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SOIL-PLANT NUTRIENT INTERACTIONS AND ECONOMIC RETURNS OF RADISH (*RAPHANUS SATIVUS* L.) CV. JAPANESE WHITE

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ABSTRACT

The present investigation was carried out during 2018-19 at College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad. The experiment was carried out with the seven treatments *viz.*, T_1 : RDF (90:50:90) NPK/ha , T_2 : T_1+ (organic manures in the form of FYM (5 t/ha)), T_3: T_1+ (organic manures in the form of vermicompost (3 t/ha)), T_4 : T_1+ (organic manures in the form of neemcake (17 kg/ha)), T_5 : T_1 + FYM (5 t/ha) + IIHR microbial consortium (300 g), T_6: T_1+ vermicompost (3 t/ha) + IIHR microbial consortium(300 g) and T_7: T_1+neemcake (17 kg/ha) + IIHR microbial consortium (300g) in a Randomized Block Design (RBD) and replicated three times. Based on one year experimentation and economics it could be concluded that higher growth yield was reported with the treatment RDF + vermicompost 3 t/ha) + IIHR microbial consortium (300 g) was best, which has also given maximum B:C:R ratio.

Key words : Radish, Japanese white, Soil nutrient uptake, Plant nutrient uptake, Economics, B: C ratio, NPK content.

Introduction

Radish (*Raphanus sativus* L.), a member of the Cruciferae family, is referred to locally as mula, mullangi, mullo, mooli and milli. It is said to be indigenous to India and China. It is among the oldest veggies. Radish is cultivated for its tuberous roots, which can be cooked as a vegetable or eaten raw in salads. It is regarded as an appetiser and is enjoyed for its strong flavour and taste. The volatile isothiocyanates (trans-4-methyl-thibutenyl-isothiocynate) give radish its distinctively strong flavour, while anthocyanin pigments give the pink cultivars their colour.

The vitamin-B and vitamin-C contents of radish roots and shoots are 15–40 mg/100 gm and 103/100 gm of edible section, respectively, making them nutrient-dense vegetables (Gopalan and Balasubramanium, 1966). The tracer minerals aluminium, titanium, barium, lithium, silicon, fluorine, and iodine are all present in radish. Though mostly grown in Punjab, Uttar Pradesh, Maharashtra, and Kashmir, radish is grown throughout the nation. It is farmed on a small scale among other minor vegetable crops in the state of Telangana.

The type and quantity of fertilizer significantly influence the quality of radishes. Particularly, optimal fertilization based on soil fertility and the specific nutrient requirements of radish not only ensures yield but also significantly improves economic and ecological benefits (Jin *et al*., 2024). These days, chemical fertilisers are the primary source of nutrients. However, continued use of only chemical fertilisers results in nutritional imbalance and negative impacts on soil, radish and human health. Given their negative effects on the environment, soil, and radish quality, it is important to find an environmentally friendly alternative that increases radish production and quality (Basnet *et al*., 2021). A shortage of N has had the biggest impact on radish plant growth, followed by a shortage of P and K. It has been discovered that the application greatly increases the radish's growth and yield. Radish growers generally over-apply chemical fertilizers, which caused nutrient supplies could not match up with crop nutrient requirement (Zhang *et al*., 2019).

Radish plants with low phosphorus levels were shorter, their leaves were malformed and their veins and borders had a pink tint. The leaves of plants lacking potassium turned from green to pale yellow, and later on, brown striations developed on the leaves. Roots began to show violet streaks, which eventually spread throughout the entire area. Although, total radish yield and quantity were impacted, the TSS content of radish rose noticeably when nitrogen levels rose (Desuki *et al*., 2005). Therefore, it is crucial to determine the radish crop's proper nutrient requirements for nitrogen, phosphate and potash in addition to organic manure. Knowing all these prospects, present study has a lot of insights.

Materials and Methods

The present study was conducted at student Farm, College of Horticulture, Rajendranagar, Hyderabad. The climate of Hyderabad is semi-arid characterized by extremes of temperature both in summer and winter, with low rainfall and moderate relative humidity. The average annual rainfall is 750-800 mm. The study was carried out during *rabi* season 2019-20. The details of the material used and material techniques adopted during the course of the present study are described below.

