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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND QUALITY ATTRIBUTES OF RADISH (*RAPHANUS SATIVUS* L.) CV. JAPANESE WHITE

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ABSTRACT

A field experiment was conducted during the season of 2021-22 at the Horticulture Research Farm of BBAU, Lucknow. The trial was carried out in a Randomized Block Design (RBD) and replicated thrice, aligned with sustainable agriculture principles, evaluated the effects of integrated nutrient management (INM) on the "Japanese White" radish across nine treatments: T_1 (NPK at 80:60:80 kg/ha), T_2 (vermicompost @ 4tons/ha), T_3 (FYM @15 tons/ha), T_4 (poultry manure @ 3 tons/ha), T_5 (50% NPK + 50% vermicompost), T_6 (50% NPK + 50% FYM), T_7 (50% NPK + 50% poultry manure), T_8 (50% vermicompost + 50% FYM) and T_9 (50% vermicompost + 50% poultry manure); the results showed that treatment T_5 outperforming others with a maximum fresh root weight of 119.08g, dry root weight of 21.09g, root length of 19.09cm, root diameter of 4.54cm and yield of 401.43q/ha, alongside superior nutritional quality viz., ascorbic acid (9.01mg/100g), total soluble solids (4.90°Brix), total sugars (5.07%) and reducing sugars (3.21%) demonstrating that a balanced 50% inorganic (NPK) and 50% organic (vermicompost) approach not only meets nutrient needs but also halves chemical fertilizers use, potentially lowering costs and enhancing sustainability in farming practices.

***Keywords*: Growth, yield, integrated nutrient management, organic manures and radish.**

Introduction

Radish (*Raphanus sativus* L.) is a root vegetable of Cruciferae family and it is an important vegetable crop worldwide (Tsouvaltzis and Brecht, 2014). Radish composition was found to be of highly medicinal and nutritional value, act as a good source of natural antioxidants due to their high levels of phenolic compounds, including tocopherols, as well as carotenoids and ascorbic acid (Natrajan, and Veeraragavathatham, 2001). Thus, it was suggested as an alternative treatment for various ailments including hyperlipidemia, coronary heart diseases and cancer (Curtis, 2003). Integrated nutrient management includes the use of inorganic, organic and microbial sources of nutrients which ensure balanced nutrient proportion by enhancing nutrient response efficiency and maximizing crop productivity of desired quality (Lata, 2013). The rosette leaves, varying in size from 10-45 cm depending on the cultivar, contribute to its distinctive features. This leafy root vegetable thrives in tropical and temperate climates, making it adaptable to various regions. Both the leaves and roots of the radish play roles in salads and cooked dishes. Cultivation of this crop is technically, feasible, economically reliable and socially and ecologically accepted. Nutrient management refers to the efficient use of nutrients into the crops to improve productivity. INM helps to obtain agronomically feasible, economically viable, environmentally sound and sustainable high crop yields (Kafle *et al.,* 2019). The edible section of the radish root develops from both the primary root and the hypocotyl (Natrajan and Veeraragavathatham, 2001). The immature pods, known as 'mongree,' can be eaten raw or cooked alone or with other vegetables. Studies in recent decades have explored the health effects of consuming cruciferous vegetables (Beevi *et al*., 2012). In India, the total area for radish cultivation was estimated to 204 thousand hectares, yielding a production of 3236 thousand metric tonnes. Major leading states in radish cultivation in India are West Bengal, Andhra Pradesh, Tamil Nadu, Maharashtra, Haryana, Chhattisgarh and Bihar (Anonymous, 2023-24).

