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Composting of papaya wastes: An aaerobic composting trial using different amendments

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ABSTRACT

An experiment was carried out in Tamilnadu Agricultural University (T.N.A.U) to test the biodegradability of stems and leaves of papaya (*Carica papaya*). For this Papaya wastes were composted along with nutrients and microbial inocula, both by mixing and without mixing with the other wastes such as banana pseudostem and vegetable wastes. Biomass, after collection, were chopped to a size of 2.5 cm, and were laid in layers, sandwiched by nutrients and microbial consortia, in an alternate manner. The inter nutrient layers were formed, using Rockphosphate, Urea and Poultry droppings. Microbial agents such as *Trichoderma viride, Pleurotus* sp and *Bacillus subtilis* were used to perform the composting. All the materials were arranged in heaps, of 1 meter height and allowed for biodegradation. For further enrichment, composts were mixed with, *Azotobacter chroocucum* at the end. From the experiment, it was revealed that the addition of succulent and nitrogen rich, biomass improves the degradablity of fibrous papaya wastes.

KEYWORDS

Biodegradation;
Composting;
Orchard waste;
Compost enrichment;
Aerobic composting;
Waste management;
Papaya waste.

INTRODUCTION

Papaya, a native fruit of tropical America, is grown in almost all tropical and subtropical regions of the world. The fruits bear their importance for their high nutritive, medicinal and commercial value. It ranks fifth in global production next to citrus, banana, pineapple and mango[7]. Nowadays because of the nutritious and delicious nature of the fruit and yield of papain, Horticulturists and Industrialists are paying more attention to papaya cultivation mainly to increase its productivity. Hence, the area under papaya cultivation has increased from 47,429ha to 73,7000ha (www.bioestate.biz/papaya.html; Database of National Horticulture Board, Ministry of Agriculture, Govt. of India). Extensive researches, covering development of new varieties, production technologies, crop protection measures and post harvest fruit handling are being carried out in many parts of the world. However, post harvest handling of papaya residues, is still in its infancy. This really needs serious attention, because, the economic life of papaya plant is only 3 to 4 years. As soon as the economic life is over, all the plants are removed and the field is cleared for next plantation. Only 10 per cent of the male plants are kept in orchards for good pollination, where dioecious varieties are cultivated. The extra male plants are uprooted. Both harvested plants and uprooted male plants are discarded from the orchards without any use.

Due to its hardiness, it remains in the disposal site for a very long period and poses nuisance to the public and environment nearby. Hence, the present study was carried out in the premises of the Department of environmental sciences,Tamilnadu Agricultural University (T.N.A.U)., Coimbatore, India, mainly to assess the biodegradability of the above waste and to make Bio-manure from the wastes with different amendments.

MATERIALS AND METHODS

Collection and preparation of materials for composting

The post harvest residues of Papaya and Banana (*Musa sapientum*) were collected from the orchard, situated in T.N.A.U and the size was reduced to about 2.5 cm. Vegetable wastes were collected from the nearby Market. Vegetables such as Beans (*Phaseolus vulgaris*), Bhendi (*Hibiscus esculentus*), Brinjal (*Solanum melongena*), Greens (*Amaranthus* sp), Mango (*Mangifera indica*), Onion (*Allium cepa*), Pumpkin (*Cucurbita* spp), Tomato(*Lycopersicum esculentum*) and Yam (*Amorphopallus* sp) were found in the waste. Since the moisture content of the material was more than 70 per cent, size reduction was not done to the vegetable wastes. Regarding papaya, to remove the latex from the materials, they were soaked in water for one day and washed before they were heaped. Pure cultures of *Aspergillus* sp and *Bacillus* sp and *Pleurotus* sp were obtained from the dept of Agricultural Microbiology, T.N.A.U, to use them as microbial inocula for composting. *Aspergillus* spp and *Bacillus* spp were subsequently cultured in the nutrient broth and *Pleurotus sp* was grown in saline glass bottles of 500ml capacity, filled with sterilized sorghum (*Sorghum vulgare*) grains up to one fourth of its capacity. To prepare the mixed microbial inoculants, 250ml of the broth taken from each culture and the entire spawns of *Pleurotus* sp from the two saline bottles were mixed together with 3 kg of un-sterilized soil collected from animal farm, T.N.AU. The above microbial soil mixture, after thorough mixing, was divided into three equal parts and added in-between the layers which contain the wastes. To achieve optimum Carbon/Nitrogen ratio,0.5per cent Urea $(NH_2)_2Co)$; 0.5per cent Poultry droppings; 1per cent Rock phosphate $(X_5Y\ (po_4)_3)$ were uniformly mixed with 3 kg of un-sterilized soil taken from the animal farm. This mixture was divided into three parts and used for sandwiching the waste, next to the microbial layer. Sixty per cent moisture content was maintained throughout the experiment by periodic turning of the wastes and sprinkling water subsequently.

