**Effect of different organic manures on green fruit production in Okra *(Abelmoschus esculentus* L.*)***

**ABSTRACT**

**Aims:** The single and amalgamated effect of different doses of organic manures *viz.,* Farm Yard Manure (FYM), Vermicompost and Enriched compost alone or in combination with Microbial consortia were studied in the present investigation to analyse their effect on the growth characteristics and fruit yield of Okra.

**Study design:** The experiment was laid out in Randomised Block Design (RBD) with three replications.

**Place and Duration of Study**: The experiment was conducted during 2022 in the Organic Block of Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat, Assam.

**Methodology:** The different treatment combinations such as FYM 10 t/ha (T1), FYM 5 t/ha (T2), FYM 2.5 t/ha + Microbial consortia (T3), Vermicompost 5.0 t/ha (T4), Vermicompost 2.5 t/ha (T5), Vermicompost 2 t/ha + Microbial consortia (T6), Enriched compost 2.0 t/ha (T7) and untreated control (T8) were applied at the time of final land preparation.

**Results:** The fruit yield parameters such as fruit weight (14.60 g), fruit volume (18.03 cc), fruit yield per plant (202.93 g) and total yield (95.74 q/ha) were maximum under T7 (Enriched compost 2.0 t/ha). However, the highest net return from tender fruits was produced with application of Vermicompost 2 t/ha + Microbial consortia (T6) leading to the maximum Benefit: Cost ratio of 3.80.

**Conclusion:** Thus, it can be concluded from the present experimental analysis that fruit yield parameters were significantly enhanced by Enriched Compost 2 t/ha (T7) but was not statistically superior to Vermicompost 2 t/ha + microbial Consortia (T6) which proved to be the most remunerative for tender fruit production.

*Keywords: Consortia, farm yard manure, green fruit, organic, okra, vermicompost*

1. **INTRODUCTION**

In 1960 with the advent of Green Revolution in India, farmers were presented with several upgraded techniques of farming which gave them an early and higher crop yield (Nelson *et al*., 2019). One such techniques involved abundant use of chemical fertilizers for cultivation of crops which gave them higher production in less amount of time. Such intensive farming practices resulted into a higher income benefit but caused extensive damage to soil fertility and plant health in the long run (Haribhushan *et al*., 2017). In addition to this, ample use of such fertilizers also left behind toxic residual substances in the soil which greatly affected the growth of the crops and reduced their yield and productivity. Serious effects of such residual toxicity were witnessed in vegetable crops, especially, the seed crops which require a longer growing period in the field until they attain harvest maturity (Bhusan *et al*., 2019). Moreover, the fresh consumption of such vegetables posed grave threat on human health (Raj *et al*., 1998). Therefore, this major constraint led to the increasing awareness among vegetable growers to substitute inorganic chemical fertilizers with organic manures which not only gave higher quality crops but also improved the soil health. In recent years, more focus had been given to the use of organic fertilizers and several research works were conducted for the same to analyse the best organic fertilizer, its rate and method of application. Vegetables were found to response very well towards organic fertilizers and the most commonly used ones included Farm Yard Manure (FYM), Vermicompost, Compost, Poultry Manure etc. applied alone or in combination. Organic fertilizers can be defined as the natural substances derived from decomposed plant and animal residues which can be further categorized into two types *viz*., bulky organic manures such as FYM, Vermicompost, Compost etc. and concentrated organic manures such as Oil cakes, Bone meal *etc*. The former type comprised of low amount of nutrients as compared to the latter one and thus needed to be applied in larger quantity so as to meet the nutritional requirements of the crops. FYM can be prepared from farm waste, cattle dung etc. and the percentage content of N-P2O5-K2O present in it is 0.95-0.62-2.20%. Vermicompost is formed by the action of earthworms on the undecomposed and complex soil organic matter so as to convert it into simple organic forms to be readily utilized by the plants. It contains 1.8-0.22-0.40% of N-P2O5-K2O. Compost is another type of organic manure prepared from animal or plant waste. It has very low concentration of nutrients but supplies almost all essential micronutrients to the crop. The compost can also be enriched further by inoculation of microbes and rock phosphate etc. The concentrated organic manures, however, are less used at present in India because majority of the oil cakes produced are utilized as cattle feed. According to FiBL Survey, 2021, India at present accounts for 30% of total organic producers in the world. The total cultivated area under organic farming in India is 4726714.74 ha with a total farm production of 3410195.02 metric tonnes (NPOP, 2022). India also exported 460320.40 metric tonnes of organic products in 2021-22 (NPOP, 2022).

