Qualitative Study of Organic Fertilizer of Agrowaste (Cumin Straw) Plus Cow dung Using Earthworm Species *Eisenia fetida* and *Perionyx sansibaricus*

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Abstract  The present study is incorporated with agrowaste management and biofertilizer production in tropical India. For this, an exotic earthworm species *Eisenia fetida* and a local species *Perionyx sansibaricus* were used to decompose cumin straw and cow dung and evaluated vermicomposting efficacy. Physicochemical parameters of the vermicompost were evaluated in the vermicompost. The values of all the above physicochemical parameters of *E. fetida* worked bedding material varied significantly (P<0.001) with respect to initial day values. Likewise, these parameters in the bedding substrate fed by *Perionyx sansibaricus* also varied significantly (P<0.001) as compared to 0 day values. The organic waste conversion efficiency of *E. fetida* was better than *P. sansibaricus* for cumin plus cow dung bedding. Though *E. fetida* is better agrowaste converter but both the earthworm species may be used for organic waste management in desert region. It may provide the support in the form of biofertilizer to enhance the organic farming in region of the Thar Desert.

Keywords: *Eisenia fetida*, *Perionyx sansibaricus*, vermicomposting, physicochemical properties, Cumin straw, organic farming

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1. Introduction

Use of chemical fertilizer is adversely affecting the Human health, agroecosystem, sustainability of soil and below-ground biological diversity. This problem could be overcome by adopting organic farming, which demands development of a suitable technology for proper recycling of organic wastes. There is tremendous increase in agrowastes with the increase in agricultural production. These agrowastes pollute the surrounding environment leading to diseases in animals and human. The wastes also act as a reservoir of fungal diseases of next crop. So there is a warranted need to convert the agricultural wastes into assets i.e. vermicompost. Use of vermicompost rejuvenates the exhausted soil fertility, enriches the available nutrients to sustain soil quality and enhances water holding capacity and biological resources [1,2,3]. Application of earthworm resources in conversion of agricultural, urban and industrial wastes into vermicompost is much liked method of recycling organic substrates worldwide [4,5,6].

Available nutrients in vermicompost are much higher than traditional garden compost [7]. Vermicompost is also helpful in reducing the population of soil pathogenic microorganisms [8] and inducing nitrogen fixation [9,10]. Several workers have documented the use of organic waste in vermicomposting such as sewage sludge [11,12], pig manure [13,14], combined sewage sludge and municipal refuse [15], cotton industry waste [16], industrial and vegetable waste [17], animal and vegetable waste [18,19,20,21,22], leaf litter [23], wheat straw plus paddy straw plus cow dung [24] and mustard straw plus cow dung [3]. Use of various earthworm species in vermicomposting is popularized still much study is need to evaluate composting potentials of *E. fetida* and *P. sansibaricus* for different agricultural wastes. Cumin is a very important cash crop and enormous waste is generated after each harvesting in western Rajasthan, India. But no information is available on composting of cumin waste by earthworm. At this juncture, a suitable technology should be developed to convert cumin waste into biofertilizer.

Under the above background, experiments were conducted to decompose cumin straw with cow dung by employing *Eisenia fetida* and *Perionyx sansibaricus* earthworm species.
2. Material and Methods

2.1 Collection of Material

Cumin is a spice crop grown on a large scale particularly in western parts of Rajasthan in India. Its straw was collected from agricultural farm of village-Chheela, tehsil-Lohawat of Jodhpur district (27° 01'41" N 72°28'50" E). Generally, cumin straw is dumped in huge quantity after each harvesting in Rabi season. Partially decomposed straw was collected from one season old (dumped open sky) harvested pool. Air dried cow dung was taken from a cow owner of Adeshwar Nagar of Jodhpur city. The materials were filled in bags and brought to the vermiculture laboratory. The earthworm species *Eisenia fetida* was collected from a farmer’s vermiculture centre of village Chheela with a small amount of culture material i.e. cow manure, in perforated bags. Whereas, *Perionyx sansibaricus* was used from previously prepared stock culture originally collected from Jodhpur city. These two species of earthworm were cultured separately in cow dung vermicompost. The materials were filled in bags for use in vermicomposting.

