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Compositional Evaluation of Vermicompost Prepared from Different Types of Organic Wastes using *Eisenia fetida* and Studying its Effect on Crop Growth

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ABSTRACT

Background: Vermicomposting or the conversion of organic wastes into fertile manure by earthworms has long been used in agriculture to increase production of crops. Chemical composition of vermicompost determines the quality and its use in increasing crop yield. It is important to carry out compositional analysis of the vermicompost samples if different substrates are used for their preparation.

Methods: In this study, we prepared vermicompost using earthworm *Eisenia fetida* (old name *Eisenia foetida*) and different organic wastes, namely wheat straw, bagasse, grass, neem leaves *etc*. The nutrient content (C, H, N, S, P, K and Humic Acid) was determined for each sample and the effect on plant growth was also observed.

Result: It was observed that despite the source of vermicompost, nutrient content was always higher in vermicompost than control organic waste. It was also seen that among the different sources, neem leaves and wheat straw gave rise to the most nutritious compost. The effect on plants was also seen to be much better with these vermicompost samples compared to control without added vermicompost. It was observed that the C/N ratio of the organic wastes significantly decreased during vermicompost, which indicates the increase in Nitrogen concentration easily available to plants. Not only were we able to obtain better growth of plants, we were also able to transform some agricultural wastes into useful products, which otherwise would have been dumped into a landfill or burnt, both of which would have been a waste.

Key words: Agriculture, C/N Ratio, Earthworms, Humic acid, Organic waste, Potassium, Vermicomposting, Vermiculture.

INTRODUCTION

Vermicomposting is a process in which earthworms and the associated microorganisms stabilize the organic materials in the soil and convert them to nutrient-rich humus. Earthworms consume most organic materials such as scrap paper, food preparation leftovers and residues, agricultural crop residues, animal manure, yard trimmings and organic byproducts from industries. Vermicompost is the product of vermicomposting, while vermiculture is the rearing of worms for this purpose. Economic benefits include biowastes conversion that reduces waste flow to landfills, elimination of biowastes from the waste stream, reducing the contamination of other recyclables, creation of low-skill jobs at the local level and using relatively cheap and simple technologies that make vermicomposting useful for under-developed agricultural areas (Appelhof, 1993). The three main classes of organic wastes suitable for vermicomposting are generated from animal, plant and urban settlements (Thomas *et al.*, 2012).

Vermicomposting can be added to deprived soils as earthworms convert the soil nutrients into forms which are more readily available to plants such as soluble nitrates, calcium, exchangeable phosphorus, potassium, ammonium nitrogen and magnesium (Edwards and Bohlen, 1996). The vermicompost also has emissions of earthworms and enzymes that improve growth and yield of crops (Kale *et al.*, 1992; Singh *et al.*, 2013).

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Recycling organic wastes to vermicompost using earthworms provides a mean to not only produce organic manure locally but also treat organic waste in an eco-friendly manner (Geetanjali, 2007). Vermicompost improves soil health and fertility as they add major and micro nutrients, organic matter and plant growth promoting substances besides improving the soil structure (Gopal *et al.*, 2013). Vermicompost contains reduced contaminant levels and increased nutrient saturation than the original organic materials (Ndegwa *et al.*, 2000; Laxmi *et al.*, 2014). It consists of water-soluble nutrients and is a very good soil conditioner and organic fertilizer. It is also relatively easier for plants to absorb (Coyne and Knutzen, 2010). The earthworms grind the minerals and uniformly mix them in simpler forms, making nutrients readily available for plants. The digestive systems of the worms create niches for certain species of microbes, thus creating a "living" soil environment (Edwards, 2004). Vermicompost also contains worm mucus that does not let nutrients wash away on watering the plants (Nancarrow and Taylor, 2012).

In small scale system, garden and kitchen wastes are used along with earthworms to digest the organic wastes, such as fruits and vegetables, vegetable and fruit peels and ends, coffee grounds and filters, tea bags, grains such as bread, cracker and cereal, eggshells, leaves and grass clippings, newspapers, paper toweling *etc.* (Selden *et al.*, 2005). Large scale systems require large quantities of food from reliable sources like dairy manure, sewage sludge, brewery and cotton mill waste, agricultural waste, food processing waste, grass clippings and wood chips (Sherman-Huntoon, 2000; Singh *et al.*, 2013).

