



Influence of organic manures and zinc on yield, quality and profitability of radish (*Raphanus sativus* L.) under semi-arid conditions

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Summary

The study was conducted to determine the effect of organic manures and zinc on radish's growth, yield, quality and economics. The maximum average weight of the root (193.72 g), root: shoot ratio (2.72), root yield (258.86 q/ha), ascorbic acid (13.72 mg/100g), zinc content in leaves (25.05 ppm), net return (Rs 170280/ha) and B: C ratio (2.92) were recorded and significantly influenced in treatment M₂ but these parameters were at par with M₃ except net return. In the case of zinc levels, the maximum average weight of root (194.81 g), root: shoot ratio (2.62), root yield (253.30 q/ha), ascorbic acid (13.40 mg/100g), net return (Rs 167810/ha) and B: C ratio (2.96) were recorded in treatment ZnSO₄ @ 25 kg/ha but these parameters were at par with Z₃. However, zinc content in leaves and roots (27.31 & 47.15 ppm) were recorded more in treatment Z₃ @ 30 kg/ha but these parameters did not differ significantly from treatment Z₂. The combining effect of different organic manures and zinc levels was significant on the B: C ratio. Moreover, the interactive effect between vermicompost @ 3 t/ha along with ZnSO₄ @ 25 kg/ha was significantly higher (3.27) over the rest of the treatments except M₃Z₃, M₂Z₃ and M₃Z₂, which were found statistically at par to it.

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Introduction

Radish is an important root vegetable, belongs to the family *Brassicaceae*. It can be grown around the year in almost all parts of India. Its root has huge demand as salad and leaves use for the preparation of vegetables and paratha. Radish prevents constipation, has a cooling effect rises appetite recommended for patients suffering from piles, liver troubles and jaundice. The juice of leaves is used as a laxative and diuretic. Radish is a good source of ascorbic acid, carbohydrates and supplies ample quantity of minerals. It contains 93.7 per cent water, 4.2 per cent carbohydrates, 0.1 per cent fat, 1.1 per cent protein, 37 mg calcium, 260 mg potassium, vitamin A (30 IU) and 24 mg vitamin C per 100 g of edible roots (Nath and Swamy 2020). The pungency in radish root is due to isothiocyanates (Bose et al. 2000).

Integrated nutrient management practices use a judicious combination of organic and inorganic fertilizers to increase crop productivity and build soil fertility. The total dependence on inorganic fertilizers has led to ill

effects on soil; therefore, alternative cheap organic sources of nutrients should be used (Kumar et al. 2014; Nagar et al. 20217; Samadia & Haldhar 2019). In recent years the application of different organic manures, viz., farm yard manure, vermicompost and poultry manure to maintain the fertility and productivity of soil and crop yield productivity (Mahokar et al. 2007; Samadia & Haldhar 2017). Vermicompost is a rich source of macro and micronutrients and can improve the soil's physical condition. FYM is not a rich source of nutrients but rise organic carbon content in the soil. The soil microbial establishment and the accumulation of excess humus content are increased with organic manures. It is well known that applying micronutrients is the best policy for plant quantity and quality improvements. Zinc is also an important micronutrient concerned in metabolic processes, enzymatic system and rate of maturity in plants. It is crucial for plant growth because it controls the synthesis of indole acetic acid, which noticeably regulates plant growth and activates many enzymatic reactions which are necessary for chlorophyll synthesis and carbohydrate formation (Vitosh 1994). The production of radish especially in sandy soils with low carbon content and zinc affect the crop productivity, therefore the soil application of organic manures with zinc application has beneficial effect for improving root yield. Further, keeping in view, the present experiment was conducted to find out the effect of organic manures and zinc on growth, yield, quality and economics of radish.

