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Effect of integrated nutrient management on growth and yield of radish (*Raphanus sativus* L.) cultivars

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Abstract
The field experiment was conducted at Horticulture Research Farm-I, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.) during rabi season of 2021-22 to study the Effect of Integrated Nutrient Management on Growth and Yield of Radish (*Raphanus sativus* L.) Cultivars. Three varieties and thirteen nutrients with three replications were evaluated in Factorial Randomized Block Design. The results revealed that the maximum plant height (26.32 cm), number of leaves (15.10), leaf length (21.06 cm), leaf width (5.58 cm), and maximum seed germination (97.30%) were noted in variety Kashi Mooli-40. The, maximum fresh weight of leaves (269.86 g), length of root (21.59 cm), weight of root (159.44 g), root yield kg/plot (4.01 kg) and root yield (533.84 q ha^{-1}) is observed in variety Kashi Mooli-40 and in case of nutrients the maximum plant height (26.71cm), number of leaves (17.87), leaf length (21.33 cm), leaf width (5.83 cm) and maximum germination (98.48%) was observed in treatments N_5 during growth characters. While the maximum fresh weight of leaves (272.50 g), weight of root (171.23 g) and root yield (572.93 q/ha) were recorded in treatments N_5 (RDF 75% + Azotobacter + PSB).

Keywords: Azotobacter, PSB, FYM, radish, growth and yield

Introduction
Radish (*Raphanus sativus* L.) is a popular root vegetable grown in both tropical and temperate regions belongs to the family of Cruciferae and is a native of Europe and Asia. Radish is grown for its young tender and fusiform tuberous root which is consumed either raw (salad) or cooked (vegetable). The edible part of radish is modified root that develops from primary roots as well as hypocotyls both. Radish is a good source of minerals like calcium, potassium and phosphorous and vitamin A, vitamin C and due to its medicinal properties it is prescribed for patients suffering from piles, chronic diarrhea, liver troubles and jaundice. Radish is a cool season vegetable crop but the varieties of Asiatic type can also tolerate high temperature than the European varieties. The leaves of radish are a good source for extraction of protein in a commercial basis. The characteristic pungent flavour of radish is due to the presence of volatile is thiocyanate. 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) [2]. If the nutrients are applied at the right time and in adequate quantities, optimum crop yield is obtained. 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) [6]. The chemical analysis of Vermi compost reveals that the N, P_2O_5, K_2O, content was 0.8, 1.1, 0.5, respectively. Biofertilizers are the natural fertilizer that may be used to supplement or replace chemical fertilizer in sustainable agriculture (Ebrahimpour *et al*., 2011) [1]. Consortia is a liquid bio fertilizer containing free living nitrogen fixing Azotobacter, Phosphorus solubilize bacteria (PSB). Moreover, this approach is economically cheap, technically sound, practically feasible and is capable of maintaining the sustainability in production.

Materials and Method

The experiments were conducted during winter season of 2021-22 at Horticulture Research Farm-I, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.), India. The experimental site is situated at 80° 92′'East longitude and 26° 76′' North latitude and 123 meter above MSL (Mean Sea Level). The climate of Lucknow is characterized by sub-tropical with hot, dry summer and cool winters. The soil of experimental field is sandy loam and slightly alkaline in nature with soil pH 8.2, 85.46 kg ha-1 available nitrogen, 16.62 kg ha-1 and 142.07 kg ha-1 available potash. In a Factorial Randomized Block Design with three replications, three varieties: V_1 (Kashi Aarorus), V_2 (Kashi Shweta) and V_3 (Kashi Mooli-40 with thirteen nutrients i.e. N_1-RDF 100%, N_2- RDF 75% + FYM, N_3- RDF 75% + Azotobacter, N_4- RDF 75% + PSB, N_5- RDF 75% + Azotobacter + PSB, N_6- RDF 50% + FYM, N_7- RDF 50% + Azotobacter, N_8- RDF 50% + PSB, N_9- RDF 50% + Azotobacter + PSB, N_{10}- RDF 25% + FYM, N_{11}- RDF 25% + Azotobacter, N_{12}- RDF 25% + PSB, N_{13}- RDF 25% +Azotobacter + PSB, respectively. To raise the crop, appropriate management practices have been used. Randomly five plants were selected in each plot and data was recorded on the following growth and yield parameters *viz*.- germination percentage, plant height (cm), number of leaves per plant, leaf of length (cm), leaf of width(cm), fresh weight of leaves (g), length of root (cm), weight of root (g), yield kg/plot and yield q/ha. The observations on growth and yield parameters were statistically analysis of the data obtained in different set of experiments was calculated following the standard procedure as stated by (Panse and Sukhatme, 1985) [11]. The data were analysed and are presented at the 5% level of significance.

