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Effect of integrated nutrient management on yield and quality 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 2022-23 to study the Effect of Integrated Nutrient Management on Yield and Quality 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 TSS (4.07), ascorbic acid (33.43), pH juice (7.17), dry matter content in leaves% (7.95), and dry matter content in root% (9.53) were noted in variety Kashi Mooli-40. The, maximum fresh weight of leaves (263.20 g), length of root (21.78 cm), weight of root (160.14 g), root yield kg/plot (4.06 kg) and root yield (535.82 q ha^{-1}) is observed in variety Kashi Mooli-40 and in case of nutrients the TSS (5.25), ascorbic acid (33.80), pH juice (7.43), dry matter% content in leaves (8.58), and dry matter content in root% (10.16) was observed in treatments N_5 during growth characters. While the maximum fresh weight of leaves (272.69 g), weight of root (171.59 g) and root yield (571.87 q/ha) were recorded in treatments N_5 (RDF 75% + Azotobacter + PSB).

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

Introduction
A well-liked vegetable in the Brassicaceae family in both tropical and subtropical regions is the radish (*Raphanus sativus* L.). It is widely planted in the hills and on the plains in both northern and southern India. Although it can be cultivated under cover for early production, India is the country where field cultivation on a large scale is more common. Radish promotes hunger, prevents constipation, and has a cooling impact. For those with jaundice, liver problems, or piles, it is recommended. Fresh leaf juice has laxative and diuretic properties. Radish provides a range of nutrients and is a good source of vitamin C, or ascorbic acid, with 15–40 mg per 100 g of edible part. Radish contains trace amounts of aluminum, silicon, barium, lithium, manganese, fluorine, and iodine. Ascorbic acid content is often higher in radish with pink skin than in radish with white skin. The presence of volatile isothiocynates is what gives radish its distinctively pungent flavor. Radish growth and yield are largely influenced by soil and climate factors. The soil and climate conditions needed for each kind to thrive vary. Given that India is a large country with a diversity of agroclimatic zones, a certain variety might or might not be appropriate for each region. Therefore, in these situations, it is imperative to choose a certain kind. The radish crop grows quickly and has a short growing season. Hence, judicious and proper uses of fertilizers are essential to get good yield and excellent root quality along with higher fertilizer use efficiency. It requires sufficient and readily available plant nutrients.

Using both chemical fertilizers and organic manures to increase crop output is known as integrated nutrient management. Sustaining soil fertility and supplying sufficient amounts of plant nutrients is the major objective. It makes sense economically, socially, and ecologically. Using crops more productively by using them efficiently is known as "nutrient management." High crop yields that are sustainable, economically feasible, environmentally sound, and agronomically achievable are made possible by INM (Kafle *et al*., 2019) [2]. When nutrients are supplied in enough amounts and at the right times, crops produce at their best. Farmyard manure feeds crops and strengthens the physical, chemical, and biological properties of the soil, which promotes better crop growth. (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].

Materials and Methods

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 quality and yield parameters *viz*.- TSS, ascorbic acid, dry matter content in leaves%, dry matter content in root%, fresh weight of leaves (g), length of root (cm), weight of root (g), yield kg/plot and yield q/ha. The observations on quality 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) [12]. 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 Yield and Quality of Radish (*Raphanus sativus* L.)" have been presented in this chapter.

