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Effect of organic manures and bio-fertilizers on growth and yield of radish (R*aphanus sativus* L.) *cv*. Japanese white

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Abstract
A field investigation was carried out during the *rabi* season of 2015-16 at Horticulture Farm of Department of Horticulture, Rajasthan College of Agriculture, MPUA&T, Udaipur (Rajasthan) to study the influence of organic manures and bio-fertilizers on growth and yield of radish. The experiment consisted of 15 treatments comprising of combinations of recommended dose of organic manures along with bio-fertilizers. The experiment was laid out in randomized block design with three replications. The application of PSB 4 kg/ha + vermicompost 5 t/ha (T_{12}) resulted in maximum values of growth and yield attributes *viz.*, plant height (34.5 cm), number of leaves per plant (11.82), root length (25.2 cm), root diameter (2.96 cm), root weight (115.5 g), yield per plot (6.70 kg), fresh weight of plant (224.3) and harvest index (36.42 %). Highest benefit cost ratio of 2.50 was also recorded with this treatment (T_{12}). Application of PSB 4 kg/ha + vermicompost 5 t/ha is recommended to get higher yield in radish

Keywords: Radish, organic manure, bio-fertilizer, growth, yield

Introduction
Radish (*Raphanus sativus* L.) is a member of family Brassicacceae and is a popular root vegetable in both tropical and temperate regions. Radish is grown for its young tender fusiform root and it is rich source of Ca, K, P and vitamin C. The edible roots can be used as raw, as salad or cooked. Radish roots are said to be useful in urinary complaints, piles and in gastrodynia and it is also considered as an appetizer. Radish is predominantly a cool season vegetable crop. But, Asiatic types can tolerate higher temperature than European varieties. It is an annual or biennial depending upon the type for the purpose it is grown.

Organic agriculture is gaining movement in India due to the individual as well as group efforts to conserve environments and avoid contamination of the farm produce from the use of chemical fertilizers and pesticides. The important tenet of organic food movement is that it promotes ecological soundness and sustainable use of natural resources, also maintains crop diversity. Organic agriculture practices rely upon recycling of crop residues, animal manure, farm organic residues and wastes etc. (Choudhary *et al.*, 2002) [3].

Among various factors responsible for low production of radish, nutrient management is of prime importance for maintaining higher yield and soil fertility. The increasing use of chemical fertilizers to increase vegetable production has been widely recognized but in long run it had detrimental effect on soil health, ecology, natural resources, living organisms including beneficial soil microorganism and human being. The escalating prices of chemical fertilizers and its detrimental impact on the soil, environment and human health urged the farmer to adopt organic manures and bio-fertilizers that offers the sustainable crop production and soil fertility. The application of organic manures such as FYM, vermicompost, neem cake and biodynamic manure has a positive effect on crop production.

FYM being rich in organic matter is the most commonly used manure to supplement the crops for nutrition. Vermicompost has all characteristic to use it as the most valuable organic manure. Vermicompost is a slow releasing organic manure which has most of the macro as well as micro nutrients in chelated form and fulfill the nutrients requirement of plant for longer period (Jat *et al.*, 2017) [7]. The Azotobacter and PSB are the main bio-fertilizers which are biologically active products containing bacteria and they improve soil health and fertility. They liberate growth promoting substances and vitamins which may increase crop yield

(Sharma *et al.,* 2013) [14]. Keeping this in view the present experiment was conducted to study the effect of organic manures and bio-fertilizers on growth and yield attributes of radish.

Materials and Methods

The present investigation was carried out at Horticulture Farm of Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) during *rabi* season of 2015-2016. The experiment consisted of 15 treatments in combinations of recommended dose of organic manures along with bio-fertilizers. The various treatments with their symbols are presented in Table 1. The experiment was laid out in randomized block design with three replications. Different organic manures such as farmyard manure, vermicompost, neem cake, BD and bio-fertilizer were incorporated in the field 15 days before sowing as per the treatments. Japanese White variety of radish was grown using the spacing of 30 x 8 cm. appropriate standard and uniform agronomical / cultural practices and plant protection measures were adopted for raising healthy crop. The data were recorded on five plants per treatment per plot in each replication on growth and yield parameters. Observations were recorded on plant height (cm), number of leaves per plant, root length (cm), root weight (g), root diameter (cm), root yield per plot (kg), fresh weight of plant (g) and harvest index (%). The data were statistically analysed using analysis of variance (ANOVA) for RBD following the standard procedure as suggested by Panse and Sukhatme (1985) [11]. Economics of various treatments was computed on the basis of prevailing market price of inputs and produce.

