Annals of Arid Zone 62(4): 317-322, 2023

Comparison of Organic and In-organic Sources of Nutrients in Radish for Higher Productivity and Soil Fertility

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Received: 28 February, 2023 Accepted: 23 June, 2023

Abstract: **Abstract**: A field experiment conducted in the semi-arid climate of Achrol aimed to assess the impact of various nutrient sources on radish productivity. The study involved 15 treatment combinations, encompassing five levels of organic manure (control, FYM at 10 t ha^{-1}, FYM at 15 t ha^{-1}, vermicompost at 5 t ha^{-1}, and vermicompost at 7.5 t ha^{-1}) and three levels of inorganic fertilizers (control, 75% of recommended fertilizer dosage, and 100% of recommended fertilizer dosage). The experiment followed a randomized block design with three replications. Among the different treatments, the application of vermicompost at a rate of 7.5 t ha^{-1} yielded the highest radish crop production at 25.8 t ha^{-1}. Additionally, the roots exhibited increased nitrogen content at 1.52%, phosphorus at 0.56%, and sulfur at 0.23% when vermicompost was applied at 7.5 t ha^{-1} compared to the control. Various growth parameters, such as fresh leaf weight, fresh root weight, average neck thickness, and root diameter, also demonstrated improvements with vermicompost application at 7.5 t ha^{-1}. It's noteworthy that the yield achieved with 7.5 t ha^{-1} vermicompost was statistically similar to that obtained with 100% of the recommended inorganic fertilizer dosage.

Keywords: Fertilizer, manure, nutrient, radish, root yield.

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Guest Editors

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Citation

Meena, P. D., Dhaka, R. S. and Merena, S. L. 2023. Nutrient management options for enhanced productivity of radish and fertility of the soil under semi-arid environment. Annals of Arid Zone 62(4): 317-322

https://doi.org/10.59512/aaz.2023.62.4.7

https://epubs.icar.org.in/index.php/AAZ/article/view/133886

The experiment aimed to assess the impact of organic manures and inorganic fertilizers on the yield and nutrient content of radish (*Raphanus sativus* L.), a widely cultivated root vegetable in India. Radish is known for its nutritional value, with tender tuberous roots consumed both cooked and raw. It is grown extensively in several Indian states. The cultivation area for radish is about 0.17 Mha, with an average production of 2.42 Mt. It is cultivated in both tropical and temperate regions. It can be cultivated under cover for early production but large-scale production in field is more common in Haryana, West Bengal, Punjab, Bihar, Assam, Madhya Pradesh and other states of India. Radish roots are rich in potassium and calcium, while the leaves are a good source of minerals and vitamins, including vitamin A and vitamin C. The vegetable is used in various traditional medicinal practices, and its leaves are explored for protein extraction, while the seeds can be a source of non-drying fatty oil. The study recognized the importance

of nutrient management for radish yield. Farmyard manure and vermicompost were considered integral to an integrated nutrient supply system, benefiting soil health, water retention, texture, and organic matter. The combination of chemical fertilizers (nitrogen, phosphorus, potassium) and organic fertilizers was found to produce growth-promoting substances, enhancing germination, root and shoot development, and ultimately increasing yield. Given the cost and environmental concerns associated with synthetic fertilizers, the study emphasized the need for alternative and economical sources like organic manures. The field experiment sought to provide insights into achieving optimal nutrition for radish through a combination of organic and inorganic fertilizers to ensure sustainable production. The goal was likely to find a balanced approach that maximizes yield while minimizing the environmental impact.

Materials and Methods

The winter (rabi) season experiment of 2016-17 was conducted at the Horticulture Farm, M.J.R.P. College of Agriculture & Research in Achrol, Jaipur, Rajasthan, falling under agro-climatic zone-IIIA. The experimental site is situated at 26°50" North latitude and 75°28" East longitudes at an altitude of 427 meters above mean sea level. The region is characterized by semi-arid conditions with low annual rainfall (350-450 mm). The sandy loam soil (62.48% sand, 12.66% silt and 24.86% clay) at the experimental site was slightly alkaline (pH 7.6) with low organic carbon (0.36%), nitrogen (125.4 kg N ha^{-1}), medium phosphorus (12.8 kg P2O5 ha^{-1}), and potassium content (188.8 kg K_2O ha^{-1}).

