Optimizing household waste and cow dung proportions for quality vermicompost production

ABSTRACT

Aim: To standardize the ratio of household waste and cow dung for quality vermicompost based on physical properties.
Study design: Completely Randomized Design (Factorial)
Place and Duration of Study: Vermicompost Production Unit, RPCAU, Pusa during April 2018 to June 2018.
Methodology: Household waste was combined with cow dung in three different proportions (35:65, 50:50 and 65:35 ratio of household waste and cow dung, respectively) along with rock phosphate and suitable species of earthworms @ 2 kg per ton of material at suitable temperature and moisture (37^{0}C and 65% w/w respectively) under shade. Various physical parameters were analyzed at 30, 60 and 90 days after setting the windrows.
Results: Vermicompost prepared from household waste and cow dung in (50:50) ratio recorded lowest moisture content 16.0% and highest water holding capacity (20.7%) at the end of vermicomposting process (90 days) and 94% of material passed through 4.0 mm IS sieve.
Conclusion: Vermicompost prepared from household waste and cow dung in equal proportion (50:50) emerged out as better quality vermicompost based on the observed physical characteristics.

Keywords: *Eisenia fetida, Household waste, Cow dung,PSB and Rock phosphate*

1. INTRODUCTION

Effective household waste management is an essential aspect of promoting environmental sustainability and maintaining the health and well-being of our communities. As our daily lives generate a significant amount of waste, it is crucial to adopt responsible practices that minimize the negative impacts of waste on the environment, human health, and resources. India generates approximately 133760 tonnes of municipal solid waste per day and per capita waste generation ranges from approximately 0.17 kg per person per day in small towns to 0.62 kg per person per day in cities [1]. In Bihar solid waste generation was recorded 1670 tonnes per day [2]. For hygienic disposal of organic wastes, it should be managed effectively. Household waste management encompasses a range of activities, from waste reduction and segregation to proper disposal and recycling.Vermicomposting provides an effective solution for reducing the volume of household waste. Vermicomposting is considered as an eco-biotechnological and non-thermophilic process of composting that stabilize the organic wastes, involving the action of earthworms and associated microorganisms [3]. Earthworms are considered to be natural bioreactors which are able to proliferate along with other microorganisms and effectively lead to the biodegradation of wastes.Household waste contains valuable organic matter that, when composted through vermicomposting, contributes to increasing organic matter content in the soil[4]. As organic waste goes through the vermicomposting process, it is broken down by earthworms and beneficial microorganisms. This decomposition process reduces the overall bulk and volume of the organic waste, making it more manageable and easier to handle[5]. By harnessing the power of earthworms and microorganisms, vermicomposting efficiently converts organic waste into nutrient-rich vermicompost[6, 7, 8]. This process not only diverts waste from landfills, reducing environmental impact, but also produces a valuable resource that enhances soil fertility and promotes healthy plant growth.

Keep this in view a study was conducted to evaluate the best household waste and cow dung proportion for quality vermicompost production, where household waste and cow dung was mixed in three different proportions and their quality was evaluated.

2. MATERIAL AND METHODS

2.1 Experimental site and design

The present investigation was conducted during *Kharif* 2018 at Vermicompost Production Unit and Department of Soil Science, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, in aCompletely Randomized Design (Factorial) replicated thrice with days after initiation (DAI) as Factor I and various combination of household waste and cow dung as Factor II.

2.2 Vermicompost Production

Household waste used as substrate for vermicomposting in present investigation was taken from the collection mechanism of the university which collected waste from 750 quarters, hostels present in the university campus of RPCAU, Pusa. Whereas cow dung, rock phosphate and PSB was taken from the livestock farm at Vermicompost Production Unit, RPCAU, Pusa and Department of Soil Science, Tirhut College of Agriculture, Dholi, respectively.

The household waste was combined with cow dung in different combinations i.e., 35:65, 50:50 and 65:35 ratio of household waste and cow dung, respectively at 37^0 C temperature and 65% w/w moisture in three windrows and each of size 10 ft x 2 ft x 1.5 ft under shade.Earthworm species used was *Eisenia fetida*earthworms @ 2 kg per ton of material. In all cases the substrate was enriched with addition of rock phosphate (on P_2O_5 basis @ 5% w/w) and PSB (@500 g PSB carrier based bio-fertilizer per ton of material).

Windrows	Household waste (w/w)	Cow dung (w/w)
1	210 kg (35%)	390 kg (65%)
2	300 kg (50%)	300 kg (50%)
3	390 kg (65%)	210 kg (35%)

The household waste was properly shredded into smaller pieces and mixed with cow dung in proposed ratio. Then it was partially decomposed prior to inoculation and release of earthworms so that generated heat and toxicants during the beginning of decomposition process may be neutralized to provide congenial conditions for survival and development of earthworms. After 15 days of mixing, PSB was inoculated, and rock phosphate was added to each windrow.After partial decomposition**,** *Eisenia fetida*species of earthworm @ 2 kg per ton of substrate was inoculated to each windrow and throughout the vermicomposting process, sufficient moisture was maintained.

