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Effect of biofertilizer, liquid organic manures along with inorganic fertilizers on economic yield of okra (*Abelmoschus esculentus* L. Moench)

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Abstract
An experiment was conducted at Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, during *kharif* 2019 to study the effect of biofertilizer, liquid organic manures *viz*., Panchagavya, Vermiwash, Jeevamrit and Cow urine on economic yield of okra in the open field condition. The experiment was laid in Randomized Block Design with fifteen treatments replicated twice by using the variety Parbhani Kranti. The various types of liquid organic solutions prepared from plant and animal origin are effective in promotion of growth and increasing yield in okra. Different concentration of liquid organic manures like Panchagavya (500 lit/ha), Vermiwash (100 lit/ha) and Cow urine (100 lit/ha) were given at 15, 45 and 75 DAS through foliar spray and Jeevamrit (500 lit/ha) and biofertilizer like *Azospirillium* (2.5 lit/ha) was applied through drenching at 15, 45 and 75 DAS along with Recommended dose of fertilizers (N:P:K::100:50:50]. The observations on yield parameters were recorded during the investigation. On the basis of observations recorded, the result of the present investigation revealed that, combined application of different organic liquid manures along with recommended dose of fertilizer has significant effect on economic yield of okra as compared to RDF alone. The yield parameter like weight of fruit (14.15 g), length of fruit (12.97 cm), diameter of fruit (14.81 mm), number of fruit per plant (20.73), fruit yield per plant (293.32 g) and fruit yield per ha (162.95 q/ha) were significantly superior in the treatment T_{14} [RDF + Jeevamrit + Vermiwash + Panchagavya] and it was found to be significantly superior over other treatments and gives best results as compared to Control (100:50:50 N:P:K kg/ha).

Keywords: *Azospirillum*, cow urine, Jeevamrit, okra, panchagavya, vermiwash and yield

Introduction
Okra (*Abelmoschus esculentus* L. Moench) is a fast growing, erect, herbaceous annual and belongs to the family Malvaceae. Okra is an economically important vegetable crop grown in tropical and sub-tropical parts of world. It is a warm season vegetable crop and it grows best in hot summer with minimum and maximum temperature 18 ºC and 35 ºC for cultivation as a garden crop as well as on large commercial farms. It is one of the most popular vegetable cultivated in India, commonly called as *bhendi* or lady's finger. It is popularly grown during rainy and summer season throughout India. It contain 2n=2x=132 chromosome. It has an origin in tropical or subtropical Africa. It has good nutritional value as 100 g consumable unripe fruit contains moisture 89.6 g, carbohydrates 6.4 g, protein 1.9 g, fat 0.2 g, fibre 1.2 g, minerals 0.7 g, vitamin A 88 IU, thiamine 0.07 mg, riboflavin 0.10 mg, nicotinic acid 0.60 mg and vitamin C 13 mg. The dry seeds of okra contain 14-23% edible oil and 21-25% protein (Thamburaj and Singh, 2005) [17]. Oil from okra is used in soaps, cosmetic industry and as vanaspati, while protein is used for cattle feed preparation (Bini, 2003) [1].

The current global scenario firmly emphasizes the need to adopt eco-friendly agricultural practices for sustainable food production. The cost of inorganic fertilizers is increasing enormously to an extent that they are out of reach of small and marginal farmers. The use of organic liquid products such as beejamrit, jeevamrit and panchagavya results in higher growth, yield and quality of crops. Theses liquid organic solution are prepared form cowdung, urine, milk, curd, ghee, legume flour and jaggary. They contain macro nutrients, essential micro nutrients, many vitamins, essential micro nutrients, essential amino acids, growth promoting factors like IAA, GA and beneficial microorganisms (Palekar, 2006; Natarajan, 2007; Sreenivasa *et al*., 2010) [11, 10, 16].

Continuous use of inorganic fertilizers resulted in deficiency of micronutrients, imbalance in soil physiochemical properties and unsustainable crop production. The increase cost of inorganic fertilizers, application of recommended dose is difficult to be afforded by the small and marginal farmers. Hence renewable and low cost sources of plant nutrients for supplementing and complementing chemical fertilizers should be substituted which can be afforded by majority of farming community. Integrated nutrient management would be a viable strategy for advocating judicious and efficient use of chemical fertilizers with matching addition of fermented liquid organic manure and biofertilizer to meet the nutrient requirement of crop would be an inevitable practice in the years to come for sustainable agriculture. The result of this research was helpful to identify the best biofertilizer, fermented liquid organic manures and recommended dose of fertilizer combination for maximum economic yield and sustainable cultivation of okra.

