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Effect of integrated nutrient management on growth and yield of radish (*Raphanus sativus* L.) variety Pusa Chetki long at Namsai district of Arunachal Pradesh

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Abstract
The present investigation entitled "Effect of integrated nutrient management on growth and yield of Radish (*Raphanus sativus* L.) var. Pusa Chetki Long" was carried out during the Rabi season of the year 2022-23 at the Arunachal University of Studies, Namsai, Arunachal Pradesh. The main objective of this field study was to evaluate the effect of organic manures, inorganic manures and biofertilizers with different doses on the growth and yield of radish and also to study the economics for each treatment. The experiment was laid out in Randomized Block Design (RBD) with seven treatments replicated thrice. The treatments were *via* T_0 (Control), T_1 (20 t/ ha FYM + 100: 60: 100 NPK + 0.05 Azotobacter), T_2 (16 t/ ha FYM +130: 80: 130 NPK+ 0.04 Azotobacter), T_3 (12 t/ ha FYM + 150: 90: 150 NPK + 0.05 Azotobacter), T_4 (8 t/ ha FYM + 60: 40: 60 NPK + 0.04 Azotobacter), T_5 (4 t/ ha FYM + 30:20:30NPK + 0.05 Azotobacter), and T_6 (1 t/ ha FYM + 15:10:15 NPK + 0.04 Azotobacter). The results revealed that application of T_3 (12 t/ ha FYM + 150: 90:150 NPK + 0.05 Azotobacter) recorded significantly higher plant height, number of leaves and yield attributes like root length, root girth, fresh weight of root and root yield. Also recorded highest B:C ratio under the treatment T_3 (12 t/ ha FYM + 150: 90:150 NPK + 0.05 Azotobacter).

Keywords: Organic manures, inorganic fertilizers, biofertilizers, FYM, NPK, azotobacter, radish and B:C

Introduction
Radish (*Raphanus sativus* L.) is an important winter season vegetable, grown throughout the country. It is both an annual and biennial crop that belongs to the family Cruciferae. In the last few decades, India has made a quantum jump in vegetable production, securing the second position after China in the world with an area of 9.542 million hectares and production of 168.3 million tonnes. Our demand of vegetables will be 225 million tonnes by 2020 and 350 million tonnes by 2030, to meet out the requirement of 300 g per capita per day for balanced diet (Sharma *et al*., 2018) [25]. Radish is a fast-growing root vegetable that grows well in cool and moist climates. It thrives best in well-draining sandy loams with a pH of 5.8 to6.8 and a temperature range of 10 to 18 °C (50–65°F). It is a short-duration vegetable and takes only 50 to 65 days to come to harvest. Generally, Radish is grown for the consumption of its fresh tender tuberous root which can be used as cooked or raw food as a salad. Its green leaves are a good source of vitamin A and are also used as green leafy vegetables (Reddy, 2020) [24]. It contains mustard oils which give it pungency. The pungent flavour in radish is due to the presence of volatile Isothiocyanates.

Radish being a short duration and quick growing crop. The root growth is rapid and uninterrupted. Hence, for the production of good quality roots and higher yield, optimum fertilizers especially nitrogen, phosphorous and potassium assume special significance. The growth of radish plant is checked due to lack of nitrogen and substantially by phosphorous and potassium (Lucas and De Frietas, 1960) [15].

Integrated nutrient management is the combined application of chemical fertilizers and organic manures for crop production. Its main aim is the maintenance of soil fertility and the supply of plant nutrients in adequate amounts. It is ecologically, socially and economically viable. Nutrient management refers to the efficient use of crops to improve productivity. INM helps to obtain agronomically feasible, economically viable, environmentally sound and sustainable high crop yields (Kafle *et al.,* 2019) [4].

It is necessary to balance the soil nutrient input with the crop requirement. If the nutrients are applied at the right time and in adequate quantities, optimum crop yield is obtained. Integrated nutrient management is a tool which can offer good options and economic choices to supply plants with sufficient amounts of most macro- and micronutrients also can reduce the dose of chemical fertilizers, create favourable soil physiochemical conditions and healthy environment. Optimum nutrition should be provided through organic, inorganic, and biofertilizers sources for smooth and better production.

