weight (9.83g), length of fruit at marketable stage (13.10cm), girth of fruit (2.02cm), no. of fruit per plant (23.98/plant), no. of seeds per fruit (48.39), fruit yield per plant(g) 235.65g, fruit yield per plot (kg) 7.78kg, fruit yield (t/ha)

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19.44, TSS (14.61^{o}Brix), ascorbic acid (21.31 mg/100g). Net economic returns of treatment were highest in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) Rs.472592.83 with highest cost benefit ratio of (4.27).

Keywords: Inorganic fertilizers; bio- fertilizers; okra; growth; yield; quality.

1. INTRODUCTION

Bhindi or Okra botanically known as (*Abelmoschus esculentus* L. Moench) belongs to the Malvaceous family having chromosome number of Okra 2n=130. The origin of okra is tropical Africa. Okra seed germinates in 25-35^{o}C but fast germination observed at 35^{o}C Seeds of okra does not germinate below 20^{o}C temperature. Temperature above 42^{o}C cause flower drop [1].

Its tender green fruits are used as a vegetable and are generally marketed in fresh form, but sometimes in canned or dehydrated form. Major states of cultivation in India are Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pradesh, Karnataka, and Assam**.** West Bengal and Karnataka are major producers of okra. Okra is a good source of vitamin A and C. Vitamin A is high as 88 I. U. and vitamin C 13 mg per 100 gm of edible portion. It is rich source of calcium, potassium, and other mineral matters. Calcium and Potassium content ranges from 66 mg to 103 mg per 100 gm of edible portion. It contains 89.6% water and the food value per 100 gm of edible portion is carbohydrates 6.4 gm, protein 1.9 gm, fiber 1.2 gm, magnesium 53 mg, phosphorus 56 mg, Sulphur 30 mg, and oxalic acid 8 mg [2]. Okra is cultivated for its fibrous fruits or pods containing round, white seeds. The fruits are harvested when immature and consumed as a vegetable.

Inorganic fertilizers are industrially manufactured chemicals containing plant nutrients. Nutrient content is higher fertilizers than organic manures and nutrients are released almost immediately [3-6]. Nitrogen impart green color to plant, encourages vegetative growth. It is present in most of substances of cells. Nitrogen is essential constituent of protean. It is constituent of protoplasm of chlorophyll and coenzyme. It plays an important role in synthesis of Auxin [7-9]. While Phosphorus can increase the disease resistance, enhance new cell formation and necessary for root development and required for formation and maturity of grain. It is essential constituent for nucleic acid & phytin. The most essential function are energy storage and transfer of energy (ADT and ATP), act as energy currency. Potassium on the other hand helps in stomata regulation, provide disease and drought tolerance in plant. It is responsible for quality products. It is essential for formation and translocation of sugars, helps in chlorophyll formation. It is useful in stress condition because it secretes 60 enzymes [10,11,12].

Biofertilizers have also become an important component for the crops, it holds a great promise to improve crop yields through better nutrient supplies. Azotobacter and Azospirillum are the two most important non-symbiotic N-fixing bacteria and considered to be very important for fixation of N in non-leguminous crops [13,14]. Under appropriate conditions, Azotobacter and Azospirillum an enhance plant development and promote the yield of several agricultural/horticultural important crops in different soils and climatic regions [15,16,17]. These beneficial effects of Azotobacter and Azospirillum on plants are attributed mainly to an improvement in root development, an increase in the rate of water and mineral uptake by roots, displacement of fungi and plant pathogenic bacteria and, to a lesser extent, biological N2 fixation [18,19-22]. Besides N2fixation, Azotobacter synthesizes and secretes considerable amounts of biologically active substances like B vitamins, nicotinic acid, pantothenic acid, biotin, heteroxins, gibberellins etc. which enhance root growth of plants [23]. Another important characteristic of Azotobacter association with crop improvement is excretion of ammonia in the rhizosphere in the presence of root exudates, which helps in modification of nutrient uptake by the plants [24]. The ability of Azospirillum to produce plant growth regulatory substances along with N2fixation stimulate growth and thereby productivity. The changes that occur in the plant roots help in transport of minerals and water [25,26-28].

Several researchers reported that there is no single source of nutrient which can meet the nutrient demand of the crops. Therefore, all the nutrient sources inorganic and biofertilizers should be applied in appropriate combination. Combination of inorganic and biofertilizer

contributes to better farm management, minimizing environmental pollution, improving soil productivity, and the production of safe food and feed.