The integrated nutrient management system approach utilizes a judicious combination of inorganic fertilizers and organic manures in building soil fertility and to increase the production potential of any crop (Khalid *et al*., 2015). Integrated nutrient management (INM) combines inorganic, organic and biological fertilizers to maximize crop yield while preserving soil health and the environment. It ensures sustainable, profitable, and environmentally responsible agriculture (Kafle *et al*., 2019). Rising chemical fertilizer costs highlight the need for integrated nutrient management, incorporating organic materials like FYM, poultry manure and vermicompost. Vermicompost, especially, improves soil efficiency and value more than inorganic fertilizers (Ansari and Sukhraj, 2010). Scientific research leads strong support to the notion that vermicompost serves as a noteworthy catalyst for plant growth (Guerrero III and R. D., 2010). A study by Ansari and Ismail (2008) revealed that the vermicast produced by worms contains 7.37% nitrogen and 19.58% phosphorus in the form of P_2O_5. Furthermore, poultry manure contributes to increased soil fertility, aeration and water retention capabilities (Khatri *et al*., 2019). Much like poultry waste, alternative organic manures, such as other animal manures, exhibit boosted nitrogen content, phosphate and potassium (Duncan, 2005). Recent research highlights vermicompost is having strong potential, as it results from microbial and earthworm-aided decomposition (Kafle *et al.*, 2019). FYM helps to improve crop growth by providing nutrition and improving the physical, chemical and biological properties of soil (Mengistu and Mekonnen, 2012) Additionally, specific studies indicate that applying vermicomposting leachates or water extracts as foliar sprays or substrate supplements enhances the growth and establishment of tomato plants (Tejada *et al*., 2008) and strawberry (Singh *et al*., 2010). Combining vermicompost with chemical fertilizers resulted in improved radish yields. Vermicompost, rich in macro and micronutrients, enhances soil fertility. Studies show that combining organic manure with reduced synthetic fertilizers reduces chemical dependence and improves radish growth. (Subramani *et al*., 2010; Kumar and Chauhan, 2014; Singh *et al*., 2024). Hence, in light of these details, the current study was carried out to assess how integrated nutrient management affects radish growth and yield.

Materials and Methods

The investigation was carried out during the rabi season of 2021-22 at Horticulture Research Farm, Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.), India. The climate in Lucknow is characterized as subtropical, featuring a maximum temperature range of 19 ^{0}C to 40 ^{0}C in summer and 5.5 ^{0}C to 19 ^{0}C in winter. The soil composition is sandy loam with a mild alkaline pH of 8.2. The available nitrogen content is 85.46 kg/ha, while available phosphorus and potash were measured at 16.62 kg ha^{-1} and 142.07 kg/ha, respectively. The experimental field underwent extensive ploughing and cultivation, utilizing a combination of a cultivator and disc harrow followed by planking and levelling to achieve optimal soil texture. The seeds of the Japanese White cultivar underwent treatment with carbendazim at a rate of 2g per kg of seed before being sown. Sowing occurred in November, with seeds spaced at 30 cm (row) x 15 cm (plant) on ridges measuring 1.50m x 1.50m.

A Randomized Block Design was employed to organize nine treatments with three replications. The details of the treatments are T_1- NPK (RDF)-80:60:80 Kg/ha, T_2-Vermicompost @ 4 tons/ha, T_3-FYM @15 tons/ha, T_4-Poultry manure @ 3 tons/ha, T_5-NPK (50 %) + Vermicompost (50%), T_6-NPK (50%) + FYM (50%), T_7-NPK (50%) + Poultry manure (50%), T_8-Vermicompost (50%) + FYM (50%), T_9-Vermicompost (50%) + Poultry manure (50%).

