SAARC J. Agric., 23(1): 212-223 (2025) DOI: https://doi.org/10.3329/sja.v23i1.81421

SAARC Journal of Agriculture
Journal Homage: https://www.banglajol.info/index.php/SJA

Effect of Different Doses of Vermicompost Mixed with NPK Fertilizer on Summer Radish (*Raphanus sativus* L.)

M. S. Ali*, H. B. Aslam, N. Mohammad, M. E. Rahman
S. F. T. Z. Anny, M. H. Munna and K. Hossen

Department of Agriculture, Faculty of Science, Noakhali Science and Technology University, Bangladesh

Abstract

Radish (*Raphanus sativus* L.) is a root vegetable widely known all over the world for its nutritional value. Bangladesh grows radish to meet high demand, but overuse of chemical fertilizers harms health and the environment. Integrating organic methods with reduced chemical fertilizers offers a sustainable solution. Keeping this in mind, a field experiment was conducted at A-To-Z Agro Farm, Bagatiprara, Natore, Bangladesh, during July to September 2024 to examine the growth and yield-contributing parameters of radish as affected by different doses of vermicompost mixed with NPK fertilizer. Four treatments and three replications were included in the randomized complete block design of the experiment. The treatments were, T_0 (0 NPK + 0 vermicompost), T_1 (100% NPK + 3 t ha^{-1} vermicompost), T_2 (100% NPK + 6 t ha^{-1} vermicompost) and T_3 (100% NPK + 9 t ha^{-1} vermicompost). The highest plant height (38.70 cm), number of leaves (15.96), leaf length (30.76 cm), leaf diameter (7.75 cm), root length (20.02 cm), root diameter (3.49 cm), root weight (108.27 g), gross yield (30.32 t ha^{-1}), marketable yield (30.28 t ha^{-1}) and benefit cost ratio (BCR) (2.37) were observed from treatment T_3 (100% NPK + 9 t ha^{-1} vermicompost), whereas the lowest data were obtained from treatment T_0 (Control). According to the results, T_3 treatment, i.e., 100% NPK + 9 t ha^{-1} vermicompost, showed improved growth, yield and yield-contributing characteristics of radish.

Keywords: Growth, NPK, Radish, Vermicompost, Yield

* Corresponding author: sabuj1412@student.nstu.edu.bd

Received: 02.05.2025 *Accepted: 20.06.2025*

Introduction

Radish, *Raphanus sativus* L., is a root vegetable and herbaceous plant that is part of the family Cruciferae, genus *Raphanus* and species *Sativus* (Ali et al., 2023). It is widely cultivated and consumed around the globe and is regarded as component of the human diet (Banihani, 2017). It is an excellent source of calcium, potassium, and phosphorus along with vitamin C, and can be consumed raw in salads or prepared as a vegetable (Dulal et al., 2021). Furthermore, the flavor, size, and length of the edible radish root vary worldwide (Banihani, 2017). According to Jadhav et al. (2014), it is also used to treat chronic diarrhea, insomnia, and neurological headaches. Radish began in four locations: Southwest Asia, East Asia, the Mediterranean region, and the tropical areas of South Asia (Vavilov, 1926). Radish, in Bangladesh known as Mula, is a popular root crop grown to consume as vegetables throughout the year except summer season. In the summer season, bulbing may be reduced which leads to poor growth and yield (Drost, 2020). As cool-season crops, radishes suffer from summer heat, which can cause inadequate root development or early flowering (bolting). Radish grows plentiful in most of the regions of Bangladesh including as homestead and roof cultivation also (Ghosh et al., 2014; Ali et al., 2023). The total area cultivated for radish is reported to be 76943.14 acres with the annual production rate 469204.49 metric tons (BBS, 2023).

Application of fertilizer for crop production is one of the most common practices among the farmers of Bangladesh. Nitrogenous, phosphatic, and other chemical fertilizers are typically applied by farmers to offer plant nutrients and greatly increase plant yield (Pahalvi et al., 2021). However, combining chemical and organic fertilizers has drawn interest as a sustainable way to increase crop yield and soil fertility. Organic fertilizer contains many benefits including increasing soil fertility, soil microbial growth, soil aeration, water holding capacity, suppress plant population etc. Organic compost has a slow-release impact on nutrients which enables farmers to save money since they distribute nutrients into the plant gradually (Hossain et al., 2024). In recent years, various organic fertilizers, biofertilizers, and biopesticides have been suggested as a way to reduce the reliance on harmful chemical fertilizers, especially in vegetable cultivation (Gandhi and Sundari, 2012). Organic manures, such as vermicompost, have gained popularity recently as a way to preserve soil fertility and productivity while boosting crop productivity (Pokharel et al., 2023).

