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INFLUENCE OF DIFFERENT PROPORTIONS OF ORGANIC MANURES ON GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L.)

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ABSTRACT

A field experiment was conducted at research and demonstration block of Research Institute on Organic Farming, UAS, GKVK, Bengaluru during 2016 and 2017 to study the effect of different proportions of organic manures viz., compost, vermicompost and poultry manure on growth and yield of okra. The experiment was laid out in Randomised Completely Block Design. There were twelve treatments consisted with different proportions of organic manures and these were replicated thrice. Among the different proportions of organic manure treatments, T_{12} [T_5 (C:VC: PM-50:25:25 %) + application of jeevamrutha at 20, 40, 60 and 80 DAS] recorded significantly higher fruit yield (7.41 and 8.98 t ha-1), number of fruits per plant (14.56 and 16.26), fruit weight per plant (231.23 and 266.95 g) and fruit length (14.78 and 16.55 cm), plant height (97.72 and 108.44 cm at harvest), leaf area (3354 and 3728 cm_2 $plant_{-1}$ at 90 DAS), TDMA (72.84 and 77.85 g plant-1 at harvest), as compared to rest of treatments. Whereas, application of 100 per cent N equivalent through compost alone (T_1) recorded lower fruit yield (T1-5.43 and 6.37 t ha_{-1}), number of fruits per plant (9.81 and 10.88), fruit weight per plant (162.07 and 177.23 g) and fruit length (10.06 and 11.17 cm), lower plant height (71.63 and 77.96 cm at harvest), leaf area (2350 and 2551cm_2 $plant_{-1}$ at 90 DAS), TDMA (50.09 and 53.23 g $plant_{-1}$ at harvest) during kharif, 2016 and summer, 2017, respectively.

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INTRODUCTION

In the present context, escalating cost of production year after year and greater demand for organic produce are making to search other alternative production practices for sustainable soil health and crop productivity. In this direction, organic agriculture is getting wider acceptance and recognition as sustainable alternative. The long felt information crunch and scientific explanation are being addressed. There is a need to exploit organic farming approaches using local manurial sources of nutrients *viz*., compost, vermicompost and poultry manure with cropping system mode (Sreenivasa, 2007). Okra (*Abelmoschus esculentus* L.) is one of the most well-known vegetable crop belongs to family *Malvaceae*. It is valued for its edible green pods. The Okra originated in Ethiopia. The plant is cultivated in different regions all around the world *viz*., tropical, subtropical and warm temperate climatic regions. It is one of the chief vegetable crop grown for its immature pods that can be consumed as a fried or boiled vegetable or may be added to salads, soups and stews (Kashif *et al*., 2008). It is a nutritious vegetable which can be grown in all types of soils starting from light sandy loam to clay soils and can be cultivated round the year in the country (Rana *et al*., 2009). Globally okra is cultivated on an area of 2.16 million hectares with an annual production of 8.9 million tonnes with an average productivity of 3.79 tonnes per hectare. It is mainly grown in India, Nigeria, Sudan, Pakistan, Ghana, Egypt, Benin, Saudi Arabia, Mexico and Cameroon. Largest area and production is in India followed by Nigeria. In India, it is cultivated in an area of about 0.485 million hectares with an annual production of 5.5 million tonnes with an average productivity of 11.34 tonnes per hectare (Anon., 2016). Major okra growing states in India are Maharashtra, Andhra Pradesh and Tamilnadu. However, it is mainly grown as vegetable purpose in all the states. Under arable production system organic manures suffer from the drawback of slow release of nutrients for plant uptake at initial stages, may cause

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Table 1. Fruit yield (t ha^{-1}) and stalk yield (q ha^{-1}) of okra as influenced by different proportions of organic manures during 2016 and 2017