Farm Yard Manure helps to improve crop growth by providing nutrition and improving the physical, chemical and biological properties of soil (Mengistu and Mekonnen *et al*, 2012) [18]. Farm Yard Manures (FYM) is available in plenty in locality and can be effectively utilized for vegetable production. It is bulky in nature and containing small quantity of nutrients which are required in large quantities, however it also contains trace or micronutrients in sufficient amount, the deficiency of which cannot be supplemented by others.

Biofertilizers or microbial activity are eco-friendly, non-bulky, cheap, and renewable sources of nutrients for plants. The application of biofertilizers also helps in improving biological activities of soil. Nitrogen fixing bacteria belongings to genus Azospirillum is known to increase the yield by 5 to 20 percent with a saving of nitrogen up to 40 percent of the recommended dose.

Azotobacter can add 20-25 kg N ha-1, Phosphorus Solubilizing bacterial biofertilizers can solubilize 30-50 kg P2O5 ha-1 and Potassium Solubilizing bacterial biofertilizers not only enhance plant growth and yield but also can lessen the use of agrochemicals and support eco-friendly crop production. They liberate growth promoting substances and vitamins which may increase crop yield (Sharma *et al*., 2013) [26]. Azospirillum not only fixes biological nitrogen but also produces a growth regulator like substance (Sunderavelu and Muthukrishnan, 1993) [28].

Materials and Method

The present experiment was conducted to find out the effect of integrated nutrient management with different doses of each fertilizers on growth and yield of radish (*Raphanus sativus* L.,) at Arunachal University of Studies, Namsai Arunachal Pradesh during the months of November to December 2022. Namsai lies between 27.66920N latitude and 95.86440E longitude at an elevation of average 156 meter from MSL. Namsai belongs to sub-tropical zone and falls under the agro-climatic zone of Eastern Himalaya region (by KVK, Momomg, Namsai district under ICAR AP Centre Basar, Arunachal Pradesh) with an average annual rainfall of 3500-4000 mm, at the temperature of 280 c to 400 c during summer and 100 c to 250 c during winter respectively, with humidity 90% during summer and 62% during winter. The soil type of the experimental field is sandy loam and acidic in nature with a pH 5-6. The experiment was laid out in a Randomized Block Design (RBD) with seven treatments replicated thrice. The treatments were *via* T_0 (Control), T_1 (20 t/ ha FYM + 100: 60: 100 NPK + 0.05 Azotobacter), T_2 (16 t/ ha FYM +130: 80: 130 NPK+ 0.04 Azotobacter), T_3 (12 t/ ha FYM + 150: 90: 150 NPK + 0.05 Azotobacter), T_4 (8 t/ ha FYM + 60: 40: 60 NPK + 0.04 Azotobacter), T_5 (4 t/ ha FYM + 30:20:30NPK + 0.05 Azotobacter), and T_6 (1 t/ ha FYM + 15:10:15 NPK + 0.04 Azotobacter). Seeds were sown in recommended spacing of 25 x 15 cm between rows and plants. All the recommended agronomic practices and crop husbandry were followed to raise a good crop. Different dose of FYM @ t/ha and different doses of NPK fertilizers (Nitrogen through Urea, Phosphorus through Single Super Phosphate and Potassium through Murate of Potash) according to treatments will be applied in all the treatments and replications. The entire dose of FYM, phosphorus and potassium and half dose of nitrogen will be applied at the time of last ploughing whereas, half dose of nitrogen will be applied at 25 days after sowing at the time of weeding-cum hoeing. Three plants were selected randomly from each net plot to record the observation namely, Days Taken to harvest, plant height (cm), length and girth of roots (cm), weight of root (g), no. of leaves (cm), Root Yield/plot (kg) and Benefit: Cost ratio. The data recorded on different parameter during the year of investigation were statically analysed as per the statistical methods described by (Panse and Sukhatme, 1985) [19].