Five plants were chosen arbitrarily within each plot and marked for the purpose of documenting information related to yield and quality characteristics. These attributes encompass fresh weight (g), dry weight (g), root length (cm), root diameter (cm), root yield (q/ha), ascorbic acid (mg/100g), T.S.S. (^{0}B), total sugars (%), reducing sugar (%) and non- reducing sugar (%), respectively. The root length (cm) was measured from the crown to the distal end of the root by manual scale. The root diameter (cm) was measured with the help of vernier callipers. The fresh weight of root was taken by weighing on electronic balance immediately after harvesting and expressed in gram. While for dry weight, the radish whose fresh weight was taken was dried in hot air oven at 60^0C for 48 hours. After oven drying, dry weight of the selected radish was taken with the help of electronic balance and expressed in gram. The yield of each treatment was calculated based on the yield of each treatment and then calculated in quintals per hectare. For quality attributes, the Ascorbic acid content of root was determined by diluting the known volume of juice with 3% meta-phosphoric acid and titrating with 2, 6 dichlorophenol-indo phenol solutions (A.O.A.C., 1990), till the faint pink colour was obtained. The total sugars, reducing sugars and non-reducing sugar was determined by the method suggested in Ranganna (1997). The data were statistically analysed following the standard procedure as stated by (Panse and Sukhatme, 1985) and presented at the 5% level of significance.

Results and Discussion

Effect of integrated nutrient management on yield parameters of radish

Fresh root weight and dry root weight (g)

There were notable differences in the fresh weight of roots among various treatments, as indicated in Table 1 and Fig.1. Treatment T_5 [NPK (50%) + Vermicompost (50%)] exhibited the highest fresh root weight (119.08 g), followed by T_7 (112.08 g). Conversely, the lowest fresh root weight of (90.08 g) was observed in T_1 treatment. Similarly, significant variations within treatments were observed for the dry weight of roots. Treatment T_5 also recorded the highest dry root weight (21.09 g), with T_7 following closely at 19.07 g. The lowest dry root weight (10.09 g) was noted in T_1 treatment.

Root diameter and root length (cm)

The data recorded revealed significant variations in the root diameter among the different treatments as detailed in Table 1 and Fig.1. Treatment T_5 [NPK (50%) + Vermicompost (50%)] exhibited the highest root diameter (4.54 cm), a value comparable to treatment T_7 [NPK (50%) + Poultry manure (50%)] with a root diameter (4.22 cm). Conversely, treatment T_1 [NPK (RDF)] registered the smallest root diameter (3.11 cm). Significant variations were also noted among treatments in terms of root length, the plots that received a nutrient combination of NPK (50%) + Vermicompost (50%) exhibited the greatest root length, measuring (19.09 cm). In contrast, plots treated with NPK (50%) + Poultry manure (50%) resulted in shorter roots, measuring (18.01 cm), compared to those treated with NPK (50%) + Vermicompost (50%). The treatment T_1 [NPK (RDF)] recorded the shortest root length (11.09 cm).

Fiber content (mg/100g)

The result presented in Table 1 and Fig.1 showed that fiber content of radish was ranged from 485.04 mg/100g to 780.03 mg/100g. Significantly, fiber content of radish was observed with the application of NPK 50% + vermicompost 2 ton/ha in T_5 (780.03 mg/100g) followed by T_7 (740.07 mg/100g) with the application of NPK (50%) + Poultry Manure (50%) - 1.5 ton/ha. and the minimum fiber content of radish was observed in treatment T_1 (485.04 mg/100g).

Root yield (q/ha)

