Research Article

Effect of Nitrogen and Bio-organics on Growth and Yield of Okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract

A field experiment was conducted at Horticulture farm, S.K.N. College of Agriculture, Jobner on effect of nitrogen and bio-organics on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] under loamy sand soils during *kharif* season 2013. The results showed that the application of 100 kg N ha^{-1} (T_3) produced highest and significantly both growth attributes *viz*. plant height at 30, 60 DAS and at harvest, number of branches per plant, leaf area, chlorophyll content and yield attributes like (Number of fruits per plant, fruit length, fruit weight, fruit yield plot^{-1} and fruit yield ha^{-1} as compared to control (T_0), 60 kg (T_1) and 80 kg N ha^{-1} (T_2). Similarly, results also showed that application of vermicompost @ 5 t ha^{-1} + *Azotobacter* significantly increased the above growth and yield attributes as compared to rest of treatments. Application of 100 kg N ha^{-1} with vermicompost @ 5 t ha^{-1} + *Azoctobacter* proved the best treatment combination in terms of fruit yield per plot, fruits yield ha^{-1} in comparison to other treatment combinations.

Keywords: Okra, nitrogen, vermicompost, *Azotobacter*, growth and yield

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Introduction

Okra (*Abelmoschus esculentus* L) is commonly known as bhindi or lady's finger belonging to family Malvaceae. It is one of the oldest cultivated crops and presently grown in many countries and is widely distributed from Africa to Asia, Southern Europe and America It is an important fruit vegetable crop cultivated in various states of India. Several species of the genus *Abelmoschus* are grown in many parts of the world among them *Abelmoschus esculentus* is most commonly cultivated in Asia and has a great commercial demand due to its nutritional values. In Rajasthan, okra is grown on 0.14 million hectares with the production of 0.88 million tonnes and in India it is grown on 0.231 million hectares with the production of 6.35 million tonnes [1].

Okra is cooked with meat for flavoring and because of high mucilaginous content, the pods are ideal for both thickening and flavoring stews and soups. The pods can also be boiled or fried and eaten as a vegetable. Okra is cultivated for its immature fruits to be consumed as a fresh and canned food as well as for seed purpose. Fruits of okra contain a mucilaginous substance that thickens the soup and stews. Okra has a relatively good nutritional value and is a good complement in developing countries where there is often a great alimentary imbalance. It is a good source of vitamin A, B, C and also rich in protein, carbohydrates, fats, minerals, iron and iodine. The green fruits (per 100 g edible portions) of okra contains 89.6 per cent of moisture, 1.9 g protein, 88 IU of vitamin A, 0.07 mg thiamine, 0.1 mg riboflavin, 13 mg vitamin C, 0.7 g minerals like 103 mg potassium, 6.9 mg sodium, 56 mg phosphorus, 66 mg calcium, 1.5 mg iron, 30 mg sulphur and other nutrients [2].

Fertilizers are generally applied to improve the crop yield, nutritional quality and aesthetic value of crops. Nitrogen, phosphorus and potassium are among the common major nutrients, which are essential for the growth and development of all plant species. Among macro nutrients, the nitrogen has great significance in plant growth. It is the important part of plant parts such as chlorophyll, amino acid, proteins and pigments. Nitrogen makes leafy vegetables and fodder more succulent. It also increases the protein content of food and feed. Therefore proper attention must be given to these nutrients while planning a project on plant nutrition [3]. As the soils of Rajasthan are light in texture having high pH and low N content, an application of nitrogen is quite essential for proper growth and development of plants.

Among the manures, vermicompost is being a stable fine granular organic matter, when added to soil, it loosens the soil and improves the passage to the entry of air. The organic carbon in vermicompost releases the nutrients slowly and steadily into the system and enables the plant to absorb the nutrients. The soil enriched with vermicompost provides additional substances that are not found in chemical fertilizers [4].

The occurrence of nitrogen fixing micro-organism such as *Azotobactor* within the plant of economics importance has been harnessed in Indian agriculture. Several workers reported that there are several free living bacteria found the roots of plant, which convert atmosphere nitrogen to the usable ammonical form. *Azotobactor chroococcum*, a heterotrophic bacterium fixes atmospheric nitrogen symbiotically and used as an inoculants for plants. Besides fixing nitrogen, it produces antifungal metabolizes and certain vitamin and growth promoting substances which increase seed germination and initial vigour in inoculated sorghum plants [5]. *Azotobactor* is free living bacteria. It has been reported to fix 20 kg N ha^{-1} in field of non legume crop and also secretes some growth promoting substances. The most feasible and economically viable fertilizer package is one which improves the crop yield with ought deterioration soil health.