The species of earthworms most commonly used for vermicomposting include *Eisenia foetida* (the red wiggler), *Eudrilus eugeniae* (African Nightcrawlers), *Eisenia hortensis* (European nightcrawlers), *Perionyx excavatus* (Blueworms) and *Lumbricus rubellus* (Selden *et al.*, 2005). These species can be found in soil rich in organic matter throughout North America and Europe. They live in compost, rotting vegetation and manure piles (Hale, 2008). Since they feed on wastes and are shallow- dwelling, they can easily adapt to living in the confines of a worm bin. However, *Lumbricus terrestris* are not recommended as they burrow much deeper than can be accommodated by most compost bins (Domínguez and Gómez-Brandón, 2012).

The present study was undertaken with the objectives of :

1. Analyzing and comparing nutrient contents of vermicompost prepared from different organic wastes locally available using red worm *Eisenia fetida*.
2. Assessing the growth enhancing ability of vermicompost samples obtained on the selected plants.

MATERIALS AND METHODS

All the five vermicompost types produced using different substrates (neem leaves, sugarcane bagasse, orange peels, wheat straw, rice straw and sawdust) in the small scale experiment in pots on trial basis and then grown in tanks, the Vermicompost samples obtained were analyzed for their composition and their effect on plant growth. The vermicompost were prepared during monsoon season from late June to mid September 2018 in the premises of Institute of Home Economics, Hauz Khas, New Delhi, India (Mean temp 30-35°C, humidity 70-75%). The steps were as follows:

Collection of Organic Wastes

The locally available organic wastes selected for this study were grass, saw dust, wheat straw, bagasse and neem leaves.

Preparation of Tank for rearing *Eisenia fetida*

The tank was prepared in the dimensions of 100x40x40cm in length, width and height using concrete, cement, stones as materials for construction on sides and it was filled with grass leaves mixed with cowdung so as to rear maximum number of worms (*Eisenia fetida*).

Experimental Setup for the preparation of Vermicompost

Pot experiment

In this, cemented pots of sizes 16 inch height x 14 inch diameter, each of capacity 10kg, with small holes at the bottom were used. Small pebbles were placed in these pots followed by spreading a shallow layer of sand of approximately 1 cm. On this layer, 1 kg cow dung was added and then 40 earthworms were introduced in each pot. After adding 5 kg of following substrates separately: grass, wheat straw, saw dust, neem leaves, bagasse in these pots the mixture was covered with big dried leaves and wire mesh. The experiment was set up in duplicate for each substrate. The composting mixture was allowed to stand for 15 days by sprinkling water every 2-3 days. After turning, further incubation was allowed till another 15 days. A set up without earthworms was taken as control. After successful trial run in pots the experiments were set up in pits for the production of vermicompost.

Pit experiment

Pits of sizes 1m length x 80cm width x 20cm depth, made of bricks, concrete and cement on four sides but not on floors were constructed. The vermicomposting setup was prepared by putting one inch layer of pebble at the bottom and then a shallow layer of sand, 4 kg cow dung layer, earthworm 2 kg over cow dung layer and finally 20kg of organic waste. The five substrates were used in duplicates namely grass, wheat straw, saw dust, neem leaves and bagasse. The contents were covered with a framed wire mesh cover. Turning was done after 2 weeks and water was added regularly to avoid drying up of the biomass.

Harvesting Compost

Vermicompost was ready after two months (60 days). When the vermicompost was ready, worms were harvested and compost samples were processed for different parameters. The vermicompost samples were allowed to dry in pits/pots for 3-4 days. The samples were collected, sieved and packed inside airtight plastic bags. Samples were stored at refrigeration temperature and analysed for chemical composition and effect on plant growth.

C, H, N and S Analysis

The contents of carbon, hydrogen, nitrogen and sulphur present in the dried and finely powdered vermicompost samples were analyzed using CHNS analyzer (at Delhi University Instrumentation Center). The samples were homogenized, weighed in tin containers and introduced into the combustion reactor via the Autosampler together with oxygen. After combustion, the resultant gases were separated via GC column and percentage of C H N S was finally detected by a Thermal Conductivity Detector.

