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Effect of combination of organic manure and biofertilizer for better growth and yield of beetroot (*Beta vulgaris* L.)

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Abstract
The present investigation entitled "Studies on organic production of beetroot (*Beta vulgaris* L.) was carried out during *rabi* season of year 2016-2017 at Horticulture Farm, Department of Horticulture, Dr. PDKV, Akola. The experiment was laid out in Randomised Block Design (RBD) with three replications and ten treatments comprises 100 % RDF, FYM, vermicompost, neem cake alone and in combination with *azotobacter*, PSB, VAM as soil treatment.

The results of present investigation indicated that, the growth parameters in terms of germination, plant height, leaves per plant, and yield attributes was increased due to different organic sources of nutrient and *azotobacter*, PSB, VAM. All organic sources of the nutrients influenced the growth, yield and quality parameter of beetroot.

The treatment combination of organic nutrient sources T_6 i.e. vermicompost @ 9.2 tha^{-1} + *azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (40 kg ha^{-1}) as soil treatment was found to be significantly superior for growth viz., plant height (28.85 cm), Number of leaves/plant(14.27), Leaf area(107.60 cm^2),Days required for harvesting (78.33) and yield attributes i.e. root weight (158.33 g), root length (8.03 cm), Root yield $hectare^{-1}$ (q) (234.33) of beetroot, which was at par with treatment T_7 i.e. neem cake @ 2.5 tha^{-1} + *azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (40 kg ha^{-1}) as soil treatment.

Considering the cost economics, the treatment T_6 i.e. vermicompost @ 9.2 t ha^{-1} + azotobacter (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (40 kg ha^{-1})) were found to be most remunerative and profitable as per its benefit cost ratio (3.51:1) as compared to remaining treatment and absolute control (T10).

Keywords: beetroot, biofertilizers, organic manure, growth and yield

Introduction
In human nutrition Vegetable play an important role as they provide carbohydrates, protein, fat, vitamin and mineral. It is also called as protective food. For daily consumption 300 g of vegetables in which 125 g green leafy vegetables, 100 g root and tubers and 75 g other vegetable is recommended. India ranks second in the world for area and production of vegetables. The total area under vegetable in India is 8.98 million ha. and with 156.32 million tonnes of annual production and average productivity level is 17.4 tonnes/ha. An area under vegetable crops in Maharashtra is 6.11 lakh ha with 75.04 lakh tonnes of annual production and average productivity 12.3 tha^{-1}. The major growing states of vegetables are West Bengal, Bihar, Uttar Pradesh, Karnataka, Punjab, Maharashtra and Assam.

The addition of organic fertilizer to agricultural soil has beneficial effect on crop development and yield by improving soil physical and biological properties. Organic and biofertilizer in comparison to the chemical fertilizer have lower nutrient content and slow release but they are as effective as chemical fertilizer over long period of usage. Also, several researchers revealed that organic manuring increased the vegetative growth and biomass production effectively. In recent year's use of organic manures like FYM, vermicompost, neemcake for improving the productivity of crops and maintaining soil fertility and productivity of soil is gaining prominence. The organic manuring has positive influence on soil texture and water holding capacity (Kale *et al.*, 1991) [2]. Several attempts have been made to increase yield potential of root crops, but they are concerned with use of inorganic fertilizers which results in loss of soil fertility and soil health. In this context, the use of organics and biofertilizers like FYM, vermicompost, neemcake, Fermented cow dung slurry, *azotobacter* VAM and PSB is gaining more importance for getting higher yield.

Nutrient management is most important in beet root to obtain good growth and higher yield of root crops. The crop benefiting microbial inoculatants generally called biofertilizers, help in augmenting the crop productivity through effective mobilization of major plant nutrient like N, P and K and other minor nutrients needed by the crop. These beneficial microorganisms are also known to secrete plant growth promoting substances like IAA, GA, Cytokinins, vitamins for the improvement of crop growth, yield and for quality produce. (Kumar *et al.*, 2013) [3].