Okra (*Abelmoschus esculentus*) is one of the major vegetable crops with largest export potential (APEDA, 2020). It is a warm season crop grown for its edible pod which is botanically known as capsule (Graham *et al*., 2017). The plant is annual, herbaceous in nature with deep tap root system and an erect stem having 3-5 branches (Drost and Ernst, 2012). The leaves are palmately lobed and alternately arranged in the stem. Flowers are large, solitary and borne at the axil with calyx, corolla and stamens fused at the base (Gemede *et al*., 2015). Although the plant is self-pollinated in nature yet the bright showy colour of the flowers facilitates cross pollination (about 10%) making it an often-cross pollinated crop. The flowers bloom only for a day and fall off leaving behind a small, green pod (Hamon and Koechlin, 1991). The pods continue to grow and become elongated in shape. At maturity these are filled with numerous round to oval, dark-coloured seeds. The tender pods are used as vegetable which are highly rich in nutrients and contains mucilaginous substance (Gemede *et al*., 2015). High iodine content of the fruit helps to cure Goitre whereas the leaves are used against inflammation and dysentery (Nwokocha, 2024; Dantas *et al*., 2021]. The roots and stem are used for clearing sugarcane juice for the preparation of Jaggary (Yadav *et al*., 2020). The seeds are also used as a substitute for coffee in many Arabian countries (Qi, 2017). Dry seed of Okra contains good amount of edible oil and protein (Sharma, 1993). Therefore, almost all parts of the plant can be economically used.

The major Okra producing states in India are Gujarat, West Bengal, Bihar, Madhya Pradesh, Orissa, Chhattisgarh, Uttar Pradesh, Andhra Pradesh, Tamil Nadu and Assam. Gujarat is the leading producer state in India with an annual production of 1019.42 tonnes (NHB, 2022).

Proper growth of the okra plants depends largely on the availability of soil nutrients which can be efficiently supplied through the application of fertilizers and manures. Although use of chemical fertilizers gives an early result but in the long run such persistent applications leave a high residual effect thus degrading soil health and pollution of ground water. Therefore, use of organic manures is highly beneficial as it enriches the soil, does not pose a threat to human health and ecosystem as a whole. Application of organic manures helps to maintain the microbial growth in the soil and provides all the essential nutrients to the crop naturally without degrading the soil physical and chemical properties. It helps to retain the moisture and improve soil texture. Application of FYM in Okra is found to increase the plant height, number of branches, number of fruits per plant, fruit length and yield of the crop. It also escalates the dry matter accumulation in the fruit (Miglani *et al*., 2017). Use of enriched compost improves the physical condition of the soil and stimulates a healthy soil micro-floral growth. The effect of compost on increasing the growth and yield of okra was studied by Adebayo in 2010. Vermicompost acts as a soil conditioner and provides different macro and micro nutrients to the soil. The earthworms used in vermicompost leaves the soil 5-11% richer in essential plant nutrients. Application of vermicompost increases the soil quality by improving the water holding capacity, porosity and other physical attributes of the soil which in turn helps in better plant growth and also enhances the germination rate of seeds (Nejatzadeh, 2024). Thus, the use of organic manures increases the yield and productivity of crops, ensuring no loss of natural properties of soil. Taking all these perspectives into consideration an experiment on organic fruit production of Okra have been designed to study the effect of different types of organic manure on the plant growth and green fruit yield of Okra.

1. **MATERIALS AND METHODS**

The experiment was conducted in 2022 at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during the kharif season from the period of July to October. The location of the experimental field falls under Upper Brahmaputra Valley Agro Climatic Zone of Assam at 26°72´ N latitude and 94°19´ E longitude at an elevation of 86.8 m above mean sea level. The field was uniform, levelled and free of any water stagnation. The variety of okra used in the present experiment was Arka Anamika the seeds of which were collected from Indian Institute of Horticultural Research (IIHR), Bengaluru, Karnataka. The different types of organic manures used in the experiment were Farm Yard Manure (FYM), Vermicompost and Enriched Compost alone or in combination with microbial consortia. The details of the treatment combinations are T1: FYM 10 t/ha, T2: FYM 5.0 t/ha, T3: FYM2.5 t/ha + Microbial Consortia, T4: Vermicompost 5.0 t/ha, T5: Vermicompost 2.5 t/ha, T6: Vermicompost 2.0 t/ha + Microbial Consortia, T7: Enriched Compost 2.0 t/ha, T8: Untreated Control.

* 1. **Soil sampling and analysis**

It was found that the soil of the experimental plot was acidic in nature. Further to determine the fertility status of the soil, representative soil samples were collected from seven different points distributed randomly in the field up to a depth of 25 cm and were composited together to carry out the physical and chemical analysis, the results of which are displayed in the Table 1.

