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RESEARCH ARTICLE

Utilization of Different Plant Species available in Coconut Plantation to Produce Nutrient Rich Vermicompost

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ABSTRACT

Vermicomposting is a well known technology that produces a valuable organic fertilizer from organic waste. Weeds in coconut plantations are good organic sources for vermicompost production. The experiment was carried out to evaluate the quality of vermicompost produced by different weed or plant species commonly available in coconut plantations and also to evaluate the effect of these residues on the earth worm activity in the vermicomposting process. Vermicomposts were produced using different plant or weed species collected from coconut plantations in combination with cattle manure.

The highest N content and worm growth was found in the vermicompost produced using *Puereria phasioloides, Gliricidia sepium* and *Tithonia diversifolia.* The highest P content was recorded in vermicompost samples produced using *Tithonia diversifolia* and *Panicum maximum. Tithonia diversifolia*, *Puereria phasioloides* and *Gliricidia sepium* showes significantly higher K content than the other plant species residues. Organic Carbon content was significantly high in vermicompost made with *Tithonia diversifolia, Gliricidia sepium, Tephrosia purpurea, Chromoleana odorata, Panicum maximum* and *Hyptis suaveolens.* Worm multiplication rate was significantly lower % by *Lantana camara, Chromoleana odorata, Hyptis suaveolens* and *Vernonie zeylanica* substrates, possibly due to chemical compounds present in these plant species. The results shows that *Gliricidia sepium, Puereria phasioloides* and *Tithonia diversifolia* are the best species for vermicomposting when compared with other weed species in coconut plantations.

Key words: coconut, compost, *Gliricidia sepium, Tithonia diversifolia,* weeds

INTRODUCTION

Coconut is a tropical perennial plantation crop and its canopy structure requires a wide spacing between palms, which permits abundant sunlight to the understory. As a result, the unutilized space beneath the plantation becomes invaded by a wide range of perennial and annual weed species (Liyanage and Liyanage, 1989). Such weeds invariably compete with coconut for soil moisture and nutrients, affecting its growth and yield, and obstructing routine estate practices (Senarathne *et al.,* 2003). Management of the understory weed growth is, therefore an essential agronomic practices in maintaining a coconut plantations.

Weed management in coconut plantations are commonly done using herbicide applications and mechanical weeding, which are costly to the growers. With the increasing costs of all inputs which are used for agriculture new innovative alternative agronomic practices needs to be introduced for farmers to minimize the cost of production of coconut plantations.

Different weed or plant residues commonly available in any agricultural land can be converted to a potential plant-nutrient enriched resource - compost and vermicompost that can be utilized for sustainable land restoration practices (Suthar and Singh, 2008). Vermicomposting is a mesophilic process and is the process of ingestion, digestion, and absorption of organic wastes by earthworms followed by excretion of castings through their metabolic systems during which the biological activity of earthworms enhances plant-nutrients of organic waste (Venkatesh and Eevera, 2008). Vermicompost possesses higher and more soluble levels of major nutrients - nitrogen, phosphorus, potassium and magnesium (Bansal and Kapoor, 2000; Singh and Sharma, 2002; Reddy and Okhura, 2004) compared to the substrate or underlying soil, and normal compost. During the process, the nutrients locked up in the organic waste are changed to simple and more readily available and absorbable forms such as nitrate or ammonium nitrogen, exchangeable phosphorus and soluble potassium, calcium, magnesium in the worm's gut (Lee, 1985 and Atiyeh *et al.,* 2002). Vermicompost is often considered a supplement to fertilizers and it releases the major and minor nutrients slowly with significant reduction in C/N ratio, synchronizing with the requirement of plants (Kaushik and Garg, 2003).

In coconut plantations, there are large numbers of weedy plant species which are produce large quantities of biomass. Therefore, these resources can be used for the production of vermicompost. Nutrient contents, changes in the worm population and rate of vermicompost production could be affected by the species of weed used for vermicompost production, but have not been evaluated. Studies on the use of different weeds or plant species to produce vermicompost in coconut plantations have also not been studied from tropical regions, where coconut is a very important crop The purpose of this research was to assess the quality of vermicompost produced using different weedy plant species and the influence of these feed stock species on the growth and reproduction of the worms.

MATERIALS AND METHODS

This experiment was carried out at the vermicomposting unit of the Coconut Research Institute, Lunuwila, in the Low country Dry Zone of North Western province of Sri Lanka from August 2010 to May 2011. The area is characterized by bi-modal pattern of rainfall with an annual mean precipitation of 1500 mm. Approximately 65% of the annual rainfall is received from September to February (Maha Season).

