Impact of Vermicompost as a Base Fertilizer for Radish (*Raphanus sativus* L.) Cultivation

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Abstract

Higher dosages of chemical fertilizers and other plant growth regulators increased the crop yield, but at the same time cause detrimental effects for human beings and environment. Usage of organic fertilizers has come forward to minimize the usage of synthetic fertilizers. A pot experiment was carried out in Crop farm, Eastern University, Sri Lanka in between February to July in 2019 to analyze the effect of vermicomposting on growth and yield of radish. The experiment was laid out in a Completely Randomized Design (CRD) with five treatments and four replicates. The experiment was comprised with treatments; planting radish in soil with synthetic fertilizers at recommended rate (T1), planting radish in soil mixed with vermicomposting in the rate 10 t/ha (T2), 8 t/ha (T3), 6 t/ha (T4) and 4 t/ha (T5). Variety *Beeralu* was used for the experiment. T4 gave maximum plant height and fresh weight of leaves at 2^{nd} and 4^{th} WAP. Number of leaves was maximum in T4 at 2^{nd} WAP. Tuber length and fresh weight of tuberous root was superior in T4 at 2^{nd} and 4^{th} WAP. Dry weight of leaves was not significantly varied with different levels of vermicomposting while dry weight of tuberous roots gave higher values in T4 at 6^{th} WAP which was not significantly differed with control. T4 gave superior total yield of radish/pot at each weekly interval. As most of the growth and yield parameters are superior in T4, the study concludes that, the better rate of vermicomposting that can be used to plant radish in sandy regosol is 6 t/ha for the better performance of radish.

Keywords: Vermicomposting, organic fertilizers, synthetic fertilizers, tuberous root, base fertilizer

1. Introduction

Radish (*Raphanus sativus* L.) belongs to genus *Raphanus*, family *Brassicaceae* or *Cruciferae* originated from the Central and Western China and India (Dongarwar et al., 2017). It has been identified as a widely held root vegetable in both tropical and temperate regions (Samir et al., 2019). Tuberous root is the most popular eating part of radish, while the entire plant is edible and the top leaf part can be consumed as a leafy vegetable (Dongarwar et al., 2017). Radish is a source of carbohydrates, sugars, dietary fibers, protein, and even some fat and fluoride (Banihani, 2017). As well, radish is rich in vitamin C (ascorbic acid), vitamin A, folic acid and minerals such as potassium, calcium, iron and phosphorus which are important in human nutrition and health (Dongarwar et al., 2017; Samir et al., 2019). Radish is popular to use as a household remedy in order to treat many diseases such as jaundice, gallstone, liver diseases, rectal prolapse, indigestion, and other gastric pains. Not only that, radish contains unique bioactive compounds such as glucosinolates and isothiocyanates that have been recently known to be important in health benefits to humans (Banihani, 2017).

The degradation and pollution of soil and water bodies due to excess use of chemical fertilizers is a major concern nowadays. Therefore, shifting to organic fertilizers as a substitute for chemical fertilizers is the best method to support sustainable agriculture (Mahmud et al., 2020). When compared to inorganic fertilizers, the use of vermicompost is an essential alternative source of fertilizer with

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environmental benefits, increased production, and improved crop quality (Kiran et al., 2019). Vermicompost can be prepared with the decomposition of waste things such as kitchen waste and agro residues. Vermicompost has been identified as a product with high porosity, aeration, drainage, and water-holding capacity, as well the vast surface area with fine particles has offered vermicompost the ability of providing strong absorbability and retention of nutrients (Saranraj and Stella, 2012). When preparing vermicompost, important nutrients such as nitrogen, phosphorus, potassium, and calcium present in the raw material are transformed through microbial action into available forms for plants. Vermicompost consist of macronutrients such as N, P, K (Nitrogen 2-3%, Phosphorus 1.55-2.25% and Potassium 1.85-2.25%) and micronutrients with advantageous microbes (Actinomycetes, *Azotobacter*, *Rhizobium*, *Nitrobacter* and Phosphate Solubilizing Bacteria, ranging from 102-106 per g of vermicompost) and plant growth regulators (auxins, cytokinins and gibberellins) which are required for plant growth (Chaulagain et al., 2017). This study was conducted to evaluate how vermicomposting effect on growth and yield of radish.