Vermicompost is an inexpensive organic substance made by combining the beneficial effects of microorganisms and earthworms through the bio-oxidation of organic substrates (Khatun et al., 2023; Baghel et al., 2018; Lim et al., 2016). It acts as a great soil additive composed that can enhance soil health and nutrient status. Vermicompost improves seed germination, seedling strength, plant growth, flowering, fruiting, root development, color, shelf life, and quality of commercially produced vegetables (Peyvast et al., 2008; Premsekhar and Rajashree 2009). The use of vermicompost along with low-quantity chemical fertilizers has enhanced radish yield (Subramani et al., 2010; Kiran et al., 2016). Thus, the aim of the study was to determine the suitable doses of vermicompost along with NPK fertilizer on the growth and yield contributing parameters of summer radish.

Materials and Methods

Experimental site and soil

A-To-Z Agro Farm at Bagatiprara, Natore, Bangladesh, conducted the experiment from July to September of 2024. The region was included in the High Ganges River Floodplain's agro-ecological zone-11 (AEZ). The soil at the experiment location had loamy characteristics with a pH of 8.1 and organic matter content was 1.35% prior to the experiment. The status of pre-experiment soil properties is given in table 1.

Table 1. Soil chemical properties of study site

Soil characteristics	Value
pH	8.1
Organic matter (%)	1.35
Total nitrogen (%)	0.93
Exchangeable potassium (mg/100 g soil)	0.34
Phosphorus (%)	1.54

Experimental treatments and design

The study was structured using a Randomized Complete Block Design (RCBD) featuring four treatments and three replications

The treatments follow:

T_0 = Control (0 NPK + 0 vermicompost)

T_1 = (100% NPK + 3 t ha^{-1} vermicompost)

T_2 = (100% NPK + 6 t ha^{-1} vermicompost)

T_3 = (100% NPK + 9 t ha^{-1} vermicompost)

The area was 15 m^2 which was split into three equivalent blocks. Four plots were further obtained by each block. Four treatments were subsequently distributed at random. Consequently, there were 12 (4 × 3) unit plots in the experiment field. Each area measured 1 m × 1 m. The spacing between plots and blocks was maintained at 0.25 m and 0.5 m, respectively.

Seed collection

As an experimental planting material, XL 35 (variety) radish was utilized. These seeds were obtained at the "Nahid Seed Store" in Baneshar Bazar, Rajshahi and vermicompost were collected from the local market.

Land preparation

To produce ideal conditions, a power tiller was used for preparing the land, then it was thoroughly ploughed and harrowed. The soil was turned into good tilth and the clods were broken at the same time. Unwanted materials like stubble and weeds were carefully removed from the plots that were laid aside for planting and seeding.

Sowing of seeds

On July 25, 2024, the seeds of radish were sown in the designated plot. The line-sowing method was used to plant the seed. In the experiment field, seeds were planted in unit plots with 25 cm × 15 cm plant spacing. Each unit plot had 28 plants following germination.

Vermicompost application

Vermicompost was utilized as a base application during the final preparation of the land. The overall concentrations of key nutrients in vermicompost are shown in Table 2.

Table 2. Chemical composition of vermicompost

Nutrient Element	Composition (%)
Nitrogen (N)	1.0 - 2.5
Phosphorus (P)	0.5 - 1.5
Potassium (K)	1.0 - 2.0
Calcium (Ca)	1.5 - 2.5
Sulfur (S)	0.2 - 0.3
Iron (Fe)	0.05 - 0.15
Zinc (Zn)	0.01 - 0.05

Source: ACI fertilizer

Application of fertilizer

Recommendation dose of chemical fertilizer for radish cultivation is shown in Table 3. During the land preparation process, the entire amount of TSP was applied. The entire amount of urea and MOP were applied in two split doses to enhance nutrient uptake efficiency and minimize nutrient loss. Half of the urea and potash were utilized as a base during the final land preparation. Urea and potash were applied as side dressing 25 days after the radish was sown.

Table 3. Recommendation dose of chemical fertilizers

Fertilizer	Quantity (kg ha^{-1})
Urea	140
TSP	50
MoP	100

Intercultural operation

The emergence of seedlings was finished in seven days. Thinning was performed 16 days post-seeding. To maintain the plots weed-free, weeding was performed twice. When necessary, hand sprayers were used to apply irrigations. Four applications of garlic juice and neem leaf extract were made to manage fungicides and insects.

