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RESEARCH ARTICLE

BENEFICIAL EFFECT OF ORGANIC FERTILIZERS ON THE YIELD CHARACTERS, MICROBIAL DYNAMICS AND SOIL NUTRIENT STATUS

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ABSTRACT

The application of organic fertilizers had a positive effect on yield characters such as number of flower buds, number of fruits and length of fruits in Okra. The results revealed that flower formation was higher in plants amended with organic manure followed by Farmyard manure (FYM). The fruit length and fruit weight were significantly increased with the soil amended with vermicompost. The fruit weight was directly correlated with the harvest index of okra. The organic fertilizers significantly increased the bacterial and fungal population in the amended soil than control soil. The vermicompost amended soil had the maximum population level of both bacteria and fungi followed by organic manure. The positive effect of organic fertilizers also reflected the soil nutrient content also. There was a significant difference was observed on the macronutrients such as N and P in the organic fertilizer amended soil over the control. From the present study, it is clear that the amendment of organic fertilizers had beneficial effect on yield characters of okra. Further, the beneficial effect was not only yielding but also in the soil characters as well as nutrient status of the soil also. The cumulative effect of soil characters boost up the yield characters of okra.

INTRODUCTION

Okra, also known as *"lady's finger"* is one of the popular nutritious vegetables in India. The pods usually gathered while they are green, tender and at immature stage. The plant is cultivated throughout the tropical and warm temperate regions of India especially in Tamil Nadu for their fibrous fruits. Botanically, okra is a perennial flowering plant belongs to the Malvaceae family and named scientifically as *Abelmoschus esculentus*. Okra cultivation is very common in Tamil Nadu because of its agroclimatic nature. Organic farming can provide quality food without adversely affecting the soil's health and the environment; however, a concern is whether large-scale organic farming will produce enough food for India's large population. Certified organic products including all varieties of food products including basmati rice, pulses, honey, tea, spices, coffee, oilseeds, fruits, cereals, herbal medicines, and their value-added products are produced in India.

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The production of these organic crops is reviewed with regard to sustainable agriculture in India (Yadav *et al.,* 2013). The organic sources supplying N, P, and K and also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate the plants to absorb the nutrients. Application of organic sources encouraged the growth and activity of beneficial microorganisms in the soil and is also helpful in alleviating the increasing incidence or deficiency of secondary and micronutrients and is capable of sustaining high crop productivity and soil health. The farmers can in turn, get good remuneration from organically produced crops and if included in high value crop rotations due to their heavy demands in domestic, national and international markets (Sofia *et al.,* 2006).

The traditional agricultural practice of applying nutrients is through organic manures such as green manures, farmyard manure (FYM). Organic manure applications improved the soil physical properties through increased soil aggregation (Zhang and Fang, 2007) and improved aggregate stability (Barzegar *et al.,* 2002).

Organic fertilizer plays a vital role in the soil fertility and productivity and act as a reservoir of plant nutrients especially nitrogen, phosphorous, potassium and micronutrients and as well prevents leaching of nutrients. Poultry manure, sheep manure and cow dung manure are very good sources of organic matters and play a vital role in soil fertility improvement as well as supplying primary, secondary and micronutrients for crop production (Roddy and Reddi, 1992).

The use of organic inputs such as crop residues, manures and compost has great potential for improving soil productivity and crop yield through improvement of the physical, chemical and microbiological properties of the soil as well as nutrient supply (Tandon, 1992; Stone and Elioff, 1998). It follows that if a sustained productive agriculture is to be achieved, practices which maintain or increase soil organic matter reserves must be adopted. Organic fertilizers nourish soil organisms which, in turn, slowly make nutrients available to plants. The commonest materials of animal origin are wastes such as farmyard manure, poultry manure and cow dung which are cheap and contain nutrients that support better root development leading to higher crop yields (Abou El - Magd *et al*., 2005). Organic manures are mineralizing gradually and nutrients become available. However, the nutrient content of manure varies and the reason is that the fertilizer value of manure is greatly affected by diet, amount of bedding, storage and application method. Compost is also a slow release fertilizer and the nutrient value of compost varies a lot and depends on what it is made from. Aside from N, P and K, it supplies varying amounts of secondary nutrients and micronutrients (Harris *et al*., 2001; Yuda *et al.,* 2016).

