Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP4: 91-94

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(Special Issue- 4)
National Seminar
"Role of Biological Sciences in Organic Farming"
(March 20, 2019)

Evaluation of biofertilizers and inorganic fertilizers on vegetative growth and yield of okra (*Abelomoschus esculentus* L. Moench)

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Abstract
An experiment was conducted at the farm of S. Boota Singh, village Midda, Distt. Shri Muktsar Sahib, Punjab, India, during the year 2018 for the evaluation of biofertilizers and inorganic fertilizers on vegetative growth and yield of okra (Abelomoschus esculentus L. Moench). The treatments were, T_1 - Azotobacter + 50% N + 100% P & K, T_2 - Azotobacter + 75% N + 100% P & K, T_3 - PSB + 50% P + 100% N & K, T_4 - PSB + 75% P + 100% N & K, T_5 – Control. The effect of these factors on plant height, stem girth, number of leaves per plant, number of branches per plant, number of flowers, number of fruits per plant, yield per picking and total yield was observed. Out of these treatments, T_1 has performed better in one parameter which is plant height (107.2) cm and T_2 performed better in all remaining parameters number of branches (5.2), number of leaves (34.4), stem girth 5.12 number of flowers per plant 16.6, number of pods per plant (12.6), yield per picking and total yield (52.76) qtl/acre It is concluded from the experiment that higher yield can be obtained T_2 (Azotobacter + 75% N + 100% P & K).

Keywords: inorganic fertilizers, vegetative growth, yield of okra.

Introduction
Okra or lady's finger (*Abelmoschus esculentus* (L.) Moench) is an important vegetable of the tropical and sub tropical region of the world. It belongs to the family Malvaceae. The word okra is of Africa origin and means Lady's fingers in Igbo, a language spoken in Nigeria (Olaniyi *et al.* 2010) [1]. It is native to Ethopia and Sudan, the north-eastern African countries. Several species of the genus *Abelmoschus* is commonly cultivated in India, Nigeria, Pakistan, Ghana, Egypt, Saudi Arabia etc. In India, it is commonly grown in Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pradesh, Karnataka, Punjab and Assam (Attigah *et al.* 2013) [2]. It is a warm season crop and prefers a temperature between 22°C to 35°C. The seeds are soaked overnight prior to planting to a depth of 1–2 cm (0.39 0.79 inch) (www.Wikipedia.com) [3]. Total area and production of world under okra is reported to be 1830.4 thousand ha and 9623.7 thousand MT respectively. Highest productivity is reported from Saudi Arabia 13.3 MT/ha followed by Egypt (12.5 MT/ha). India ranks first in production and second in area. Total area under okra in India is 533 thousand ha with production of 6346 thousand MT covering India's 5.7 per cent of total vegetable area. India produces 6346 thousand MT of Okra. Its productivity in India is 11.9 MT/ha (NHB 2014) [4].

Material and Methods
The experiment was conducted at the farm of S. Boota Singh, village Midda, Distt. Shri Muktsar Sahib, Punjab, India, during the year 2018. The experiment was conducted in five different plots with each having dimensions of 5×5 m. The treatments were, T_1 - Azotobacter + 50% N + 100% P & K, T_2 - Azotobacter + 75% N + 100% P & K, T_3 - PSB + 50% P + 100% N & K, T_4 - PSB + 75% P + 100% N & K, T_5 – Control. The land was prepared to fine tilth by repeated ploughing and harrowing. Seeds were treated with Azotobacter and PSB for 2-3 hours and seeds were kept under shady place. Seeds of variety 'Arka Anamika' were sown @10-12 kg/hectare in lines at the rate of two seeds per hill manually at a spacing of 45 cm between rows and 30 cm between plants. Sowing was done on 23 march, 2018 and seedlings

emerged out from the soil after 6 days of sowing. The field was first irrigated immediately after sowing of seeds then the subsequent irrigations given when required depending upon the soil moisture and weather condition. Fertilizers were applied with the help of broadcasting method @ 25:8:25 N:P:K. Additional 25 kg of N was applied after one month of sowing. Plant height was measured with the help of measuring tape, stem girth with the thread at interval of 15 days, number of leaves per plant, number of branches per plant, number of flowers, number of fruits per plant were counted manually and first reading was noted after 30 days of sowing. Yield per picking and total yield were calculated and weighed with the help of weighing machine. The okra pods were picked in the morning hours at an interval of 3-5 days at maturity stage.