Effect of varieties and nutrients on quality parameters

Quality parameters – There was significant effect of varieties on total soluble solids content in radish at harvesting stage. Variety, V_3 (Kashi Mooli-40) had registered maximum total soluble solids content which was higher than all other varieties. Minimum total soluble solids were observed in case of variety V_1 (Kashi Aarorus). Though the difference between V_1 and V_2 was significant. Similar results have been also reported by Kumar *et al*., (2022) [3] in radish. Fertility levels had exhibited significant effect on total soluble solids content. Highest total soluble solids content was found with fertility level N_5. Minimum total soluble solids were observed in case of fertility level N_{11}. The findings of the present experiment revealed significant effect of varieties on ascorbic acid content in root. Among the varieties, maximum ascorbic acid content was recorded with variety V_3 (Kashi Mooli-40) which was followed by V_2 (Kashi Sweta). Minimum ascorbic acid content was noted with variety, V_1 (Kashi Aarorus). There finding are in agreement with Kumar *et al.,* (2022) [3] and Rawat *et al.* (2014) [13]. Fertility levels had also exhibited significant effect on ascorbic acid content in radish. Highest ascorbic acid content was recorded with fertility level N_5, followed by fertility level N_8. Minimum ascorbic acid content was revealed under fertility level N_1. Similar results were obtained by Kumar *et al.,* (2022) [3] and Rawat *et al.* (2014) [13].

The data indicated significant influence of varieties on pH juice in radish. Variety, V_3 (Kashi Mooli-40) had recorded maximum pH juice followed by V_2 (Kashi Sweta). Minimum pH juice was recorded with variety, V_1 (Kashi Aarorus). Similar findings were obtained by Kumar *et al.,* (2022) [3]. There was significant effect of fertility levels on pH juice. Fertility level N_5 had showed maximum pH juice. Minimum pH juice was observed in fertility level N_6.

Finding revealed significant effect of variety and fertility levels on Dry matter in leaves (%) in radish. Variety, V_3 (Kashi Mooli-40) had taken maximum dry matter content in leaves. It was followed by V_2 (Kashi Sweta). Minimum dry matter content in leaves were taken by variety V_1 (Kashi Aarorus). Similar results have been reported by Rawat *et al.* (2014) [13]. Among the fertility levels, N_5 has recorded maximum dry matter content in leaves. Minimum dry matter content in leaves were recorded infertility level N_{13}.

Dry matter in root (%) was recorded after harvesting. The data exhibited significant effect of varieties and fertility levels on harvesting index. Among the variety, V_3 (Kashi Mooli-40) recorded maximum dry matter in root (%) followed by V_2 (Kashi Sweta). Minimum Dry matter in root (%) was observed in case of variety, V_1 (Kashi Aarorus). Significant different among varieties for dry matter in root (%) have been also reported by Nargave *et al.*, (2018) [7]. dry matter in root (%) was significantly affected by nutrients levels. Maximum dry matter in root (%) was found under nutrients level N_5 which was followed by N_{11}. The lowest dry matter in root (%) was recorded under fertility level. Similar results were obtained by Nargave *et al.*, (2018) [7].

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) (21.78 cm), followed by variety V_2 (Kashi Sweta) (21.56). 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 (160.14 g), followed by variety V_2 (159.66 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.

Table 1: Effect of varieties and INM on quality parameters of radish during 2022-23

Symbol	(TSS) (^{0}Brix)	Ascorbic acid	pH of Juice	Dry matter in leaves (%)	Dry matter in root (%)
Varieties					
V_1	3.57	31.00	6.66	7.33	9.07
V_2	3.92	31.54	7.07	7.95	9.30
V_3	4.07	33.43	7.17	7.81	9.53
S.Em±	0.024	0.167	0.046	0.052	0.061
CD at 5%	0.067	0.470	0.130	0.147	0.171
Nutrients					
N_1	3.76	32.00	6.77	7.47	9.45
N_2	3.59	31.97	6.69	7.52	9.35
N_3	3.95	31.93	6.87	7.51	9.45
N_4	3.62	31.77	7.05	7.57	9.45
N_5	5.25	33.80	7.43	8.58	10.16
N_6	4.10	31.63	6.60	7.74	8.98
N_7	3.84	31.68	7.40	7.39	9.10
N_8	4.41	32.53	7.04	7.89	9.14
N_9	4.03	32.52	7.33	6.83	9.37
N_{10}	3.21	31.67	6.60	8.01	9.43
N_{11}	3.03	31.13	6.92	8.02	8.76
N_{12}	3.73	32.16	7.13	8.34	9.85
N_{13}	3.54	31.06	6.76	7.21	9.04
S.Em ±	0.049	0.347	0.096	0.109	0.126
CD at 5%	0.139	0.978	0.271	0.307	0.356

