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AGRO-WASTE MANAGEMNT BY VERMICOMPOSTING USING *EISENIA FETIDA* AND *PERIONYX SANSIBARICUS* EARTHWORMS

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ABSTRACT

Agro-waste like fennel straw blended with cow dung was recycled to analyze biochemical changes during composting process treated with earthworms *Eisenia fetida* and *Perionyx sansibaricus*. Both the species of earthworms were separately inoculated in composting substrate bedding for a period of 90 days. Fennel straw mixed with dry cow dung in 1:1 ratio was prepared as bedding substrate for earthworms in vermicomposting experiment. The changes in physical and biochemical parameters of vermicompost samples during decomposition progression were recorded at specific interval of time. At different level of vermicomposting significant raise in electrical conductivity, total N, available phosphorus and potassium, along with drop in pH, organic C and C/N ratio was recorded from experimental vermibeds. The result showed that vermicomposting of fennel straw plus cow dung amended into nutrient rich material known as organic fertilizer. In this vermicomposting experiment *E. fetida* shows better functional activity than *P. sansibaricus.* The results suggested that enriched compost obtained from decomposition of wastes (agro and livestock waste) through vermicomposting with efficient worms will be utilized to enhance physico-chemical and biological properties of soil; leading to better plant growth and production of crop.

Key words: Agro-waste, bedding, organic fertilizer, recycle, straw.

INTRODUCTION

Agricultural waste and domestic animal excreta can be naturally decomposed in an environment by helping of earthworms. The use of earthworms in composting process decreases the time of stabilization of the waste and produces an efficient bio-product called organic fertilizer. The production of organic fertilizer from earthworms by using organic waste as raw materials was called vermicompost. Vermicompost is the most promising bio-fertilizer which has been commonly used in crop cultivation. It increases growth and productivity of plants providing nutrient supply. It is also profitable and eco-friendly. As a result of earthworm degradation activity, the mineralization of nutrients increases, soil health recovers, crop productivity enhances and it also helps in pollution control. Vermicomposting is the process of conversion of organic wastes by certain species of earthworms to valuable humus like material which is used as natural soil conditioner (Dominguez & Edwards, 2004). Using of cow dung in vermin-compost provides a better environment for earthworm functioning than any other livestock dung and it produces higher quality of vermin-cast (Loh *et al.,* 2005). Epigeic species of earthworm are commonly used earthworms for vermicomposting. Due to their natural ability to feed organic wastes, high reproduction rate and short life cycle epigeic species are considered suitable for vermicomposting (Garg *et al.,* 2006).

Recycling of different waste in to an organic fertilizer is one of most popular methods for waste management (Ostos *et al.,* 2009). Such technique can also be used to engender additional revenue. Barren land and land degraded through mining could be engineered physically, chemically and biologically and made fertile by earthworms. Hence earthworms are termed as ecosystem engineers (Munnoli *et al.,* 2010). Zularisam *et al.* (2010) observed various types of agricultural waste consumed by earthworms, such as vegetable waste, cattle dung, soybean meals, agricultural residue, sewage sludge and other industrial refuse. Physiochemical changes during composting and vermicomposting of spinach was evaluated by Sharma *et al.* (2011). They observed various chemical changes in raw organic compost leading to change in percentage of nitrate, phosphate, sodium, magnesium, and potassium. This process produces organic manure rich in plant nutrient and humus. Vermicompost offers an attractive alternate to promote sustainable agriculture and secure agricultural, industrial, domestic and hospital wastes management (Pathma & Sakthive 2012). The application of vermicompost might be used in plantation fields in order to reduce chemical fertilizer in environment (Chouhan & Singh 2013). Producing vermicompost could be adjusted to find suitable and optimal conditions for earthworm cultivation to a high quality of fertilizer for plantations.

