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Biomanagement of *Parthenium hysterophorus* (Asteraceae) using an earthworm, *Eisenia fetida* (Savigny) for recycling the nutrients

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ABSTRACT

In India, the weed Parthenium hysterophorus is of alien origin and very difficult to control as it has occupied most of the area in both cropped and non cropped ecosystems. The available chemical or mechanical control measures are neither feasible nor economical. Therefore, weed management strategy needs to be shifted towards non chemical methods. Vermicomposting is a biological waste management technology by which organic fraction of the waste stream is decomposed by microorganisms and earthworms in controlled environmental conditions to a level in which it can be handled, stored, and applied in the agricultural fields without adverse impacts on the environment. In this experiment, Parthenium hysterophorus was blended with cow dung and press mud at various proportions, kept for pre-treatment for 21 days and subsequently vermicomposted for a period of 60 days under shade using earthworm Eisenia fetida. The substrate moisture content and temperature were monitored regularly. At the end of experiment, vermicompost showed decrease in pH and total organic carbon (TOC), but increase in EC, total nitrogen (TN), total phosphorus (TP) and total potassium (TK) contents. The C: N ratio of final vermicompost also reduced in different treatments. The data revealed vermicomposting of cow dung alone (T_1) and Parthenium hysterophorus, cow dung and press mud mixed at equal proportion (T_6) produced a superior quality manure with desirable C: N ratio and higher nutritional status than other treatments. This study suggests that the Parthenium hysterophorus could be successfully converted into highly valuable manure using E. fetida.

Keywords: *P. hysterophorus,* Vermicompost, *Eisenia fetida,* Nutrient content.

INTRODUCTION

Parthenium hysterophorus L. (Asteraceae) is an annual herbaceous terrestrial weed, which occurs in most of the tropical countries of the world. *P. hysrerophorus* is commonly known as congress grass has spread to Africa, Australia and Asia during last 100 years where it has got the status of “Worst weed”. In India *Parthenium* weed was first noted near Poona in Maharashtra State in 1951. By 1972 it had spread into the majority of the Western States from Kashmir in the north to Kerala in the south. Continuing to spread it was found in Assam in 1979 and is now present almost throughout the subcontinent and is probably the dominant weed in Karnataka and Tamilnadu States where it infests about 5 million ha.

P. hysterophorus is a dangerous imported weed and is poisonous, pernicious, allergic and aggressive and poses a serious threat human being and livestock. At present it is one of the most troublesome and obnoxious weed of wasteland, forest, pasture, agricultural land and cause nuisance to mankind [1]. Chemically parthenin is the toxic substance present in the weed and is the causative factor for many problems. Analysis has indicated that all the plant parts including trichomes and pollen contains toxins called sesquiterpene lactones. The major component of these toxins being parthenin another phenolic acid such as caffic acid, vanillic acid, anisic acid, chlorogenic, parahhdroxy benoic acid and p-anisic acid are lethal to human and animal [2]. The complete eradication of these weeds is very difficult and costly without further use of their biomass. The green matters of these weeds have tremendous potential for being used as organic manures. The direct incorporation of their green matter in soil causes poor germination of seed and reduction in crop yields [3]. In India, *P.hysterophorus* causes a yield decline of up to 40% in agricultural crops.

Various attempts have been made to control, utilize or destroy, *P.hysterophorus* weed [4, 5]. It has successfully resisted eradication by chemical, biological and integrated methods. On the other hand, when viewed as a resource, it appears to be a possible raw material for vermicomposting. There is on increasing attention in vermicomposting research, i.e., testing new wastes, new worm species and evaluation of the vermicompost in recent past [5]. Various weeds, e.g., water hyacinth, have effectively been converted into vermicompost [6]. Hence, the authors hypothesized that vermicomposting can be an alternate technology for the management of *P.hysterophorus.* Therefore, present investigation was taken up to utilize a harmful weed (*P.hysterophorus*) mixed with organic supplements (cow dung and press mud) through vermitechnology and may provide a valuable product in the form of nutrient rich manure i.e., vermicompost.