MATERIALS AND METHODS

A nursery experiment was conducted with the aim of finding of beneficial effect of various organic fertilizers in okra (*Abelmoshcus esculentus* (L.) Moench. with respect to yield, soil nutrients and microbial status. The seeds of okra and organic fertilizers were obtained for Tamilnadu Agricultural University. Six treatments were made in the pot with the soil mixture of black soil, red soil and sand (T1 - Control, T2 - Farm yard manure, T3 - Organic manure, T4 - Neem cake, T5 - Vermicompost and T6 - Wood ash. Organic fertilizers were applied 10g each at the top soil of the pots at regular intervals.

In the organic fertilizer amended plants, the yield characters such as number of flowers, fruit length, fruit weight and harvest index were studied. The numbers of flower buds and fruits were counted in both control and organic manure amended plants. The length of okra fruits were measured from the base to the tip of the fruit in centimeters by meter scale. The harvested fruits were weighed with the help of electronic balance and expressed in gram. The harvest index was worked out from the data of total dry matter production and fruit yield based on Gomieroa *et al.* (2011) method. To study the effect of organic fertilizers on the microbial dynamics, population level of bacteria and fungi were enumerated. Rhizosphere soil samples were collected from the organic manure amended plant and untreated control soil. The soil samples were air dried under shade and used for the isolation and enumeration of bacteria and fungi. The isolation and enumeration of bacterial cells was carried out by dilution plate technique using nutrient agar medium and for fungi, Potato Dextrose Agar (PDA) medium was used. Further, nutrient content of amended and control soil such as total nitrogen and available phosphorus were also studied. Total nitrogen in the soil was estimated by Kjeldhal method (AOAC, 1996). The available phosphorus in the soil was estimated following the method of Olsen *et al.* (1954). The obtained data from the yield character, soil nutrients and microbial dynamics were subjected to analysis of variance (ANOVA) and the significant means were segregated by critical difference (CD) at 0.05% (CD P= 0.05%) level of significance.

RESULTS AND DISCUSSION

Yield Characters of Organic Amended Okra

The results revealed that there was a significant on yield characters with reference to various organic fertilizers amendments. The application of organic manure significantly increased the flower formation than other organic fertilizers and the effect was higher than the untreated control plants. Numerically organic manure produced average of 16 flowers per plant followed by 11 flowers in wood ash amended plants. In control plants only 4 flowers were produced. Further, the organic fertilizers had a positive impact of the fruit length. Among different fertilizers tested, the application of vermicompost produced the fruits with higher length compared to others. The fruit weight was significantly increased by the application of organic amendments. It was ranged from 5.41g in vermicompost treated plants to 2.22g in the control plants. The harvest index was significantly higher with soil amended with vermicompost (Table 1).

Organic amendments greatly affect the yield of okra such as number of flower, number of fruits, fruit length and fruit weight. The yield effect was varied with the types of organic manures. The beneficial effect of organic manures in combination with each other was also noticed in the yield components namely number of tillers per meter row length, number of ear heads per meter square and seed weight. Significantly higher number of tillers per meter row length was recorded with vermicompost and poultry manure (Patil and Bhilare, 2000). The higher yield may be due fact that these organic manures supplies direct available nutrients such as nitrogen to the plants and these organic manures improves the proportion of water stable aggregates of the soil. This was attributed to cementing action of polysaccharides and other organic compounds released during the decomposition of organic matters, thus leading to taller plants, increased number of leaves, tillers and in turn the final yield (Hendrix *et al*., 1994).

Patnaik (1992) reported that the application of vermicompost significantly increase the yield, sweetness and reduce the harvesting period when compared to the control, where as application in combination with neem cake gave significantly higher and better yield than control and higher yield, improved quality of custard apple (*Annona squamosa*). Baby (2002) reported that the application of organic inputs such as compost, neem cake, wood ash and rock phosphate along with biofertilizers gave higher yield. On the other hand, in treatment with organic manures wherein biofertilizers were not given, there was a reduction in the yield. Inoculation of biofertilizers along with organic manure gave better results than their individual application. Desai *et al*., (1999) reported that the application of vermicompost with N fertilizer gave higher dry matter and grain yield of wheat (*Triticum aestivum*) and (*Coriandrum sativum*).