Generally, vermicompost with high mineral concentration was able to stimulate the growth of number of soil microorganisms in agricultural fields as well as providing nutrients for plant cultivation (Yan *et al.,* 2013; Nweke, 2013). It contains a lot of macro and micro nutrients, such as nitrogen, potassium, phosphorus, calcium and magnesium. In addition, vermicompost is more advantageous than conventional organic compost in terms of being odorless, having adjustable pH and low electrical conductivity (Khommami *et al.,* 2013). Mandel *et al.* (2014) carried out work on municipal solid waste management and indicated fertilizing potential of compost. Recycling of organic waste like cow dung by vermicomposting using *Eisenia fetida* was performed and enhancement in compost competence with better plant growth promoting activity was observed. (Kapoor *et al.,* 2015). Manaig (2016) studied various vermicomposting process and states that efficiency may be measured by the worm number or biomass and quality of vermicast. Chaulagain *et al.* (2017) also reported that the use of compost improves the growth of plants. In the present analysis, common culture was used to find out the composting potential of epigeic earthworm species.

MATERIALS AND METHODS

In this experiment two epigenic earthworm species i.e. *Eisenia fetida* (Savigny) and *Perionyx* *sansibaricus* (Parrier) were used. *E. fetida* were procured from vermicompost unit of Kanhaiya Goashala, Pal Balaji Road, Jodhpur, and other species *P. sansibaricus* was collected from study area (Sirohi district). For preparation of a bedding material, fennel straw was mixed with cow dung. These bedding materials served as food recipe for earthworms. Different component of bedding substrate like, fennel straw agricultural waste was collected from farmers of Sirohi district area and cow dung was gathered from livestock owners of Jodhpur city. Bedding for vermibeds designated in triplicate sets (each 3kg) in a ratio of 1:1 (fennel straw waste plus cow dung) in plastic containers (30 cm diameter × 25 cm height) and moistened to stabilize within 48 hours. In the experimental sets 25 worms of each species were inoculated separately. One set of control bedding material (without earthworm) was run jointly. The culturing plastic containers were perforated at 2-3 places to allow surplus water. The moisture level of vermibeds was maintained at 60-80% by spraying water periodically on vermibeds. The temperature of vermibeds was 27 ± 3^0 C and was sustained by using wet jute cloths.

The experiment was conducted for 90 days to estimate the decomposition potential of earthworm species. The different physico-chemical parameters of compost (without earthworm) and vermicompost produced during experiment were analyzed. Temperature was noted daily using a thermometer, and moisture content was measured gravimetrically. The pH and electric conductivity of samples were recorded by a digital pH meter and conductivity meter respectively. Total organic carbon (TOC) was measured by Walkey-Black method (1934); the total nitrogen was calculated by Kjeldahl method as described by Jackson (1973); available phosphorus was estimated by extraction with sodium bicarbonate (Olsen *et al.,* 1954) as the exchangeable potassium cation was determined after extracting the soil using ammonium acetate-extractable method (Simard, 1993). The C/N ratio was calculated from the measured values of C and N. A one way analysis of variance (ANOVA) was computed using SPSS 20.0 programm to test the level of significance of difference between the vermicomposts produced by the two earthworms and compost samples with respect to nutrient parameters.

RESULTS

Fennel straw plus cow dung bedding material with and without earthworm exhibited significant changes ($P<0.001$) in physiochemical properties with respect to decomposition period. In the control, bedding the values of pH, organic carbon and C/N ratio decreased. While the electrical conductivity, total nitrogen, phosphorus and potassium increased significantly. In control bedding total nitrogen increased by 1.19 fold. In contrast, organic carbon and C/N ratio declined by 19.09% and 32.44% respectively.

Working of *E. fetida* in the bedding materials showed significant variation ($P<0.001$) in the level of pH, organic carbon and C/N ratio, electrical conductivity, total nitrogen, phosphorus and potassium. The pH value declined to 12.26%. In the same way, organic carbon decreased by 49.96%, and C/N ratio reduced by 77.59%. On the contrary, vermiculture bedding showed 2.04, 2.23, 1.84 and 2.49 fold rises in electrical conductivity, total nitrogen, phosphorus and potassium respectively after 90 days as compared to initial values (Table 1, Fig.1).

