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Research Article

EFFECT OF DIFFERENT ORGANIC FERTILIZERS ON THE GROWTH AND YIELD OF LADY'S FINGER, *Abelmoschus esculentus* (L.) MOENCH

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A B S T R A C T

Organic fertilizers are applied to plants and /or soils to improve soil fertility, plant vigour, quality and yield of the plant. Organic based fertilizers are used both in organic and conventional agriculture. In the present study, the vegetable crop *Abelmoschus esculentus* (L.) Moench was taken and the growth studies were carried out. The germination study carried out using different organic fertilizers showed 100% germination in almost all the treatments. In control, it was90%.The shoot length was found to be higher in T_4 i.e., combination of VAM+ Vegetable compost+ Phosphobacteria on the 30thdayand45thday.Similar to shoot length, the root length was more inT_1on the 30th day. The fresh weight of the plant was minimum on all the days in control plants. On the 45th day, 60th day and 75th day, the fresh weight of the plant was more in plants treated with VAM fungus. The dry weight of the plants showed significant increase in plants treated with VAM fungus (T_1).The number of leaves was more in plants treated with combination of fertilizers. On the 75th day, the number of the fruits formed was more in plants treated with vegetable compost which shows that, a the compost starts degrading, releases the nutrients and it is being absorbed by the plant and results in increase in the growth and yield of the vegetable crop.

INTRODUCTION

Plants are a major group among the living organisms, which support and help the life line of the human beings as well as other living organisms. They have always sustained human civilization through the biologically active compounds they contain in them. Plants are essential for human nutrition. Plants provide us food and shelter. Vegetables are naturally good and contain lots of minerals and vitamins. They helpin protecting our body against cancers, diabetes and heart diseases. Vegetables provide essential amino acids which are required by the body for survival. Fruits and vegetables which are rich in antioxidants are known for their beneficial effects against degenerative diseases (Sharma *et al*., 2017). Vegetables play a vital role in the improvement of the diet of mankind (Kibria *et al*., 2013). Bio-fertilizers are microbial preparations containing living cells of different microorganisms which have the ability to mobilize plant nutrients in the soil from unusable to usable form. It is considered environmental friendly, play a significant role in the crop production, help to build up the lost micro flora and improve the soil fertility (Zhang *et al.,* 2013).

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Bio-fertilizers such as VAM, Phosphobacteria and Vegetable compost have potential practical applications, which contribute very much in increasing the crop productivity through increased biological nitrogen fixation, increased availability or uptake of nutrients through phosphate solubilization or increased absorption, stimulation of plant growth or by rapid decomposition of organic residues (Kumar *et al*., 2017).

Abelmoschus esculentus L. is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. Itbelongs to Malvaceae family. It is also known as lady's finger or okra in English. It is a popular and common vegetable. It is one of the most important vegetable crop in India and grown over a wide range of soil and climatic condition (Smriti and Ram,2018). All parts of okra like fresh leaves, buds, flowers, pods, stems and seeds can be used for different purpose and hence it is a multipurpose crop in term of its use. The mucilage found in okra maybe used for plasma replacement (Madison and Maramag, 2013).Okraisanannual crop propagated from seed, grown for its green tender fruits, which are cooked and consumed as a vegetable in a variety of ways.

MATERIALS ANDMETHODS

The plant taken for the present study was *Abelmoschus esculentus* (L.) Moench. Growth studies were carried out

under different treatments of organic fertilizers namely Vesicular Arbuscular Mycorrhiza, Vegetable compost and Phosphobacteria at different stages of growth of theplants.

Collection of the seeds

Seeds of *Abelmoschus esculentus* (L.) Moench were obtained from the Tamil Nadu Agricultural University, Coimbatore.

Collection of Organic Fertilizers

The organic fertilizers such as VAM, Vegetable compost and Phosphobacteria were collected from TNAU, Coimbatore.

METHODS

Pot Culture Experiment

Theseeds of *Abelmoschus esculentus* (L.) Moenchobtained from TNAU, Coimbatore were soaked in different organic fertilizers overnight. Later, the seeds were sown in pots (30cm×24cm×30cmsizedpots) containing red soil and sandy soil in the ratio 1:1. The treated pots were maintained in triplicates. The effect of different organic fertilizers on the growth and yield parameters of *Abelmoschus esculentus* (L.) Moench were assessed. The different organic fertilizer treatments given were:

T_0- Control
T_1- Vesicular Arbuscular mycorrhiza
T_2- Vegetable compost
T_3- Phosphobacteria
T_4- VAM + Vegetable compost + Phosphobacteria

Growth Parameters

Plant samples were uprooted carefully on the 30th, 45th, 60th and 75th day and the following growth parameters were measured and recorded for all the treatments.

