

A Comparative Study on Agrowaste Conversion into Biofertilizer Employing Two Earthworm Species

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Abstract Disposal of groundnut waste is a major problem in agriculture sector. So, groundnut husk combined with cow dung was subjected to vermicomposting employing an exotic (*Eisenia fetida*) and a native (*Perionyx sansibaricus*) earthworm species. Separate vermibeds were prepared which contained crushed groundnut husk blended with cow dung in equal ratio (1:1). Vermicomposting was allowed for 90 days and different physicochemical parameters of vermibeds were monitored on 0, 15, 30, 45, 60, 75 and 90th day. The process of composting at different time intervals indicated significant increase in electrical conductivity, total nitrogen, available phosphorus and potassium, but there was decline in pH, organic carbon and C/N ratio after inoculation of earthworms. The *E. fetida* was found better than *P. sansibaricus* in decomposition of agrowaste and production of nutrient rich vermifertilizer. This eco-friendly technology may be used by farmers for agrowaste conversion, income generation and environmental cleaning.

Keywords: agrowaste, earthworm, composting, biofertilizer

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1. Introduction

The disposals of agro-wastes have now become a major problem for world. Agro-wastes can be converted into assets by using the decomposition potentials of earthworm. It is a logical approach for making compost with high porosity, aeration, water-holding capacity and microbial biomass [1,2]. Vermicompost has a huge surface area, providing strong absorb ability and retention of nutrients. It contains nutrients in such a form which can be easily taken up by the plants. Garg et al. [3] described decomposition of kitchen waste, agro-residues, institutional and industrial wastes using *Eisenia fetida*. Pramanik et al. [4] worked on vermicompost of biodegradable organic wastes under liming and microbial inoculants. They observed changes in C, N, P, K and enzyme activities and found cow dung as the best substrate for vermicomposting. Suthar and Singh [5] documented vermicomposting of domestic wastes having *Perionyx excavates* and *Perionyx sansibaricus*. Application of vermicompost showed remarkable increase in height of plant, number of leaves, plantlets, stalk circumferences and width of the leaf base. It is composed of organic waste altered by different earthworm digestive activities into a homogeneous product of high nutritional value and with great possibilities for its application in agriculture [6]. Recycling of distillery sludge from sugarcane industries

has been done to produce vermicompost using *Eudrilus eugeniae* and *Eisenia fetida* [7]. Kanan et al. [8] carried out an experiment on vermicomposting of black gram, leaf litter, paddy straw, sorghum and green weeds in combination to cow dung employing *Eisenia fetida*. The utilization of earthworms in vermicomposting decreases the time of stabilization of waste and produces an efficient bioproduct i.e., vermicompost [9]. Vermicompost is a sustainable alternative to chemical fertilizers and also acts as an utter growth promoter and protector of plants [10,11].

Yadav et al. [12] conducted experiment on organic manure production from cow dung and biogas slurry by vermicomposting under field conditions. They showed that the vermicompost had lower pH, total organic carbon, organic matter and carbon/nitrogen ratio but higher electrical conductivity, nitrogen, phosphorous and potassium content than the raw substrate. The financial feasibility study concluded that vermicompost production is a viable enterprise [13]. In vermicomposting the crop residue of low fertilization potential is converted into a nutrient enrich substrate [14,15]. Manohar et al. [16] worked on vermicomposting of plant debris, cattle dung and wastepaper inoculated with *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavates* for 60 days. They reported a significant increase in total nitrogen, available phosphorus and exchangeable potassium, while a decrease was found in pH and C/N ratio during composting. Similar results have been obtained by Kumar [17,18] using *Eisenia fetida* and *Perionyx sansibaricus* for

agrowaste management and vermicomposting potential assessment in leaf litter and kitchen waste plus goat dung bedding through vermicomposting. The increase in living standards around the world has created an emergent demand for such organic products cultivated by using of bio-pesticides and bio-fertilizers, which are healthier for consumers and environment friendly [19]. A proper supply chain of organic waste and cattle dung can attract people to produce vermicompost on a large scale [20]. Few workers [21,22] explained the use of vermicomposting in agriculture for improving soil quality and plant growth. Ramnarain et al. [23] introduced *Eisenia fetida* in a substrate containing dry grass clipping, rice straw and cow manure and found an excellent vermicompost containing essential macro and micronutrients.

