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Effect sago bagasse blended with biogas plant slurry on growth and reproduction of *Perionyx ceylanensis* Mich. and *Lampito mauritii* (Kinberg) for large scale vermicompost production

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ABSTRACT

The primary objective of this study was to assess the growth and reproduction potential of Perionyx ceylanensis Mich. and Lampito mauritii (Kinberg) on sago bagasse (SB) blended with biogas plant slurry (BPS) in different vermicomposting treatments. The growth and fecundity of both worms was monitored for 12 weeks. Maximum growth was recorded in VT6, VT5 and VT4 for P. eylanensis and VT12, VT11 and VT10 for L. mauritii, respectively. Earthworms biomass gain and reproduction was favorably up to 60% SB+ 40% BPS feed composition in the treatments. However, increasing proportions of SB in different vermicomposting treatments affected the growth and reproduction of P. eylanensis and L. mauritii. The 100% worm mortality was recorded in SB alone vermicomposting treatment (VT6 and VT12) for both worms. The results also demonstrated the both worms growth and reproduction are not significantly affected if SB content is up to 60% in the vermicomposting treatments. These observations indicate P. eylanensis may be a more efficient breeder than L. mauritii. Hence, it was concluded that the growth and reproduction of these species was associated strongly with the quality of the substrate, especially with their chemical as well as biological composition.

Key words: *P. ceylanensis, L. mauritii,* sago bagasse, biomass production, reproduction rate.

INTRODUCTION

Sago is a common edible starch in the form of globules is obtained by processing the tubers of tapioca. India acquires significance in the universal tapioca scenario due to its highest productivity in the world. Similarly within India, Tamil Nadu stands first in respect of processing of tapioca into sago and starch throughout the nation, meeting about 80% of country's demand. Sago industry is one of the major small scale sectors in India with more than 800 sago starch units located in Salem District of Tamil Nadu and the processing of sago generates enormous quantities of biodegradable solid and liquid wastes which are highly organic, foul smelling and acidic in nature [1]. Sago waste is a rich fibrous residue and it is usually disposed of subsequent to the extraction of starch from the sago trunk. Cecil (2002) [2] reported that every 100kg of sago starch in pith, about 10kg of sago bagasse (hampas) is generated, and this sago bagasse are likely to be discarded into rivers or open dumps without any facilities for waste management and this practice may cause soil and water pollution. However, unavailability of land and public awareness has made such open dumps expensive and unfeasible. Apart from this, disposal of solid wastes in open dumps leads to wastage of organic and inorganic nutrients present in the waste which might be recovered and used as manure in agricultural fields [3]. Therefore, appropriate technologies, which are environmentally viable and economically feasible, are needed for efficient management of sago bagasse.

Vermicomposting involves bio-oxidation and stabilization of organic material by the joint actions of earthworms and mesophilic microorganisms under aerobic conditions. It is well established that a large number of organic wastes can be ingested by earthworms and converted into humus like material termed as vermicompost [4]. Many organic wastes have been converted into vermicompost using different earthworm species include cattle dung [5], mango leaves [6], pig waste [7], sheep waste [8], poultry droppings [3], water hyacinth [9], paper waste [10], textile mill and industrial sludge [11,12], guar gum industrial waste [13], bagasse [14]. Although, literature is available on utilization of earthworms for agriculture, animal, poultry, sewage and industrial wastes recycling, but utilization of sago bagasse using native species *P.ceylanensis* and *L. mauritii* is yet to be proven for vermiculture and vermicomposting process. Therefore, the objective of the present paper is to produce earthworm biomass for large scale production of vermicompost from Sago bagasse amended with organic supplements (biogas plant slurry) using *P.ceylanensis* and *L. mauritii*.

