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Thippi Compost: A Possible Avenue for Cassava Starch Factory Solid Waste Management

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Abstract

In India, cassava cultivation is mostly confined to South India. In Tamil Nadu, cassava tubers are used as an industrial raw material for starch and sago production. About 8-10 large scale starch factories and 150-200 small scale starch and sago production units in Tamil Nadu are producing around 40-60 tonnes of solid waste (thippi) per annum creating serious environmental pollution. The present study was undertaken to explore the possibility of managing the waste by composting it into a nutrient rich organic manure. A representative composite thippi sample was made from different lots of the samples collected from the cassava starch factory premises in Tamil Nadu. Physico-chemical, biochemical and microbiological analysis of thippi revealed that it has high water holding capacity (89%), good porosity (94.6%) and low bulk density (0.58 g cm^{-3}). Thippi was acidic in nature with very low nutrient content and very high C:N ratio (82:1), which makes it unsuitable as a manure. Hence it was enriched with cheap and easily available nutrient rich sources like cassava leaves/*Gliricidia* leaves/*Azolla* for N, apart from cow dung, P and K sources viz., Mussooriephos and rock powder respectively involving three different composting agents viz., microbial consortium containing *Trichoderma*, P and K solubilisers, waste management culture and earthworm (*Eudrilus eugeniae)*. Composting was done on a pilot scale for a period of two months with nine treatment combinations. The mean N, P, K, Ca, Mg, Fe, Cu and Mn contents of thippi compost was 1.32%, 3.82%, 0.4%, 2.18%, 0.96%, 1.11%, 0.08%, 11.23 ppm and 89.93 ppm respectively, which is 3.5, 49, 7, 3.25, 8.1, 185, 100, 2.5 and 12 times than that in thippi. Starch, cellulose and C:N ratio in thippi compost were reduced but protein was enhanced considerably without any cyanide and fibre contents. Among the treatment combinations, thippi enriched with cow dung, cassava leaves and *Gliricidia* leaves along with Mussooriephos and rock powder composted by earthworm was found to be the best.

Key words: Thippi, cassava, compost, C:N ratio, earthworm

Introduction

In India, cassava cultivation is mostly confined to South India especially in the states of Kerala, Tamil Nadu and Andhra Pradesh. In Tamil Nadu, cassava is grown as an industrial crop for the large scale production of starch and sago. It is known that, besides about 8-10 large scale starch factories, about 150-200 small size sago and starch production units are in operation in Tamil Nadu, generating about 40-60 tonnes of solid waste per annum (Tapasnandy et al., 1996). Hence, the cassava processing industry is often perceived by local people as contributing significantly to environmental damage especially to soil biological health.There is dearth of information on the extent of soil damage due to cassava starch factory solid waste as well as the positive and negative impacts of these residues on crop production. Hence, the objective of the present study was to find out the possible ways to utilize the solid residue for plant nutrition in a recycling mode.

Materials and Methods

Estimation of thippi

A rapid survey was conducted in Salem district of Tamil Nadu, where large scale starch factories and small scale starch and sago production units are concentrated. The samples of thippi collected from different starch factory premises of Salem district, Tamil Nadu was mixed together and a representative sample was formed. These samples were analysed for their physical properties viz., colour using Munsell colour chart, water holding capacity, bulk density and porosity using Keen Rackzowski method (Iswaran,1980). The chemical properties viz., pH, organic carbon (OC), primary nutrients viz., total nitrogen (N), phosphorus (P), potassium (K), secondary nutrients viz., calcium (Ca), magnesium (Mg) and micronutrients viz., iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) were analysed following standard analytical procedures for organic manures (FAI, 2011). The population of bacteria, fungi and actinomycetes colonies were estimated following the procedure of Wollum (1982) using specific media for each organism.The biochemical properties viz., starch, cellulose, fibre, protein and cyanide were also determined (Sadasivam and Manickam, 1991).

Composting procedure

As thippi was found very poor in all the essential elements, it was first enriched with N, P and K rich raw materials. Cow dung cassava leaves, *Gliricidia* leaves and *Azolla* as N source, Mussooriephos as P source and rock powder as K source were used for enriching the thippi.

