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Effect of organic manures and bio-fertilizers on growth and yield characters of radish (*Raphanus sativus* L.) cv. Pusa Chetki

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Abstract

This research investigates the impact of the combination of organic fertilizers and bio-fertilizers to radish growth and yield as well as their influence on soil health for two consecutive seasons from 2022 to 2024. The treatments comprised bio-amendments from farm yard manure (FYM), vermicompost, neem cake, biodynamic preparation BD 500, azotobacter, and phosphate solubilizing bacteria. The results revealed that the combination of PSB with Vermicompost (T₁₂) in a pattern has resulted to highest expansion of the crop as it attained 34.40 superficial cm, 11.75 leaf count per plant, and moreover 25.41 cm in root length, the weight and the yield of rooted plants in specific area of land were recorded at 115.84 grams and 7.12 kilograms respectively categorizing T₁₂ as the most effective treatment. Enhanced results were also recorded with PSB with FYM (T₁₁). However, T₁₂ was slightly better. Samples treated with only BD 500 had the reduced performance in all parameters that were measured. The most efficient way on nutrient uptake, microbial activity and influenced structures of the soils were shown in treatment with PSB and VERMICOPMPST. This combined method also promotes environmentally friendly farming practices by lessening dependence on chemical fertilizers while increasing the productivity of crops. The results highlight the usefulness of organic and bio fertilizers in enhancing and making farming practices more sustainable.

Keywords: Vermicompost, bio-fertilizer, organic manure and radish

1. Introduction

Radish (*Raphanus sativus*), a Brassicaceae family member, is a widely cultivated root vegetable prized for its flavor and nutritional value. Thriving in cool seasons, it adapts to diverse climates, with Asiatic varieties enabling year-round growth in regions like peninsular India. Radishes, consumed raw or cooked, are rich in calcium, potassium, phosphorus, and vitamin C. Known in traditional medicine for digestive and urinary benefits, their leaves offer diuretic properties, while seeds yield oils for industrial use. India produced 2.512 million metric tonnes in 2022–23. Emphasizing sustainability, organic farming and bio-fertilizers enhance yields, though more regional research is needed for optimization.

2. Material and Methods

2.1 Study area

The experiment was carried out at the Horticulture Farm of Sunrise University, Alwar, located in the southeastern region of Rajasthan.

2.2 Layout and Design of Experiment

The experiment was designed in a randomised block with 15 treatments and three replications. The treatments were presented in Table 1.

2.3 Growth and yield attributes

Data collected included plant height, stem girth, root length, fresh plant weight, and dry plant weight. Five plants were randomly selected from each pot and tagged for all data recordings. The plant height was measured from the ground level to the plant's highest point using a meter scale for precision. The total number of leaves was counted on tagged plants at harvest time.

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Table 1: Details of treatments:

S. No.	Treatments	Symbols
1	FYM (20 t/ha)	T ₁
2	Vermicompost (5 t/ha)	T ₂
3	Neem cake (2.5 t/ha)	T ₃
4	BD 500 (75 g/ha)	T ₄
5	<i>Azotobacter</i> (4 kg/ha)	T ₅
6	<i>Azotobacter</i> (2 kg/ha) with FYM (10 t/ha)	T ₆
7	<i>Azotobacter</i> (2 kg/ha) with Vermicompost (2.5 t/ha)	T ₇
8	<i>Azotobacter</i> (2 kg/ha) with Neem cake (1.25 t/ha)	T ₈
9	<i>Azotobacter</i> (2 kg/ha) with BD 500 (75 g/ha)	T ₉
10	Phosphate solubilizing bacteria (PSB) (4 kg/ha)	T ₁₀
11	T ₁₀ with FYM (20 t/ha)	T ₁₁
12	T ₁₀ with Vermicompost (5 t/ha)	T ₁₂
13	T ₁₀ with Neem cake (2.5 t/ha)	T ₁₃
14	T ₁₀ with BD 500 (75 gm/ha)	T ₁₄
15	Control (RDF 70:50:50 kg NPK)	T ₁₅

Fresh root weight was determined for five plants using a digital weighing balance, with the average calculated during the harvest phase. The root diameter of five plants was measured at harvest using a vernier caliper, and the average diameter was expressed in centimeters. The average fresh root weight of five plants was multiplied by the total plant population per plot to estimate the overall fresh root weight for each treatment. The harvest index was computed by dividing the economic yield by the biological yield and multiplying the result by 100.

2.4 Statistical analysis

To assess the significance of variation in the data obtained from various growth, yield, and quality characteristics, the analysis of variance (ANOVA) technique was utilized, as suggested by Fisher (1950) for a randomized block design. The significance of differences in treatment effects was tested using the 'F' test at a 5% level of significance, and the critical difference (CD) was calculated wherever the results were found to be significant.

