Conversion of sago wastes for biofertilizer production using *Lampito mauritii* and its effect on growth performance of *Amaranthus campestris*

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Utilization of agro-industry wastes in the production of biofertilizers by vermicompost method with analysis of their micro and macro nutrients was done to ascertain their efficiency in farming. In this bioconversion process, earthworms feed on the farm wastes products. Agro industry waste, sago solid waste was blended with cow dung manure in the ratio of 1: 1 and vermicomposted for 60 days in an earthen pot using *Lampito mauritii* earthworm species. Temperature, pH and moisture content were daily monitored. The analysis of the micro and macro mineral nutrients of the vermicompost and the synthetic fertilizer were done using standard protocol. Both the vermicompost and the synthetic fertilizer were used for the cultivation of Spinach (*Amaranthus campestris*). Among the five different sample of sago solid waste mixture tested, the T4 and T5 treatments showed better quality vermicompost with higher nutritional status, morphological parameters (total, shoot and root length, fresh and dry weight of the plant) pigmentation (chlorophyll 'a', chlorophyll 'b', total chlorophyll) of *A. campestris.* This work suggests that biostabilization of sago industry solid waste using earthworm could be a potential technology to convert noxious industrial by–product into nutrient rich biofertilizer.

Key words: *Amaranthus campestris,* bio-fertilizer, *Lampito mauritii*, Sago mill waste

INTRODUCTION

Agriculture is an important sector of Indian economy as it contributes about 17% to the total GDP and provides employment to over 60% of the population. Generally, the agriculture was mainly based upon a package of various agricultural inputs, namely the use of high-yielding varieties of different crops, water, pesticides and chemical fertilizers. Currently, the total agricultural output is lost due to depletion of soil fertility and also partially associated with unfavourable distribution of rainfall, drought, storm and floods.

The major problem faced by the farmers are high cost of inorganic fertilizers require for the plant growth (Anita *et al*. 2013). The chemical fertilizer pollutes the air, soil and water polluting agents during the production of crops. Similarly indiscriminate and excessive use of pesticides produced health hazards in animals and human beings and soil macro/micro flora and fauna (Gupta and Singh, 2008). Thus, to reinforce the development of sustainable agriculture, use of bio-fertilizers has assured great promise to mete out the nutrient demand.

Agricultural-based industries produced the vast amount of residues every year. These residues are released to the environment without proper disposal procedure that may cause to environmental pollution and harmful effect on human and animal health. So, now it is a worldwide concern to dictating the improvement of alternative cleaner and renewable bioenergy resources (Okonko *et al*. 2009). The process of composting of organic material using community, physical and chemical properties are popularly known as the farmer's friend. Vermicomposting is increasingly becoming popular as an organic solid waste management strategy. In this bio-conversion process, earthworms feed on the organic waste to produce vermicasts and vermiwash as products. The vermicasts also termed vermicompost are rich in nitrogen (N), phosphorous (P) and potassium (K) as well as trace elements. Vermiwash is obtained as a leachate during the vermicomposting

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process and is also a liquid bio-fertilizer (Manyuchi, 2013).

Sago palm (*Metroxylon sagu* Rott.) is one of the few starch-bearing palm species found in the tropics which grows on peat soils and wetlands. A high concentration of starch deposit occurs in the trunk of the palm and it has been harvested to produce starch for human consumption and industrial purposes (Alimon, 2009). In tapioca cultivation, India is one of the largest producers of sago in the world. In India, Tamil Nadu State stands first (64%) in respect of tapioca production and also processing of tapioca into starch and sago. Tapioca is being cultivated in major 14 districts including Namakkal (21%), Dharmapuri (19%), Salem (15%), Villupuram (14%), Trichy (9%), Erode (5%) and Thiruvannamalai (5%) in an area of 1.21 lakh hectare. During sago starch extraction, a large amount of effluent generated and these effluents containing rich in carbohydrates, fibers and dense suspended solids, unextracted starch, cellulose (fibrous residue from pith), nitrogenous compounds, cyanoglucosides and insoluble fibers and reported to be acidic and emitting a foul smell thus causing pollution and deteriorating the environment quality globally (Wee*et al*. 2017). In the view of above facts, the present study has been initiated to investigate the conversion of sago wastes for biofertilizer production using *Lampito mauritii* and its effect on growth performance of *Amaranthus campestris.*