Treatments	Fruit yield (t ha^{-1})		Stalk yield (q ha^{-1})	
	2016	2017	2016	2017
T_1	5.43	6.37	9.96	11.20
T_2	5.67	7.02	10.99	11.76
T_3	5.63	6.81	10.66	11.63
T_4	5.50	6.62	10.36	11.37
T_5	6.02	7.32	11.46	12.53
T_6	5.73	7.14	11.17	11.88
T_7	6.55	7.85	12.55	13.68
T_8	5.57	6.76	10.57	11.44
T_9	6.14	7.41	11.61	12.78
T_{10}	6.25	7.66	12.01	13.02
T_{11}	6.90	8.26	13.54	14.75
T_{12}	7.41	8.98	14.78	16.35
Mean	6.07	7.35	11.64	12.70
S.Em ±	0.28	0.36	0.60	0.63
C.D. (P=0.05)	0.83	1.06	1.76	1.85

LEGENDS:
T_1: 100 % N equivalent through Compost (C)
T_2: 100 % N equivalent through Vermicompost (VC)
T_3: 100 % N equivalent through Poultry manure (PM)
C : VC : PM
T_4: 75 : 25 : 0 (3:1:0)
T_5: 50 : 25 : 25 (2:1:1)
T_6: 25 : 75 : 0 (1:3:0)
C : VC : PM
T_7: 25 : 50 : 25 (1:2:1)
T_8: 25 : 0 : 75 (1:0:3)
T_9: 25 : 25 : 50 (1:1:2)
T_{10}: 33 : 33 : 33 (1:1:1)
T_{11}: T_5 + Microbial consortia (*Azotobacter spp.*, PSB, *Pseudomonas spp.* and *Trichoderma spp.*)
T_{12}: T_5 + Jeevamrutha application (at 20, 40, 60 and 80 DAS)
Note: DAS - Days after sowing, **NS**- Non significant
(RDF : 125:75:63 kg N:P_2O_5:K_2O /ha -Reference for N equivalent application of organic manures)

significant reduction in crop yield resulting in lower farm income. It can be overcome by the judicious use of organic manures by tracing the positive aspects of compost/ vermicompost/poultry manure and liquid manures, a more synchronized system can be achieved to maintain long term soil fertility and to sustain higher productivity of crops. Fermented liquid manures apart from readily available nutrients, they have higher microbial load and contain plant growth promoters, which helps in improving plant growth, metabolic activities and resistance to pest and diseases (Devamkumar *et al*., 2008; Sreenivasa *et al*., 2009). Keeping all above facts in the mind, the present investigation was conducted to study the effect of different proportions of organic manures *viz*., compost, vermicompost and poultry manure on growth and yield of okra.

MATERIAL AND METHODS

A field experiment was conducted at research and demonstration block of Research Institute on Organic Farming, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru which is situated in Eastern dry zone of Karnataka at a latitude of 12^o 58′ North, longitude of 75^o 35′ East and at an altitude of 930 m above mean sea level. The experiment was conducted study the effect of different proportions of organic manures *viz*., compost, vermicompost and poultry manure on growth and yield of okra during *kharif* - 2016 and summer 2017 under irrigated condition. The experiment was laid out in Randomised Completely Block Design and treatments were replicated thrice. The net plot size was 2.9 m × 2.6 m (7.54 m²). Recommended dose of nutrients for okra is 125:75:63 N:P_2O_5:K_2O kg ha^{-1} and nutrients were supplied through organic manures on the basis of nitrogen equivalent. There were twelve treatments consisted with different proportions of organic manures *viz*., T_1: 100 % N equivalent through Compost (C), T_2: 100 % N equivalent through Vermicompost (VC), T_3: 100 % N equivalent through Poultry manure (PM) and C : VC : PM proportions *i.e.,* T_4: 75 : 25 : 0 (3:1:0), T_5: 50 : 25 : 25 (2:1:1), T_6: 25 : 75 : 0 (1:3:0), T_7: 25 : 50 : 25 (1:2:1), T_8: 25 : 0 : 75 (1:0:3), T_9: 25 : 25 : 50 (1:1:2), T_{10}: 33 : 33 : 33 (1:1:1), T_{11}: T_5 + Microbial consortia (*Azotobacter spp.,* PSB, *Pseudomonas spp.* and *Trichoderma spp.*), T_{12}: T_5 + Jeevamrutha application (at 20, 40, 60 and 80 DAS) and these treatments were replicated thrice. Organic manures were incorporated into the soil, three weeks prior to sowing. Soil of the experimental site was red sandy loam with a pH of 6.73, EC (0.22 dSm^{-1}), low in organic carbon (0.42 %) and medium in available nitrogen (298 kg ha^{-1}), P_2O_5 (29 kg ha^{-1}) and K_2O (237 kg ha^{-1}).