MATERIALS AND METHODS

Parthenium hysterophorus (PT) plants collected from the Annamalai University campus, Tamil Nadu, India were washed, shade dried, and cut into pieces of 3-4 cm length. Press mud (PM) was obtained from effluent treatment plant of E.I.D. Parry Sugar Mill located at Nellikkuppam, Tamil Nadu, India. Fresh Cow dung (CD) was collected from the agricultural farm, Faculty of Agriculture, Annamalai University, Tamil Nadu, India. The main physico-chemical characteristics of CD, PM, and PT are given in Table 1. Composting earthworm species *Eisenia fetida* (Savigny) of different age groups were cultured and developed outside the laboratory on partially degraded cow dung as feed. *Eisenia fetida* (30±4 days old) were randomly picked from the culture and used for the purpose of this experiment.

Six vermicomposting treatments were established having 3kg of feed mixture each containing CD, PM and PT alone and CD, PM mixed with PT in different rations (Table 2). Cement tank measuring 60cm height and 30cm diameter were used and filled with 3kg substrate. Each treatment was established in six replicate. The feed mixtures were turned manually every day for 21 days in order to semi compost the feed so that it becomes palatable to worms. After 21 days fifty *Eisenia fetida* were introduced in each treatment. All the treatments were kept in dark at room temperature. The moisture content was maintained at 60-70% during the experiment. The containers were covered with moist jute to prevent moisture loss& to keep away the pest. The 0 days refers to the day of inoculation of earthworms after precomposting of 21 days.

Substrate samples drawn from all the treatment combinations were dried under shade and physico-chemical properties were analyzed. The pH and electrical conductivity (EC) were determined using double distilled water suspension of each vermicompost in the ratio of 1:10 (w/v) that had been agitated mechanically for 30 min and filtered through Whatman No. 1 filter paper. Total nitrogen (TN) was measured by microkjeldahl method [7]. Total organic carbon (TOC) content in the samples was measured by chromic acid oxidation method [8]. Total phosphorus (TP) was estimated by vanadomolybdo phosphoric acid yellow color method [9] using a colorimeter (Model 115, Systronics, India). Total potassium (TK) was estimated by the standard method of Jackson [9] using flame photometer (Model 128, Systronics, India). C: N ratios were calculated from the measured value of C, and N. All the results reported in the text are the mean of six replicates. One-way ANOVA was used to analyze the significant differences among different treatments for studied parameters. Tukey's t-test as a post hoc was also performed to identify the homogeneous type of treatments for the various parameters. The probability levels used for statistical significance were $P < 0.05$ for the tests.

RESULTS AND DISCUSSION

Physico-chemical characteristics of the initial feed mixtures and vermicompost are given in Fig. 1 to 7. The nutrient value of vermicompost depends on several factors viz., nature of feed substrate, aeration, moisture, temperature and earthworm species used in the process. Therefore it is essential to identify various physic-chemical characteristics, such as pH, electrical conductivity, total organic carbon, total nitrogen, total phosphorus, total potassium, metal content etc. to quantify the dynamics of vermicomposting process.

The pH of vermicompost was significantly different than initial substrate material (Fig. 1). In the present study, the pH of all the feed combinations decreased from alkaline (7.8±0.2–8.3±0.1) to slightly acidic (6.4±0–6.9±0.2). Similar observations have been reported by other scientists for vermicomposting process. The decreasing tendency in pH during vermicomposting corroborates with the findings of other researchers [10, 11]. The decrease in pH during vermicomposting may be due to Co_2 and organic acids produced by microbial metabolism [12]. Therefore, the effects of earthworms on pH during vermicomposting is probably related to increases in the mineral nitrogen content of the substrates, changes in the ammonium-nitrate equilibrium and accumulation of organic acids from microbial metabolism or from the production of fulvic and humic acids during decomposition [13]. An increase in EC was recorded after vermicomposting process (Fig. 2). The final EC was in the range 2.52±0.07–3.19±0.21dSm^{-1} in different treatments after vermicomposting. The EC of vermicompost obtained from T_1 and T_6 treatments were significantly different from other treatments. The increase in EC may be due to increased level of soluble salts in available forms due to mineralization of the feed mixtures by earthworms and micro-organisms [5].

