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Study of Bio-fertilizer Produced from Agro-waste (Sesame Straw) and Cow Dung Using *Eisenia fetida* and *Perionyx sansibaricus* in Arid Environment

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ABSTRACT

In this study, an analysis of organic fertilizer of an agro-waste (Sesame straw) plus cow dung was carried out using an epigeic earthworm species *Eisenia fetida* and *Perionyx sansibaricus*. Sesame straw is abundantly produced after each harvesting of the crop in Kharif season in arid region of tropical India. The compost produced in presence and absence of earthworm exhibit significant ($P < 0.001$) and non-significant ($P > 0.05$) changes in physicochemical properties respectively. In control bedding, the values of water holding capacity enhanced significantly ($P < 0.05$) by 1.28 fold, while organic carbon and C/N ratio decreased significantly ($P < 0.05$) by 19.93% and 31.25% respectively after 60 days of composting. Working of *E. fetida* in the bedding material showed significant ($P < 0.001$) difference in the level of pH, electrical conductivity, water holding capacity, organic carbon, total nitrogen, C/N ratio, available phosphorous and available potassium. After 60 days of working of *P. sansibaricus*, these physicochemical properties of the bedding substrate also changed significantly ($P < 0.001$). Analysis of vermibed showed a gradual increase in electrical conductivity, water holding capacity, total nitrogen, available phosphorus and available potassium by 1.51, 1.86, 1.95, 1.78 and 1.75 fold respectively. While the values of pH, organic carbon and C/N ratio declined by 9.30%, 41.80% and 71.48% respectively within 60 days of decomposition. Thus, *E. fetida* and *P. sansibaricus* can be applied for production of organic fertilizer of sesame chaff plus cow dung to fulfill the requirement of bio-fertilizers for organic farming and agro-waste management in arid environment.

1. Introduction

Agricultural sector contributes huge potential resources of plant nutrients in the form of wastes. Due to lack of appropriate disposal techniques, these wastes are either dumped or burnt in the agriculture fields after each harvesting. Which caused serious environmental pollution

and diseases in subsequent crops. When the agro-wastes burnt after each harvesting in agricultural fields, it produces toxic gases caused air pollution, while dumping agro-waste releases greenhouse gases such as methane, H₂S etc. Pesticide treated decomposing organic wastes leached toxic elements to underground water and pollute the underground water resources as well as drained

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to rivers, lakes and ponds and caused eutrophication. There is tremendous increase in agro-wastes with the increase in agricultural production. These agro-wastes also contaminate the surrounding environment leading to diseases in animals and human. The wastes also act as a reservoir of fungal diseases of next crop. Thus, there is a warranted need of eco-friendly organic waste management technique to convert agricultural wastes into valuable biofertilizer^[21].

A global problem for the disposal of wastes has arisen due to excessive growth in human population and consequent increase in industrial and agricultural activities^[13]. Peculiar feeding and burrowing habits of earthworms make them most useful converters of wastes. A highly esteemed initiative has been done on commercial earthworm farming in other countries^[31]. Preparation of nutrient rich organic manure from wastes can enormously help in rural based economy^[26]. It has been well documented that earthworms can process all kinds of organic wastes such as household garbage, municipal wastes, sewage sludge, wastes from paper, wool and food industries, various organic wastes mixer^[10,2,32,14]. Earthworm may also play an important role in pollution control using it in organic waste decomposition and production of biofertilizer^[21,22].

During the last two decades, various workers from India and other parts of world have been involved in the work of recycling as vermicompost of different types of organic wastes from agriculture sector, cattle farm, industries, household, piggery farm and sewage^[7,3,36,27,24,35,31,21,23,22]. But work on vermicomposting of a waste of specific crop is not reported. Therefore, in the present study, an agro-waste of sesame crop and cow dung mixed bedding material was decomposed to produce bio-fertilizer using earthworm species *Eisenia fetida* and *Perionyx sansibaricus*. Physicochemical properties of bio-fertilizer produced were estimated. A comparative study on sesame straw conversion efficiency of both the earthworms in laboratory conditions was planned and executed. The agro-waste management and bio-fertilizer production through vermiculture are very much required for sustainable agriculture, human health, conservation of environment and ecosystem of the planet earth.

