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Research Article

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Effect of Different Organic Manures on Growth, Yield, and Quality of Late Season Radish (Raphanus Sativus) in Paklihawa, Rupandehi, Nepal

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ABSTRACT

Radish (*Raphanus sativus L.*) is a major root vegetable crop in Nepal. Organic manures are an indispensable substitute for the highly toxic inorganic fertilizers. A research experiment was conducted at the horticulture farm of Institute of Agriculture and Animal Science (IAAS), Paklihawa campus, Rupandehi, Nepal to investigate the effect of different organic manures on the growth, yield, and quality of Tokinashi variety of late-season radish. The experiment was conducted in a randomized complete block design (RCBD) with three replications. The seven different treatments were farm yard manure (FYM) (30 t ha^{-1}), poultry manure (20 t ha^{-1}), FYM (15 t ha^{-1}) + poultry manure (10 t ha^{-1}), FYM (15 t ha^{-1}) + vermicompost (2.5 t ha^{-1}), vermicompost (5 t ha^{-1}), FYM (15 t ha^{-1}) + Bone meal (5 t ha^{-1}), and control (without use of organic manures). Poultry manure was observed significant effect on the growth and yield attributes of radish. The effect of poultry manure over other treatments, viz. plant height (31.17 cm), number of leaves (20.53), shoot length (29.68 cm), crown spread (51.4 cm), root length (28.6 cm), root diameter (10.81 cm), average root weight (130.2 gm), average shoot weight (71 gm), root dry weight (125.33 gm), harvest index (64.85%), shoot yield per hectare (16.22 t ha^{-1}), biological yield per hectare (50.3 t ha^{-1}), root yield per hectare (23.87 t ha^{-1}), and total soluble solid (1.13 ^{0}Brix) were recorded maximum at harvest (77 days after sowing). The ascorbic acid was recorded maximum (0.181 mg ml^{-1}) in vermicompost. It can be concluded that poultry manure can be used for higher yield for late-season radish cultivation under Rupandehi, Terai condition of Nepal.

Keywords: Radish, Farm Yard Manure, Poultry Manure, Vermicompost, Yield, Quality

Introduction

Radish (*Raphanus sativus L.*) is one of the members of the Brassicaceae family and is one of the most significant edible, nutritious, and short-duration root vegetable crops growing in tropical to temperate zones of the globe [1]. Its popularity might be owing to its broader environmental tolerance, simple cultivation techniques, and larger range of usage [2]. Radish is high in minerals and phytochemicals. Leaves are rich in macronutrients such as calcium, sodium, potassium, fiber, fatty acids, and non-flavonoid polyphenols, but sprouts are high in flavonoids such as anthocyanins, beta-carotene, and vitamin C. Roots are strong in non-flavonoid polyphenols, as well as terpenes, and derivatives, and glucosinolates, which are likewise abundant in seeds [3]. The area under production of radish in Nepal is about 18,175 hectares, and total production is 289,558 metric tons with an average productivity of 15.93 metric tons per hectare [4]. MoALD reported the production of radish in Rupandehi district of Nepal at 4082 metric tons in 245 hectares, with an average productivity of 16.66 tons per hectare [4]. It ranks 5th in terms of fresh vegetable production in Nepal, cultivating in all 77 districts of the country. Radish cultivation is influenced by soil, climate, season, variety, and techniques.

Radish has a short growing season; it may be harvested in 22 to 60 days, making it one of the best choices for vegetable production [5]. Lower-fertile soils are not tolerated by radish plants [6]. While radish is not picky about soil composition, it does require a lot of humus [7]. For the root to grow well, organic fertilizer must be introduced into the soil. Increased water penetration and retention; improved soil structure, aeration, and porosity; increased microbial life; and improved nutrient availability and uptake to satisfy crop needs are some advantages of using organic fertilizer. Because breakdown occurs more quickly in tropical soils, organic fertilizers are considerably more crucial [8]. Organic compost can improve the soil in a variety of ways, but it also exhibits a gradual nutrient-release impact [9]. Thus, it is economical for farmers to use organic fertilizers due to the slow release of organic fertilizer to the plant [10]. Chemical fertilizers deteriorate the quality of soil and kill beneficial microorganisms Organic manures such as FYM, vermicompost, and neem cake have gained favor in recent years for enhancing crop productivity while maintaining soil fertility and productivity [11].