Material and Methods

A field experiment was conducted at Horticulture Farm, S.K.N. College of Agriculture, Jobner during *Kharif* season 2013 entitled "Effect of nitrogen and bio-organics on growth and yield of okra [Abelmoschus esculentus (L.) Moench]". The climate of this region is typically semi-arid, characterized by extremes of temperatures during both summer and winter. During summer, the temperature may go as high as 48^0C while in winters, it may fall as low as -1^0C. The long term average annual rainfall of Jobner is 300-400 mm, most of in July and August. The mean daily temperature maximum and minimum during the growing season of okra fluctuated 37.1 and 9.5^0C, relative humidity ranged from 50 to 90 per cent. The soil was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon (0.27 %) with low available nitrogen (133.80 kg ha^{-1}), phosphorus (8.14kg ha^{-1}) and medium in potassium content (148.15 kg ha^{-1}). Water of this area is saline in nature. The pH and ECe of water were 8.2 and 3.1 dSm^{-1}, respectively. The experiment was comprised of 24 treatment combinations in split plot design keeping six nitrogen levels viz. T_0 (control), T_1 (60 kg N/ha), T_2 (80 kg N/ha), T_3 (100 kg N/ha), T_4 (120 kg N/ha) and T_5 (140 kg N/ha) in main plots and biofertilizer inoculation viz. F_0 (Control), F_1 (*Azotobacter*), F_2 (Vermicompost @ 5 t/ha) and F_3 (Vermicompost (5 t/ha) + *Aztotobacter*) in sub plots. Arka anamika is a yellow vein mosaic virus resistant variety. It is of inter specific origin between *Abelmoschus esculentus* and a wild species *Abelmoschus manihot* spp. *tetraphyllus*. It is an early maturing and takes about 50 days for first flowering after sowing and about 55 days for the first picking. Fruits are medium, green, rough, 5-ridged and start after 5-6^{th} node onward. It is high yielding and gives 200 q/ha of green fruit.

A uniform half dose (45 kg N ha^{-1}) of nitrogen through urea with dose of 60 kg P_2O_5 ha^{-1} through single super phosphate, 60 kg K_2O ha^{-1} through murate of potash as per treatment was drilled about 3-4 cm deep in the soil at the time of sowing. The remaining dose of nitrogen through urea was applied in two equal splits at 25 and 45 DAS of crop. The vermicompost and biofertilizers was applied in the beds as per treatments and was thoroughly incorporated in to the soil at the time of sowing. For application of biofertilizers, 125 g of Jaggery was mixed in one litre of boiled water. Appropriate quantity (50 g) of *Azotobacter* 100 g of culture was poured in Jaggery solution separately and stirred well. The seeds were allowed to air dry in shade and sown on the same day after inoculation.

Result and Discussion

Effect of nitrogen on growth attributes

The application of 100 kg N ha^{-1} (T_3) significantly increased the plant height at 30 DAS, 60 DAS and at harvest over its preceding levels. Significant higher height at 30 DAS (31.25 cm), at 60 DAS (95.20 cm) and at harvest (113.0 cm) was recorded under treatment T_3, while it was recorded minimum (26.70 cm, 77.20 cm and 90.60 cm) under control. Treatment (T_3) was statistically at par with treatment T_4 and T_5. This might be due to better nutritional environment in the root zone for growth and development of plant by the application of nitrogen. The nitrogen is considered as one of the major nutrients required for proper growth and development of the plant. Nitrogen is the most indispensable of all mineral nutrients for growth and development of the plant as it is the basis of fundamental constituents of all living matter. These results of present investigation are in agreement with those of [6, 7] in okra.