Materials and Method

The present investigation entitled, "Studies on organic production of beetroot (*Beta vulgaris* L.) Was carried out during *rabi* season of 2016-2017 at Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

The experiment was laid out in Randomized Block Design with three replication. There were 10 treatment tested to study the effect of different organic nutrient sources on growth, yield and quality parameters in beetroot vr. Detroit Dark Red. In the treatments, T_1 includes recommended dose of fertilizers (125:50:70 kg of NPKha^{-1}). T_2, T_3 and T_4 (T_2 - Farm yard manure, T_3 - vermicompost and T_4 - neemcake) the only organic sources of nutrients are used. In the treatment T_5, T_6 and T_7 T_5 – FYM @ 12.5 tha^{-1} + azotobacter (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (40 kg ha^{-1}), T_6 – vermicompost @ 9.2 t ha^{-1} + azotobacter (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM(40 kg ha^{-1}) and T_7 – neemcake @ 2.5 t ha^{-1} + azotobacter (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM(40 kg ha^{-1}). In treatment T_8, T_9 and T_{10} (T_8 – Fermented cow dung slurry @ 6 lit/m^2 in 2 splits, T_9 - Fermented cow dung slurry @ 6 lit/m^2 in 2 splits + azotobacter (100g/200lit) + PSB (100g/200lit) + VAM (200/200lit) and T_{10} – Absolute control).

Results and Discussion

1. Germination (%)

The effect of different organic nutrient sources on germination (%) was found to be statistically non significant.

2. Plant height (cm)

The plant height was significantly increased by the application of treatment T_6 i.e. vermicompost @9.2 t ha^{-1} + azotobacter 10 kg ha^{-1}) + PSB(10 kg ha^{-1}) + VAM(10 kg ha^{-1}) followed by neemcake @ 2.5 t ha^{-1}+ azotobacter (10 kg ha^{-1}) + PSB(10 kg ha^{-1}) + VAM (10 kg ha^{-1}) at 20, 60 and 80 DAS.

At 20 DAS significantly maximum plant height (11.44 cm) was recorded in treatment T_6, which was at par with treatment T_7 (11.30 cm), T_5 (10.69 cm), T_3 (10.58 cm), T_1 (10.45 cm), T_4 (9.10 cm) and T_2 (9.08 cm) and significantly superior over remaining treatments.

At 60 DAS, the significantly maximum plant height 27.09 cm was recorded in treatment T_6 which was at par with treatment T_7 (25.81 cm), T_5 (25.69 cm), T_1 (24.35 cm) and T_3 (24.14 cm) and was significantly superior other the remaining treatments.

At 80 DAS, significantly maximum plant height (28.85 cm) was recorded in treatment $T_6$and it was at par with T_7 (28.06 cm), T_5 (26.85 cm), T_1 (27.37 cm) and T_3 (26.52 cm) which was significantly superior over all other treatments.

3. Leaves per plant

At 20 DAS, maximum number of leaves per plant (6.80) was observed in treatment T_6 i.e. vermicompost @9.2 t ha^{-1} + azotobacter 10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1}), which was significantly superior over rest of the treatments.

At 60 DAS, significantly maximum number (12.07) of leaves per plant was observed in treatment T_6, which was at par with T_7 (11.80), T_1 (11.73), T_5 (11.30) and T_3 (11.27), indicating significantly superior over remaining treatments.

At 80 DAS, maximum number of leaves per plant (14.27) were observed in treatment T_6 i.e. vermicompost @9.2 t ha^{-1} + azotobacter 10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1}), which was at par with treatment T_7 (13.80), T_5 (12.93) and T_1 (14.13).

4. Leaf area (cm^2)

The effect of different organic nutrient sources on average leaf area was found to be statistically significant.

At 80 DAS, the maximum average leaf area (107.60 cm^2) was recorded in treatment T_6 i.e. vermicompost @9.2 t ha^{-1} + azotobacter 10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1}), indicating significantly superior over all other treatments which was at par with treatment T_1 (101.44 cm^2), T_2 (83.33 cm^2), T_5 (95.81 cm^2), indicating significantly superior over all other treatments. The lowest leaf area (71.32 cm^2) was observed in T_{10} i.e. absolute control.

The average Leaf area was significantly increased by macro and micronutrients, possibly because nitrogen helps in greater assimilation of food material by the plant, which resulted in greater meristematic activities of cells and consequently the number of leaves, length and width of leaf of plant.

5. Days for harvesting

The effect of different organic nutrient sources on days for harvesting was found to be statistically significant.

The minimum days for harvesting (78.33) was recorded in treatment T_6 i.e. vermicompost @9.2 t ha^{-1} + azotobacter 10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM(10 kg ha^{-1}), which was at par with T_7 (81.67), T_5 (81.67), T_3 (85.00) and T_1 (80.00) indicating minimum significantly superior over all other remaining treatments. Whereas, maximum number of days for harvesting recorded in T_{10} (93.33) i.e. absolute control.

The beneficial effect of combined application of organic manure and biofertilizer might be attributed to the increased efficiency of organic manure and supply of all the essential nutrients in a balanced amount.

6. Root length (cm)

The effect of different organic nutrient sources on root length was found to be statistically significant.