Table - 1:- Composition of treatments used for experimentation (dry weight basis)

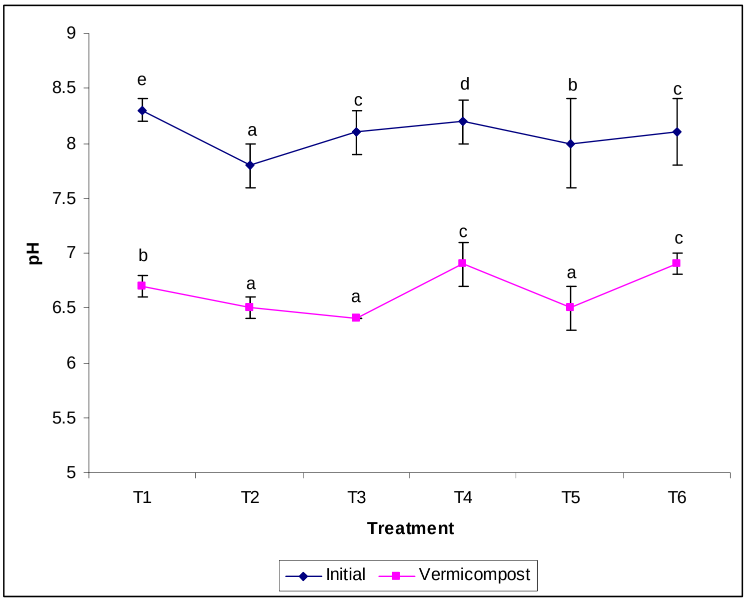
Treatment (T) No.	Cowdung (g)	Pressmud (g)	Parthenium (g)
T_1	3000	0	0
T_2	0	3000	0
T_3	0	0	3000
T_4	1500	0	1500
T_5	0	1500	1500
T_6	1000	1000	1000

CD- Cowdung; PM- Pressmud; PT- Parthenium

Table – 2:- Initial physico-chemical characteristics of Cow dung, Pressmud and *P.hysterophorus* used in experiment

Parameters	Cow dung	Pressmud	Parthenium
pH	8.3±0.1	7.8±0.2	8.1±0.2
EC(dS m^{-1})	1.40±0.02	2.70±0.09	2.30±0.05
TOC (g kg^{-1})	451±11.5	485±19.5	416±27.3
TN (g kg^{-1})	7.5±0.3	11.4±0.6	7.9±0.4
TP (g kg^{-1})	5.8±0.2	5.2±0.4	4.3±0.2
TK (g kg^{-1})	4.3±0.1	6.3±0.2	5.2±0.4
C:N ratio	60.13±4.8	42.54±3.5	52.65±4.1

Fig. 1:- Comparison of pH between initial substrate and vermicompost obtained from different treatments (Mean ± *SD*, *n=6*)

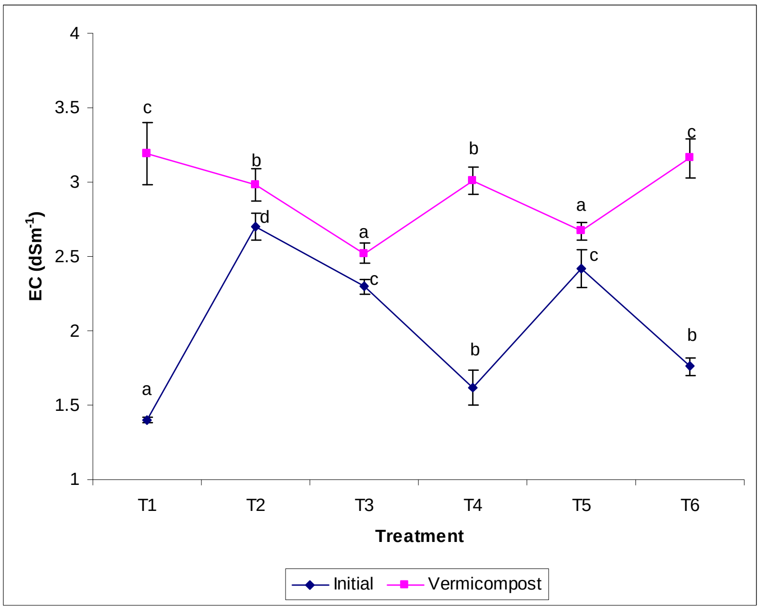


Values with different letters are significantly different (ANOVA; Tukey's test, P < 0.05)

Total organic carbon (TOC) decreased in all the treatments, remarkably in those which contained higher concentration of CD and PM. It may be due to the mineralization of organic matter. As the PT in the feed mixtures, the TOC content decreased as compared to initial feed mixtures during vermicomposting process (Fig. 3). Minimum TOC was recorded in T_1 (226±10.4 g kg^{-1}) and T_2 (231±13.6 g kg^{-1}) treatment after vermicomposting. The combined action of earthworms and microorganisms may be responsible for TOC loss from the initial feed waste in the form of CO2. Similar observations have been reported by Prakash and Karmegam [14] during vermicomposting of sugar industry waste.

