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Effect of bio fertilizers on growth and yield of Radish (*Raphanus sativus* L.) Cv. Arka Nishant

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Abstract
The present investigation was carried out at CRC-1 field of ITM University, Department of Horticulture, Gwalior, (M.P.) during winter season of 2022-23. The experiment was laid out in Randomized Block Design (RBD) replicated thrice including ten treatments T_1 (Control), T_2 (RDF 100:80:50 Kg/ha), T_3 (FYM 15t/ha + Azotobacter 25% more + PSB 25% more) T_4 (FYM 15t/ha + Azotobacter 50% more + PSB 50% more) T_5 (FYM 15t/ha + Azotobacter 75% more + PSB 75% more) T_6 (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) T_7 (Vermicompost 10t/ha + Azotobacter 25% more + PSB 25% more) T_8 (Vermicompost 10t/ha + Azotobacter 50% more + PSB 50% more) T_9 (Vermicompost 10t/ha + Azotobacter 75% more + PSB 75% more) T_{10} (Vermicompost 10t/ha + Azotobacter 100% more + PSB 100% more). The application of (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) T_6 was found superior to growth parameters as compared to other treatments and recorded maximum growth (*viz.* plant height (cm), number of leaves per plant, length of leaves (cm). The application (Vermicompost 10t/ha + Azotobacter 100% more + PSB 100% more) T_{10} was found superior to yield parameters as compared to other treatments

Keywords: Radish, biofertilizers, organic matter

Introduction
Radish (*Raphanus sativus* L.) is one of the most significant root crops in the Cruciferae family. It is grown in both tropical and temperate climates and the world's temperate areas probably an Asian native. Radish is cultivated for its tasty young, sensitive and cylindrical roots consumed raw as a salad and vegetable (Jaisankar, 2018) [3]. Radish is a popular culinary vegetable and cash crop. "*Raphanus*" derives its scientific name from the Latin word raphanos, which means easily reared. It is a short-season crop that takes 30-60 days to mature and is marketable. It is appropriate for intercropping, relay cropping, and companion cropping systems. Radish roots come in a variety of shapes, including round, oval, icicle, half-long, and long. Long kinds can also be conical, cylindrical, or oblong. The most abundant mineral in radish is potassium, even though it also contains calcium, magnesium, copper, manganese, phosphorus, and sodium in low amounts, as well as iron, zinc, and molybdenum. Fresh raw radish is high in vitamin C and B vitamins, including folic acid, riboflavin, thiamine, and B6. Radish intake assists in preventing piles, bloating, and stone development in the urinary tract, as well as heals jaundice and stimulates hunger.

It's a usual crop consumed in both tropical and cold climates. It is planted as both a yearly and a seasonal crop that generates roots and seeds. It is extensively grown in India, including West Bengal, Uttar Pradesh, Bihar, Himachal Pradesh, Gujarat, Punjab, and Haryana (Sahu *et al*., 2018) [10]. According to World Scenario, the largest radish-producing state, West Bengal, has an area of roughly 40.70 thousand hectares and produces 508.75 thousand MT of radish, with Nadia and Murshidabad districts leading the way, followed by Haryana and Punjab. It is planted on a total of 209 hectares in the Punjab, achieving 3347 the case of MT (NHB 2021-2022).

Application of bio-fertilizers inoculating in vegetable fields has become crucial because Azotobacter and Azospirillum in atmospheric nitrogen, as well as produce biologically growth advancing substances, all while PSB are important microbes in releasing and making available phosphorus by colonizing the root surface to develop plant roots.

Materials and Methods

In the winter season of 2022-23, practical field studies were conducted within the Horticulture department's field at the School of Agriculture, ITM University, Gwalior. The research activities took place at the Crop Research Center-1, located in Sithouli, Gwalior, Madhya Pradesh (474001). Gwalior falls within the subtropical zone and is positioned at latitude of 26.21240 N and a longitude of 78.17720 E. The elevation of this location is 478 meters above sea level. The climate in Gwalior is characteristic of the subtropical zone. Gwalior district receives approximately 900 mm of rainfall each year on average. Cloudy weather with heavy rainfall over an extended length of time can have a negative impact on the local agricultural sector. The experiment was laid out in Randomized Block Design (RBD) replicated thrice including ten treatments T_1 (Control), T_2 (RDF 100:80:50 Kg/ha), T_3 (FYM 15t/ha + Azotobacter 25% more + PSB 25% more) T_4 (FYM 15t/ha + Azotobacter 50% more + PSB 50% more) T_5 (FYM 15t/ha + Azotobacter 75% more + PSB 75% more) T_6 (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) T_7 (Vermicompost 10t/ha + Azotobacter 25% more + PSB 25% more) T_8 (Vermicompost 10t/ha + Azotobacter 50% more + PSB 50% more) T_9 (Vermicompost 10t/ha + Azotobacter 75% more + PSB 75% more) T_{10} (Vermicompost 10t/ha + Azotobacter 100% more + PSB 100% more). The application of (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) T_6 was found superior to growth parameters as compared to other treatments and recorded maximum growth (*viz.* plant height (cm), number of leaves per plant, length of leaves (cm). The application (Vermicompost 10t/ha + Azotobacter 100% more + PSB 100% more) T_{10} was found superior to yield parameters as compared to other treatments (*viz.* Length of root (cm), Diameter of root (cm), Fresh weight of root (g), Dry weight of root (g), average weight of root (g), total root yield/ plot.