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.

Effect of varieties and nutrients on growth parameters

Germination percentage: From Table No.1, it can be observed that the highest Germination percentage was recorded on variety V_3 (Kashi Mooli-40) (97.30%), followed by variety V_1 (96.94). The analysis result of Germination percentage showed non- significant difference between different varieties. Seed germination is influenced by various environmental factors such as availability of moisture, light, air, and optimum temperature. Similar finding had been reported by pant *et al.*, (2021) [7].

Growth parameters: The finding pertaining to growth parameters *viz*., plant height, number of leaves, length of leaves and width of leaves were observed at harvesting stage. There was significant effect of different genotype and nutrients levels on all the growth parameters.

Variety, V_3 (Kashi Mooli-40) recorded maximum plant height (26.32 cm) at harvesting stage and followed by V_2 (Kashi Sweta) (25.81cm), while the minimum plant height was found with variety V_1 (Kashi Aarorus). The variation in plant height of radish varieties may be due to their genetic constituent. These finding are in agreement with the finding of Rawat *et al.*, (2014) [12].

Among nutrients levels N_5, (RDF75% + Azotobacter + PSB) has reported maximum plant height at harvesting stages. While minimum plant height was found with nutrients level N_1. highly significant results of plant height for different nutrients levels was observed in radish. The findings are also agreements with the Upadhyay *et al.*, (2021) [9].

The number of leaves per plant was influenced significantly due to different treatments of genotypes and nutrients levels. Maximum number of leaves per plant was observed in variety V_3 (Kashi Mooli-40) at harvesting stages, followed by variety V_2 (Kashi Sweta). Minimum number of leaves per plant was observed with variety V_1 (Kashi Aarorus). These findings are in agreement with the findings of Singh and Rajodia (2001) [13]. Nutrients levels had exerted significant effect on number of leaves per plant. Among the nutrients level maximum number of leaves were recorded with nutrients level N_5 (RDF 75%+ Azotobacter+ PSB) (17.81). While the minimum number of leaves was found with nutrients level N_1 (12.48). The increase in number of leaves may be due to increased availability of higher dose of fertility levels. Similar results have been reported by Thapa *et al* (2003) [14].

The length of leaves per plant was influenced significantly due to different treatments of genotypes and nutrients levels. Maximum length of leaves per plant was observed in variety V_3 (Kashi Mooli-40) at harvesting stage, followed by variety V_2 (Kashi Sweta). Minimum number of leaves per plant was observed with variety V_1 (Kashi Aarorus). Among nutrients levels N_5, (RDF 75%+ Azotobacter+ PSB) has reported maximum length of leaves at harvesting stages. While minimum length of leaves was found with nutrients level N_1. highly significant results of length of leaves for different nutrients levels was observed in radish.

As from the experiment width of leaves per plant was affected significantly with different treatments at harvesting stage. Variety V_3 (Kashi Mooli-40) recorded significantly maximum width of leaves per plant i.e. (5.58 cm) at harvesting stage as compared to variety V_2 (Kashi Sweta). Among nutrients levels N_5, (RDF 75%+ Azotobacter+ PSB) has reported maximum width of leave at harvesting stages. While minimum width of leaves was found with nutrients level N_1. highly significant results of width of leaves for different nutrients levels was observed in radish.

Table 1: Effect of varieties and INM on growth parameters of radish during 2021-22

Symbol	Germination %	Plant height	Number of leaves	Width of leaves	Length of leaves
Varieties					
V_1	96.94	25.13	14.87	5.20	19.92
V_2	96.81	25.81	14.94	5.38	20.27
V_3	97.30	26.32	15.10	5.58	21.06
SE.m. ±	0.621	0.165	0.091	0.037	0.113
CD at 5%	NS	0.466	NS	0.103	0.319
Nutrients					
N_1	96.24	24.37	12.48	4.49	19.13
N_2	96.62	25.49	14.36	5.23	20.12
N_3	97.37	26.26	15.22	5.63	20.87
N_4	97.18	26.39	15.53	5.53	20.87
N_5	98.48	26.71	17.87	5.83	21.33
N_6	96.33	26.59	14.23	5.76	21.11
N_7	96.70	25.53	14.51	5.36	20.31
N_8	97.11	27.22	14.65	5.73	21.19
N_9	97.12	25.91	16.26	5.59	20.67
N_{10}	97.28	25.34	15.65	4.80	19.72
N_{11}	96.45	24.08	15.14	5.43	20.26
N_{12}	97.48	25.37	15.59	5.47	19.92
N_{13}	96.65	25.57	13.11	5.39	19.91
SE.m. ±	1.293	0.34	0.189	0.076	0.235
CD at 5%	NS	0.96	0.534	0.215	0.664

