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Effect of conjoint use of organic manures and inorganic fertilizers on the growth and yield of radish (*Raphanus sativus* L.)

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Abstract
The study was conducted at the Research farm of Abhilashi University, Mandi (H.P) during the winter season of 2023. Seven treatments have been studied using a randomized block design with three replications. The main objective of the research was to assess the impact of different organic manures and inorganic fertilizers on the growth and yield of radish crops. The results revealed that treatment T_6 [(N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)] recorded the maximum values of all parameters *viz*., plant height (29.58 cm), number of leaves per plant (13.14 cm), leaf length (26.07 cm), root length (34.42 cm), the weight of whole plant (341.18 g), yield per plot (10.92 kg) and yield per hectare (503.31 q) due to the combined use of organic manures with inorganic fertilizers which provide enough nutrients for their growth and development. The higher soil pH (6.4) was recorded in treatment T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)], the higher organic carbon (1.03%) was recorded in treatment T_3 [Vermicompost (100%)] and higher water holding capacity (25.97%) was observed in treatment T_1 [Farm Yard Manure (100%)]. The higher available N (305.28 kg/ha), P (37.55 kg/ha) and K (247.63 kg/ha) were recorded under treatment T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)]. In terms of economics, the maximum cost of cultivation (₹ 83,627) was recorded in treatment T_3 [Vermicompost (100%)] while the gross income (₹ 2,51,654), net income (₹ 1,76,012) and B: C ratio (2.33) was recorded highest under treatment T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)] which is combined application of organic and inorganic materials.

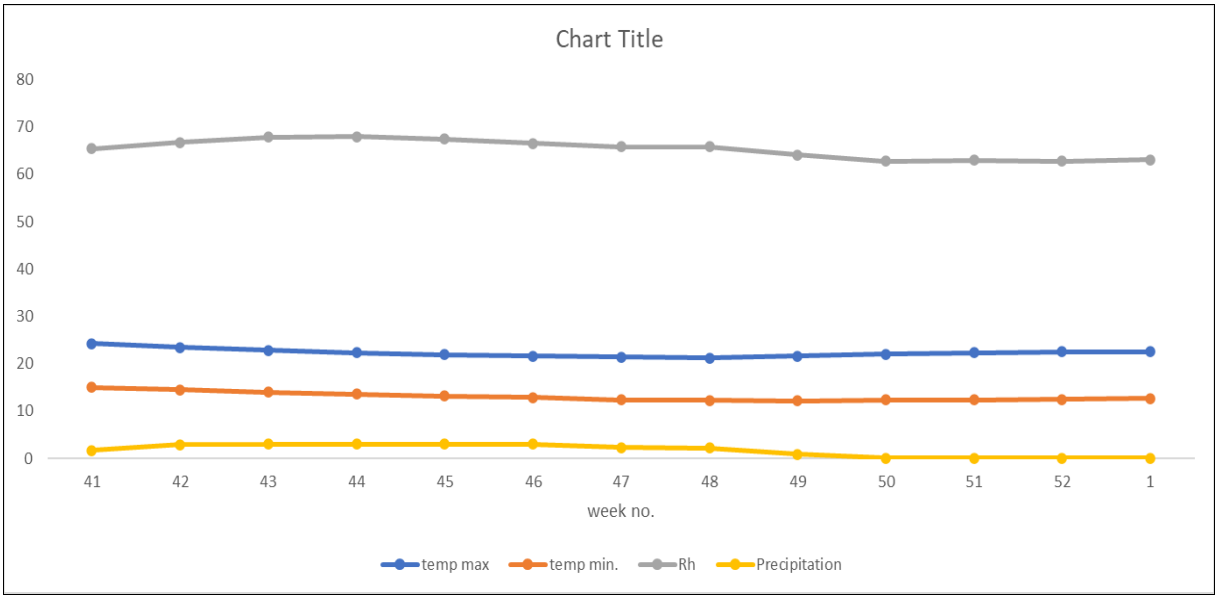
Keywords: Radish, fertilizers, yield, economics, manures