2. MATERIALS AND METHODS

The experiment was conducted at Vegetable Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, and PRAYAGRAJ (UP) during March – June2022. All the facilities necessary for cultivation, including labor were made available in the department. The design of the experiment was randomized block design with three replication and 15 treatments. The data was recorded for the following parameters viz plant height (cm), plant spread (cm^2), days to first flowering, days to 50% flowering, days to first fruit setting, days to first fruit picking, weight of the fruit (g), length of the fruit at marketable stage (cm), girth of the fruit (cm), no. of seeds per fruit, No. of fruit per plant (g), average yield (kg), total yield (t/ha), TSS (^{0}Brix), ascorbic acid (mg/100g), cost of cultivation (Rs.), gross return (Rs.), Benefit cost ratio.

3. RESULTS AND DISCUSSION

The Study on effect of different inorganic fertilizers and biofertilizers on growth, yield, and quality of okra (*Abelmoschus esculentus*) var. TMOH 346 in Prayagraj was carried out at Research Field of Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) in the year 2021-2022. The experiment was conducted in a Randomized Block Design (R.B.D.) with three replications. Mean data of all the traits were subjected to statistical analysis and salient features of experimental finding are mentioned below:

3.1 Growth Parameter

The differences in plant growth among the plants might be due to influence of various levels of inorganic fertilizers and biofertilizers, soil and environmental conditions. Nitrogen can impart green color to the plant, encourage vegetative growth. It is present in most of substances of cells it is essential constitute of protein. It plays an important role in synthesis of auxin. Phosphorus enhances new cell formation and necessary for root development (Nem Raj Sunda., 2011).

In Table 1 Statistical analysis showed that all the traits were found significant from the experiment it was observed that T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) shows the maximum plant height 9.30cm in 20 Days, 30.23cm in 40 Days and 43.58cm in 60 days, followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 9.27cm in 20 days, 29.29cm in 40 Days and 41.81cm in 60 days. The minimum plant height 6.63cm in 20 days 23.22cm in 40 days and 30.58cm in 60 days was found in T_1 RDN (100:80:80) N:P: K. The maximum plant spread 19.94cm^2 in 20 days, 34.64cm^2 in 40 days and 60.74cm^2 in 60 days was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 17.67cm^2 in 20 days, 32.87cm^2 in 40 days and 57.08cm^2 in 60 days. The minimum plant spread 13.07cm^2 in 20 days 19.79cm^2 in 40 days and 40.41cm^2 in 60 days was found in T_1 RDN (100:80:80) N:P: K.

3.2 Earliness Parameter

Khan et al. [29] reported the difference in days to flowering might be due to the genetic variation among the treatments. The early flowering may be attributed to the genetic makeup of the cultivar. Regarding the nitrogen fertilizer treatments, the higher doses of N delayed blooming. This may be because excessive supply of N promotes luxuriant and succulent vegetative growth dominating the reproductive phase. As P enhances development of reproductive parts stimulates blooming and fruit setting, therefore minimum days to flowering were recorded in plot fertilized with lowest dose of N (100 kg ha-1) combined with phosphorus and potassium. The results are in line with that of who reported that number of days to flowering was reduced by P and increased by N in okra. The differences in days to first fruit setting among the plants might be due to expression to the growing soil and environmental conditions. This may be due to the continued release of nutrients during the growing period of crop [30]. The faster and more vegetative growth results in early flowering as well as early picking of fruits. Days to first pickings and productive span were significantly affected with the application of different fertilizer treatments. This increase might have been on account of combined effect of chemical fertilizers and biofertilizers, which

favorably influenced flowering and fruit and ultimately resulted in increased productive span. These findings agree with the results of [31]. The least number of days to flowering 33.98 days was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 34.21 days. The maximum number of days was found in T_1 RDN (100: 80: 80) N: P: K 51.26days (Table 2). The least number of days to 50% flowering 42.43 days was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 44.23 days. The maximum number of days was found in T_1 RDN (100: 80: 80) N: P: K 64.51days (Table 2). The least number of days to first fruit setting 46.95 days was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 49.05 days. The maximum number of days was found in T_1 RDN (100:80:80) N: P: K 69.76 days (Table 2). The least number of days to first fruit picking 48.68 days was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 51.38 days and the maximum number of days was found in T_1 RDN (100:80:80) N: P: K 72.66 days (Table 2).