Results and Discussion

A perusal of data (Table 2) revealed that application of plant nutrients through organic manures and bio-fertilizers significantly affected the growth and yield attributes of radish. It is evident from the data that application of PSB 4 kg/ha + vermicompost 5 t/ha (T_{12}) resulted significantly maximum plant height (34.5 cm) and number of leaves (11.82 per plant) which were followed by (33.7 cm) plant height and (11.60) leaves per plant with the application of PSB 4 kg/ha + FYM 20 t/ha (T_{11}). The increase in plant height and number of leaves was may be due to the vital macro and micronutrient availability with vermicompost (Giraddi, 1993) [5]. Organic manure addition also acts as stimulation for supply of plant nutrient during the course of microbial decomposition and enables the crop to utilize nutrient and water more efficiently. The results are in close agreement with the findings of Dhananjaya (2007) in radish and Jeptoo *et al*. (2013) [4, 8] in carrot.

The maximum values of root attributes *i.e.* root length (25.2 cm), root weight (115.5 g) and root diameter (2.96 cm) were achieved by application of PSB 4 kg/ha + vermicompost 5 t/ha (T_{12}) followed by T_{11}. The application of vermicompost and bio-fertilizer favored the metabolic and auxin activities in plant and ultimately resulted in increased root weight, root diameter, root length and finally the total yield. The size of root was directly influenced by the enhanced vegetative growth of the plants. This might have accumulated more carbohydrates, resulting in to increased diameter of the root, which is food storage organ as reported by Bhandari *et al.* (2012) [2]. Decrease in bulk density and increase in porosity and water holding capacity of the soil due to organic manures might have contributed in increasing the root volume of the plants. Yadav and Vijayakumari (2003) [16] indicated that application of vermicompost along with other organic manures increased the root volume or width in chilli.

It is explicit from data presented in Table 2 that the highest fresh weight of plant (224.3 g) and harvest index (36.42 %) were recorded in T_{12} treatment *i.e.* PSB 4 kg/ha + vermicompost 5 t/ha. The increase in fresh weight of roots and whole plant may be due to higher level of nitrogen from vermicompost. The nitrogen will also be synthesized into amino acids which are built into complex proteins and help in promoting the luxurious growth of crop (Muthuswamy and Muthukrishnan, 1971). Yadav and Vijayakumari (2003) [10, 16] reported that fresh weight of plants was higher in chilli supplemented with vermicompost and NPK. Sendur *et al.* (1998) [13] indicated that the application of RDF along with vermicompost and bio-fertilizers caused higher growth and dry matter accumulation in carrot.

The results showed that the highest root yield (6.70 kg per plot) was obtained with application of PSB 4 kg/ha + vermicompost 5 t/ha (T_{12}), followed (6.10 kg per plot) by the application of PSB 4 kg/ha + FYM 20 t/ha (T_{11}) as compared (4.59 kg) to 100 % RDF of NPK (70:50:50 kg/ha) through inorganic fertilizers (control). However, minimum root yield per plot (4.38 kg) was recorded with the application of BD 500 @ 75 g/ha (T_4). Organic manure and PSB are likely to be directly responsible for increasing crop yields either by accelerating the respiratory process by increasing cell permeability due to hormone growth action or combination of all these processes. Phosphobacteria would have improved the availability of phosphorus which caused increased uptake of phosphorus by plants. Further, vermicompost by improving the soil structure and soil organic matter would have reduced the loss of nitrogen by increased cation and anion exchange capacities in soil, thereby enhancing the root development and yield. These finding are in conformity with those of Patil *et al.* (2007) [12] in onion Singh *et al.* (2012) [15] in garlic and Jeptoo *et al*. (2013) [8] in carrot. Jadhav *et al*. (2014) [6], Ziaf *et al*. (2015) and Khalid *et al.* (2015) [9, 17] also confirmed these findings in radish.