3. Results

3.1 Plant height

Several treatments were used including organic amendments (Farm Yard Manure, Vermicompost, and Neem Cake), biofertilizers (*Azotobacter* and Phosphate Solubilizing Bacteria [PSB]), and biodynamic preparation BD 500. Results revealed that the tallest plants were recorded in the treatments where PSB was incorporated with organic composts, which were respectively PSB with FYM (T₁₁) and PSB with Vermicompost (T₁₂) with pooled averages of 33.60 cm and 34.40 cm. This could be due to improved nutrient availability and microbial activity hence promoting kalb growth and uptake of nutrients. On the other hand, BD 500 (T₄) used by itself never produced large plants, indicating that it was not effective in stimulating growth when used alone. Emphasizes the potential of these combinations in providing all nutrients needed for growth without or minimal use of fertilizers thereby promoting better soil and plant health. Biofertilizers such as PSB and Azo with nitrogen fixing and phosphorus solubilizing properties have proven their positive results when added together with organic nutrients creating a fertile source to the crops. The results indicate that there is an opportunity to practice sustainable agriculture by maximizing crop production, which calls for the growing of green crops, which in turn recommends more studies on the proportions

of treatments to be applied to provide better measures of food and environmental safety in the future.

3.2 No. of leaves per plant

The influence of multiple treatments on the leaf per plant over two successive growing seasons (2022-2023 & 2023-2024), combining data in order to look at the patterns. Given the organic amendments (Farm Yard Manure [FYM], Vermicompost, Neem Cake), biofertilizers (*Azotobacter*, Phosphate Solubilizing Bacteria [PSB]), biodynamic preparation BD 500, and standard recommended fertilizer dosage (RDF) several treatments were used. It was found out that addition of PSB in combinations with Vermicompost (T₁₂) and PSB in combination with FYM (T₁₁) resulted in the most leaf production averaging 11.75 and 11.55 leaves per plant, respectively. This combination may be providing a conducive environment for availability of nutrients and enhanced activities of soil microbes, which, in turn, stimulates foliage growth. Otherwise, the BD 500 (T₄) had the lowest average count of leaves (8.75), thereby indicating that this is not a suitable growth promoter for leaves when used by itself. Even if moderate effects were noticed for use of *Azotobacter* with organic amendments, positive outcomes as far as leaf production is concerned were experienced with combinations of PSB. These results affirm the necessity of integrating organic composts with biofertilizers for improving crop growth and upholding sustainability. The present study brings forth useful knowledge on nutrient management to farmers by considering the ways of fertilizing crops to increase yields as well as to promote sustainable agriculture.

3.3 Root length (cm)

The study emphasizes the benefits of combining organic and bio-fertilizer methods for promoting healthier root growth and sustainable agriculture. This synergistic approach improves soil nutrient content and microbial diversity, enhancing radish root length and nutrient absorption. Organic manures provide slow-releasing nutrients, while bio-fertilizers boost soil microbial activity, fostering robust root development and resilience against environmental stress. The most effective treatment, T₁₂, involved phosphorus solubilizing bacteria (PSB) at 4 kg ha⁻¹ and vermicompost at 5 t ha⁻¹, yielding the longest roots—25.41 cm in 2022-23 and 24.86 cm in 2023-24. T₁₁, combining PSB with farmyard manure (FYM), produced slightly shorter roots. In comparison, 100% inorganic fertilizer treatment resulted in significantly shorter roots, while the lowest root length was recorded in treatment T₄ (BD-500). The findings underscore the practical value of integrating organic and bio-fertilizers in improving crop yields and advancing sustainable farming practices.

3.4 Root weight (g)

The study highlights the significant role of combining organic manures and bio-fertilizers in enhancing root weight and overall plant health in radish cultivation. This synergy improves soil fertility, microbial activity, and nutrient availability, promoting better nutrient uptake and biomass accumulation. Treatment T₁₂ (PSB 4 kg ha⁻¹ + vermicompost 5 t ha⁻¹) recorded the highest root weight at 115.84 g (2022-23) and 115.16 g (2023-24), followed by T₁₁ (PSB + FYM), with 105.54 g and 104.86 g, respectively. In contrast, 100% RDF (NPK 70:50:50 kg ha⁻¹) produced

significantly lower root weights (79.54 g and 78.86 g), while T₄ (BD-500) showed the least performance. Treatment T₁₂ showed a 45.83% and 52.98% increase in root weight compared to T₁₅ and T₄. The findings advocate for shifting from synthetic fertilizers to sustainable practices using organic and bio-fertilizers, enhancing crop productivity, soil health, and environmental sustainability.