After 90 days of working of *P. sansibaricus* physiochemical properties of the bedding materials changed significantly ($P<0.001$). The vermibeds showed gradual enrichment in electrical conductivity, total nitrogen, phosphorus and potassium. But, the pH, organic carbon and C/N ratio decreased by 11.04%, 38.00% and 61.72% respectively within 90 days of decomposition. On the other hand, the compost showed 1.63, 1.62, 1.69 and 2.19 fold increases in electrical conductivity, total nitrogen, phosphorus and potassium respectively (Table 1, Fig.1).

DISCUSSION

Physiochemical properties of fennel straw plus cow dung bedding materials showed different trends in control and experimental groups (Table 1,

Table 1. Effects of earthworms (*E. fetida*/*P. sansibaricus*) on decomposition of fennel straw plus cow dung bedding materials at different durations. Each datum is the mean±SEM of three replicates.

Physico-chemical properties	Group	Decomposition period (day)							F-value	P-value
		0	15	30	45	60	75	90		
pH	Control	8.14±0.008	8.10±0.008	8.06±0.012	8.01±0.015	7.95±0.012	7.89±0.017	7.83±0.014	75.04	<0.001
	E. fetida	8.15±0.012	8.06±0.015	7.87±0.046	7.79±0.026	7.55±0.026	7.31±0.032	7.15±0.020	182.13	<0.001
	P.sansibaricus	8.15+0.026	8.07±0.030	8.01±0.027	7.88±0.043	7.61±0.037	7.42±0.008	7.25±0.037	103.68	<0.001
EC(dSm^{-1})	Control	1.40±0.020	1.46±0.014	1.55±0.008	1.63±0.011	1.72±0.013	1.81±0.012	1.88±0.014	163.07	<0.001
	E. fetida	1.41±0.020	1.65±0.035	1.88±0.042	2.14±0.040	2.43±0.037	2.75±0.043	2.89±0.037	222.76	<0.001
	P.sansibaricus	1.41±0.011	1.57±0.033	1.69±0.033	1.78±0.043	2.01±0.047	2.13±0.037	2.31±0.039	76.47	<0.001
OC(g kg^{-1})	Control	422.33±0.88	402.67±1.76	385.00±0.57	366.33±1.45	355.33±2.33	345.00±0.57	341.67±1.45	652.89	<0.001
	E. fetida	422.33±0.66	382.33±3.71	345.67±3.52	319.66±4.37	276.66±3.84	239.67±4.37	211.33±3.71	435.73	<0.001
	P.sansibaricus	422.67±1.20	388.00±4.04	348.33±3.71	328.00±4.04	285.33±3.71	268.33±3.84	262.03±1.45	336.54	<0.001
TN(g kg^{-1})	Control	8.01±0.017	8.21±0.023	8.48±0.029	8.79±0.030	9.07±0.037	9.36±0.027	9.59±0.024	456.23	<0.001
	E. fetida	8.00±0.023	9.72±0.181	10.55±0.152	13.90±0.152	15.42±0.175	16.78±0.172	17.86±0.185	535.77	<0.001
	P.sansibaricus	7.99±0.047	9.32±0.165	10.38±0.192	11.09±0.200	11.78±0.170	12.66±0.185	12.96±0.199	107.60	<0.001
C/N ratio	Control	52.70±0.043	48.92±0.121	45.38±0.128	41.60±0.050	39.01±0.069	37.20±0.125	35.60±0.105	4174.2	<0.001
	E. fetida	52.75±0.161	39.34±0.389	29.93±0.102	22.96±0.107	17.93±0.050	14.28±0.130	11.82±0.084	6785.8	<0.001
	P.sansibaricus	52.88±0.205	41.61±0.312	33.57±0.267	29.56±0.174	24.21±0.035	21.18±0.047	20.24±0.218	3394.6	<0.001
P(g kg^{-1})	Control	4.15±0.005	4.21±0.015	4.27±0.008	4.34±0.012	4.40±0.011	4.45±0.015	4.53±0.011	136.44	<0.001
	E. fetida	4.15±0.017	4.45±0.043	5.14±0.045	5.80±0.050	6.39±0.045	7.07±0.050	7.65±0.033	965.83	<0.001
	P.sansibaricus	4.15±0.012	4.35±0.043	4.99±0.047	5.57±0.043	6.03±0.047	6.52±0.043	7.03±0.040	689.19	<0.001
K(g kg^{-1})	Control	3.25±0.008	3.34±0.008	3.47±0.014	3.58±0.012	3.64±0.008	3.72±0.017	3.77±0.017	216.55	<0.001
	E. fetida	3.25±0.017	3.60±0.030	4.39±0.060	5.54±0.053	6.34±0.056	7.34±0.055	8.12±0.080	914.16	<0.001
	P.sansibaricus	3.24±0.020	3.42±0.053	4.12±0.084	4.69±0.052	5.75±0.045	6.59±0.044	7.12±0.047	665.17	<0.001