Potassium estimation

Atomic Absorbance Spectrophotometer (at Delhi University Instrumentation Center) was used for the analysis of potassium element in the vermicompost samples.

Phosphorus and humic acid

The phosphorus content of vermicompost samples were estimated by acid digestion of sample followed by the use of molybdate reagent (Jackson,1973). Vermicompost samples were examined for humic Acid content using the methods reported in the literature (Page ,1982).

Effect of vermicompost on plant growth

Tomato, brinjal and capsicum plants were grown for two months in the soil supplemented with the vermicompost samples and in the soil without vermicompost (control). Fresh and Dry Weights were measured in all the vermicompost samples.

Statistical analysis

Two-way analysis of variance (ANOVA) was computed using SPSS (version No. 10) to test the level of significance of difference between the vermicompost samples produced by the *Eisenia fetida* during vermicomposting of different organic wastes samples with respect to nutrient parameters and effect of vermicompost on plant growth.

RESULTS AND DISCUSSION

Vermicomposting has been proven to be a very efficient method of increasing crop production and yield, due to high nutritional content and better water percolation and aeration of soil. It also improves plant growth by enhancing germination and crop yield, improving root growth and structure and enriching the soil with microbes. In this study, we try to understand the various aspects of vermicomposting when earthworm *Eisenia fetida* (red-worms) are grown on different organic waste materials such as grass, saw dust, wheat straw, sugarcane bagasse, neem leaves, *etc*. We have quantified the nutrient quality of the various vermicompost samples obtained from these locally available organic wastes and studied the effect of the obtained vermicompost samples on the growth of some crops such as tomato, brinjal and capsicum.

The results confirmed the ability of *E. fetida* to convert these organic wastes into nutritious vermicompost. The major nutrient and the organic carbon contents in the vermicompost produced using these wastes are given in Table 1 and 2.

C, N, H and S estimation

It can be clearly seen that the vermicompost produced from neem leaves had the highest Organic Carbon content (31.40%) followed by sawdust based vermicompost (26.56%). The maximum total nitrogen content present in the vermicompost the samples was also observed in neem leaves vermicompost (2.147%) followed by wheat straw vermicompost (1.847%). Similarly, neem leaves vermicompost showed maximum hydrogen and sulphur content (Table 1). C/N ratio below 20 was observed in all the vermicompost samples which show increased availability of nitrogen to the growing plants when added to them. Similar results were reported for bagasse vermicompost by Thomas *et al* (2012). When the C/N ratio for an organic substrate ranges between 1 and 15, mineralization and release of Nitrogen occurs very rapidly, which can then be taken up by plants. The lower the C/N ratio, the more rapidly nitrogen will be released into the soil for immediate crop use (Brust 2019). In all the five organic wastes, vermicomposting resulted in lowering of C/N ratio, the most significant decrease was in sawdust from 325 to 18.16 followed by bagasse vermicompost showing C/N ratio 16.19 as compared to control with C/N ratio of 110. Vermicomposting also resulted in lowering C/N ratio for other organic waste indicating improved fertilizer quality of vermicomposts prepared from the organic wastes (Table 1).

Potassium, phosphorus and humic acid estimation

Analysis of Potassium, Phosphorus and Humic Acid content of different vermicompost samples show that these samples differ greatly in their composition (Table 2). Wheat straw based vermicompost show maximum potassium (17.2mg/g) followed by bagasse based vermicompost sample which also show comparatively high potassium content (16.3 mg/g). The phosphorous contents of all the vermicompost samples were found to be in the range of 14-20 mg/g). Increase in the content of N and P in vermicompost samples were also reported by Liu *et al* (2012). Humic Acid content of the

Table 1: C, H, N and S analysis of different vermicompost samples.