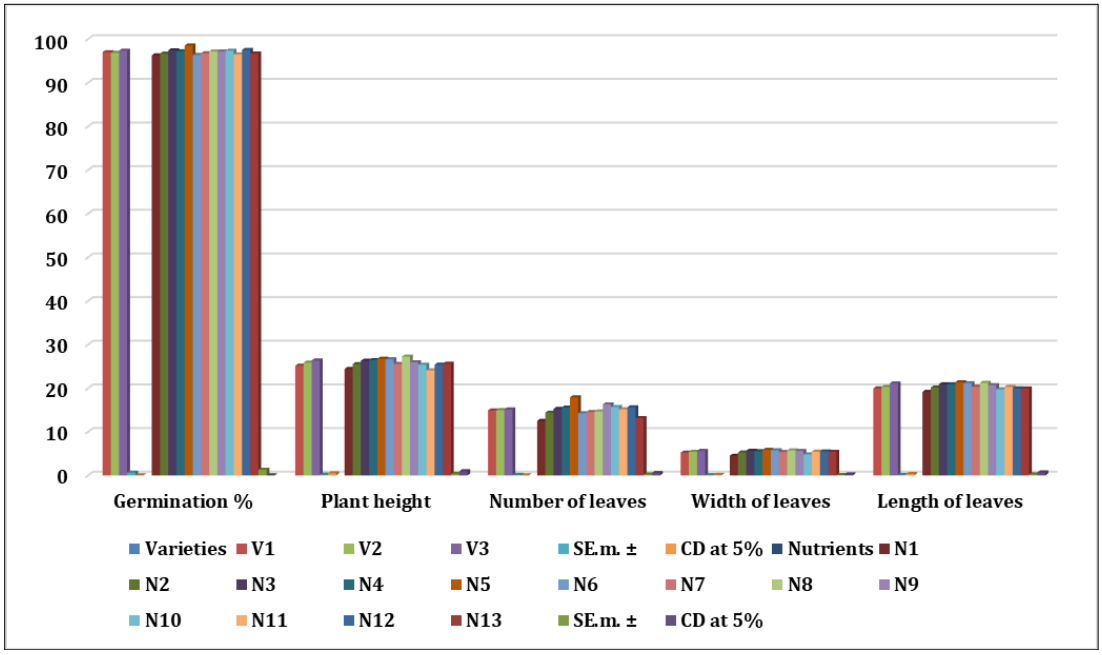

Fig 1: Effect of varieties and INM on growth parameters of radish during 2021-22

Effect of varieties and nutrients on yield parameters

The root length found at the time of harvesting stage significantly longest root length were recorded in variety V_3 (Kashi Mooli-40) (21.59 cm), followed by variety V_2 (Kashi Sweta) (21.01 cm). The analysis showed significant difference between treatments for root length. The weight of root found at the time of harvesting stage significantly highest root weight were recorded in variety V_3 (159.44 g), followed by variety V_2 (158.90 g).

The finding pertaining yield *viz*. root length and weight of root nutrients N_5 (RDF 75%+ Azotobacter+ PSB) was recorded highest root length and root weight. The increase in length of root, weight of root may be attributed to solubilisation of plant nutrients by addition of FYM and bio fertilizers leading to increase uptake of azotobacter. The increase application of FYM applied increased the soil porosity and water holding capacity while ultimately help is in the root growth and development. Similar result was observed by Kumar *et al*., (2022) [3] the maximum fresh weight of root obtained by application of inorganic fertilizers with organic manures to increase fresh weight.

Variety, V_3 (Kashi Mooli-40) recorded maximum fresh weight of leaves /plant (269.86 g) at harvesting stage and followed by V_2 (Kashi Sweta) (260.41 g), while the minimum fresh weight of leaves /plant was found with variety V_1 (Kashi Aarorus). The variation in fresh weight of leaves /plant of radish varieties may be due to their genetic constituent. These finding are in agreement with the finding of Rawat *et al.*, (2014) [12]. Fresh weight of leaves of plant increased significantly by the different INM treatments. The significantly fresh weight of leaves was recorded in nutrients N_5 (272.50 g) and minimum weight of fresh leaves was recorded under N_1 (242.55 g). This is due to FYM also function as source of food and energy for soil micro flora

which bring transformation of inorganic nutrients present in soil. The finding are also agreements with finding Yawalkar *et al*., (2007) [10].

