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Research article

Technical feasibility and effectiveness of vermicomposting at household level

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Abstract: Understanding the value of vermicompost, an attempt was made to study the technical feasibility and effectiveness of vermicomposting at household level and to analyze and compare the performance of the crops grown using vermicompost. The study was carried out during April (2013) to January (2014) at Madampe in Puttlam, Sri Lanka. Initially three vermicomposting units were established separately using six plastic bins with 45 cm diameter and 40 cm height each. The locally available earthworm species, *Eisenia fetida* and *Eisenia* andrei were used to prepare vermicompost using shredded paper as the bedding material. Five treatments with five replicates of control (T1), inorganic fertilizer (T2), vermicompost (T3), garden compost (T4), and a combination of vermicompost + inorganic fertilizer (50:50) (T5) were tested with potted okra (*Abelmoschus esculentus*) using randomized block design. The growth parameters and the yield characteristics were recorded during the period of six to fifteen weeks of planting. The data were statistically analyzed using ANOVA and LSD test. Results revealed that the average marketable fruit yield per plant for T3 was the highest among five treatments. The results indicated that there was a significant difference between vermicompost and other treatments on the average marketable yield of okra. The average yield of T3 showed 63%, 50% and 37% increase compared to that of T1, T2 and T4 respectively. It also showed 18% increase of yield in T5 when compared to T2. Vermicomposting provide an environmental friendly way of increasing the crop yield. Use of local earthworms to the typical process of vermicomposting could be a successful and a sustainable win-win solution to protect the environment.
Keywords: Vermicompost - Earth worm - Environment - Degradable waste - Crop yield.

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INTRODUCTION

Earthworms digest the organic matter accumulated on earth through the process of vermicomposting and produce vermicompost. It is an environmental friendly way of minimizing degradable waste generated by day-to-day activities.

Vermicomposting is a novel technique, applying the concept of using earthworms to turn "garbage" into "black gold”. The worms consume the waste materials and excrete them in the form of worm castings. The worms coat the organic material with their mucous excretions which contain micro-organisms. After the microbial pre-decomposition the worms convert the pre-fermented compost material into worm humus, along with mineral substances (Dekoff *et al*. 2012). Vermicomposting can be practiced anywhere, even on a small scale, and easily integrated into any agricultural system. A properly designed vermicomposting system processes organic waste into vermicompost within 2–3 months. This self-aerated process does not require mechanical aeration or mixing.

Home-gardening is a common practice at Madampe, in Puttlam district of Sri Lanka. Application of chemical fertilizers over a period could result in poor soil health, reduction in productivity, and increase in incidences of pest and disease and cause environmental pollution (Ansari *et al*. 2010, Abafita *et al*. 2014). But, using vermicompost as a fertilizer could create a significant change in the field of organic agriculture by

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minimizing environmental hazards. Vermicompost is a complete, balanced, natural feed for all types of plants, and could safely be used for vegetables, flowers, fruit trees and foliage and field crops. The application of vermicompost to the field contributed towards the maintenance and improvement of soil fertility (Chaoui 2010).

Understanding the value of this cost-effective product of vermicompost, an attempt was made to study the technical feasibility of producing vermicompost at household level, to study the effectiveness of vermicompost for the potted vegetable crops at home garden and to compare the performance of the crops grown with vermicompost, garden compost, inorganic fertilizer and the combination of vermicompost + inorganic fertilizer.

MATERIALS AND METHODS

The study was carried out during April, 2013 to January, 2014 at household level in Madampe, located at the Puttlam district of Sri Lanka and initially three vermicomposting units were established separately using six plastic bins with 45 cm diameter and 40 cm height each, at household level. The locally available earthworm species, *Eisenia fetida* L. and *Eisenia andrei* L. were used for the purpose of vermicompost preparation. Two bins were used to prepare one bin system. Large holes about three centimetres in diameter were drilled around the upper bin to facilitate air circulation and about 12 to 16 holes of 5 millimetre in diameter were drilled at the bottom of the upper bin to facilitate the drainage of excess water retain in the bed to maintain the moisture level inside of the upper bin and another bin was placed underneath to collect the drained water. The bin system was designed in such a way to enable vermicompost collection from the upper bin and vermiwash from the lower bin as by-product.