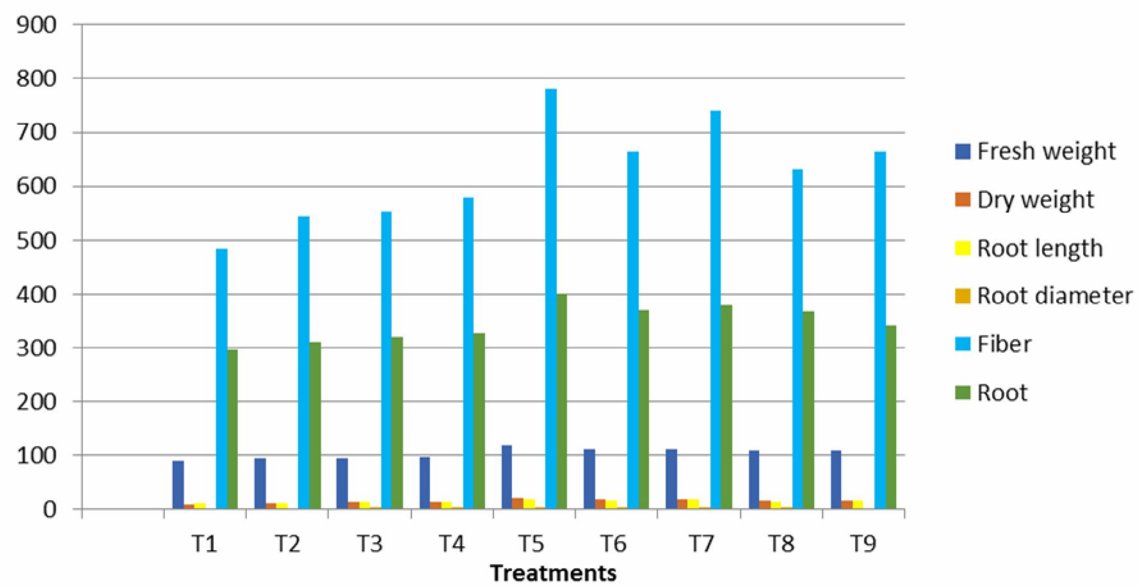
The impact of various treatments on radish root yield per hectare is presented in Table 1 and illustrated in Fig.1. Treatment T_5 [NPK (50%) + Vermicompost (50%)] significantly influenced root yield, yielding the highest at 401.43 q/ha following closely by T_7 [NPK (50%) + Poultry manure (50%)] with a yield of 380.46 q/ha. In contrast, the lowest yield of 297.09 q/ha was observed in treatment T_1 [NPK (RDF)].

The application of organic fertilizers leads to elevated levels of total organic carbon in the soil, whereas the use of chemical fertilizers decreases the amount of total organic carbon, basic cation contents, along with a decrease in soil pH. Consequently, this positive impact on the soil brings about modifications in soil structure, ultimately contributing to increased long-term yields (Reza and Jafar, 2007). By breaking down and turning organic waste into beneficial compost that may help with the development of root length and root girth, earthworms significantly contribute to soil fertility and productivity (Khutate *et al*., 2006). Vermicomposting produces chemicals that promote plant growth, which cause cell division, multiplication and elongation to occur more quickly in the meristematic zone of the plant. The availability of more nutrients and their delayed release, which coincides with the radish root's stage of development, along with the enhanced root development and root aeration, may be the reason for their greater efficacy. Similar reports were also supported by Zucco *et al*. (2015); Khatri *et al*. (2019); Kumar and Gupta (2018); Mishra *et al*. (2020); Kushwaha *et al*. (2020); Aswathi *et al*. (2021) and Kumar, *et al*. (2024) in radish.

Table 1 : Effect of integrated nutrient management on the yield characters of radish.

Treatments	Fresh weight of root (g)	Dry weight of root (g)	Root length (cm)	Root diameter (cm)	Fiber content (mg/100g)	Root yield (q/ha)
NPK (RDF) -T_1	90.08	10.09	11.09	3.11	485.04	297.09
Vermicompost @ 4 tons/ha – T_2	95.09	12.09	12.08	3.21	543.04	312.06
FYM @15 tons/ha – T_3	96.03	13.09	13.05	3.66	553.07	321.09
Poultry manure @ 3 tons/ha – T_4	98.04	14.03	14.05	4.11	579.04	326.79
NPK (50 %) + Vermicompost (50%) – T_5	119.08	21.09	19.09	4.54	780.03	401.43
NPK (50%) + FYM (50%) - T_6	111.08	18.02	17.04	3.88	664.03	370.26
NPK (50%) + Poultry manure (50%) – T_7	112.08	19.07	18.01	4.22	740.04	380.46
Vermicompost (50%) + FYM (50%) – T_8	110.09	17.07	15.04	3.74	631.05	368.04
Vermicompost (50%) + Poultry manure (50%)-T_9	109.08	16.09	16.08	3.36	665.04	342.06
S. Em (±)	4.94	0.73	0.71	0.15	29.55	16.46
CD (P=0.05)	14.94	2.23	2.14	0.45	89.36	49.78