Preparation of Jeevamrutha

Jeevamrutha was prepared by mixing 10 kg of cow dung, 10 litre of cow urine, 2 kg of jaggery, 2 kg of pigeon pea flour and hand full of soil collected from farm. All these were put in 200 litres plastic drum and mixed thoroughly and volume was made up to 200 litres by adding water. The mixture was stirred well in clock wise direction thrice a day plastic drum was kept shade covered with wet jute bag. Jeevamrutha was fermented for 10 days and applied to the plants manually at of 20, 40, 60 and 80 days after sowing (DAS) as per treatments (Palekar, 2006).Experimental data collected was subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as outlined in Gomez and Gomez (1984). Critical difference (CD) values were calculated whenever the "F" test was significant at 5 per cent level.

RESULTS AND DISCUSSION

Effect of different proportions of organic manures on growth and yield parameters of okra: Results obtained in the present field experimental trial showed that significantly higher fruit yield (7.41 and 8.98 t ha^{-1}) was produced in T_{12} [T_5 (50:25:25 %) + application of jeevamrutha at 20, 40, 60 and 80 DAS] as compared to other treatments and it was 26.72 and 29.06 per cent increase in yield over application of 100 per cent N equivalent through compost alone (T_1-5.43 and 6.37 t ha^{-1}). It was found on par with T_{11} [(T_5 + microbial consortium)-(6.90 and 8.26 t ha^{-1})]. This was followed by T_7 [(C:VC:PM - 25:50:25 %) - (6.55 and 7.85 t ha^{-1})], T_{10}

Table 2. Yield parameters at harvest of okra as influenced by different proportions of organic manures during 2016 and 2017

Yield parameters								
Treatments	Number of fruit plant $^{-1}$		Fruit length (cm) at 2nd picking		Fruit weight (g plant $^{-1}$)		Fruit diameter (cm)	
	2016	2017	2016	2017	2016	2017	2016	2017
T_1	9.81	10.88	10.06	11.17	162.07	177.23	1.57	1.67
T_2	10.75	12.06	10.99	12.32	171.83	196.78	1.71	1.84
T_3	10.54	11.68	10.79	11.95	168.75	190.58	1.68	1.78
T_4	9.95	11.33	10.20	11.61	164.47	184.75	1.59	1.73
T_5	11.40	12.60	11.63	12.85	182.29	205.83	1.82	1.92
T_6	10.93	12.27	11.17	12.53	175.27	200.28	1.74	1.87
T_7	12.39	14.31	12.82	14.52	202.84	234.22	1.97	2.17
T_8	10.24	11.58	10.48	11.85	165.96	188.82	1.64	1.77
T_9	11.56	12.77	11.80	13.01	184.94	208.58	1.84	1.94
T_{10}	11.84	13.23	12.07	13.46	189.33	216.22	1.88	2.01
T_{11}	13.24	15.24	13.66	15.45	210.83	241.11	2.04	2.16
T_{12}	14.56	16.26	14.78	16.55	231.23	266.95	2.15	2.32
Mean	11.43	12.85	11.70	13.11	184.15	209.28	1.80	1.93
S.Em ±	0.53	0.64	0.60	0.65	8.58	10.39	0.08	0.10
C.D. (P=0.05)	1.57	1.87	1.77	1.90	25.16	30.49	0.25	0.28