- ✓ Shoot length(cm)
- ✓ Root length(cm)
- ✓ Numberofleaves
- ✓ Fresh weight(gm)
- ✓ Dry weight(gm)

Hoot Length

The shoot length of the plants was measured with the help of a scale from the shoot collar point to shoot apex and expressed in centimeter. Ten seedlings were randomly selected from each treatment and their shoot length was measured using cm scale and recorded as cm/seedling. Three readings were taken for statistical analysis.

Root Length

Theplantsweretakenfromcontrolpotandothertreatmentpotsandwashedtogetrid off adhering soil particles. Then, the length of the roots was measured with the help of a scale from root collar point to root tip and expressed in centimeter. Ten seedlings were randomly selected from each treatment and their root length was measured using cm scale and recorded. Number of leaves

The number of leaves present in the uprooted plants were calculated.

Fresh Weight

Fresh weight of the plants was measured with the help of an electronic digital balance and expressed ingrams.

Dry weight

The collected plant materials were keptinhotairovenat 55°Cfor24hours.Then, the dry weight of the plants was measured using an electronic digital balance and expressed in grams.

Yield parameters

Number of fruits

The number of fruits obtained on the 45th day, 60th day and 75th day were calculated for *Abelmoschus esculentus* (L.) Moench.

Fruit weight

The fruit weight of the plant was measured with the help of an electronic digital balance and expressed in grams.

Fruit length

The length of the fruit was measured with the help of a scale and expressed in centimeter. Ten fruits werer and omly selected from each treatment and their fruit length keptinhotairovenat was measured using cm scale and recorded as cm/seedling. Three readings were taken for statistical analysis.

Statistical Analysis

The data obtained from various growth parameters were subjected to statistical analysis as per the procedure of Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

The study conducted in *Abelmoschus esculentus* (L.) Moench showed the following results

Germination

The germination study carried out using different organic fertilizers showed 100% germination in almost all the treatments. In control, it was 90% and in combination of fertilizers, it was 93% (Table 1).

Shoot Length

The plant grew upto 75 days and so the growth parameters were measured upto 75 days. The shoot length was estimated at different stages of growth of the plant. On the 30th day, the shoot length was higher in T_4 i.e combination of VAM+ Vegetable compost+ Phosphobacteria. The readings observed was 27.17± 1.04 cm (Table 2)

On the 45th day again, the shoot length was found to be more in T_4 (43.00 ± 1.00 cm). On the 60th day of growth, the shoot length was more in T_1 i.e., plants treated with VAM fungus and the readings observed was 47.17± 0.76 cm. On the 75th day of growth, the shoot length was observed to be higher in T_2 (50.00 ± 1.50 cm), the plants treated with vegetable compost (Plate 1-4).

Root length

Similar to shoot length, the root length of *Abelmoschus esculentus* (L.) Moench at different stages of growth was measured and tabulated (Table 3). On the 30th day of growth,

the root length was more in T_1 (9.17±1.04). T_3 and T_4 had similar readings of 8.17 ± 0.76 cm on the 30th day. On the 45th day and 75th day of growth, the root length was higher in T_2 i.e., the plant treated with vegetable compost and the values were found to be 12.00 ± 1.00 and 19. 00 ± 1.50 cm respectively. On the 60th day of growth, the root length was more in plants treated with phosphobacteria (19.00 ± 0.50 cm). This might be due to the soil being enriched by the phosphate solubilizing bacteria.

Microorganisms such as bacteria, fungi and actinomycetes play a principle role in Nitrogenfixation and P availability in soil which may increase the uptake of N and P through plant roots (Rao *et al*., 2014).The present study is in accordance with the resul to btained by Razzak *et al*.(2018)on the use of Toma to was tecom post for the production of vegetable seedlings.