**Table 1. Physical and chemical analysis of initial soil sample**

|  |  |  |
| --- | --- | --- |
| Particulars | Values | Methods followed |
| Soil texture | Sandy loam | Feel method |
| pH (1:2.5) at 19°C ATC | 5.38 | pH meter with Glass Electrode Method **(Jackson, 1973)** |
| Organic Carbon (%) | 0.38 | Wet Digestion Method **(Walkley, 1947)** |
| Available Nitrogen (kg/ha) | 195.10 | Modified Kjeldahl Method **(Jackson, 1973)** |
| Available Phosphorous (kg/ha) | 13.58 | Bray’s Method **(Jackson, 1973)** |
| Available Potassium (kg/ha) | 239.21 | Flame Photometric Method **(Jackson, 1973)** |

* 1. **Organic manure preparation**

Farm Yard Manure (FYM) is a type of bulky organic manure formed by the decomposition of wastes collected from the farm yard which were then allowed to decompose for an average of six months before they were ready to be applied in the field. The NPK content of prepared FYM as analysed was found to be 0.48%, 0.32% and 0.52% respectively. Vermicompost was collected from the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat. The nutrient content of vermicompost was found to be 1.67% nitrogen, 0.88% phosphorous and 1.86% potassium along with other minerals, enzymes and hormones. Enriched compost was prepared by adding 170 g of Rock Phosphate and 15 g of Microbial Consortia to the farm compost thus enriching it. The microbial consortia applied in this experiment included strains of microbes such as *Azospirillum*, *Azotobacter* and *Rhizobium*.

* 1. **Experimental Details**

The experiment was conducted in the field consisting of 8 treatment combinations with 3 replication of each treatment laid out in a randomised block design. The experimental area was ploughed with the help of a tractor drawn disc plough and brought to a suitable fine tilth. It was then levelled and all other crop residues and weeds were removed manually. Once the land was completely free of stubbles, it was further divided into twenty-four smaller sub-plots having a dimension of 3.0 m × 2.4 m. The seeds of the selected variety were soaked in water overnight, dried in shade and sown in line in the field directly at a spacing of 50 cm × 40 cm. Organic fertilizers viz., FYM, Vermicompost and Enriched compost were applied in the field alone or in combination with Microbial consortia as per the treatment requirements. All the fertilizers as mentioned were applied as basal doses after the final land preparation during the month of June. FYM was applied at the rate of 10 t/ha and 5 t/ha and again 2.5 t/ha in combination with microbial consortia. Similarly, Vermicompost was applied at the rate of 5 t/ha and 2.5 t/ha and again in combination with microbial consortia at the rate of 2 t/ha. For 1 quintal of each of Vermicompost and FYM, 1.5 kg of Microbial Consortia was mixed. Finally, Enriched compost was applied at the rate of 2 t/ha.

* 1. **Sampling techniques and Data Collection**

Five plants were selected from each plot randomly and tagged so as to collect all the necessary observations relating to the tender fruit production parameters such as plant height, leaves per plant, leaf area, days to 50% flowering and fruit harvest, stem girth, plant fresh and dry weight, fruits per plant, fruit weight and volume, fruit yield per plant, total fruit yield, and harvest latitude. Finally, the economics of production was studied by calculating the cost of cultivation and gross return of the produce. All the fixed and variable costs during the entire cropping period was considered to compute the total cost of production per hectare.

* 1. **Statistical analysis**

An average of all the recorded data was taken and were subjected to statistical analysis. Fisher’s method of Statistical Analysis of Variance in Randomized Block Design (RBD) as described by Panse and Sukhatme was used to analyze the experimental data obtained from various observations collected during the cropping period (Panse *et al*., 1967). The ‘F’ value was determined so as to find the significance or non-significance of variance due to various treatment combinations.

1. **RESULTS AND DISCUSSION**
	1. **The impact of different organic manures on plant growth parameters**