Table 1. Effect of organic fertilizers on the yield characters of okra

S. No.	Treatment	Number of flowers (Per Plant)	Fruit length (cm/fruit)	Fruit weight (g/fruit)	Harvest Index
1	Control	4.0[d] ±0.33 (100)	4.7[d] ±0.27 (100)	2.22[f] ±0.06 (100)	9.628[e] ±0.18 (100)
2	Farmyard manure	10.0[b] ±0.88 (557)	7.0[d] ±0.45 (105)	3.45[e] ±0.12 (107)	19.42[d] ±0.23 (201)
3	Organic manure	16.0[a] ±0.57 (614)	7.2[c] ±0.37 (107)	4.33[c] ±0.16 (134)	10.85[c] ± 0. 27 (112)
4	Neem cake	8.0[c] ±0.66 (171)	8.5[b] ±0.40 (110)	3.91[d] ±0.04 (121)	14.83[a] ±0.21 (154)
5	Vermicompost	10.0[b] ±0.88 (357)	9.5[a] ±0.28 (137)	5.41[a] ±0.06 (168)	25.32[b] ± 0.24 (263)
6	Wood ash	11.0[b] ±0.88 (400)	7.8[bc] ±0.26 (119)	4.81[b] ±0.06 (149)	24.53[a] ±0.19 (254)
CD P = 0.05 %		1.561	0.497	0.0342	0.6834

Table 2. Microbial dynamics of bacteria and fungi in the organic amended soil

S. No.	Treatment	Population level ($\times 10^7$ g soil dry weight)		Soil Nutrient content	
		Bacteria	Fungi	N (%)	P (ppm)
1	Control	1.10[d] ± 0.19 (100)	1.07[d] ±0.17 (100)	42[f] ±0.22 (100)	1.5[f] ±0.18 (100)
2	Farmyard manure	3.8[c] ±0.88 (345)	2.9[c] ±0.21 (271)	60[b] ±0.18 (149)	2.2[e] ±0.21 (126)
3	Organic manure	4.1[b] ±0.24 (372)	1.7[b] ±0.32 (158)	64[a] ±0.21 (162)	3.2[a] ±0.27 (153)
4	Neem cake	2.9[a] ±0.21 (263)	2.0[a] ±0.27 (186)	52[d] ±0.17 (130)	2.7[d] ±0.27 (132)
5	Vermicompost	4.7[b] ±0.23 (427)	3.2[a] ±0.31 (299)	51[e] ±0.24 (127)	3.0[b] ±0.18 (147)
6	Wood ash	3.4[b] ±0.31 (309)	2.6[b] ±0.21 (242)	59[c] ±0.23 (142)	2.8[c] ±0.18 (138)
CD P = 0.05 %		0.1864	0.2321	2.5219	0.6341

Makinde *et al.,* (2007) reported that the combination of farmyard manure and inorganic fertilizer significantly influenced cucumber yields compared to farmyard manure and fertilizer alone especially at higher rates of application. Aliyo (2000) observed in pepper (*Capsicum annum*) with application of FYM and poultry manure significantly higher fruit compared with other treatment. Mondal *et al*. (1993) observed better net production values in potato when 75% RDF was applied together with FYM at 10 t /ha.

Microbial Dynamics of Organic Amended Soil

The nursery experiment clearly indicated that an increase in the population level of bacteria and fungi in organic fertilizers amended soil than control soil. Among them, the bacterial count was higher in soil treated with vermicompost followed by organic manure. The same trend was observed in fungal population also (Table 2). The organic amendments significantly increased the soil microbial population especially bacteria and fungi. There was a remarkable difference in the microbial enrichment among the organic fertilizers. The physical and chemical nature of particular organic manure strongly affected the population level of both bacteria and fungi.

