Research Article

Combined Impacts of Compost, Poultry Manure and NPK Fertilizers on Yield of Okra Plant (*Abelmoschus esculentus* L.)

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Abstract | Vegetables produce a great contribution in maintaining the proper diet of human beings. Especially Okara has been gained more importance due to its nutritional value. According to the U.S. Department of Agriculture (USDA) 100 grams of okra contains about 1.93g, 0.19 g, 7.45 g 3.2 g and 1.48 g of protein, fat, carbohydrates, fiber and sugar, respectively. As well as one gram of okra contain 31.3 mg and 299mg of vitamin K and potassium, respectively. Therefore, to examine the effect of different forms of fertilizers (organic and inorganic) on the yield and physiochemical attributes of okra *Abelmoschus esculentus* a field trial was conducted. For this purpose, organic form of fertilizers like kitchen waste, poultry manure and compost were used while the inorganic sources were NPK fertilizer. This experiment was laid out in the field area of soil and water testing laboratory for research, Bahawalpur in growing seasons from July to October of 2017. Treatments were arranged in Two factorial Completely Randomized Design CRBD fashion with three replications and six treatments. Treatments are arranged as control T_1 (Without fertilizer + No Poultry Manure + No compost), T_2 (NPK full dose @ 150 kg ha^{-1}N, 75 kg ha^{-1}P and 60 kg ha^{-1}K), T_3 (full dose of poultry manure (PM) @ 30 ton ha-1), T_4 (50% NPK+50% Poultry Manure i.e. 75 kg ha^{-1}N, 37.5 kg ha^{-1}P and 30 kg ha^{-1}K +15 ton ha^{-1} PM), T_5 (full dose compost @ 30 ton ha^{-1}), T_6 (50% NPK+ 50% compost i.e. 75 kg ha^{-1}N, 37.5 kg ha^{-1}P and 30 kg ha^{-1}K + 15 ton ha^{-1} compost). Plants growth and yield parameters were determined like the total number of leaves per plant, plant height, fruit length, root and shoot dry weight, fresh fruit weight, the total number of fruits per plant, fruit yield and total yield increase. No significant increase was observed in the yield and growth of okra under control and full NPK fertilizer treatment. Application of organic fertilizers like poultry manure and compost as well as its mixture with full NPK considerably increase the growth and total yield attributes of Okra. On the other hand, in contrast to all other treatments, the joint use of 50% NPK+50% PM exhibits the most significant impact on okra growth.

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Introduction

The diet of mankind can be improved by the maximum use of vegetables. Among all vegetables, okra has significant nutritional value and contributes maximum value in fulfilling the proper nutrition in the human diet. Scientifically okra is known as *Abelmoschus esculentus* (L.) Moench and

Hibiscus esculentus, (Anwar et al., 2011), and locally it is called as bhindi in Pakistan, krajiabkheaw in Thailand, okra plant, kacang, ochro, gombo, okoro, quingumbo, kopi arab, and bendi in South East Asia (Kumar et al., 2010). Okra, *Abelmoschus esculentus* (L.) Moench, is also normally called as lady's finger. It belongs to the "Malvaceae" family (Ndunguru and Rajabu, 2004) due to the flowering and edible fruit parts. In Pakistan, okara is cultivated on about 2.2×105 ha area, which gives the yields about 2.9×106 tons of green edible pods (Kashif et al., 2008). Okra is of African origin where it has been cultivated for more than 4000 years but now is also grown in world's different tropical and warm temperature areas, like Greece, Iran, Egypt, India, Japan, southern United States, and Turkey, Philippine (PanagiotisArapitsas, 2008). The 100g of edible portion contains 88.6g water, 8.20g carbohydrate, 2.10g protein, 200mg fat, 1.70g fibers, 84 mg Calcium, 90 mg phosphorous, 1.20mg iron, 47mg ascorbic acid as well as riboflavin, carotenes in considerable quantity is present. (Sorapong Benchasri, 2012).

Moreover, due to the scarcity, high cost and random usage of inorganic fertilizers in the world organic fertilizer achieving the great importance day by day (Adewole and Adeoye, 2008). There is insufficient literature regarding the proper use of organic and inorganic fertilizers to attain a higher crop production of okra (Awe et al., 2006). Additionally, organically fertilized okra is much more suitable than the chemically cultivated counterpart (Taiwo et al., 2002).

Pakistan blessed with natural resources as it is agricultural land and has a great mean for agricultural production. Unfortunately, due to lack of awareness and management, the fertility status is decreasing day by day alarmingly (Anjum et al., 2016). From the last three decades, the demand for food increased and to fulfill this requirement use of organic and inorganic fertilizer is increased (Roy et al., 2006). The adverse effect of chemical fertilizer is more so this practice is more hazardous for soil health and environment (Savci, 2012). Under these circumstances, the soil fertility status and crop production can be increased or sustained by the addition of organic fertilizer in the soil as it is the only alternative for this problem (Ali et al., 2008). Proper maintenance and sustainability of agricultural land is prerequisite and addition of organic sources like poultry manure, and kitchen compost can play a vigorous part in the sustainability of fertility status of soil and crop production (Shahariar et al., 2013). Proper use of organic amendments is an environment-friendly, economical and ergonomically sound practice which has already been established by many researchers (Van der Vossen, 2005).

Therefore, to increase the production of Okra and to meet the demand for food the use of organic amendments as a fertilizer source is getting prime importance day by day.