MATERIALS AND METHODS

Solid sago wastes are collected from Varalakshmi Sago factory, Mallur, Salem district of Tamil Nadu. Cow dung is collected from the nearby cattle farms. The physiochemical parameters of sago wastes and cow dung i.e., pH, EC, organic carbon, nitrogen, phosphorous, potassium, sulphur, zinc, boron and iron were analyzed by using standard method of Tandon, (1993) and Vasanthi *et al.*(2014). A pilot experiment with six plastic pots (25cm diameter and 40cm height) carries 3.0 kg of substrates (sago solid waste + dry cow dung at 1:1 ratio) with a small hole at the bottom to remove the excess water with three replication was carried out in KandaswamiKandars College, Velur, Namakkal, Tamil Nadu, India. Biofertilizers (*Azospirillum*, *Phosphobacterium*, and *Rhizobium*) along with 1.0 g/kg tosubstrate were added (Subramaniam, 2006) as shown Table1. These substrates were subjected to pre-decomposing process for 20 days. Native earthworms (*Lampito mauritii*) (30nos.) were introduced to each experimental tub. Approximately 60 – 80% of moisture level was maintained throughout the experimental period (60 days) by the sprinkle of a sufficient quantity of tap water. After 60 days, the vermicompost was formed from sago waste + cowdung mixture and it was analyzed in the laboratory to determine the different physicochemical parameters by using the method of Tandon (1993) and Vasanthi *et al.* (2014).

Amaranthus campestris seeds were procured from Priya Agro Farm, Namakkal, Tamil Nadu. The experimental plots were arranged in Completely Randomized Design (CRD) with triplicate. *A. campestris* seeds (5.0 g) were sown in the experimental plot (size 60 x 60 cm) with a gap of 15cm between each plot. Plots werelabeled as T0- Control (Soil alone); T1- Vermicompost; T2- Vermicompost +*Azospirillum*; T3- Vermicompost + *Phosphobacterium*; T4- Vermicompost +*Rhizobium*; T5 Vermicompost +*Azospirillum* + *Phosphobacterium* + *Rhizobium.*Each experimental plot received 200 g of respected vermicompost samples at 3 days interval and water sprinkled daily twice.

Growth parameters of *A. campestris* were recorded on 15th day after germination. Growth parameters were assessedby random sampling from the experimental plots such as chlorophyll, shoot length (cm), root length (cm), fresh plant weight (g), dry plant weight (g), dry matter (%), moisture (%), leaf length (cm), leaf breadth (cm), chlorophyll A, B, and total (mg/g). The chlorophyll content was analysed following method of Lichtenthaler (1987).The physico-chemical parameters of sago mill waste vermicompost and *A.campestris* plant growth, along with biochemical analysis data were statistically computed by One-way ANOVA. The software used was graphpad prism software.

RESULTS AND DISCUSSION

Physico-chemical properties of Sago waste, cowdung and vermicompost

The data in Table 2 shows the result of the physical and chemical analysis of the raw sago waste, cow dung and vermicompost (Sago waste + cowdung). Wide variations of physical and chemical

Table.1. Decomposed substrates along with Earthworms (*Lampito mauritii*) and biofertilizers