Source of Vermicompost	Organic Carbon %	Nitrogen %	C/N ratio		Hydrogen %	Sulphur %
			Control	Vermicompost		
Grass	7.15 [a]	0.753 [a]	30 [a]	9.49 [a]	1.229 [a]	0.138 [a]
Neem Leaves	31.40 [e]	2.147 [e]	40 [b]	14.62 [c]	4.742 [e]	0.355 [e]
Sawdust	26.56 [d]	1.497 [d]	325 [e]	18.16 [e]	3.838 [d]	0.325 [d]
Sugarcane Bagasse	18.35 [b]	1.133 [b]	110 [d]	16.19 [d]	2.693 [b]	0.171 [b]
Wheat Straw	22.14 [c]	1.847 [c]	80 [c]	11.98 [b]	3.321 [c]	0.244 [c]
CD (P = 0.05)	0.708	0.043	0.67	0.37	0.135	0.038
SEM	2.204	0.133	28.83	0.82	0.315	0.023

Significantly different values (using Duncan's multiple range test at $p < 0.05$) between different treatments are marked by lowercase letters.

vermicompost samples were in the range of (0.034-0.089 g/g) with maximum content seen in wheat straw. Other researchers also reported that earthworm casts or vermicompost possess high contents of nitrogen (Bansal and Kapoor, 2000), phosphorus (Parmanik *et al.,* 2010) and humic acids (Atiyeh *et al,* 2002; Arancon *et al.,* 2006).

Effect on plant growth

Vermicomposting converts the unavailable forms of nutrients present in soil to the forms that are readily available to the plants, due to combined actions of earthworms and their respective microorganisms (Edwards and Fletcher, 1988). In all cases, better growth in terms of fresh weight and dry weight was observed in case of plants grown with vermicompost than control plants without vermicompost, as shown in Fig 1-3 and Table 3. The increase in plant growth in case of added vermicompost is attributed to high N, P, K, humic acid and plant growth hormones.

Also, through this study it was possible to transform some agricultural wastes into useful products, which otherwise would have been dumped into a landfill or burnt, both of which would have been a waste, or resulted in pollution. Organic farming is sustainable farming, as it is environmental friendly. Vermicompost is nutritionally richer than manure and chemical fertilizers. It acts as a growth promoter and protects crop plants. Many reports talk about the improvements in growth, physiology and biochemistry

Table 2: Potassium, phosphorus and humic acid content estimation of different vermicompost samples.

Source of vermicompost	Potassium content (mg/g of vermicompost)	Phosphorus content (mg/g of vermicompost)	Humic acid content (g/g of vermicompost)
Grass	13.3 [a]	16.2 [b]	0.034 [a]
Neem Leaves	13.2 [a]	20 [d]	0.086 [c]
Sawdust	15.5 [b]	16.5 [b]	0.088 [c]
Sugarcane Bagasse	16.3 [b]	18 [c]	0.074 [b]
Wheat Straw	17.2 [c]	14 [a]	0.089 [c]
CD (P = 0.05)	0.725	1.18	0.067
SEM	0.441	0.559	0.006

Significantly different values (using Duncan's multiple range test at $p < 0.05$) between different treatments are marked by lowercase letters.

Fig 1: Tomato plants growing A) On Wheat Straw Vermicompost and B) Without any Vermicompost.

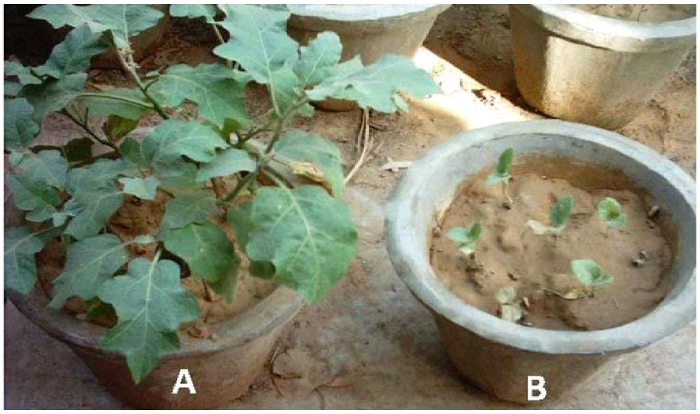

Fig 2: Brinjal plants growing A) On Grass Vermicompost and B) Without any Vermicompost.