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The usage of sustainable farming practices has significantly increased in recent years as a result of growing consumer concern about concerns including food quality, environmental safety, and soil conservation. The use of organic fertilizers like livestock manure has been identified as one of the cornerstones of sustainable agriculture, which has been defined as a collection of practices that preserve resources and the environment without compromising human needs [12]. With this in mind, the current study was carried out to assess the potential of organic manures to boost the growth, yield, and quality of radish during the late season. The originality of our study was evaluating the performance of radish in the late season using organic manures in Terai conditions in Nepal.

Methodology

Research location

The research was carried out at the Institute of Agriculture and Animal Science, Paklihawa, Rupandehi, Nepal, from January 2023 to March 2023. The research site is located at the geographical coordinates 27^{o}40'60" N, 83^{o}25'0" E and lies at 79 masl.

Table 1: Monthly meteorological information from January 2023 to March 2023

Year	Month	Average minimum temperature (^{o}C)	Average maximum temperature (^{o}C)
2023	January	8.9	18.59
2023	February	11.05	25.35
2023	March	14.78	31.24

Experiment Details

The experiment was set in a randomized complete block design (RCBD) with seven treatments and three replications. The treatments were T_1 (FYM 30 t ha^{-1}), T_2 (poultry manure 20 t ha^{-1}), T_3 (FYM 15 t ha^{-1} + poultry manure 10 t ha^{-1}), T_4 (FYM 15 t ha^{-1} + vermicompost 2.5 t ha^{-1}), T_5 (vermicompost 5 t ha^{-1}), T_6 (FYM 15 t ha^{-1} + bone meal 5 t ha^{-1}), and T_7 (control). The spacing between row to row and plant to plant was 20 cm × 20 cm. The distance between treatments was maintained at 50 cm, while the distance between replications was 1 m. The size of an individual plot was 4 m^2 (2 m × 2 m). There were 100 plants in each plot.

Crop Management

The field was tilled until a fine tilth was obtained. The field was prepared, and organic manures were incorporated as per the treatment two days before sowing. High-quality seeds of the Tokinashi variety were sown in the field at a depth of 2-3 cm on January 9, 2023. Intercultural activities were carried out as needed, including five days of mulching the plot, watering following moisture requirements, re-sowing and thinning out to maintain the target plant population, weeding and earthing up at the beginning of plant growth, and plant protection measures.

Sampling and Data Recording

Data were recorded from 10 randomly selected plants, i.e. sampled plants from each plot leaving the border plants. The observations were recorded for growth parameters such as plant height, number of leaves, shoot length, leaf length, leaf width, and canopy cover; yield parameters such as root length, root diameter, fresh root weight, dry root weight, biological yield, economic yield, harvest index; and quality parameters such as total soluble solid (TSS) and vitamin C content. All other data were recorded at the time of harvest, while plant height and leaf count were measured at 28, 35, 42, 49, 56, 63, 70, and 77 days after sowing (DAS).

Leaf Length, Leaf Width, and Canopy Cover (cm)

At harvest, three plants were chosen at random from each plot, and leaf length, leaf width, and canopy coverage were taken. Crown spread was measured in centimeters by taking the mean diameter of the canopy of an individual plant in several directions. Leaf length and leaf width were taken from three leaves on each sampled plant. Leaf width was taken from 3 places in each leaf, i.e. top, mid, and bottom.