Materials and Methods

This research work was conducted during the growing seasons from July to October of 2017 at a government form located at a regional agricultural research institute. The research trial was set up in a Randomized Complete Block Design (CRBD) with six various treatments and three repeats of every treatment. There was a total (6 treatments × 3 replications) of 18 plots each having an area of 2 m × 2 m. Seeds of a hybrid variety named as Bahari F-1 were collected from the local market. Seeds were dipped in water and use the floating method to check the viability of seeds. Three to four seeds were dibbled on ridges at the distance of 15 cm plant to plant while row to row distance was 40 cm. Proper thinning was done after 15 days of sowing, and healthy plants were maintained all over the trial area. Irrigation was done after the 10-15 days. All management practices were done as recommended in production technology. The doses of inorganic and organic fertilizers were fixed by standard practices as approved by government Agriculture research department. The nitrogen application was completed in three equal splits while the recommended dose of phosphorous was applied at the time of soil preparation as a basic dose (Table 1). Description of treatments as:

T_1= Control (Without fertilizer + No Poultry Manure + No compost); T_2= NPK full dose @ 150 kg ha^{-1}N, 75 kg ha^{-1}P and 60 kg ha^{-1}K; T_3= Full poultry manure (PM) @ 30 ton ha^{-1}; T_4= 50% NPK+50% Poultry Manure i.e. 75 kg ha^{-1}N, 37.5 kg ha^{-1}P and 30 kg ha^{-1}K +15 ton ha^{-1} PM; T_5= Full dose of compost @ 30 ton ha^{-1} and T_6= 50% NPK+ 50% compost i.e. 75 kg ha^{-1}N, 37.5 kg ha^{-1}P and 30 kg ha^{-1}K + 15 ton ha^{-1} compost.

Data collection

To examine the plant growth data were collected after 15, 30, 45, 60 and 75 days of seedling germination. The edible portion or fruits were harvested in portions.

Table 1: *Physico-chemical properties of soil before experiment.*

pH (1:1)	Electrical conductivity (1:10)	Available-P (mg kg^{-1})	Available-K (mg kg^{-1})	CEC (meq/100g soil)	Total Nitrogen (%)	Organic matter (%)	Soil Texture (Clay loam)		
							Sand	Silt	Clay
8.1	2.1	8.0	155	10.8	0.031	0.83	25	40	35

Table 2: *The impacts of poultry manure, compost and NPK on post-harvest physico-chemical properties of soil.*

Treatments/ ha^{-1}	pH (1:1)	Electrical conductivity (1:10)	Available-P (mg kg^{-1})	Available-K (mg kg^{-1})	CEC (meq/100g soil)	Total Nitrogen (%)	Organic matter (%)
T1 = Control (No fertilizer + No PM + No compost)	8.1	2.1	8.0	155	10.8	0.031	0.83
T2 = Full NPK @ 150 kg ha^{-1} N, 75 kg ha^{-1} P and 60 kg ha^{-1} K	8.1	2.1	8.2	160	11.1	0.031	0.83
T3 = Full poultry manure (PM) @ 30 ton ha^{-1}	8.1	2.3	8.2	155	10.9	0.031	0.86
T4 = 50% NPK+50% PM i.e. 75 kg ha^{-1} N, 37.5 kg ha^{-1} P and 30 kg ha^{-1} K +15 ton ha^{-1} PM,	8.1	2.3	8.6	160	11.1	0.032	0.83
T5 = Full compost @ 30 ton ha^{-1}	8.1	2.4	8.5	156	11.2	0.032	0.88
T6 = 50% NPK+50% compost i.e. 75 kg ha^{-1} N, 37.5 kg ha^{-1} P and 30 kg ha^{-1} K + 15 ton ha^{-1} compost	8.1	2.4	8.6	163	12.1	0.031	0.84

A number of fresh fruits per plant, fruit length, and fruit fresh weight was examined. The data regarding dry plant weights were collected after the final harvest.

Statistical analysis: Two way ANOVA in Randomized Complete Block Design was applied using Statistix 8.1 Software.

Results and Discussion

Combined effect of compost, poultry manure and NPK on soil physic-chemical properties

The results of the study (Table 2) showed no statistically significant impact ($p<0.05$) between various treatments through all the physicochemical properties of soil except organic matter contents of soil which was 0.86% in treatment 3 (@ 30 ton ha^{-1} P.M) and 0.88% in treatment 5 (Full compost @ 30 ton ha^{-1}), respectively as compared to control (0.83%). Similarly, the significant increase in CEC of soil was observed in treatment 5 which was 11.2 meq/100g and 12.1meq/100g in treatment 6, respectively as compared to control where it was 10.8meq/100g.

Growth parameters

Total number of leaves per plant: From the results it was observed that the total No. of leaves per plant was the maximum in combined organic amendment 50% NPK+50% Poultry Manure (T4) during the recorded period i.e. 30, 45, 60 and 75 DAYS (Figure 1) as compare the control treatment (T1) where the total No. of leaves plant^{-1} was minimum. In comparison to the control (T1), the other treatment containing full Application of NPK in (T2) didn't significantly enhance the total number of leaves per plant while at 30 and 45 DAYS the use of full PM (T3) considerably increase total No. of leaves per plant but not at 60 and 75 DAYS. Besides to 50 % compost with 50 % NPK (T6), similar results were observed. At 30, 45, 60 and 75th-day maximum increase in some leaves per plant with 50 % NPK+ 50% PM (T_4) was observed as compared to control treatment (T_1) and a full dose of NPK fertilizer (T_2). On the other hand, except control (T1) and T2 all other remaining application rate T_3 (full PM), T_4 (50% NPK+ 50% PM), T_5 (full compost)) and T_6 (50 % NPK+ 50% compost) were statistically found alike with each other at 15, 30, 45 and 60th days.