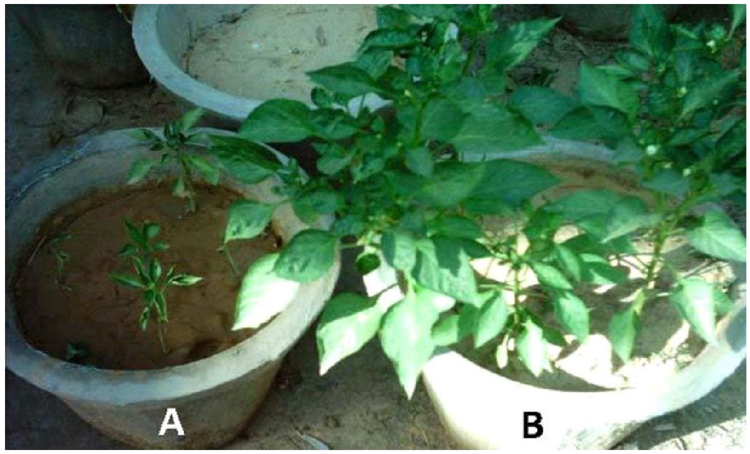

Fig 3: Capsicum plants growing A) Without any vermicompost and B) On grass vermicompost.

Table 3: Effect of addition of vermicompost on plant growth measured as fresh weight (g) after 45 days of sowing.

Vermicompost Sample	Weight of Tomato (g)		Weight of Brinjal (g)		Weight of Capsicum(g)	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
Neem leaves	40.1 [e]	28.7 [e]	18.2 [c]	10.1 [c]	15.3[cd]	8.2 [d]
Sawdust	24.0 [b]	11.8 [b]	16.5 [b]	8.3 [b]	13.6 [b]	6.0 [a]
Sugarcane bagasse	26.6 [c]	13.1 [c]	20.2 [e]	9.5 [c]	14.7[c]	5.8 [a]
Wheat straw	29.6 [d]	14.7[d]	18.5 [c]	9.4 [c]	16.2[d]	6.8 [b]
Grass	26.5 [c]	12.4[bc]	16.9 [b]	8.5 [b]	12.7 [b]	7.5 [c]
Control (without vermicompost)	20.2 [a]	9.7 [a]	11.6 [a]	7.4 [a]	8.3 [a]	5.5 [a]
CD (P=0.05)	1.40	1.02	1.03	0.645	0.91	0.441
SEM	1.51	1.53	0.67	0.23	0.63	0.24

Significantly different values (using Duncan's multiple range test at $p < 0.05$) between different treatments are marked by lowercase letters.

of plants when treated with vermicompost (Sangeetha and Thevanathan, 2010; Illanjiam *et al.*, 2019).

CONCLUSION

High organic carbon and high content of major nutrients N, P, K and Humic Acid in the vermicompost samples prepared from different organic wastes available locally establishes the ability of the *Eisenia fetida* to effectively recycle these wastes to valuable manure at farm level. In this paper, the role of vermicomposting in agriculture as well as in waste management has been emphasized, by showing better nutritional values of vermicompost and also the increased crop production in vermicompost treated soil. In all types of vermicomposts, growth of tomato, brinjal and capsicum were seen to be better than soil without vermicompost. All these observations strengthen our understanding of the role of vermicomposting in waste management and agriculture. Moreover, we also observed that the C/N ratio of the soil highly decreased on adding vermicompost, which indicates the increase in Nitrogen concentration, which is beneficial to plants. We successfully obtained better growth of plants while minimizing and utilizing agricultural wastes. Consequently, the observed results strongly suggest that vermicompost and its beneficial microbes might be explored as efficient for the enhanced growth of vegetable crops in the near future.

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REFERENCES

Appelhof, M. (1993). Worms eat our garbage: Classroom activities for a better environment. Flower Press, Kalamazoo, MI 49002.

Arancon, N.Q., Edwards, C.A., Lee, S. and Byrne, R. (2006). Effects of humic acids from vermicomposts on plant growth. European Journal of Soil Biology. 42: 565-569.

Atiyeh, R.M., Lee, S., Edwards, C.A., Arancon, N.Q. and Metzger, J.D. (2002). The influence of humic acids derived from earthworm-processed organic wastes on plant growth. Bioresource Technology. 84(1): 7-14.