The three different composting agents used were a microbial consortium containing *Trichoderma*, P and K solubiliser; a waste management culture and earthworm (*Eudrilus eugeniae).* There were nine treatment combinations, which included three combinations of raw materials and three composting agents (Table 1). The solid waste (thippi), raw materials and composting agents were taken in the ratio 5:1: 0.05.The raw materials viz., cow dung, cassava leaves/*Gliricidia* leaves, *Azolla*, Mussooriephos and rock powder were also analysed for their nutrient contents following standard analytical procedures (FAI, 2011).

A pilot scale preparation of the compost was undertaken for a period of two months in large plastic basins of 0.8 m diameter and 0.5 m height with fabricated metallic wire mesh lids in order to ensure both aeration as well as protection from rodents. Proper moistening of the mixture was done at periodic intervals to maintain moisture content at 40-60% for enabling better composting. After the stipulated period, the decomposed mixture obtained was properly dried under shade for one week, passed through 2 mm sieve and the manure

Table 1. Treatment details of thippi composting

Treatments	Components	Culture /organism used	*Ratio
T_1	Thippi, cow dung, Mussooriephos, rock powder	Microbial consortium	5:1:0.1:0.1:0.1
T_2	Thippi, cow dung, Mussooriephos, rock powder	Earthworm (200 number)	5:1:0.1:0.1
T_3	Thippi, cow dung, Mussooriephos, rock powder	Waste management culture	5:1:0.1:0.1: 0.1
T_4	Thippi, cowdung, *Gliricidia* leaves, cassava leaves, Mussooriephos, rock powder	Microbial consortium	5:1:0.5:0.5:0.1:0.1: 0.1
T_5	Thippi, cowdung, *Gliricidia* leaves, cassava leaves, Mussooriephos, rock powder	Earthworm (200 number)	5:1:0.5:0.5:0.1:0.1:0.1
T_6	Thippi, cowdung, *Gliricidia* leaves, cassava leaves, Mussooriephos, rock powder	Waste management culture	5:1:0.5:0.5:0.1:0.1:0.1
T_7	Thippi, cowdung, *Azolla*, Mussooriephos, rock powder	Microbial consortium	5:1:1:0.1:0.1:0.1
T_8	Thippi, cowdung, *Azolla*, Mussooriephos, rock powder	Earthworm (200 number)	5:1:1:0.1:0.1:0.1
T_9	Thippi, cowdung, *Azolla*, Mussooriephos, rock powder	Waste management culture	5:1:1:0.1:0.1:0.1

*Ratio of the components and culture/organism used obtained was kept in dry polythene bags for further studies.

Estimation of thippi compost and statistical analysis

The composts made from the nine different treatments were further analysed for their physico-chemical, biological and biochemical properties as in the case of thippi. The population of N fixers (Jensen, 1950), P and K solubilizers (Girgis et al., 2008) were also estimated. Data were subjected to statistical analysis using Duncans Multiple Range Test (DMRT).

Results and Discussion

Rapid appraisal of the environmental pollution due to thippi

Cassava processing industry was found to have negative effects, mainly site specific effects on the environment by producing unpleasant odours and unsightly display of waste. It was understood that during the rainy season the leachates would pollute the ground water supply.

Physico-chemical, biological and biochemical properties of thippi

Physical properties

Based on Munsell colour chart, the colour of thippi was 10YR8/3 (whitish cream). Analysis of physical properties of thippi indicated high water holding capacity (89%), good porosity (94.6%) and low bulk density (0.581 g cm^{-3}).

Chemical properties

The thippi is acidic in nature with a mean pH value of 3.6 and very poor contents of both major, secondary and micronutrients. The organic C content of thippi was 31% and the electrical conductivity was 2.8 dS m^{-1}. The N, P, K, Ca, Mg, Fe, Cu, Mn and Zn contents of thippi was 0.38%, 0.07%, 0.05%, 0.056%, 0.06%, 60 ppm, 4.3 ppm, 7.8 ppm and 7.5 ppm, respectively. The C:N ratio of thippi was found to be very wide (82:1) indicating that it was not at all suitable for soil application as a manure as it can immobilize the soil available nutrients during decomposition resulting in a temporary nutrient depletion (Allison, 1973).