The final vermicompost prepared from the household waste changed into dark brown colour as well as became friable and granular in texture as compared to the initial substrate. The vermicompost was collected with the help of wooden slab. At first upper layer of vermicompost heap was scraped lightly and left undisturbed for 30 minutes. Till that time earthworms will go downwards. Then cast was collected by using wooden slab and process is repeated weekly until cast is collected fully.

2.3Materials Required

Equipment and apparatus- hot air oven and keen box
Glasswares- beaker, measuring cylinder, petri dish, 4 mm IS sieve

2.4Methodology for quality assessment of vermicompost

The vermicompost samples were taken out from the three windrows at different time interval i.e., at 30, 60 and 90 days after setting the windrows for analyzing various physical parameters in order to determine the better quality vermicompost prepared from the three windrows having different combination of household waste and cow dung.

2.5 Physical parameters

2.5.1Moisture content (%)

The moisture content of the vermicompost was recorded at various time intervals (at 30, 60 and 90 days after setting the windrows) from the three windrows separately as moisture percent by weight as described by FCO [9].

2.5.2Maximum water holding capacity (%)

The maximum water holding capacity of the vermicompost was recorded at various time intervals (at 30, 60 and 90 days after setting the windrows) from the three windrows. It was determined by Keen Raozkowski box method described by Piper[10].

2.5.3Odour

Odour of the vermicompost was observed by smelling test as described by FCO [9].

2.5.4Bulk density

Bulk density determination of the vermicompost from three windrows was done at different time intervals by tapping method as described by FCO [9].

2.5.5Particle size

Particle size of the vermicompost was determined by sieving method (using 4 mm IS sieve) as described by FCO [9].

3. RESULTS AND DISCUSSION

3.1 Chemical properties of substrate used for vermicomposting

The pH and EC were low in household waste as compared to cow dung (Table 1). The total organic carbon (48.31%) and total nitrogen (2.35%) in household waste was higher than in cow dung. C:N ratio was observed to be low in household waste (20.55) than cow dung (38.26). Total phosphorus content was high in cow dung (0.26%) and total potassium content was higher in household waste (2.40%). Total Fe and Zn were higher in household waste whereas total Cu and Mn were observed to be higher in cow dung.

Table 1: Chemical properties of substrates used for vermicomposting

Properties	Household waste	Cow dung
pH	7.27	8.80
EC (dSm^{-1})	0.78	1.443
Total organic carbon (%)	48.31	21.43
Total nitrogen (%)	2.35	0.56
C:N ratio	20.55	38.26
Total phosphorus (%)	0.23	0.26
Total potassium (%)	2.40	0.74
Total Fe (mg kg^{-1})	1165.00	1058.00
Total Cu (mg kg^{-1})	15.90	23.50
Total Mn (mg kg^{-1})	98.00	343.10
Total Zn (mg kg^{-1})	139.40	94.90

3.2 Quality assessment of vermicompost

The vermicompost was taken out from the three windrows at different time interval i.e., at 30, 60 and 90 days after setting the windrows for analyzing various physicochemical parameters in order to determine best quality vermicompost prepared among the three windrows having different combination of household waste and cow dung.

3.3 Changes in physical properties during vermicomposting

The changes in physical properties of vermicompost prepared with household waste and cow dung in three different combinations were periodically studied at an interval of thirty days during vermicomposting process and the data have been presented under various sub heads.

3.4 Moisture content (%)

The moisture content of the vermicompost prepared in three different windrows was recorded at an interval of 30 days ranged from 18.8 to 19.8%, 12.2 to 21.0% and 16.0 to 22.8% at 30 days, 60 days, and 90 days, respectively during the vermicomposting process (Table 2).Thevermicompost prepared from household waste and cow dung in 35:65 ratio recorded lowest moisture content (18.76%) during initial 30 days of vermicomposting, while the vermicompost from the household waste and cow dung in equal proportion (50:50) recorded lowest moisture content 12.2% and 16.0% at 60 days and 90 days respectively which was also within the range described by FCO (1985).

3.5 Maximum water holding capacity (%)

Maximum water holding capacity was recorded to be 26.3 to 33.3%, 23.0 to 24.7% and 19.4 to 20.7% at 30 days, 60 days, and 90 days, respectively (Table2). At 30 days of vermicomposting process, household waste and cow dung in 35:65 ratio recorded highest water holding capacity (33.3%), while 65:35 ratio of household waste and cow dung recorded lowest water holding capacity (26.3%). At the end of vermicomposting process i.e., at 90 days, household waste and cow dung in equal proportion (50:50) recorded highest water holding capacity (20.7%) followed by 35:65 ratio (20.3%) and 65:35 ratio of household waste and cow dung (19.4%).