Introduction
Radish (*Raphanus sativus* L.) is the most popular edible root vegetable that grows worldwide. It comes under the family Brassicaceae and originated from the Mediterranean region. The chromosome number of radish is 2n= 2x= 20. This leafy, root vegetable is appropriate for both temperate and tropical climates. The leaves and roots are eaten raw or cooked as vegetables. In India, it has grown over 203.03 thousand MT ha with a production of 3.22 million MT (Anonymous 2021a) [1]. West Bengal, Haryana, Bihar and Assam are important leading radish-producing states. In Himachal Pradesh, it is grown in an area of about 2.09 thousand hectares with a production of 44.74 thousand tonnes (Anonymous 2021b) [2]. It is grown for its tender, edible, young and fusiform roots which can be consumed as a salad or cooked vegetable. Radish roots have 94.4% moisture, 0.7 g protein, 3.4 g carbohydrates, 0.02 mg riboflavin, 0.06 mg thiamine, 15 mg ascorbic acid and 35 mg calcium per 100 g. Radish leaves are high in minerals, vitamins A, C and their roots are high in potassium and calcium. Radish is recommended for patients who are suffering from diseases like neurological headaches, chronic diarrhea, urinary complaints, insomnia and piles (Singh and Bhandari 2015). The continuous use of chemical fertilizers, often in excess over a long period in arable land has led to contamination of food material, environmental pollution and depletion of soil fertility. Therefore, organic manures are a necessary alternative because they are cheaper and provide better soil and water quality than synthetic fertilizers, which are more expensive (Kumar *et al*. 2014) [8].

However, the balanced use of organic and inorganic materials maintains the soil health and crop quality. So, using both organic manure and inorganic fertilizers is the only way to achieve a high-quality root yield while maintaining the health of the soil.

Material and Methods

Experimental site: The study was carried out at Research Farm, Department of Horticulture, School of Agriculture, Abhilashi University, Mandi (H.P.) during the winter season of 2023-24. Geographically the experimental farm is located at the latitude of 31º33'34''N and longitude of 77º00'44''E and a height of 1,416 meters above the average ocean level.



Meteorological data of experimental farm was recorded from October 2023 to January 2024.

Table 1: Treatment details

Notations	Treatments
T_1	FYM (100%)
T_2	NPK (100%)
T_3	Vermicompost (100%)
T_4	NPK (50%) + FYM (50%)
T_5	NPK (50%) + Vermicompost (50%)
T_6	NPK (50%) + Vermicompost (25%) + FYM (25%)
T_7	Control

Note: Recommended dose of fertilizers 50: 100: 50 kg/ha N, P_2O_5 and K_2O

Design of experiment

The experiment was laid out in Randomized Block Design with three replications comprising seven treatment combinations of inorganic fertilizer with organic manures. The layout plan is provided below:

Variety	Meenakshi (Radish)
Design	Randomized Complete Block Design (RCBD)
Replications (s)	3
Treatments	7
Plot size	1.3 m ×1.5 m
Spacing	30 cm × 10 cm
Date of sowing	13th October, 2023

Growth studies

The maximum plant height (29.58 cm), maximum number of leaves per plant (13.14) and length of leaves (26.07 cm) were recorded in treatment T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)] which was statistically at par with treatment T_5 [N: P: K (50%) + Vermicompost (50%)] However, the minimum plant height (18.98 cm), number of leaves per plant (9.11) and length of leaves (16.44 cm) were observed in T_7 (Control). Because NPK fertilizers provide essential nutrients for plant growth where nitrogen stimulates the development of leaves, phosphorus promotes strong root systems and potassium promotes overall plant health including leaf structure and function. NPK fertilizers supply the macronutrients needed for leaf growth and development. Vermicompost and FYM increase soil organic matter, improving microbial activity, nutrient availability and supplying an evenly balanced nutrient profile. Similar results were also in concordance with the findings reported by Bhattrai and Rana (2012) [4], Anand *et al* (2023) [3] Sandhu and Kaur (2022) [10] and Khede *et al*. (2019) [7].