Result and Discussion

1. Plant height

The data from the table no.1 reveals that the plant height at 30 and 45 days after sowing. The plant height was significantly affected by the various treatments the maximum plant height is observed at 30 days (22.12 cm) in the treatment T_6 (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) followed by T_5 (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) 21.72 and minimum was observed at T_1 (Control) 16.40 and at 45 days maximum plant height was observed at (27.87 cm) T_6 (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) followed by T_5 27.82 cm (FYM 15t/ha + Azotobacter 75% more + PSB 75% more) and minimum plant height was observed at T_1 (Control) 20.77 cm. The same outcomes were noted by Jat *et al.*, (2022) [8].

Table 1: Effect of various treatments on Plant height (cm)

Symbol	Treatments	Plant height (cm)	
		30 DAS	45 DAS
T_1	Control	16.40	20.77
T_2	RDF	16.47	25.30
T_3	FYM 15 t/ha+ Azotobacter 25% More+ PSB 25% More	20.93	24.77
T_4	FYM 15 t/ha+ Azotobacter 50% More+ PSB 50% More	20.39	26.75
T_5	FYM 15 t/ha+ Azotobacter 75% More+ PSB 75% More	21.72	27.82
T_6	FYM 15t/ha+ Azotobacter 100% More +PSB 100% More	22.12	27.87
T_7	Vermicompost 10 t/ha+ Azotobacter 25% More+ PSB 25% More	19.34	26.12
T_8	Vermicompost 10 t/ha+ Azotobacter 50% More+ PSB 50% More	20.50	27.37
T_9	Vermicompost 10t/ha+ Azotobacter 75% More+ PSB 75% More	18.60	27.12
T_{10}	Vermicompost 10 t/ha+ Azotobacter 100% More+ PSB 100% More	21.25	27.69
	Mean	19.77	26.16
	SE(m)	1.115	1.1447
	C.D. at 5%	3.31	3.401
	C.V. (%)	9.77	7.58

*****RDF= Recommended dose of fertilizer
*DAS= Days after sowing

2. Number of leaves /plant

Perusal of table 2. Reveals that the mean leaves of plants at 30 days. The maximum number of leaves per plant (8.87) was observed at the T_6 (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) followed by T_4 8.73 (FYM 15t/ha + Azotobacter 50% more + PSB 50% more) and minimum was observed at (7.60) T_2 (RDF 100:80:50 Kg/ha) and at 45 days the maximum number of leaves is observed (10.87) at T_5 **(**FYM 15 t/ha+ Azotobacter 75% More+ PSB 75% More) followed by (10.80) T_6 (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) and minimum is observed (8.73) at T_1 (Control). Similar observations were founded by Saroj *et al.*, (2020) [9] at cauliflower.

Table 2: Effect of various treatments on number of leaves /plant and length of leaves.

Symbol	Treatments	Number of leaves/plant		Length Of Leaves (cm)	
		30 DAS	30 DAS	45 DAS	45 DAS
T_1	Control	7.67	16.68	19.27	8.73
T_2	RDF	7.60	20.29	23.95	10.53
T_3	FYM 15 t/ha+ Azotobacter 25% More+ PSB 25% More	7.87	21.04	23.39	10.60
T_4	FYM 15 t/ha+ Azotobacter 50% More+ PSB 50% More	8.73	21.34	23.81	10.73
T_5	FYM 15 t/ha +Azotobacter 75% More+ PSB 75% More	8.47	19.29	25.59	10.87
T_6	FYM 15t/ha+ Azotobacter 100% More+ PSB 100% More	8.87	22.97	27.65	10.80
T_7	Vermicompost 10 t/ha+ Azotobacter 25% More+ PSB 25% More	8.27	19.87	23.62	9.40
T_8	Vermicompost 10 t/ha+ Azotobacter 50% More+ PSB 50% More	8.27	22.31	25.85	9.27