Materials and Methods

The investigation was carried out at the Department of Horticulture, Vansantrao Naik Marathwada Krishi vidyapeeth, Parbhani, during the year 2019 in the month of July – October to know the effect of biofertilizer, liquid organic manures along with inorganic fertilizers on economic yield of okra. The experiment was laid out in randomized block design with 15 treatments and each replicated twice. The treatments involved were T_1 [Control (100:50:50 kg/ha)], T_2 [RDF + Vermiwash], T_3 [RDF + Jeevamrit], T_4 [RDF + Cow urine], T_5 [RDF + Panchagavya], T_6 [RDF + Biofertilizer], T_7 [RDF + Jeevamrit + Vermiwash], T_8 [RDF + Jeevamrit + Cow urine], T_9 [RDF + Jeevamrit + Panchagavya], T_{10} [RDF + Jeevamrit + Biofertilizer], T_{11}[RDF + Jeevamrit + Cow urine + Panchagavya], T_{12} [RDF + Jeevamrit + Cow urine + Biofertilizer], T_{13} [RDF + Jeevamrit + Vermiwash + Cow urine], T_{14} [RDF + Jeevamrit + Vermiwash + Panchagavya] and T_{15} [RDF + Jeevamrit + Vermiwash + Cow urine + Panchagavya + Biofertilizer]. The plot size was 3.0 m × 2.0 m and spacing followed by 60 cm × 30 cm. the land was brought to a fine tilth through ploughing and tillage. Irrigation channels and bunds were maintained properly.

The dibbling of seed directly in the open field condition, before dibbling the seed were treated with Beejamrit by dipping for 5 hrs. Light irrigation was given after sowing. Recommended dose of fertilizer (NPK) was applied before dibbling of seed. Recommended dose Nitrogen, phosphorus and potash were applied through urea, single superphosphate and muriate of potash, respectively at 100 kg N/ha, 50 kg P_2O_5/ha and 50 kg K_2O/ha. Application of full dose of Phosphorous & Potassium and half dose of Nitrogen were applied just before the dibbling of seed and remaining half dose of Nitrogen was just 30 days after sowing. Application of liquid organic manures *viz.*, vermiwash (100 lit/ha), panchagavya (500 lit/ha) and cow urine (100 lit/ha) was applied through spraying at 15, 45 and 75 DAS, jeevamrit (500 lit/ha) was applied through drenching at 15, 45 and 75 days after sowing and application of *Azospirillum* (2.5 lit/ha) through drenching at 15, 45 and 75 days after sowing.

All cultural practices were followed regularly during crop growth and observations were recorded on yield parameters i.e. Fruit length (cm), fruit weight (g), diameter of fruit (mm), number of fruit per plant, fruit yield per plant (g) and fruit yield per ha (q).

The data generated during the investigation was subjected to statistical analysis to test the significance among the treatments on various characters of okra under study was done according to the procedure given by Panse and Sukhatmane (1985) [12].

Results and Discussion

In the present study, yield parameters (Table 1.) were significantly higher with the application of T_{14} [RDF + Jeevamrit + Vermiwash + Panchagavya], which might due to the increased availability of nutrient at initial stage through recommended dose of fertilizer (100:50:50 NPK/ha) in addition to nutritional and other benefits from liquid organic manures.

The data on yield parameters as influenced by different treatments of liquid organic manures and inorganic fertilizers is presented in Table 1. The findings of the present study as well as relevant discussion have presented under the following heads.

1. Length of fruit (cm)

The significantly maximum length of fruit (12.97 cm) recorded in the treatment T_{14} [RDF + Jeevamrit + Vermiwash + Panchagavya], which was statistically at par with treatments T_{11} (12.55 cm) & T_{13} (12.84 cm). While, lowest fruit length (9.40 cm) was recorded under the treatment T_1 [control].

2. Diameter of fruit (mm)

The significantly maximum diameter of fruit (14.81 mm) recorded in the treatment T_{14} [RDF + Jeevamrit + Vermiwash + Panchagavya] which was superior over rest of treatments and stastistically at par with treatment T_{13} [RDF + Jeevamrit + Vermiwash + Cow urine] (14.73 mm). However, the minimum diameter of fruit (12.30 mm) was recorded in treatment T_1 [control].

3. Weight of fruit (g)

The maximum weight of fruit (14.15 g) was recorded with the treatments T_{14} [RDF + Jeevamrit + Vermiwash + Panchagavya], which was at par with treatments T_{15} (14.02 g), T_{13} (14.07 g), T_{12} (14.10 g), T_{11} (14.05 g), T_{10} (14.00 g), T_9 (13.92 g), T_7 (13.83 g), T_8 (13.75 g) and T_5 (13.52 g). However, the minimum weight of fruit (12.97 g) was recorded in treatment T_1 [control].