Three vermicomposting bins namely bin 01; bin 02 and bin 03 were prepared using shredded paper as the bedding material. The paper materials were torn into small pieces moistened and filled about 17–18 cm of the bin. Then a handful of soil from worms' original habitat and about sixty local earthworms per each bin were added. After adding earthworms another thin layer of paper was laid above.

Water was added to those units to keep them moist. At the beginning a very small amount of grit material and a small amount of vegetable matter, coffee filters, and fruit leftover were added. Gradually the amount of food added was increased. The product of vermicompost was harvested after 90 days. A homogenized vermicompost sample was obtained and then it was subjected to physiochemical characterization. To analyse the effectiveness of the prepared vermicompost, the okra (*Abelmoschus esculentus* L.) was grown with the following treatments (Table 1).

Table 1. The treatments used during the experiment.

Treatment	Abbreviations	Quantity/plant
Control	[CON]	No additions
Inorganic fertilizer	[CHE]	Urea-5.4 g , TSP -10.8g , MOP-2.7 g
Vermicompost	[VC]	270 g
Compost	[COM]	215 g
Vermicompost + Inorganic fertilizers (50:50)	[CHE + VC]	135g of vermicompost and Urea-2.7 g , TSP -5.4g , MOP-1.35 g

The pot experiments were placed using a randomized block design with five replicates for each treatment. The pots were filled with sterilized dry soil (5 kg) with other supplements, according to the treatments used as shown in table 1. The Initial soil samples and garden compost were subjected to physiochemical analysis. The growth parameters such as average plant height (cm), average number of leaves per plant, average stem circumference (cm), average inter nodal distance at the harvesting stage (cm), average root height (cm), average number of pods per plants, average length of pods at the harvesting stage (cm), average width of pods at the harvesting stage (cm), average marketable fruit yield (g), average number of diseased leaves per plant at the harvesting stage, average number of days taken for flowering, average number of days plant bare pods and average number of days taken the pods to mature after plucking were recorded during the period of 6–15 weeks of planting.

The results were recorded and the means for each treatment were compared statistically using ANOVA with the help of the MINITAB 15 software.

RESULTS

Around 6150 g of vermicompost and 575 ml of vermiwash were produced using about 4200 g of raw material. The temperature change during vermicomposting was observed and shown in figure 1.

