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Effect of integrated nutrient management on growth, yield and quality of radish (*Raphanus sativus* L.) cv MAHY 22

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Abstract
Experiment was conducted during *Rabi* season of 2020-21 at experimental field of Department of Horticulture, College of Agriculture, Indore (M.P.). To entitled "Effect of integrated nutrient management on growth, yield and quality of radish (*Raphanus sativus* L.)". The experiment consisting of eight treatment combination with control, FYM, vermicompost, poultry manure, neem cake, PSB, *Azotobactor* as well as NPK was laid out in randomize block design with three replications. On the basis of present investigation it is concluded that the treatment T_6 {50% RDF + 50% (12.5% Neem cake + 12.5% Vermicompost + 12.5% FYM+ 12.5% Poultry manure) + PSB + *Azotobacter*} was found to be the best treatment combination in respect of highest growth and yield parameters of radish. This treatment also showed extreme quality parameters respectively.

Keywords: INM, growth, yield, quality, radish

Introduction

Radish (*Raphanus sativus* L.) is a member of the Brassicaceae family is native to Europe or Asia. It is a most popular root crop grown all over the world. It is grown for its young fleshy tuberous roots which are eaten raw or as a salad or cooked. Radish is a cool season crop and broadly divided into two groups: European or temperate and Asiatic or tropical. The Asiatic varieties although are higher yielders yet poor in quality attributes, whereas, European varieties are small in size, early in maturity and rich in quality parameters (Tripathi *et al*., 2017) [22]. In India major radish growing states are West Bengal, Bihar, Assam, Uttar Pradesh and Madhya Pradesh *etc.* The present area under radish in India is 209 thousand ha with the production of 3060 thousand MT. In Madhya Pradesh, an area under radish is 10.7 thousand ha with the production is 152.56 thousand MT (Anonymous, 2018) [1]. Now a day's chemical fertilizers are the main source of nutrients. But continuous use of only chemical fertilizers causes nutritional imbalance and harmful effects on properties of soil, radish as well as on human health. Considering their harmful effects on soil, environment as well as on the quality of radish it is necessary to find out an eco-friendly alternative that improves the production and quality of radish. Integrated Nutrient Management is an alternative for sustained crop production rather than the use of chemical fertilizer only (Chapagain, *et al*., 2010) [4].

Integrated Nutrient Management is defined as the use of inorganic, organic and biological nutrient sources in optimum condition to achieve and sustain optimum yield with-out harming the soil ecosystem and environment. INM helps to obtain agronomically feasible, economically viable, environmentally sound and sustainable high crop yields (Kafle *et al.*, 2019) [7]. Organic manure like farmyard manure (FYM), poultry manure and vermicompost should also be used as they also make the soil fertile and give nutrition to plant. FYM helps to improve crop growth by providing nutrition and improving the physical, chemical and biological properties of soil (Mengistu & Mekonnen, 2012) [14]. Vermicompost brings positive changes in both soil quality and productivity than chemical fertilizers (Ansari & Sukhraj, 2010) [2]. Similarly, another organic manure *i.e.* poultry manure has a high amount of nitrogen, phosphorus and potassium than manure of other animals (Duncan, 2005) [5]. Poultry manure also helps to improve the water holding capacity, aeration and fertility status of soil (Khatri *et al.*, 2019) [9].

Nitrogen is abundantly available (70-80 percent) in the atmosphere but the plants cannot take it directly from the atmosphere, hence nitrogen requirement of the plant is generally met out with the use of chemical fertilizers however. The application of nitrogen with different doses increases plant growth and yield of radish (Patel *et al*., 1992) [17]. Phosphorus has its beneficial effect on early root development, plant growth, yield and quality. Indian soils have poor to medium status in available phosphorus for crops. Potassium regulates transpiration through opening and closing of the stomata by affecting activities of guard cells (Mandal and Chatterjee, 1973) [11].