3.5 Root diameter (cm)

The study underscores the critical role of organic fertilizers and bio-fertilizers in enhancing root diameter, a key factor in improving nutrient and water uptake, plant health, and resilience. The highest root diameter recorded was 3.08 cm (2022-23) and 3.1 cm (2023-24) using PSB at 4 kg ha⁻¹ combined with vermicompost at 5 t ha⁻¹. This synergistic approach enriches soil fertility, promotes microbial activity, and strengthens root systems, enabling plants to withstand environmental stresses like drought and wind. These findings emphasize the importance of sustainable farming practices, showcasing how organic amendments improve soil health and agricultural productivity while mitigating the environmental impacts of synthetic fertilizers, such as soil degradation and water pollution. By adopting organic inputs, farmers can enhance crop yields, resilience, and sustainability, addressing challenges posed by climate change and the growing global food demand while ensuring the long-term health of soils and ecosystems.

3.6 Fresh weight of plant (g)

The study highlights the significant benefits of combining organic manures and bio-fertilizers for enhancing plant weight, nutrient uptake, and overall soil health in radish cultivation. Treatment T₁₂, which used phosphate solubilizing bacteria (PSB) at 4 kg ha⁻¹ and vermicompost at 5 t ha⁻¹, achieved the highest fresh weight of 227.44 g

(2022-23) and 228.42 g (2023-24). T₁₁, combining PSB with farmyard manure (FYM), followed with weights of 213.94 g and 214.92 g, respectively. In contrast, the 100% RDF treatment with synthetic fertilizers yielded lower weights of 201.44 g (2022-23) and 202.42 g (2023-24), while T₄ (bio-fertilizers at 500 g ha⁻¹) had the lowest results. This improvement is attributed to the synergistic effects of organic inputs and bio-fertilizers, enhancing microbial activity, soil structure, and nutrient availability. These findings advocate for integrated nutrient management, promoting sustainable agriculture, better yields, economic benefits, and reduced reliance on synthetic fertilizers.

3.7 Root yield per plot (kg)

The study highlights the benefits of integrating organic manures and bio-fertilizers for enhancing soil fertility, nutrient availability, and radish yields. Treatment T₁₂, involving phosphate-solubilizing bacteria (PSB) at 4 kg ha⁻¹ combined with vermicompost at 5 t ha⁻¹, achieved the highest root yields of 6.94 kg per plot (2022-23) and 7.12 kg (2023-24), surpassing conventional methods. T₁₁, combining PSB with farmyard manure (FYM), followed with yields of 6.34 kg and 6.52 kg, respectively. In contrast, the 100% recommended dose of fertilizers (RDF) with synthetic inputs produced significantly lower yields of 4.83 kg (2022-23) and 5.01 kg (2023-24). Treatment T₁₂ showed yield increases of 45.96% and 52.96% over T₁₅ and T₄, emphasizing the synergy between organic and biological inputs. This approach improves soil structure, microbial activity, and phosphorus availability, leading to healthier, more resilient plants. The findings advocate for sustainable practices, offering economic benefits, reduced reliance on synthetic fertilizers, and alignment with global sustainability goals.

Table 2: The effects of different treatments on plant height, number of leaves per plant, and root length over two growing seasons (2022-23 and 2023-24).

Treatment Symbol	Treatment details	Plant height (cm) in 2022-23	Plant height (cm) in 2023-24	Leaves/ plant in 2022-23	Leaves/ plant in 2023-24	Root Length (cm) in 2022-23	Root Length (cm) in 2023-24
T ₁	FYM (20 t/ha)	32.8	32.2	10.94	10.56	23.01	22.46
T ₂	Vermi compost (5 t/ha)	33.4	32.8	11.54	11.16	23.61	23.06
T ₃	Neem cake (2.5 t/ha)	31.2	30.6	10.14	9.76	21.81	21.26
T ₄	BD 500 (75 g/ha)	24.2	23.6	8.94	8.56	18.81	18.26
T ₅	<i>Azotobacter</i> (4 kg/ha)	27.7	27.1	9.34	8.96	20.41	19.86
T ₆	<i>Azotobacter</i> (2 kg/ha) + FYM (10 t/ha)	31.7	31.1	10.34	9.96	22.21	21.66
T ₇	<i>Azotobacter</i> (2 kg/ha) + Vermi compost (2.5 t/ha)	32.5	31.9	10.74	10.36	22.81	22.26
T ₈	<i>Azotobacter</i> (2 kg/ha) + Neem cake (1.25 t/ha)	31.5	30.9	10.54	10.16	22.01	21.46
T ₉	<i>Azotobacter</i> (2 kg/ha) + BD500 (75 g/ha)	28	27.4	9.74	9.36	21.61	21.06
T ₁₀	PSB (4 kg/ha)	26.4	25.8	9.14	8.76	21.21	20.66
T ₁₁	PSB (4 kg/ha) + FYM (20 t/ha)	33.9	33.3	11.74	11.36	25.01	24.46
T ₁₂	PSB (4 kg/ha) + Vermi compost (5 t/ha)	34.7	34.1	11.94	11.56	25.41	24.86
T ₁₃	PSB (4 kg/ha) + Neem cake (2.5 t/ha)	32.2	31.6	10.34	9.96	22.61	22.06
T ₁₄	PSB (4 kg/ha) + BD 500 (75 g/ha)	27.4	26.8	9.54	9.16	21.01	20.46
T ₁₅	RDF	32	31.4	10.54	10.16	22.41	21.86
	C.D. (5%)	2.74	2.43	0.93	0.67	1.981	1.674
	SEm ±	0.94	0.63	0.32	0.21	0.68	0.54