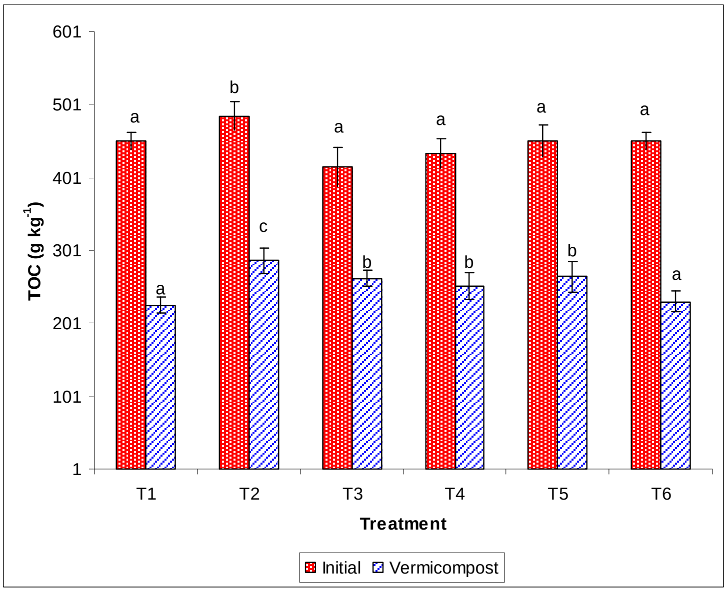
Total nitrogen (TN) content in the vermicomposts was higher than initial waste mixture. In the present study initial TN content of the waste mixtures was in the range of 7.5±0.3–11.4±0.6 g kg^{-1} (Fig. 4). Whereas, TN content of vermicompost was in the range of 12.9±0.6–23.9±1.3 g kg^{-1} after vermicomposting. The increasing trend in TN content during vermicomposting corroborates with the findings of other researchers [11,15,16]. According to Hait and Tare [17] losses in organic carbon due to substrate utilization by microbes and earthworms and their metabolic activities as well as water lose by evaporation during mineralization of organic matter might be responsible for nitrogen addition. However, nitrogen enrichment pattern mainly depends upon the total amount of N preset in the feed material and the extent of mineralization during vermicomposting [18, 19, 20].

Fig. 2:- Comparison of EC (dSm^{-1}) between initial substrate and vermicompost obtained from different treatments (Mean ± *SD, n=6*)



Values with different letters are significantly different (ANOVA; Tukey's test, $P < 0.05$)

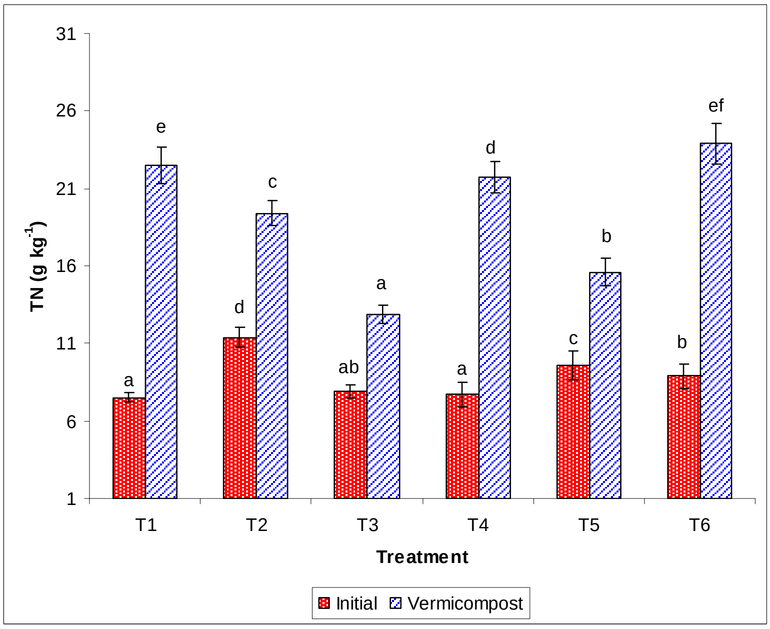
Fig. 3:- TOC ($g\ kg^{-1}$) content of initial substrate and vermicompost in different treatments (Mean ± *SD, n=6*)