Root Length and Root Diameter (cm)

Root length was taken from 3 sampled plants in each plot using a scale while the root diameter of these plants was taken from the top, mid, and bottom of the root using a rope and scale at the time of harvest.

Root and Shoot Weight (gm)

The sample plants were weighed following the measurement of the dry weight of the root. They were placed in a hot air oven at 60 °C for 24 hours, and the dry weight of the root was measured.

Biological Yield, Economic Yield, and Harvest Index

The sampled plants were uprooted, and biological yield (weight of root + shoot) and economic yield (weight of root only) were measured.

$$\text{Harvest index} = \frac{\text{Economic yield (t ha}^{-1})}{\text{Biological yield (t ha}^{-1})} \text{ X } 100\%$$

Total soluble solid (TSS)

From each plot, one sample plant was extracted. Below 2 cm from the crown, 10 grams of each root were cut and crushed to create a homogenized sample, and 10 ml of distilled water was then added. The juice was extracted using a muslin cloth, and a digital refractometer was used to calculate the TSS.

Ascorbic Acid Content (mg ml^{-1} juice)

Approximately 100 ml of distilled water and 50 mg of the sodium salt of 2,6-dichlorophenolindophenol (DCIP) were heated on a hot plate to create the dye solution. After being allowed to cool, it was diluted to 200 ml with purified water. 100 ml of distilled water was used to dissolve 0.5 g of oxalic acid. Standard ascorbic acid was created by weighing 0.01g of ascorbic acid, diluting it with oxalic acid, and then preparing the final volume to 10 ml. Oxalic acid in the amount of 10 ml and a standard ascorbic solution in the amount of 1 ml were combined to standardize the color. The solution was titrated against the dye solution until a 15-second-long pink color was achieved. Then 10 ml of oxalic acid and 1 ml of juice were combined [13]. The following formula was used to calculate the ascorbic acid content of juice:

Concentration of Vitamin C in juice (mg ml^{-1}) =

$$\frac{\textit{DCIP (ml) used to titrate the radish juice}}{\textit{DCIP (ml) used to titrate standard solution}} \text{ X } \textit{1mg ml}^{-1}$$

Statistical Data Analysis

Data were statistically analyzed following analysis of variance (ANOVA) with the help of the R (version 4.3.1) program. The significant difference among treatment means was compared by the least significant difference (LSD) at a 5% level of probability.

Results

Effect of Organic Manures on Growth Parameters

Organic manures are important for improving soil quality and are beneficial for harmonizing nutrient availability, which promotes plant growth [14]. The findings of this study showed that radish responded well to organic manures and their mixtures. After 77 DAS, the plant height (31.17 cm) and number of leaves (20.53) were maximum in T_2 (poultry manure 20 t ha^{-1}) comparable with T_3 (FYM 15 t ha^{-1} + poultry manure 10 t ha^{-1}) and were significantly different ($p<0.05$) from other organic manures, whereas plant height (16.58 cm) and number of leaves (10) were observed minimum in control (Figures 1 and 2).