Results and Discussion

The results obtained from the experimental study entitled **"**Effect of Integrated Nutrient Management on Growth and Yield of Radish (*Raphanus sativus* L.)" have been presented in this chapter.

Growth parameters

Table 1: Effect of INM on growth parameters of radish *cv*. Pusa Chetki Long

No. of Treatments	Treatment combination	Germination (%)	Plant height (cm)			No. of leaves count-1 (cm)		
			20 DAS	30 DAS	40 DAS	20 DAS	30 DAS	40 DAS
T_0	Control	94.33	7.17	17.00	27.67	9.67	14.00	14.33
T_1	20 t/ ha FYM + 100: 60:100 NPK + 0.05 Azotobacter	97.33	11.17	20.43	32.17	13.00	15.00	16.00
T_2	16 t/ ha FYM +130: 80: 130 NPK + 0.04 Azotobacter	98.00	13.33	22.17	40.00	14.00	16.67	17.00
T_3	12 t/ ha FYM + 150: 90:150 NPK + 0.05 Azotobacter	98.67	15.00	23.00	40.83	14.33	17.00	17.00
T_4	8 t/ ha FYM + 60: 40: 60 NPK+ 0.04 Azotobacter	96.33	11.00	20.50	32.00	13.33	15.67	16.00
T_5	4 t/ ha FYM + 30:	95.67	9.67	19.33	30.00	12.67	14.00	15.33

	20: 30 NPK+ 0.05 Azotobacter							
T_6	1 t/ ha FYM + 15: 10: 15 NPK + 0.04 Azotobacter	95.33	8.67	18.33	29.00	11.33	14.00	14.33
S.E(d)		1.21	1.04	0.82	0.88	1.21	0.51	0.56
C.D (5%)		2.68	2.29	1.81	1.94	2.67	1.12	1.23

Germination percentage

From Table No. 1, it can be observed that the highest Germination percentage was recorded on T_3 (12 t/ ha FYM + 150: 90: 150 NPK + 0.05 Azotobacter) (98.67) followed by T_2 (98.00). The analysed result of Germination percentage showed significant (p<0.05) difference between different treatments. Seed germination is influenced by various environmental factors such as availability of moisture, light, air, and optimum temperature. This may be due to better moisture holding capacity, supply of adequate amount of nutrients due to favourable soil conditions (Reddy *et al.*, 2011) [23]. The FYM possesses a positive effect on increasing soil carbon while applied alone or incorporated with biofertilizers and inorganic fertilizers (Chumyani *et al*., 2012) [3]. Similar findings had been reported by Pant *et al*., (2021) [2].

Plant height (cm)

Among the treatments, T_3 (12 t/ ha FYM + 150: 90: 150 NPK + 0.05 Azotobacter) recorded the maximum value of plant height during different stages (15.00 cm, 23.00 cm and 40.83 cm at 20, 30 and 40 DAS). This is due to FYM import physical, chemical and biological properties of soil which help better nutrient absorption and utilization by plants resulting in better plant growth Pant *et al*., 2021) [20]. According to Poudel *et al*., (2018) [21] highly significant results of plant height for different nitrogen levels was observed in radish. The findings are also agreements with the Upadhyay *et al*., (2021) [29] by application of organic manures and biofertilizers on growth and yield of radish var. Kashi Shweta. Similarly observed by Kumar *et al*., (2022) [11] impact of growth and quality on radish as influenced by different doses of NPK.