The highest root length (8.03 cm) was recorded in treatment T_6 i.e. vermicompost @9.2 t ha^{-1} + azotobacter 10 kg ha^{-1}) + PSB(10 kg ha^{-1}) + VAM(10 kg ha^{-1}) followed by T_7 (7.80 cm), T_5 (7.63 cm) and T_1 (7.92 cm) which was at par with each other, while the lowest root length was recorded in T_{10} (6.20 cm) i.e. control.

7. Root weight (g)

The effect of different organic nutrient sources on root weight was found to be significant.

The significantly maximum root weight (158.33 g) was recorded in treatment T_6 i.e. vermicompost @9.2 t ha^{-1} + azotobacter 10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1}), which found at par with T_7 (135.33 g) and T_1 (141.0 g), and statistically significant over all other remaining treatments. The minimum root weight was recorded in T_{10} (95.33 g) with absolute control.

8. Root yield hectare^{-1} (q)

The effect of different organic nutrient sources on root yield hectare^{-1}was found to be statistically significant.

The highest root yield ha^{-1} was recorded in T_6 (234.33 q) with the application of treatment T_6 i.e. vermicompost @9.2 t ha^{-1} + *azotobacter* 10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1}) which was significantly superior over all other treatments.

Table 1: Germination (%) as influence by various treatments of organic nutrient sources

Treatments	Germination (%)
T1 RDF (125:50:70 kg NPK ha^{-1})	75.00 (60.07)
T2 Farm yard manure @ 12.5 t ha^{-1}	71.00 (57.54)
T3 Vermicompost @ 9.2 t ha^{-1}	71.67 (57.98)
T4 *Neem* cake @ 2.5 t/ha	71.21 (57.74)
T5 FYM @ 12.5 t ha^{-1} + *azotobacter* (10 kg/ha) + PSB (10 kg/ha) + VAM (40kg/ha)	73.33 (58.93)
T6 Vermicompost @ 9.2 t ha^{-1} + *azotobacter* 10 kg ha^{-1}) +PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1})	76.67 (61.76)
T7 *Neem* cake @ 2.5t/ha + *azotobacter* (10 kg/ha) + PSB (10 kg/ha) + VAM (40kg/ha)	74.77 (60.12)
T8 Fermented cow dung slurry @ 6 lit/m2 in 2 splits	70.00 (56.84)
T9 Fermented cow dung slurry @ 6 lit/m^2 in 2 split + *azotobacter* (10 kg/ha) + PSB(100g/200lit) + VAM (200g/200lit)	70.67 (57.21)
T10 Absolute control.	69.67 (56.70)
'F' test	NS
SE(m)±	3.563
CD at 5%	10.585

Table 2: The average plant height (cm) as influence by various treatments of organic nutrient sources

Treatments	Plant height(cm)		
	20 DAS	60 DAS	80 DAS
T1 RDF (125:50:70 kg NPK ha^{-1})	10.45	24.35	27.37
T2 Farm yard manure @ 12.5 t ha^{-1}	9.08	19.53	20.71
T3 vermicompost @ 9.2 t ha^{-1}	10.58	24.14	26.52
T4 *Neem* cake @ 2.5 t/ha	9.10	21.18	23.63
T5 FYM @ 12.5 t ha^{-1} + *azotobacter* (10 kg/ha) + PSB (10 kg/ha) + VAM (40kg/ha)	10.69	25.69	26.85
T6 Vermicompost @ 9.2 t ha^{-1} + *azotobacter* 10 kg ha^{-1}) +PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1})	11.44	27.09	28.85
T7 *Neem* cake @ 2.5t/ha + *azotobacter* (10 kg/ha) + PSB (10 kg/ha) + VAM (40kg/ha)	11.30	25.81	28.06
T8 Fermented cow dung slurry @ 6 lit/m2 in 2 splits	7.73	18.45	21.74
T9 Fermented cow dung slurry @ 6 lit/m^2 in 2 split + *azotobacter* (10 kg/ha) + PSB(100g/200lit) + VAM (200g/200lit)	8.29	18.60	20.62
T10	7.04	16.77	20.16
'F' test	Sig.	Sig.	Sig.
SE(m)±	0.906	1.589	1.606
CD at 5%	2.693	4.720	4.772

Table 3: Leaves per plant as influence by various treatments of organic nutrient sources