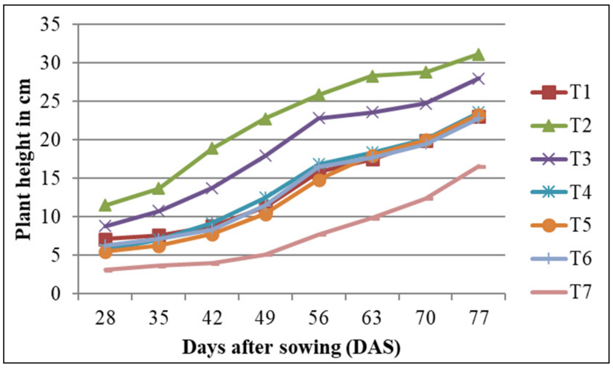

Figure 1: Effect of organic manures on plant height of radish

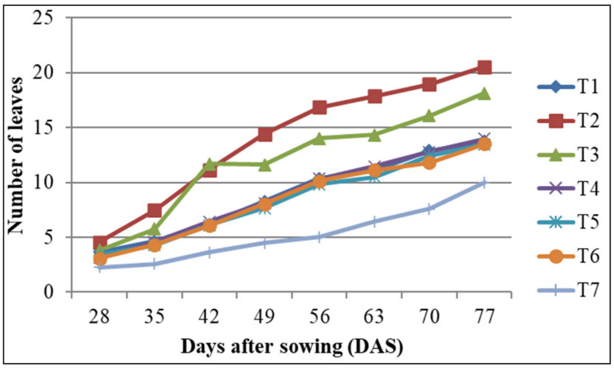

Figure 2: Effect of organic manures on the number of leaves of radish

T_7 (control) had a significantly shorter root length than the other treatments. The highest (28.6 cm) and lowest root length (17.74 cm) were observed in T_2 (poultry manure 20 t ha^{-1}) and T_7 (control), respectively (Figure 3). Similarly, shoot length was significantly higher (29.68 cm) in T_2 (poultry manure 20 t ha^{-1}) and lower (20.91 cm) in T_7 (control) (Figure 3). Khatri et al. reported enhanced growth parameters in radish; Kankam et al., reported increased growth parameters in carrot; and Tiwari et al. reported increased growth parameters in beetroot; and Williams et al. reported increased growth parameters in cucumber with the application of poultry manure [15-18].

Leaf length, leaf width, and crown spread in T_7 (control) were significantly lower than other treatments. The highest (26.23 cm) and lowest (18.53 cm) leaf lengths were observed in T_2 (poultry manure 20 t ha^{-1}) and T_7 (control), respectively (Figure 4). Similarly, leaf width was significantly higher (5.44 cm) in T_1 (FYM 30 t ha^{-1}) and lower (4.4 cm) in T_7 (control) (Figure 4). Crown spread was higher (51.4 cm) in T_2 (poultry manure 20 t ha^{-1}) and lower (37.8 cm) in T_7 (control) (Figure 4).

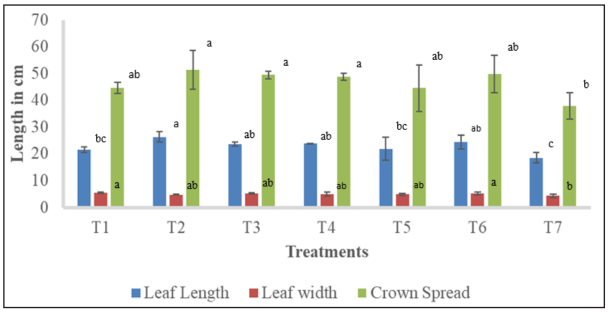

Figure 4: Effect of organic manures on leaf length and leaf width of radish

Effect of Organic Manures on Yield Parameter

The root diameter was found to be significantly higher in poultry manure 20 t ha^{-1} (10.81 cm), followed by FYM 15 t ha^{-1} + poultry manure 10 t ha^{-1} (10.73 cm), and lower in control (5.64 cm).

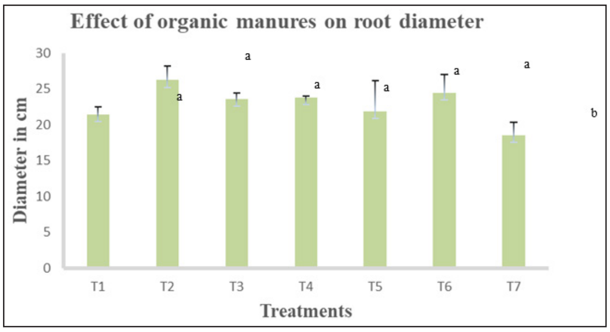

Figure 5: Effect of organic manures on root diameter of radish

The root weight, shoot weight, and biological yield were found to be significantly higher ($p<0.05$) in T_2 (poultry manure 20 t ha^{-1}), with values of 130.2 gm, 71 gm, and 201.2 gm, respectively, whereas they were lower in T_7 (control), with values of 14.07 gm, 19.6 gm, and 33.67 gm (Table 2).