The crop was fertilized with recommended nitrogen, phosphorus and potassium kg per ha in the form of urea, single superphosphate and murate of potash, respectively as a basal dose as per the treatments. Harvesting was done when the roots become ready for harvesting in about 55-60 days after sowing. Soil sample were collected randomly from plough layer depth with the help of soil sampling tube before sowing and after harvesting of crops from each plot and mixed thoroughly, dried to air crushed sieved through 2mm sieves. The soil sampled prepared was subjected to chemical analysis for evaluating soil fertility status by following procedure:

a) **Available nitrogen in soil (kg/ha) :** Determination of available nitrogen was done by alkaline permanganate method suggested by Subbiah and Asija (1956).

b) **Available phosphorus in soil (kg/ha) :** The estimation of available P was done by using Olsen extract (0.5 N) Sodium bicarbonates solution of (pH 8.5) as referenced by Olsen *et al*. (1954). It was determined as stannous chloride reduced blue colour. The extraction procedure adopted was described by and colour in the extract using UV visible spectrophotometer.

c) **Available potassium in soil (kg/ha) :** The available amount of potassium was determined by using normal neutral ammonium acetate flame photometer (Black, 1965).

The plant samples from each plot were collected randomly at harvest stage of the crop and were oven dried at 60^0C temperature for about 48 hours. Grinding of oven dried plant and the wet digestion (2:1 nitric acid and per chloric acid) of plant samples were carried out. The method adopted for the estimation of nitrogen in plant is discussed briefly as under. For plant analysis, the N content in plant samples was determined by following the method as described by AOAC (1995). Nitrogen was estimated by Micro-Kjeldhal method. The phosphorus content of the di-acid digested plant sample was determined by Vanadomolybdo phosphoric yellow color method (Jackson, 1967) and expressed in percentage on dry weight basis. The potassium content in plant samples was determined by flame photometer method as described by Jackson (1967) and expressed in percentage on dry weight basis.

The data on all the character studied were subjected to statistical analysis. The standard method of analysis of variance for randomized block design (RBD) described by Panse and Sukhatme (1967) was used. For economic assessment, following points are considered:

a) **Cost of cultivation (Rs/ha) :** The cost of the following items was considered for working out the cost of cultivation for this experiment. It included labour charges for sowing, thinning & weeding, irrigation, manures and fertilizers application, spraying of pesticides and harvesting. The prices of the input that were prevailing at the time of their use were taken into account to work out the cost of cultivation.

b) **Gross income (Rs/ha) :** Gross returns were calculated using the total root yield per hectare and the prices of roots at the time of marketing were taken into accounts.

c) **Net income (Rs/ha) :** The net income per hectare was calculated by using the following formula.

Net income = Gross income – Cost of cultivation

d) **Benefit cost ratio :** The benefit cost ratio for different treatments was worked out based on the price of inputs used for cultivation and price of marketable produce in local market by using following formula and it is expressed in ratio.

$$\text{Benefit: Cost ratio} = \frac{\text{Net income (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

Table 1 : Treatment combinations applied during the present investigation.

Treatment	Treatment combinations
T_1 :	RDF (90:50:90) NPK/ha
T_2 :	T_1+organic manures in the form of FYM (5t/ha)
T_3 :	T_1 + organic manures in the form of vermicompost (3t/ha)
T_4 :	T_1 + organic manures in the form of neemcake (17kg/ha)
T_5 :	T_1 + FYM (5t/ha) + IIHR microbial consortium (300g)
T_6:	T_1 + verimicompost (3t/ha) + IIHR microbial consortium (300g)
T_7 :	T_1 + neemcake (17kg) + IIHR microbial consortium (300g)