Data collection

Data on plant height, leaf number, leaf length, leaf diameter, root length, root diameter, root weight, gross yield, and marketable yield of radish were recorded from six plants chosen at random from per plot.

Statistical analysis

Minitab17 was used to do a statistical analysis on the recorded data for the various parameters in this study. Analysis of variance (ANOVA) was conducted using the F-test, and significant differences among means were determined using the LSD test at a 1% level of significance. Data analysis followed the methodology outlined by (Gomez and Gomez, 1984).

Results and Discussion

Plant height

The height of radish plants was noticeably affected by the use of varying levels of vermicompost (Table 4). The maximum plant height was measured from treatment T_3 (100% NPK + 9 t ha^{-1} vermicompost), reaching 38.70 cm, followed by 31.97 cm recorded from treatment T_2. In contrast, the minimum plant height was 22.25 cm observed from the plants of the control plot, which was not supplied with any treatment. Similarly, Khede et al. (2019) observed that applying vermicompost with NPK integration increased plant height. Kumar and Gupta (2018); Calderon and Mortley (2021) also observed similar growth with increasing doses in radish. More accessible nitrogen, which is necessary for the production of structural proteins, may be the source of this improved growth in higher doses of vermicompost (Edwards, 1988).

Table 4. Effect of vermicompost and NPK on vegetative growth of radish

Treatment	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf diameter (cm)
T_0	22.25d	10.68d	20.79d	5.08d
T_1	29.64c	12.44c	25.78c	6.13c
T_2	31.97b	13.56b	27.32b	6.83b
T_3	38.70a	15.96a	30.76a	7.75a
CV (%)	4.52	4.32	2.95	2.51
LSD (0.01)	4.20	1.72	2.34	0.49
Level of significance	**	**	**	**

T_0 = Control (0 NPK + vermicompost), T_1 = (100% NPK + 3 t ha^{-1} vermicompost), T_2 = (100% NPK + 6 t ha^{-1} vermicompost), T_3 = (100% NPK + 9 t ha^{-1} vermicompost); CV=Co-efficient of variation; LSD=Least Significant Difference; **=Significant at 1% level of probability

Number of leaves

The number of leaves per plant of radish was significantly affected ($p<0.01$) by the application of vermicompost and NPK fertilizer (Table 4). The maximum number of leaves per plant (15.96) were counted from treatment T_3 (100% NPK + 9 t ha^{-1} vermicompost), followed by treatment T_2 (13.56), T_1 (12.44), and T_0 (10.68), respectively. According to Jaisankar (2018); Uddain et al. (2010); Dulal et al. (2021), the plot that received the highest dose of vermicompost also had the most leaves per plant. The use of vermicompost may enhance the number of leaves per plant by supplying essential macro and micronutrients (Jaisankar, 2018).

Leaf length

Leaf length of radish was significantly affected due to vermicompost with NPK growth stage of radish. The longest leaf length (30.76 cm) was recorded from treatment T_3 (100% NPK + 9 t ha^{-1} vermicompost), which was followed by treatment T_2 (27.32 cm), T_1 (25.78 cm), where the shortest leaf length (20.79 cm) was measured from the treatment T_0 (no fertilizer). This finding indicated that using various amounts of vermicompost combined with NPK had enhanced the leaf length of radish. The application of vermicompost significantly enhanced radish leaf length (Hossain et al., 2024).

Leaf diameter

Table 4 illustrated that the combined action of vermicompost and NPK had a considerable impact on leaf diameter, with a statistically significant difference between dosages. The control plot (T_0), which received no dosages, had the minimum leaf diameter (5.08 cm), while treatment T_3 (100% NPK + 9 t ha^{-1} vermicompost) had the maximum leaf diameter (7.75 cm). Calderon and Mortley (2021) observed a greater growth in terms of leaf area with higher doses of vermicompost, which is consistent with our results. The high concentration of macro and micro nutrients particularly carbon in vermicompost may have contributed to increased soil fertility and consequently increase leaf diameter (Xu and Mou, 2016).

Root length

There was a substantial difference in radish root length when integrated with varying rates of vermicompost (Table 5). Following treatment T_3 (100% NPK + 9 t ha^{-1} vermicompost), which had the highest root length at 20.02 cm, where T_2 (18.08 cm), T_1 (15.57 cm), and the control plot T_0, which had the lowest root length at 13.15 cm. Radish cultivated in vermicompost applied plots grew longer roots, according to Gupta (2011); Dulal et al. (2021); Politud (2016) which validates the results of our investigation. Vermicompost enhanced root and shoot development, which aiding in vegetative growth (Edwards et al., 2004).