Root yield per plot (kg) and q/ha The significantly maximum root yield of plant was recorded in variety V_3 (Kashi Mooli-40) (4.01 kg and 533.84 q), respectively, followed by variety V_2 (Kashi Sweta) (4.00 kg and 529.45 q) respectively. In case of nutrients the maximum root yield in treatments N_5 (RDF 75%+ Azotobacter+ PSB) (4.35 kg and 572.93 q) respectively and minimum root yield in treatment N_1 (3.57 kg and 473.03 q) respectively. Probable reason for increased root yield due to humus substance could have mobilised the reserve food materials to the sink through increased activity of hydrolysing and oxidizing enzymes. The result of this results had been found similar with the results of Mehwish *et al.*, (2016) [5]. This result revealed that incorporation of INM 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) [8]. and Kumar *et al*., (2017) [4]. Which correspond to these findings. Similar results were also recorded by Kiran *et al*., (2019) [15]

Table 2: Effect of varieties and INM on yield parameters of radish during 2021-22

Symbol	Fresh weight of leaves (g)	Length of root (cm)	Weight of root (g)	Root yield (kg/plot)	Root yield (q/ha)
Varieties					
V_1	251.54	20.20	151.87	3.80	506.63
V_2	260.41	21.01	158.90	4.00	529.45
V_3	269.86	21.59	159.44	4.01	533.84
SE.m. ±	1.64	0.132	0.889	0.026	3.351
CD at 5%	4.64	0.371	2.508	0.073	9.457
Nutrients					
N_1	242.55	19.45	142.37	3.57	473.03
N_2	253.73	20.55	153.16	3.84	508.97
N_3	261.55	21.25	161.06	4.04	535.32
N_4	262.75	21.52	162.13	4.07	538.87
N_5	272.50	22.56	171.23	4.35	572.93
N_6	264.73	21.65	164.27	4.12	546.00
N_7	254.20	20.54	153.69	3.86	510.74
N_8	265.55	21.81	165.02	4.14	548.52
N_9	258.02	21.01	157.58	3.95	523.72
N_{10}	252.28	20.41	151.69	3.81	504.08
N_{11}	254.46	20.67	154.00	3.86	511.77
N_{12}	252.49	20.54	152.02	3.82	532.79
N_{13}	249.70	20.18	149.35	3.75	496.26
SE.m. ±	3.42	0.27	1.850	0.054	6.975
CD at 5%	9.66	0.77	5.221	0.152	19.686

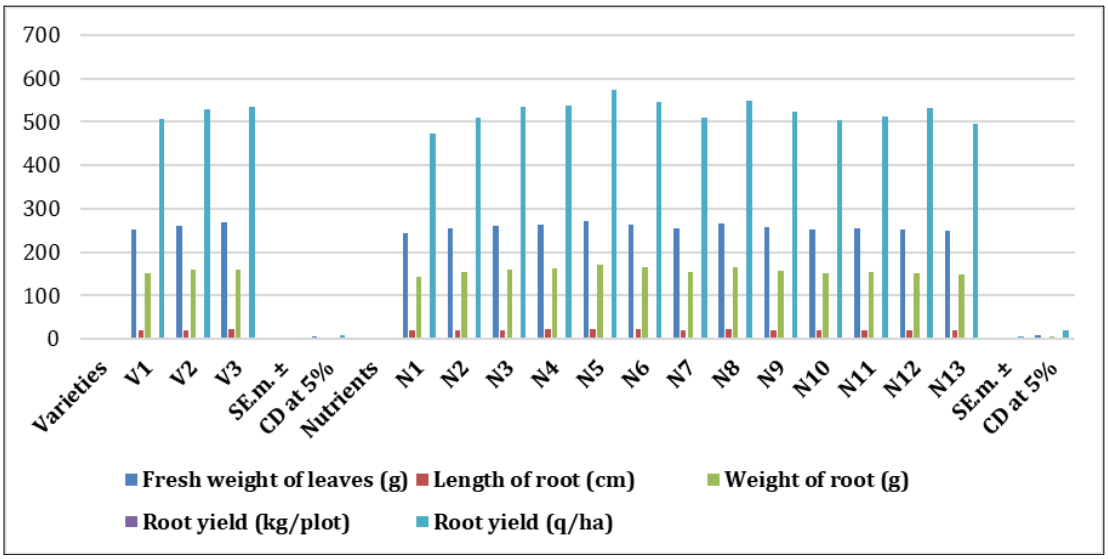

Fig 2: Effect of varieties and INM on yield parameters of radish during 2021-22

Conclusion

It may be concluded from the findings of the present study that among the different varieties of radish, variety V_3 (Kashi Mooli-40) recorded superior performance for growth and yield attributes. Among the nutrients, application of N_5 (RDF 75% +Azotobacter + PSB) is superior for growth and yield parameters of radish.

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