Plant height: In 15 Days, 30 Days, 45 Days, 60 Days, and 75th days of plants the variation on plant height occurred from 20.67 cm (T1) to 25.33 cm (T3), 66.22 cm (T1) to 87.2 cm (T3), 99.99 cm (T1) to 135 cm (T4), 149 (T1) to 187.22 cm (T3) and 181.78 cm to (T1) to 226 cm (T4) respectively (Figure 2). From the results it was revealed that the minimum plant growth was constantly observed in control treatment (T1) while the maximum was obtained with the treatment

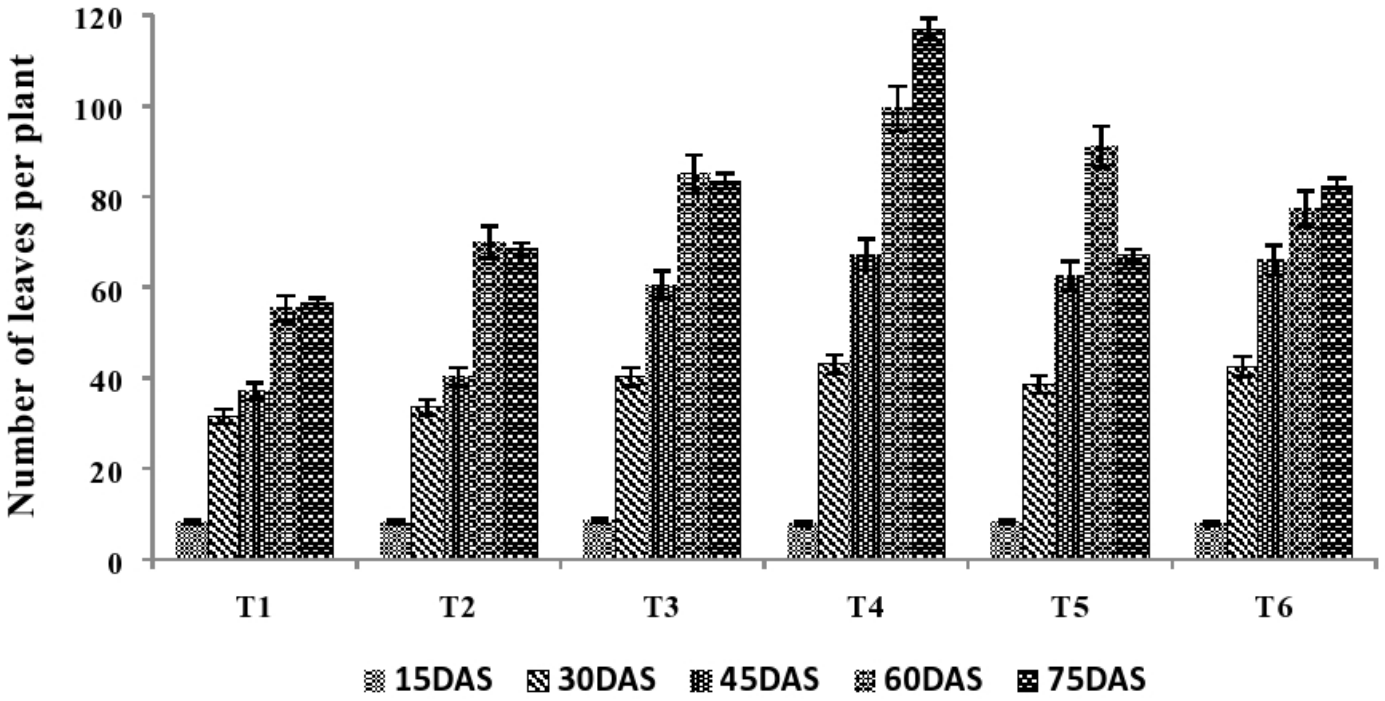

Figure 1: *Combined effect of compost, poultry manure and NPK on total number of leaves per plant.*