Treatments	Leaves per plant		
	20 DAS	60 DAS	80 DAS
T1 RDF (125:50:70 kg NPK ha^{-1})	5.93	11.73	14.13
T2 Farm yard manure @ 12.5 t ha^{-1}	5.57	9.93	11.28
T3 vermicompost @ 9.2 t ha^{-1}	5.73	11.27	11.73
T4 *Neem* cake @ 2.5 t/ha	5.60	10.57	11.60
T5 FYM @ 12.5 t ha^{-1} + *azotobacter* (10 kg/ha) + PSB (10 kg/ha) + VAM (40kg/ha)	5.80	11.30	12.93
T6 Vermicompost @ 9.2 t ha^{-1} + *azotobacter* 10 kg ha^{-1}) +PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1})	6.80	12.07	14.27
T7 *Neem* cake @ 2.5t/ha + *azotobacter* (10 kg/ha) + PSB(10 kg/ha) + VAM (40kg/ha)	5.87	11.80	13.80
T8 Fermented cow dung slurry @ 6 lit/m2 in 2 splits	5.33	9.73	10.73
T9 Fermented cow dung slurry @ 6 lit/m^2 in 2 split + *azotobacter* (10 kg/ha) + PSB(100g/200lit) + VAM (200g/200lit)	5.47	9.87	10.87
T10 Absolute control.	5.20	9.47	10.60
'F' test	Sig	Sig	Sig
SE(m)±	0.255	0.446	0.686
CD at 5%	0.757	1.327	2.038

Table 4: Leaf area (cm^2) and Days required for harvesting as influence by various treatments of organic nutrient sources

Treatments	Leaf area (cm^2)	Days required for harvesting
	80 DAS	
T1 RDF (125:50:70 kg NPK ha^{-1})	101.44	80.00
T2 Farm yard manure @ 12.5 t ha^{-1}	83.33	88.33

T3 vermicompost @ 9.2 t ha^{-1}	86.26	85.00
T4 *Neem* cake @ 2.5 t/ha	85.93	86.67
T5 FYM @ 12.5 t ha^{-1} + *azotobacter* (10 kg/ha) + PSB (10 kg/ha) + VAM (40kg/ha)	95.81	81.67
T6 Vermicompost @ 9.2 t ha^{-1} + *azotobacter* 10 kg ha^{-1}) +PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1})	107.60	78.33
T7 *Neem* cake @ 2.5t/ha + *azotobacter* (10 kg/ha) + PSB (10 kg/ha) + VAM (40kg/ha)	104.25	81.67
T8 Fermented cow dung slurry @ 6 lit/m2 in 2 splits	79.91	91.67
T9 Fermented cow dung slurry @ 6 lit/m^2 in 2 split + *azotobacter* (10 kg/ha) + PSB(100g/200lit) + VAM (200g/200lit)	83.05	90.00
T10 Absolute control.	71.32	93.33
'F' test	Sig.	Sig
SE(m)±	7.119	2.377
CD at 5%	21.153	7.061

Table 4: Root length (cm), root weight (g) and Root yield $hectare^{-1}$(q) as influence by various treatments of organic nutrient sources

Treatments	Root length (cm)	Root weight(g)	Root yield $hectare^{-1}$(q)	B:C ratio
T_1 RDF (125:50:70 kg NPK ha^{-1})	7.92	141.00	208.67	1 : 3.05
T_2 Farm yard manure @ 12.5 t ha^{-1}	6.70	104.67	155.00	1 : 2.68
T_3 vermicompost @ 9.2 t ha^{-1}	7.00	123.33	182.67	1 : 2.81
T_4 *Neem* cake @ 2.5 t/ha	6.83	115.33	170.67	1: 2.76
T_5 FYM @ 12.5 t ha^{-1} + *azotobacter* (10 kg/ha) + PSB (10 kg/ha) + VAM (40kg/ha)	7.63	133.67	198.00	1 : 3.14
T_6 Vermicompost @ 9.2 t ha^{-1} + *azotobacter* 10 kg ha^{-1}) + PSB (10 kg ha^{-1}) + VAM (10 kg ha^{-1})	8.03	158.33	234.33	1 : 3.51
T_7 *Neem* cake @ 2.5t/ha + *azotobacter* (10 kg/ha) + PSB (10 kg/ha) + VAM (40kg/ha)	7.80	135.33	200.33	1: 3.33
T_8 Fermented cow dung slurry @ 6 lit/m2 in 2 splits	6.37	96.33	143.00	1: 2.28
T_9 Fermented cow dung slurry @ 6 lit/m^2 in 2 split + *azotobacter* (10 kg/ha) + PSB(100g/200lit) + VAM (200g/200lit)	6.53	98.33	145.67	1: 2.36
T_{10} Absolute control.	6.20	95.33	141.33	1: 2.26
'F' test	Sig.	Sig	Sig.	
SE(m)±	0.271	5.452	8.058	
CD at 5%	0.804	16.199	23.941	

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