2.2. Processing of Materials

The collected cumin straw and cow dung were left for one week at room temperature. Dried cow dung was powdered on hard surface, whereas mustard straw was grinded in mixer-grinder after thorough chopping. The powdery materials were sieved by 1mm (palatable size for earthworm) pore sized net separately and stocked in plastic bags for use in vermicomposting.

2.3. Experimental Planning of Vermiculture

Three sets in triplicate of vermicompost beds (500g each) were prepared using powered cumin straw and cow dung in equal ratio in plastic containers (30 cm x 25 cm) and moistened to stabilize within 48 hours. In the experimental set, 25 mature worms of each species (*E. fetida* and *P. sansibaricus*) were inoculated separately. One set of control bedding material (without earthworm) was run simultaneously. The plastic containers for culture were perforated at 2-3 places to assist leaching of excess water. However, leached water was collected in other containers and reused for watering the vermicompost beds so as to prevent the washout of nutrients. The vermiculture experiment was conducted for 60 days. During composting period, 60-70% moisture was maintained by spraying water on the bedding regularly. The temperature of vermicompost was 30±3°C and wet jute cloth was used to maintain the temperature of vermicompost.

2.4. Analysis of Bedding Materials

During decomposition, changes in pH, electrical conductivity, water holding capacity, organic carbon, total nitrogen, carbon/nitrogen ratio, available phosphorus and potassium were estimated after an interval of 15 days of worm working viz., 0, 15, 30, 45 and 60 day. For this purpose, 10g dry weight basis samples were collected from each experimental as well as control vermicompost in plastic pouches. The pH and electrical conductivity of bedding materials were measured with the help of a digital pH meter. An examination of Degtjareff method was used for determination of organic carbon [25]. Total nitrogen was measured by Kjeldahl method [26] employing Kel plus system (Kes-20 and Distyl-EM). Available phosphorus was estimated as described by Anderson and Ingram [27] and exchangeable potassium was determined by the method of Simard [28]. The temperature of vermicompost was recorded with the help of thermometer (MEXTECH multi-thermometer). Moisture of bedding substrates was estimated by oven drying method.

The collected data was subjected to statistical analysis. A one way analysis of variance (ANOVA) was performed to test the level of significance. The level of significance was set at 0.05.

3. Results and Discussion

Cumin straw plus cow dung bedding material showed significant changes (P<0.001) in physicochemical properties of earthworm worked vermicompost with respect to decomposition duration. Whereas control bedding material indicated insignificant changes (P<0.05). However, water holding capacity increased significantly (P<0.05) by 1.44 fold. Likewise, organic carbon and C/N ratio declined significantly (P<0.05) by 32.17% and 43.20% respectively as compared to initial level.

Introduction of *E. fetida* in the bedding material showed significant (P<0.001) increase in electrical conductivity, water holding capacity, total nitrogen, phosphorus and potassium by 1.59, 2.25, 2.26, 1.83 and 2.07 fold respectively. While pH, organic carbon and C/N ratio decreased significantly (P<0.001) by 12.19%, 64.34% and 81.13% respectively from 0 to 60 days.

Like *E. fetida*, physicochemical properties of the bedding material differed significantly (P<0.001) after 60 days feeding of *P. sansibaricus*. The bedding material exhibited increase in electrical conductivity, water holding capacity, total nitrogen, phosphorus and potassium by 1.39, 2.21, 1.91, 1.59 and 1.84 fold respectively. However, values of pH, organic carbon and C/N ratio decreased significantly (P<0.001) by 12.19%, 64.34% and 81.13% respectively within 60 days of the earthworm activities (Figure 1).