EC, Electric conductivity; OC, Organic carbon; OM, Organic matter; TN, Total Nitrogen; C/N ratio, Carbon/Nitrogen ration; K, Potassium; P, Phosphorus; Control, bedding material without earthworm.

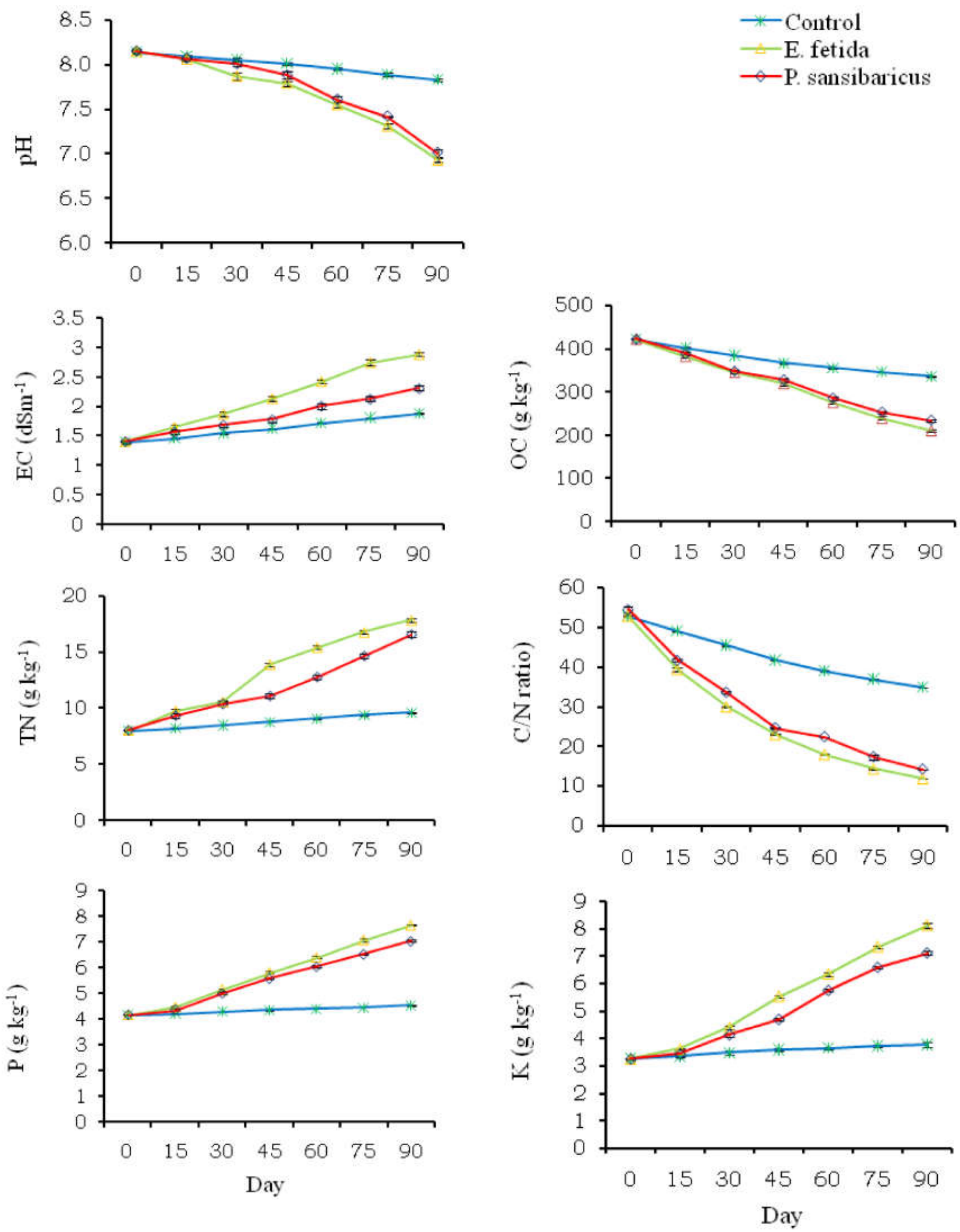

Fig. 1. Effects of earthworms (*Eisenia fetida, Perionyx sansibaricus*) on pH, electric conductivity (EC), organic carbon (OC), total nitrogen (TN), phosphorus (P) and potassium (K) in fennel straw plus cow dung bedding material.

Fig.1). The results obtained indicated decline in pH, organic carbon and C/N ratio of vermicomposting as well as control compost at the end of composting. The value of pH showed 1.03%, 12.26% and 11.04% decrease in control, *E. fetida* and *P. sansibaricus* bedding substrates respectively. Higher reductions were observed in *E. fetida* contained bedding followed by *P. sansibaricus* and control (without earthworm). During composting the pH level declined from alkaline to acidic and close to neutral medium in the vermicompost. This may be due to increasing decomposition, mineralization and production of acids by earthworm from different activities. It can be supported by the findings of others (Hami & Hutha, 1986; Bentiz *et al.,* 1999; Ndegwa *et al.,* 2000; Sreenivasan, 2013) who described shifting of pH towards acidic is attributed by bioconversion of the organic material into various intermediate types of organic acids and higher mineralization of the nitrogen and phosphorous into nitrites/nitrates and orthophosphate respectively. Hami and Hutha (1986), Elvira *et al.* (1998), Nath *et al.* (2009) postulated that the lower pH in the final vermicompost samples might have been due to the production of CO_2 and organic acids by microbial activity during the process of bioconversion of different substrate in the feed given to earthworms. Most of the other works on vermicomposting (Albanell *et al.,* 1988; Elvira *et al.,* 1996, 1998; Mitchell, 1997; Easha *et al.,* 2015; Daman *et al.,* 2016) are in agreement to the present studies.