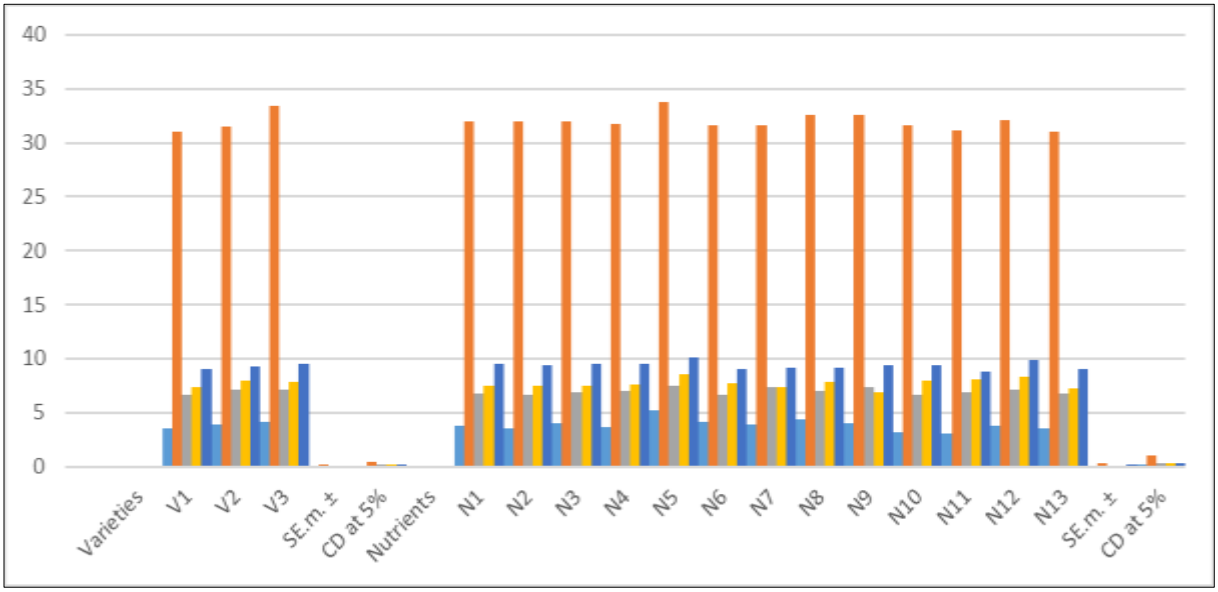

Fig 1: Effect of varieties and INM on quality parameters of radish during 2022-23

Among the variety, V_3 (Kashi Mooli-40) recorded maximum fresh weight of leaves /plant (263.20 g) at harvesting stage and followed by V_2 (Kashi Sweta) (262.76 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) [13]. 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 (272.69 g) and minimum weight of fresh leaves was recorded under N_{11} (244.14 g). This is due to Azotobacter 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) [11].

Root yield per plot (kg) and q/ha The significantly maximum root yield of plant was recorded in variety V_3 (Kashi Mooli-40) (4.06 kg and 535.82 q), respectively, followed by variety V_2 (Kashi Sweta) (4.00 kg and 530.72 q) respectively. In case of nutrients the maximum root yield in treatments N5 (RDF 75%+ Azotobacter+ PSB) (4.35 kg and 571.87 q) respectively and minimum root yield in treatment N_{11} (3.57 kg and 466.35 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 Azotobacter 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) [9]. and Kumar *et al.*, (2017) [4]. Which correspond to these findings. Similar results were also recorded by Kiran *et al.*, (2019) [14].