No. of leaves (cm)

At 20, 30 and 40 DAS, the highest no. of leaves plant-1 (14.33, 17.00, and 17.00) were recorded in treatment T_3 (12 t/ ha FYM + 150: 90: 150 NPK + 0.05 Azotobacter), respectively. While lowest no. of leaves plant-1 (9.67, 14 and 14.33) in treatment T_5 (4 t/ ha FYM + 30:2:30 NPK + 0.05 Azotobacter), respectively. This may be due to combination of inorganic fertilizers with organic manure to increase in cation exchange capacity, and water holding capacity. It can also supply all the necessary primary and secondary nutrients require for plant growth *i.e.*, leaves plant-1. Above result are in conformity with Basnet *et al.*, (2021) [1] Mani and Anburani (2018) [16] and Mehwish *et al.*, (2016) [17]. Balbande *et al.*, (2023) [2] observed the maximum no. of leaves by application of integrated nutrient management in radish. Another reason might be due to higher level of nitrogen application which increased the plant height and ultimately the leaf number. Similar finding had been reported by Kumar *et al.*, (2022) [11] observed that the application of different doses of nitrogen significantly influenced the number of leaves.

This result clearly depicted that integrated usage of NPK + organic manures considerably boosted no. of leaves, this might be attributed to availability of balanced nutrition to the growing crop that enhanced no. of leaves (Khalid *et al*., 2016) also reported that increase in no. of leaves when a combination of NPK along with FYM and Biofertilizers were used.

Yield parameters

Table 2: Effect of INM on yield attributes of radish *cv*. Pusa Chetki Long

No. of treatments	Treatment combination	Root length (cm)	Root girth (cm)	Fresh root Weight plant-1 (g)	Root yield plot-1 (kg)	Total yield (q/ha -1)	B:C
T_0	Control	19.33	3.33	140.00	4.63	115.71	2.4
T_1	20 t/ ha FYM + 100: 60: 100 NPK + 0.05 Azotobacter	22.33	4.13	175.00	9.10	227.50	3.1
T_2	16 t/ ha FYM +130: 80: 130 NPK + 0.04 Azotobacter	25.67	5.00	198.33	9.57	239.17	3.4
T_3	12 t/ ha FYM + 150: 90: 150 NPK + 0.05 Azotobacter	27.00	5.10	206.67	9.57	239.25	3.6
T_4	8 t/ ha FYM + 60: 40: 60 NPK + 0.04 Azotobacter	22.00	3.93	168.33	7.10	177.50	3.0
T_5	4 t/ ha FYM + 30: 20: 30 NPK + 0.05 Azotobacter	20.83	3.70	158.33	6.27	156.67	2.9
T_6	1 t/ ha FYM + 15: 10: 15 NPK + 0.04 Azotobacter	19.67	3.47	150.00	5.25	131.21	2.6
S.E (d)±		1.45	0.23	9.16	0.40	9.99	-
C.D (5%)		3.19	0.51	20.16	0.88	22.02	-

Root length and root girth

The root length found at the time of harvesting stage significantly longest root length were recorded in T_3 (27.00 cm) followed by T_2 (25.67 cm), T_1 (22.33 cm), T_4 (22.00 cm), T_5 (20.83 cm), T_6 (19.67 cm) and T_0 (19.33 cm) respectively. The analysis of variance showed significant (p<0.05) difference between treatments for root length. The root girth found at the time of harvesting stage significantly thickest root girth were recorded in T_3 (5.10 cm) followed by T_2 (5.00 cm), T_1 (4.13 cm), T_4 (3.93 cm), T_5 (3.70 cm), T_6 (3.47 cm) and T_0 (3.33 cm) respectively. The analysis of variance showed significant (p<0.05) difference between treatments for root length.

The findings pertaining yield parameters *viz*. root length and root girth treatments T 3 (12 t/ ha FYM + 150: 90: 150 NPK + 0.05 Azotobacter) was recorded highest root length and root girth. The increase in length of root, girth of root may be attributed to solubilisation of plant nutrients by addition of FYM and biofertilizers leading to increase uptake of NPK. The increased application of FYM applied increased the soil porosity and water holding capacity while decrease the bulk density (Rasool *et al*., 2008) [22], which ultimately help is in the root growth and development. The results are also in agreement with the earlier findings by Mehwish *et al.*, (2016) [17]. Balbande *et al.*, (2023) [2] who stated that due to the application of INM the yield parameters of the plant increase the root length and root girth in radish var. MAHY22.