Decomposition of cumin straw plus cow dung in absence and presence of earthworm showed significant changes. The pH of control group bedding declined by 4.01%. However, pH in *E. fetida* induced compost decreased by 12.19% and in *P. sansibaricus* inoculated bedding by 11.25% during 60 days of composting period. Maximum pH value declined in *E. fetida* compost followed by *P. sansibaricus* and control group. The reduction in pH value may be due to formation of acids and release of CO₂ during decomposition and earthworm respiration respectively. In the control group decline in pH was because of microbial activity. Decreased trend of pH in the vermicompost and compost substrates is in agreement to the reports of previous workers [3,5,19,29,30] who showed lower pH. The present findings are contradictory to the work of some researchers who described a gradual increase in pH from substrate to compost to vermicompost [31,32]. Electrical conductivity...
increased by 1.08 fold in control group, while it increased by 1.59 and 1.39 fold in *E. fetida* and *P. sansibaricus* compost respectively. The EC value of vermicompost differed significantly in comparison to control. However, *E. fetida* showed greater increase in electrical conductivity of compost bedding. Increasing trend of electrical conductivity during composting and vermicomposting was probably due to release of minerals such as potassium, phosphorus and calcium in the available form. Our results are supported by the observations of earlier workers [3,33,34,35,36]. It has been also documented that increase in EC may be probably due to the degradation of organic matter releasing minerals such as exchangeable Ca, Mg, K and P in the available form, that is, in the form of cations in the vermicompost and compost [37]. Likewise, the present investigations are also vindicated [23]. He studied the earthworm numbers and biomass and their impact on Physicochemical characteristics of vermicompost. He observed that the leaf litter waste decomposition by *E. eugeniae* and *D. modesta* on day 40 produced vermicompost that had an increased level of nutrients like total nitrogen, available *Perionyx sansibaricus* and available potassium and decreased level of pH, organic carbon and C/N ratio. However, the present findings are not in conformity to the report [38] who demonstrated reduction in EC during vermicomposting.

**Figure 1.** Physicochemical properties (pH, EC-electrical conductivity; WHC-water holding capacity; OC- Organic carbon; C/N- carbon-nitrogen ratio; Total nitrogen; Phosphorus and Potassium) of Control, *E. fetida* and *P. sansibaricus* worked vermibeds of Cumin straw plus cow dung from 0 to 60 days period
Water holding capacity improved by 1.44 fold in control group. Whereas, in the E. fetida and P. sansibaricus bedding materials, it increased by 2.25 and 2.21 fold respectively. The water holding capacity was enhanced due to fragmentation of substrate by earthworm digestive system and mineralization during composting. The present finding was supported by the work [8] who found that vermicompost is a peat like material with excellent structure, aeration, drainage and water holding capacity. Similarly, the documentation of other workers show increased water holding capacity after vermicomposting [39]. In contrast, organic carbon of the compost and vermicompost decreased from their initial level of substrate in control as well as experimental group. Figure 1 showed that organic carbon of earthworm containing bedding material was consumed significantly (P<0.001) faster than control group. In this respect, E. fetida was better as compared to P. sansibaricus.

Total nitrogen, available phosphorus and potassium increased by 1.19, 1.10 and 1.05 fold respectively as compared to their 0 day values in control substrate. Whereas, vermicompost prepared by E. fetida and P. sansibaricus showed increase in its values by 2.26, 1.83 and 2.07 fold and 1.91, 1.59 and 1.84 fold respectively as compared to starting values. Our findings revealed that organic waste processed by earthworms had considerably higher level of organic nutrients. Higher level of nitrogen, phosphorus, potassium, calcium and magnesium in vermicompost has also been reported [24,34,40]. The increase in nitrogen, phosphorus and potassium and decrease in the organic carbon and C/N ratio in the earthworm compost are in concurrence with the documentation of previous investigator [41].

4. Conclusions

Cumin straw plus cow dung bedding materials were used to prepare vermicompost by two earthworm species viz., Eisenia fetida and Perionyx sansibaricus. Physicochemical properties of verminbeds were analyzed periodically. Water holding capacity, electrical conductivity, total nitrogen, phosphorus and potassium increased as a function of vermicomposting period. However, pH, organic carbon and C/N ratio decreased gradually during the experiments. Cumin straw can be a very useful organic material for vermicomposting. Both the E. fetida and P. sansibaricus species of earthworms were found suitable for preparation of vermicompost of cumin straw in rural area. This strategy may be adopted for popularization of this ecofriendly vermitechnology for benefit of human beings and environment.