LEGENDS:
T_1: 100 % N equivalent through Compost (C)
T_2: 100 % N equivalent through Vermicompost (VC)
T_3: 100 % N equivalent through Poultry manure (PM)
C : VC : PM
T_4: 75 : 25 : 0 (3:1:0)
T_5: 50 : 25 : 25 (2:1:1)
T_6: 25 : 75 : 0 (1:3:0)
C : VC : PM
T_7: 25 : 50 : 25 (1:2:1)
T_8: 25 : 0 : 75 (1:0:3)
T_9: 25 : 25 : 50 (1:1:2)
T_{10}: 33 : 33 : 33 (1:1:1)
T_{11}: T_5 + Microbial consortia (*Azotobacter spp.*, PSB, *Pseudomonas spp.* and *Trichoderma spp.*)
T_{12}: T_5 + Jeevamrutha application (at 20, 40, 60 and 80 DAS)
(RDF : 125:75:63 kg N:P_2O_5:K_2O /ha -Reference for N equivalent application of organic manures)

Note: DAS - Days after sowing, **NS**- Non significant

Table 3. Growth parameters of okra as influenced by different proportions of organic manures during 2016 and 2017

Growth parameters								
Treatments	Plant height (cm)		Number of leaves per plant (at 90 DAS)		Leaf area (cm2 plant-1) (at 90 DAS)		Leaf area index (at 90 DAS)	
	2016	2017	2016	2017	2016	2017	2016	2017
T1	71.63	77.96	13.55	14.56	2350	2551	1.31	1.42
T2	74.75	81.68	14.33	16.06	2488	2817	1.38	1.56
T3	74.17	80.95	14.09	15.58	2445	2733	1.36	1.52
T4	72.44	79.20	13.74	15.14	2384	2654	1.32	1.47
T5	79.40	87.23	15.17	16.75	2637	2940	1.46	1.63
T6	75.47	82.36	14.61	16.33	2537	2864	1.41	1.59
T7	86.37	95.27	16.81	18.62	2878	3286	1.60	1.83
T8	73.45	79.64	13.86	15.45	2405	2709	1.34	1.50
T9	80.91	88.97	15.38	16.96	2674	2977	1.49	1.65
T10	82.37	90.66	15.73	17.54	2737	3081	1.52	1.71
T11	91.00	100.60	18.26	19.83	2995	3358	1.66	1.87
T12	97.72	108.44	19.34	21.22	3354	3728	1.86	2.07
Mean	79.97	87.75	15.41	17.00	2657	2975	1.48	1.65
S.Em ±	3.73	4.34	0.72	0.84	123.80	147.46	0.07	0.08
C.D. (P=0.05)	10.93	12.73	2.10	2.47	363.10	432.48	0.20	0.24

LEGENDS:
T_1: 100 % N equivalent through Compost (C)
T_2: 100 % N equivalent through Vermicompost (VC)
T_3: 100 % N equivalent through Poultry manure (PM)
C : VC : PM
T_4: 75 : 25 : 0 (3:1:0)
T_5: 50 : 25 : 25 (2:1:1)
T_6: 25 : 75 : 0 (1:3:0)
C : VC : PM
T_7: 25 : 50 : 25 (1:2:1)
T_8: 25 : 0 : 75 (1:0:3)
T_9: 25 : 25 : 50 (1:1:2)
T_{10}: 33 : 33 : 33 (1:1:1)
T_{11}: T_5 + Microbial consortia (*Azotobacter spp.*, PSB, *Pseudomonas spp.* and *Trichoderma spp.*)
T_{12}: T_5 + Jeevamrutha application (at 20, 40, 60 and 80 DAS)
(RDF : 125:75:63 kg N:P_2O_5:K_2O /ha -Reference for N equivalent application of organic manures)