Organic carbon in *E. fetida* and *P. sansibaricus* contained compost declined sharply as compared to their starting value by 49.96% and 38% respectively. The control bed also showed decrease in organic carbon while magnitude of decrease was lower than that of vermicomposting after 90 days period of decomposting. The present results are in agreement to reports of Nath *et al.* (2009) who showed that total organic carbon declined by 45-50% drastically as compared to their initial level. Easha *et al.* (2015) observed that a large portion of the TOC was lost as CO_2 (between 27% and 46%) by the end of the vermicomposting feeding. Likewise, there was 20-30% loss of TOC in the form CO_2 during decomposition and mineralization of industrial sludge and wastes (Elvira *et al.,* 1998; Kaushik and Garg, 2003; Tripathi and Bhardwaj, 2004; Gupta & Garg, 2008). Findings of this work is also supported by Daman *et al.* (2016) who recorded that the organic carbon gradually reduced during recycling of waste of rose flower (*Rosa berberia*) through vermicomposting using earthworm species *Eisenia foetida* and *Eudrilus eugeniae.*

On the other hand the value of electric conductivity of the bedding material increased as compared to preceding days. The values of EC in control, *E. fetida* and *P. sansibaricus* increased by 1.30, 2.04 and 1.63 folds respectively as compared to 0 days of decomposition. Possibly it was due to decomposition of organic matter and release of salts during mineralization process. Seetha devi *et al.* (2012) and Arumugam *et al.* (2015) reported that the increase in EC might be due to the release of different mineral salts in available form such as phosphate, ammonium, potassium during the degradation of organic matter. In contrast to this, Nath *et al.* (2009) and Kaur *et al.* (2014) recorded decrease in EC during vermicomposting.