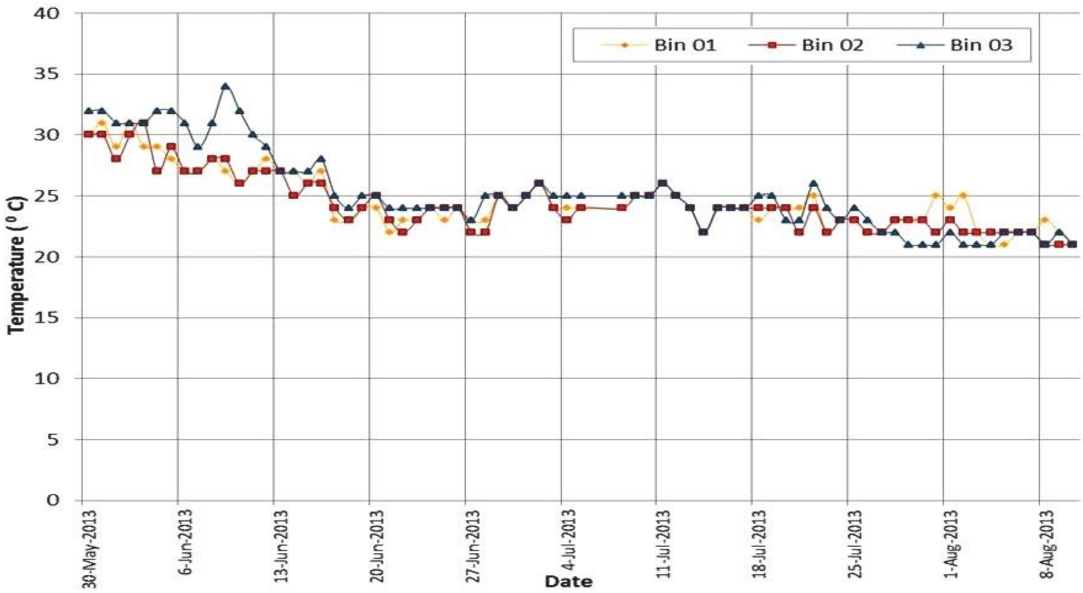

Figure 1. Temperature change during Vermicomposting.

The physiochemical properties of vermicompost, garden compost and the soil used were listed in table 2. While various growth parameters of okra plants were shown in table 3 to 5.

Table 2. Physiochemical properties of vermicompost, soil and garden compost.

Parameter	Vermicompost	Compost	Soil
OM	17.77%	76.90%	20.72%
N	0.91%	1.15%	0.48%
P	0.14%	0.17%	0.11%
K	0.2%	0.6%	0.5%
C	9.90%	44.35%	11.95%
C/N ratio	10.87	38.56	24.85
pH	6.98	7.21	7.25
EC	1.1	0.2	0.4
Moisture content	15.58%	12.20%	11.64%
Bulk density	0.5 g cm^{-3}	1.3 g cm^{-3}	1.6 g cm^{-3}
Particle density	2.49 g cm^{-3}	2.50 g cm^{-3}	2.68 g cm^{-3}
Porosity	0.76	0.48	0.40

Table 3. The Effect of different treatments on average plant height and number of leaves per plant at 50th day, 65th day and 80th day from the date of planting (Mean±SD).

S.N.	Treatment	Average plant height (cm)			Average number of leaves per plant		
		At 50 days	At 65 days	At 80 days	At 50 days	At 65 days	At 80 days
1	CON	12.4±2.6	34.2±4.6	45.8±4.7	5.4±0.5	7.8±1.3	10.8±1.3
2	CHE	21.4±2.5	54.2±9.1	65.4±8.3	7.0±0.7	9.6±0.5	14.2±1.3
3	VC	17.4±1.5	37.4±6.9	59.6±3.2	6.0±1.2	8.8±1.0	12.6±0.5
4	COM	17.2±2.0	36.8±5.6	46.8±5.2	6.0±1.2	8.4±1.1	11.4±1.1
5	CHE + VC	20.0±1.4	49.6±4.5	48.6±7.4	6.4±0.5	9.0±1.2	13.2±0.8

Table 4. The effect of different treatments on average number of pods, fruit length, fruit width, fruit weight and marketable fruit yield per plant (Mean±SD).

S.N.	Treatment	Average number of pods per plant	Average length of pods at harvest (cm)	Average width of pods at harvest (cm)	Average weight of pods at harvest (g)	Average marketable fruit yield per plant (g)
1	CON	7.6±0.8	13.3±1.5	5.4±0.8	26.6±1.5	202.2±23.8
2	CHE	8.4±1.5	15.9±1.4	6.8±0.4	32.6±3.9	273.8±49.4
3	VC	14.8±1.3	16.4±1.1	7.0±0.7	37.2±1.9	550.6±48.5
4	COM	11.4±1.3	15.6±3.8	5.9±0.8	30.2±4.7	344.3±40.5
5	CHE + VC	9.2±0.4	16.4±0.8	6.8±0.5	36.2±5.9	333.0±16.9

Table 5. The effect of different treatments on number of days taken for flowering, number of days plants bear fruits and number of days taken for the pods to mature after plucking per plant (Mean±SD).