Materials and Methods

The present investigation was carried out in Rabi season from November 2020 to January 2021 at the Experimental Field of Department of Horticulture, College of Agriculture, Indore (M.P.). The treatments combinations are as under - T_1 (Control), T_2 (50% Neem cake + 50% Vermicompost + PSB + *Azotobacter*), T_3 (50% Neem cake + 50% Poultry manure + PSB + *Azotobacter*), T_4 (50% Neem cake + 50% FYM + PSB + *Azotobacter*), T_5 (25% Neem cake + 25% Vermicompost + 25% FYM + 25% Poultry manure + PSB + *Azotobacter*), T_6 [50% RDF + 50% (12.5% Neemcake + 12.5% Vermicompost + 12.5% FYM+ 12.5% Poultry manure) + PSB + *Azotobacter*], T_7 [75% RDF + 25% (6.25% Neemcake + 6.25% Vermicompost + 6.25% FYM+ 6.25% Poultry manure) + PSB + *Azotobacter*] and T_8 [100% RDF (Recommended dose of fertilizers 100:50:50 kg/ha N:P:K, respectively)] *etc*. The pure, healthy, disease and insect free vigorous and good quality seed of radish variety MAHY 22 was used for sowing. Using the seed rate of 9 kg ha^{-1}, maintaining row to row distance of 30 cm and plant to plant distance of 10 cm. The seed sowing was done 1.5 cm deep to facilitate proper root production. Irrigation was applied immediately after seed sowing and then once in 5-8 days. The crop was well manure with different organic manures such as farm yard manure, vermicompost, neem cake, poultry manure and bio-fertilizer was incorporated in the field before sowing as per the treatments. RDF was applied in all treatments before sowing of radish. Harvesting of radish was done on 30th December to 15th January, 2021. The observations were recorded on five randomly selected plants from each plot on different growth, yield and quality characters. The data was analyzed by adopting the standard procedure of Panse and Sukhatme (1985) [16]. Wherever, the results were found significant, critical differences (CD) were computed at 5 percent level of probability to draw statistical conclusions.

Result and Discussion

Effect of INM on growth parameters

The results of the present investigation showed that there was a significant difference on the growth parameters *viz.* plant height, number of leaves $plant^{-1}$, length of leaves at 20, 40 & 60 at DAS and fresh weight &dry weight of root at 60 DAS. The results of the growth parameters are presented in Table-1& 2.

Plant height (cm)

At 20, 40 and 60 DAS, treatment T_6 {50% RDF + 50% (12.5% NC + 12.5% VC + 12.5% FYM + 12.5% PM) + PSB + *Azotobacter*}, was recorded significantly maximum plant height *i.e.* 38.25 cm, 37.88 cm and 36.90 cm. However, the minimum plant height was observed in treatment T_1 (Control) *i.e.* 14.19 cm, 31.25 cm and 32.92 cm, respectively. The probable reasons for increased plant height 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 required for plant growth *i.e.* height. Similar results have been reported by Basnet *et al*. (2021) [3] and Mani and Anburani (2018) [12].

Number of leaves per plant

At 20, 40 and 60 DAS, the highest number of leaves $plant^{-1}$ (5.93, 10.30 and 13.23) were recorded in treatment T_6 {50% RDF + 50% (12.5%NC + 12.5% VC + 12.5% FYM+ 12.5% PM) + PSB + *Azotobacter*}, respectively. While, lowest number of leaves $plant^{-1}$ (2.97, 6.75 and 9.73) were observed in treatment T_1 (Control), 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) [3], Mani and Anburani (2018) [12] and Mehwish *et al.* (2016) [13].

Leaf length (cm)

In respect of different type of INM treatment recorded longest length of leaf with treatment T_6 {50% RDF + 50% (12.5% NC + 12.5% VC + 12.5% FYM + 12.5% PM) + PSB + *Azotobacter*} *i.e.* 12.55 cm, 31.85 cm and 35.40 cm. The shortest length of leaf was recorded in treatment T_1 (Control) *i.e.* 11.33 cm, 26.24cm and 28.16 cm at 20, 40 and 60 DAS, respectively. Probable reasons for enhanced leaf length may be due to primitive effects of macro and micronutrients on vegetative growth which ultimately lead to more photosynthetic activities. These results are similar line with the finding of Jat *et al*. (2017) [6], Kumar *et al.* (2014) [10] and Uddain *et al.* (2010) [23] in radish.

Leaf area $plant^{-1}$ (cm^2)

The significantly maximum leaf area $plant^{-1}$(278.43, 538.22 and 765.89 cm^2) were recorded in treatment T_6 {50% RDF + 50% (12.5% NC+ 12.5% VC + 12.5% FYM+ 12.5% PM) + PSB + *Azotobacter*}. However, the minimum leaf area $plant^{-1}$(179.90, 365.34 and 642.28 cm^2) was recorded in treatment T_1 (Control) at 20, 40 and 60 DAS, respectively. The feasible reason for increase leaf area may be due to the higher uptake of nutrients especially iron and magnesium from the soil resulting in greater photosynthetic activity and humic acid contributed to the increased leaf area. The result obtained is in harmony with the results of Mani and Anburani (2018) [12] and Subramani *et al.* (2011) [20] in radish.