2. Materials and Methods

A pot experiment was carried out at the crop farm, Eastern University, Sri Lanka, in February-July in 2019 to appraise the influence of vermicompost on growth and yield of radish. Crop farm of Eastern University Sri Lanka located in the latitude of 7^0 43^0 and the longitude of 81^0 42E. It belongs to the agro ecological region of low country dry zone in Sri Lanka. The mean annual rainfall of the crop farm ranges from 1400 mm to 1680 mm and temperature varies from 30 ^{0}C to 32 ^{0}C. The soil type used was sandy regosol.

This experiment was carried out using a Completely Randomized Design (CRD) with five treatments and four replicates. Treatments were as follows.

Table 1: Treatments imposed in the experiment

Treatments	Rate of application
T1 (Control)	Planting radish in soil with no vermicompost
T2	Planting radish in soil mixed with vermicompost in the rate 10 t/ha
T3	Planting radish in soil mixed with vermicompost in the rate 8 t/ha
T4	Planting radish in soil mixed with vermicompost in the rate 6 t/ha
T5	Planting radish in soil mixed with vermicompost in the rate 4 t/ha

Vermicompost was prepared by using the barrel method at the crop farm of Eastern University by using fruit wastes such as banana, papaw and orange and crop residues obtained from the local market and other crop residues. Thread sized red earthworms were collected from the animal farm at Eastern University. At the beginning, 50 earthworms were introduced per barrel. It was kept for 3 months for the decomposition prior to use. Plastic pots with volume 11 liter were filled with soil leaving $1/3^{rd}$ from the top and vermicompost was mixed at each rate in accordance with treatments two days before planting. Basal was applied two days before planting, at the rate of Urea 90 kg/ha, Triple Super Phosphate (TSP) 110kg/ha and Muriate of Potash (MOP) 65 kg/ha for control treatment (T1) according to the recommendation of Department of Agriculture (DOA), Sri Lanka and vermicompost was applied according to the treatment (T2-T5).Three seeds of radish variety *Beeralu* were planted per one pot. Top dressing was incorporated with soil three weeks after planting, at the rate of Urea 90 kg/ha and Muriate of Potash (MOP) 65 kg/ha for all treatments in accordance with DOA, Sri Lanka. All the agronomic practices such as weeding and irrigation were done according to the DOA, Sri Lanka. Parameters such as plant height, tuber length, number of leaves per plant, fresh weight of leaves and tuber and dry weight of leaves and tuber were measured at two weeks interval up to three readings. Plant height was measured from the tip of the plant to the ground level. Collected data was analyzed using SAS for continuous data and Minitab for discontinuous data.

3. Results and Discussion

3.1 Plant height

The plant height showed significant difference (P<0.05) at 2nd and 4th week after planting (WAP). The plant height in T3 and T4 at 2nd and 4th WAP were significantly greater compared to control (T1). The highest values were observed in T4 at 2nd WAP (13.7 cm) and 4th WAP (19.6 cm) (Table 2). But at 6th WAP, there was no any significant difference (P>0.05) in plant height in between treatments. That may be due to the insufficiency of vermicompost as it was not applied for top dressing. But, synthetic fertilizers were applied for all treatments. However, there was no significant difference (P>0.05) between T3 and T4. Taller plants may have been resulted due to the presence of humic acids and micro and macronutrients in vermicompost (Pant et al., 2009). Not only was that, the nitrification inhibition properties of vermicompost in the soil and rapid elongation and multiplication of cell with the adequate quantity of nitrogen may cause higher plant heights (Khede et al., 2019). The plant height of radish was higher with the treatment of vermicompost than the control treatment (Kumar and Gupta, 2018). Joshi et al. (2015) stated that, maximum plant height of potato (*Solanumtuberosum*) was detected when vermicompost mixed with 100 % NPKS (chemical fertilizers). Plant height of pak choi was higher with the application of non-aerated vermicompost than aerated vermicompost (Pant et al., 2009). The results from Khede et al. (2019) revealed that, the application of 50% recommended fertilizer dosage+25% Vermicompost+25% Poultry Manure resulted significantly maximum plant height followed by the treatment with 50% recommended fertilizer dosage+50% Vermicompost.