MATERIALS AND METHODS

Sago bagasse, biogas plant slurry and earthworm *P.ceylanensis* and *L. mauritii*: The sago bagasse (SB) was collected from a sago factory in Salem, Tamil Nadu (India). The digested biogas plant slurry (BPS) was obtained from the storage tank of an on-farm biogas plant in Faculty of Agriculture, Annamalai University. The SB was mixed with BPS in different proportions (Table 1). The initial properties of SB and BPS are reported in Table 2. Two native species of earthworms *Perionyx ceylanensis* and *Lampito mauritii* were chosen for this experiment and both worms were cultured on partially degraded cow dung as feed in the laboratory, department of zoology, Annamalai University, Tamilnadu, India and were randomly picked for experimentation.

Treatment design: Cement tanks measuring 30cm height, 60cm length and 45cm width were used. Each vermicomposting treatment consisted of six replicates with 5kg of feed materials for both species of worms. The tank were kept under shade and irrigated with necessary quantity of water on alternate days to ensure that the substrate moisture content and was maintained at approximately 70% [15]. After the completion of pre-composting period of 14 days, 100 un-clitellated hatchlings of both worms were randomly picked from stock culture and introduced in each vermicomposting treatment. Each treatment was established in six replicate. 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 and to keep away the pest. The 0 days refers to the day of inoculation of earthworms.

Growth and reproduction study: Biomass production and reproduction potential, i.e., maximum biomass gained at end (mg worm^{-1}), net biomass gain (mg worm^{-1}), growth rate (mg worm^{-1} day^{-1}), total number of cocoon, total hatchling number and mortality rate by *P.ceylanensis* and *L. mauritii* in each treatment were recorded periodically for 84 days. The feed in the container was turned out then earthworms and cocoons were separated from the feed by hand sorting, after which they were counted and weighed after washing with water. Then all earthworms and the feed (but not cocoons) were returned to their respective treatments. The earthworms were weighed with full gut. At the end of the experiment, earthworms and cocoons were separated and maximum biomass gained at end (mg worm^{-1}), net biomass gain (mg worm^{-1}), growth rate (mg worm^{-1} day^{-1}) total number of cocoon, total hatchling number and mortality rate of both worms were recorded. 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. The probability levels used for statistical significance were $P < 0.05$ for the tests.

RESULTS AND DISCUSSION

Earthworm biomass production, reproduction rate and mortality of *P.ceylanensis* and *L. mauritii* in different studied vermicomposting treatments (VT_1 – VT_{12}) were evaluated. Statistically *P.ceylanensis* and *L. mauritii* showed significant difference in biomass production and reproduction potential, i.e., maximum biomass gained at end (mg worm^{-1}), net biomass gain (mg worm^{-1}), growth rate (mg worm^{-1} day^{-1}), total number of cocoon, total hatchling number and mortality rate of worms among different vermicomposting treatments (Tables 1- 4). *P.ceylanensis* showed a maximum and minimum mean individual biomass achieved at end on VT6, VT5 and VT4 treatments, respectively (Table 1). Similarly, *L. mauritii* showed a maximum and minimum mean individual biomass gained at end on VT12 and VT9 treatments, respectively (Table 3). Further, *L. mauritii* showed significantly higher mean individual weight gained in VT12, followed by VT11, VT10, VT8 and VT9, respectively. However, in the present study biomass gain (mg worm^{-1}) and growth rate (mg worm^{-1}) of *P.ceylanensis* in VT6 treatment was higher than other treatments

studied and the order of net biomass gain and growth rate (mg worm^{-1}) among treatments was: VT6> VT5> VT4> VT2 >VT3 (Table12). Similarly, net biomass gain (mg worm^{-1}) of and growth rate (mg worm^{-1}) of *L. mauritii* in VT12 treatment was higher than other treatments studied. The order of net biomass gain and growth rate (mg worm^{-1}) among treatments was: VT12> VT11> VT10> VT8 > VT9 (Table 3).