Economic evaluation of treatments indicated (Table 2) that during the experimental year application of PSB 4 kg/ha + vermicompost 5 t/ha (T_{12}) gave the highest net return of 194371 rupees per hectare. Highest B: C ratio (2.50) was also obtained by PSB 4 kg/ha + vermicompost 5 t/ha (T_{12}) followed by T_{10} and T_{14} treatment. Adhikari (2009) [1] reported that higher benefit cost ratio was obtained in organic production system in carrot which was also confirmed by Jadhav *et al*. (2014) [6] in radish.

In the present investigation, supplementation of radish with vermicompost along with PSB bio-fertilizers resulted in higher growth and yield parameters. Therefore, to produce sustainable higher yield of radish it is recommended to make use of PSB 4 kg/ha + vermicompost 5 t/ha to enhance growth and yield in addition to improve soil fertility in radish cultivation.

Table 1: Treatments detail with their symbol

S. No.	Treatment details	Symbol
1.	FYM (20 t/ha)	T_1
2.	Vermi compost (5 t/ha)	T_2
3.	Neem cake (2.5 t/ha)	T_3
4.	BD 500 (75 g/ha)	T_4
5.	Azotobacter (4 kg/ha)	T_5
6.	Azotobacter (2 kg/ha) + FYM (10 t/ha)	T_6
7.	Azotobacter (2 kg/ha) +Vermi compost (2.5 t/ha)	T_7
8.	Azotobacter (2 kg/ha) + Neem cake (1.25 t/ha)	T_8
9.	Azotobacter (2 kg/ha) + BD500 (75 gm/ha)	T_9
10.	PSB (4 kg/ha)	T_{10}
11.	PSB (4 kg/ha) + FYM (20 t/ha)	T_{11}
12.	PSB (4 kg/ha) + Vermi compost (5 t/ha)	T_{12}
13.	PSB (4 kg/ha) + Neem cake (2.5 t/ha)	T_{13}
14.	PSB (4 kg/ha) + BD 500 (75 g/ha)	T_{14}
15.	Control (RDF 70:50:50 kg NPK)	T_{15}

Table 2: Effect of organic manures and bio-fertilizers on growth, yield and economics of radish *cv*. Japanese White

Treatment	Plant height (cm)	Number of leaves per plant	Root Length (cm)	Root weight (g)	Root diameter (cm)	Fresh weight of plant (g)	Yield per plot (kg)	Harvest index (%)	Gross Returns (Rs/ha)	Net Returns (Rs/ha)	B:C Ratio
T_1	32.6	10.8	22.8	98.8	2.69	202.1	5.73	34.57	232904	140404	1.52
T_2	33.2	11.4	23.4	99.8	2.78	204.8	5.79	34.46	235261	157761	2.04
T_3	31.0	10.0	21.6	92.3	2.38	190.4	5.35	34.28	217581	127581	1.42
T_4	24.0	8.8	18.6	75.5	2.02	163.3	4.38	32.70	177978	125328	2.38
T_5	27.5	9.2	20.2	76.2	2.11	175.5	4.42	30.71	179628	126628	2.39
T_6	31.5	10.2	22.0	91.8	2.50	195.3	5.32	33.24	216403	143653	1.97
T_7	32.3	10.6	22.6	92.3	2.66	196.4	5.35	33.24	217581	152331	2.33
T_8	31.3	10.4	21.8	88.7	2.42	189.6	5.14	33.08	209095	137595	1.92
T_9	27.8	9.6	21.4	76.3	2.32	176.3	4.43	30.61	179864	126964	2.40
T_{10}	26.2	9.0	21.0	76.6	2.26	176.8	4.44	30.64	180571	127671	2.41
T_{11}	33.7	11.6	24.8	105.2	2.84	210.8	6.10	35.29	247991	155091	1.67
T_{12}	34.5	11.8	25.2	115.5	2.96	224.3	6.70	36.42	272271	194371	2.50
T_{13}	32.0	10.2	22.4	94.8	2.61	203.6	5.50	32.93	223475	133075	1.47
T_{14}	27.2	9.4	20.8	76.7	2.19	166.3	4.45	32.62	180807	127757	2.41
T_{15}	31.8	10.4	22.2	79.2	2.57	198.3	4.59	28.25	186700	129778	2.28
SEm ±	0.78	0.32	0.46	1.80	0.05	3.91	0.11	0.98			
C.D. (5%)	2.26	0.94	1.33	5.22	0.16	11.33	0.32	2.86			

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