Yield studies

The yield parameters were influenced by both the organic manures and inorganic fertilizers. The maximum root length (34.42 cm), maximum weight of plant (341.18 g), maximum yield per plot (10.92 kg) and maximum yield per hectare (503.31 q) were observed in treatment T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)] which was statistically at par with treatment T_5 [N: P: K (50%) + Vermicompost (50%)]. On the other hand, the minimum root length (25.33 cm), minimum weight of fruit (181.85 g), minimum yield per plot (5.82 kg) and minimum yield per hectare (268.27 q) were recorded in T_7 (Control). The combined use of these components provides a nutrient-rich environment that promotes vigorous plant growth. FYM enhances soil structure and moisture retention, providing an ideal environment for radish root growth. Vermicompost enriches soil with nutrients and microorganisms, leading to healthier and more vigorous plant growth. NPK fertilizers improve radish yield by supplying essential nutrients to the plants. Similar results of this present investigation were also in concordance with the findings reported by Sandhu and Kaur (2022) [10], Khede *et al*. (2019) [7] and Anand *et al* (2023) [3].

Soil studies

Available N, P and K (kg/ha)

The maximum amount of available nitrogen (305.28kg/ha) was exhibited in treatment T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)] which was statistically at par with the treatment T_2. The maximum amount of available phosphorus (37.55 kg/ha) and available potassium (247.63 kg/ha) was exhibited in treatment T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)] followed by treatment T_2. However, the minimum amount of available nitrogen (208.19 kg/ha), available phosphorus (18.79 kg/ha) and available potassium (192.33 kg/ha) was measured in T_7 (Control). It might be due to the use of organic manures in large quantities, including vermicompost, which increases the soil's ability to retain nutrients by releasing more nitrogenous molecules into the soil. In addition to the decrease in potassium fixation and its release as a result of organic matter interacting with clay particles, the beneficial impact of vermicompost and farm yard manure on available K may also be linked to the direct supply of potassium to the soil. Similar results of this investigation were also in concordance with the findings reported by Gangadharappa *et al*. (2020) [6].

Soil pH, OC (%) and WHC (%)

The highest pH (6.04) was observed in the treatment T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)]. Whereas, the minimum pH (5.71) was recorded in T_7 (Control). The results of organic carbon and water holding capacity were significantly impacted by various organic manures and inorganic fertilizers. The highest water holding capacity (25.97%) in soil was observed in treatment T_1 [Farm Yard Manure (100%)] followed by treatment T_6 while the highest organic carbon (1.03%) in soil was observed in treatment T_3 [Vermicompost (100%)] followed by treatment T_5. However, the lowest organic carbon (0.59%) was recorded in T_2 (Control) and the lowest water-holding capacity (15.55%) was observed in T_7 (Control). Similar results of this investigation were also in concordance with the findings reported by Valerio Pita *et al*. (2012) [13], Diya *et al*. (2023) [5] and Ramakal *et al* (1998) [9].

Economics

The combination of both organic manures and inorganic fertilizers has a significant effect on economics. The highest cost of cultivation (₹ 83,627) was found in treatment T_3 [Vermicompost (100%)] followed by T_1 i.e. (₹ 79,627). whereas the lowest cost of cultivation was found in T_7 (Control) i.e. (₹ 57177). The economics in terms of gross return (₹ 2,51,654), net return (₹ 1,76,012) and B: C ratio (2.33) was also maximum in T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)] and the minimum gross return (₹ 1,34,134), net return (₹ 76,957) and B: C ratio (1.35) was incurred in T_7 (Control) respectively.

Table 2: Physico-chemical parameters of the experimental plot

Sr. No.	Parameters	Values obtained	Methods used
1.	Water holding capacity (%)	18.1	Keen's box method (Keen and Raczkowaski 1973)
2.	Soil pH (1: 2.5 soil: water)	5.9	Glass electrode method (Jackson 1973)
3.	Available Nitrogen (kg/ha)	209.4	Alkaline potassium permanganate method (Subbiah and Asija 1956)
4.	Available Phosphorus (kg/ha)	13.8	Olsen's method of extraction with 0.5 1$NaHCO_3$ at pH 8.5 (Olsen *et al* 1954)
5.	Available Potassium (kg/ha)	196.7	Neutral ammonium acetate method (Merwin and Peech 1950)
6.	Organic carbon (%)	0.7	Rapid titration method (Walkley and Black 1934)