Materials and Methods

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The experiment was conducted during *Rabi* season of 2020-21 at the Horticulture Farm of S.K.N. College of Agriculture (SKNAU), Jobner. This site falls in agro-climatic zone 3-A semi-arid eastern plain zone. The experiment was conducted in a factorial randomized block design with three replications. It consisted of sixteen treatment combinations viz., organic manure: M₀ (control), M₁: FYM (9 t/ha), M₂: vermicompost (3 t/ha) and M₃: poultry manure (3.6 t/ha) and second factor i.e., zinc sulphate: Z₀: (control), Z₁: zinc sulphate (20 kg/ha), Z₂: zinc sulphate (25 kg/ha) and Z₃: zinc sulphate (30 kg/ha). The recommended dose of NPK used for radish crops was 45:48:48 kg per ha. The crop was maintained and other practices were followed as per the package of practices for the region. The physio-chemical properties of the experimental field having organic carbon (0.15%), available nitrogen (140.56 kg/ha), phosphorus (18.40 kg/ha), potassium (157.60 kg/ha) and zinc content (0.50 ppm), Soil pH 8.1 and EC (0.80 dsm⁻¹). NPK content in different sources of organic manure was viz., FYM, Vermicompost and Poultry manure (0.5:0.25:0.50; 1.5:1.00:1.10 and 1.5:2.15: 1.20) All the observations were taken at harvest and post-harvest. Yield parameters viz. root weight per plant, are calculated with the help of an electronic weighing machine. The root: shoot ratio was calculated by dividing the weight of leaves' weight by the roots' weight. Root yield was measured by the given formula: Root yield (q/ha) = (Root yield (kg/plot) X 10000)/(Net area of the plot (m²) X 100). Quality parameter like TSS was determined with the help of a hand refractometer and ascorbic acid was measured with the method given by Ranganna (1977). The zinc content in roots and leaves was measured with the Atomic Absorption Spectrophotometer (Lindsay and Norvell 1978). The data were statistically analyzed by the standard technique of analysis of variance (ANOVA) and significance was tested by F-test at 5% level of significance.

Results and Discussion

Effect of organic manures and zinc on yield attributes

The average weight of root, root: shoot ratio and root yield were influenced significantly by organic manures and zinc levels (Fig.1). The treatment M₂ was recorded a significantly maximum average root weight (193.72 g), root: shoot ratio (2.72) and root yield (258.86 q/ha) in comparison to M₀ (control) and M₁ (FYM @ 9 t/ha) but these parameters have not differed from treatment M₃ (poultry manure @ 3.6 t/ha). Vermicompost improves the physical properties of soil by decreasing the bulk density

and increasing the soil water holding capacity of sand soils resulting average weight of root, root shoot ratio and root yield increase. Among the various organic manures, the vermicompost is a rich source of macro and micronutrients, which supply 30 per cent of the total crop requirement as it is a potential source of readily available nutrients for plant root growth. Nitrogen derived from earthworms supplies maximum nutrient elements and contains beneficial microbes like nitrogen-fixing bacteria, mycorrhizae and growth-promoting substances. The present findings are in conformity with the findings of Jaisankar (2018), Kushwah et al. (2020) and Dulal et al. (2021) in radish. Among the zinc levels, treatment Z₂ recorded significantly higher average root weight (194.81 g), root: shoot ratio (2.62) and root yield (253.30 q/ha) in comparison to the control) and Z₁ but these parameters were at par with Z₃. The increased growth parameters provided greater sites for photosynthesis and diversion of photosynthates towards the sink. The main functions of zinc in plant as a metal activator of several enzymes like dehydrogenase, proteinase and peptidases so that root weight as well as yield was increased. The higher values of net returns and B:C ratio under these treatments could be ascribed to the higher root yield of radish obtained under these treatments (Table 2). Similar findings were also recorded by Khatemenla et al. (2018) in onion.

The interactive effect of organic manures and zinc (Fig 2, 3 & 4) significantly influenced overall improvements of the average weight of root, root yield and B:C ratio of radish. A significantly higher average weight of root (215.39 g) was recorded in M₂Z₂ (vermicompost @ 3t/ha and ZnSO₄ @ 25 kg/ha) over the rest of the treatment combinations. Significant maximum root yield (290.61 q ha⁻¹) and B:C ratio was recorded in M₂Z₂ (vermicompost @ 3t/ha and ZnSO₄ @ 25 kg/ha) over rest of treatment combinations except M₂Z₃, M₃Z₂ and M₃Z₃. The average weight of root and root yield enhanced under these treatments might be due to the increasing level of fertility status of the soil by adding vermicompost. Zinc and vermicompost is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops. The increased gross and quality might be due to the effect of micronutrients which plays a decisive role in improving the productivity of the crop. Similar findings were also reported by Seema (2017) in spinach and Alam et al. (2021) in carrot.