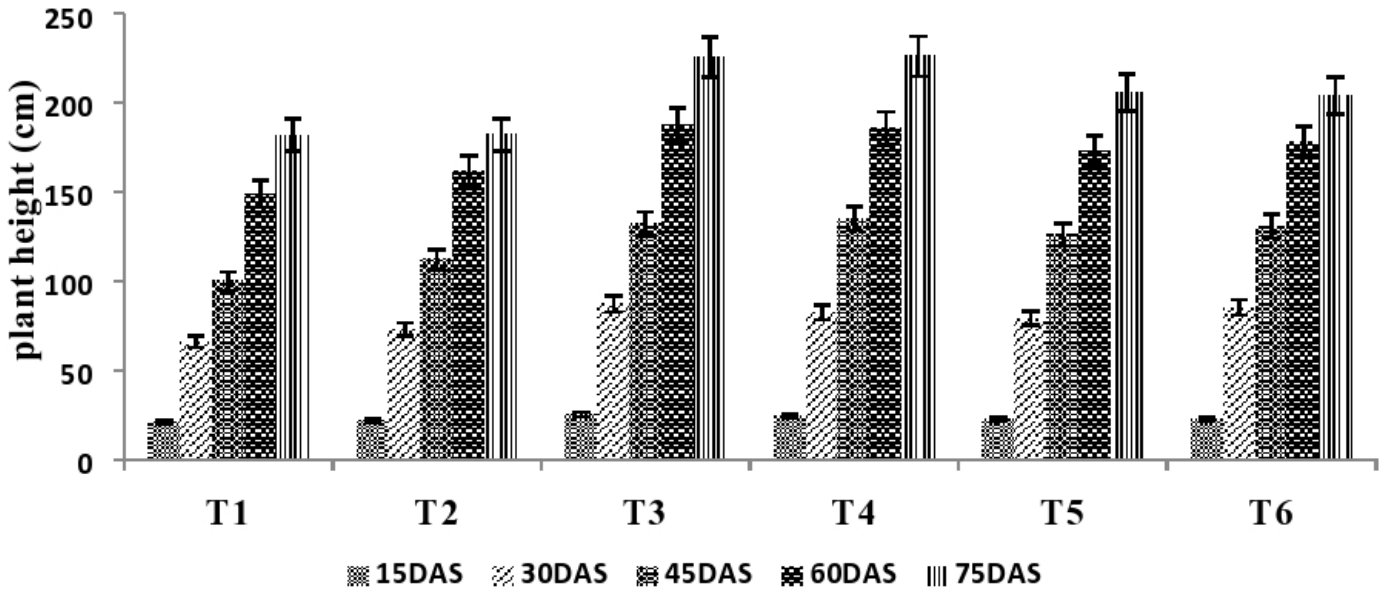

Figure 2: *Combined effect of compost, poultry manure and NPK on plant height.*

containing full dose of the poultry manure (T3) at 15, 30 and 60 Days and at 45 and 75 Days the maximum growth was observed at treatment (T4) containing 50% NPK+50% PM. The present study also revealed that during the period of 15, 30, 45, 60 and 75 there is no significant variation in the height of plant in no fertilizer (control) and full NPK fertilizer although the addition of poultry manure in T3 significant variation on plant height was observed. In treatment with full PM, the plant height values are 25.33 cm at 15 Days, 87.22 cm at 30 Days, 132.11 cm at 45 Days, 185.78 cm at 60 Days and 226 cm at 75 Days. At the treatment 4 with 50% NPK + 50% PM significantly higher values had been observed then control. In treatment 5 with full compost application considerable increase was observed at 30 and 45 Days but not at 15, 60 and 75 Days.

Shoot dry weight: The shoot dry weight of plants was observed from 63.81 to 137.74g/ plant (Figure 3). The lowest shoot dry weight was observed at treatment no. 2 where a recommended dose of chemical fertilizer NPK was applied while the highest value 137.74g was observed at the treatment no. 4 where 50% NPK dose