The height of the plant was recorded at three different stages of the crop *viz*., 30, 45 and 60 days after sowing (Table 2). At all these three stages of growth, the plant height was found to be highest under treatment T6 (Vermicompost 2 t/ha + Microbial Consortia) which was 47.35 cm, 80.87 cm, 93.67 cm at 30, 45 and 60 days after sowing respectively. However, the minimum plant height was recorded under treatment T8 (Untreated Control). The number of leaves per plant under various treatment was also recorded (Table 2). It was found that at 30 days after sowing the number of leaves was recorded to be highest (12.61) when the plants were treated with Vermicompost 2 t/ha + Microbial Consortia (T6) whereas the lowest number of leaves per plant were recorded under treatment T3 (FYM 2.5 t/ha + Microbial Consortia). But it was found that the number of leaves per plant at 45 and 60 days after sowing was highest under treatment T7 (Enriched Compost 2 t/ha) which was 17.02 and 22.82 respectively and lowest under treatment T8 (Untreated Control). Similarly, the leaf area (Table 2) was recorded to be maximum under T4 (Vermicompost 5 t/ha) which was 45.13 cm2 at 30 days after sowing whereas at 45 and 60 days after sowing, it was found to be maximum i.e., 56.11 cm2 and 62.28 cm2 respectively when Enriched Compost 2 t/ha (T7) was applied to the plants. However, all the three crop stages showed minimum leaf area under treatment T8 (Untreated Control). The stem girth (Table 3) was also recorded which was found to be highest (13.82 mm) when the plants were treated with Vermicompost 5 t/ha (T4) at 30 days after sowing. At 45 and 60 days after sowing, the stem girth was recorded maximum under treatment T7 (Enriched Compost 2 t/ha) which was 16.12 mm and 19.57 mm respectively. All the three crop stages recorded minimum stem girth under treatment T8 (Untreated Control). The effect of different organic manures on plant fresh and dry weight were also recorded (Table 3). It was found that at 30 days after sowing the plants attained maximum fresh and dry weight (9.09 g and 2.18 g respectively) under treatment T6 (Vermicompost 2 t/ha + Microbial Consortia) and T7 (Enriched Compost 2 t/ha) respectively. At 45 days after sowing, the plant fresh and dry weight was found to be highest (15.49 g and 6.83 g respectively) under treatment T7 (Enriched Compost 2 t/ha). Whereas at 60 days after sowing, the plant recorded maximum fresh weight (26.05 g) under treatment T7 (Enriched Compost 2 t/ha) whereas the maximum dry weight (8.96 g) was recorded under two treatment conditions T1 (FYM 10t/ha) and T6 (Vermicompost 2 t/ha + Microbial Consortia). The plants recorded both minimum fresh and dry weight under treatment T8 (Untreated Control) at all stages of its growth.

**Table 2**. **Effect of organic manures on plant height, number of leaves per plant and leaf area at 30, 45 and 60 days after sowing**

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments | Plant height (cm) | Number of leaves per plant | Leaf area (cm2) |
| 30 \*DAS | 45 DAS | 60 DAS | 30 DAS | 45 DAS | 60 DAS | 30 DAS | 45 DAS | 60 DAS |
| T1 | 46.42 | 66.42 | 82.14 | 10.40 | 14.41 | 18.07 | 42.14 | 48.73 | 50.64 |
| T2 | 44.32 | 55.42 | 72.45 | 8.64 | 13.57 | 16.25 | 38.91 | 41.61 | 48.99 |
| T3 | 46.08 | 61.15 | 81.57 | 6.83 | 13.79 | 17.67 | 40.96 | 40.27 | 54.83 |
| T4 | 46.90 | 70.38 | 90.51 | 10.06 | 17.00 | 20.92 | 45.13 | 50.37 | 55.92 |
| T5 | 45.67 | 60.92 | 80.22 | 11.52 | 14.41 | 18.95 | 33.02 | 41.58 | 54.47 |
| T6 | 47.35 | 80.87 | 93.67 | 12.61 | 16.62 | 20.16 | 41.97 | 53.95 | 60.19 |
| T7 | 46.69 | 75.79 | 90.28 | 12.42 | 17.02 | 22.82 | 43.91 | 56.11 | 62.58 |
| T8 | 28.73 | 55.09 | 66.87 | 10.18 | 13.47 | 15.46 | 26.39 | 33.77 | 40.15 |
| SEd (±) | 4.09 | 3.79 | 3.89 | 1.16 | 1.85 | 1.66 | 1.73 | 2.29 | 2.75 |
| CD (5%) | 8.77 | 8.13 | 8.35 | 2.50 | 3.98 | 3.56 | 3.72 | 4.90 | 5.91 |

*\*DAS: Days after sowing*

**Table 3. Effect of different organic manures on stem girth and plant fresh and dry weight as recorded at 30, 45 and 60 days after sowing**

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments | Stem girth (mm) | Plant fresh weight (g) | Plant dry weight (g) |
| 30 DAS | 45 DAS | 60 DAS | 30 DAS | 45 DAS | 60 DAS | 30 DAS | 45 DAS | 60 DAS |
| T1 | 12.03 | 14.41 | 17.79 | 7.01 | 10.13 | 18.35 | 2.00 | 5.45 | 8.96 |
| T2 | 11.07 | 13.15 | 16.57 | 5.57 | 10.00 | 16.02 | 1.72 | 4.22 | 6.13 |
| T3 | 11.62 | 14.64 | 18.79 | 5.54 | 12.55 | 19.00 | 1.68 | 5.46 | 7.05 |
| T4 | 13.82 | 14.23 | 19.01 | 8.64 | 13.00 | 20.15 | 2.17 | 5.66 | 8.16 |
| T5 | 12.18 | 13.82 | 18.24 | 7.67 | 12.46 | 18.01 | 2.06 | 4.90 | 7.14 |
| T6 | 12.69 | 15.07 | 19.00 | 9.09 | 14.00 | 24.01 | 2.02 | 6.56 | 8.96 |
| T7 | 13.48 | 16.12 | 19.57 | 8.33 | 15.49 | 26.05 | 2.18 | 6.83 | 8.75 |
| T8 | 11.77 | 12.28 | 14.35 | 5.06 | 9.00 | 14.46 | 1.34 | 3.89 | 5.89 |
| SEd (±) | 0.39 | 0.41 | 0.74 | 0.26 | 0.62 | 1.27 | 0.37 | 0.40 | 0.86 |
| CD (5%) | 0.83 | 0.89 | 1.58 | 0.56 | 1.34 | 2.71 | 0.78 | 0.87 | 1.84 |