Treatments

T_1 - Azotobacter + 50% N + 100% P & K
T_2 - Azotobacter + 75% N + 100% P & K
T_3 - PSB + 50% P + 100% N & K
T_4 - PSB + 75% P + 100% N & K
T_5 - Control

Results and Discussions

Plant height (cm)

As from the experiment, maximum plant height (79.2) was recorded in the treatment T_1 (Azotobacter + 50% N +100% P & K) and the height of plants under control was recorded to be minimum (65.8 cm). So, Sharma *et al.* [5] observed that B3 (Azotobacter + PSB) has maximum plant height (67.30cm) followed by B0 (Azotobacter) 7kg/ha (53.96cm). Similarly, Choudhary *et al.* [6] studied the impact of bio-fertilizers and chemical fertilizers on growth and yield of okra (*Abelmoschus esculentus* L.) Moench and the results showed that Azosprillium (5kg ha^{-1}+ RD NPK) has maximum plant height (96.03cm).

Number of leaves per plant

It was observed that the minimum numbers of leaves (25.2) were recorded in the untreated plants which is T_5. The maximum numbers of leaves (34.4) were observed in T_2 (Azotobacter + 75% N + 100% P & K). So, Kumar *et al.* [7] observed that application of RDF (T_1) recorded the highest no. of leaves per plant (14.66) with the B: C ratio of 3.89 followed by T_2 [75% RD of NPK + Vermicompost @ 1 t ha^{-1} (mixed with Microbial consortium)]. Similarly, Kumar *et al.* [8] studied the impact of different NPK levels and biofertilizers on growth and seed parameters of okra,The experiments consisted of 13 treatments comprised of NPK, Azospirillum, PSB and VAM including control. The results showed that T_{11} has maximum no. of leaves per plant (28.17 cm) at 60 DAS.

Stem girth

The maximum stem girth (5.34 cm) was observed in plants treated with T_2 (Azotobacter + 75% N + 100% P & K) followed by T_1, T_3 and T_4 with stem girth of 5.12 cm, 5.02 cm and 4.94 cm and 2.20 cm, respectively. The minimum value of stem girth was recorded where where no fertilizer was applied (T_5) and the value was 4.40. So, Molik *et al.* [9] studied the effect of organic and inorganic fertilizers on the growth of NH-Ae 47-4 variety of okra. The treatments were poultry litter, cow dung, NPK and urea (week after planting). It was recorded that poultry litter has highest stem girth (2.23cm) at 8WAP. Similarly, Olowoake *et al.* [10] studied the Growth and yield of okra (Abelmoschus esculentus L.) as influenced by NPK, jatropha cake and organomineral fertiliser on an Alfisol. There were 4 treatments including control and treatments were control, NPK, Grade A, jatropha cake. It was recorded that Grade A has highest stem girth (3.5cm).

Number of pods

Maximum numbers of pods per plant (12.6) were observed in plants which were provided with the Azotobacter + 75% N + 100% P & K. Minimum number of pods per plant (8.8) were recorded in unfertilized treatment. So, Abeykoon *et al.* [11] also observed that the application of recommended doses of fertilizers increased the number of pods in okra. Das *et al.* [12] also observed the similar results in okra.

Total yield

As from the experiment it was observed that, maximum yield (52.76) was found in T_2 plot and minimum yield (40.41) was found in unfertilized plot i.e in T_5 plot. So, Limbachiya *et al.* [13] observed that in micronutrients, b_2 (20 kg/ha) has maximum yield whereas in biofertilizers, maximum yield was found PSB (20ml/kg) seed. Similar results were obtained in Anisa *et al.* [14] studied the effect of biofertilizers on yield attributing characters and yield of okra and it was recorded that higher yield observed in T_{10} =FYM (as per POP) + ¾ (NPK) + Azospirillum +AMF + frateuria. Because maximum number of fruits were found in T_{10}.