Table 3: The effects of various treatments on root diameter, fresh plant weight, yield per plot, and harvest index over two growing seasons (2022-23 and 2023-24).

Treatment Symbol	Root diameter (cm) in 2022-23	Root diameter (cm) in 2023-24	Fresh weight of plant (g) in 2022-23	Fresh weight of plant (g) in 2023-24	Yield plot ⁻¹ (kg) in 2022-23	Yield plot ⁻¹ (kg) in 2023-24	Harvest index (%) in 2022-23	Harvest index (%) in 2023-24
T ₁	2.81	2.83	205.24	206.22	5.97	6.15	36.98	37.69
T ₂	2.9	2.92	207.94	208.92	6.03	6.21	36.87	37.58
T ₃	2.5	2.52	193.54	194.52	5.59	5.77	36.69	37.4
T ₄	2.14	2.16	166.44	167.42	4.62	4.8	35.11	35.82
T ₅	2.23	2.25	178.64	179.62	4.66	4.84	33.12	33.83
T ₆	2.62	2.64	198.44	199.42	5.56	5.74	35.65	36.36
T ₇	2.78	2.8	199.54	200.52	5.59	5.77	35.65	36.36
T ₈	2.54	2.56	192.74	193.72	5.38	5.56	35.49	36.2
T ₉	2.44	2.46	179.44	180.42	4.67	4.85	33.02	33.73
T ₁₀	2.38	2.4	179.94	180.92	4.68	4.86	33.05	33.76
T ₁₁	2.96	2.98	213.94	214.92	6.34	6.52	37.7	38.41
T ₁₂	3.08	3.1	227.44	228.42	6.94	7.12	38.83	39.54
T ₁₃	2.73	2.75	206.74	207.72	5.74	5.92	35.34	36.05
T ₁₄	2.31	2.33	169.44	170.42	4.69	4.87	35.03	35.74
T ₁₅	2.69	2.71	201.44	202.42	4.83	5.01	30.66	31.37
C.D. (5%)	0.233	0.175	17.351	17.342	0.484	0.374	3.137	2.741
SEm ±	0.08	0.02	5.959	6.21	0.166	0.114	1.077	1.241

3.8 Harvest index (%)

The study emphasizes the benefits of integrating organic manures and bio-fertilizers in improving the radish harvest index. Treatment T₁₂, combining phosphate-solubilizing bacteria (PSB) at 4 kg ha⁻¹ with vermicompost at 5 t ha⁻¹, achieved the highest pooled harvest index of 39.185%, followed by T₁₁ (PSB + FYM) at 38.055%. In contrast, the Recommended Dose of Fertilizer (RDF) treatment yielded the lowest index at 31.015%. These results underscore the synergy of organic and biological inputs in enhancing soil fertility, microbial activity, and nutrient availability. The steady nutrient release from organic manures and the phosphorus solubilization by PSB optimize plant growth and yield, outperforming conventional synthetic fertilizers. This integrated approach not only boosts productivity but also promotes soil health, reduces dependency on chemical fertilizers, and aligns with sustainability goals. The findings advocate for adopting sustainable nutrient management practices to improve crop yields, ecosystem health, and long-term agricultural viability.

4. Conclusion

The research elucidates the considerable advantages of merging organic manures with bio-fertilizers, especially the cumulation of vermicompost at 5 t ha⁻¹ and phosphorus-solubilizing bacteria (PSB) at 4 kg ha⁻¹. This option outperformed other treatments by showing the highest plant heights and the highest leaf counts in two consecutive years. Instead, manure from the farm yard which was mixed with bacteria resulted in favorable indications, becoming the basis for the further use of these organic amendments. On the contrary, the treatment with BD 500 was the one to be the worst, with the lowest number of growing parameters. Through these experiences, to choose appropriate organic amendments and bio-fertilizers aim thus in utilizing plant growth, thus, boosting the practices of agriculture and productivity of the crops.

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