Methodology of heaping

Treatment details

Composting Experiment was carried out with papaya wastes in four experiments, each with three replicates. The treatment (T) details are as follows:

T1- Papaya wastes (100 kg)+ 3kg inocula+3kg nutrient mixture

T2- Papaya wastes (50 kg) + Banana wastes (50 kg) + 3kg inocula+3kg nutrient mixture

T3- Papaya wastes (50 kg) + Market Wastes (50 kg) + 3kg inocula+3kg nutrient mixture

T4- Papaya wastes (33Kg) + Banana wastes (33 kg) + Market Wastes (33) 3kg inocula+3kg nutrient mixture

Initially the base of the heap was formed by spreading about 15 kg of wastes. Above that, one part (1 kg) of soil plus microbial consortia prepared was evenly sprinkled. Again 15 kg of waste was added, and one part (1 kg) of nutrients mixed soil was spread. Totally six layers of wastes and 3 layers of nutrients and 3 layers of microbial consortia were laid in a manner described above. Finally, 10 kg of waste material was spread to cover the final nutrient layer to complete one heap. All the four sides of the heap were tapered in the form of trapezoid. Temperature of the materials was recorded daily, using Mercury Thermometer. The materials in the heap were turned upside down at a fortnightly interval to avoid compaction. Water was sprinkled to bring the moisture to 60 per cent whenever moisture content decreased below 40 per cent.

Enrichment with biofertilizer

After composting was over, the heap was left undisturbed for ten days mainly to facilitate curing. When the temperature of the heap had stabilized to around 25-27^{0}C, it was enriched with the biofertilizer, *Azotobacter chroococum* at 250 g per kg of composted materials. Finally, it was allowed for another 15 days,

TABLE 1 : Methodology used for compost analyses

Parameters	Method	Reference
Moisture	Drying in Hot air Oven @105^{0}C	Mooijman and Lustenhouwer (1987)
pH	Compost, distilled water @1:10	Falcon et al. (1987)
Organic Carbon	Chromic acid wet digestion method	Walkley and Black (1934)
Total Nitrogen	Using semi automatic kjeldahl apparatus	Bremner (1965)
Total Phosphorus	Vanadomolybdate yellow colour method	Jackson (1973)
Total potassium	EEL Flame photometer	Jackson (1973)

TABLE 2 : Composition of banana, papaya and market wastes prior to composting

Parameters	Papaya	Banana	Market
Moisture (per cent)	65.0	73.6	74.5
pH(1:10)	6.7	6.9	5.9
Electricalconductivity(dSm-1)	0.4	0.5	0.5
Nitrogen	0.6	1.4	1.4
Carbon Nitrogen ratio	59.5	34.5	29.1