Root diameter

As shown in Table 5, the application of varying rates of vermicompost along with NPK fertilizer had a substantial impact on root diameter. The maximum root diameter 3.49 cm was observed in the treatment T_3 (100% NPK + 9 t ha^{-1} vermicompost), followed by treatment T_2 (100% NPK + 6 t ha^{-1} vermicompost) measuring 3.06 cm. The minimum root diameter (1.69 cm) was measured in the control (T_0) treatment. According to Gupta (2011); Dulal et al. (2021) and Politud (2016), radishes grown in plots treated with vermicompost developed roots with greater diameter, which supports the findings of our study.

Root weight

The application of vermicompost and NPK fertilizer resulted in a statistically significant difference in the weight of radish root (Table 5). The root weight at 108.27 g was the highest for treatment T_3 (100% NPK + 9 t ha^{-1} vermicompost), followed by treatment T_2 (100% NPK + 6 t ha^{-1} vermicompost) which weighed 75.02 g. Moreover, the root weight at 20.54 g was the lowest for control treatment T_0. Dulal et al. (2021) similarly observed highest root weight with the increasing doses of vermicompost.

Gross yield

Radish gross yield was significantly affected ($p<0.01$) by the application of vermicompost and NPK fertilizer (Table 5). Treatment T_3, which received 100% NPK with 9 t ha^{-1} of vermicompost had the maximum yield (30.32 t ha^{-1}), followed by the T_2 (21.00 t ha^{-1}). However, treatment T_0, produced the lowest yield (5.75 t ha^{-1}). Our finding was supported by Mahorkar et al. (2007); Gupta et al. (2011); Kumar and Gupta (2018) and Dulal et al. (2021) where in all cases radish produced highest yield with increasing dose of vermicompost and lowest in control. According to some research, plant growth is aided by vermicomposting leachates or water extracts of those substrate amendments (Tejada et al., 2008).

Table 5. Effect of vermicompost and NPK on yield and yield attributes of radish

Treatment	Root Length (cm)	Root Diameter (cm)	Root weight (g)	Gross Yield (t ha^{-1})	Marketable Yield (t ha^{-1})
T_0	13.15d	1.69d	20.54d	5.75d	5.63d
T_1	15.57c	2.68c	53.41c	14.96c	14.91c
T_2	18.08b	3.06b	75.02b	21.00b	20.95b
T_3	20.02a	3.49a	108.27a	30.32a	30.28a
CV (%)	3.20	1.57	4.21	4.21	4.15
LSD (0.01)	1.62	0.13	8.20	2.30	2.25
Level of significance	**	**	**	**	**

T_0 = Control (0 NPK + 0 vermicompost), T_1 = (100% NPK +3 t ha^{-1} vermicompost), T_2 = (100% NPK + 6 t ha^{-1} vermicompost), T_3 = (100% NPK + 9 t ha^{-1} vermicompost); CV=Co-efficient of variation; LSD=Least Significant Difference; **=Significant at 1% level of probability

Marketable yield

The use of vermicompost and NPK fertilizer had a substantial ($p<0.01$) impact on radish marketable yield (Table 5). With 100% NPK and 9 t ha^{-1} of vermicompost, treatment T_3 produced the highest yield (30.28 t ha^{-1}), followed by treatment T_2 (20.95 t ha^{-1}). Treatment T_0, on the other hand, yielded the least amount (5.63 t ha^{-1}). Mahorkar et al. (2007); Gupta et al. (2011); Kumar and Gupta (2018); Dulal et al. (2021) all corroborated our findings, showing that radish yielded the most in all cases with increasing vermicompost doses and the lowest in the control.