Table 2: Effect of organic manures on root weight, shoot weight, and biological yield per plant at 77 DAS

Treatments	Root weight per plant per plot (gm)	Shoot weight per plant per plot (gm)	Biological yield per plant per plot (gm)
FYM (30 t ha^{-1})	$55.73^{bc}\pm4.45$	$34.00^{cd}\pm4.01$	$89.73^{bc}\pm8.39$
Poultry Manure (20 t ha^{-1})	$130.20^{a}\pm6.18$	$71.00^{a}\pm6.94$	$201.20^{a}\pm12.90$
FYM (15 t ha^{-1}) + Poultry manure (10 t ha^{-1})	126.73a±24.40	$60.13^{ab}\pm7.26$	$186.87^{a}\pm30.80$
FYM (15 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})	$64.40^{b}\pm6.02$	$42.27^{bc}\pm3.35$	$106.67^{b}\pm9.36$
Vermicompost (5 t ha^{-1})	$60.07^{b}\pm18.90$	$34.67^{cd}\pm6.76$	$94.73^{b}\pm25.40$

FYM (15 t ha^{-1}) + Bone meal (5 t ha^{-1})	73.13^{b}±18.90	42.27^{bc}±8.14	115.40^{b}±26.70
Control	14.07^{c}±2.83	19.60^{d}±3.47	33.67^{c}±5.73
LSD (0.05)	42.28***	19.74**	60.43***
CV (%)	31.30	25.56	28.71
Grand mean	74.90	43.42	118.32

Note: LSD= Least Significant Difference, CV= Coefficient of Variations, *** = significant at p≤ 0.001, ** = significant at p≤ 0.01, * = significant at p≤ 0.05. Treatments means are separated by least significant difference (LSD), and the columns are represented by the same letter(s) and are non-significantly different from each other at a 5 % level of significance.

There was a significant difference ($p<0.05$) among organic manures on dry weight of root and found maximum in T_2 (Poultry manure 20 t ha^{-1}) and minimum in T_7 (control) with values 125.33 gm and 7 gm respectively while there is not much difference in harvest index which was found to be maximum in 67.04% in T_3 (FYM 15 t ha^{-1} + poultry manure 10 t ha^{-1}) while minimum in T_7 (control) with value 41.4% (Table 3).

Table 3: Effect of organic manures on dry root weight and harvest index at 77 DAS

Treatments	Dry weight of Root	Harvest Index (HI)
FYM (30 t ha^{-1})	60.67^{bc}±22.80	62.30^{a}±1.15
Poultry Manure (20 t ha^{-1})	125.33^{a}±21.40	64.85^{a}±1.25
FYM (15 t ha^{-1}) + Poultry manure (10 t ha^{-1})	124.67^{a}±12.30	67.04^{a}±2.84
FYM (15 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})	47.33^{bc}±10.70	60.32^{a}±0.41
Vermicompost (5 t ha^{-1})	50.67^{bc}±21.30	60.89^{a}±5.15
FYM (15 t ha^{-1}) + Bone meal (5 t ha^{-1})	72.67^{ab}±22.00	62.78^{a}±1.95
Control	7.00^{c}±3.22	41.40^{b}±4.10
LSD (0.05)	56.10**	7.59***
CV (%)	45.20	7.13
Grand mean	69.76	59.94

Note: LSD= Least Significant Difference, CV= Coefficient of Variations, *** = significant at p≤ 0.001, ** = significant at p≤ 0.01, * = significant at p≤ 0.05. Treatments means are separated by least significant difference (LSD), and the columns are represented by the same letter(s) and are non-significantly different from each other at a 5 % level of significance.