The experiment comprised 15 treatment combinations involving five different levels of organic manure (control, FYM @ 10 t ha^{-1}, FYM @ 15 t ha^{-1}, vermicompost @ 5 t ha^{-1}, vermicompost @ 7.5 t ha^{-1}) and three levels of inorganic fertilizers (control, 75% RDF, 100% RDF) in a randomized block design replicated thrice. Different organic manures such as farm yard manure (FYM) and vermicompost (VC) were incorporated in the field before sowing as per the treatments. The cultivation of the 'Pusa Rashmi' radish variety involved planting with a spacing of 20×10cm. Standard and uniform agronomic and cultural practices, along with plant protection measures, were implemented to ensure the cultivation of a healthy crop. Observations, including fresh weight of leaves, fresh weight of roots, average neck thickness, and root diameter, were recorded. These observations were taken from five randomly selected plants within each treatment to determine various growth and yield parameters. The average values of these parameters are presented in the tables, reflecting the overall performance of the radish variety under different treatments. Various growth and yield parameters, including fresh weight of leaves, fresh weight of roots, average neck thickness, and root diameter, were recorded from randomly selected plants in each treatment.

Soil samples were collected initially up to 15 cm depth from site and 5 soil samples from each plot were collected at the time of harvesting of the crop and analyzed for pH, electrical conductivity, organic carbon, and nutrient content. Additionally, total nitrogen, phosphorus, potassium, and micronutrients in radish roots were determined through laboratory analyses. The air-dried soil samples were passed through 2 mm sieve. Soil pH (1:2 soil: water) and electrical conductivity (EC 1:2 soil: water) were determined. Soil organic carbon was determined by using Walkley and Black method according to Jackson (1973). The available nitrogen was estimated by using alkaline permanganate ($KMnO_4$) method (Subbiah and Asija, 1956), available phosphorus by Olsen's method (Olsen *et al*., 1954) and available potassium by flame photometer (Jackson, 1973). The DTPA-extractable micronutrients were estimated as per Lindsay and Norvell (1978). To assess the nutritional composition of the radish roots, the following methods were employed:

Total Nitrogen Content: Roots (0.5 g dry weight each) underwent digestion with 10 ml of analytical grade concentrated sulphuric acid (H_2SO_4), along with a pinch of digestion mixture ($CuSO_4$ + K_2SO_4 + selenium + mercury oxide). The Kjeldahl's apparatus was used for estimation.

Phosphorus, Potassium, and Micronutrients Content: Wet digestion was performed using the method outlined by Piper (1966) and phosphorus was calorimetrically determined

Table 1. Effect of organic manures and inorganic fertilizer on yield attributes and yield of radish

Treatment	Average fresh weight of leaves (g plant^{-1})	Average fresh weight of root (g)	Average neck thickness (cm plant^{-1})	Average diameter of root (cm plant^{-1})	Root yield (t ha^{-1})
Organic manure					
Control	71.28	117.08	7.63	3.07	14.99
FYM (10 t ha^{-1})	77.74	174.95	9.03	3.35	19.28
FYM (15 t ha^{-1})	81.07	179.81	9.35	3.47	20.02
VC (5 t ha^{-1})	83.64	181.55	9.96	3.78	23.38
VC (7.5 t ha^{-1})	89.06	195.96	10.85	4.36	25.75
S Em±	1.74	3.03	0.24	0.09	0.3840
LSD (0.05)	5.05	8.77	0.69	0.27	1.1130
Inorganic fertilizer					
Control	72.45	117.45	8.16	2.67	14.54
RDF (75%)	81.68	193.11	9.75	3.66	22.00
RDF (100%)	87.54	199.05	10.19	4.54	25.50
SEm±	1.35	2.34	0.19	0.07	0.297
LSD (0.05)	3.91	6.79	0.54	0.21	0.862

using the vanado-molybdate method. Potassium weas estimated using flame photometer and micronutrients (Fe, Cu, Mn, Zn) using atomic absorption spectrophotometer.