3.6 Bulk density (Mg m^{-3})

Results obtained on bulk density have been presented in Table 2. A scrutiny of data reveals that the bulk density of vermicompost prepared from all the three substrate combinations recorded a decreasing trend during vermicomposting process. The bulk density varied from 1.1 (50:50 ratio) to 1.7Mg m^{-3} (65:35 ratio) at 30 days, whereas at 60 days it varied from 1.1 (50:50 ratio) to 1.5Mg m^{-3} (65:35 ratio) and at end of vermicomposting process i.e., at 90 days it varied from 0.8 (50:50 ratio) to 1.3 Mg m^{-3} (65:35 ratio). Household waste and cow dung in equal proportion (50:50) recorded lowest bulk density from the start of vermicomposting process (1.1 Mg m^{-3}) to the preparation of final vermicompost (0.8 Mg m^{-3}).

Table 2: Changes in moisture content, maximum water holding capacity and bulk density during vermicomposting

Windrows	Moisture content (%)			Maximum water holding capacity (%)			Bulk density (Mg m^{-3})		
	30 days	60 days	90 days	30 days	60 days	90 days	30 days	60 days	90 days
HW 35% + CD 65%	18.8	18.2	22.8	33.3	24.7	20.3	1.3	1.2	0.9
HW 50% + CD 50%	19.8	12.2	16.0	27.0	23.0	20.7	1.1	1.1	0.8
HW 65% + CD 35%	19.5	21.0	21.2	26.3	23.3	19.4	1.7	1.5	1.3
	CD (5%)			CD (5%)			CD (5%)		
DAI	0.526			0.051			1.137		
HW + CD	0.526			0.051			1.137		
Interaction	0.912			0.088			1.969		

3.7 Odour

The final prepared vermicompost from three different combinations of household waste and cow dung was determined using qualitative smelling test and an earthy smell was observed which indicated the maturity of compost. Foul odour was absent in final product.

3.8 Particle size

At the end of vermicomposting process, it was observed that the 94% of material passed through 4.0 mm IS sieve in case of vermicompost prepared from household waste and cow dung in in 50:50 ratio while in case of 35:65 ratio 96% of final product passed through 4.0 mm IS sieve. However, in case of vermicompost prepared from household waste and cow dung in 65: 35 ratios, only 70% of the material passed through 4.0 mm IS sieve.

4. CONCLUSIONS

Vermicompost prepared from household waste and cow dung in equal proportion (50:50) emerged out as best quality vermicompost on the basis of physical properties of the resulting product. Overall, vermicomposting brings about positive changes in the physical properties of organic waste, including volume reduction, improved texture, moisture regulation, odor reduction, and nutrient enrichment. These transformations make the resulting vermicompost a valuable resource for enhancing soil fertility, promoting plant growth, and supporting sustainable gardening practices.

ACKNOWLEDGEMENT

The authors sincerely acknowledge all the facilities provided by Department of Soil Science, RPCAU, Pusa and help received in the form of fellowship.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

This investigation was a part of M.Sc. thesis research work of Mrs. Alpana Kusum who performed the analysis. It was carried out by her successfully with the support of fellow researchers Mrs. NituKumari,BiplabChoudhari, DeepikaSahu and NainsiNaya who provided valuable suggestions and proper guidance during writing of this manuscript as well as contributed to analysis tools.

REFERENCES

1. Kumar, A., Dhyani, B.P., Rai, A., and Kumar, V. (2017). Residual effect of applied vermicompost and NPK to rice on growth and yield of succeeding wheat and chemical properties of soil. *International Journal of Current Microbiology and Applied Sciences,* **6**(11), 1087-1098.
2. CPCB, Annual Report, 2015–2016, *Published by Central Pollution Control Board (CPCB), Delhi, India.*
3. Edwards, C.A. and Burrows, I. (1988). The potential of earthworm composts as plant growth media*. In: Earthworms in Environmental and Waste Management.* SPB Academic Publ. B.v., The Netherlands, 21-32, 211-220.
4. Chiranjeeb, K. (2019). Effect of household-waste-based vermicompost on carbon pool, functional-indicator microbes and plant growth.*M.Sc. (Agri.) thesis*.Dr. Rajendra Prasad Central Agricultural University, Pusa (Bihar).
5. Kusum, A. (2019). Vermicompost from household waste and its effect on soil properties and crop growth.*M.Sc. (Agri.) thesis.*Dr. Rajendra Prasad Central Agricultural University, Pusa (Bihar).
6. Sari, S., Aksakal, E.L. and Angin, I. (2017). Influence of vermicompost application on soil consistency limits and soil compactibility. *Turkish Journal of Agriculture and Forestry,* **41**(5), 357-371.
7. Baghel, B., Sahu, R., and Pandey, D. (2018). Vermicomposting an economical enterprise for nutrient and waste management for rural agriculture. *International Journal of Current Microbiology and Applied Sciences,* ***7***(2), 3754-3758.
8. Kusum, A., Jha, S. and Tedia, K. (2023). Changes in physical properties during composting.The Pharma Innovation Journal, **12**(3): 1633-1636.
9. Fertilizer Control Order (1985). Biofertilizers and organic fertilizers in Fertilizer (control) order, 1985. Published by National Centre of Organic Farming, Dept. of Agriculture and Corporation, Ministry of Agriculture, Govt. of India.
10. Piper, C.S. (1966). Soil and plant analysis.*Hans publishers, Bombay*, 401.