Number of branches per plant (2.64), leaf area and chlorophyll content in leaves had significantly increased with the application of different levels of nitrogen. Application of 100 kg N ha^{-1} resulted in significantly higher number of branches per plant (2.64), higher leaf area (1205 cm^2) and higher chlorophyll content (1.65 mg $100g^{-1}$) as compared to control, 60 and 80 kg N ha^{-1}. But it was remained statistically at par with treatment T_4 and T_5. It is also a main constituent of protoplasm, cell nucleus, amino acids, proteins, chlorophyll and many other metabolic products. The biological role of nitrogen as an essential constitute of chlorophyll in harvesting solar energy, phosphorylated compound in energy transformation, nucleic acids in the transfer of genetic information and the regulation of cellular metabolism and of protein as structural units and biological catalysts is well known. Hence, the growth and growth attributes attained the highest values for the plants fertilized with 100 kg N ha^{-1}. These results of present investigation are in agreement with those of [8] in okra.

Effect of nitrogen on yield attributes

The application of 100 kg N ha^{-1} resulted in the maximum and significantly more values of yield and yield attributes *viz*., number of fruits per plant (24.70), fruit length (19.52 cm), fruit weight (14.42 g), fruit yield per plot and fruit yield ha^{-1} (149.34 q ha^{-1}) as compared to control, 60 and 80 kg N ha^{-1}, whereas, all the above mentioned parameters remained statistically at par with 120 and 140 kg N ha^{-1}. It is relevant to mention here that adequate supply of nitrogen to plants not only promotes the synthesis of food but also its subsequent partitioning in sink. The application of nitrogen favoured the metabolic and auxin activities in plant and ultimately resulted in increased fruit size, number to fruits per plant, fruit weight and yield ha^{-1}. These findings are similar of those reported by [9-13] in okra crop.

Effect of bio-organics on growth attributes

Application of vermicompost @ 5 t ha^{-1} + *Azotobacter* alone or in combination had influenced the plant height significantly at 30 DAS, 60 DAS and at harvest over control. The maximum plant height at 30 DAS, 60 DAS and at harvest (32.64 cm, 100.34 cm and 116.82 cm) was observed under treatment F3, while, minimum plant height was (27.24 cm, 80.54 cm and 95.43 cm) recorded under control. These findings clearly indicated that vermicompost and *Azotobacter* played a significant role in enhancing the growth of okra. The beneficial effect of vermicompost on plant growth might be attributed to the fact that the earthworms mineralize macro and micronutrients during vermicompost and made available to crop plants for longer period. The results are in close conformity with the findings of [14, 15] in okra.

Table 1 Effect of nitrogen and bio-organics on growth attributes of okra

Treatments	Plant height (cm)			Number of braches per plant	Leaf area (cm^2) at flowering	Chlorophyll content in leaves (mg g^{-1})
	30 DAS	60 DAS	At harvest			
Nitrogen level (kg/ha)						
Control (T_0)	26.70	77.20	90.60	2.04	980.00	1.23
60 (T_1)	28.30	84.10	100.30	2.28	1065.00	1.38
80 (T_2)	29.80	90.50	106.70	2.48	1145.00	1.52
100 (T_3)	31.25	95.20	113.00	2.64	1205.00	1.65
120 (T_4)	31.80	98.10	115.20	2.70	1225.00	1.70
140 (T_5)	32.10	99.80	116.80	2.74	1235.00	1.73
SEm±	0.44	1.33	1.83	0.03	11.15	0.04
CD (P = 0.05)	1.37	4.16	5.75	0.11	35.01	0.12
Bio-organics						
Control (F_0)	27.24	80.54	95.43	2.10	985.00	1.26
Azotobacter (F_1)	29.14	87.94	104.82	2.39	1110.00	1.49
Vermicompost @5t/ha (F_2)	30.94	94.44	111.32	2.63	1210.00	1.64
Vermicompost (5 t/ha) + *Azotobacter* (F_3)	32.64	100.34	116.82	2.81	1265.00	1.75
SEm±	0.53	1.69	1.78	0.05	23.98	0.03
CD (P = 0.05)	1.52	4.83	5.09	0.14	68.59	0.09

Data indicated in **Table 1** revealed that application of bio-organics had influenced the number of branches per plant, leaf area and chlorophyll content in leaves significantly. The maximum branches per plant (2.81), leaf area (1265 cm^2) and chlorophyll (1.75 mg 100 g^{-1}) content were recorded under treatment F_3. Application by bio-organics i.e. vermicompost @ 5t ha^{-1} + Azotobacter in combination also resulted in the highest number of branches, leaf area and chlorophyll content in leaves as compared to rest of the treatments. Vermicompost has solublizing effect on some mineral compounds present in the soil and brings about the conversion of a number of chemical elements into available form to plants. In addition, they also improve the structure, aeration and water holding capacity of soil. The results are in close conformity with the findings of [16].