Nine weedy plant species namely *Tithonia diversifolia*, *Puereria phasioloides*, *Gliricidia sepium*, *Tephrosia purpurea*, *Hyptis suaveolens*, *Panicum maximum*, *Lantana camara*, *Chromoleana odorata* and *Vernonie*manure. The proportion of cattle manure and plant residues was mixed at ratio 1:2 weight basis. The mixture was added to black polythene bags, (gauge 500) having height and diameter of 60cm and 30cm. After adding the mixture, 20 worms from selected species (*Eisenia foetida*) and

200ml of water was added into each polythene bag and kept in the shade house. The treatments were arranged in Complete Randomized Design with five replicates. Small holes were made at the bottom of the each polythene bag to remove excess water, although worms could not move through them. This mixture was kept for eight weeks to decompose the materials. Once a week mixtures were taken out from the bags and mixed well to facilitate aeration. After mixing, 100ml of water was added into each bag. The weight and length of all 20 worms were measured before introducing to the bags.

Growth measurement of worms

Initial weight, length and numbers of worms were determined and counted as the first growth measurement before introducing to the mixtures. Thereafter, weight, length and number of worms were measured and counted at monthly intervals.

Nutrient analysis of vermicompost

Prepared vermicompost were air dried and sieved using a 2mm sieve, and 100g samples were obtained from each treatment. The following parameters were measured in each samples. The pH of samples was recorded by a digital pH meter. The organic matter content and organic carbon were measured by Walkey-Black method (Walkley and Black, 1934), the total N was estimated by the Kjeldahl method (Jackson, 1973), and the total P and K contents by calorimetric method (Anderson and Ingram, 1993) and flame photometric method (Simard, 1993) respectively. Data analysis riment was conducted using an Analysis of Variance (ANOVA) with the Statistical software and the significance of the differences between means was tested using Least Significant Differences (LSD) at P=0.05 (SAS Institute 1999).

Treatment combinations:

T_1 – Cattle manure 1/3 (w/w) + *Panicum maximum* residues 2/3 (w/w)

T_2 - Cattle manure 1/3 (w/w) + *Chromoleana odorata* residues 2/3 (w/w)

T_3 - Cattle manure 1/3 (w/w) + *Lantana camara* residues 2/3 (w/w)

T_4 - Cattle manure 1/3 (w/w) + *Hyptis suaveolens* residues 2/3 (w/w)

T_5 - Cattle manure 1/3 (w/w) + *Tephrosia purpurea* residues 2/3 (w/w)

T_6 - Cattle manure 1/3 (w/w) + *Vernonie zeylanica* residues 2/3 (w/w)

T_7 - Cattle manure 1/3 (w/w) + *Puereria phasioloides* residues 2/3 (w/w)

T_8 - Cattle manure 1/3 (w/w) + *Tithonia diversifolia* residues 2/3 (w/w)

T_9 - Cattle manure 1/3 (w/w) + *Gliricidia sepium* residues 2/3 (w/w)

RESULTS AND DISCUSSION

Different weedy plant species biomass on worm population

The warm population in all the treatments increased with time. The number of worms in different composting substrates were statistically significant (P=0.05). During the experimental period, the highest % of worm population increases were observed in cattle manure with *G. sepium*, *T. diversifolia* and *P. phasioloides* compost mixtures and the values were 700, 650 and 585% respectively (Table 1).

The lowest increments were observed in cattle manure with *C. odorata, V. zeylanica* and *L. camara* composting mixtures and the values were 129, 139 and 145% respectively (Table 1).

The differential increase in the number of worms noted in different composting substrates during the vermicomposting process could be due to the substrate quality, especially the chemical compounds (Reinecke *et al.*, 1992). Some plants species exude some toxic compounds to the environment and these are poisonous to living organisms (Atiyeh *et al.,* 2000).

The average individual weight and length of worms in different vermicomposting mixtures were different. The highest individual weight and length of earthworms were observed in the vermicompost mixtures produced using plant species *P. phasioloides, T. diversifolia* and *G. sepium* (Tables 2 and 3).