S.N.	Treatment	Average number of days taken for flowering	Average number of days a plants bear pods	Average number of days taken for the pods to mature after plucking
1	CON	67.2±2.3	35.6±3.8	3.4±0.5
2	CHE	61.8±5.9	40.0±3.4	4.6±0.5
3	VC	42.2±4.9	53.0±6.9	5.4±0.5
4	COM	46.6±7.7	47.6±1.8	4.0±0.7
5	CHE + VC	56.6±7.9	40.2±6.1	4.4±0.5

The means of treatments did not differ significantly ($P<0.05$) for the average number of leaves at 50 days per plant, the average number of leaves at 65 days per plant , average length of pods at harvest. Whereas for the other parameters such as average plant height at 50 days (cm),average plant height at 65 days (cm),average plant height at 80 days (cm),average number of leaves per plant at 80 days, average number of pods per plant, average width of pods at harvest (cm), average weight of pods at harvest (g), average marketable yield per plant (g), average number of days taken for flowering per plant, average number of days a plant effectively bear pods, number of days taken for the pods to mature after plucking per plant investigated, the means of treatments showed statistically significant differences.

The least significant difference test (LSD) was applied to the selected parameters to find out the differences. The calculated LSD values and significant mean differences for each parameter obtained during statistical analysis were given in table 6.

Table 6. LSD values and mean differences at 5% significance level.

S.N.	Parameter	LSD	Mean difference
1	Average plant height at 50 days (cm)	2.74	9 (T1 – T2),5 (T1 – T3), 4.8 (T1- T4), 7.4 (T1 – T5), 4 (T2 – T3), 4.2 (T2 – T4)
2	Average plant height at 65 days (cm)	8.47	20.2 (T1 – T2),15.4 (T1 – T5), 17 (T2- T3), 17.6 (T2 – T4),12.2(T3 – T5), 12.8 (T4 – T5)
3	Average plant height at 80 days (cm)	8.01	19.6(T1 – T2),13.8(T1 – T3), 18.6(T2- T4), 16.8 (T2 – T5),12.8(T3 – T4), 11 (T3 – T5)
4	Average number of leaves per plant at 80 days	1.40	3.4 (T1 – T2), 1.8 (T1 – T3), 2.4 (T1 – T5), 1.6 (T2 – T3), 2.8 (T2 – T4),1.8 (T4 – T5)
5	Average number of pods per plant	1.53	7.2 (T1 – T3), 3.8 (T1 – T4), 1.6 (T1 – T5), 6.4 (T2 – T3), 3.0 (T2 – T4), 3.4 (T3 – T4), 5.6 (T3 – T4), 2.2 (T4 – T5)
6	Average width of pods at harvest (cm)	0.95	1.4 (T1 – T2), 1.56 (T1 – T3), 1.44 (T1 – T5), 1.04 (T3 – T4)
7	Average weight of pods at harvest (g)	5.26	6 (T1 – T2), 10.6 (T1 – T3), 9.6 (T1 – T5), 7.0 (T3 – T4), 6.0 (T4 – T5)
8	Average marketable yield per plant (g)	50.2	71.6(T1 – T2), 348.4 (T1 – T3), 142.1 (T1 – T4), 130.9 (T1 – T5), 276.8 (T2 – T3), 129.5 (T2 – T4), 59.3 (T2 – T5), 206.3 (T3 – T4), 217.4 (T3 – T5)
9	Average number of days taken for flowering per plant	7.80	25.0 (T1 – T3), 20.4 (T1 – T4), 10.6 (T1 – T5), 19.6 (T2 – T3), 15.2 (T2 – T4), 14.4 (T3 – T5), 10.0 (T4 – T5)
10	Average number of days a plant effectively bear pods	9.14	16.4 (T1 – T3), 12.0 (T1 – T4), 15 (T2 – T3), 12.8 (T3 – T5)
11	Number of days taken for the pods to mature after plucking per plant	0.76	1.2 (T1 – T2), 2.0 (T1 – T3), 1.0 (T1 – T5),0.8 (T2 – T3), 1.4 (T3 – T4), 1.0 (T3 – T5)