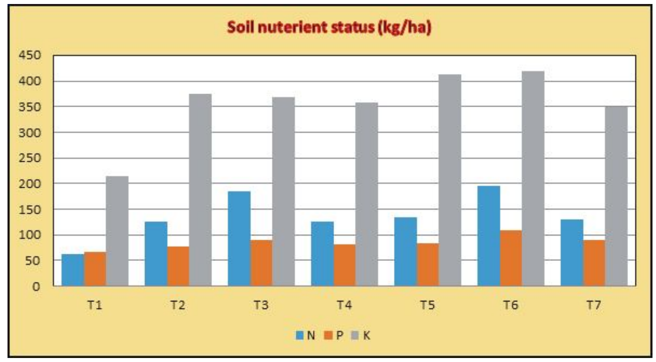

Fig. 1 : Effect of integrated nutrient management soil nutrient status (kg/ha) at after harvest on radish.

Note: T_1 : RDF (90:50:90) NPK /ha
T_2 : T_1 + organic manures in the form of FYM (5 t/ha)
T_3 : T_1 + organic manures in the form of vermicompost (3 t/ha)
T_4 : T_1 + organic manures in the form of neem cake (17 kg/ha)
T_5 : T_1 + FYM (5 t/ha) + IIHR microbial consortium (300 g)
T_6 : T_1 +Vermicompost (3 t/ha) + IIHR microbial consortium (300 g)
T_7 : T_1 + neem cake (17 kg) + IIHR microbial consortium (300 g).

Results and Discussion

The results obtained in the present investigation are mentioned under the following subsections:

- **Soil nutrient status at the harvest of the crops :** During harvesting of the crop, the NPK content from the soil was estimated and described below. Data regarding nitrogen content revealed that significantly maximum nitrogen content was recorded in treatment T_6:T_1 + vermicompost (3 t/ha) + IIHR microbial consortium (300 g) followed by other treatments T_3, T_5, T_7, T_2 and T_4 while minimum nitrogen content was retained in T_1 (63.0 kg/ha) under study with T_4 (Table 2). The graphical representation is given in the Fig. 1. For available potassium content, the significantly maximum potassium content of radish (108 kg/ha) was recorded in treatment T_6 (T_1 + vermicompost (3 t/ha) + IIHR microbial consortium (300 g) and T_3 (90 kg/ha) and T_7 (90 kg/ha) which were at par with each other and minimum potassium content in (67.5 kg/ha) was recorded in treatment where RDF was applied (Table 2), respectively.

  For available phosphorus content in the soil, the significantly maximum phosphorous content of radish (418 kg/ha) was recorded in treatment T_6 (T_1 + vermicompost (3 t/ha) + IIHR microbial consortium (300 g) our treatment under the study. It was followed by the treatment T_5 (412kg/ha) and T_2 (374 kg/ha), while minimum phosphorous content (214 kg/ha) was in treatment T_1 where RDF was applied (Table 2), respectively. The data enunciated on available nitrogen, phosphorous and potassium content in the soil after harvest of the crop revealed that highest values was recorded in T_6: (T_1 + vermicompost (3 t/ha) + IIHR microbial consortium (300 g). The results corroborated by the studies conducted in radish by Kumar *et al.* (2014).

- **Nitrogen, Phosphorous and Potassium content (kg/ha) in dry herb of plant :** For analysing the plant- soil nutrient interaction, the NPK content from plants was also estimated which was mentioned here. Data regarding nitrogen content in dry herb recorded

Table 2 : Effect of integrated nutrient management soil nutrient uptake at harvest on radish (kg/ha).

Treatment	Treatment Detail	N	P	K
T_1	RDF (90:50:90) NPK/ha	63^g	67.5^f	214^g
T_2	T_1 + organic manures in the form of FYM (5t/ha)	126^f	76.5^e	374^c
T_3	T_1 + organic manures in the form of vermicompost (3t/ha)	185^b	90^b	368^d
T_4	T_1 + organic manures in the form of neemcake (17kg/ha)	126^f	81^d	357^e
T_5	T_1 + FYM (5t/ha) + IIHR microbial consortium (300g)	135^c	83.25^c	412^b
T_6	T_1 + vermicompost (3t/ha) + IIHR microbial consortium (300g)	195^a	108^a	418^a
T_7	T_1 + neemcake (17kg) + IIHR microbial consortium (300g)	130^e	90^b	350^f
	CD@5%	1.34	1.45	3.22
	SEm±	0.43	0.47	1.45

Table 3 : Effect of integrated nutrient management on Plant nutrient uptake at harvest (kg/plant) on radish.