2. Materials and Methods

2.1 Collection of Materials

Sesame is an oil crop grown on a large scale particularly in western region of Rajasthan of India. Its straw was collected from agricultural farm of village-

Chhila, tehsil-Phalodi of Jodhpur district. Sesame straw is dumped in huge quantity after each harvesting (27.0141 N; 72.2850 E) in Kharif season. Partially decomposed straw was collected from one season old heap. Air dried cow dung was also collected from the same site. The materials were filled in jute bags and brought to the vermiculture laboratory. Earthworm species *Eisenia fetida* was used from stock culture in cow dung, basically it was collected from Shri Kanhaiya Gaushala, Pal road, Jodhpur (26.23538 N, 72.96809 E). While, *Perionyx sansibaricus* was used from previously prepared stock culture in cow dung bedding material, originally collected from a sewage site of Nehru Park of Jodhpur city (26.27544 N, 73.01378 E).

2.2 Processing of Organic Waste Materials

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

2.3 Experimental Planning of Vermiculture

Triplicate sets of vermibeds (500 g dry weight each) were prepared using powdered sesame straw and cow dung in 1:1 ratio in plastic tub having 5 litre capacity. The material was moistened to stabilize within 2 days. In the experimental set, 25 clitellates worms of each species (*E. fetida* and *P. sansibaricus*) were inoculated separately. One set of control bedding material (without earthworm) was also maintained parallel. The culturing plastic containers were perforated 2-3 places to drain excess water. However, leached water was collected in other containers and reused for watering the vermibed so as to prevent the washout of nutrients. The vermiculture experiments were conducted for 60 days. During composting period, moisture was maintained between 60 to 70 percent by sprinkling water on the bedding regularly. The temperature of vermibed was maintained 30 ± 3 °C and wet Jute cloth was used to maintain the temperature of vermibed.

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 observed after an interval of 15 days of worm working viz., 0, 15, 30, 45 and 60 day. For this purpose, 10 g dry weight basis samples were collected

from each experimental as well as control bedding in plastic pouches. The pH and electrical conductivity of bedding materials were measured with the help of a digital pH and EC meter respectively. Walkley-Black method was used for determination of organic carbon^[37]. Total nitrogen was measured by Kjeldahl method as described by Jackson employing Kel plus system (Kes-20 and Distyl-EM)^[11]. Available phosphorus was estimated as described by Anderson and Ingram^[1] and exchangeable potassium was determined by Simard method^[34]. The temperature of vermibed was recorded with the help of thermometer (MEXTECH multi-thermometer). Moisture of bedding substrates was estimated by oven drying method.

2.5 Statistical Analysis of Data

Triplicate set of data were collected by analyzing each set of beddings. Standard error of mean (SEM) was calculated for the triplicate data. A one way analysis of variance (ANOVA) was performed to test the level of significance in physicochemical properties of control and experimental bedding substrates.

3. Results

Sesame straw plus cow dung bedding material with and without earthworm exhibited significant changes ($P < 0.001$) in physicochemical properties with respect to decomposition period. In control bedding the values of pH, electrical conductivity, total nitrogen, phosphorous and potassium did not vary significantly ($P > 0.05$). While water holding capacity enhanced significantly ($P < 0.05$) by 1.28 fold. Organic carbon and C/N ratio varied significantly ($P < 0.05$) by 19.93% and 31.25% respectively after 60 days.

Working of *E. fetida* in the bedding material showed significant ($P < 0.001$) difference in the level of pH, electrical conductivity, water holding capacity, organic carbon, total nitrogen, C/N ratio, phosphorous and potassium. The pH value decreased by 10.95%. Similarly, organic carbon reduced by 44.09% and C/N ratio by 78.10%. On the other hand, vermicompost showed 1.83, 1.92, 2.65, 2.10 and 2.14 fold increases in electrical conductivity, water holding capacity, total nitrogen, phosphorus and potassium respectively after 60 days of the earthworm working as compared to initial values.

After 60 days of working of *P. sansibaricus*, physicochemical parameters of the bedding material changed significantly ($P < 0.001$). The vermibed showed a gradual increase in electrical conductivity, water holding capacity, total nitrogen, phosphorus and potassium.

However, values of pH, organic carbon and C/N ratio decreased by 9.30%, 41.80% and 71.48% respectively within 60 days of decomposition. Unlike these, the compost showed 1.51, 1.86, 1.95, 1.78 and 1.75 fold increase in electrical conductivity, water holding capacity, total nitrogen, phosphorus and potassium respectively after 60 days working of *P. sansibaricus* as compared to 0 day level (Figure 1).