T_9	Vermicompost 10t/ha+ Azotobacter 75% More+ PSB 75% More	7.93	18.51	23.25	9.80
T_{10}	Vermicompost 10 t/ha+ Azotobacter 100% More+ PSB 100% More	8.33	22.73	27.16	10.20
	Mean	8.2	20.50	24.35	10.09
	SE(m)	0.24	1.1382	1.1229	0.4325
	C.D. at 5%	0.74	3.382	3.336	1.285
	C.V. (%)	5.27	9.62	7.99	7.42

Length of leaves (cm)

Perusal of table 2. Reveals that the mean length of leaf, are presented in table no.2. The maximum length of leaf 30 days 22.97 at T_6 (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) followed by T_{10}(22.73)(Vermicompost 10 t/ha+ Azotobacter 100% More+ PSB 100% More) and minimum was observed at (16.68) T_1 (Control).and at 45 days maximum is observed (27.65) at T_6 (FYM 15t/ha + Azotobacter 100% more + PSB 100% more) followed by T_{10} (Vermicompost 10 t/ha+ Azotobacter 100% More+ PSB 100% More) 27**.**16 and minimum is observed 19.27 at T_1 (Control). The vegetative parameters like leaf length were greatly influenced by organic source and similar findings were observed by Subedi *et al.*, (2018) [10].

Length of root (cm)

The application of organic manures and biofertilizers in different combinations influenced the length of root, are presented in table no.3. The maximum length of root is observed at T_{10} (25.24 cm**)** Vermicompost 10 t/ha+ Azotobacter 100% More +PSB 100% More followed by T_4 (22.28 cm) FYM 15 t/ha+ Azotobacter 50% More+ PSB 50% More and minimum is observed at T_6 (15.03 cm) FYM 15t/ha+ Azotobacter 100% More+ PSB 100% More. Earthworms contribute significantly to soil fertility and production by digesting and turning organic waste into beneficial compost, which may aid in the development of root length. Similar results have been reported by Jaisankar, (2018) [3].

Table 3: Effect of various treatments on Length of root (cm) and Diameter of root (cm)

Symbol	Treatments	Length of root(cm)	Diameter of root(cm)
T_1	Control	17.11	2.68
T_2	RDF	21.00	2.95
T_3	FYM 15 t/ha+ Azotobacter 25% More+ PSB 25% More	19.85	2.99
T_4	FYM 15 t/ha+ Azotobacter 50% More+ PSB 50% More	22.28	3.00
T_5	FYM 15 t/ha +Azotobacter 75% More+ PSB 75% More	21.44	2.79
T_6	FYM 15t/ha+ Azotobacter 100% More +PSB 100% More	15.03	2.41
T_7	Vermicompost 10 t/ha+ Azotobacter 25% More+ PSB 25% More	21.23	2.87
T_8	Vermicompost 10 t/ha+ Azotobacter 50% More+ PSB 50% More	20.52	3.02
T_9	Vermicompost 10t/ha +Azotobacter 75% More+ PSB 75% More	15.45	2.52
T_{10}	Vermicompost 10 t/ha+ Azotobacter 100% More +PSB 100% More	25.24	3.25
	Mean	19.92	2.85
	SE(m)	1.3744	0.1488
	C.D. at 5%	4.084	0.442
	C.V. (%)	11.95	9.04

Diameter of root (cm): Diameter of root was significantly influenced by application of organic manures and biofertilizers are presented in table no.3. The maximum diameter of root was observed (3.25 cm) at T_{10} Vermicompost 10 t/ha+ Azotobacter 100% More +PSB 100% More, followed by T_8 (3.02) Vermicompost 10 t/ha+ Azotobacter 50% More +PSB 50% More and minimum was observed at T_6 (2.41 cm) FYM 15t/ha+ Azotobacter 100% More+ PSB 100% More. These results are consistent with those published by Khede *et al*., (2019) [6].

Fresh weight of root (g): Data in respect of fresh weight of root (g) influenced by organic manures and biofertilizers are presented in table no.4. It is evident from the data that the fresh weight of root was significantly affected by organic manures and biofertilizers. The maximum fresh weight of root is observed (130.27g) at T_{10} Vermicompost 10 t/ha+ Azotobacter 100% More +PSB 100% More, followed by (98.47) T_2 (RDF 100:80:50 NPK kg/ha) and minimum is observed at T_9 (49.33 g) Vermicompost 10 t/ha+ Azotobacter 75% More +PSB 75% more. Similar observations have been reported by Uddain *et al.*, (2010) [4].