* 1. **The impact of different organic manures on green fruit and fruit yield parameters**

The different treatment combinations had significant effect on the green fruit quality and total fruit yield of the plants. The number of green fruits per plant was recorded to be highest (13.90) under treatment T7 (Enriched Compost 2 t/ha). Similarly, the fruit weight and fruit volume were also found to be highest in the plants treated with Enriched Compost 2 t/ha (T7) which was 14.60 g and 18.03 cc respectively. The fruit yield per plant and total fruit yield were also recorded and it was found that plants under treatment T7 (Enriched Compost 2 t/ha) attained the maximum fruit yield per plant which was 202.93 g and maximum total fruit yield which was 95.74 q/ha. However, all these parameters were found to be minimum under plants treated with T8 (Untreated control). The variation in all the fruit and fruit yield parameters under each treatment per replication are presented in Table 4.

**Table 4.** Effect of different organic manures on green fruit and fruit yield parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Treatments | Number of fruits per plant | Fruit length (cm)  | Fruit weight (g)  | Fruit volume (cc) | Fruit yield per plant (g) | Total fruit yield (q/ha)  |
| T1 | 11.13 | 13.07 | 14.55 | 15.33 | 161.88 | 76.52 |
| T2 | 9.10 | 12.33 | 13.56 | 14.02 | 123.23 | 58.17 |
| T3 | 10.57 | 13.10 | 13.41 | 16.25 | 141.79 | 68.95 |
| T4 | 13.23 | 13.25 | 13.94 | 16.23 | 184.48 | 85.85 |
| T5 | 12.67 | 12.79 | 13.29 | 15.57 | 168.64 | 76.10 |
| T6 | 13.00 | 12.85 | 14.35 | 17.75 | 186.62 | 92.20 |
| T7 | 13.90 | 14.21 | 14.60 | 18.03 | 202.93 | 95.74 |
| T8 | 8.00 | 8.38 | 8.69 | 9.33 | 69.22 | 29.50 |
| SEd (±) | 0.95 | 0.53 | 0.49 | 0.84 | 13.79 | 7.22 |
| CD (5%) | 2.03 | 1.13 | 1.04 | 1.79 | 29.58 | 15.48 |

   

D

C

B

A

**Fig. 1.** **The differences in the length of the pod under various organic treatments (A: Enriched Compost 2.0 t/ha; B: Vermicompost 5.0 t/ha; C: FYM2.5 t/ha + Microbial Consortia; D: Untreated Control)**

It was observed from the experimental analysis that application of different organic manures in combination with microbial consortia had significantly increased the growth characteristics and fruit yield in Okra. The growth parameter such as plant height was found to increase considerably at all three stages of the crop *i.e*., at 30, 45 and 60 days after sowing on application of Vermicompost 2 t/ha + Microbial Consortia (T6) followed by Enriched Compost 2 t/ha (T7) and Vermicompost 5 t/ha (T4) whereas the Untreated Control (T8) recorded the lowest plant height. This clearly implied that the application of organic manures had a positive impact on plant height in comparison to the control treatment. These results are in consonant with the findings in Brinjal (Babu and Panicker, 2010) and in Turmeric (Kadam and Kamble, 2020).

The number of leaves per plant was found to be maximum on application of Vermicompost 2 t/ha + Microbial Consortia (T6) followed by Enriched Compost 2 t/ha (T7) at 30 days after sowing whereas at 45 and 60 days after sowing highest number of leaves were observed when Enriched Compost 2 t/ha (T7) was applied followed by Vermicompost 2 t/ha + Microbial Consortia (T6). Similar results were also reported by in Okra (Balliah and Muthulakshmi, 2017), in Brinjal (Babu and Panicker, 2010) and in Sweet corn (Pangaribuan *et al*., 2017). This might be due to the fact that organic manures may it be Compost or Vermicompost when enriched with beneficial micro-organism provided essential micronutrients such as Zinc, Copper, Iron, Manganese etc., to the crops which in turn improved the biochemical synthesis of important plant hormones such as Auxin and Gibberellic acid and pigments such as Chlorophyll etc., which led to higher carbohydrate production and improved plant growth (Balliah and Muthulakshmi, 2017) thus increasing the number of leaves per plant.