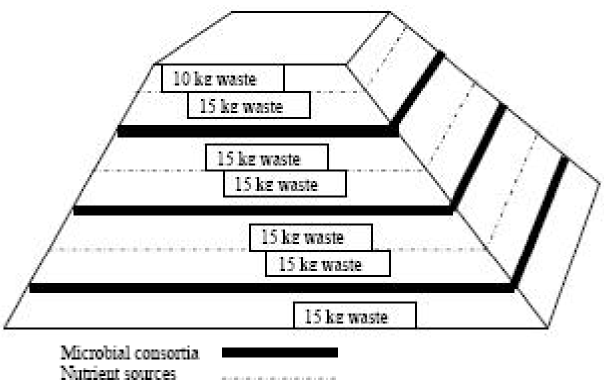

Figure 1: Diagrammatic representation of compost heap

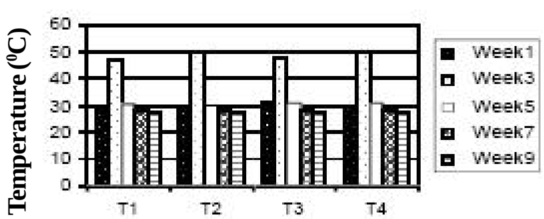

Figure 2 : Temperature changes during composting (^{0}C)

under adequate aeration and moisture condition for further enrichment.

Physico-chemical analyses

A known weight of samples, were dried at 60^{0}C in an hot air oven to constant weight and moisture content was determined gravimetrically.The sample after drying was ground and used for chemical analyses to estimate pH, EC, nitrogen, phosphorous, potassium and total organic carbon.

Statistical analysis

The experimental data were statistically analysed to find out the influence of various treatments on the biodegradation rate, as suggested by Panse and Sukhatme (1978).The critical difference was worked out at 5 per cent probability level (p=0.05).

RESULTS AND DISCUSSION

Preliminary analyses

Initially the moisture contents of Papaya, Banana and Market wastes were 65.0, 73.6 and 74.5 per cent respectively. The pH was 6.7 for papaya, 6.9 for banana and 5.9 for market wastes. The percent Nitrogen content was high (1.4) for both market and Banana wastes and was less for Papaya (0.6). The carbon nitrogen ratios for papaya, banana and market wastes were 59.5, 34.5 and 29.1 respectively.

Temperature changes

The rise in temperature was rapid in the first month; with a gradual decrease later on and finally reached the ambient temperature. Among all the four treatments, T_2 and T_4 recorded the maximum temperature, which was 50.1^{0}C and 50^{0}C, respectively. The use of poultry droppings and microbial aerobic respiration might have contributed to the heat development[2,4,5].

Changes in pH

Regarding the pH of the heap, a slight reduction was noticed in the first week after that, it was gradually increased throughout the period. Among the four treatments T_4 recorded maximum pH change, which was 8.3. The rises in pH might be due to the volatilization of ammonia as result of microbial decomposition of nitrogen rich organic wastes[4,8].

Changes in the concentration of major nutrients: nitrogen, phosphorus and potassium

Of the four treatments studied, T_4 found to have maximum nitrogen, phosphorus and potassium content with value of 1.0, 0.08 and 1.4 per cent respectively