Experiments	Sago Solid Waste + Cow Dung (Ratio)	Earthworm and Biofertilizers (1g/kg)
T1	1 : 1	*Lampito mauritii*
T2	1 : 1	*L.mauritii+ Azospirillum*
T3	1 : 1	*L.mauritii+ Phosphobacterium*
T4	1 : 1	*L.mauritii+ Rhizobium*
T5	1 : 1	*L.mauritii+ Azospirillum + Phosphobacterium + Rhizobium*

Table. 2: Physico-chemical analysis of Sago waste, cowdung and vermicompost

Experiments	pH	EC dS m^{-1}	OC (%)	N (%)	P(%)	K(%)	S (%)	Zn (ppm)	B (ppm)	Fe (ppm)
Sago waste	6.31 ±0.15	3.11 ±0.36	42.53 ±2.73	0.72 ±0.14	0.36 ±0.05	0.27 ±0.05	0.85 ±0.06	3.36 ±0.18	0.49 ±0.10	1.27 ±0.07
Cow dung	7.72 ±0.07	2.22 ±0.43	55.60 ±1.90	1.61 ±0.24	0.62 ±0.08	0.62 ±0.08	1.48 ±0.19	5.67 ±0.36	0.79 ±0.05	2.40 ±0.11
T1	7.60 ±0.05	5.41 ±0.88	43.97 ±0.64	2.69 ±0.13	2.17 ±0.07	2.79 ±0.41	1.15 ±0.05	2.54 ±0.17	0.82 ±0.02	3.43 ±0.26
T2	7.77 ±0.08	3.17 ±0.25	41.25 ±3.42	3.06 ±0.36	2.50 ±0.09	2.86 ±0.30	1.10 ±0.07	2.94 ±0.19	0.85 ±0.02	3.60 ±0.16
T3	7.85 ±0.08	3.79 ±0.47	36.98 ±1.86	3.07 ±0.50	2.67 ±0.63	2.87 ±0.10	1.06 ±0.04	3.21 ±0.08	0.87 ±0.03	3.66 ±0.32
T4	7.92 ±0.24	3.38 ±0.26	38.57 ±3.30	3.17 ±0.33	2.86 ±0.45	2.96 ±0.30	1.25 ±0.09	3.52 ±0.14	0.89 ±0.07	3.73 ±0.16
T5	7.93 ±0.20	3.36 ±0.19	39.41 ±2.73	3.33 ±0.41	2.80 ±0.15	3.04 ±0.27	1.03 ±0.12	3.46 ±0.13	1.14 ±0.09	3.61 ±0.12