Table 2: Plant height (cm)

Treatment	2nd WAP	4th WAP	6th WAP
T1	10.3±0.37c	15.5±1.15c	22.3±1.11
T2	12.9±0.40b	15.9±1.05bc	20.1±0.59
T3	13.4±0.41a	18.3±0.67a	22.4±1.12
T4	13.7±0.23a	19.6±1.12a	24.8±1.12
T5	11.0±0.49bc	16.6±0.73b	23.4±0.89
F test	**	**	ns

Each value represents mean ± standard error of four replicates. F test: - **: P<0.01; ns: not significant
Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

3.2 Tuber length

Tuber length showed significantly greater values (P<0.05) with the application of different rates of vermicompost at 2nd and 4th WAP (Table 3).Tuber length was greater in T4 at 2nd WAP which was par with T2 and T3 but was greater than control. At 4th WAP also, tuber length was greater in T4 than control. But, at 6th WAP, any significant difference was not observed in tuber length with the tested treatments. Organic manures can reduce bulk density and increase porosity and water holding capacity of soil. Also, solubalization of plant nutrients may increase with the addition of vermicompost thus, it will increase the uptake of N, P, and K (Khede et al., 2019). Both the facts can cause higher tuberous root lengths of radish. The maximum tuber length and was noticed in 75% of vermicompost concentration of potato (Chandra, 2015). The treatment with vermicompost prepared from non-legume and legume waste at 2:1 ratio attributes with maximum root length in carrot (Chatterjee et al., 2014).

Table 3: Tuber length of radish (cm)

Treatment	2nd WAP	4th WAP	6th WAP
T1	7.7±0.22b	11.4±0.26c	18.3±0.50
T2	8.8±0.11a	12.9±0.24bc	19.9±1.22
T3	8.9±0.13a	13.5±0.29b	19.8±1.07
T4	9.2±0.23a	14.4±1.04a	20.8±2.14
T5	8.1±0.08b	13.4±0.54b	20.3±0.94
F test	**	**	ns

Each value represent mean ± standard error of four replicates. F test: - **: P<0.01; ns: not significant Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

3.3 Number of leaves

The P values and chi–square values for number of leaves represent that there is a significant difference (P<0.05) at 2nd WAP and no any significant difference at 4th and 6th WAP (Table 4). Higher levels of nitrogen can increase the number of leaves per plant (Silva et al., 2016). Vermicompost contain nitrogen (2–3%) (Sinha et al, 2009). As well, the release of nutrients through vermicompost is slower and thus enriching available nutrient pool also results higher number of leaves per plant. Both the reasons may affect for higher number of leaves in T4 (6) than the control in 2nd WAP. The number of leaves per plant is significantly superior in treatment T4 (50% RDF+50% Vermicompost). According to the findings of Khede et al. (2019), highest number of leaves was found in the treatment with 50 % recommended dose of fertilizers+50 % vermicompost. Chandra (2015) cited that, no significant variation of number of leaves per plant of potato was found due to altered vermicompost levels. Singh and Chauhan (2009) found that, application of vermicompost to the French bean can promote the number of leaves of each plant.