DISCUSSION AND CONCLUSION

Temperature change during vermicomposting was observed at the beginning of the experiment as shown in figure 1. Initially the temperature of the substrate was high and then decreased gradually as the composting process progressed. During the first phase of vermicomposting process the heat released by the oxidative action of intense microbial activity and earthworm activity on the organic matter may be the reason for the high temperature. When compost maturation stage occurred, the compost temperature dropped to that of the ambient and then decreased with the progress of the composting process which was probably due to the decreased earthworm activity resulted by full conversion of waste into degradable material. It may also be attributable to regular sprinkling of water.

The C content and the N content of vermicompost were 9.90% and 0.91% respectively (Table 2). The values were same as with the study done by TNAU agriculture portal (2014) and with the findings of Ansari & Sukhraj (2010). The reduction of C was 77.6% higher in vermicomposting compared to the ordinary composting process, which may be due to the fact that earthworms could have a higher assimilating capacity. Slightly high N level was identified in the prepared vermicompost than garden soil (Table 2). The enhancement of N in vermicompost was probably due to mineralization of the organic matter containing proteins and the conversion of ammonium-nitrogen into nitrate (Suthar 2008). The N level was 54.2% higher in vermicompost than soil but N content was 8.6% lower than that of garden compost.

The C: N ratio of vermicompost was 10.87:1 and that was in a range that could make the nutrients easily available to the plants. The lower the C/N ratio, the higher is the efficiency level of mineralization. A comparatively lower C/N ratio in vermicompost implied that there was an enhanced organic matter mineralization than that of garden compost (Table 2).

pH was 6.98 and the value being around seven emphasized that it was in a neutral range, which promotes the availability of plant nutrients like NPK. EC of vermicompost was higher than garden compost and soil (Table 2).

As the bulk density and particle density are important measures of porosity, the results indicated that vermicompost had an increased porosity which could facilitate the availability of nutrients to crop growth. The porosity was 36% and 47% higher than that of the garden compost and soil respectively. The moisture content of prepared vermicompost was also 21% and 25% higher than the garden compost and soil respectively (Table 2).

The other physiochemical characteristics including the dark black color of vermicompost and the absence of foul odor indicated that the decomposition of waste was a complete process.

Samaranayake *et al.* (2010) reported that vermicompost appeared to be generally superior to conventionally produced compost as it had high levels of bio-available nutrients, high level of beneficial soil microorganisms, rich in growth hormones, humic acids which promote root growth and increase the nutrient uptake. It was free of pathogens, free of toxic chemicals and thus vermicompost could protect plants against various pests and diseases. According to Singha *et al.* (2009) the earthworm humus contained the essential nutrients of nitrogen (N), phosphorus (P) and potash (K) in much larger quantities than those present in the soil or in comparable compost.

The statistical analysis revealed that there was a significant difference between the treatments for the parameters given in Table 6.Average plant height observed during the trial at 50 days and 65 days were maximum for plants treated with T2 [CHE] followed by T5 [CHE + VC], T3 [VC],T4 [COM] and T1 [CON] respectively (Table 3). It was maximum for plants treated with T2 [CHE] followed by T3 [VC], T5 [CHE + VC], T4 [COM] and T1 [CON] respectively at 80 days (Table 3).

Average number of leaves per plant observed after 50 days and 65 days did not differ statistically and at 80 days of planting it was maximum for plants treated with T2 [CHE], followed by T5 [CHE + VC], T3 [VC], T4 [COM] and T1 [CON] respectively (Table 3).