Fig. 1. Effect of integrated nutrient management on the yield attributes of radish



Effect of integrated nutrient management on quality attributes of radish

Ascorbic acid (mg/100g)

The results presented in Table 2 and illustrated in Fig.2 showed that ascorbic acid of radish was ranged from 6.20mg/100g to 9.01mg/100g. Significantly, the highest value of ascorbic acid of radish was observed with the application of NPK 50% + vermicompost 2 ton/ha in T_5 (9.01mg/100g) followed by T_8 (8.76 mg/100g) with the application of Vermicompost (50%) + FYM (50%) while the minimum value of ascorbic acid in radish was recorded in T_4 (6.20mg/100g).

T.S.S (^{0}Brix)

The result presented in Table 2 and illustrated in Fig. 2 showed that T.S.S. of radish were ranged from 2.40 ^{0}Brix to 4.90 ^{0}Brix. Significantly, the highest value of T.S.S of radish was observed with the application of NPK 50% + vermicompost 2 ton/ha in T_5 (4.90 ^{0}Brix) followed by T_8 (4.50 ^{0}Brix) with the application of Vermicompost (50%) + FYM (50%) and the minimum T.S.S in radish was recorded in T_1 (2.40 ^{0}Brix).

Total sugars (%)

The result presented in Table 2 and illustrated in Fig.2 showed that total sugars of radish were ranged from 3.33% to 5.07%. Significantly, the highest amount total sugars of radish were observed with the application of NPK 50% + vermicompost 2 ton/ha in T_5 (5.07%) followed by T_8 (4.98%) with the application of Vermicompost (50%) + FYM (50%) and the minimum total sugars in radish was recorded in T_3 (3.33%).

Reducing sugar (%)

The result presented in Table 2 and illustrated in Fig.2 showed that reducing sugar of radish were ranged from 2.32% to 3.21%. Significantly, the highest value of reducing sugar of radish was observed with the application of NPK 50% + vermicompost 2 ton/ha in T_5 (3.21%) followed by T_8 (2.87%) with the application of Vermicompost (50%) + FYM (50%) and the minimum reducing sugar in radish was recorded in T_4 (2.32%).

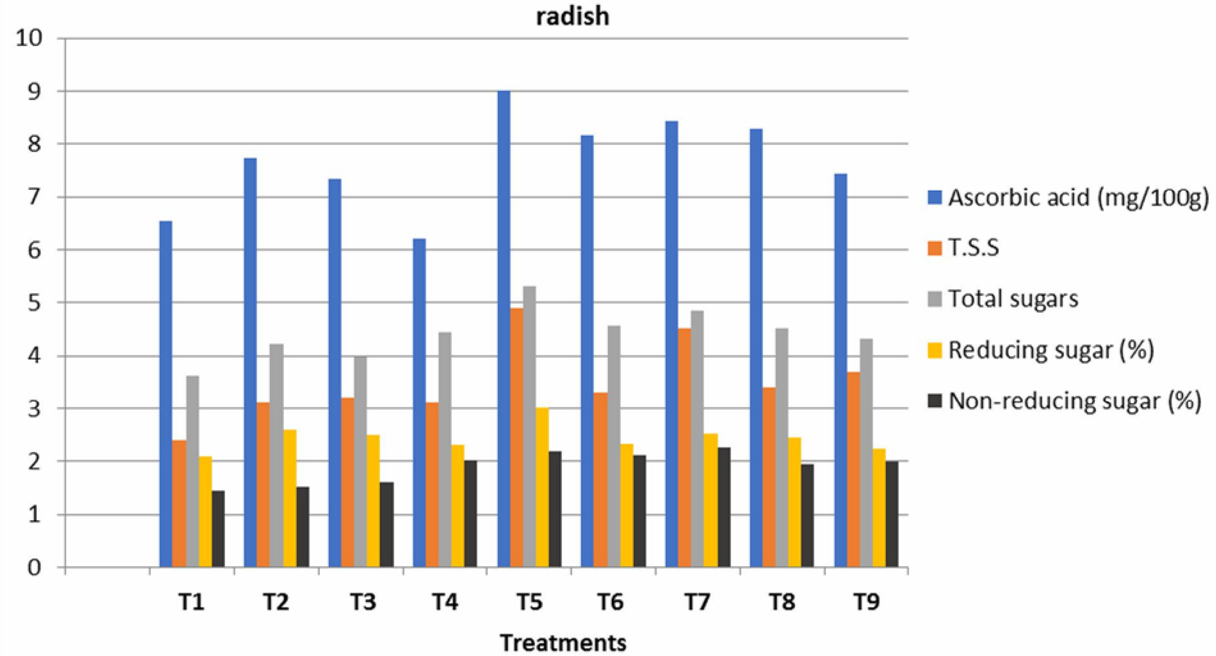
Non-reducing sugar (%)