Table 1 Germination percentage of the *Abelmoschus esculentus* (L.) Moench

Treatments	Germination percentage (%)
T_0	90
T_1	100
T_2	100
T_3	100
T_4	93

Table 2 Shootlength (cm) of *Abelmoschu sesculentus* (L.) Moench at different stages of growth

Treatments	30th day	45th day	60th day	75th day
T_0	21.17 ± 1.04	30.00±0.50	30.00±5.00	45.00±1.00
T_1	10.0 ± 0.50	40.00±0.50	**47.17±0.76**	37.50±1.32
T_2	19.17±0.76	38.0±0.50	40.67±1.53	**50.00±1.50**
T_3	25.17±0.76	32.0±1.00	43.00±1.00	40.33±1.04
T_4	**27.17±1.04**	**43.00±1.00**	45.00±1.00	45.50±1.32
SEd	0.6912	0.6055	1.9972	1.0220
CD(P< 0.05)	1.5401	1.3492	4.4501	2.2771

Values are given as mean ± of three samples in each group

Fresh weight

The fresh weight of the plant was calculated during the 30th day, 45th day, 60th day and 75th day of growth and the results were tabulated in (Table 4)

In control plants, the fresh weight was minimum on all the days measured. On the 30th day, the fresh weight was higher in plants treated with combination of fertilizers i.e., VAM+ Vegetable compost+ phosphobacteria. On the 45th day, 60th day and 75th day, the fresh weight of the plant was found to be more in plants treated with VAM fungus and the values were found to be 14. 80± 1.20 g, 32.20 ± 0.75gm and 19.67gm respectively.

Table 3 Root length (cm) of *Abelmoschus esculentus* (L.) Moench at different stages of growth

Treatments	30th day	45th day	60th day	75th day
T_0	4.17±0.76	8.50±0.50	8.50±0.50	11.83±0.76
T_1	**9.17±1.04**	11.50±0.50	16.50±1.00	14.33±0.76
T_2	5.17±1.04	**12.00±1.00**	12.00±1.00	**19.00±1.50**
T_3	8.17±0.76	9.50±0.50	**19.00±0.50**	15.17±2.25
T_4	8.17±0.76	10.50±0.50	12.00±1.32	11.33±0.76
SEd	0.7226	0.55164	0.7528	1.1005
CD(P< 0.05)	1.6102	1.1506	1.6773	2.4521

Values are given as mean ± of three samples in each group

Plate 1 Growth of *Abelmoschus esculentus* (L.) Moench on the 30th day

Plate 2 Growth of *Abelmoschus esculentus* (L.) Moench on the 45th day

Plate 3 Growth of *Abelmoschus esculentus* (L.) Moench on the 60th day

Plate 4 Growth of *Abelmoschus esculentus* (L.) Moench on the 75th day

Dry weight

After taking the fresh weight of the plants, the plants were kept in hot air oven to measure the dry weight. The dry weight of *Abelmoschus esculentus* (L.) Moench was calculated at different stages of growth and tabulated (Table 5). On the 30th day, the dry weight of the plant was more in plants treated with combination of fertilizers and it was found to be 2.21 ± 0. 10 g.

On the 45th day, 60th day and 75th day, the dry weight was higher in plants treated with VAM fungus (T_1) and the readings observed were 3.70 ± 0.23 g, 8.28 ± 0.20 g and 4.83 ± 0.60 g respectively.

Number of leaves

The number of leaves present in the shoot system was counted and tabulated (Table 6).On the 30th day of growth, the number of leaves was more in T_1, T_3 and T_4 and it was found to be 4.67 ± 0.58. On the 45th day, control plants had more number of leaves (6.00 ±1.00).On the 60th day, the number of leaves increased in plants treated with vegetable compost and phosphobacteria and the reading was 6.00 ±1.00 (Table 6). On the 75th day of growth, the number of leaves increased drastically in plants treated with combination of fertilizers and it was found to be 13. 63 ±0.97 (Table 6).

The mycorrhizal fungi mobilize phosphates and other micronutrients lik ezinc, boron and molybdenum from adjacent soil to the root system through hyphal network. Enhanced up take of phosphorus and increased plant growth due to inoculation of soil with VAM fungi in horticultural crops such as chilli, tomato, asparagus, potato, lettuce and onion have been reported by Bagyaraj and Sreeramulu,(1982)and Suryawanshi *et al*.(2013).

Girth

The girth of the stem of the *Abelmoschus esculentus* (L.) Moench was calculated at different stages of growth and tabulated (Table 7).On the 30th day and 45th day, the girth of the stem was more in T_4 i.e. plants treated with combination of fertilizers and it was found to be 1.83 ± 0. 08 cm and 2.30 ±0.46 cm respectively. On the 60th day, the girth increased in plants treated with VAM fungus (2.80 ± 1.00 cm). On the 75th day, the girth was more in T_2 (2.00 ± 0.20 cm).