Vermicomposting is an eco-friendly approach for reimbursement of nature's indebtedness [24]. They suggested for the renovation of such technology despite significant lapses and gaps in research and elaboration programs. The importance of the earthworms in waste management, environmental conservation, organic farming and sustainable agriculture has been highlighted by several workers [5,25,26,27,28]. Groundnut is intensely grown in some parts of world, where farmers face the problem of disposal of its residues. Groundnut wastes pollute the vicinity during decomposition, produce bad odour and act as source of infectious disease in the locality. The exotic and native earthworm species may have different potential in stabilizing organic wastes. Hence our hypothesis was designed to test the relative efficiency of two vermicomposting species (*Eisenia fetida* and *Perionyx sansibaricus*) in conversion of groundnut waste into nutrient rich vermifertilizer.

2. Materials and Methods

2.1. Material Collection and Experimental Design

The cattle dung was collected from livestock owners of colony located in front of Jai Narain Vyas University, Jodhpur and the groundnut husk was collected from agriculture landowners of Sirohi district. The earthworm species *Eisenia fetida* was obtained from vermicomposting unit of Kanhaiya Goashala, Pal Balaji Road, Jodhpur, and *Perionyx sansibaricus* was collected from field of Sirohi district. Separate vermibeds were prepared for *E. fetida* and *P. sansibaricus* using partially decomposed groundnut husk mixed with cow dung. The moisture of culture medium was maintained at 65-80% throughout the period of experimentation by spraying of water. Vermibeds temperature ($27\pm 3^{\circ}\text{C}$) was maintained by covering with wet jute cloths. Triplicate sets of vermibeds (each 3kg) were prepared in a ratio of 1:1 (groundnut husk: cowdung) in containers (30cm diameter \times 25cm height) with perforation to drain excess water. They allowed to partially decomposes before inoculation of earthworms. In the experimental sets 25 worms of each species were inoculated separately. Control beddings (without earthworm) were kept for comparison. This whole setup was maintained for 90 days

to examine the decomposition potential of both the earthworm species.

2.2. Vermicompost Analysis

During vermicomposting the physicochemical parameters of vermibeds were recorded at different time of intervals. The pH of vermibed was determined by using pH meter. Temperature was recorded by thermometer and moisture content was estimated gravimetrically. The organic carbon, nitrogen, available phosphorus and exchangeable potassium were estimated by methods of Walkey-Black [29], Kjeldahl [30], Olsen et al. [31] and Simard [32] respectively. The C/N ratio was calculated by the values of carbon and nitrogen. One-way analysis of variance (ANOVA) of the data was performed with the help of SPSS package.

3. Results

Groundnut husk plus cow dung bedding material showed significant changes ($P<0.001$) in physiochemical properties of both control and experimental groups with respect to decomposition period. In the control and experimental beddings, the values of pH, organic carbon and C/N ratio declined, whereas the electrical conductivity, total nitrogen, phosphorus and potassium increased significantly. In control bedding the value of total nitrogen increased by 1.25-fold. On the contrary, organic carbon and C/N ratio declined by 23.36% and 39.14% respectively. The *E. fetida* inoculated bedding showed significant changes ($P<0.001$) in physiochemical parameters during 90 days of decomposition. The values of pH, organic carbon and C/N ratio decreased by 13.55%, 51.73% and 79.46% respectively. However, the electrical conductivity, total nitrogen, phosphorus and potassium increased by 1.90, 2.35, 1.72 and 2.33-fold respectively in worm working bedding after 90 days as compared to initial values (Figure 1). Likewise, physiochemical properties of the *P. sansibaricus* containing bedding varied significantly ($P<0.001$) after 90 days. The bedding material showed increase in electrical conductivity, total nitrogen, phosphorus and potassium by 1.79, 2.13, 1.55 and 2.04 fold respectively. whereas, the pH, organic carbon and C/N ratio reduced by 12.67%, 46.46% and 74.93% respectively. The changes were more prominent in the bedding containing *E. fetida* than that of *P. sansibaricus* bedding (Figure 1).