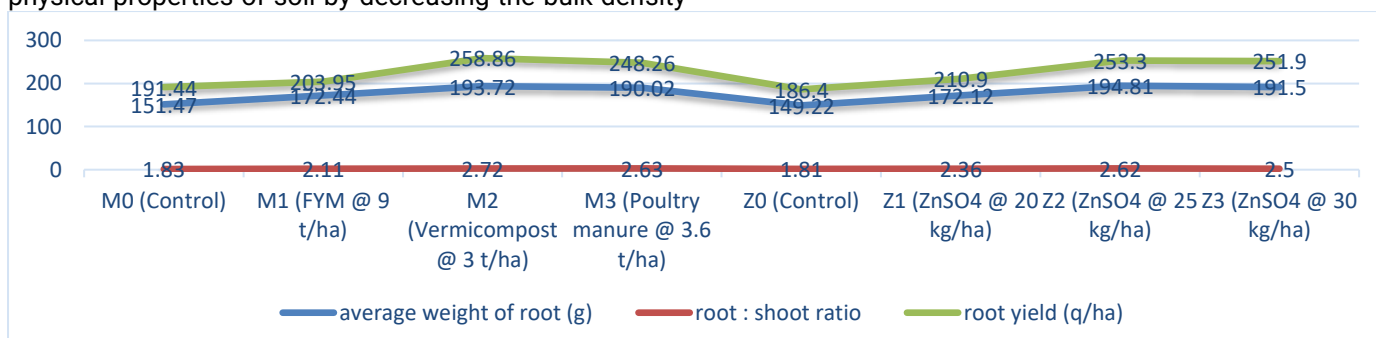


Figure 1. Effect of different organic manures and zinc levels on average weight of root, root: shoot ratio and root yield of radish

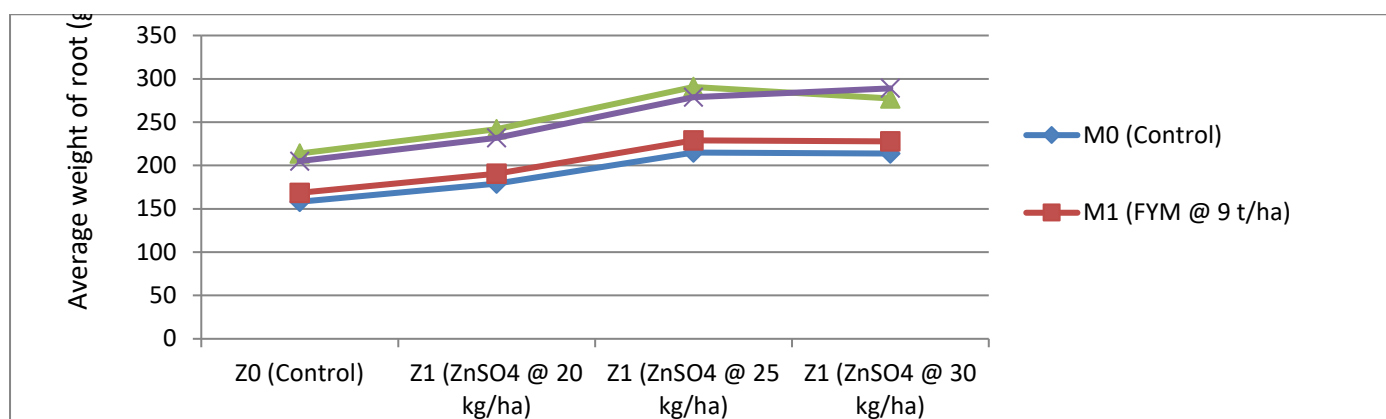


Figure 2. Interactive effects of different organic manures and zinc levels on average weight of root of radish