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References

[1] Chauoi, H.I., Zibilske, L.M. and Ohno, T., Effects of earthworm casts and compost on soil microbial activity and plant nutrient availability. Soil Biol. Biochem., 2003, 35, 295-302.
[2] Arancon, N. Q., Clive, A., Edwards, Stephen Lee and Robert B., Effects of humic acids from vermicomposts on plant growth. Eur. J. Soil Biol., 2006, 42, 565-569.
[3] Panwar, K.R. and Tripathi G., Studies on agrowaste conversion efficiency of the earthworm species Eisenia fetida and Perionyx sansibaricus. J. Exp. Zool., India, Vol. 20, Supplement 1, 2017, pp. 1453-1457.
[4] Edwards, C. A., Breakdown of animal, vegetable and industrial waste by earthworms. In: Earthworms in Waste and Environmental Management (C. A. Edwards and E. P. Neuhauer, eds.), S. P. B. Academic, Hague, 1988, pp. 21-31.
[5] Mistry J. Mukhopadhyay A. P. and Baur G. N., Status of N P K in vermicompost prepared from two common weed and two medicinal plants. Int. J. Appl. Sci. Biotechnol., 3, 193-196, 2015.
[6] Sangwan P., Kaushik CP and Garg V.K., Vermiconversion of industrial slag for recycling the nutrients. Bioren. Technol., 2008, 99, 8699-8704.
[7] Dickerson, G.W., Vermicomposting. Cooperative Extension Service. College of Agriculture and Home Economics. New Mexico State University, 2004.
[8] Dominguez, J. and Edwards, C. A., Effects of stocking rate and moisture content on the growth and maturation of Eisenia andrei (Oligochaeta) in pig manure. Soil Biol. Biochem., 1997, 29, 743-746.
[9] Mba, C.C., Vermicomposting and biological N-fixation. In: 9th International Symposium on Soil Biology and Conservation of the Biosphere. Szeji, J, Budapest: Akademiai Kiado. 1987.
[10] Tereshchenko, N.N. and Naplekoova N.N., Influence of different ecological groups of earthworms on the intensity of nitrogen fixation. Biol. Bull. Rus. Acad. Sci., 2002, 29, 628-632.
[11] Mitchell M. J., Mulligan R. M., Hartenstein R. and Neuhauer E. F., Conservation of slugs into “topsoil” by earthworm. Compost Science, 1977, 18, 28-32.
[12] Neuhauer, E. F., Loehr, R. C. and Malecki, M. R., The potential of earthworms for managing sewage sludge. In: Earthworms and Waste Management. Edwards, C.A. and Neuhauer, E. F. (Eds.), SPB Acad. Publ., The Netherlands, 1988, pp. 9-20.
[13] Chang, P.L.S. and Griffiths, D.A., The vermicomposting of pre-treated pig manure. Biological Wastes, 1988, 24, 57-69.
[14] Wong, S.H. and Griffiths, D.A., Vermicomposting in the management of pig-waste in Hong Kong. World J. Microbiol. Biotechnol., 1991, 7, 593-595.
[15] Grapelli A., Tomati, U. and Gall E., Vermicomposting of Combine Sewage sludge and Municipal refuse. In: International Symposium on Agriculture and Environmental Prospects in Earthworm Farming. Rome, Italy, 1983, pp 87-94.
[16] Albanell, E., Plaxixts and Cabrero, T., Chemical changes during vermicomposting Eisenia fetida of Sheep manure mix with cotton industrial waste. Biol. Fertil., 1988, 6, 266-269.
[17] Bano K., Kale R. D. and Ganjan G. N., Culturing of earthworm Eudrilus eugineae for cast production and assessment of worm cast as biofertilizer. J. Soil Biol. Ecol. 1987, 7 (2), 98-104.
[18] Edwards, C. A., The use of earthworm in the breakdown and management of organic wastes. In: Earthworm Ecology (ed. Edwards, C. A.). CRC Press, Boca Raton, 1998, pp. 327-354.
[19] Tripathi, G. and Bhardwaj, P., Comparative studies on biomass production, life cycles and composting efficiency of Eisenia fetida (Savigny) and Lampito mauritii (Kinberg). Bioren. Technol., 2004, 92, 275-283.
[20] Suthar, S. and Singh, S., Vermicomposting of domestic waste using two epigeic earthworms (Perionyx excavatus and Perionyx sansibaricus). Int. J. Environ. Sci. Tech., 2008, 5, 99-106.