3.3 Yield parameter

Increase in yield attributes fruit weight(g), length of fruit at marketable stage(cm), girth of fruit(cm), no. of fruit per plant, fruit yield per plant(g), fruit yield per plot (kg), fruit yield (t/ha) might occur due to increased photosynthetic area and translocation of photosynthates in plants which subsequently accelerated the formation of a greater number of large sized fruits with a greater number of seeds/ fruits resulting in increase in fruit weight. The increase in fresh fruits weight of okra due to bio-fertilizer application could be attributed to easy solubilization effect of released plant nutrient leading to improve nutrient status and water holding capacity of the soil. The results obtained agreed with the findings of [32]. The maximum number of fruits per plant 23.98 was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 22.82 and the minimum was found in T_1 RDN (100:80:80) N: P: K 15.71 (Table 2). The maximum length of the fruit 13.10 cm was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 11.80cm and the minimum length of the fruit was found in T_1 RDN (100:80:80) N: P: K 7.40cm (Table 2). The maximum weight of the fruit 9.83g was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 8.23g and the minimum weight of the fruit was found in T_1 RDN (100:80:80) N: P: K 6.06g (Table 2). The maximum girth of the fruit 2.02cm was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 1.90cm and the minimum girth of the fruit was found in T_1 RDN (100:80:80) N: P: K 1.20cm (Table 2). The maximum number of seeds per fruit 48.39 was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 42.31 and the minimum number of seeds per plant was found in T_1 RDN (100:80:80) N: P: K 26.64 (Table 2). The maximum number of seeds per fruit 48.39 was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 42.31 and the minimum number of seeds per plant was found in T_1 RDN (100:80:80) N: P: K 26.64 (Table 2). The maximum fruit yield per plant (g) was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) 235.65g followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) 187.86g and the minimum fruit yield per plant (g) was found in T_1 RDN (100:80:80) N: P: K 95.19g (Table 2). The maximum fruit yield per plot (kg) was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) (7.78kg) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) (6.20kg) and the minimum fruit yield per plot (kg) was found in T_1 RDN (100:80:80) N: P: K 95. (3.14kg) (Table 2). The total yield per hectare varies from 19.44 to 7.85 t/ha. The maximum yield tons per hectare of okra was recorded in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) (19.44t/ha) whereas minimum average yield per hectare was recorded in T_1 RDN (100:80:80) N: P: K (7.85 t/ha) (Table 2).

3.4 Quality Parameter

The maximum vitamin C (mg/100g) 21.31 was observed in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB)

Table 1. Effect of different inorganic fertilizers and bio fertilizers on growth parameter of okra (TMOH 346)

Treatment	Plant height (cm)			Plant spread (cm^2)		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T_1	6.63	23.22	30.58	13.07	19.79	40.41
T_2	7.12	27.05	36.33	14.90	27.16	48.86
T_3	7.34	27.17	37.08	15.10	26.81	49.30
T_4	7.37	26.70	34.67	14.02	22.44	44.75
T_5	7.73	27.80	37.16	15.75	28.47	50.31
T_6	9.23	29.27	41.34	17.41	31.54	55.97
T_7	9.17	29.10	40.32	16.64	29.48	55.77
T_8	9.30	30.23	43.58	19.94	34.64	60.74
T_9	7.93	25.80	36.09	14.75	26.51	46.92
T_{10}	7.71	25.51	35.23	14.57	25.59	46.17
T_{11}	7.58	27.10	35.18	14.23	24.48	45.56
T_{12}	7.43	27.65	37.62	15.34	28.13	49.67
T_{13}	9.06	29.03	38.41	16.03	29.16	53.67
T_{14}	7.84	27.85	38.10	16.19	28.88	52.61
T_{15}	9.27	29.29	41.81	17.67	32.87	57.08
F-Test	S	S	S	S	S	S
SE(d) $\pm$	0.54	0.61	0.65	0.25	0.63	0.5
$CD_{0.05}$	1.10	1.24	1.34	0.52	1.3	1.03
C.V.	8.22	2.71	1.81	1.98	2.82	1.22

Table 2. Effect of different inorganic fertilizers and bio fertilizers on earliness and yield parameter of okra (TMOH 346)