The leaf area and stem girth at 30 days after sowing was found to be maximum when Vermicompost 5 t/ha (T4) was applied followed by Enriched Compost 2 t/ha (T7). However, at 45 and 60 days after sowing, application of Enriched Compost 2 t/ha (T7) followed by Vermicompost 2 t/ha + Microbial Consortia (T6) and Vermicompost 5 t/ha (T4) recorded maximum leaf area and stem girth respectively in the crops. Although, in both the parameters the prominent treatments were at par with the best treatment. It was also found that the minimum leaf area and stem girth was registered in Untreated Control (T8) which indicated that application of organic manures improved the physical attributes of the crop in comparison to the control treatment. These results were also in line with substantial findings in Okra (Balliah and Muthulakshmi, 2017; Ansari and Sukhraj, 2010). The increase in leaf area and stem girth can be attributed to the fact that Enriched compost and Vermicompost contain all the major nutrients required for enhancing shoot growth and accumulation of biomass in the crop plants and thus facilitating inherent synthesis of plant growth hormones like IAA, GA, Cytokinins *etc*. (Gajbhiye *et al*., 2003). Moreover, the presence of beneficial micro-organisms in Enriched compost also piloted the increase in mobilization of certain soil bound nutrients and improved the soil physical conditions which in turn led to deeper penetration of roots and higher absorption of nutrients leading to higher stem girth and leaf area expansion. This validation was also supported in other crops such as Guava (Trivedi *et al*., 2014) and Banana (Balerao *et al*., 2009).

The application of Vermicompost 2 t/ha + Microbial Consortia (T6) resulted in the maximum fresh weight of plants at 30 days after sowing followed by application of Vermicompost 5 t/ha (T4). However, at 45 and 60 days after sowing, the highest plant fresh weight was observed in treatment with Enriched Compost 2 t/ha (T7) followed by treatment with Vermicompost 2 t/ha + Microbial Consortia (T6) whereas the minimum fresh weight of plants in all the stages of growth was obtained under Untreated Control (T8). Therefore, the increase in fresh weight of the plants on application of such organic manures might be correlated with the increase in height, number of leaves, leaf area and stem girth of the plant as discussed earlier. The findings of the analysis were in conformity with results found in Chickpea (Ditta *et al*., 2018). The dry weight of the plant at 30 and 45 days after sowing was also found to maximum when Enriched Compost 2 t/ha (T7) was applied followed by application of Vermicompost 5 t/ha (T4) and Vermicompost 2 t/ha + Microbial Consortia (T6) respectively. At 60 days after sowing both FYM 10 t/ha (T1) and Vermicompost 2 t/ha + Microbial Consortia (T6) showed maximum plant dry weight followed by Enriched Compost 2 t/ha (T7). Similar findings were observed by in 2004 in Rice (Kavitha *et al*., 2004). The trend followed in dry weight of plants might be due to the fact that application of organic manures such as Vermicompost and Enriched compost as basal dose during crop growth improved the porosity and water holding capacity of the soil facilitating higher root growth which in turn enhanced the nutrient uptake from the soil and subsequently increased the biomass of the plant resulting in higher plant dry weight.

The number of fruits per plant, fruit weight, fruit volume, fruit yield per plant and total fruit yield were found to be highest when the plants were supplied with Enriched Compost @ 2 t/ha (T7). The harvest latitude was found to be longest under Vermicompost 2 t/ha + Microbial Consortia (T6), followed by Enriched Compost 2 t/ha (T7) which, however, was statistically at par with T6. Similar trend was also observed in all the mentioned fruit parameters of okra (Abha *et al*., 2019; Kumar *et al*., 2021). The notable increase in fruit yield and quality on application of Enriched compost can be ascribed to the fact that decomposition of the organic manure released heat and carbon dioxide facilitating the growth of micro-organisms by creating a favourable environment around the rhizosphere which in turn increased the mobilization of soil nutrients and thus enhanced the nutrient uptake of plants producing higher fruit yield (Jain *et al*., 2017). It was also reported by Lieten (1996) in Strawberry that increase in carbon dioxide stimulated the increase in fruit weight and volume where compost decomposition can again be held accountable (Lieten,1996). Furthermore, *Azospirillum* was also found to secrete plant hormones such as Auxin and Gibberellin which enhanced the number of fruits per plant, fruit weight and fruit volume.