Biochemical properties

The biochemical analysis revealed high content of starch (60%), cellulose (22%), fibre (6-9%), low protein (2.4%) and negligible cyanide (10.7 ppm) content.

Microbiological properties

Microbiological characterization revealed very few bacterial colonies (3×10^6 cfu ml^{-1}) and there was no evidence of actinomycetes and fungi.

Nutrient composition of the raw materials used for composting

The raw materials viz., cow dung, *Gliricidia*, cassava leaves, *Azolla*, Mussooriephos and rock powder used for enriching thippi while composting also were analyzed for their nutrient contents and the results are given in Table 2. Manios (2004) recommended the incorporation of nutrient rich organic wastes to ensure a good final product of the composted manure.

Physico-chemical, biological and biochemical properties of thippi compost

According to Jimenez and Garcia (1989) and Brinton (2000), the compost quality is determined by its physical, chemical and biological characteristics.

Physical properties

The thippi compost had hue of 5 YR, 7.5 YR and 10 YR, value of 3, 4 and 5 and chroma of 2, 3, 4 and 6. The colour was brownish black. According to Dick and Mc Coy (1993), colour is one of the most important aspects determining the maturity of the compost and the ideal colour for mature compost is brown to black and crumbly

Table 2. Nutrient content (%) of organic materials used for composting

Materials	N	P_2O_5	K_2O	Ca	Mg	Fe	Mn	Cu	Zn
Cow dung	1.02	1.13	0.65	0.172	0.850	0.586	0.075	0.0105	0.0241
Azolla	3.01	0.33	1.40	0.671	0.241	0.386	0.108	0.0021	0.0077
Gliricidia leaves	3.71	0.24	1.90	0.611	0.210	0.068	0.040	0.0009	0.0023
Cassava leaves	3.22	0.51	0.68	0.417	0.221	0.126	0.048	0.0005	0.0097
Mussooriephos	-	34.00	-	-	-	-	-	-	-
Rock powder	-	-	0.021	-	-	-	-	-	-

with an earthy smell. The thippi compost had these qualities and can be regarded as a mature compost.

The moisture content of thippi compost ranged from 14.57 to 19.13% in the different compost treatments. The treatment,T_8 had the significantly highest (19.13%), which was on par with all the treatments, except T_1 and T_2. Porosity was significantly highest for the treatment,T_5 (71.14%), which was on par with T_6. The treatment,T_4 had the highest water holding capacity of 73.71%, which was on par with T_3, T_5, T_6 and T_9. Bulk density was lowered significantly in T_4 (0.23%), which was on par with T_2, T_5, T_6 and T_9. The mean moisture content, water holding capacity, porosity and bulk density values were 17.02%, 73.8%, 70.1% and 0.236 g cm^{-3}respectively (Table 3).

Chemical properties

The thippi compost obtained under the different treatment combinations had substantially very high major, secondary and micronutrients. The highest contents of N, P and K of 2.38, 3.78 and 0.51% were observed in the treatments T_5, T_2 and T_6 respectively. (Table 4). The N, P and K contents in the thippi compost increased by 2-6, 40-55 and 5-10 times more than that in thippi. The treatments, T_1 and T_7 had highest contents of Ca and Mg, whereas the treatment, $T_{2,}$ had all the micronutrients at the highest level. The mean Ca and Mg contents of thippi compost were 2.18 and 0.97% respectively, with Ca content in the range of 1.42-2.66% and Mg content of 0.77- 1.16%. The mean Fe, Mn, Cu and Zn contents of the thippi compost was1.11%, 0.08%, 11.23 ppm and 89.93 ppm respectively. The C:N ratio of the composted thippi was 8:1. Dick and McCoy (1993) reported the C:N ratio of a mature compost as 10:1 and according to Hue and Sobieszczyk (1991), C:N ratio of $<$15:1 strongly favours the mineralization process.