Note: DAS - Days after sowing, **NS**- Non significant

[(C:VC:PM - 33:33:33 %) – (6.25 and 7.66 t ha^{-1})], T_9 [(C:VC:PM - 25:25:50 %) – (6.14 and 7.41t ha^{-1})] and T_5 [(C:VC:PM - 50:25:25 %)- (6.02 and 7.32 t ha^{-1})] during both the seasons, respectively (Table 1). Increase in the fruit yield within T_{12} was 6.88 and 8.01 per cent over T_{11} (T_5 + microbial consortium), 11.60 and 12.58 per cent over T_7 (C:VC:PM - 25:50:25 %), 15.65 and 14.69 over T_{10} (C:VC:PM - 33:33:33 %), 17.13 and 17.48 per cent over T_9 (C:VC:PM - 25:25:50 %) and 18.75 and 18.48 per cent over T_5 (C:VC:PM - 50:25:25 %). This is attributed to combination of compost, vermicompost and poultry manure along with application of jeevamrutha could have released the nutrients slowly into the soil solution to match the required absorption pattern of okra. Probably, the adequate supply of nutrients could have promoted the fruit yield. These results are in conformity with findings of Wagh *et al*. (2014) in okra, Shubham Sachan *et al*. (2017) in okra, Rekha Gonal (2017) in baby corn and Ramesh *et al*. (2015) in tomato. According to Basha (2015) reported that application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM 5 t ha^{-1}+ microbial consortium recorded significantly higher grain yield (3152 kg ha^{-1}) and straw yield (4083 kg ha^{-1}) of aerobic rice over alone application FYM equivalent to RDN as it helped in optimizing the availability of nutrients coincides with crop demand. Yield is the manifestation of growth and yield parameters. The increase in yield in treatment -T_{12} (T_5 + application of jeevamrutha at 20, 40, 60 and 80 DAS) might be due to significant improvement in yield parameters such as higher number of fruits (14.56 and 16.26 plant^{-1}), fruit length (14.78 and 16.55 cm) and fruit weight (231.23 and 266.95 g plant^{-1}) (Table 4.62 and Fig. 4.9, 4.10). Increased yield parameters might be due to higher total dry matter accumulation (TDMA) (57.31 and 61.56 g plant^{-1}) recorded with treatment T_{12}.

Table 4. Growth parameters of okra as influenced by different proportions of organic manures during 2016 and 2017

Growth parameters								
Treatments	Leaf area duration in days (60 to 90 DAS)		SPAD meter readings (at 90 DAS)		Total dry matter accumulation (g plant^{-1}) at harvest		Days to 50 % flowering	
	2016	2017	2016	2017	2016	2017	2016	2017
T_1	30.75	33.75	49.57	51.94	50.09	53.23	44.8	43.9
T_2	32.93	37.08	52.41	57.76	53.42	57.37	46.8	45.9
T_3	32.34	36.04	51.51	55.91	53.01	56.73	46.4	45.4
T_4	31.17	35.10	50.27	54.18	51.77	55.50	45.6	44.6
T_5	34.88	38.86	55.45	60.45	56.75	61.13	47.3	46.8
T_6	33.53	37.87	53.41	58.80	53.93	57.96	47.0	46.1
T_7	38.13	43.20	61.43	67.90	61.73	66.76	48.3	47.3
T_8	31.67	35.82	50.70	55.39	52.49	55.81	46.0	45.0
T_9	35.37	39.35	56.22	61.27	57.83	62.34	47.7	46.8
T_{10}	36.19	40.72	57.50	63.54	58.87	63.53	47.9	46.8
$_{11}$	39.44	44.14	64.18	72.54	66.04	70.50	48.4	47.4
T_{12}	44.07	49.03	69.72	77.58	72.84	77.85	49.0	48.0
Mean	35.04	39.25	56.03	61.44	57.40	61.56	47.1	46.2
S.Em ±	1.68	1.95	2.61	3.04	2.68	3.06	2.19	2.25
C.D. (P=0.05)	4.92	5.71	7.65	8.92	7.85	8.96	NS	NS

LEGENDS:

T_1: 100 % N equivalent through Compost (C)
T_2: 100 % N equivalent through Vermicompost (VC)
T_3: 100 % N equivalent through Poultry manure (PM)
C : VC : PM
T_4: 75 : 25 : 0 (3:1:0)
T_5: 50 : 25 : 25 (2:1:1)
T_6: 25 : 75 : 0 (1:3:0)
C : VC : PM
T_7: 25 : 50 : 25 (1:2:1)
T_8: 25 : 0 : 75 (1:0:3)
T_9: 25 : 25 : 50 (1:1:2)
T_{10}: 33 : 33 : 33 (1:1:1)
T_{11}: T_5 + Microbial consortia (*Azotobacter spp.*, PSB, *Pseudomonas spp.* and *Trichoderma spp.*)
T_{12}: T_5 + Jeevamrutha application (at 20, 40, 60 and 80 DAS)
(RDF : 125:75:63 kg $N:P_2O_5:K_2O$ /ha -Reference for N equivalent application of organic manures)