1. **CONCLUSION**

It can be concluded from the experimental findings that application of 2 t/ha of Enriched Compost (T7) produced the maximum plant growth and fruit yield of okra but was not statistically superior to Vermicompost 2 t/ha + microbial Consortia (T6). The maximum plant height was recorded under treatment T6 (Vermicompost 2 t/ha + Consortia) whereas all other growth parameters such as number of leaves per plant, leaf area, stem girth, plant fresh weight and plant dry weight showed maximum result under treatment T7 (Enriched Compost 2 t/ha) at 60 days after sowing. The number of fruits per plant, fruit weight and fruit volume were found to be maximum under treatment T7 (Enriched Compost 2 t/ha). The fruit yield per plant and total fruit yield were also found to be the highest when the crop was treated with T7 (Enriched Compost 2 t/ha).However, thecomputation of production economics revealed that Vermicompost 2 t/ha + microbial Consortia (T6) to be the most remunerative option for tender fruit production in Okra.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

1. **REFERENCES**
2. Nelson, A.R.L.E., Ravichandran, K. & Antony, U. (2019). The impact of the Green Revolution on indigenous crops of India. *J. Ethn. Food* 6, **8**. https://doi.org/10.1186/s42779-019-0011-9
3. Haribhushan, A., Telem, R.S. & Wani, S.H. (2017). Integrated Nutrient Management for Sustainable Maize (*Zea mays* L.) Production in Acidic Soil of Senapati District, Manipur, India.*Int.J.Curr.Microbiol.App.Sci.* 6(**7**):690-695. doi: <https://doi.org/10.20546/ijcmas.2017.607.085>
4. Bhusan, A., Sharma, V., Gupta, V., Sharma, R., Gupta, S. & Kumar, D (2019). Organic seed production in Okra var. Seli special in mid hills of North-Western Himalayan region. *Eco. Env. & Cons*. 25 (**1**): 2019; pp. (424-427). ISSN 0971–765X.
5. Raj, A.K. & Kumar, V.L.G. (1998). Effect of Organic Manures and *Azospirillum* inoculation on Yield and Quality of Okra (*Abelmoschus Esculentus* (L.) Moench). *Veg. Sci*. 28(**2**): 179-181 (2001).
6. FiBL Survey. (2021). The Research Institute of Organic Agriculture, Switzerland. https://www.fibl.org
7. NPOP. (2022). National Programme for Organic Production. https://apeda.gov.in.
8. APEDA. (2020). Agricultural and Processed Food Products Export Development Authority, Government of India. <https://apeda.gov.in/apedawebsite>.
9. Graham, J. O., Agbenorhevi, J. K. & Kpodo, F. M. (2017). Total Phenol Content and Antioxidant Activity of Okra Seeds from Different Genotypes. *American J. of Food and Nutrition*, *5*(**3**), 90-94.
10. Drost, D. & Ernst, T. (2012). Okra in the Garden.
11. Gemede, H. F., Ratta, N., Haki, G. D., Woldegiorgis, A. Z. & Beyene, F. (2015). Nutritional quality and health benefits of okra (*Abelmoschus esculentus*): A review. *J Food Process Technol*, *6*(458), 2.
12. Hamon, S. & Koechlin, J. (1991). The reproductive biology of okra. 2. Self-fertilization kinetics in the cultivated okra (*Abelmoschus esculentus*), and consequences for breeding. *Euphytica*, *53*(1), 49–55. <https://doi.org/10.1007/BF00032032>
13. Nwokocha, G. C. (2024). Evaluation of Iodine and Goitrogens in Selected Vegetables from Owerri Imo State in Nigeria. *Asian J. of Biochem., Genetics and Mol. Bio*. https://doi.org/10.9734/ajbgmb/2024/v16i6385
14. Dantas, T. L., Buriti, F. C. A. & Florentino, E. R. (2021). Okra *(Abelmoschus esculentus L.)* as a Potential Functional Food Source of Mucilage and Bioactive Compounds with Technological Applications and Health Benefits. *10*(**8**), 1683. <https://doi.org/10.3390/PLANTS10081683>
15. Yadav, R. K., Ghasolia, R. P. & Yadav, R. K. (2020). Studies of Physiological Parameters on the Growth of Sclerotio Formation of Rhizoctonia solani with Okra (*Abelmoschus esculentus* L. Moench). *Int.J.Curr.Microbiol.App.Sci.*, *9*(**5**),524–531. https://doi.org/10.20546/IJCMAS.2020.905.059
16. Qi, Y. (2017). *Okra coffee and preparation method thereof*.
17. Sharma, B. R. (1993). *Okra: Abelmoschus spp.* (pp. 751–769). *Pergamon*. https://doi.org/10.1016/B978-0-08-040826-2.50056-4
18. NHB. (2022). National Horticulture Board. https://www.nhb.gov.in.