These analytical techniques provided detailed insights into the nitrogen, phosphorus, potassium, and micronutrient content of the radish roots, essential information for understanding the plant's nutritional profile.

The collected data underwent statistical analysis using ANOVA, and differences between treatment means were assessed using the F-test. Standard error of means (SEm±) and critical difference ($P<0.05$) were calculated to determine significant differences between treatments.

Results and Discussion

Yield and yield attributing characters

The present study revealed that elevated levels of organic manures positively influenced growth parameters, including fresh weight of leaves and neck diameter, as well as yield (Table 1). Notably, the application of 7.5 t ha^{-1} vermicompost demonstrated the most significant impact on plant growth. This improvement could be attributed to the enhanced moisture-holding capacity and increased availability of major and micro nutrients in the soil, creating favorable conditions facilitated by vermicompost (Akay, 2019; Durukan *et al*., 2019). These findings align closely with the results reported by Lakra *et al*. (2017) and Satari *et al*. (2020). Additionally, vermicompost may have boosted the efficiency of nitrogen-fixing bacteria and accelerated humification, leading to heightened availability of both native and added nutrients in the soil, thereby resulting in increased yield and improved yield-related characteristics (Jat *et al*., 2017; Kumar *et al*., 2014). The application of FYM at 15 t ha^{-1} also demonstrated a significant increase in yield attributes and total yield. This enhancement is attributed to the comprehensive improvement in the physical, chemical, and biological properties of the soil by FYM, leading to increased growth parameters, yield attributes, and overall yield. FYM serves as a source of all essential nutrients for plants, fostering enhanced food synthesis and efficient partitioning to the sink. Additionally, FYM acts as an energy source for soil microflora, facilitating the transformation of inorganic nutrients into readily utilizable forms for plants. The study results clearly highlight that increasing levels of nitrogen (N), phosphorus (P), and potassium (K) significantly augmented various growth parameters and total yield (Table 1). The most substantial increase was observed under the treatment of 100% RDF (recommended dose of N, P, K). This outcome can be attributed to the creation of a favorable nutritional environment in the root zone for optimal plant growth and development. N, P, and K are essential nutrients crucial for maintaining

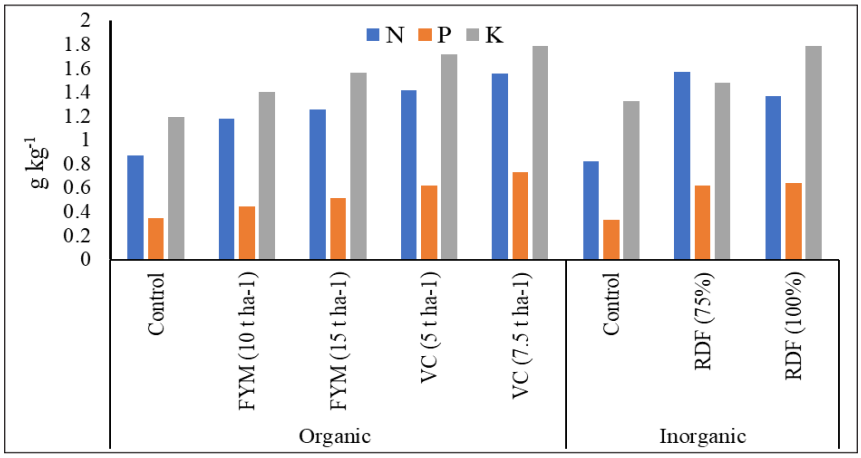

Fig. 1. Effect of organic and inorganic nutrient management on N, P and K content in roots of radish.

proper metabolism in plants. Nitrogen, being a key component of various cellular structures, plays a vital role in metabolic processes. Phosphorus, as a constituent of nucleic acids and phytin, is important for early-stage growth and stimulation of the root system, facilitating efficient translocation of nutrients. These findings align with the results reported by various researchers, emphasizing the positive impact of nutrient management on crop growth and yield (Lakra *et al*., 2017; Verma *et al*., 2017; Kumawat *et al*., 2018; Rajwade and Bahadur, 2018; Durukan *et al*., 2019; Manimegala and Gunasekaran, 2020; Satari *et al*., 2020).