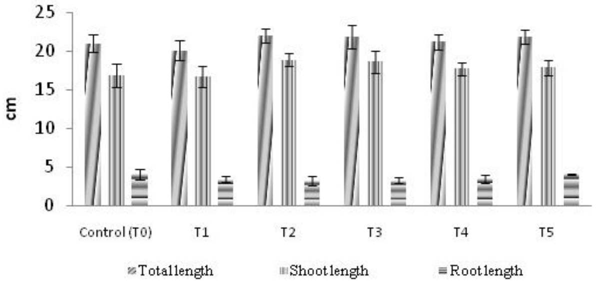

Fig. 1. Growth of *A. campestris* on the 15th day of germination

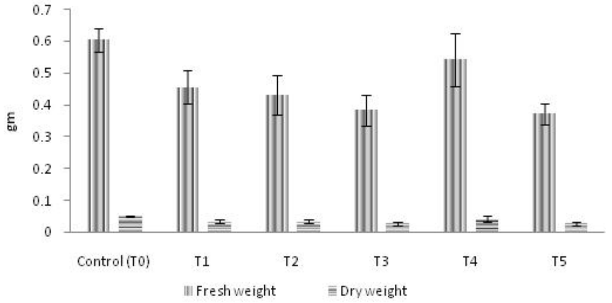

Fig. 2: Fresh and Dry weight of *A.campestris* on the 15th day of germination

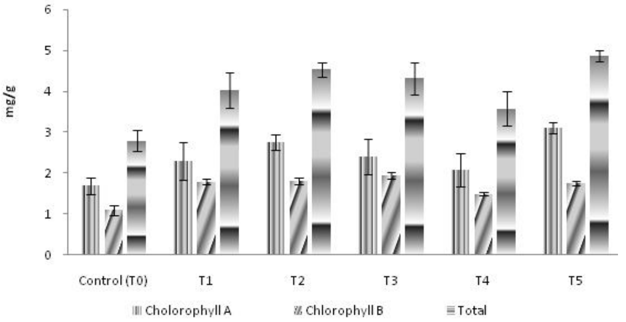

Fig. 3: Chlorophyll content of *A.campestris* on the 15th day of germination

constituents of raw sago waste and compost were obtained. Ramesh *et al.*(2013) had reported that the physico-chemical features of water have significant influence on the biodegradability and toxicity of pollutants.

The pH of the sago waste was 6.31 and it increased progressively i.e., 7.60 to 7.93 by the secretion of calciferous gland of earthworms on the 60th day of the experiment. pH of organic matter has a significant impact on the efficiency of overall process and it could be the limiting factor for the survival and growth of earthworms. After vermicomposting usually pH decreases from alkaline to acidic or neutral. The pH change towards neutrality may be due to the mineralization of nitrogen and phosphorus into nitrites or nitrates and orthophosphates. Pramanik *et al*. (2007) have postulated that composition of organic matter leads to the formation of ammonium (NH_4) ions and humic acids. Suthar and Singh (2008) also reported that the shift in pH could be due to microbial decomposition during the process of vermicomposting. The electrical conductivity of the sago waste was 3.115 dS m^{-1} and it was higher in all vermicompost experiment, particularly T1 treatment (5.41dS m^{-1}). Janakiram and Sridevi (2011) have reported that the electrical conductivity in matured aerobic compost increased as the composting period progressed. The organic carbon of the sago waste was 42.53 and it was found to decrease at almost all vermicompost experiments except T1 experiment. The highest organic carbon (43.97) was recorded in T1 experiment and the lowest organic carbon (36.98) was recorded in T3 experiment. Organic carbon decreased in all the treatments except T1 during vermicomposting. Earthworms break and homogenize the ingested material through muscular action of their foregut and, also add mucus and enzymes in ingested material, this increase the surface area for microbial action. The combined action of earthworms and microorganisms may be responsible for OC loss from the organic wastes in the form of CO_2 (Prakash and Karmegam, 2010).

The nitrogen content in the vermicompost mixture increased gradually in all the samples and this increase was the highest significant at T5, 3.33%; followed by 3.17% in T4. According to Medina-Sauza *et al*. (2019) reduction in organic carbon due to substrate utilization by microbes and earthworms and their metabolic activities as well as water loss by evaporation during mineralization of organic matter might be responsible for nitrogen addition. The study conducted by Singh (2009) indicated increased values of *Azotobacter* (the nitrogen fixing bacteria) in vermicompost as compared to the conventional aerobic and anaerobic composts.In the present study the higher amount of potassium was observed in all the experiments while it was lower in raw sago waste (0.36%). The highest potassium (3.04%) was recorded in T5sample and the lowest potassium (2.79%) was recorded in T1 experiment. Potassium is one of the essential nutrients for plant growth along with nitrogen and phosphorus. It is used by plants in several physiological processes including manufacturing and movement of sugars, cell division, root development etc. Similarly, John Paul *et al*. (2011) have also reported an increase in potassium in vermicomposts after bioconversion of municipal solid wastes by *Perionyx ceylanensis* earth worm.