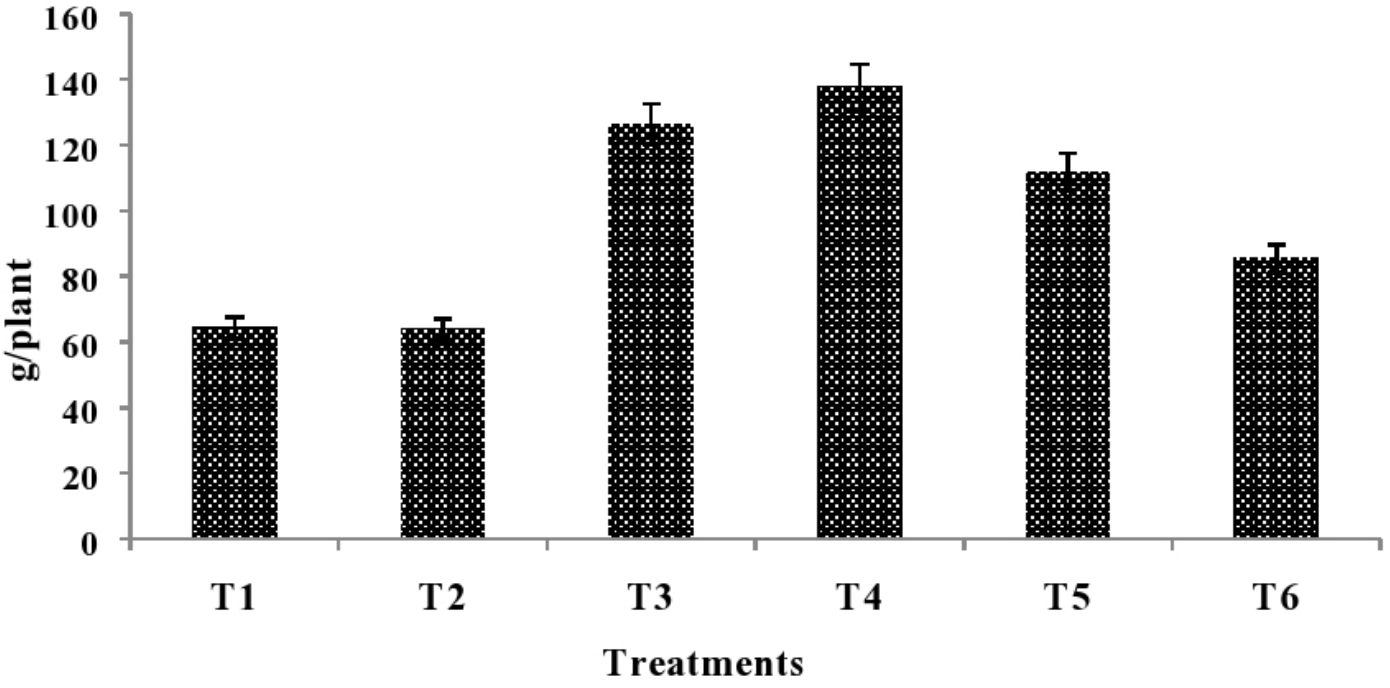

Figure 3: *Effect of compost, poultry manure and NPK on shoot dry weight.*

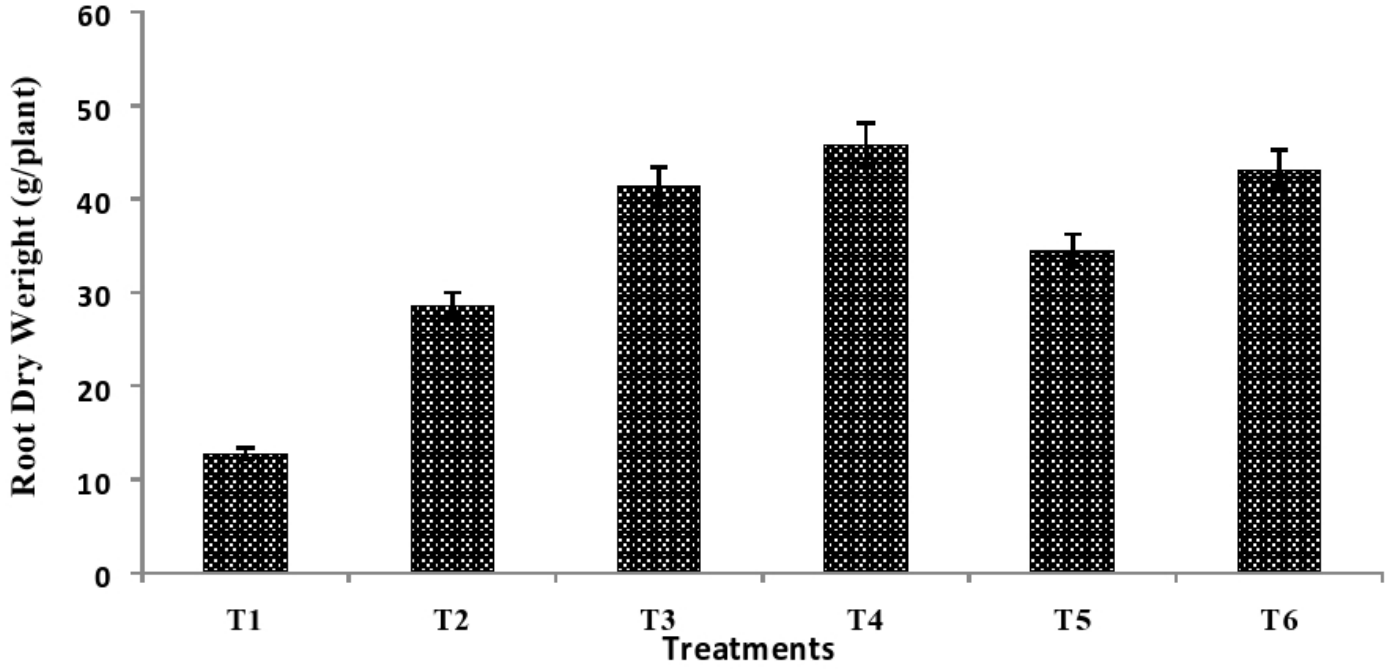

Figure 4: *Effect of compost, poultry manure and NPK on root dry weight.*

and 50% Compost was added. Organic fertilizer gave the best result as compare to the chemical fertilizer. From the results, it was evident that treatment no. 3 (full PM) and treatment no. 4 (50% NPK+50%PM) gave significantly best results in contrast to the control and treatment no. 2 (recommended NPK) where statistically no significant variation was observed in T3 and T4. While statically T1 (control) was similar to T2 (NPK), T_5 (full dose of compost) and T_6 (@ 50%NPK+ 50% dose of compost).

Root dry weight: Plants oven dry root weight was recorded, and data showed maximum Root dry weight (45.79g) in T4 while the minimum (12.72g) in control T1 (Figure 4). Treatments comprising on organic and inorganic fertilizers gave the higher results as compared to the control treatment where no fertilizer was applied. Combination of organic fertilizer with inorganic fertilizer in T4 and T6 give significantly higher results in contrast to the NPK alone.