Table 1. Treatment proportion of sago bagasse and biogas plant slurry

Vermicomposting treatments	Substrate Proportion
P.ceylanensis	
VT1	SB (100%) + BPS (0%)
VT2	SB (0%) + BPS (100%)
VT3	SB (80%) + BPS (20%)
VT4	SB (60%) + BPS (40%)
VT5	SB (40%) + BPS (60%)
VT6	SB (20%) + BPS (80%)
L.mauritii	
VT7	SB (100%) + BPS (0%)
VT8	SB (0%) + BPS (100%)
VT9	SB (80%) + BPS (20%)
VT10	SB (60%) + BPS (40%)
VT11	SB (40%) + BPS (60%)
VT12	SB (20%) + BPS (80%)

VT-Vermicomposting treatment; SB- Sago bagasse; BPS - Biogas plant slurry.
The figures in parenthesis indicate the percent content in the initial substrate.

Table 2. Initial physico chemical properties of sago bagasse and biogas plant slurry

Property	Sago bagasse	Biogas plant slurry
pH	5.2±0.07	7.9±0.06
TOC (g kg^{-1})	472.7±32	407.5±21
TN (g kg^{-1})	5.4±0.13	6.9±0.21
TP (g kg^{-1})	4.7±0.11	5.8±0.15
TK (g kg^{-1})	3.2±0.21	4.3±0.11
Ca (g kg^{-1})	1.2±0.06	2.1±0.09
Mg (g kg^{-1})	1.5±0.04	1.1±0.05
Na (g kg^{-1})	1.5±0.06	1.4±0.03
C/N	87.5±4.5	59.1±2.5

All values are mean of six replicates

Table 3. Biomass production by *P. ceylanensis* in different vermicomposting treatments of SB with BPS after 12 weeks (mean ± SEM, n=6)

Vermicomposting treatments	Mean initial biomass Worm^{-1} (mg)	Max. biomass gained Worm^{-1} (mg)	Net biomass gained Worm^{-1} (mg)	Growth rate Worm^{-1}day^{-1}
VT1	107±5.4	ND	ND	ND
VT2	105±3.5	614±6.4	509±2.9	7.0±0.03
VT3	109±6.2	611±11.8	502±5.6	6.0±0.06
VT4	106±7.5	734±14.5	628±7.0	7.5±0.08
VT5	111±6.3	772±17.2	661±10.9	7.9±0.12
VT6	108±7.4	781±13.6	673±6.2	8.0±0.07

ND-Not detected; all values are reported as mean ± standard deviation between six replicates.

Table 4. Reproduction rate of *P. ceylanensis* in different vermicomposting treatments of SB with BPS after 12 weeks (mean ± SEM, n=6)

Vermicomposting treatments	Total no. of cocoon after 84 days	Total no. of hatchlings after 84 days	Total mortality after 84 days (%)
VT1	ND	ND	100±0.0
VT2	261±21	82±6	12.5± 5.0
VT3	228±34	80±12	45.8 ± 10.5
VT4	365±20	137±21	11.4 ± 4.2
VT5	394±25	139±19	5.2 ± 0.5
VT6	418±18	142±26	5.0 ± 0.9

ND-Not detected; all values are reported as mean ± standard deviation between six replicates.

Table1 5. Biomass production by *L.mauritii* in different vermicomposting treatments of SB with BPS after 12 weeks (mean ± SEM, n=6)

Vermicomposting treatments	Mean initial biomass Worm^{-1} (mg)	Max. biomass gained Worm^{-1} (mg)	Net biomass gained Worm^{-1} (mg)	Growth rate Worm^{-1}day^{-1}
VT7	145 ± 3.7	ND	ND	ND
VT8	149 ± 11.0	728±14.5	583±3.5	7.2±0.04
VT9	152 ± 8.3	705±12.4	553±4.1	6.6±0.07
VT10	144 ± 5.4	827±14.6	683±9.2	8.1±0.04
VT11	148 ± 10.4	851±14.3	703±3.9	8.4±0.05
VT12	145 ±8.5	859±16.8	714±8.3	8.5±0.03

ND-Not detected; all values are reported as mean ± standard deviation between six replicates.