Theses microorganism had a positive impact on the growth and development of crop plants. The population dynamics of these microorganisms directly affected the betterment of the organic amended crop plants. The highest bacterial population in vermicompost treated soil. This may be due to the physical nature of the manure. The bacterial population was higher in organic treatment than in inorganic treatments (Kandeler and Marschner, 2003). Arancon *et al*. (2006) observed that the contributions of vermicompost to the field soils were the increased microbial populations and activities which are key factor in rates of soil nutrient cycling, production of plant-growth-influencing materials, the build-up of plant resistance or tolerance to crop disease and nematode attack. The enrichment of soil nitrogen through biological fixation of nitrogen by the host legume plant could have also affected the microbial diversity. Sinha (2001) reported that the application of green manure enriched with bacteria and fungi have proven to be great importance in improving the yield of mulberry plants but the present study indicated that drip irrigation along with green manure highly enrich the growth parameters of mulberry plants by favoring the rhizosphere microbial population. Kale *et al*. (1992) observed that the application of vermicompost may produce significantly greater increases in the abundance of N-fixers, actinomycetes and spore formers than in soil supplemented with inorganic fertilizers. Among the organic N sources, application of FYM, neem cake registered maximum population of bacteria, fungi and actinomycetes. The soil microbes continue to increase with the advancement of crop growth (Marinari *et al*., 2000). Baath and Arnebrant (1994) observed that wood-ash application enhanced the microbial activities in the soils.

Nutrients Status of Organic Amended Soil

The amendment of various organic fertilizers significantly increased the soil macro elements such as total nitrogen (N) and available phosphorus (P) in the amended soil. The nutrient content was significantly higher in all treated soil than control. The nutrient status of enriched manures revealed that the total N was higher soil enriched organic manure followed by farmyard manure. In the case of available P, the organic manure amended soil has higher level of available P followed by vermicompost (Table 2). Osman *et al*. (2010) reported that manure improved soil physical properties as well as chemical properties. Prasad and Rokima (1992) reported that the increase in available P content with the integrated use of organic, inorganic and biofertilizers. Suthar (2006) reported that the vermicomposting of crop residues mixed with cattle dung resulted in an increase in total N, available P and exchangeable K content of it. Therefore, ready vermicompost relatively contains more exchangeable plant nutrient than those by other plant growth media. Lawal and Girei (2013) reported that farmyard manure increased the nutrient content of soil and other physico-chemical properties of the soil.

Vermicompost contain nutrients such as nitrates, exchangeable phosphorus, soluble potassium, calcium, and magnesium in plant available forms (Edwards 1998) and have large particular surface area that provides many microsites for microbial activity and for the strong retention of nutrients (Shi-wei and Fu-zhen 1991). Uptake of nitrogen (N), phosphorus (P), potassium (K) and magnesium (Mg) by rice (*Oryza sativa*) plant was highest when fertilizer was applied in combination with vermicompost (Jadhav *et al*., 1997). Tejada and González (2009) reported that in *Aquic xerofluvent* soil, the application of vermicompost significantly enhanced soil biological properties (soil microbial biomass, soil respiration and soil enzymatic activities), soil humus-enzymes complexes, nutrition (N, P, and K plant contents, pigments, and leaf soluble carbohydrate concentrations) and improved yield and quality parameters of rice.

Neem cake is the cheap and easily available nitrogen inhibitors that inhibits nitrification process in soil and improved the N recovery from applied N in arable soil (Abbasi *et al*., 2011). The addition of neem cake positively affected the available N, P, K and Mn content of soil resulting in better growth and yield of mung bean crops and it also increased the cation exchange capacity and soil respiration (Abdechamid *et al*., 2004). It was observed a distinct increase in the concentrations of N, P, K, S, in soil plus fly ash mixtures after trial with concomitant increase in fly ash percentage. The use of organic manures increased soil organic matter and total N, increased the effectiveness of soil P, increased the population of soil organisms, especially some bacteria, and increased the activities of some soil enzymes such as urease. Further, the organic manures increased soil organic matter content and thus total nitrogen. Green manuring has been reported to increase the organic carbon, available nitrogen, phosphorus (Mann and Ashraf, 2000; Pennington *et al.,* 2015).

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