Yield Parameters

Number of fruits

The number of fruits formed by the application of different organic fertilizers was calculated and tabulated (Table 8).The fruits started forming during the 45th day of the plant growth. On the 45th day and 60th day, the number of fruits formed were more in T_1 (4.00 ± 1.00 and 6.00 ± 1.00 respectively).

On the 75th day, the number of the fruits formed was more in plants treated with vegetable compost which shows that, as the compost starts degrading, it releases the nutrients and it is being absorbed by the plant and results in increase in the growth and yield of the vegetable crop.

Fruit weight

The weight of the fruits formed during different stages of growth using different treatments was measured and tabulated (Table 9).

The fruit weight of an individual fruit was measured. It was found to be 7.52 ±0. 11g on the 45th day in plants treated with combination of fertilizers. On the 60th day and 75th day, the fruit weight was found to be more in plants treated with phosphobcteria and the values were 13.20 ± 0.75 g and 13.63 ± 0.97 g respectively.

Fruit length

The length of the fruit was measured at different stages of growth and tabulated (Table 10). The fruit length was expressed in cm. On the 45th day of the growth, the fruit length was found to be more in plants treated with combination of fertilizers and it was 15.33 ± 0. 58 cm. On the 60th day, T_2 and T_3 plants showed an increase in fruit length (14.33 ± 0.76 cm and 14.33± 1.53 cm respectively). On the 75th day again, the fruit length increased in T_4 (14.50 ± 0. 50 cm).

Table 4 Fresh weight (g) of *Abelmoschu sesculentus* (L.) Moench at differentstages of growth

Treatments	30th day	45th day	60th day	75th day
T_0	3.88±0.38	9.22±0.75	10.23±1.86	16.00±1.50
T_1	6.08±0.20	**14.80±1.20**	**32.20±0.75**	**19.67±1.26**
T_2	5.82±1.59	9.22±1.00	20.43±1.25	18.50±2.29
T_3	9.38±0.70	10.01±1.00	24.89±1.65	17.67±1.61
T_4	**10.87±0.47**	12.62±1.20	24.40±0.90	16.83±0.76
SEd	0.6618	0.8671	0.1028	1.2780
CD(P< 0.05)	1.4746	1.946	2.4571	2.8476

Values are given as mean ± of three samples in each group

Mal *et al*. (2013) have earlier shown that the maximum vegetative growth, yield attributing characters and fruit yield was found in integrated application of fertilizers as compared to recommended dosage of chemical fertilizers and organic manure.

Padma priya and Anu Geetham (2015) have shown that the co-inoculation of *Azospirillum* and Phosphate solubilizing bacteria improve the soil characters, plant growth and yield of okra.

The results of the present study are in accordance with the studies carried out by Sharma *et al*. (2016).

Table 5 Dry weight (g) of *Abelmoschu sesculentus* (L.)Moench at different stages of growth

Treatments	30th day	45th day	60th day	75th day
T_0	0.58±0.06	1.59±0.34	2.80±0.60	4.37±0.51
T_1	1.55±0.44	**3.70±0.23**	**8.28±0.20**	**4.83±0.60**
T_2	1.51±0.48	1.63±0.48	6.02±0.29	4.77±0.64
T_3	1.80±0.34	2.08±0.30	6.83±0.40	4.60±0.53
T_4	**2.21±0.10**	2.65±0.28	6.71±0.19	4.50±0.35
SEd	0.2716	0.2743	0.3016	0.4382
CD(P<0.05)	0.6052	0.6113	0.6719	0.9763

Values are given as mean ± of three samples in each group

Table 6 No.of leaves of *Abelmoschu sesculentus* (L.) Moenchat different stages of growth

Treatments	30th day	45th day	60th day	75th day
T_0	2.67±0.58	**6.00±1.00**	**6.00±1.00**	5.67±1.15
T_1	**4.67±0.58**	5.00±1.00	5.67±0.58	7.33±0.58
T_2	3.67±0.58	5.00±1.00	**6.00±1.00**	7.33±0.58
T_3	**4.67±0.58**	4.00±1.00	**6.00±1.00**	6.00±1.00
T_4	**4.67±0.58**	5.00±1.00	5.00±1.00	**13.63±0.97**
SEd CD(P< 0.05)	0.4714	0.7303	0.7601	0.8165
	1.0504	1.6272	1.6937	1.8193

Values are given as mean ± of three samples in each group

Kumar *et al*. (2017) have earlier shown that the nutrient availability is increased by the application of different nutrients there by increasing the growth, yield and quality of okra. The current results areinclose conformity with the findings of Selvi and Perumal (2000) and Swain *et al*. (2003) in okra. The present results are in concurrence with the findings of Nuruzzaman *et al*.(2003). Similar observations that the combined use of organic manures, inorganic fertilizer and organic fertilizers supported better fruit yield in okra, have also been reported by Jadhav *et al*. (2008) and Islam *et al*. (2011).