Treatment	Treatment Detail	N	P	K
T_1	RDF (90:50:90) NPK/ha	0.924[a]	0.36[a]	0.33[a]
T_2	T_1 + Organic manures in the form of FYM (5 t/ha)	1.12[a]	0.51[ab]	0.35[a]
T_3	T_1 + Organic manures in the form of vermicompost (3 t/ha)	1.05[a]	0.421[ab]	0.38[a]
T_4	T_1 + Organic manures in the form of neemcake (17 kg/ha)	1.12[c]	0.42[ab]	0.37[a]
T_5	T_1 + FYM (5 t/ha) + IIHR microbial consortium (300 g)	1.31[a]	0.46[ab]	0.39[a]
T_6	T_1 + Vermicompost (3 t/ha) + IIHR microbial consortium (300 g)	1.38[a]	0.66[a]	0.45[s]
T_7	T_1 + Neemcake (17 kg) + IIHR microbial consortium (300g)	1.12[bc]	0.62[ab]	0.38[a]
	CD@5%	0.24	0.27	0.25
	SEm ±	0.08	0.09	0.08

Table 4 : Gross return, Net return (Rs/ha) and B:C ratio as influenced by INM in radish.

Treatment	Root yield (t/ha)	Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (RS/ha)	B:C:R ratio
RDF (90:50:90) NPK/ha	14.52	21,780	15,240	6,540	1:1.42
T_1 + organic manures in the form of FYM (5 t/ha)	18.29	27,435	16,821	10,614	1:1.63
T_1 + organic manures in the form of vermicompost (3 t/ha)	20.00	30,000	16,671	13,329	1:1.79
T_1 + organic manures in the form of neemcake (17 kg/ha)	17.58	26,370	17,956	8,414	1:1.46
T_1 + FYM (5 t/ha) + IIHR microbial consortium (300 g)	22.42	33,630	11,512	22,118	1:2.92
T_1 + vermicompost (3t/ha) + IIHR microbial consortium (300 g)	25.98	38,970	17,956	21,014	1:1.17
T_1 + neemcake (17 kg) + IIHR microbial consortium(300g)	20.50	30,750	19,171	11,579	1:1.60

that significantly maximum nitrogen content in dry herb was of plant evaluated in treatment T_6 (1.38%) under study followed by the treatments T_2, T_5 in T_7 as intermediate while minimum nitrogen content in dry herb was retained T_1 (0.924%) with T_3 (Table 3), respectively. For potassium content, the data from dry herbs recorded was significantly maximum potassium content in dry herbs which was produced in treatment T_3 (0.66%) followed by the treatments T_7, T_5 and T_4 as intermediate and minimum potassium content in dry herbs was retained in T_1(0.36 %) with T_2 (Table 3), respectively. The data is presented in graphical format in the Fig. 2.

Significantly maximum phosphorous content in dry herb of radish (0.45) was recorded in treatment T_7 (T_1 + vermicompost (3t/ha) + IIHR microbial consortium (300 g). It was followed by the treatments T_5 (0.39 %) and T_7 (0.38%), while minimum phosphorous content in dry herb of plant (0.33%) was recorded in treatment T_1 where RDF was applied (Table 3 and Fig. 2). The maximum nitrogen, phosphorous and potassium content in dry herb was recorded in T_6: T_1 + vermicompost (3t/ha) + IIHR microbial consortium (300 g) Similar results were observed by Kumar *et. al.* (2014) in radish.

- **Economic assessment :** The economics of different treatment combinations consisting of land configuration and fertilizer level worked out by considering the prevailing market price of produce and input is furnished. For economic assessment, root yield in t/ ha was assessed. The net income was calculated by removing the cost of cultivation of radish cultivar from the gross income. Total selling price of radish was estimated to be Rs. 1500 per ton.