Nutrient Content

The nutrient content results (N, P, K, and Fe, Cu, Mn, and Zn) in roots are illustrated in Figures 1 and 2. Application of organic manures and fertilizers positively influenced nutrient content by enhancing their availability. Notably, vermicompost at 7.5 t ha^{-1}, which also resulted in the highest yield, exhibited the highest values for nutrient content in roots. This could be attributed to the more easily available nutrients from vermicompost compared to FYM. Vermicompost, being slightly acidic with a pH of 6.6, contains higher organic matter and available plant nutrients than other organic materials (Boyhan *et al*.,1999; Levy and Taylor, 2003). The data indicated a significant increase in macro and micro-nutrient concentrations with higher rates of inorganic fertilizers alone, contributing to enhanced nutrient concentration in radish plant roots. Furthermore, the combination of

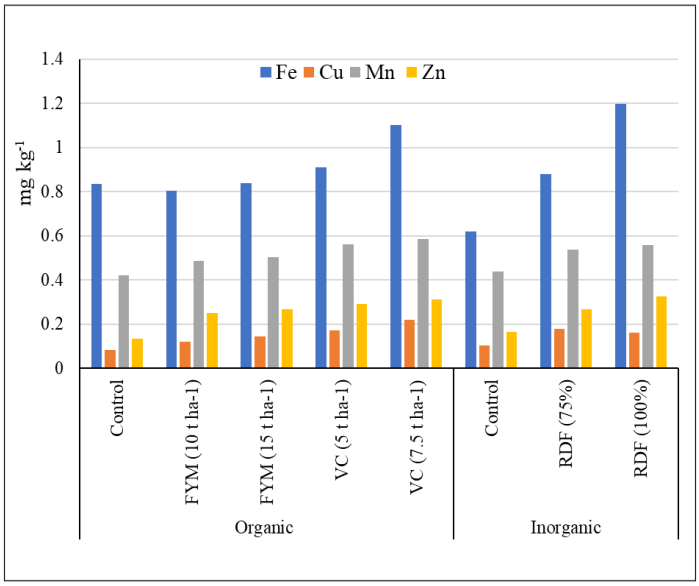

Fig. 2. Effect of organic and inorganic nutrient management on Fe, Cu, Mn and Zn content in roots of radish.

N, P, and K from inorganic fertilizers with organic materials stimulated the accumulation of nutrient elements in radish roots compared to the application of inorganic fertilizers alone (data not presented). This suggests a synergistic effect between inorganic fertilizers and organic materials in increasing soil-available macro and micronutrient status. The results underscore the importance of the combined use of mineral fertilizers with organic matter to create optimal conditions for maximizing benefits.

Soil fertility status

The results also demonstrated a significant increase in the availability of macro and micronutrients in the soil with the application of organic materials compared to the control (data not presented). The decomposition of organic materials likely contributed to the production of organic and inorganic acids, which could have led to a decrease in soil pH, thereby increasing nutrient availability in the rhizosphere zone. This aligns with findings from various studies reporting positive effects following the incorporation of organic fertilizers into the soil (Ahmed and Osman, 2003; El-Etr *et al*., 2004; Mahmoud, 2000). Researchers like Resole and Forghani (2006) have also noted that different organic materials influence the content of trace elements in the soil. Specifically, the application of vermicompost at 7.5 t ha^{-1} resulted in the highest values for trace elements, potentially due to its higher initial content of these elements. The impact of organic materials on iron (Fe) uptake by radish might be linked to the use of their organic carbon as an energy source by soil microorganisms. As these microorganisms mineralize, they release organic acids, which decrease soil pH and enhance the availability of Fe (Bokhtiar and Sakurai, 2005). Furthermore, the results indicated that the recommended doses of inorganic fertilizers (N, P, and K) in combination with organic materials further stimulated nutrient accumulation in the soil compared to the application of inorganic fertilizers alone.

Conclusion

Based on the results obtained from this study, it can be concluded that the application of vermicompost at a rate of 7.5 t ha^{-1} emerged as the most effective treatment, yielding favorable outcomes in terms of crop yield and related parameters.

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