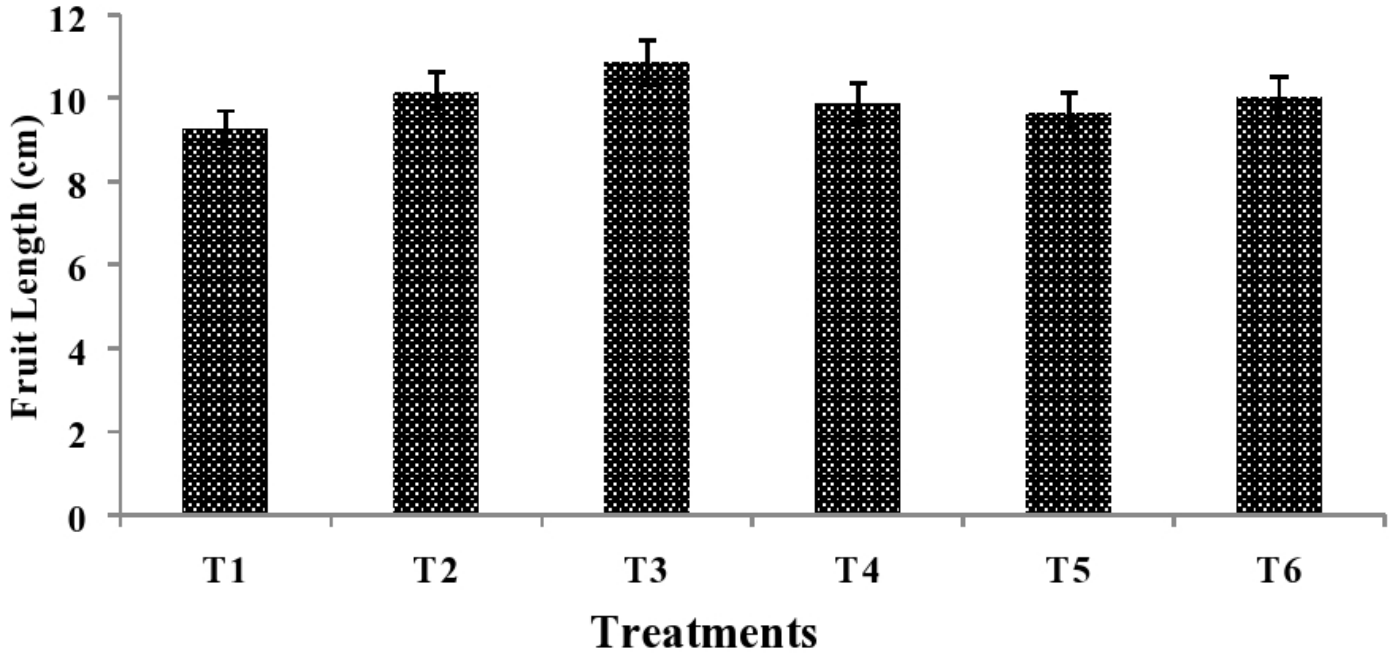

Figure 5: *Effect of compost, poultry manure and NPK on fruit length.*

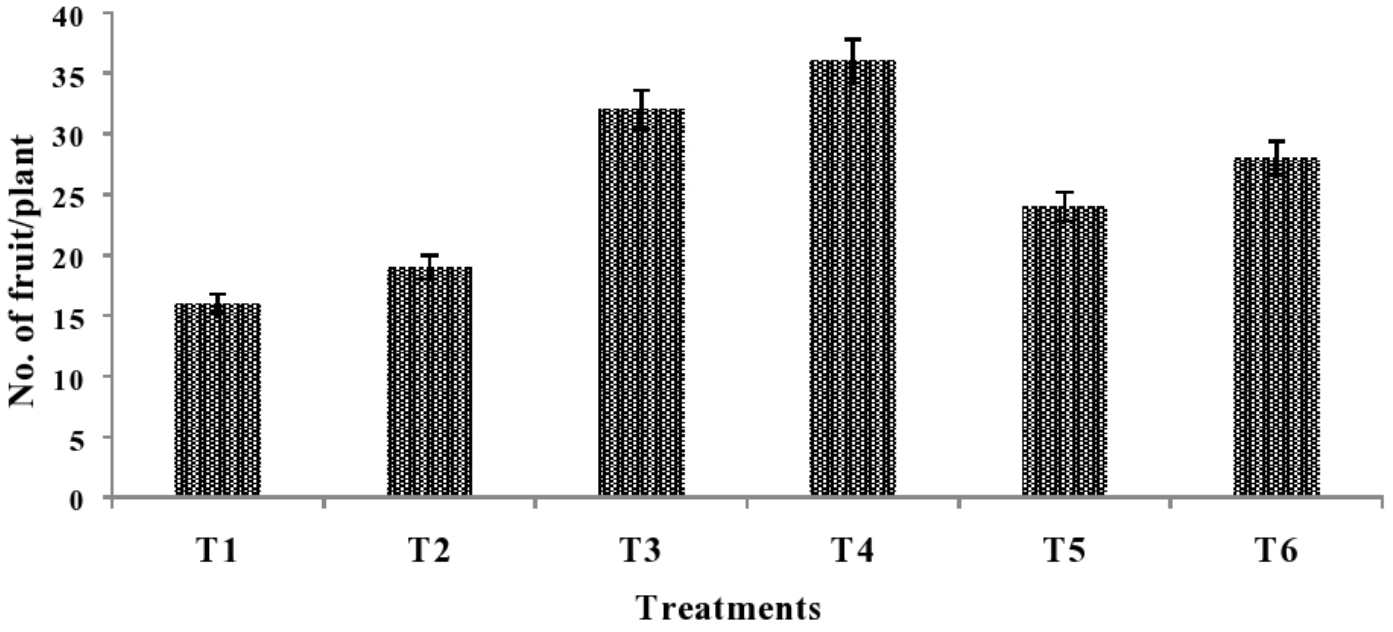

Figure 6: *Effect of compost, poultry manure and NPK on number of fruit per plant.*

Fruit length: In all treatments, the flower emerging started after four weeks of sowing and fruit development started at about six weeks in all plots this trend sustained up to end of experiment. Fruit length of okra was in the range of 9.23cm to 10.84 cm in all the treatments (Figure 5). The lowest length of fruit was in control (T1). Statistically no significant increase in fruit length and fresh weight of fruit was recorded through the application of kitchen compost and poultry manure as compared to the control treatment

A total number of fruits per plant: Among all yield parameters, the total numbers of fruits per plant were found to be the most important factor contributing to the yield of okra. A total number of fruits per plant varies from 16 to 36 (Figure 6). The minimum numbers of fruit per plants were obtained with control treatment T1 while the highest yield was obtained from T4 comprising on 50% NPK and 50% compost. Statically there is no significant difference among T3 and T4 while there is significantly higher yield than control treatment. Statically all treatments are similar to each other without any discrimination of treatments dose.