Table 4: Effect of various treatments on fresh weight of root (g) and Dry weight of root (g)

Symbol	Treatments	Fresh weight of root(g)	Dry weight of root(g)
T_1	Control	54.56	7.38
T_2	RDF	98.47	9.53
T_3	FYM 15 t/ha+ Azotobacter 25% More+ PSB 25% More	78.09	6.72
T_4	FYM 15 t/ha+ Azotobacter 50% More+ PSB 50% More	85.33	9.71
T_5	FYM 15 t/ha+ Azotobacter 75% More+ PSB 75% More	94.80	9.79
T_6	FYM 15t/ha+ Azotobacter 100% More +PSB 100% More	60.00	7.54
T_7	Vermicompost 10 t/ha+ Azotobacter 25% More+ PSB 25% More	66.67	7.76
T_8	Vermicompost 10 t/ha+ Azotobacter 50% More+ PSB 50% More	84.60	9.87
T_9	Vermicompost 10t/ha+ Azotobacter 75% More+ PSB 75% More	49.33	7.27
T_{10}	Vermicompost 10 t/ha+ Azotobacter 100% More +PSB 100% More	130.27	17.54
	Mean	80.21	9.31
	SE(m)	5.6907	0.6741
	C.D. at 5%	16.908	2.003
	C.V. (%)	12.29	12.54

Dry weight of root (g)

Dry weight of root was significantly influenced by application of organic manures and biofertilizers, data is presented at table no.4. The maximum dry weight of root is observed at T_{10} (17.54 g) Vermicompost 10 t/ha+ Azotobacter 100% More +PSB 100% More, followed by T_8 (9.87) Vermicompost 10 t/ha+ Azotobacter 50% More +PSB 50% More and minimum is observed at (6.72 g) T_3 FYM 15t/ha+ Azotobacter 25% More+ PSB 25% More. Similar findings have been reported by khede *et al.*, (2019) [6].

Average weight of root (g)

Data in respect of fresh weight of root (g) influenced by organic manures and biofertilizers are presented in table no.5. It is evident from the data that the average weight of root was significantly affected by organic manures and biofertilizers. The maximum average weight of root is observed (130.27g) at T_{10} Vermicompost 10 t/ha+ Azotobacter 100% More +PSB 100% More, followed by (98.47) T_2 (RDF 100:80:50 NPK kg/ha) and minimum is observed at T_9 (49.33 g) Vermicompost 10 t/ha+ Azotobacter 100% More +PSB 100% more.

Table 5: Effect of various treatments on average weight of root (g) and total root yield per plot (kg)

Symbol	Treatments	Average weight of root (g)	Total root yield/Plot
T_1	Control	54.56	1.037
T_2	RDF	98.47	1.793
T_3	FYM 15 t/ha+ Azotobacter 25% More+ PSB 25% More	78.09	1.350
T_4	FYM 15 t/ha+ Azotobacter 50% More+ PSB 50% More	85.33	1.473
T_5	FYM 15 t/ha+ Azotobacter 75% More+ PSB 75% More	94.80	1.760
T_6	FYM 15t/ha+ Azotobacter 100% More +PSB 100% More	60.00	1.077
T_7	Vermicompost 10 t/ha+ Azotobacter 25% More+ PSB 25% More	66.67	1.290
T_8	Vermicompost 10 t/ha+ Azotobacter 50% More+ PSB 50% More	84.60	1.390
T_9	Vermicompost 10t/ha+ Azotobacter 75% More+ PSB 75% More	49.33	0.977
T_{10}	Vermicompost 10 t/ha+ Azotobacter 100% More +PSB 100% More	130.27	1.813
	Mean	80.21	1.396
	SE(m)	5.4998	0.1202
	C.D. at 5%	16.341	0.357
	C.V. (%)	11.88	14.91

Total root yield/plot (kg)

The data from the table no.5 reveals that the total root yield /plot (kg). The maximum root yield is observed (1.813 kg) at T_{10} Vermicompost 10 t/ha + Azotobacter 100% More + PSB 100% More, followed by (1.793) at T_2 (RDF 100:80:50 NPK kg/ha) and minimum is observed at T_9 (0.977 g) Vermicompost 10 t/ha+ Azotobacter 100% More + PSB 100% more. Similar results were reported by Verma *et al.*, (2017) [12].

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