4. Discussion

Decaying of groundnut husk plus cow dung in absence and presence of earthworms is shown in Figure 1. The pH of control bedding decreased by 4.22%. However, pH in *E. fetida* worked compost declined by 13.55% and in *P. sansibaricus* inoculated bedding by 12.67% during 90 days of composting period. Maximum decline in pH value was in *E. fetida* compost followed by *P. sansibaricus* and control group. The dropping of pH value may be due to formation of acids, release of CO_2 and respiratory activity of earthworm during decomposition. It declined in control

group due to microbial activity. Decreased trend of pH in the vermicompost and compost substrates is in conformity to the results obtained by others [16,17,18,23,33-38]. However, the present observations are contradictory to the work of Nagavallema et al. [39] who reported a gradual increase in pH of composting substrate. Decomposition of organic matter leads to formation of ammonium ions and humic acids and these two components have exactly opposite effects on the pH. Presence of carboxylic and phenolic groups in humic acids lowers the pH, while ammonium ions increase the pH of the system. Electrical conductivity (EC) increased by 1.29-fold in control group, whereas it enhanced by 1.90 and 1.79-fold in *E. fetida* and *P. sansibaricus* worked bedding respectively. Increase in electrical conductivity was higher in *E. fetida* containing

bedding than *P. sansibaricus* inoculated materials. Increasing pattern of EC during composting and vermicomposting was probably due to release of minerals such as potassium, phosphorus and calcium in the available form. These results are supported by the findings of earlier workers [16,17,18,23,38,40-43]. It has been documented that increase in EC may be due to degradation of organic matter and release of minerals such as exchangeable Ca, Mg, K and P in the available form that is in the form of cations in the compost and vermicompost [44]. On the other hand, the observations on electrical conductivity during vermicomposting are contradictory to the reports of some workers who described decrease in electrical conductivity [3,45,46].