Table 1: Effect of plant species on development of worm population

Different plant species	Average number of worms			% increase
	Initial time	After 1st month	After 2nd month	
T_1 - Panicum maximum	20	46.5 ± 2.5	61.25 ± 3.8	213
T_2 - Chromoleana odorata	20	24.25 ± 1.8	45.75 ±2.5	129
T_3 - Lantana camara	20	32.50 ± 2.2	49.00 ± 2.6	145
T_4 - Hyptis suaveolens	20	33.25 ± 2.2	58.75 ±2.7	194
T_5 - Tephrosia purpurea	20	37.25 ± 2.4	75.25 ± 4.0	276
T_6 - Vernonie zeylanica	20	39.75b ± 2.4	47.75± 2.5	139
T_7 - Puereria phasioloides	20	76.50 ± 4.1	137.00± 6.3	585
T_8 - Tithonia diversifolia r	20	76.00± 4.1	150.50 ±6.4	650
T_9 - Gliricidia sepium	20	78.50 ± 4.2	160.25 ±6.4	700
L.S.D. (P=0.05)	-	**8.82**	**8.49**	

Table 2: Worm growth (length) as affected by plant species

Different plant species	Averge worm length (cm)			% increase
	Initial time	After 1st month	After 2nd month	
T_1 - *Panicum maximum*	8	9.20±0.02	10.24±0.08	29
T_2 - *Chromoleana odorata*	8	8.12±0.06	9.88±0.12	23
T_3 - *Lantana camara*	8	8.79±0.10	9.54±0.07	19
T_4 - *Hyptis suaveolens*	8	9.78±0.05	10.26±0.08	29
T_5 - *Tephrosia purpurea*	8	10.24±0.06	11.98±0.03	50
T_6 - *Vernonie zeylanica*	8	9.36±0.05	10.56±0.11	33
T_7 - *Puereria phasioloides*	8	11.86±0.15	13.46±0.20	70
T_8 - *Tithonia diversifolia*	8	11.98±0.02	12.51±0.04	57
T_9 - *Gliricidia sepium*	8	11.34±0.20	12.87±0.17	63
L.S.D. (P=0.05)	**-**	**0.152**	**0.17**	

Table 3: Effect of different plant species on weight of worms

Different plant species	Averge worm weight (g)			% increase
	Initial time	After 1st month	After 2nd month	
T_1 - *Panicum maximum*	0.64	1.28±0.03	**2.44±0.05**	281
T_2 - *Chromoleana odorata*	0.64	2.32±0.05	**2.86±0.08**	347
T_3 - *Lantana camara*	0.64	1.98±0.03	**2.56±0.05**	300
T_4 - *Hyptis suaveolens*	0.64	1.88±0.04	**2.76±0.05**	331
T_5 - *Tephrosia purpurea*	0.64	2.08±0.10	**3.02±0.15**	372
T_6 - *Vernonie zeylanica*	0.64	1.78±0.08	**2.42±0.05**	278
T_7 - *Puereria phasioloides*	0.64	2.43±0.07	**3.78±0.05**	491
T_8 - *Tithonia diversifolia r*	0.64	2.56±0.16	**3.98±0.05**	522
T_9 - *Gliricidia sepium*	0.64	2.88±0.07	**4.02±0.09**	528
L.S.D. (P=0.05)	-	0.08	**0.09**	

The length of worms increased by 70% in *P. phasioloides,* 57% in *T. diversifolia* and 63% in *G. sepium* (Table 2) while weight increased by 528% in *G. sepium*, 522% in *T. diversifolia* and 491% in *P. phasioloides* at the end of the experiment (Table 3).

The mean individual length and weight also varied depending on the substrates. When introduced into different composting mixtures worms showed increased growth rates and reproduction activities (Suthar and Singh, 2008). The increase in average individual body weight of worms was noted in substrate characters during vermicomposting process, which could be due to the substrate quality or could be related to fluctuating environmental conditions (Edwards *et al.* 1998 and Suthar, 2007).

Effect of different plant substrates on nutrient content of vermicompost

Significantly higher total N and K were recorded in the vermicompost samples produced by *P. phasioloides, T. diversifolia* and *G. sepium* and significantly (P<0.05) higher total N and K contents (Table 4). The minimum total N and K content were in compost with *L. camara, V. zeylanica* and *P. maximum.* The highest total N and K contents were as follows:- N was 15.46mg kg^{-1} in *P. phasioloides*, 14.99mg kg^{-1} in *G. sepium* and 13.88mg kg^{-1} in *T. diversifolia* compost mixtures, K was 35.21mg kg^{-1} in *T. diversifolia*, 22.71mg kg^{-1} in *G. sepium* and 21.50mg kg^{-1} in *P. phasioloides* compost mixtures. The present study revealed that vermicompost prepared from leguminous plant species biomass possessed considerably higher levels of total N when compared to non leguminious plant species. The enhancement of total N in vermicompost was probably due to mineralization of the organic matter containing proteins (Bansal and Kapoor, 2000) and conversion of ammonium nitrogen into nitrate (Suthar and Singh, 2008; Atiyeh *et al.* 2000). However, earthworms can boost the nitrogen levels of the substrate during digestion in their gut, adding their nitrogenous excretory products, mucus, body fluid, enzymes and even though the decaying dead tissues of worms (Suthar, 2007).