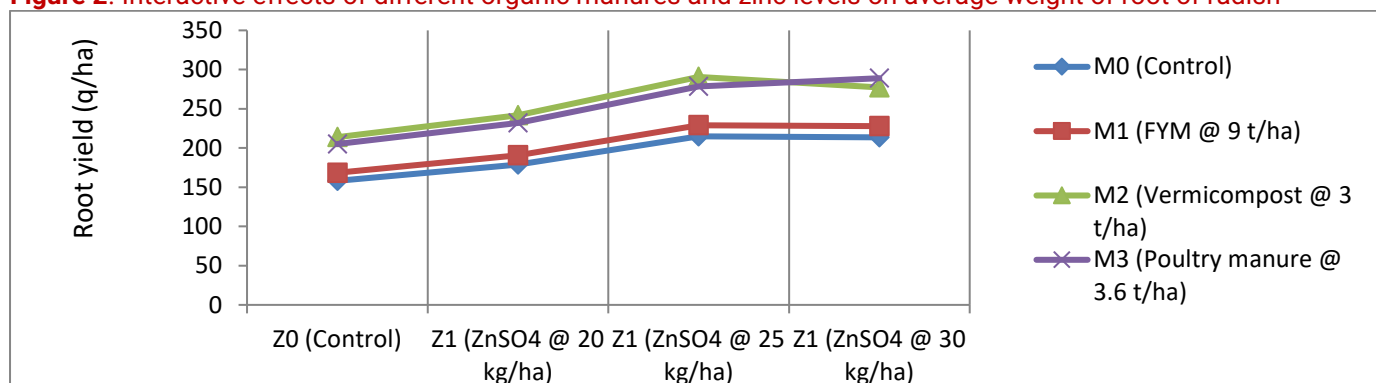


Figure 3. Interactive effects of different organic manures and zinc levels on root yield of radish

Effect of organic manures and zinc on quality parameters

Quality of radish roots in terms ascorbic acid, zinc content in leaves and roots were influenced significantly by organic manures and zinc application (Table 1). The treatment M₂ was recorded significantly maximum ascorbic acid (13.72 mg/g), zinc content in leaves and roots (25.05 & 47.92 ppm) over M₀ and M₁ but these parameters remained at par with treatment M₃ while in case of TSS there was no significant difference observed between the treatments. This may be attributed to increased available P and total K contents in this treatment. The K and P nutrition positively effects on acid and zinc content. Vermicompost effectively enhanced quality by improving various physico-chemical changes in soils in response to the soil's physical, chemical and biological properties. Similar results are

found by Gyewali et al. (2020) in radish and Negeri (2020). Among the zinc levels, treatment Z₂ recorded significantly high ascorbic acid (13.40 mg/g) in comparison to Z₀ (control) and Z₁ (ZnSO₄ @ 20 kg/ha) but these parameters were at par with Z₃. However, zinc content in leaves and roots (27.31 & 47.15 ppm) was recorded more in treatment Z₃ over Z₀ and Z₁ but these parameters are not significantly differed from treatment Z₂. There is a non-significant difference between treatments in TSS. This might be due to the more significant movement and availability of nutrients resulting in accelerated breakdown of complex polysaccharides into simple sugars and promote direct accumulation in developing roots and leaves. Zinc enhanced metabolic activities involved in the biosynthesis processes such as carbohydrates. Anitha et al. (2022) reported the same trend of results in radish.

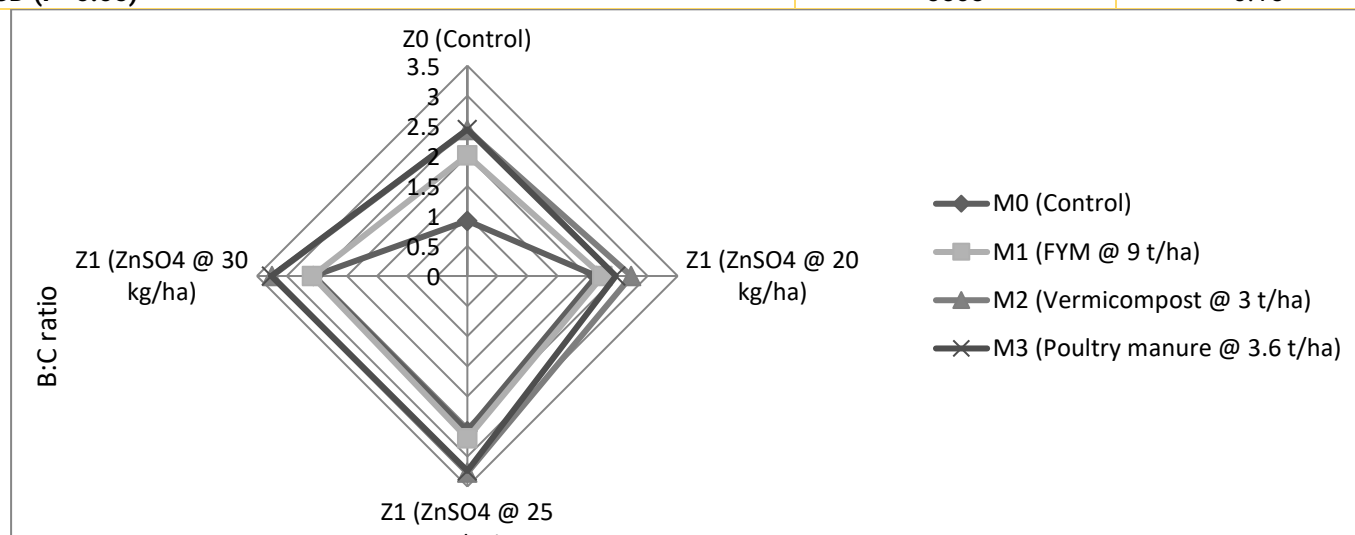
Table 1. Effect of organic manures and zinc on quality parameters of radish