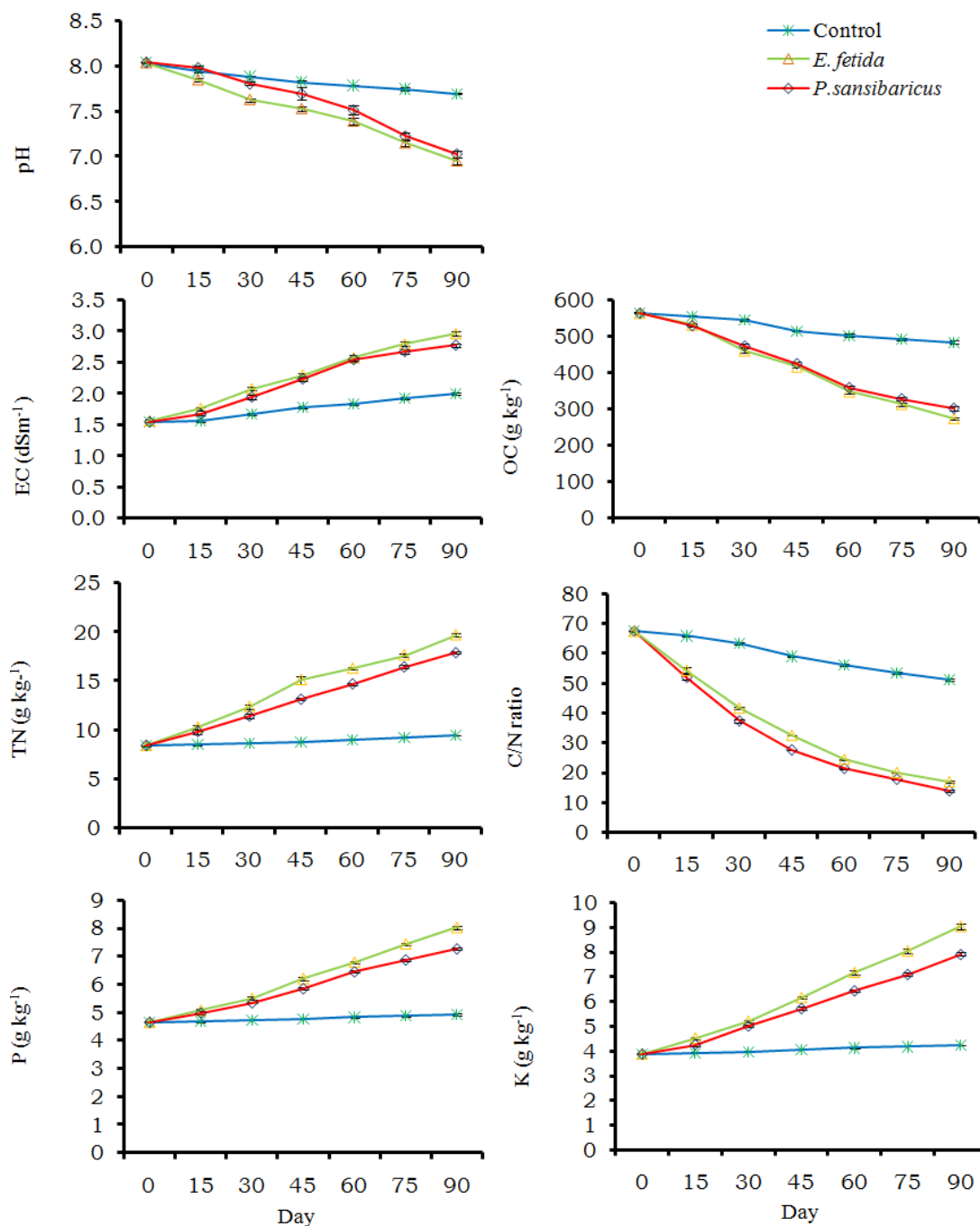


Figure 1. Effects of the earthworm species *Eisenia fetida* and *Perionyx sansibaricus* working on pH, electric conductivity (EC), organic carbon (OC), total nitrogen (TN), phosphorus (P) and potassium (K) of ground nut husk plus cow dung bedding materials. One-way ANOVA showed significant ($p < 0.001$) changes in different physiochemical parameter as a functioning of decomposition period

On contrary to electric conductivity, organic carbon of the compost and vermicompost decreased from their initial stage to the end of the 90th days in earthworm containing bedding as well without earthworm bedding. Similar results were obtained by Guest et al. [47] who showed decrease in carbon concentration from 20 to 16% during composting. Organic carbon of earthworm inoculated bedding reduced faster than control group (Figure 1). In this respect, *E. fetida* was better as compared to *P. sansibaricus*. Different studies have revealed that earthworm activities bring about significant decline in organic carbon level of waste resources and accelerate waste stabilization process [48,49]. Carbon is a major constituent of organic molecules and buildings blocks of organisms and thus needed as the source of energy for the composting process [50].

In control substrate the value of total nitrogen, available phosphorus and potassium increased by 1.25, 1.05 and 1.09 folds respectively as compared to their 0-day values. However, vermicompost produced by *E. fetida* and *P. sansibaricus* exhibited increase in nitrogen, phosphorus and potassium by 2.35, 1.72 and 2.33-fold and 2.13, 1.55 and 2.04-fold respectively as compared to their initial values. The present findings revealed that major nutrients increase significantly in organic wastes processed by earthworms. Nitrogen is an essential building block which is enhanced due to mineralization of plant residues and conversion of ammoniacal nitrogen [51]. Other workers [52,53] also described increase in nitrogen due to vermicomposting. When the soil is mixed with cow dung vermicompost, it raises its total phosphorus content [54]. Increase in concentration of phosphorus is due to phosphorylation of organic matter as an outcome of earthworm working [55]. Kaviraj and Sharma [40] documented increase in potassium level due to decomposition of organic matter by biological activity of earthworm that exchange insoluble potassium into soluble potassium. An increase in profile of nitrogen, potassium and phosphorus occur during waste decomposition [28,56,57]. Experimental observations may be supported by the findings of other investigators [3,17,18,58] who recorded increase in amount of total nitrogen, available phosphorus and exchangeable potassium but decline in pH and C: N ratio as a function of decomposition period.

5. Conclusion

The present experiment revealed that the agricultural waste mixed with domestic animal excreta can be converted into valuable forms with excellent nutrient value. The earthworm *E. fetida* was better than *P. sansibaricus* in agrowaste conversion. Composting worm working is a bio-renewable, eco-friendly, sustainable and suitable technique for recycling of agrowaste. Utilization of such technology at a large scale may help restoration of degraded land on a sustainable basis.

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