Treatment	Days to first flowering	50% flowering	Days to first fruit setting	Days to first fruit picking	No. of fruit per plant	Fruit length (cm)	Fruit weight (g)	Fruit girth (cm)	No. of seeds per plant	Fruit yield (g)	Fruit yield (kg)	Fruit yield (t/ha)
T_1	51.26	64.51	69.76	72.66	15.71	7.40	6.06	1.20	26.64	95.19	3.14	7.85
T_2	42.83	53.54	58.20	61.09	19.86	9.68	7.54	1.49	33.83	149.72	4.94	12.35
T_3	42.03	52.68	56.82	59.83	20.48	9.92	7.58	1.54	34.43	155.15	5.12	12.80
T_4	46.77	57.82	62.34	65.15	19.21	8.13	7.09	1.23	29.97	136.16	4.49	11.23
T_5	38.58	48.69	53.24	56.35	20.76	11.19	7.71	1.71	37.22	159.96	5.28	13.20
T_6	34.84	44.17	49.56	51.61	22.69	11.58	8.16	1.87	40.30	185.11	6.11	15.27
T_7	37.20	46.86	51.11	54.01	21.64	11.48	8.06	1.85	39.82	174.31	5.75	14.38
T_8	33.98	42.43	46.95	48.68	23.98	13.10	9.83	2.02	48.39	235.65	7.78	19.44
T_9	43.73	54.39	58.83	61.54	20.20	9.55	7.45	1.44	32.97	150.56	4.97	12.42
T_{10}	44.74	55.62	59.84	63.28	19.69	9.16	7.37	1.39	31.90	145.08	4.79	11.97
T_{11}	45.52	56.43	60.98	63.57	19.63	8.92	7.24	1.33	31.12	142.04	4.69	11.72
T_{12}	40.94	51.38	55.90	59.04	20.26	10.98	7.66	1.64	35.75	155.11	5.12	12.80
T_{13}	38.12	48.00	52.40	55.15	21.37	11.45	7.89	1.81	39.06	168.54	5.56	13.90
T_{14}	38.44	48.35	52.60	55.46	20.58	11.31	7.82	1.77	38.47	161.01	5.31	13.28
T_{15}	34.21	44.23	49.05	51.38	22.82	11.80	8.23	1.90	42.31	187.86	6.20	15.50
F-Test	S	S	S	S	S	S	S	S	S	S	S	S
SE(d) $\pm$	0.57	0.57	0.62	0.59	0.14	0.20	0.06	0.03	0.71	1.90	0.06	0.15
$CD_{0.05}$	1.18	1.18	1.28	1.21	0.29	0.42	0.14	0.07	1.45	3.90	0.12	0.32
C.V.	1.72	1.37	1.37	1.24	0.84	2.46	1.10	2.64	2.40	5.26	1.45	1.45

Table 3. Effect of different inorganic fertilizers and bio fertilizers on quality parameter economic parameters of okra (TMOH 346)

Treatment	Ascorbic acid (mg/100g)	TSS (^{o}Brix)	Total cost of cultivation (Rs. ha-1)	Net return (Rs. ha-1)	B:C
T_1	16.09	11.30			
T_2	17.07	12.81	112190.60	123415.05	1.10
T_3	17.40	13.08	110241.60	260310.12	2.36
T_4	15.87	12.23	110136.60	273853.13	2.49
T_5	17.59	13.25	110286.60	226710.14	2.06
T_6	19.29	13.80	110361.60	285545.67	2.59
T_7	19.17	13.74	110511.60	347626.33	3.15
T_8	21.31	14.61	110406.60	321017.25	2.91
T_9	16.89	12.68	110631.60	472592.83	4.27
T_{10}	16.77	12.55	108067.60	264564.44	2.45
T_{11}	16.66	12.41	107962.60	251101.16	2.33
T_{12}	17.50	13.17	108112.60	243440.77	2.25
T_{13}	18.52	13.51	108187.60	275707.65	2.55
T_{14}	17.89	13.40	108337.60	308795.93	2.85
T_{15}	19.86	13.91	108232.60	290257.83	2.68
F-Test	S	S	108457.60	356504.81	3.29
SE(d) $\pm$	0.32	0.08			
$CD_{0.05}$	0.66	0.18			
C.V.	2.22	0.83			

19.86 and the minimum vitamin C was recorded in T_1 RDN (100:80:80) N: P: K 16.09 (Table 3). The maximum TSS (□Brix) was recorded in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) (14□Brix) followed by T_{15} (50% + 100% PK + Azotobacter + Azospirillum + PSB) (13.91□Brix) and the minimum TSS (□Brix) was recorded in T_1 RDN (100:80:80) N:P:K (11.30□Brix) (Table 3 Significantly, the maximum net returns per hectare was obtained by T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) Rs.47,2592.83 with cost benefit ratio of 4.27 and minimum net returns per hectare was obtained in T_1 RDN (100:80:80) N:P:K Rs.123415.05 with 1.10 cost benefit ratio (Table 3).

4. CONCLUSION

Based on the results on the present investigation entitled "Effect of different inorganic fertilizers and bio fertilizers on growth, yield and quality of Okra (*Abelmoschus esculentus*)" it was concluded that T_8 75%N + 100%PK + Azotobacter + Azospirillum + PSB was found superior in terms of plant height (cm), plant spread($cm^{2)}$, days to first flowering, days to 50% flowering, days to fruit setting, days to first fruit picking, fruit weight(g), length of fruit at marketable stage(cm), girth of fruit(cm), no. of fruit per plant, fruit yield per plant(g), fruit yield per plot (kg), fruit yield (t/ha), TSS (^{0}Brix), ascorbic acid (mg/100g). Net economic returns of treatment were highest in T_8 (75%N + 100%PK + Azotobacter + Azospirillum + PSB) Rs.472592.83 with highest benefit cost ratio of (4.27).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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