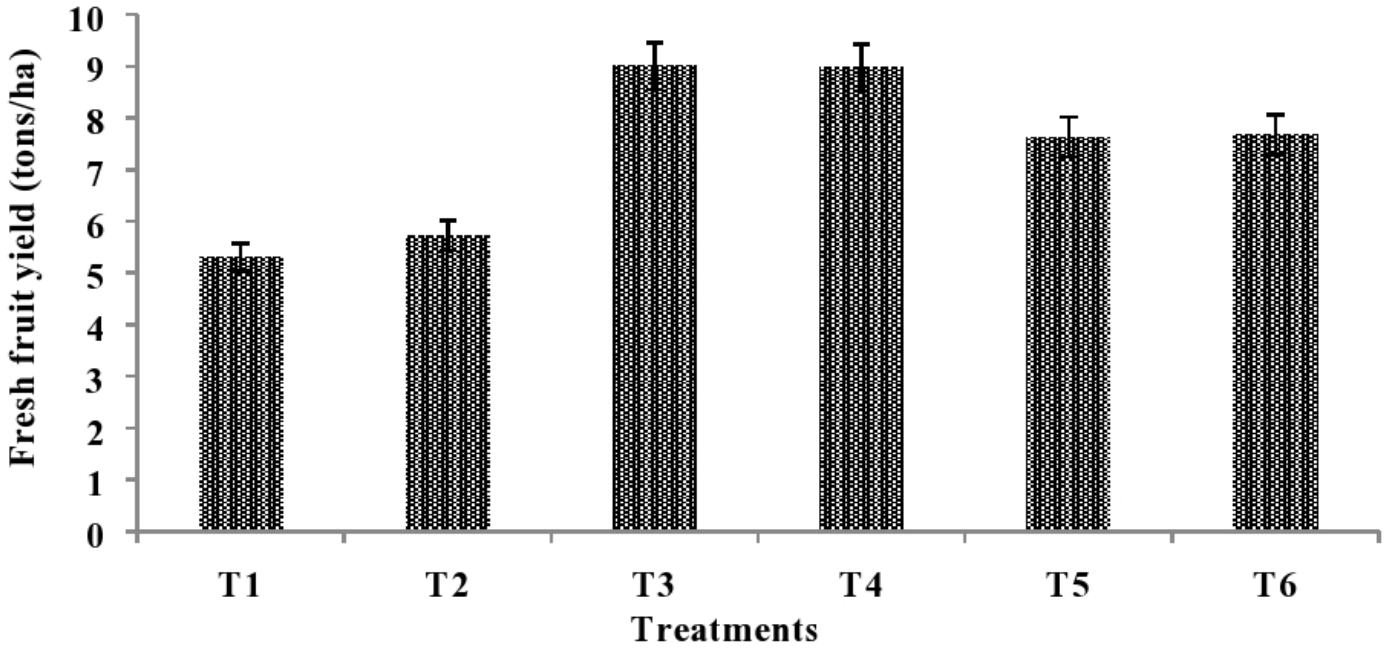

Figure 7: *Effect of compost, poultry manure and NPK on fresh fruit yield.*

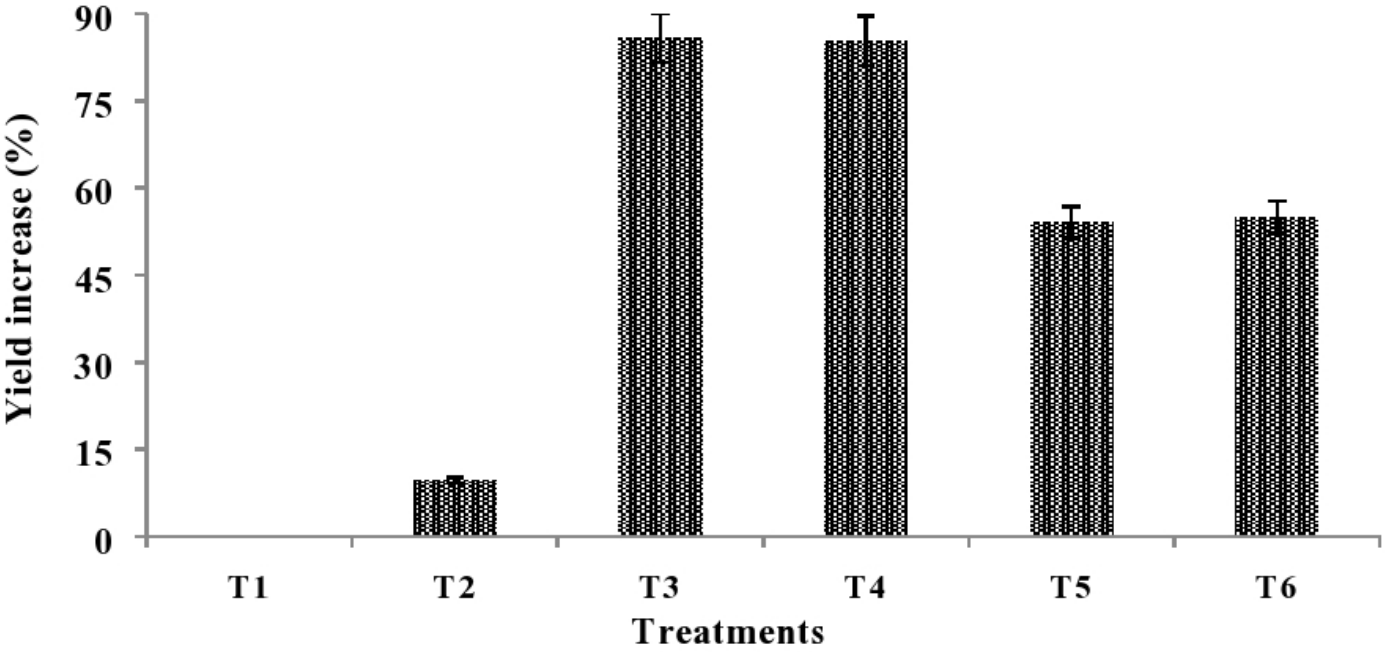

Figure 8: *Effect of compost, poultry manure and NPK on total yield increase.*

Fresh fruit yield: Highest fresh fruit yield was recorded in T3 (9 tons/ha) while the lowest fresh fruit yield was in control treatment (Figure 7). T3 containing full poultry manure and T4 containing 50% PM and 50% NPK showed significantly higher yield than control while both these treatments are statistically similar to each other. At T2 fresh fruit, yield was 5.73 tons /ha was recorded which is significantly higher than control. In T5 and T6 7.63 tons /ha and 7.67 tons /ha fresh fruit yield was recorded, respectively.