Fresh weight of plant (g)

Fresh weight of plant increased significantly by the different INM treatments. The significantly maximum fresh weight of plant (420.85 g) was recorded in treatment T_6 {50% RDF + 50% (12.5% NC + 12.5% VC + 12.5% FYM+ 12.5% PM) + PSB + *Azotobacter*}. While, the minimum fresh weight (246.60 g) was recorded in treatment T_1 (Control).This may be due to the application of inorganic fertilizers with organic manure to increase the fresh weight. These finding corroborates with the results of Mehwish *et al*. (2016) [13], Kumar *et al.* (2014) [10], Vijayakumari *et al.* (2012) [24] and Uddain *et al*. (2010) [23] in radish.

Dry weight of plant (g)

The treatment T_6 {50% RDF + 50% (12.5%NC+ 12.5% VC + 12.5% FYM+ 12.5% PM)+ PSB + *Azotobacter*} recorded the maximum dry weight of plant (14.05 g). Whereas, the minimum dry weight of plant (8.95 g) was recorded in treatment T_1 (Control).These results are similar line with the finding of Mehwish *et al*. (2016) [13], Kumar *et al*. (2014) [10] and Vijayakumari *et al.* (2012) [24].

Effect of INM on yield parameters

Effect of integrated nutrient management (different organic manures, inorganic fertilizers and their combinations with PSB & *Azotobacter*) on radish was studied in respect of yield parameters *i.e.* root length (cm), root weight (g), root diameter (cm) and root yield plot^{-1} (kg) were observation recorded at 60 DAP. The results of the yield parameters are presented in Table-3.

Root length (cm), Root weight (g) and Root Diameter (cm)

The significantly longest root length (26.09 cm), maximum root weight (120.39 g) and thickest root diameter (3.89 cm) were recorded with the treatment T_6 {50% RDF + 50% (12.5% NC+ 12.5% VC + 12.5% FYM + 12.5% PM) + PSB + *Azotobacter*}. While, the shortest root length (16.95 cm), minimum root weight (60.87g) and thinnest root diameter (2.08 cm) were recorded in treatment T_1 (Control).The feasible reason for increase root length, root weight and root diameter may be due to the decrease in bulk density and increase in porosity and water holding capacity of the soil due to organic manures. Another possible reason the increase in length of root, weight of root and diameter of root may be attributed to solubilization of plant nutrients by addition of poultry manure and vermicompost leading to increase uptake of NPK. The results are also in agreement with the earlier findings by Randy (2016) [18], Mehwish *et al.* (2016) [13], Khalid *et al.* (2015) [8] and Kumar *et al.* (2014) [10].

Root yield plot^{-1} (kg)

Among the different INM treatments, the maximum root yield (26.97 kg plot^{-1}) was noted in the treatment T_6 {50% RDF + 50% (12.5% NC + 12.5% VC + 12.5% FYM + 12.5% PM) + PSB + *Azotobacter*}. While, it was listed lowest root yield (12.43 kg plot^{-1}) in treatment T_1 (Control).Probable region for increased root yield plot^{-1}due to humus substances could have mobilized the reserve food materials to the sink through increased activity of hydrolyzing and oxidizing enzymes. The result of this research have been found little bit similar with the result of Mehwish *et al.* (2016) [13] in radish.

Effect of INM on quality parameter

Quality parameter of the radish root was studied with respect to T.S.S. (^{0}Brix) and shelf life of radish (days) after harvesting. The results of the quality parameters are presented in Table-3.

Total soluble solids (^{0}Brix)

The highest total soluble solids (5.12^{0}Brix) was recorded in treatment T_6 {50% RDF + 50% (12.5% NC + 12.5% VC + 12.5% FYM+ 12.5% PM) + PSB + *Azotobacter*). Whereas, the least total soluble solids (3.06^0 Brix) was recorded in T_1 (Control). This may be due to accumulation of more reserve substances in root. These finding are found similar with the result of Nargave *et al.* (2018) [15], Singh *et al.* (2016) [19] in radish and Sunandarani and Mallareddy (2007) [21] in carrot.

Shelf Life

The physical appearance of each root sample was assessed daily. After 3 days of harvesting, the best quality root by visual quality rating was found from treatment T_6 {50% RDF + 50% (12.5% NC+ 12.5% VC + 12.5% FYM + 12.5% PM) + PSB + *Azotobacter*}.