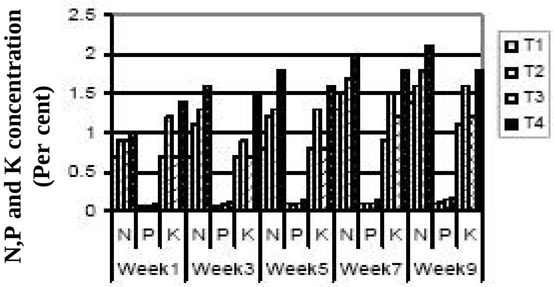

Figure 3 : Changes in N,P and K content of the material during composting

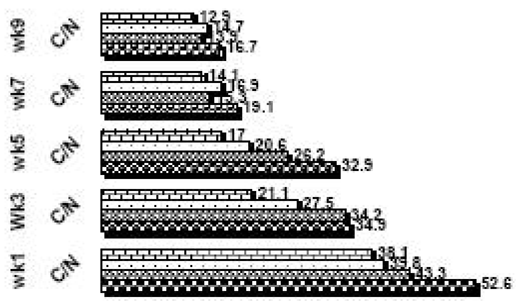

Figure 4 : Changes in C/N ratio during composting

TABLE 3 : Changes in pH during composting

Treatments	Days of composting				
	Week1	Week3	Week5	Week7	Week9
T1(Papaya)	6.5	7.0	7.2	7.4	7.6
T2(Papaya+Banana)	6.8	7.2	7.4	7.7	7.8
T3(Papaya+Market)	5.8	7.1	7.3	7.5	7.6
T4(Banana+Papaya +Market	6.4	7.2	7.6	7.8	8.3

TABLE 4 : Changes in carbon content (per cent) and C/N ratio of the material during composting

Treatments	Changes during composting									
	Week1		Week3		Week5		Week7		Week9	
	C	C/N	C	C/N	C	C/N	C	C/N	C	C/N
T1(Papaya)	37	52.6	34	34.9	28	32.9	24	19.1	24	16.7
T2(Papaya+Banana)	42	43.3	37	34.2	31	26.2	22	15.3	22	13.9
T3(Papaya+Market)	39	39.8	35	27.5	29	20.6	28	16.9	26	14.7
T4(Banana+Papaya +Market)	42	38.1	33	21.1	30	17.0	28	14.1	27	12.9

(Figure 3 here). Concentration of major nutrients was increased throughout the experiment and was maximum in T_4.At the end of composting the amount of nitrogen, phosphorus and potassium were 2.1, 0.16 and 1.8 per cent respectively. The weight loss is due to the production of carbon di - oxide as a result of aerobic respiration by the microbes during waste degradation. The production and release of carbon di-oxide during composting and subsequent raise of nitrogen, phosphorus and potassium content of the composted materials have has also been reported by several authors[3,6].

Changes in organic carbon and carbon/nitrogen ratio

During first three weeks, reductions in total organic carbon was found to be significant in all the four treatments. The ratio between carbon and nitrogen was maximum in T_1 and minimum in the rest of the treatments. Mixing of nitrogen poor papaya wastes with nitrogen rich other materials such as banana, vegetable wastes, urea and poultry wastes might have contributed for such carbon nitrogen ratio reduction. Reduction was maximum in second and third week of composting. The release of carbon di-oxide, as a result of rapid and enhanced microbial metabolism in the early stages, might have contributed for such rapid drop in carbon content, which indirectly contributes for the nitrogen enhancement[1,3]. In the seventh and ninth week it reached below 19 invariably in all the treatments and was very low in T_4, which was 12.9 per cent only.

CONCLUSION

The optimum moisture content of 60 per cent was maintained throughout the experiment, mainly to avoid anaerobic decomposition where bad odour is the major problem. Since the temperature of the heap, during the entire period was above the mesophilic range (37^0C), most of the mesophilic pathogenic organisms might have got killed during the temperature raise. As the carbon/ nitrogen ratio of the finished compost was lesser (12.9 per cent), it would not cause 'nitrogen robbing' when it is used for crop production. Among all the four treatments, rapid reduction in carbon / nitrogen ratio was noticed in T_4. The nutrient status of the compost, in terms of nitrogen, phosphorus and potassium content, was also maximum in T_4. Hence, from the experiment, it has been revealed that instead of composting papaya alone, wastes from other agricultural and horticultural residues that are succulent and rich in nitrogen, can be added. It not only speeds up the process, also enhances its manure value. This technique of composting would benefit the farmers, orchard owners and people for managing and recycling their crop residues effectively. In future, efficient microbial strains and low-priced nutrient substrates are to be identified, to further reduce the composting period. In addition, a comprehensive study on microbial metabolism of the related microorganisms used in the study and their substrate specificity are to be accomplished. A complete pot culture experiment with the finished compost is essential for testing their toxicity and their potential in crop production.

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