4. Discussion

Physicochemical properties of sesame straw plus cow dung bedding material showed different trends in control (without earthworm) and experimental (with earthworm) groups (Figure 1). The results obtained indicated reduction in pH, organic carbon and C/N ratio of vermicompost as well as control compost at the end of composting. Control, *E. fetida* and *P. sansibaricus* processed composts showed 3.80%, 10.95% and 9.30% decreases in pH respectively. Higher reductions were observed in *E. fetida* followed by *P. sansibaricus* and control. However, pH of control bedding material did not vary significantly ($P > 0.05$) with respect to initial level. During the composting process the pH level declined from alkaline to acidic close to neutral medium in vermicompost. This may be because of enhanced decomposition and mineralization by earthworm and production of acids during the decomposition. It can be supported by the observations of Ndegwa *et al* who described pH shift toward acidic condition due to mineralization of nitrogen and phosphorus into nitrates/nitrites and ortho-phosphate and bioconversion of organic materials into intermediate species of organic acids^[20]. Similarly, other workers^[8,5,6,19] also concluded that production of CO₂ and organic acid by microbial decomposition lowered the pH of substrate.

Organic carbon in *E. fetida* and *P. sansibaricus* induced compost decreased sharply as compared to their starting levels by 44.09% and 41.80% respectively. The control bed also showed a decline in organic carbon but degree of decrease was significantly ($P < 0.05$) lesser than vermicompost after 60 days period of decomposition. Present results are in agreement to the report of Elvira *et al* who showed that large proportion of organic matter in the initial substrate was as loss as CO₂ between 20 to 43 percent as organic carbon by the end of vermicomposting^[5]. Nath *et al* observed that total organic carbon declined (45 to 50%) drastically as compared to their initial levels^[19]. Likewise, other workers also reported 20 to 45 percent loss of total nitrogen in the form of CO₂ from agriculture wastes and industrial sludge during vermicomposting occurred^[5,15,36].