Table 4: Number of leaves per plant in radish

Treatment	2nd WAP	4th WAP	6th WAP
T1	4	6	7
T2	4	7	7
T3	4	7	7
T4	6	7	9
T5	5	7	8
P value	0.028	0.112	0.075
Chi-square	10.91	7.50	10.00

3.4 Fresh weights of leaves and tuberous roots

In both 2nd and 4th WAP, the highest values for fresh weight of leaves were resulted in T4. But, there was no any significant difference (P>0.05) at 6th WAP. The higher nutrient content which increases the biomass in leaves, as well as the ability of vermicompost to increase the water holding capacity of soil which will lead to the higher content of water in leaves may be the reasons for the higher fresh weight of leaves in the radish treated vermicompost than the control. Hasan et al. (2018) cited that, fresh weight of carrot leaves varied significantly due to different levels of vermicompost giving the superior in plants treated with vermicompost and minimum in control. The application of vermicompost among the different treatments of other organic manures showed significantly superior values over other treatments in respect to plant fresh weight of leaves as well compared to control (Koodi, 2016).

Table 5: Fresh weight of leaves of radish (g)

Treatment	2nd WAP	4th WAP	6th WAP
T1	0.49±0.07c	6.49±0.43c	22.19±1.25
T2	0.92±0.06b	6.04±0.24dc	23.08±1.09
T3	0.72±0.07bc	7.34±0.45b	21.92±0.60
T4	1.19±0.09a	9.84±0.11a	22.09±1.36
T5	0.89±0.07b	5.13±0.45d	21.52±0.95
F test	**	**	ns

Each value represent mean ± standard error of four replicates. F test: - **: P<0.01; ns: not significant Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Fresh weight of tuberous roots of radish was significantly affected (P<0.05) by the application of vermicompost (Table 5). The superior value for fresh weight was obtained by T4 (0.22 g) which was at par with T3 (0.18 g) at 2nd WAP. Fresh weight of tuberous root at 4th and 6th WAP (final harvesting) showed the similar pattern with higher value in T4 which was not significantly differed with T1 (control). Better tuber yield in radish plant may be attributed with various components in vermicompost such as macro (N, P, K) and micro (Ca, Mg, Mn, Iron, sulfur, Zinc and Copper) nutrients, plant growth hormones (Indole acetic acid, Indole butyric acid, Naphthalene acetic acid and Gibberellic acid), vitamins (Vitamin A, B1, B2, B3, C and E), enzymes, and many beneficial microbes such as Nitrogen fixation bacteria and hormones synthesizing microbes such as *Azospirillumbrasilence*, *Azospirillumlipoferum* and *Azotobacterpaspali* (Ramamurthy et al., 2015). A considerably increased root weight of radish in the soil which incorporate 10% content of vermicompost was resulted in comparison with the soil without vermicompost (Kovacik et al., 2018). Fresh weight of roots of carrot was significantly higher with the different levels of vermicompost than without vermicompost (Hasan et al., 2018).

Table 6: Fresh weight of tuberous root of radish (g)

Treatment	2nd WAP	4th WAP	6th WAP
T1	0.14±0.04b	6.14±0.37a	80.22±1.82a
T2	0.15±0.02b	5.45±0.31bc	72.20±2.62b
T3	0.18±0.02ba	5.84±0.15bc	73.55±2.41b
T4	0.22±0.01a	6.27±0.46a	84.82±3.15a
T5	0.14±0.02b	3.99±0.12c	62.65±2.40c
F test	*	*	*

Each value represent mean ± standard error of four replicates. F test: - *: P<0.05
Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

3.5 Dry weight of leaves and tuber root

There was no significant difference (P>0.05) in leaf dry weight,however, asignificant difference (P<0.05) was observed in tuberous root dry weight at harvest at 6th WAP. With the higher availability of nitrogen in vermicompost with the combination of recommended dose of synthetic fertilizers applied as top dressing may have produced the higher dry weight of radish compared to the control. Dhananjaya (2007) recorded that, the highest dry weight of leaves per plant was recorded with the application of poultry manure at 1.25 t per ha (50%)+vermicompost at 1.75 t per ha (50%). Contradictory to the present experiment, Kiran et al. (2016) cited that, maximum dry weight of leaves of radish was produced with the sole application of NPK (synthetic fertilizers). Dry matter of leaves was higher in radish plants treated with vermicompost than the control treatment without organic manures (Uddain et al., 2010).