The maximum number of leaves observed with T2 [CHE] could be accounted by the fact that chemical fertilizers were high in nitrogen, which was responsible for rapid plant growth. According to Lazcano et al.(2011), the enhanced plant growth of the plants treated with vermicompost may be attributed to various direct and indirect mechanisms, including biologically mediated mechanisms such as the supply of plant-growth regulating substances, and improvements in soil biological functions.

The average number of pods per plant observed were maximum for plants treated with T3 [VC] followed by T4 [COM], T5 [CHE + VC], T2 [CHE] and T1 [CON] respectively (Table 4). Average width of the pods at harvesting was maximum for plants treated with T3 [VC] followed by almost the same amount for T5 [CHE + VC] and T2 [CHE], T4 [COM] and T1 [CON] respectively (Table 04). The average fruit weight per plant observed during harvesting was maximum for plants treated with T3 [VC] followed by T5 [CHE + VC], T2 [CHE], T4 [COM] and T1 [CON] respectively (Table 4).

The average marketable fruit yield per plant for T3 [VC] was recorded as 550.6 g and it was the highest. The amount of fruit yield thereafter reduced in the order of T4 [COM], T5 [CHE + VC], T2 [CHE], and T1 [CON] respectively (Table 4). Yield is the most important parameter which would broach the importance of the whole process of cultivation. The significant effect of vermicompost compared to those with other treatments, indicate that there was significant difference between vermicompost and control (T3-T1), vermicompost and chemical fertilizers (T3-T2), vermicompost and garden compost (T3-T4), and also between vermicompost and the mixture of chemical fertilizer + vermicompost (T3-T5) on the average marketable yield production (Table 4).

As the soil condition was much more enhanced while using vermicompost there was no wonder of having the highest significant difference between vermicompost and control. The average yield of okra during the trial showed significantly greater response in comparison with the control by 63%. It was proved that soil enriched with vermicompost provides additional substances that were not found in chemical fertilizers (Ansari & Ismail, 2008).

Results clearly indicated a better performance of okra using the vermicompost rather than that of chemical fertilizers by 50%. Chemical analysis of vermicompost and compost (Table 2) showed that vermicompost prepared was superior to the garden compost. Hence the yield was higher in vermicompost by 37% than that of garden compost. However results showed using a mixture of chemical fertilizers and vermicompost was also giving a good yield than using chemical fertilizers alone by 18%.

The average number of days taken for flowering per plant observed was minimum for plants treated with T3 [VC] followed by T4 [COM], T5 [CHE + VC], T2 [CHE] and T1 [CON] respectively (Table 5). The average number of days plant effectively bear pods was maximum for plants treated with T3 [VC] followed by T4 [COM], T5 [CHE + VC], T2 [CHE] and T1 [CON] respectively (Table 5). The average number of days taken for the pods to mature observed after harvesting was maximum for plants treated with T3 [VC] followed by T2 [CHE], T5 [CHE + VC], T4 [COM] and T1 [CON] respectively (Table 5). These results indicated that by using vermicompost the okra pods could be harvested earlier as well as for a longer period compared to the other treatments.

The results of the mean comparisons together with LSD (Table 6) confirmed that there was a large variation in fertilizer effects depending on the type of fertilizer used. It indicated that the applications of vermicompost had an emphatic effect on plant growth and production. Vermicomposting provided an environmental friendly way of increasing the crop yield.

The nutrient content of the prepared vermicompost and its effect on the productivity of okra implied that it is effective to practice in the field instead of applying chemical fertilizers. Organic manure provides a very effective solution for increasing organic waste fraction. It was possible to adopt the technique of vermicomposting in terms of reducing household waste at the source of production. Use of local earthworms to the typical process of vermicomposting seems to be a success and it would result the balanced vermicompost to protect the environment balance. Therefore it could be concluded that vermicomposting was ideal for an efficient sustainable management of the environment and the economy.

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