Table 4: Effect of plant substrates on nutrient content of vermicompost

Different plant species	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}	Organic matter (%)	p^H
T_1 - Panicum maximum	10.60±0.16	11.21±0.29	20.51±0.34	25.58±0.25	7.32
T_2 – C. odorata	13.25±0.24	10.37±0.12	17.87±0.21	23.21±0.13	7.58
T_3 - Lantana camara	11.65±0.13	8.88±0.33	15.82±0.24	19.59±0.18	8.13
T_4 - Hyptis suaveolens	13.85±0.29	7.84±0.24	18.44±0.19	25.99±0.15	8.04
T_5 - Tephrosia purpurea	12.27±0.19	10.41±0.20	16.41±0.15	22.48±0.26	7.78
T_6 - Vernonie zeylanica	8.44±0.06	9.44±0.09	16.19±0.16	18.53±0.09	7.23
T_7 – P. phasioloides	15.46±0.09	9.01±0.07	21.50±0.09	18.56±0.08	7.64
T_8 - Tithonia diversifolia	13.88±0.27	14.41±0.13	35.21±4.5	26.51±0.16	7.54
T_9 - Gliricidia sepium	14.99±0.16	8.45±0.08	22.71±0.14	25.83±0.14	7.91
L.S.D (P=0.05)	0.26	0.28	2.19	0.22	ns

Vermicomposting technology is an efficient process for recovering K from organic waste (Suthar, 2007 and Manna *et al.* 2003). The present findings corroborated with Delgado *et al.* (1995), who reported a higher K concentration in the end product prepared from sewage sludge. The microorganisms present in the worms gut probably converted insoluble K into a soluble form by producing the microbial enzymes (Kaviraj and Sharma, 2003). The highest total P content (14.41mg kg^{-1}) was found in in *T. diversifolia*, followed by 11.21 mg kg^{-1} in *P. maximum* and 10.41mg kg^{-1} in *T. purpurea* compost mixtures. The total P content of the compost samples also varied with the type of substrate. The worms during vermicomposting converted the insoluble P into soluble forms with the help of P solubilizing microorganisms present in the gut, making it more available to the plant (Ghosh *et al.* 1999; Padmavathiamma *et al.* 2008; Suthar and Singh, 2008).

Effect of different plant substrates on organic matter content and pH of vermicompost

The pH variation was not significantly different between plant species (Table 4). The near neutral pH of vermicompost may be attributed by the secretion of NH_4^+ ions that reduce the pool of H^+ ions (Tripathi and Bhardwaj, 2004) and the activity of calciferious glands in earthworms containing carbonic anhydrase that catalyze the fixation of CO_2 as $CaCO_3$, thereby preventing the development of low pH values (Kale *et al.* 1982). However, the initial pH of the raw materials has a robust correlation with the ability of the waste conversion into vermicompost, where a lower pH resulted in faster conversion (Hasnah and Hasnuri, 2008). Significantly higher organic matter contents were recorded in the vermicompost samples produced by *T. diversifolia, H. suaveolens, G. sepium* and *P. maximum* composting mixtures (Table 2). The lowest organic matter content was observed in compost from *V. zeylanica, L. camara* and *P. phasioloides*. These findings agree with those of earlier authors (Garg and Kaushik, 2005). The organic carbon is lost as CO_2 through microbial respiration and mineralization of organic matter causing an increase in total N (Crawford, 1983). Parts of the carbon in the decomposing residues are released as CO_2 and a part is assimilated by the microbial biomass (Cabrera *et al.* 2005). Microorganisms use the carbon as a source of energy for decomposing the organic matter. The reduction is higher in vermicomposting compared to the ordinary composting process, which may as earthworms have higher assimilating capacities

CONCLUSIONS

The highest nutrient contents and worm growth were found in the vermicompost produced using *P. phasioloides, G. sepium* and *T. diversifolia.* Organic matter content was significantly high in *T. diversifolia, H. suaveolens, G. sepium* and *P. maximum.* Moreover, the vermicompost of leguminous plant species possessed higher nutrient contents due to N base materials. Accordingly, P. *phasioloides, G. sepium* and *T. diversifolia* are the best plant species for vermicompost production out of nine species studied. This could be developed to an integrated system where manure of livestock in coconut lands, weed thrashes and coconut residues are recycled effectively within the system. Main feature of an in-*situ* vermicomposting system in the coconut basin is that it is cost effective and self regulatory which will be ideal for resource poor small coconut holders.

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