Sahu *et al*. (2014) have earlier shown that the application of PSB along with *Azotobacter* and full dose of nitrogen, potash and half dose of phosphorus resulted in significant increase in growth and yield of okra.

Table 7 Girth (cm) of thes tem of *Abelmoschu sesculentus* (L.)Moench at different stages of growth

Treatments	30th day	45th day	60th day	75th day
T_0	0.84±0.12	1.50±0.50	2.10±0.90	1.47±0.31
T_1	1.42±0.09	2.20±0.46	**2.80±1.00**	1.60±0.20
T_2	1.22±0.16	1.70±0.82	2.20±0.80	**2.00±0.20**
T_3	1.62±0.20	2.00±0.50	2.17±0.58	1.93±0.25
T_4	**1.83±0.08**	**2.30±0.46**	2.14±1.00	1.70±0.40
SEd	0.1130	0.4604	0.7102	0.2300
CD(P< 0.05)	0.2517	1.0259	1.5825	0.5124

Values are given as mean ± of three samples in each group

Table 8 No. of fruits of *Abelmoschus esculentus* (L.) Moench on the 45th, 60th and 75th day

Treatments	45th day	60th day	75th day
T_0	2.00±0.00	3.67±0.58	5.00±0.58
T_1	**4.00±1.00**	**6.00±1.00**	7.33±0.58
T_2	2.00±1.00	4.00±1.00	**8.00±1.00**
T_3	3.50±2.78	5.83±0.58	7.50±0.58
T_4	3.00±1.00	5.33±0.58	8.00±0.58
SEd	0.5208	0.6325	1.1972
CD(P< 0.05)	1.0364	1.4092	2.6676

Values are given as mean ± of three samples in each group

The improvement in the growth of plant may be attributed to the better root development, mineral uptake and plant water relationship and also the ability of the microorganisms to fix the atmospheric nitrogen to the soil and made available to the growing plants (Choudhary *et al*.,2015).

Anisa *et al.* (2016) have proved that the combined application of bio-fertilizers along with double dose of farmyard manure increased the fruit yield per plant.

Naidu *et al.* (2000) have earlier concluded that a significant increase of microbes in soil could be found with the application of manure, vermicompost and bio-fertilizers, thus increasing the total yield in okra.

Table 9 Fruit weight (g) of *Abelmoschus esculentus* (L.) Moench

Treatments	45th day	60th day	75th day
T_0	5.84±0.12	5.93±0.35	9.17±0.65
T_1	7.14±0.43	11.27±0.42	10.43±0.23
T_2	6.10±0.17	8.87±5.79	11.57±0.87
T_3	6.73±0.15	**13.20±0.75**	**13.63±0.97**
T_4	**7.52±0.11**	11.33±0.65	12.10±0.46
SEd	0.1879	0.5649	2.1536
CD(P< 0.05)	0.4188	1.2587	4.7984

Values are given as mean ± of three samples in each group

Table 10 Fruit length (cm) of *Abelmoschus esculentus* (L.) Moench at different days

Treatments	45th day	60th day	75th day
T_0	10.50±1.32	10.67±1.53	10.50±1.00
T_1	13.00±1.00	14.00±1.00	12.83±1.26
T_2	15.00±0.50	14.33±0.76	10.05±8.63
T_3	14.00±1.00	14.33±1.53	12.17±0.76
T_4	15.33±0.58	14.17±0.76	14.50±0.50
SEd	0.7601	0.9545	3.2223
CD(P< 0.05)	1.6937	2.1268	7.1798

Values are given as mean ± of three samples in each group

Application of VAM and other fertilizer issuggested to be used in order to improve the effective growth and yield of crop plants. The okra fiber possesses an excellent quantity of cellulose. Hence, it can be used as cellulosic raw materials in cellulose based industries.

Compost produced by bacteria and kitchen was tehashighnutrient values that can be effectivelyusedasbiocompostandtherebyreducetheapplicatio noforganicfertilizer.In general, plants supplied with mycorrhiza have better growth than plants without Mycorrhiza. The mutual relationships between mycorrhizal fungi and host plants yield positive benefits for both.

The present conclusion is based on the investigation done using pot culture experiments. Further studies are required under field trial to support the current study.

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