Table 3: Effect of organic manures and inorganic fertilizers on plant height (cm), number of leaves per plant, leaf length (cm)

Treatments	Plant height (cm)	Number of leaves per plant	Leaf length (cm)
Farm Yard Manure (100%)	21.53	9.76	18.78
N: P: K (100%)	24.51	11.08	21.46
Vermicompost (100%)	22.83	10.33	20.75
N: P: K (50%) + Farm Yard Manure (50%)	26.57	11.65	23.29
N: P: K (50%) + Vermicompost (50%)	28.06	12.59	24.31
N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)	29.58	13.14	26.07
control	18.98	9.11	16.44
SE(m) (±)	0.72	0.39	0.63
CD $_{(0.05)}$	2.23	1.20	1.93

Table 3: Effect of organic manures and inorganic fertilizers on root length (cm), weight of whole plant (g), yield per plot (kg) and yield per hectare (q)

Treatments	Root length (cm)	Weight of whole plant (g)	Yield per plot (kg)	Yield per hectare (q)
Farm Yard Manure (100%)	27.86	269.96	8.64	398.24
N: P: K (100%)	29.97	281.70	9.01	415.57
Vermicompost (100%)	28.72	277.84	8.89	409.87
N: P: K (50%) + Farm Yard Manure (50%)	31.27	308.34	9.87	454.86
N: P: K (50%) + Vermicompost (50%)	32.81	314.27	10.06	463.61
N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)	34.42	341.18	10.92	503.31
Control	25.33	181.85	5.82	268.27
SE(m) (±)	0.70	5.76	0.18	8.49
CD $_{(0.05)}$	2.15	17.74	0.57	26.17

Table 4: Effect of organic manures and inorganic fertilizers on available N, P and K, soil pH, water holding capacity (%) and organic carbon (%)

Treatment	Soil pH	Water holding capacity (%)	Organic carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available potassium (kg/ha)
Farm Yard Manure (100%)	5.84	25.97	0.95	264.27	22.97	218.75
N: P: K (100%)	6.03	22.45	0.65	297.52	33.42	242.19
Vermicompost (100%)	5.92	16.37	1.03	273.87	24.16	220.91
N: P: K (50%) + Farm Yard Manure (50%)	5.98	21.58	0.94	281.58	26.72	232.54
N: P: K (50%) + Vermicompost (50%)	6.01	20.17	0.97	288.76	31.12	240.27
N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)	6.04	24.92	0.87	305.28	37.55	247.63
Control	5.71	15.55	0.59	208.19	18.79	192.34
SE(m) (±)	0.09	0.32	0.01	4.10	0.51	4.24
CD (0.05)	NS	0.98	0.03	12.64	1.58	13.06

Table 5: Effect of different treatments on the economics of radish

Notation	Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B: C ratio
T_1	Farm Yard Manure (100%)	79,627	1,99,122	1,19,495	1.50:1
T_2	N: P: K (100%)	67,208	2,07,784	1,40,576	2.09:1
T_3	Vermicompost (100%)	83,627	2,04,934	1,21,308	1.45:1
T_4	N: P: K (50%) + farm yard manure (50%)	74,642	2,27,429	1,52,787	2.05:1
T_5	N: P: K (50%) + vermicompost (50%)	76,642	2,31,805	1,55,164	2.02:1
T_6	N: P: K (50%) + farm yard manure (25%) + Vermicompost (25%)	75,642	2,51,654	1,76,012	2.33:1
T_7	control	57,177	13,4,134	76,957	1.35:1

Conclusion

This experiment concluded that combine use of organic and inorganic fertilizers has a beneficial effect on growth yield and soil. From the present studies, it can be concluded that among all the treatments, treatment T_6: [NPK (50%) + Vermicompost (25%) + FYM (25%)] performed best for most of the growth, yield and economic status followed by treatment T_5 [(N: P K (50%) + Vermicompost (50%)]. Soil available NPK was also improved in treatment T_6 [NPK (50%) + Vermicompost (25%) + FYM (25%)]. Therefore, it may be concluded that treatment T_6 [(N: P: K (50%) + Farm Yard Manure (25%) + Vermicompost (25%)] has been proven best for growing radish and maintaining soil health.

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