Table 7: Dry weight of leaf and tuberous root of radish (g) at 6th WAP

Treatment	Leaf	Tuberous root
T1	2.08±0.34	7.32±1.09a
T2	1.98±0.47	5.20±1.20b
T3	1.96±0.47	5.01±1.40b
T4	2.03±0.61	7.51±1.40a
T5	1.86±0.39	4.37±1.21c
F test	ns	*

Each value represent mean ± standard error of four replicates. F test: - ns: not significant; *: P<0.05
Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Table 7 expresses that there was significant difference (P<0.05) in dry weight of root at 6th WAP. T4 showed the greatest tuber dry weight compared to other treatments which was statistically similar to the T1 control (Table 7). Organic fertilizers convey almost all micro and macronutrients needed for the plants growth (Koodi, 2016). Vermicompost is also an organic fertilizer with lots of nitrogen, phosphorus and potassium as well as micronutrients (Chaulagain et al., 2017). It may cause to increase the dry weight of tuberous roots in radish over control. Application of poultry manure at 1.25 t per ha (50%)+vermicompost at 1.75 t per ha (50%) produced significantly highest dry weight of roots (Dhananjaya, 2007). The treatment with vermicompost (50%)+poultry manure (50%) produced highest dry weight of roots of radish (Kumar et al., 2014). The maximum and significantly higher dry weight of radish root was recorded in 50% recommended dosage of fertilizers+25% Vermicompost+25% Poultry Manure, followed by 50% recommended dosage of fertilizers+50% Vermicompost (Khede et al., 2019).

3.6 Total yield

Total radish yield/pot showed significant difference (P<0.01) at each weekly interval giving the superior values for the T4 as shown in the Table 8. The vermicompost application favored the metabolic and auxin activities in plant and resulting in increased the total yield of radish (Mali et al., 2018). Yield of beetroot was superior with the application of vermicompost than the control (Kibatu and Mamo, 2014). Getaneh and Mezgebu (2019) investigated that, there was no any significant difference in total yield of carrot when grown under the combination of synthetic nitrogen and vermicompost.

Table 8: Total yield of radish/pot (g)

Treatment	2nd WAP	4th WAP	6th WAP
T1	0.63±0.09c	12.63±0.60c	102.42±1.36b
T2	1.07±0.08b	11.48±0.45c	95.28±0.66b
T3	0.90±0.09b	13.18±0.51b	95.47±1.69b
T4	1.41±0.08a	16.11±0.54a	106.91±1.77a
T5	1.03±0.08b	9.11±0.34c	84.17±1.26b
F test	**	**	**

Each value represent mean ± standard error of four replicates. F test: - **: P<0.01
Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

4. Conclusion

The results from the experiment showed that vermicomposting played a significant role in the growth and yield in radish. It was found that most of the growth and yield parameters were affected with different levels of vermicomposting.T4 gave maximum plant height and fresh weight of leaves at 2nd and 4th WAP. Number of leaves was maximum in T4 at 2nd WAP. Tuber length and fresh weight of tuberous root was superior in T4 at 2nd and 4th WAP. Dry weight of leaves was not significantly varied with different levels of vermicomposting while dry weight of tuberous roots gave higher values in T4 at 6th WAP which was not significantly differed with control. Total yield of radish/pot was greater in T4 at each weekly interval. The study concludes that, the 6 t/ha rate of vermicomposting as basal with recommended inorganic top dressing can be suggested as the most appropriate rate for better performance of radish. According to the present results, the usage of synthetic fertilizers can be reduced by using vermicomposting as a basal fertilizer for the production of radish. It will be eco-friendly and make safe for human health to some extent.

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