Among the different treatment combinations, thippi enriched with cow dung, cassava leaves and *Gliricidia* leaves along with Mussooriephos and rock powder composted with earthworm was found to be the best as it may be economical as the raw materials are cheap, easily available and nutrient rich. According to Jeyabal and Kuppuswamy (2001), vermicomposting using earth worms can accelerate the mineralization rate and can convert the raw materials into casts with higher nutritional value than traditional composting methods which can sustain soil quality and better productivity.

The nutrient contents in thippi compost prepared from different treatment combinations are presented in Table 4.

Biological properties

The microbiological analysis also showed high population of bacteria, fungi, actinomycetes and a few N fixers and P solubilisers (Table 5). In the treatments,T_1, $T_4$and T_5, where microbial consortium containing *Trichoderma* as one of the component microbes was used, there was the presence of the fungus, *Trichoderma* in the compost, which in turn indicated its survival even after composting. The presence of *Trichoderma* in the compost is a beneficial factor as it is a biocontrol agent against many fungal pathogens. In treatments,T_2, T_5 and T_8, where earthworms were used for composting, there was 2-3 fold increase in their number during the final stage of composting. Among the three earthworm

Table 3. Physical properties of thippi compost

Treatments	Moisture (%)	Porosity (%)	Water holding capacity (%)	Bulk density (g cm^{-3})	Colour
T_1	14.57^{d}	69.12^{c}	72.51^{d}	0.241^{a}	10YR3/6
T_2	15.32^{dc}	69.21^{c}	72.88^{bdc}	0.236^{ba}	7.5YR3/4
T_3	17.38^{bac}	69.02^{c}	73.25^{bac}	0.240^{a}	10YR4/3
T_4	16.83^{bdac}	70.34^{b}	73.71^{a}	0.230^{b}	10YR3/4
T_5	18.83^{a}	71.14^{a}	73.08^{bdac}	0.233^{ba}	5YR3/3
T_6	16.24^{bdc}	70.77^{ba}	73.52^{ba}	0.236^{ba}	5YR4/3
T_7	18.05^{ba}	69.06^{c}	72.73^{dc}	0.241^{a}	10YR5/2
T_8	19.13^{a}	69.40^{c}	72.67^{dc}	0.239^{a}	10YR3/4
T_9	16.84^{bdac}	70.34^{b}	73.21^{bdac}	0.238^{ba}	5YR3/2
Mean	17.02	73.80	70.10	0.236	-

Values with the same superscript in a coloumn are not significantly different

Table 4. Nutrient composition (%) of thippi compost from different treatment combinations

Treatments	N	P_2O_5	K_2O	Ca	Mg	Fe	Mn	Cu	Zn
T_1	0.8500^{d}	3.0250^{c}	0.3200^{ef}	2.6550^{a}	1.07^{b}	1.013^{ab}	0.0754^{bc}	0.00124^{ab}	0.0081^{b}
T_2	1.0750^{cd}	3.7750^{a}	0.3500^{def}	1.9950^{d}	0.98^{d}	1.329^{a}	0.0872^{a}	0.00153^{a}	0.0106^{a}
T_3	0.8900^{d}	3.6800^{ab}	0.3050^{f}	2.4150^{ab}	1.05^{c}	1.103^{ab}	0.0804^{ab}	0.00082^{ab}	0.0086^{ab}
T_4	1.4250^{b}	2.6850^{d}	0.4000^{bcd}	2.5200^{ab}	0.83^{g}	0.803^{b}	0.0638^{d}	0.00076^{b}	0.0083^{b}
T_5	2.3800^{a}	2.9750^{c}	0.4700^{ab}	1.4200^{e}	0.77^{h}	0.930^{b}	0.0660^{cd}	0.00095^{ab}	0.0092^{ab}
T_6	1.5450^{b}	3.1800^{c}	0.5100^{g}	2.2900^{bc}	0.98^{d}	1.111^{ab}	0.0780^{ab}	0.00105^{ab}	0.0087^{ab}
T_7	1.1750^{bc}	3.4750^{b}	0.4100^{bcd}	2.6300^{a}	1.16^{a}	1.071^{ab}	0.0845^{ab}	0.00128^{ab}	0.0089^{ab}
T_8	1.4950^{b}	3.8600^{a}	0.4300^{bc}	1.6400^{e}	0.92^{e}	1.330^{a}	0.0885^{a}	0.00134^{ab}	0.0095^{ab}
T_9	1.0650^{cd}	3.9400^{a}	0.3800^{cde}	2.0550^{cd}	0.91^{f}	1.294	0.0798^{ab}	0.00114^{a}	0.0092^{ab}
Mean	1.32	3.40	0.40	2.18	0.97	1.11	0.08	0.001	0.009