Bansal, S. and Kapoor, K.K. (2000). Vermicomposting of crop residues and cattle dung with *Eisenia foetida*. Bioresource Technology. 73(2): 95-98.

Brust, G.E. (2019). Management strategies for organic vegetable fertility. Safety and Practice for Organic Food (pp. 193-212). Academic Press.

Coyne, K. and Knutzen, E. (2010). The urban homestead: Your guide to self-sufficient living in the heart of the city. Process Media.

Domínguez, J. and Gómez-Brandón, M. (2012). Vermicomposting: composting with earthworms to recycle organic wastes. Management of organic waste. Rijeka, Croatia: In Tech. 29-48.

Edwards, C.A. (ed.). (2004). Earthworm ecology. CRC press.

Edwards, C.A. and Bohlen, P. J. (1996). Biology and ecology of earthworms, Chapman and Hall Press. London United Kingdom.

Gitanjali, G. (2007). Organic manure production through vermitechnology. Agricultural Science Digest. 27(4): 270-272.

Gopal, M., Gupta, A. and Thomas, G.V. (2013). Bespoke microbiome therapy to manage plant diseases. Frontiers in Microbiology. 4: 355.

Hale, C. (2008). Great Lakes Worm Watch: How citizen scientists have documented the distributions of exotic earthworms in the western Great Lakes Region. 93rd ESA Annual Meeting.

Illanjiam, S., Sivakumar, J. and Sundaram, C.S. (2019). Microbial diversity of vermicompost and its efficacy on organic vegetables. Life Science Informatics Publication. 5(1): 806-819.

Jackson, M.L. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Kale, R.D., Mallesh, B.C., Kubra Bano and Bhagyaraj, D.J. (1992). Influence of vermicompost application on available micronutrients and selected microbial populations in paddy field. Soil Biology and Biochemistry. 24: 1317-1320.

Lakshmi, C.S.R., Rao, P.C., Sreelatha, T., Madhavi, M., Padmaja, G. and Sireesha, A. (2014). Changes in enzyme activities during vermicomposting and normal composting of vegetable market waste. Agricultural Science Digest-A Research Journal. 34(2): 107-110.

Liu, F., Zhu, P. and Xue, J. (2012). Comparative study on physical and chemical characteristics of sludge vermicomposted by *Eisenia fetida*. Procedia Environmental Sciences. 16: 418-423.

Nancarrow, L. and Taylor, J.H. (2012). The Worm Book: The Complete Guide to Gardening and Composting with Worms. Ten Speed Press.

Ndegwa, P.M., Thompson, S.A. and Das, K.C. (2000). Effects of stocking density and feeding rate on vermicomposting of biosolids. Bioresource Technology. 71(1): 5-12.

Page, A.L. (1982). Methods of soil analysis. Part 2. Chemical and microbiological properties. USA: American Society of Agronomy.

Pramanik, P., Ghosh, G.K. and Chung, Y.R. (2010). Changes in nutrient content, enzymatic activities and microbial properties of lateritic soil due to application of different vermicomposts: a comparative study of ergosterol and chitin to determine fungal biomass in soil. Soil use and Management. 26(4): 508-515.

Sangeetha, V. and Thevanathan, R. (2010). Biofertilizer potential of traditional and panchagavya amended with seaweed extract. The Journal of American Science. 6(2): 61-67.

Selden, P., DuPonte, M., Sipes, B. and Dinges, K. (2005). Small-scale vermicomposting. Home Garden HG-45. 1-4

Sherman-Huntoon. R. (2000). Latest developments in mid-to-large-scale vermicomposting. Biocycle. 41(11): 51- 54.

Singh, R., Nigam, A., Verma, G. and Kapila, R. (2013). Vermicomposting-A technology for waste management and recycling and its relevance to horticulture. International Journal of Innovative Horticulture. 2(1): 44-51.

Thomas, G.V., Palaniswami, C., Gopal, M. and Gupta, A. (2012). Recycling coconut leaf-agro wastes mixture using Eudrilus sp. and growth promotion properties of coconut leaf vermicompost. International Journal of Innovative Horticulture. 1(2): 113-118.