As per the data presented in Table 4, the B: C ratio is affected by the application of different integrated nutrient management in radish it is checked for the data that B: C regarded from 1.17 to 2.92 in different treatment under study. More ratio is observed in the treatment T_6 (T_1 +

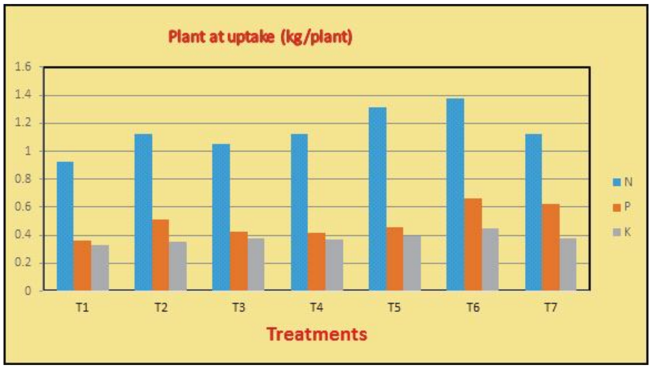

Fig. 2 : Effect of integrated nutrient management plant nutrient status at harvest (kg/ plant) on radish.

Note: T_1 : RDF (90:50:90) NPK/ha
T_2 : T_1 + organic manures in the form of FYM (5 t/ha)
T_3 : T_1 + organic manures in the form of vermicompost (3 t/ha)
T_4 : T_1 + organic manures in the form of neem cake (17 kg/ha)
T_5 : T_1 + FYM (5 t/ha) + IIHR microbial consortium (300 g)
T_6 : T_1 +Vermicompost (3 t/ha) + IIHR microbial consortium (300 g)
T_7 : T_1 + neem cake (17 kg) + IIHR microbial consortium (300 g)

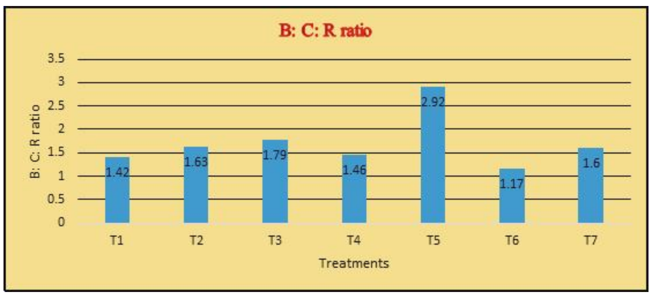

Fig. 3 : B:C:R ratio of integrated nutrient management in radish.

Note: T_1 : RDF (90:50:90) NPK/ha
T_2 : T_1 + organic manures in the form of FYM (5 t/ha)
T_3 : T_1 + organic manures in the form of vermicompost (3 t/ha)
T_4 : T_1 + organic manures in the form of neem cake (17 kg/ha)
T_5 : T_1 + FYM (5 t/ha) + IIHR microbial consortium (300 g)
T_6 : T_1 +Vermicompost (3 t/ha) + IIHR microbial consortium (300 g)
T_7 : T_1 + neem cake (17 kg) + IIHR microbial consortium (300 g)

vermicompost (3 t/ha) + IIHR microbial consortium (300g). It was followed by the treatment T_3 (1.79) and treatment T_2 (1.63), while treatment T_4 (1.46) showed less B: C compared to all treatments under study.

Conclusion

The present study reached up to the conclusion that maximum nitrogen, phosphorous and potassium content in dry herb was recorded in T_6:T_1+ vermicompost (3 t/ ha) + IIHR microbial consortium (300 g) as compared to rest of the treatments. From the economics point of view, the data pertaining to gross returns, net returns and BCR was as influenced by INM in radish in table 4. The treatment with T_5: T_1 + FYM (5 t/ha) + IIHR microbial consortium (300 g) occurred gross returns of Rs. 33,650 per hectare, over returns of Rs. 22,118 per/ha and BCR of 2.92 the next best treatment was T_6.

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Conflict of interest

The authors report no conflicts of interest in this article.

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