Note: DAS - Days after sowing, **NS**- Non significant

This might be due to taller plants (97.72 and 108.44 cm at harvest) which resulted in more number of leaves (19.34 and 21.22 at 90 DAS) and more leaf area (3354 and 3728 cm^2 plant^{-1} at 90 DAS) (Table 2,3,4). Overall vegetative growth parameters were influenced due to application of nutrient through combination of organic manures was proved beneficially for increasing growth of okra crop. The increased and uniform supply of nutrients at all the stages of plant growth could be due to combined effect of compost, vermicompost and poultry manure. In addition to this application of jeevamrutha could also contribute to an increase in growth parameters and enhancement in biological efficiency of crop plants. Abundant supply of nutrients through these organics increases the protoplasmic constituents and accelerated the process of cell division and elongation. Integration of organic manures and jeevamrutha might have increased growth and yield contributing attributes. Similar results of improvement in growth and yield parameters with combined application of organic manures in various crops were also observed by Patil *et al*.(2012a) in chickpea; Sharada (2013) in greengram-*rabi* sorghum and Kiran *et al*. (2015a) in chickpea. According to Shubham Sachan *et al.* (2017), significantly higher vegetative growth and yield parameters of okra *viz*., plant height, number of leaves, dry weight of plants, number of fruits fruit length, dry weight of fruits and total fruit yield were recorded in the treatment T_{12} receiving combination of FYM (2.5 t ha^{-1}) + poultry manure (2.5 t ha^{-1}) + vermicompost (2.5 t ha^{-1}) +NPK (75 %). Further, increase in plant height (97.72 and 108.44 cm at harvest) which resulted in more number of leaves (19.34 and 21.22 at 90 DAS) and more leaf area (3354 and 3728 cm^2 plant^{-1} at 90 DAS), LAI (1.86 and 2.07 at 90 DAS), LAD (44.07 and 49.03 days at 60 to 90 DAS) and SPAD meter readings (69.72 and 77.58 at 90 DAS) probably due to the ability of compost, vermicompost and poultry manure promotes vigorous growth, increase meristematic and physiological activities in the plants due to supply of plant nutrient and improvement in the soil properties. Thereby, resulting in the synthesis of more photo-assimilates which is used in producing fruits (Dauda *et al*., 2008).

In the present investigation, difference in growth and yield components which lead to significant yield differences could be traced back to significant variation in dry matter production and its accumulation in various plant parts *viz*., stem, leaves and reproductive parts. The benefits of vermicompost on productivity could be attributed to increased activity of beneficial micro flora especially bacteria, actinomycetes and fungi which constitute the work force in soil. End product of organic manure is humus which constitutes humic acid, fulvic acid and humin. Humic acid enhances the production of RNA, which is essential for many biochemical processes in the cell. Humic acid influence several metabolic processes, such as photosynthesis, respiration, nucleic acid synthesis and ion uptake (Selvakumar, and Gupta, 2006). Several researchers have indicated that humic acid enhanced growth and yield of crops by stimulating the activities of some enzymes. Enhancement of chlorophyll content with application of humic substances in organic manures has been reported. The dry matter production in the above treatments could be related to higher photosynthetically active assimilary surface area. Photosynthetic capacity of a plant depends upon the dry matter accumulation in leaves, stem and reproductive parts. These growth parameters enable the plant to trap higher quantity of solar energy with higher leaf surface area convert into chemical energy. This helps in accumulation of higher dry matter in the reproductive parts which intern might have led to the higher dry fruit yield of okra. From the present study, it can be concluded that application of different source organic manures (compost: vermicompost: poultry manure) at different proportions are beneficial in improving growth and yield of okra.

Conclusion

I have given only general conclusion but as per my major adviser suggestion; please indicated the best and on par treatment. From the present study, it can be concluded that application of organic manures viz., compost: vermicompost: poultry manure at 50:25:25 per cent along with application of

jeevamrutha at 20, 40, 60 and 80 DAS or microbial consortia are beneficial in improving growth and yield of okra.

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