Conclusion

It may be concluded from the findings of the present study that among the all combinations, the treatment of T_6 {50% RDF + 50% (12.5% NC + 12.5% VC + 12.5% FYM + 12.5% PM) + PSB + *Azotobacter*} was found to be the most effective in invigorating the growth parameters *i.e.* plant height, no. of leaves per plant, leaf area, leaf length, fresh weight and dry weight of plant, yield parameters *i.e.* root length, root weight, root diameter and root yield per plot of radish. This treatment also showed extreme quality parameters *i.e.* Total soluble solids and shelf life respectively. Closely followed by treatment T_7 {75% RDF + 25% (6.25% Neem cake + 6.25% Vermicompost + 6.25% FYM + 6.25% Poultry manure) + PSB + *Azotobacter*}.

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Table 1: Effect of integrated nutrient management on plant height (cm), number of leaves plant^{-1}and length of leaves of radish at 20, 40 and 60 DAS.

Treatments	Plant height (cm)			Number of leaves plant^{-1}			Length of leaves (cm)		
	At 20DAS	At 40DAS	At 60DAS	At 20DAS	At 40DAS	At 60DAS	At 20DAS	At 40DAS	At 60DAS
T_1	14.19	31.25	32.92	2.97	6.75	9.73	11.33	26.24	28.16
T_2	15.33	34.44	36.90	5.30	9.20	12.57	12.27	29.90	32.95
T_3	13.71	31.61	33.95	4.25	8.90	12.05	11.98	28.95	31.75
T_4	15.30	34.20	36.70	4.43	7.90	11.77	12.05	29.37	31.88
T_5	13.81	32.97	34.18	4.95	9.05	10.98	12.18	29.54	32.45
T_6	16.77	36.17	38.25	5.93	10.30	13.23	12.55	31.85	35.40
T_7	16.25	35.22	37.88	5.77	9.43	12.60	12.36	30.34	33.57
T_8	15.25	34.25	35.87	5.02	8.87	11.65	12.22	29.73	32.64
S.Em±	0.08	0.43	0.02	0.05	0.03	0.02	0.03	0.02	0.03
CD at 5%	0.23	1.31	0.06	0.17	0.07	0.06	0.10	0.06	0.09

Table 2: Effect of integrated nutrient management on leaf area plant^{-1} (cm^2) at 20, 40, 60 DAS and fresh weight (g) &dry weight (g) of radish at 60 DAS.

Treatments	Leaf area plant^{-1} (cm^2)			Fresh weight of plant (g) at 60 DAS	Dry weight of plant (g) at 60 DAS
	At 20DAS	At 40DAS	At 60DAS		
T_1	179.90	365.34	642.28	246.60	8.95
T_2	244.56	493.98	727.18	340.15	13.05
T_3	196.78	376.32	702.36	332.52	12.11
T_4	203.65	410.48	713.62	352.97	12.67
T_5	237.90	454.63	725.04	328.17	12.90
T_6	278.43	538.22	765.89	420.85	14.05
T_7	256.46	493.98	727.88	376.48	13.54
T_8	218.05	389.40	693.32	345.63	11.34
S.Em±	0.08	0.58	0.03	0.03	0.12
CD at 5%	0.23	1.77	0.08	0.08	0.35

Table 3: Effect of integrated nutrient management on yield and quality parameters of radish at 60 DAS.

Treat. Symb.	Root length (cm)	Root weight (g)	Root Diameter (cm)	Root yield		Total soluble solids (^{0}Brix)	Shelf Life
				plot^{-1} (kg)	ha^{-1} (q)		
T_1	16.95	60.87	2.08	12.43	207.17	3.06	Non Edible
T_2	24.16	114.97	3.47	24.55	409.16	4.46	No Defect
T_3	20.43	103.50	2.77	20.16	336	3.85	Defect Moderate
T_4	21.16	97.77	2.95	21.44	357.3	3.68	Fair
T_5	22.50	111.90	3.18	23.83	397.16	4.30	Good
T_6	26.09	120.39	3.73	26.97	449.5	5.12	Excellent
T_7	25.42	116.73	3.89	25.78	429.7	4.93	Field Fresh
T_8	22.88	114.75	3.32	15.01	250.3	4.05	Defect Minor
S.Em±	0.04	0.07	0.03	0.10	12.47	0.03	-
C.D. at 5% level	0.11	0.20	0.10	0.30	35.4	0.10	-

Note: Where, NC = Neem Cake; VC = Vermi Compost; PM = Poultry Manure; FYM= Farm Yard Manure; PSB = Phosphate Solubilizing Bacteria

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