Effect of bio-organics on yield and yield attributes

Application of different bio-organics increased the yield attributes *viz.*, number of fruits per plant, fruit length, fruit weight, fruit yield per plot and fruit yield per hectare. Data in **Table 2** showed that the application of vermicompost @ 5 t ha^{-1} + *Azotobacter* enhanced all the above parameters significantly over control. Application of vermicompost @ 5t ha^{-1} + *Azotobacter* (F_3) resulted in the highest and significantly more number of fruits (25.98), fruit length (20.76 cm), fruit weight (15.13 g), fruit yield per plot (7.09 kg) and fruit yield ha-1 (164.23 q) as compared to control.

The beneficial effect of vermicompost on yield and yield attributes might be attributed to its ability of sustain availability of nutrients throughout the growing season. The vermicompost binds the soil particles into aggregates and has a profound effect on the environment of soil and its structure and increased C: N ratio. The increased balanced C:N ratio might have increased the synthesis of carbohydrates with ultimate improvement in yield and yield attributes as reported by [17-20].

Table 2 Effect of nitrogen and bio-organics on yield and yield attributes of okra

Treatments	Number of fruits per plant	Fruit length (cm)	Fruit weight (g)	Yield (kg/plot)	Yield (q/ha)
Nitrogen level (kg/ha)					
Control (T_0)	19.77	13.60	13.23	4.74	109.67
60 (T_1)	21.45	15.72	13.66	5.31	122.85
80 (T_2)	23.10	17.60	14.05	5.88	136.08
100 (T_3)	24.70	19.52	14.42	6.45	149.34
120 (T_4)	24.75	19.87	14.45	6.48	149.95
140 (T_5)	24.76	20.23	14.46	6.49	150.11
SEm$\pm$	0.46	0.44	0.11	0.02	1.64
CD (P = 0.05)	1.44	1.37	0.35	0.07	5.17
Bio-organics					
Control (F_0)	19.55	14.31	12.93	4.56	105.61
Azotobacter (F_1)	22.51	16.85	13.67	5.55	128.56
Vermicompost @5t/ha (F_2)	24.32	19.10	14.46	6.35	146.93
Vermicompost (5 t/ha) + *Azotobacter* (F_3)	25.98	20.76	15.13	7.09	164.23
SEm$\pm$	0.55	0.36	0.21	0.03	1.12
CD (P = 0.05)	1.58	1.03	0.61	0.08	3.19

Table 3 Interactive effect of nitrogen and bio-organics on yield of okra

Treatments	Bio-organics							
	Yield (kg/plot)				Yield (q ha^{-1})			
	F_0	F_1	F_2	F_3	F_0	F_1	F_2	F_3
T_0	3.67	4.47	5.11	5.71	84.95	103.42	118.19	132.10
T_1	4.11	5.00	5.72	6.39	95.17	115.85	132.40	147.99
T_2	4.55	5.54	6.34	7.08	105.42	128.32	146.65	163.92
T_3	5.00	6.08	6.95	7.77	115.69	140.83	160.94	179.89
T_4	5.02	6.11	6.98	7.80	116.16	141.40	161.60	180.63
T_5	5.02	6.12	6.99	7.81	116.29	141.56	161.78	180.83
	(S.Em. $\pm$)		**CD (P=0.05)**		**(S.Em. $\pm$)**		**CD(P=0.05)**	
For F at same level of T	0.053		0.152		2.23		6.38	
For T at same or different level of F	0.085		0.244		2.39		6.82	

Interactive effect of different nitrogen and bio-organics on yield

The yield obtained in plot receiving 120 and 140 kg N ha^{-1} was statistically at par with yield obtained under plot receiving, 100 kg N ha^{-1} and vermicompost @ 5 t ha^{-1} + *Azotobacter* (**Table 3**). Thus, it is interesting to note that 40 kg N ha^{-1} can be saved by application of vermicompost @ 5 t ha^{-1} + *Azotobacter*, along with 100 kg N ha^{-1}.

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