Total yield increase: From the results, it was clear that the minimum yield increase or no significant increase was observed in control (Figure 8). While in T3 and T4 a significant increase in total yield was observed as compared to all other treatments. Statically T3 and T4 were similar to each other. Among all treatmetns, T5 and T6 were found to be statically similar to each other, but but obvious increase in yield was observed in them as compared to the control and T2.

Organic Manures or organic amendments plays a fundamental role in maintaining the soil fertility status

as well as crop production being the core requirement for long term sustainable agriculture (Ewulo, 2005).

After examining the pre and post-harvest soil analysis data, it was revealed that the application of poultry manure and compost increases the organic matter content and Cation Exchange Capacity significantly and ultimately the soil chemical and physical properties are also improved. In pre-sowing soil analysis data, organic matter contents and CEC were 0.83%, 10.8meq/100g soil respectively, while after the application of poultry manure and compost it was recorded as 0.83% to 0.88% and 11.2 to 12.1 meq/100g soil accordingly. Our findings are parallel to the results of Soremi et al. (2017) they described that the application of poultry manure gives very encouraging outcomes and significant improvements in soil's physio-chemical properties due to the significant increase in organic matter. Imasuen (2015) reported that being a rich source of nutrients, the organic matter has an important role in improving soil aeration, water holding capacity, water permeability and improve soil structure as well as act as a pH buffer. Trupiano et al. (2017) reported that the soil physical and chemical properties improved by the addition of any compost by increasing cation exchange capacity, soil pH, moisture content, total carbon, nitrogen and phosphorous ultimately result in plant biomass accumulation.

Addition of fertilizers of organic origin in soil exerted a positive impact on the fertility of soil and growth of the plant, and it varies due to the quality of raw materials used for the production of these fertilizers. Okra seeds need moist soil with the temperature in the range of 25°C- 30°C for effective germination and show better growth in neutral to slightly alkaline soils (pH 6.5–7.5). The recorded germination (100%) with the higher rate of germination index in compost-treated plots might be attributed towards higher porosity, aeration, water holding capacity and presence of humic-like materials and other plant growth-influencing substances (such as plant growth hormones) produced by micro-organisms during composting (Aranconet al., 2004).

The results of these experiments revealed that experimental soil was not much fertile that gives the significant and profitable results without using any organic and inorganic source of fertilizer. This comparison was carried out and results revealed that the combination of compost and poultry manure with inorganic fertilizer increases the yield as compared to the control (where no source of fertilizer used). The treatment containing full poultry manure increases the yield 85.9% as compared to control. The results of this experiment were by with the outcomes reported by Mitchell and Tu (2005) and Warren et al. (2006).

Boateng et al. (2006) described that the chemical fertilizers can be replaced with Poultry manure and kitchen compost which is one of the best alternates. Soil fertility status could be enhanced by the application of Poultry manure being the best source of essential plant nutrients. Plant height, root length, biomass accumulation are increased by increasing the organic fertilizer in combination with the inorganic fertilizer (Full NPK). Fruit length, no of leaves, and of fresh fruit weight fresh fruit yield was increased significantly by using the poultry manure and compost with the combination of NPK fertilizer. These findings are in line with Asai et al. (2009) who described that amendments of organic nature could help in improving the porosity and soil's water holding capacity which results in more root growth, this, in turn, enhances the nutrient uptake from soil and as a consequence enhance biomass production. These consequences are in agreement with those reported by Hardy et al. (2001) and El-Ghadban et al. (2002) on lemongrass. In this respect, it is possible that the favorable effect of compost and microorganisms on growth characteristics may be because of their capability to enhance soil physico-chemical characteristics as well as microbiological characteristics of the soil.

Yield attributes are also given significant variation in total yield parameters like a total number of fruits per plant, fresh fruit weight and total yield under the combined use of organic and inorganic fertilizers. Verma et al. (2014) reported in an experiment that chemical fertilizer along with organic fertilizer produced the highest yield of cabbage (Brassica oleracea). Hammoda (2001) mentioned that both compost and poultry manure led to an increase in carbohydrate percentage and some macronutrients. These increases might be related to the positive effect of compost and microorganisms in increasing the root surface area per unit of soil volume, the water use efficiency and photosynthetic activity, which directly affects the physiological processes as well as the use of carbohydrates and ultimately on the fresh biomass of the plants.

Conclusions and Recommendations

Application of organic sources of fertilizers (i.e. poultry manure and compost) can enhanced the vegetable yield alone as well as in combination with NPK sources. Farmers with and less fertile soil can enhance their yield using poultry manure and their kitchen wastes on okra production. This will also ensure less environmental pollution.

Author's Contribution

The research plan and execution of research was done by Zafar A., Umair R. wrote the intrudction, Zeenat J., and Ali Z. contributed in analysis, references settings and formatting. While Muhammad A., Muhammad M., Saeed-ur-Rehman, Muhammad J.Q. contributed in methodology, sampling, data collection and statistical analysis, respectively. And Shahzada M.M. supervised the entire research work.

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