Treatments	TSS (°Brix)	Ascorbic acid (mg/100g)	Zinc content in leaves (ppm)	Zinc content in roots (ppm)
Organic manures				
M ₀ (Control)	5.04	9.00	19.70	39.10
M ₁ (FYM @ 9 t/ha)	5.26	10.60	21.40	42.52
M ₂ (Vermicompost @ 3 t/ha)	5.64	13.72	25.05	47.92
M ₃ (Poultry manure @ 3.6 t/ha)	5.50	12.80	24.62	46.71
SEm±	0.24	0.24	0.49	0.89
CD (P=0.05)	NS	0.69	1.39	2.56
Zinc				
Z ₀ (Control)	5.10	9.30	19.23	39.23
Z ₁ (ZnSO ₄ @ 20 kg/ha)	5.22	10.66	20.17	42.88
Z ₂ (ZnSO ₄ @ 25 kg/ha)	5.65	13.40	27.07	47.01
Z ₃ (ZnSO ₄ @ 30 kg/ha)	5.47	12.48	27.31	47.15

SEm±	0.24	0.24	4.34	0.89
CD (P=0.05)	NS	0.69	8.12	2.56

Table 2. Effect of organic manures and zinc on economics of radish

Treatments	Net return (Rs/ha)	B : C ratio
Organic manures		
M₀ (Control)	108360	2.05
M₁ (FYM @ 9 t/ha)	119470	2.41
M₂ (Vermicompost @ 3 t/ha)	170280	2.92
M₃ (Poultry manure @ 3.6 t/ha)	163380	2.92
SEm±	1922	0.05
CD (P=0.05)	5503	0.15
Zinc		
Z₀ (Control)	101860	1.95
Z₁ (ZnSO₄ @ 20 kg/ha)	125560	2.47
Z₂ (ZnSO₄ @ 25 kg/ha)	167810	2.96
Z₃ (ZnSO₄ @ 30 kg/ha)	166260	2.94
SEm±	1922	0.05
CD (P=0.05)	5503	0.15

**Figure 4.** Interactive effect of organic manures and zinc sulphate on B:C ratio of radish

Conclusion

It may be concluded that treatment M₂ (Vermicompost @ 3 t/ha) was superior in terms of average root weight, root: shoot ratio, root yield, economics, ascorbic acid and zinc content in roots and leaves in comparison with M₀ and M₁ but statistically at par with treatment M₃ (Poultry manure @ 3.6 t/ha). Whereas in zinc levels, Z₂ (ZnSO₄ @ 25 kg/ha) recorded maximum yield and quality parameter (expect TSS) followed by treatment Z₃ (ZnSO₄ @ 30 kg/ha). The maximum zinc content in roots and leaves was found higher in treatment Z₃ (ZnSO₄ @ 30 kg/ha) over treatment Z₀ and Z₁ but at par with treatment Z₂. Thus, the combined effect of organic manures and zinc levels *i.e.*, vermicompost @ 3 t/ha along with ZnSO₄ @ 25 kg/ha (M₂Z₂) can be recommended to enhance yield, profitability and quality of radish.

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Declarations of interests

All authors of this manuscript declare that they have no conflict of interest.

Data sharing

All relevant data are within the manuscript.

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