Value of electrical conductivity of the bedding material

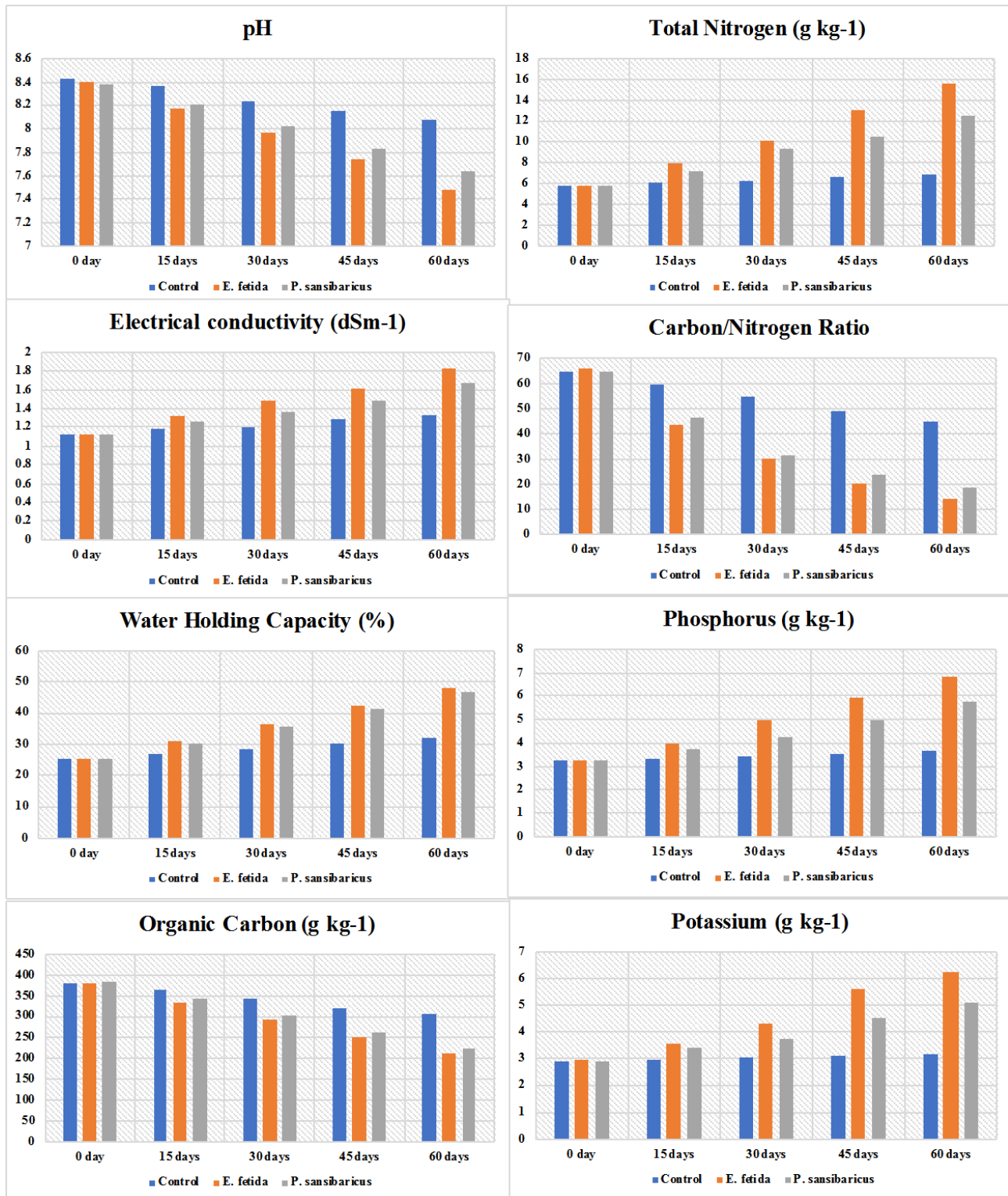


Figure 1. Showing the changes in pH, Electrical conductivity, Water holding capacity, Organic carbon, Total nitrogen, Carbon/Nitrogen ratio, Phosphorus and Potassium during the decomposition of sesame straw plus cow dung using earthworms (*Eisenia fetida* and *Perionyx sansibaricus*).

increased as compared to initial level. The values of EC in control, *E. fetida* and *P. sansibaricus* increased by 1.07, 1.83 and 1.51 fold respectively as compared to 0 day of decomposition. Possibly it was due to decomposition of organic matter and release of salts during mineralization process. Increase in electrical conductivity might have been due to the loss of organic carbon and release of different salts in available forms^[38,16]. In contrast to this, Nath *et al* reported a decrease in EC during vermicomposting^[19].

Total nitrogen level was increased after 60 days of composting of sesame straw plus cow dung bedding material. The level of nitrogen content in control bedding substrate enhanced by 1.16 fold after completion of composting duration. However, *E. fetida* and *P. sansibaricus* worked compost indicated by 2.65 and 1.95 fold increase in nitrogen content respectively. Present study revealed that organic waste conversion efficiency of *E. fetida* is better than *P. sansibaricus*. Nitrogen enhancing capacity of both species of earthworm was significantly higher than control (microbial decomposition) after 60 days of composting period. It indicates that *E. fetida* feed voraciously on organic waste rich materials. Other workers reported that earthworm increases the nitrogen content due to nitrogen mineralization from organic matter in the soil because nitrification is enhanced in worm casts^[28]. Some workers also suggested that *E. fetida* in organic waste increased nitrogen level significantly^[9]. Increasing trend of nitrogen in vermicompost was also reported by many other workers^[36,19,12].

C/N ratio, available phosphorus and potassium are other widely used indicators for maturity of organic wastes. C/N ratio was drastically declined in vermicompost as compared to control substrate. Senesi reported that decline in C/N ratio to less than 20 which indicates an advance degree of organic matter stabilization and reflects a satisfactory degree of organic waste^[33]. The C/N ratio decreases sharply during vermicomposting process^[14,36,19,25]. Available phosphorus and potassium increased significantly ($P < 0.001$) in vermicompost as compared to their starting levels. Phosphorus content increased by 2.10 and 1.78 fold in the bedding material with *E. fetida* and *P. sansibaricus* respectively in relation to 0 day composting. Similarly, potassium showed 2.14 and 1.75 fold increase in the bedding sets. The possible cause of increase in nutrients may be crumbling in alimentary canal of earthworm which breakdown the large particles into small molecules and microbial action. Similar results have been obtained by other workers^[18,29,4]. Passage of organic residue through the gut of earthworm releases nutrients including phosphorus. Release of phosphorus in available

form is performed partly by earthworm gut phosphatases and further release of phosphorus may be attributing to phosphorus stabilizing microorganism present in worm cast^[17].

5. Conclusions

An agro-waste (sesame straw) and cow dung have been converted into a valuable bio-fertilizer using two epigeic earthworm species *Eisenia fetida* and *Perionyx sansibaricus* in arid area of India. Changes in physicochemical properties viz., pH, electrical conductivity, water holding capacity, organic carbon, total nitrogen, carbon-nitrogen ratio, available phosphorus and available potassium of bedding substrates were estimated at 15, 30, 45 and 60 days of time interval. It was observed that *E. fetida* was insignificantly more potent in decomposition of this agro-wastes as compared to *P. sansibaricus*. The both earthworm species may be applied for conversion of huge amount of agro-waste into organic fertilizer for sustainable agriculture and soil ecosystem.

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