The above result indicated that, the application of liquid organic manures along with inorganic fertilizer increases the maximum fruit length, fruit length and diameter of fruit this is due to organically liquid manures are rich source of beneficial micro-organism and contain growth promoting substances which might lead to increase fruit development characters. These results were in close conformity with the findings of Prajapati (2011) [14], Patel (2012) [13], Boraiah (2013) [2], Rakesh *et al.* (2017) [15], Dutta *et al.* (2018) [4], Kumar *et al.* (2018a) [6], Kumar *et al.* (2018b) [7] and Kumar *et al.* (2018c) [9].

4. Total number of fruit per plant

The higher number of fruits (20.73) per plant was recorded under the treatment T_{14} [RDF + Jeevamrit + Vermiwash + Panchagavya] which was significantly superior over rest of treatments but it was statistically at par with treatments T_{13} (20.67), T_{11} (20.63), T_{12} (20.55), T_{15} (20.13), T_7 (20.03), T_9 (19.76) and T_{10} (19.60). Less number of fruits per plant (17.70) were recorded in the treatment T_1 [control].

5. Fruit yield per plant (g)

The treatment T_{14} [RDF + Jeevamrit + Vermiwash + Panchagavya] produced maximum fruit yield per plant (293.32 g) of okra which was at par with treatments T_{13} (290.82 g), T_{11} (289.85 g) and T_{12} (289.75 g) and significantly superior over rest of the treatments. The minimum yield per plant (229.56 g) was recorded in treatment T_1 [control].

6. Fruit yield per hectare (q)

The treatment T_{14} [RDF + Jeevamrit + Vermiwash + Panchagavya] produces significantly higher fruit yield per hectare (162.95 q) which was at par with treatments T_{15} (156.78 q), T_{13} (161.56 q), T_{12} (160.97 q) and T_{11} (161.02 q) and significantly superior over rest of the treatments. The minimum fruit yield per hectare (127.53 q) was recorded in treatment T_1 [control].

The above result indicated that, the probable reason of increasing fruit yield is due to the better availability of nutrient through both the organic and inorganic sources at right time of plant growth stage. The higher growth of plant which provide the more area for photosynthetic activities, cell division, cell expansion as well as metabolic process results in increased the yield of plant (g). The supply of nutrient might have increased the growth parameter also resulted in increased chlorophyll content, translocation and accumulation of photosynthesis towards growing points. This may lead to early flowering resulted in producing productive flowers ultimately results in increased yield per hectare (q) and more number of fruit per plant due to the application of liquid organic manures along with recommended dose of fertilizer. This results are also corroborated by the findings of Chandrakala *et al.* (2011) [3], Prajapati (2011) [14], Gore and Shreenivasa (2011) [5], Patel (2012) [13], Boraiah (2013) [2], Kumar and Devakumar (2016) [8] and Rakesh *et al.* (2017) [15].

Table 1: Effect of biofertilizer, liquid organic manures along with inorganic fertilizers on yield parameters of okra

Treatment no	Length of fruit (cm)	Diameter of fruit (mm)	Weight of fruit (g)	Total number of fruit per plant	Fruit yield per plant (g)	Fruit yield per hectare (q)
T_1	9.40	12.30	12.97	17.70	229.56	127.53
T_2	10.47	13.27	13.37	18.87	252.29	140.16
T_3	10.17	14.12	13.18	18.73	246.86	137.14
T_4	10.30	13.90	13.13	17.98	236.07	131.15
T_5	10.71	13.86	13.52	18.78	253.90	141.05
T_6	10.44	13.25	13.48	18.64	251.26	139.59
T_7	11.45	13.92	13.83	20.03	277.01	153.89
T_8	11.41	13.31	13.75	18.97	260.83	144.90
T_9	11.52	13.73	13.92	19.76	275.05	152.80
T_{10}	11.75	14.39	14.00	19.60	274.40	152.44
T_{11}	12.55	14.42	14.05	20.63	289.85	161.02
T_{12}	12.13	14.12	14.10	20.55	289.75	160.97
T_{13}	12.84	14.73	14.07	20.67	290.82	161.56
T_{14}	12.97	14.81	14.15	20.73	293.32	162.95
T_{15}	11.52	13.73	14.02	20.13	282.22	156.78
SE ±	0.173	0.056	0.212	0.467	2.353	2.126
CD at 5%	0.529	0.171	0.649	1.431	7.207	6.513

Conclusion

The study clearly revealed that, among the different treatment combination of various liquid organic manures along with inorganic source of fertilizer, most of the characters in relation to yield parameters were maximum with the treatment T14. The liquid organic manures are rich source of different plant growth hormones and beneficial micro-organism and was applied in combination of inorganic source of fertilizer (RDF) gives highest yield in okra.

Based on present investigation the application of liquid organic manures (Vermiwash, Jeevamrit, Cow urine and Panchagavya), *Azospirillium* along with recommended dose of fertilizer was found useful for increase in early growth and higher yield of okra Cv. Parbhani kranti than compared with RDF alone. The results are based on one season trial hence it is need to conduct two or more trials so that to achieve proper conclusion.

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