Values with different letters are significantly different (ANOVA; Tukey's test, $P < 0.05$)

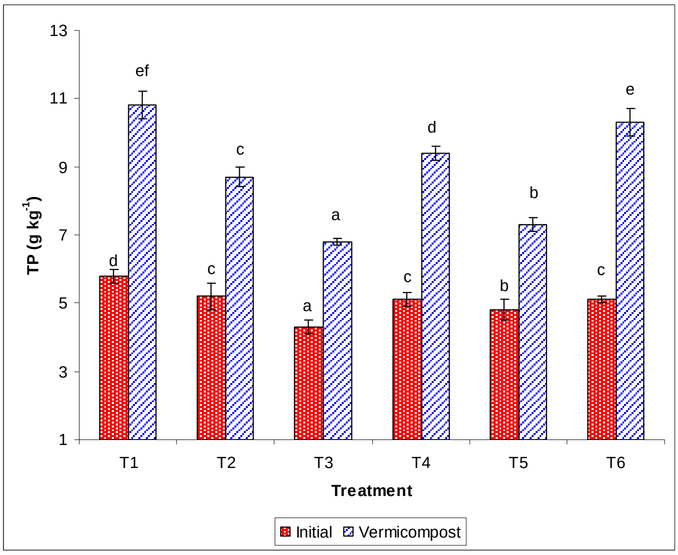
TP content was higher in vermicompost obtained in all the treatments than the initial substrates as shown in Fig. 5. The maximum increase were observed in T_1 (10.8±0.4g kg^{-1}) and T_6 (10.3±0.4 g kg^{-1}) followed by T_4 (9.4±0.2 g kg^{-1}), T_2 (8.7±0.3 g kg^{-1}), T_5 (7.3±0.2 g kg^{-1}) and T_3 (6.8±0.1 g kg^{-1}). The increasing trend in TP content during vermicomposting is consistent with the findings of other researchers [11, 15]. Gosh et al., [21] reported that the increase in TP content during vermicomposting is probably through mineralization, release and mobilization of available P content from organic waste performed partly by earthworm gut phosphates, and further release of P might be due to P-solubilizing microorganisms present in worm casts.

Fig. 4:- TN (g kg^{-1}) content of initial substrate and vermicompost in different treatments (Mean ± *SD, n=6*)



Values with different letters are significantly different (ANOVA; Tukey's test, P < 0.05)

Fig. 5:- TP (g kg^{-1}) content of initial substrate and vermicompost in different treatments (Mean ± *SD, n=6*)

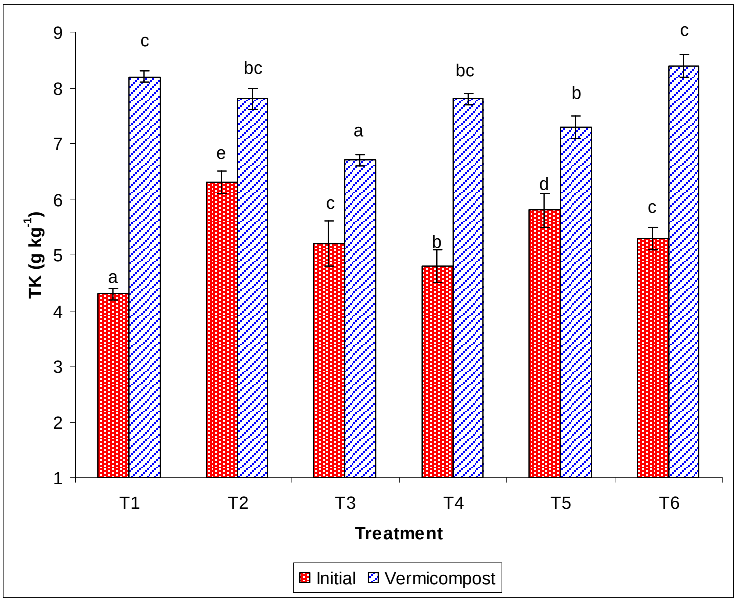


Values with different letters are significantly different (ANOVA; Tukey's test, P < 0.05)

In the present study TK concentration in the initial substrates had increased significantly by the end of vermicomposting period (Fig. 6). The maximum increase in TK was in T_6 (8.4±0.2 g kg-^{1}) and minimum in T_3 (6.7±0.1). A similar increasing trend in TK content of vermicomposting was reported by other authors [22, 11]. It has been suggested that earthworm processed material contains higher concentration of TK as compared to the feed material due to higher mineralization rate as a result of enhanced microbial activity [23,24,25].