The shoot yield, root yield, and biological yield were significantly ($p<0.05$) higher in T_2 (poultry manure 20 t ha^{-1}), with values of 16.22 t ha^{-1}, 23.87 t ha^{-1}, and 50.30 t ha^{-1} respectively followed by T_3 (FYM 15 t ha^{-1} + poultry manure 10 t ha^{-1}) while these were found to be significantly lower in T_7 (control) with values 4.90 t ha^{-1}, 3.66 t ha^{-1} and 8.42 t ha^{-1} respectively (Table 4).

Table 4: Effect of organic manures on shoot yield per hectare, root yield per hectare, and biological yield per hectare

Treatments	Shoot yield per hectare (t ha^{-1})	Root yield per hectare (t ha^{-1})	Biological yield per hectare (t ha^{-1})
FYM (30 t ha^{-1})	8.67^{cd}±1.09	11.45^{cd}±1.27	22.43^{bc}±2.10
Poultry Manure (20 t ha^{-1})	16.22^{a}±0.39	23.87^{a}±1.40	50.30^{a}±3.23
FYM (15 t ha^{-1}) + Poultry manure (10 t ha^{-1})	14.78^{ab}±1.86	22.15^{ab}±3.02	46.72^{a}±7.71
FYM (15 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})	10.54^{bc}±0.84	15.37^{bc}±2.58	26.67^{b}±2.34
Vermicompost (5 t ha^{-1})	8.67^{cd}±1.69	13.77^{c}±2.78	23.68^{b}±6.36
FYM (15 t ha^{-1}) + Bone meal (5 t ha^{-1})	10.57^{bc}±2.04	13.064^{c}±3.54	28.85^{b}±6.68
Control	4.90^{d}±0.87	3.66^{d}±0.51	8.42^{c}±1.43
LSD(0.05)	4.56**	7.88**	15.11***
CV (%)	24.13	30.02	28.71
Grand mean	10.62	14.76	29.58

Note: LSD= Least Significant Difference, CV= Coefficient of Variations, *** = significant at p≤ 0.001, ** = significant at p≤ 0.01, * = significant at p≤ 0.05. Treatments means are separated by least significant difference (LSD), and the columns are represented by the same letter(s) and are non-significantly different from each other at a 5 % level of significance.

Effect of Organic Manures on Quality Parameters

Vitamin C content was higher in vermicompost 5 t ha^{-1} (0.181 mg ml^{-1}) and lower in FYM 30 t ha^{-1} (0.135 mg ml-1), while all other treatments were intermediate between T_1 (FYM 30 t ha^{-1}) and T_5 (vermicompost 5 t ha^{-1}) with not much difference. There was no significant difference ($p<0.05$) among organic manures in TSS content. The highest TSS content observed is in poultry manure 20 t ha^{-1} (1.130 Brix) and lower in FYM (15 t ha^{-1}) + poultry manure (10 t ha^{-1}) (0.870 Brix). The highest TSS and vitamin C concentrations in radish were found in FYM (50%) and PM (50%) samples. However, vermicompost (50%) and PM (50%) had a positive impact on growth, yield, and quality metrics [19]. Subsequent application of micro-nutrients in mango increased TSS content was reported by Pokhare which may be due to increased food mobilization [20].

Table 5: Effect of organic manures on vitamin-C and TSS content of radish

Treatments	Vitamin-C	TSS content (^{0} Brix)
FYM (30 t ha^{-1})	0.135±0.011	1.030±0.033
Poultry Manure (20 t ha^{-1})	0.176±0.027	1.130±0.033
FYM (15 t ha^{-1}) + Poultry Manure (10 t ha^{-1})	0.159±0.009	0.870±0.067

FYM (15 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})	0.168±0.020	1.100±0.115
Vermicompost (5 t ha^{-1})	0.181±0.011	1.000±0.058
FYM (15 t ha^{-1}) + Bone Meal (5 t ha^{-1})	0.152±0.009	0.970±0.088
Control	0.164±0.004	0.970±0.088
LSD (0.05)	0.045	0.250
CV (%)	15.720	13.780
Grand Mean	0.162	1.010

Note: LSD= Least Significant Difference, CV= Coefficient of Variations, *** = significant at $p \leq 0.001$, ** = significant at $p \leq 0.01$, * = significant at $p \leq 0.05$. Treatments means are separated by least significant difference (LSD), and the columns are represented by the same letter(s) and are non-significantly different from each other at a 5 % level of significance.