Observations and Tables

Plant height

Table 1: Evaluation of biofertilizers and inorganic fertilizers on plant height of okra

Treatment	Plant height(cm)				
	30 Days	45 Days	60 Days	75 Days	90 Days
T_1	9.6	19.4	44.8	71.6	79.2
T_2	12.2	25.4	43.0	70.4	76.4
T_3	12.6	22.8	46.0	68.2	73.6
T_4	9.0	21.6	41.8	64.4	71.0
T_5	11.2	24.4	40.4	60.4	65.8

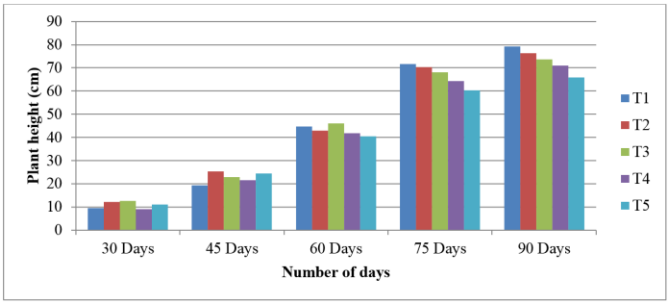

Fig 1: Evaluation of biofertilizers and inorganic fertilizers on plant height of okra

Number of leaves

Table 2: Evaluation of biofertilizers and inorganic fertilizers on number of branches of okra

Treatment	Number of branches				
	30 Days	45 Days	60 Days	75 Days	90 Days
T_1	1.4	2.4	3.8	5.0	5.0
T_2	1.4	2.6	4.0	5.2	5.2
T_3	1.6	2.2	3.6	4.4	4.4
T_4	1.2	2.2	3.6	4.6	4.8
T_5	1.2	2.4	3.6	4.2	4.2

Stem girth

Table 3: Evaluation of biofertilizers and inorganic fertilizers on stem girth of okra

Treatment	Stem girth(cm)				
	30 Days	45 Days	60 Days	75 Days	90 Days
T_1	1.59	2.67	3.52	4.72	5.12
T_2	1.80	2.83	3.92	4.64	5.34
T_3	1.71	2.79	3.44	4.44	5.02
T_4	1.58	2.91	3.93	4.50	4.94
T_5	1.36	2.60	3.28	4.02	4.40

Number of pods

Table 4: Evaluation of biofertilizers and inorganic fertilizers on number of pods of okra

Treatment	Number of pods				
	30 Days	45 Days	60 Days	75 Days	90 Days
T_1	-	6.8	11.1	8.0	1.8
T_2	-	7.2	12.6	9.2	2.4
T_3	-	7.6	10.0	7.6	2.0
T_4	-	5.8	10.2	7.4	1.2
T_5	-	5.0	8.8	6.6	0.8

Total yield

Table 5: Evaluation of biofertilizers and inorganic fertilizers on total yield of okra

Treatments	Yield per acre (qtl)
T_1	50.128
T_2	52.76
T_3	48.04
T_4	45.93
T_5	40.41

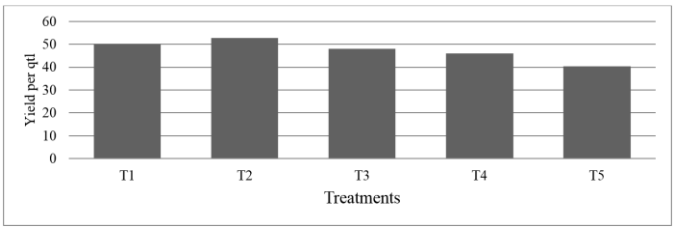

Fig 2: Evaluation of biofertilizers and inorganic fertilizers on total yield of okra

Conclusion

The present investigation was carried out for the evaluation of biofertilizers and inorganic fertilizers on vegetative growth and yield of okra. The treatments were T_1 (Azotobacter + 50% N + 100% P & K), T_2 (Azotobacter + 75% N + 100% P & K), T_3 (PSB + 50% P + 100% N & K), T_4 (PSB + 75% P + 100% N & K) and T_5 (control) treatment. The experiment concluded that among the treatments T_1 has performed better in one parameter which is plant height (107.2) cm and T_2 performed better in all remaining parameters number of branches (5.2), number of leaves (34.4), stem girth 5.12 number of flowers per plant 16.6, number of pods per plant (12.6), yield per picking and total yield (52.76) qtl/acre It is concluded from the experiment that higher yield can be obtained by T_2 (Azotobacter + 75% N + 100% P & K).

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