19. Miglani, A., Gandhi, N., Singh, N. & Kaur, J (2017). Influence of Different Organic Manures on Growth and Yield of Okra. *Int J. Adv Res in Sc and Eng*. Vol 06 (**01**), 2017. ISSN: 2319-8354.
20. Adebayo, A. G., Shokalu, A. O. & Akintoye, H. A (2010). Effect of Compost Mixes on Vegetative Development and Fruit Yield of Okra (*Abelmoscus esculentus*). IOSR *Jrl of Ag and Vet Sc* (IOSR-JAVS). Volume 3, Issue 1 (May. - Jun. 2013), PP 42-49. e-ISSN: 2319-2380, p-ISSN: 2319-2372).
21. Nejatzadeh, F. (2024). “Effect of Vermicompost and Nitrogen Fertilizer on the Growth and Production of Aloe Vera”. *Int. J. Plant Soil Sci.*  36 (**4**):337-45. https://doi.org/10.9734/ijpss/2024/v36i44486
22. Jackson, M.L (1973). Soil chemical analysis. Practice Hall of Indian Pvt. Ltd. New Delhi.
23. Walkley, A. (1947). A critical examination of a rapid method for determining organic carbon in soils – Effect of variations in digestion conditions and of inorganic soil constituents. *Soil Sci*. **63**(4): 251-264.
24. Panse, V.C. & Sukhatme, P.V. (1967). Statistical methods for Agricultural workers. *III Rev. Ed.* ICAR, New Delhi.
25. Babu, N.S. & Panicker, S. (2010). The effect of Vermicompost with different microbial fertilizers on the growth and yield of brinjal. *Baselius Researcher* ISSN 0975-8658 VOL 11 No. 2.
26. Kadam, J.H. & Kamble, B.M (2020). Effect of organic manures on growth, yield and quality of turmeric (*Curcuma longa* L.). *J. of Appl. and Nat. Sci*. 12(**2**):91-97 DOI:10.31018/jans.vi.2249 License · CC BY-NC 4.0.
27. Balliah, T.N. & Muthulakshmi, P (2017). Effect of microbially enriched vermicompost on the growth and biochemical characteristics of okra (*Abelmoschus esculentus* L.). *Adv. plants agric. res.* 6. 10.15406/apar.2017.06.00228.
28. Pangaribuan, D. H., Nurmauli, N. & Sengadji, S.F (2017). The effect of enriched compost and nitrogen fertilizer on the growth and yield of sweet corn (*Zea mays* L.). *Acta Horticulturae*. DOI: 10.17660/ActaHortic.2017.1152.52.
29. Ansari, A.A. & Sukhraj, K (2010). Effect Of Vermiwash and Vermicompost on Soil parameters and productivity of Okra in Guyana. *Pak J. Agric. Res*. Vol 23 No. 3-4, 2010.
30. Gajbhiye, R. P., Sharma, R. R. & Tewari, R. N (2003). Effect of bio-fertilizers on growth and yield parameters of tomato. *Indian J. Hortic*., **60**(4): 368-371
31. Trivedi, Y. V., Patel, N. L., Ahlawat, T. R., Gaikwad, S. S. & Bhalerao, P. P. (2014). Impact of organic manures and inorganic fertilizers on growth, yield, nutrient uptake and soil nutrient status in guava. *Ind. J. of Hort*. 2012; 69:501-06.
32. Balerao, V.P., Patil, N.M., Badgujar, C.D. & Patil, D.R (2009). Studies on integrated nutrient management for tissue cultured Grand Naine banana. *Indian J. Agril.* 43:107- 12.
33. Ditta, A., Muhammad, J., Imtiaz, M., Mehmood, S., Qian, Z. & Tu, S. (2018). Application of rock phosphate enriched composts increases nodulation, growth and yield of chickpea. *Int. J. of Recycling of Organic Waste in Agril*. 7:33–40 <https://doi.org/10.1007/s40093-017-0187-1>
34. Kavitha, R. & Subramanian, P (2004). Effect of Enriched Municipal Solid Waste Compost Application on Growth, Plant Nutrient Uptake and Yield of Rice. *J. of Agron*. 6(4) DOI:10.3923/ja.2007.586.592
35. Abha, R., Meena, M.L., Singh, R. & Mandal R.K (2019). Effect of various organic manures on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]. *J. of Pharmacognosy and Phytochemistry* 2019; 8(6): 1203-1205. E-ISSN: 2278-4136 P-ISSN: 2349-8234 JPP 2019; 8(6): 1203-1205
36. Kumar, A., Choudhary, A.S., Raj, S., Ghode, N. & Sahu, S (2021). Effect of nutrient management on yield parameters of okra. *Int. J. of Agril. and Plant Sci.* Volume 4, Issue 1, 2022, Page No. 30-34. Online ISSN: 2664-7664, Print ISSN: 2664-7656
37. Jain, N., Mani, A., Kumari, S., Kasera, S. & Bahadur, V. (2017). Influence of INM on yield, quality, shelf life and economics of cultivation of strawberry *(Fragaria x ananassa Duch.) cv.* Sweet Charlie. *Innovative Farming*. **3**(1): 6-10.
38. Lieten, F. (1996). Effect of CO2 enrichment on greenhouse grown strawberry. *III International Strawberry Symposium*. Acta Horticulture 439, Veldhoven, Netherlands. Pp. 587-596