Discussions

Increase in radish growth parameters and yield attributes as a result of subsequent application of poultry manure in soil, which leads to adsorption of nutrients by plants and hence enhances yield. The increased yield from poultry manure could be attributed to its low C: N ratio [21]. Adekiya et al. reported that with the application of poultry manure, there was a rise in the fresh rhizome yield of ginger as well as enhanced physical and chemical qualities of the soil [22]. Poultry manure 5t ha-1 lowers the bulk density by 13.9% while increasing the porosity and moisture content of the soil [23]. The increased moisture content with poultry manure treatment can be attributed to the poultry manure's mulching impact as well as improved moisture retention and water uptake due to improved soil structure and microporosity [24].

Zhang et al., n.d. reported that radish plants produce a large yield and have excellent fleshy roots, so fertilizer application is crucial [25]. All 13 of the key plant nutrients that plants need are present in poultry manure. This group consists of the elements nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo) [26]. FYM contains 0.5% N, 0.2% P, and 0.5% K [27]. As vermicompost contains significantly more nutrients than farmyard manure, such as N, P, K, Ca, Cu, Mg, Fe, and Zn, garlic (Allium sativum) grew and produced more [28]. Lycopersicon esculentum and Solanum melongena, two plant species, showed an increase in chlorophyll a, chlorophyll b, and carotenoids with an increase in the content of vermicompost (3, 6, 9, 12, and 15%) [29]. Bone meal contains significant levels of nitrogen (N), phosphorus, and calcium; therefore, meat and bone meal (MBM) is intriguing as a fertilizer for many crops [30]. Nitrogen plays a function in cell division, cell enlargement, and protein synthesis, all of which have a direct impact on vegetative development [31]. Along with boosting plant height and total leaf count, the synergistic effects of N, P, and K in the right amounts also increased photosynthate uptake and shoot weight. Higher growth parameters in poultry manure 20 tha-1 may be due to this [14].

The fact that poultry manure performed best across all tested criteria may be related to its low C/N ratio, which promotes more rapid decomposition and faster nutrient release than other forms of organic manure [15]. According to reports, 30% of the nitrogen in poultry litter comes in the form of urea or ammonium, making it easily accessible [32]. Roberts et al. reported that there is not much effect on vitamin C content with 100% vermicompost, while the study reported that a higher vitamin C concentration in tomatoes was found in 40% vermicompost [33]. Khede et al. also reported that with the addition of 25% N from vermicompost and 75% NPK fertilizer, the growth of carrots and the qualities of radish roots were both improved [34]. The higher vitamin C content in vermicompost could be due to the higher potassium content of vermicompost.

Conclusion

All of the growth and yield indices differed statistically significantly ($p \leq 0.05$) in favor of organic manures; however, there was no significant difference in quality indicators such as vitamin C content and total soluble solid (TSS) content. In all measured growth and yield metrics, T2's (poultry manure 20 t ha-1) performance was shown to be superior, followed by T3's (FYM 15 t ha-1 + poultry manure 10 t ha-1). Therefore, the application of poultry manure at the rate of 20 t ha-1 may be recommended to the radish-growing farmers of Nepal to improve production and productivity. The combination of other organic manures like FYM, vermicompost, etc. with poultry manure may be more effective than poultry manure alone. So, experimental research should be carried out in different agroclimatic conditions with several treatments and their combinations for further validation.

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