[21] Babita Devi M., Studies on yield potentials of vermicompost using Eisenia fetida in different solid waste materials. Int. J. Curr. Microbiol. App. Sci., 2017, 6, 82-85.
[22] Ohianuju Ozioma Ezeorji., et al. “Utilization of Organic Wastes in the Production of Biofertilizer (by Vermicompost using Eisenia fetida Earthworm) with Analysis of their Micro and Macro Mineral Nutrient and their Effects on Growth Rate of Fruited Pumpkin (Telfaria occidentalis) and Spinach (Spinacia oleracea)”. Acta Scientific Nutritional Health, 2020, 4(2): 01-10.
[23] Thangaraj R., Leaf Litter Waste Management by Vermicomposting Using Local and Exotic Earthworm Species. J. Sci., 2015, 5, 314-319.
[24] Panwar, K.R., Role of Earthworm (Eisenia fetida) on Organic Waste Management and pollution Control in Indian Thar desert, Int. J.Sci.Res.Sci.Tech., 2017, 3(8): 1058-1062.
[25] Walkley, A. and Black, I. A., An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 1934, 37, 29-37.
[26] Jackson, M. L., Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi, 1967, pp. 183-192.
[27] Anderson, J. M. and Ingram, J. S. I., Soil organic matter and organic carbon. In: Tropical Soil Biology and Fertility, A Hand Book of Methods (J. M. Anderson and J. S. I. Ingram, Eds.), CAB International, Wallingford, UK, 1993, P. 221.
[28] Simard, R. R., Ammonium acetate extractable elements. In: Soil Sampling and Methods of Analysis. Martin, R. and Carter, S. (Eds.) Lewis Publisher, Florida, USA, 1993, 39-43.
[29] Haimi, J. and Huhta, V. Comparison of composts produced from identical wastes by vermistabilization and conventional composting. Pedobiologia, 1987, 30, 137-144.
[30] Ndegwa, P. M., Thompson, S. A. and Das, K. C., Effects of stocking density and feeding rate on vermicomposting of biosolids. Biores. Technol., 2000, 71, 5-12.
[31] Mitchell, A. and Alter, D., Suppression of labile aluminium in acidic soils by the use of vermicompost extracts. Soil Sci. Plant Analy., 1993, 24, 1171-1181.
[32] Nagavallamma, K. P., Wani, S. P. and Stephane, L., Vermicomposting: recycling wastes into valuable organic fertilizer. J. SAT Agric. Res., 2006, 2, 1-17.
[33] Kaviraj and Sharma, S., Municipal solidwaste management through vermicomposting employing exotic and local species of earthworms. Biores. Technol., 2003, 90, 169-173.
[34] Jadia, C. D. and Fulekar, M. H., Vermicomposting of vegetable waste: a bio-physicochemical process based on hydro-operating bioreactor. Afr. J. Biotechnol., 2008, 7, 3723-3730.
[35] Pattnaik, S. and Reddy, M. V., Nutrient status of vermicompost of urban green waste produced by three earthworm species-Eisenia fetida, Eudrilus eugeniae and Perionyx excavatus. Appl. Environ. Soil Sci., 2010, 10, 1-13.
[36] Patyal V., Study if vermicomposting technology for organic waste management. Int. J. Innov. Research Sci., 2017, 6, 313-318.
[37] Tognett, F.Laos., F., Mazzarino, M. J. and Henandez, M. T., Composting vs vermicomposting: a comparison of end product quality. Comp. Sci. Util., 2005, 13, 6-13.
[38] Karthikeyan, V., Sathyamoorthy, G. L. and Murugesan, R., Vermicomposting of market waste in Salem, Tamilnadu, India. In: Proc. Int. Conf. Sust. Sol. Waste Manag., Chennai, India, 5-7 Sep. 2007, pp. 276-281.
[39] Joshi, N. and Sharma, S., Physicochemical characterization of sulphidation pressmud composted and vermicomposted pressmud. Rep. Opin., 2010, 2, 79-82.
[40] Kitturmath, M. S., Girradi, R. S. and Basavaraj, B., Nutrient changes during earthworm, Eudrilus eugeniae (Kinberg) mediated vermicomposting of argro-industrial wastes. Karnataka J. Agric. Sci., 2007, 20, 653-654.
[41] Garg, P., Sharma, S. and Satya, S., Culturing of exotic (Eisenia fetida) and local (Allolobophora parva) earthworm species in different substrates for rural waste management. In: 2nd Int. Conf. (Sust. Ener. Environ.), India, 21-23 Nov., 2006.