Amount of total nitrogen increased after 90 days of composting of fennel straw plus cow dung bedding materials. The nitrogen content in control bedding substrate was enhanced by 1.19 fold after completion of composting. However, *E. fetida* and *P. sansibaricus* worked bedding indicates 2.23 and 1.62 fold increase in nitrogen value respectively. The present study showed that organic waste conversion efficiency of *E. fetida* was more than *P. sansibaricus.* Nitrogen content rising capacity of both worms was significantly higher than that of control after 90 days of composting period. It indicated that *E. fetida* was more active and fed voraciously on organic waste rich materials. Gunadi *et al.* (2002) documented that earthworms enrich the nitrogen profile of vermicompost through microbial mediated nitrogen transformation, as well as through addition of mucus and nitrogenous wastes secreted by earthworms. Increasing trend of nitrogen in vermicomposting was also supported by Tripathi and Bhardwaj (2004), Nath *et al.* (2009), Joshi and

Sharma (2010), Ponmani *et al.* (2014), Chellachamy and Dinakaran (2015) and Daman *et al.* (2016).

Available phosphorus, potassium and C/N ratio are other generally used indicators for maturity of organic wastes. C:N ratio was radically declined in vermicomposting as compared to control substrate. The increase in earthworm population might be related with the decrease in C:N ratio with the advancement of time (Ndegwa *et al.,* 2000). The loss of carbon as carbon dioxide through microbial respiration and simultaneous addition of nitrogen by worms in the form of mucus and nitrogenous excretory material lowered the C:N ratio of the substrate (Suthar, 2007). Pattnaik and Reddy (2010), Ponmani *et al.* (2014) and Chellachamy and Dinakaran (2015) also reported decrease in C/N ratio during vermicomposting. Available phosphorus and potassium increased significantly ($P<0.001$) in vermicomposting as compared to their starting level. Phosphorus content increased by 1.84 and 1.69 folds in the bedding material with *E. fetida* and *P. sansibaricus* respectively in relation to advancement of time (0 days to 90 days) of composting. In the same way, potassium level increased in compost inoculated with *E. fetida* and *P. sansibaricus* by 2.49 and 2.19 folds respectively. This is probably due to the decomposition of organic carbon by the microbial biomass present in the compost (Mondini *et al.,* 2003). The presence of large number of micro flora in the gut of earthworm might play an important role in increasing P and K contents in the process of vermicomposting (Sharma, 2008). Potassium and phosphorus content increased in composting due to reduction of organic matter by respiratory activity of earthworms. Some previous studies also indicate enhanced potassium content in vermicompost by the end of the experiment (Manna *et al.,* 2003; Suthar, 2007). According to Atiyeh *et al.* (2002) level of potassium was increased in vermicompost. Similar results have been obtained by various researchers (Padmavathi, 2013; Ponmani *et al.,* 2014; Chellachamy and Dinakaran, 2015; Daman *et al.,* 2016; Sandeep et al 2017; Sharma & Garg, 2017).

CONCLUSIONS

The results of present vermicomposting experimental study suggested that agricultural waste like; fennel straw mixed with dry cow dung could be used as earthworm feeds for the production of valuable compost. In this experiment vermicomposting of a new composition of organic waste using the two epigeic earthworm exhibited some very promising results. It caused some significant changes in bedding materials indicating its utility in crop production. Thus, vermicompost from agricultural wastes has been a good source of nutrients in addition to organic compost and chemical fertilizers. To achieve high efficiency one of the keys is selection of proper substrate and which is composed of bedding material and food source for the worms and vise-versa.

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