The result presented in Table 2 and illustrated in Fig.2 showed that non-reducing sugar of radish were ranged from 0.73% to 2.13%. Significantly, the highest value of non-reducing sugar of radish was observed with the application of Poultry Manure @ 3 tons/ha in T_4 (2.13%) followed by T_7 (2.02%**)** with the application of NPK (50%) + Poultry manure (50%), however, it was at par with T_8 (2.00%) while the minimum non- reducing sugar in radish was recorded in T_1 (1.51%). Similar reports were also supported by El-Desuki *et al.* (2005), Kumar *et al.* (2017), Mishra *et al.* (2020), Yousaf *et al.* (2021), Dulal *et al.* (2021), Meena *et al*. (2023), Raza *et al*. (2024), Bashir *et al*. (2025) and Aouabe *et al*. (2025) in radish.

Table 2 : Effect of integrated nutrient management on the quality parameters of radish

Treatments	Ascorbic acid (mg/100g)	T.S.S (^{0}Brix)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugar (%)
NPK (RDF) -T_1	6.54	2.40	3.61	2.33	1.21
Vermicompost @ 4 tons/ha – T_2	7.74	3.10	4.21	2.42	1.70
FYM @15 tons/ha – T_3	7.35	3.20	3.33	2.56	0.73
Poultry manure @ 3 tons/ha – T_4	6.20	3.10	4.45	2.32	2.13
NPK (50 %) + Vermicompost (50%) – T_5	9.01	4.90	5.07	3.21	1.76
NPK (50%) + FYM (50%) - T_6	8.16	3.30	4.57	2.65	1.82
NPK (50%) + Poultry manure (50%) – T_7	8.43	3.40	4.86	2.73	2.02
Vermicompost (50%) + FYM (50%) – T_8	8.76	4.50	4.98	2.87	2.00
Vermicompost (50%) + Poultry manure (50%)-T_9	7.45	3.70	4.21	2.52	1.60
S.E.m (±)	0.36	0.17	0.20	0.12	0.03
CD (P=0.05)	1.11	0.51	0.62	0.38	0.08

Fig. 2. Effect of integrated nutrient management on the quality attributes of radish



Conclusion

The experiment's findings highlight that a balanced integration of 50% NPK and 50% vermicompost significantly enhances radish yield and quality attributes surpassing the outcomes of using full doses of recommended inorganic fertilizers while advancing the sustainability of agricultural systems by cutting chemical inputs. Similarly, the combination of 50% NPK with 50% poultry manure proved statistically comparable to the vermicompost blend, positioning poultry manure as a practical and effective organic substitute, broadening options for farmers. Collectively, these results demonstrate that halving inorganic fertilizer applications and supplementing with organic sources meets 50% of nutrient demands, reducing cultivation costs, mitigating environmental degradation from chemical overuse and fostering long-term soil health, resource conservation and economic viability key pillars of sustainable agriculture that support resilient food production systems in the face of climate challenges and growing global demand.

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