Values with the same superscript in a coloumn are not significantly different

Table 5. Microbial population (cfu ml^{-1}) of thippi compost from various treatment combinations

Treatments	Bacteria	Fungi	Actinomycetes	N fixers	P solubilisers	K solubilisers
T_1	14×10^{8}	3×10^{6}	9×10^{6}	3×10^{7}	1×10^{6}	-
T_2	16×10^{9}	5×10^{5}	8×10^{6}	1×10^{7}	-	-
T_3	14×10^{9}	3×10^{6}	19×10^{5}	8×10^{6}	-	1×10^{6}
T_4	12×10^{8}	4×10^{6}	16×10^{6}	8×10^{7}	3×10^{6}	1×10^{6}
T_5	11×10^{8}	2×10^{7}	4×10^{6}	12×10^{6}	-	-
T_6	21×10^{9}	3×10^{5}	28×10^{6}	5×10^{7}	-	-
T_7	44×10^{9}	1×10^{6}	12×10^{6}	8×10^{6}	1×10^{6}	-
T_8	15×10^{7}	4×10^{6}	22×10^{6}	9×10^{7}	3×10^{6}	-
T_9	16×10^{8}	2×10^{6}	4×10^{6}	8×10^{7}	-	-

composted treatments, the earthworm population was highest for T_5 as there was more leafy and organic materials. Composting is a microbiologically mediated process carried out by bacteria, fungi and actinomycetes (Epstein, 1996), hence it is quite natural that their population will increase during composting.

Biochemical properties

Analysis of the biochemical properties viz., starch, cellulose, fibre, protein and cyanide indicated substantial reduction of all unfavourable traits, except protein, due to composting. While the starch and cellulose contents in the thippi compost were reduced to 4% and 2% respectively, no fibre and cyanide contents were noticed in the compost. However, the protein content of the compost was raised to 8.3%. The biochemical properties of the thippi compost are presented in Table 6. As composting finally result in the production of mature stabilized product, there is reduction in the hemicelluloses and cellulose during the composting process as suggested by Chefetz et al. (1998) The substantially low content of the above decomposition products with vermicomposting can be due to the fact that earthworms can accelerate mineralization and high humification compared to other methods as suggested by Jeyabal and Kuppuswamy (2001)

Table 6. Biochemical properties of thippi compost (%)

Treatments	Starch	Cellulose	Protein
T_1	5.02^{a}	3.38^{d}	5.31^{f}
T_2	2.97^{f}	1.96^{h}	6.71^{e}
T_3	4.48^{c}	4.04^{b}	5.57^{f}
T_4	4.03^{d}	4.23^{a}	8.90^{c}
T_5	3.14^{e}	2.31^{g}	14.87^{a}
T_6	4.99^{a}	3.13^{e}	9.65^{b}
T_7	5.10^{a}	3.59^{c}	7.34^{d}
T_8	3.11^{e}	1.77^{i}	9.90^{bc}
T_9	4.74^{b}	2.99^{f}	6.65^{e}
Mean	4.18	3.04	8.32

Values with the same superscript in a coloumn are not significantly different

Conclusion

As the preliminary survey indicated the upcoming hazardous effects of thippi in the factory premises of Salem district, where cassava has presently emerged as a cash crop, the safe disposal of the same deserves special attention. The physical, chemical and biochemical properties of thippi revealed that it cannot be used as such as a fertilizer since it is poor in all essential plant nutrients. But the compost made from thippi was superior in all essential plant nutrients and as the process is very cheap, practically feasible and economical, the present technology will definitely pave the way for its utilization in nutrient management.

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