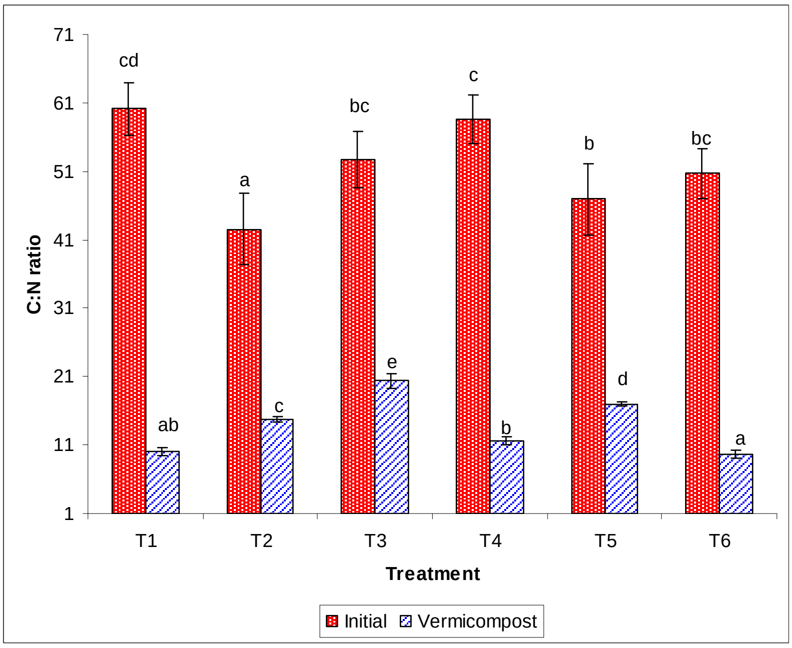
Senesi [26] reported that a decline in C: N ratio to less than 20 indicates an advanced degree of organic matter stabilization and reflects a satisfactory degree of maturity of organic wastes. In the present study vermicompost obtained at the end of experiment had lower C: N ratio, as compared to the initial value (Fig. 7). The C: N ratio is used as an index for maturity of organic wastes as well as a very important parameter because plants cannot assimilate nitrogen unless the ratio is in the order of 20 or less [27]. Initial C: N ratio was in the range of 42.54±5.2–60.13±3.8 before the inoculation of earthworm in the feed mixture. Finial C: N ratios were in the range of 9.66±0.65–20.38±1.04 in vermicompost. These data suggest that C: N ratio of less than 20 is considered to be an indication of compost maturity. Senapati et al., [28] have reported that the loss of organic carbon as Co_2 due to microbial respiration and addition of earthworm N excrements increase the levels of nitrogen and thereby lowers the C: N ratio during vermicomposting. In the present study the change in C: N ratio reflects the degree of organic waste mineralization and stabilization rate during vermicomposting.

Fig. 6:- TK (g kg^{-1}) content of initial substrate and vermicompost in different treatments (Mean ± *SD, n=6*)



Values with different letters are significantly different (ANOVA; Tukey's test, P < 0.05)

Fig.7:- Comparison of C: N ratio between initial substrate and vermicompost in different treatments (Mean ± *SD, n=6*)



Values with different letters are significantly different (ANOVA; Tukey's test, P < 0.05)

CONCLUSION

In the present study, vermicompost produced from *E. fetida* possessing higher nutrient contents and lower C: N ratio. However 100% of the *P.hysterophorus* was not suitable feed mixture for *E. fetida*. Therefore it was mixed with other organic waste like cattle dung and press mud to enhance the nutrient contents. So it can be used as valuable manure. In the present study it was proved that vermicomposting could be introduced as an effective technology to convert the *P.hysterophorus* into a nutrient rich product for sustainable agriculture.

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