The phosphorous content in the vermicompost mixture increased gradually in all the samples and this increase was the highest significant in T4, 2.86%; followed by 2.80% in T5(Huang *et al.* 2014) reported that the increase in total P was attributed to the net loss of dry mass, which generally concentrated the phosphorus in the composting pile. Sulphur content was maximum in all the experiments T1 to T5 (1.03 to 1.25) while it was 0.85% in raw sago waste. Sulfur promotes the efficiency of nitrogenous and phosphorus fertilizers and increases the efficiency of crops to uptake micronutrients (Halfawi *et al*. 2010). Similarly, Almatawahand Al-Surrayai(2019) reported that the soils amended with sulphur was significantly increased soil SO_4 levels upon the addition of organic matter compared with sulfur alone or organic matter alone.

Zinc content high in T4 experiment with 3.52 ppm and low at T1 experiment with 2.54 ppm. Yadav and Garg (2010) reported that zinc concentrations were 20-110% higher in vermicompost of the food industry sludge. The boron content was high in the T5 experiment with 1.14ppm and low in raw sago waste with 0.49ppm. Boron plays an important role in the physiological process of plants, such as cell elongation, cell maturation, meristematic tissue development, and protein synthesis (Shireen *et al.*2018). Chitdeshwari and Poongothai, (2003) observed that the positive role of Boron in quality improvement through its involvement in the synthesis of protein and amino acids. Maximum iron (Fe) content was observed in T4 experiment (3.73ppm) and minimum in raw sago waste with 1.17 ppm.

Growth of Amaranthus campestris with sago waste vermicompost

The total length of the *Amaranthus campestris* plant in control was 21.002cm. In the treatments T2 showed the highest height of 22.054 cm in compared to other experiments least was observed in T1 treatment. Shoot length was high in T2 treatment with 18.862 cm and low in the T1 treatment with 16.698 cm, in control shoot length was 16.912cm. Root length was high in control with 4.090 cm in compared to the other treatment and the length of the root was from 3.192 to 4.078 cm (Fig. 1). Enhanced root growth was probably due to vermicompost improved the soil's physical properties particularly soil porosity, structure, water holding capacity and supplied other plant growth-promoting substances. Thus the application of vermicompost significantly increased plant growth by improving soil physical properties (Jagan *et al*. 2014).

The fresh weight per plant was higher in control with 0.603 g followed by 0.542 g in the treatment T4. Maximum dry weight per plant (0.041 g) was observed in T4 and lowest was observed in T5 with 0.027 g, and the dry weight was lowest in the control (Fig. 2). The enhanced plant growth may be due to the beneficial microbes in the biofertilizers and plant growth regulators and other plant growth influenced factors present in the vermicompost (Pathma and Sakthivel, 2012)

Chlorophyll A and B content were high in T5 experiment, lowest was observed in the control (Fig. 3).Results of present study are also in line with the findings of Amiri *et al*. (2017) that vermicomposting significantly increased chlorophyll contents. During plants vegetative growth period the total chlorophyll content increases up to flowering time and then its level reduces in reproductive and senescence periods (Riccardi *et al*. 2014).

CONCLUSION

The present study shows that vermicomposting can be used as a potential tool to bio-convert sago solid waste into vermicompost. However, it is suggested that the sago solid waste should be mixed and blended (cowdung and *Lampito mauritii*) with easily degraded substrate before it could be applied. In general, sago solid waste mixtures yielded better quality vermicompost. Among all the sago solid waste vermicompost, the Vermicompost + *Rhizobium* and Vermicompost +*Azospirillum* + *Phosphobacterium* + *Rhizobium*(T4 and T5 treatments) showed better quality vermicompost with higher nutritional status as compared to the other mixtures. The application of sago industry based vermicompost has increased the morphological parameters (total, shoot and root length, fresh and dry weight of the plant) pigmentation (chlorophyll 'a', chlorophyll 'b', total chlorophyll) of the *A. campestris* in all the treatments. The best results were observed in T4 and T5 sago vermicompost throughout the experiments. This work suggests that biostabilization of sago industry solid waste using earthworm could be a potential technology to convert noxious industrial by– product into nutrient rich biofertilizer.

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