Economic performance of radish

Table 6 displays a partial financial assessment of how organic fertilizer dosages affect radish yield. Among the treatments used, the overall production cost varies from tk. 52,500 ha^{-1} to tk. 319000 ha^{-1} due to application of different doses of vermicompost. The maximum cost of production tk. 319000 ha^{-1} was obtained from treatment T_3 ((NPK + 9 t ha^{-1} vermicompost) followed by T_2 (NPK + 6 t ha^{-1} vermicompost) while the minimum cost of production Tk. 52500 ha-^{1} was associated with treatment of T_0 (no organic fertilizer) followed by T_1 (NPK +3 t ha^{-1} vermicompost). The maximum gross return (Taka 757,000 ha^{-1}) was recorded from treatment T_3, which was treated with 9 t ha^{-1} of vermicompost, followed by treatment T_2 (Taka 419,000 ha^{-1}), which received 6 t ha^{-1} of vermicompost, and treatment T_1 (Taka 149100 ha^{-1}) which received 3 t ha^{-1} of vermicompost. Gross return increased for all treatments compared to the control (Taka 56,300 ha^{-1}). The treatment T_3 (NPK + 9 t ha^{-1} vermicompost) had the highest net return, Tk. 438,000 ha^{-1}. The treatment T_0 (no organic fertilizer) produced the lowest net return, Tk. 3800 ha^{-1}. The treatment T_3 (NPK + 9 t ha^{-1} vermicompost) had the highest benefit cost ratio (BCR) (2.37). Treatment T_0 (no organic fertilizer) had the lowest BCR (1.07). Ali et al. (2023)

similarly observed better economic profit of radish while supplying plants with organic fertilizer.

Table 6. Effect of vermicompost and NPK on economic performance of radish cultivation

Treatment	Gross return (Tk ha^{-1})	Cost of production (Tk ha^{-1})	Net return (Tk ha^{-1})	BCR (Benefit Cost Ratio)
T_0	56,300	52,500	3800	1.07
T_1	149100	120500	28,600	1.23
T_2	419,000	204500	214,50	2.04
T_3	757,000	319000	438,000	2.37

T_0 = Control (0 NPK + 0 vermicompost), T_1 = (100% NPK +3 t ha-^{1} vermicompost), T_2 = (100% NPK + 6 t ha^{-1} vermicompost), T_3 = (100% NPK + 9 t ha^{-1} vermicompost); BCR= Benefit Cost Ratio

Correlation analysis

The relationships between the examined characters were presented in Table 7. Plant height was strongly correlated with all traits. Strong and positive correlations occurred between number of leaves per plant and leaf length ($r = 0.96$, $p < 0.01$), as well as between number of leaves per plant and leaf diameter ($r = 0.97$, $p < 0.01$). Similarly, root length is positively correlated with root diameter ($r = 0.96$, $p < 0.01$) and root weight ($r = 0.98$, $p < 0.01$). Additionally, gross and marketable yields are perfectly correlated (1.00), implying that the marketable portion constitutes the majority of the gross yield ($r = 1.00$**,** $p < 0.01$).

Table 7. Correlation of vegetative and reproductive traits

	Plant H	Leaf N	Leaf L	Leaf D	Root L	Root D	Root W	G Yield	M Yield
Plant H	1.00								
Leaf N	0.93**	1.00							
Leaf L	0.97**	0.96**	1.00						
Leaf D	0.97**	0.97**	0.99**	1.00					
Root L	0.95**	0.95**	0.97**	0.99**	1.00				
Root D	0.96**	0.93**	0.98**	0.97**	0.96**	1.00			
Root W	0.98**	0.97**	0.98**	0.99**	0.98**	0.97**	1.00		
Gross Yield	0.98**	0.97**	0.98**	0.99**	0.98**	0.97**	1.00**	1.00	
Marketable Yield	0.98**	0.97**	0.98**	0.99**	0.98**	0.97**	1.00**	1.00**	1.00

Plant height = Plant H, Number of leaves = Leaf N, Leaf diameter = Leaf D, Root length = Root L, Root diameter = Root D, Root weight = Root W, G yield = Gross yield, M Yield = Marketable yield, **=Significant at 1% level of probability

Conclusion

The findings indicated that the application of higher doses of vermicompost with NPK fertilizer had a significant effect on various growth and yield parameters of radish, including plant height, leaf number, leaf length, leaf diameter, root length, root diameter, root weight, gross yield, and marketable yield. Comparative results of various attributes studied in the present investigation suggested that T_3 was the ideal treatment because gross yield (30.32 t ha^{-1}), marketable yield (30.28 t ha^{-1}), and benefit cost ratio (BCR) (2.37) was highest in treatment T_3 (100% NPK + 9 t ha^{-1} vermicompost). On the basis of the results, it can be concluded that a vermicompost dose of 9 t ha^{-1} with 100% NPK of provided superior performance, followed by T_2 (100% NPK + 6 t ha^{-1} vermicompost). In addition, it is recommended that further research be carried out to identify the effect of vermicompost dosages on radish to optimize organic fertilizer application practices.

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