Fresh root weight of plant increased significantly by the different INM treatments. The significantly fresh weight of plant was recorded in T_3 (206.67 g) followed by T_2 (198.33 g), T_1 (175.00 g), T_4 (168.33 g), T_5 (158.33 g), T_6 (150.00 g) and T_0 (140.00 g) respectively. Maximum fresh root weight recorded in treatments T_3 (12 t/ha +150: 90: 150 NPK+ 0.05 Azotobacter), this is due to FYM also function as source of food and source of energy for soil micro flora which bring transformation of inorganic nutrients present in soil or applied in the form of fertilizers. The findings are also agreements with findings Yawalkar *et al.*, (2007) [30]. Upadhyay *et al.*, (2021) [29] reported that due to the application of organic manures and biofertilizers T_3 was found maximum yield attributes in radish var. Kashi Shweta.

This may be due to the application of inorganic fertilizers with organic manure to increase fresh weight. The finding corroborates with the results of Mehwish *et al*., (2016) [17] in radish. Similar result was observed by Kumar *et al.*, (2022) [11] the maximum fresh root weight obtained by application of INM in radish.

Root yield per plot (kg)

The significantly maximum root yield of plant was recorded in T_3 (9.57 kg) followed by T_2 (9.57 kg), T_1 (9.10 kg), T_4 (7.10 kg), T_5 (6.27 kg), T_6 (5.25 kg) and T_0 (4.63 kg) respectively. The maximum root yield per plot recorded maximum in treatments T_3 (12 t/ha+150: 90: 150 NPK+0.05 Azotobacter). Probable reason for increased root yield per plot due to humus substances could have mobilised the reserve food materials to the sink through increased activity of hydrolysing and oxidizing enzymes. The result of this result had been found similar with the result of Mehwish *et al.*, (2016) [17] in radish. Similar result was observed by Kumar *et al.*, (2023) [31] the maximum fresh root weight obtained by application of INM in radish.

Total yield (q/ha) and B:C ratio

The significantly maximum root yield of plant was recorded in T_3 (239.25 q/ha) followed by T_2 (239.17 q/ha), T_1 (227.50 q/ha), T_4 (177.50 q/ha), T_5 (156.67 q/ha), T6 (131.21 q/ha), and T_0 (115.71 q/ha) respectively. The maximum root yield per plot recorded maximum in treatments T 3 (12 t/ha+150: 90:150 NPK+ 0.05 Azotobacter). This result revealed that incorporation of NPK in combination with FYM remarkably augmented root yield of radish. This increment in root yield might be due reduction in nutrient losses, improved fertilizer use efficiency and increased crop yield. The remarkable increased yields of radish with INM practices have been reported by Sharma *et al*., (2012) [27] and Kumar *et al.*, (2017) [13] which correspond to these findings. Similar results were also recorded by Kiran *et al*., (2019) [8] by application of organic manure and inorganic fertilizers on the growth and yield of Radish. Highest B:C ratio of 3.6 was recorded under the treatment T_3 (12 t/ha+150: 90:150 NPK+ 0.05 Azotobacter).

Conclusion

On the basis of present investigation, it is concluded that the treatment T_3 (12 t/ha FYM + 150: 90: 150 NPK + Azotobacter) was found to be the best treatment combination in terms of higher growth parameters (plant height, no. of leaves) and yield attributes like root length, root girth, fresh root of weight and root yield per plot in radish (*Raphanus sativus.* L.) *cv*. Pusa Chetki Long as compare to other treatments under Namsai Agro-climatic conditions of Arunachal Pradesh. Thus, proper management of nutrient increased the growth and development of radish. Based on the findings of this study, it may be recommended that organic manures can be used to provide nutrition radish and attain yields that generally are comparable to that obtained with Integrated Nutrient Management. A comparable level of productivity can be achieved with a lowered level of inorganic fertilizers combined with manures or INM.

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