Table 2: Effect of varieties and INM on yield parameters of radish during 2022-23

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	254.06	20.51	152.07	3.80	506.92
V_2	262.76	21.56	159.66	4.00	530.72
V_3	263.20	21.78	160.14	4.06	535.82
S.Em ±	1.66	0.134	0.878	0.025	3.384
CD at 5%	4.69	0.379	2.477	0.072	9.550
Nutrients					
N_1	259.07	20.88	156.52	3.93	519.32
N_2	256.04	20.95	153.57	3.85	509.49
N_3	265.78	21.42	162.29	4.07	538.56
N_4	267.89	22.13	165.31	4.15	548.64
N_5	272.69	23.35	171.59	4.35	571.87
N_6	267.57	21.96	164.13	4.12	544.67
N_7	254.68	20.69	152.53	3.83	506.02
N_8	266.35	22.15	164.70	4.13	546.59
N_9	261.14	20.99	158.20	3.97	524.93
N_{10}	256.21	20.98	151.95	3.81	504.09
N_{11}	244.14	19.92	140.63	3.57	466.35
N_{12}	254.99	20.89	151.16	3.80	532.88
N_{13}	253.55	20.38	152.20	3.82	504.94
S.Em ±	3.46	0.28	1.827	0.053	7.044
CD at 5%	9.76	0.79	5.156	0.149	19.881

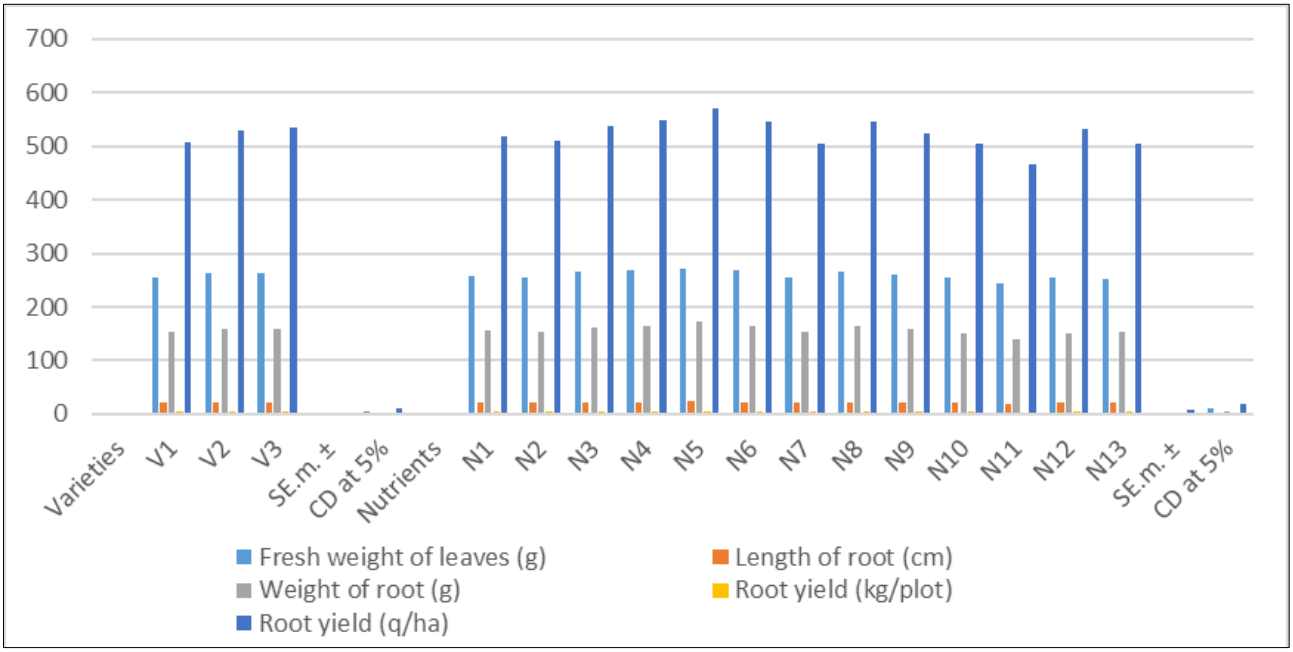

Fig 2|: Effect of varieties and INM on yield parameters of radish during 2021-22

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 quality and yield attributes. Among the nutrients levels, application of N_5 (RDF75 +Azotobacter + PSB) is superior for quality and yield parameters of radish.

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