Table 6. Reproduction rate of *L.mauritii* in different vermicomposting treatments of SB with BPS after 12 weeks (mean ± SEM, n=6)

Vermicomposting treatments	Total no. of cocoon after 84 days	Total no. of hatchlings after 84 days	Total mortality after 84 days (%)
VT7	ND	ND	100±0.0
VT8	127±18	62±5	9.7± 3.1
VT9	85±15	48±9	26.4 ± 8.5
VT10	126±14	71±7	8.9 ± 5.3
VT11	135±11	84±11	4.3 ± 0.7
VT12	141±13	83±8	4.5 ± 0.6

ND-Not detected; all values are reported as mean ± standard deviation between six replicates.

The findings from the present study, in the context of change in individual weight of worms with the stocking density corroborates with the findings of other researchers [16, 17]. (Ndegwa *et al.*, 2000; Monroy *et al.*, 2006). Edwards *et al.* [7] reported that population density of worms per unit volume or weight of feed was important in affecting the rate of biomass. Neuhauser *et al.* [18] studied impact of population density on biomass growth of *E. fetida* and reported that growth of worms was related to the substrate material. Suthar [19] reported that in addition to the biochemical properties of waste, the microbial biomass and decomposition activities during vermicomposting are also important in determining the worm biomass production. The results clearly suggested that importance of amendment (BPS) in vermicomposting of SB and may be justified in terms of the physical, chemical and biological nature of the amendment for vermicomposting.

The total cocoon numbers varied among treatments and maximum and minimum cocoons obtained at the end were in VT6 and VT3 treatment for *P.ceylanensis* and VT12 and VT9 treatment for *L.mauritii*, respectively. Similarly, the maximum number of hatchlings was observed in VT6 and VT3 treatment for *P.ceylanensis* and VT12 and VT9 treatment for *L.mauritii*, respectively (Table 2 and 4). The variation in cocoon numbers and number of hatchings in VT6, VT7 and VT5 for *P.ceylanensis* and VT12, VT11 and VT10 for *L.mauritii* was insignificant ($p<0.05$), respectively. In the present study *P.ceylanensis* and *L. mauritii* showed a statistically different pattern of mortality among different vermicomposting treatments, respectively. The 100% worm mortality (% of initial population) was recorded in SB alone treatment for both species of worms which indicate some growth retarding substances in it (Table 2 and 4). However, mortality was lower in those waste mixtures which had less SB concentrations (up to 60%) for both worms. Meharaj and Manivannan [20] have also reported some earthworms mortality during the vermicomposting of biogas plant slurry mixed with crop residues. The different mortality rates during vermicomposting may be due to the difference in the quality and chemical composition of waste mixtures used. The survival rate of earthworms also depends upon the rate of food consumption during acclimatization of worms in the waste mixtures during initial period vermicomposting. Moreover, changes in pH of substrate, higher C:N ratio of initial substrate and production of toxics or foul smelling gases maybe some of the factors responsible earthworms mortality [21] . The growth and reproduction of the *P.ceylanensis* and *L. mauritii* was best when allowed to feed up to 60% SB amended with BPS. If the prime concern is vermiculture (production of earthworms), then addition of SB up to 60 with BPS is recommended as it was found most effective to support a sustainable harvest of earthworms for vermicomposting purposes.

CONCLUSION

In the present study revealed that addition of more than 60% SB with BPS was not efficient to support various earthworms growth parameters, i.e., biomass production, growth rate, cocoon and hatchlings production for *P.ceylanensis* and *L. mauritii*. Finally it was concluded that if SB and BPS are blended in proper quantities, it would

be most effective to support a sustainable harvest of earthworms for vermicomposting purposes. Among the two native species of worms, *P. ceylanensis* exhibits better biomass production, growth rate, cocoons and hatchlings production than *L. mauritii*.

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