Pulverization of coconut leaves for efficient vermicomposting

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Vermicomposting is a useful technology for recycling agro-wastes to good quality manure. The decomposition of the wastes by oxidation followed by stabilization is driven by the combined action of earthworms and the microorganisms (Dominguez *et al.,* 2010). The earthworms chew the pre-decomposed wastes to very small pieces which facilitate bacteria, fungi and actinomycetes to further quickly decompose the material into manure. The decomposition helps in unlocking the nutrients present in the agro-wastes into easily available form for the plants.

All types of agro-wastes can be converted to vermicompost right from easily degradable vegetable wastes to highly recalcitrant wastes like coconut leaf, coir-pith and others. Urban wastes such as sewage sludge is also converted to vermicompost. The common epigeic earthworms that are used for vermicomposting of agro-wastes are African night crawler (Eudrilus eugeniae), red worm or tiger worm (Eisenia fetida), red wrigglers (Lumbricus rubellus) and blue worm or India blue worm (Perionyx excavatus) (Kale, 1998).

Addition of vermicompost helps in improving the soil porosity and water holding capacity of soils. It adds valuable organic carbon, plant nutrients and beneficial microorganisms (Gopal *et al.,* 2009) which improves the fertility and health of soil in ecologically safe manner (Thomas et al., 2007). Most of all, it helps in circular economy of the carbon i.e., the vermicomposting technology helps in recycling and sequestering carbon to soil which would have otherwise been burned or linearly removed from land and lost to environment as carbon dioxide leading to the warming up of the planet earth.

Coconut leaf vermicomposting technology

Among the many agro-wastes, plantation crops such as coconut palm generate large quantities of biomass residues. It has been estimated that from one hectare coconut garden roughly 6-8 tonnes leaf residues alone is produced annually (Upadhyay *et al.,* 1998). Owing to its high lignin content, close to 30%, the coconut leaf does not decompose easily when left to environment. It will take not less than 12 to 18 months for it to degrade naturally. ICAR-CPCRI had developed a successful technology for recycling coconut leaves to vermicompost using an indigenous strain of Eudrilus sp. earthworm (Prabhu et al., 1998) which decomposes within 60-75 day period. In this technology, the senescent coconut leaves are cut into two or three pieces using a knife and then stacked inside cement tanks (7.5 x 2 x 1m) and cow dung slurry is spread over the coconut leaves. Two to three layers of the substrate is filled inside the tank which is watered regularly. The top is covered with mulch and plastic net. The moist substrate is allowed to undergo pre-decomposition for 20-30 days and then the CPCRI Eudrilus sp. is added to the pre-decomposed substrate.

For one tonne of coconut leaf waste, about 100-200 kg cow dung slurry and 1000 earthworms are required for the effective decomposition. At the end of 60-75

days period, a maximum of 60-70% of the substrate is converted to vermicompost by this method leaving behind some 30-40 % partially decomposed material like the leaf midrib and the hard petiole portions. At the end of the process, vermicomposted material is separated from undecomposed/ partially decomposed substrate and the earthworms are separated and used for next cycle of vermicompost production. The coconut leaf vermicompost, thus produced, is air-dried and used for application in field. The undecomposed materials are segregated to be added in the next round of production for complete recycling. This method can be easily adopted by small and marginal farmers or group of farmers on a small scale. However, this method is time consuming. It requires labour to chop the leaves and stack it manually inside the tank. Approximately four mandays are required to fill four tanks of dimensions (7.5 x 2 x 1) m / (8.8 x 1 x 0.7) m with each tank capable of holding one tonne of substrate.

Vermicompost production using pulverized coconut leaves

Pulverizing or shredding improves stabilization of organic material by composting and vermicomposting (Tognetti et al., 2007). Pulverizing the coconut leaves including the woody petiole using a 40 HP tractor mounted mechanical pulverizer is an alternate option to hand chopping for scaling up the production. This pulverizer shreds a complete coconut leaf (about 5-7 m long, 3-5 kg weight), even the thick petiole base, in less than 12 seconds. Using this machine, a turnover of 2.5 to 3.0 tonne of the pulverized substrate is possible within an hour. Thus, large quantity of pulverized substrate can be easily and quickly filled inside the tank for vermicomposting.

Comparative trials with chopped and pulverized coconut leaves

Preliminary trial in basins

An experiment was initiated to study the effect of substrate size (chopped and pulverized coconut leaf) on vermicomposting efficiency in plastic basins. Coconut leaves minus the thick woody petiole base, chopped to 15 cm bits in chaff cutter, and pulverized whole coconut leaf (including the thick woody petiole) were separately mixed with cow dung in equal proportions (1:1, w/w basis) and allowed to pre-decompose for 15-20 days and then 20 kg of pre-decomposed chopped and pulverized substrates were filled separately in plastic basins. To each basin, 20 adult coconut leaf eating earthworms, Eudrilus sp., were added. Three replications per treatment were maintained. The basins were regularly watered in order to maintain about 40-50% moisture. At the end of vermicomposting period, the amount of compost produced, number of earthworms multiplied and the nutrient content and microbial load of vermicompost produced were analyzed.

The vermicompost turnover and the earthworm multiplication were higher in the pulverized material compared to chopped coconut leaves, by 7% and 13% respectively. Similarly, higher potash content and pH was observed in the vermicompost produced from pulverized coconut leaves (Fig.1).

Microbial analysis too showed that pulverized vermicompost had higher fungi, actinomycetes and fluorescent pseudomonads count on dry weight basis (Table1). The trial indicated that the earthworms were able to convert the pulverized coconut leaf including woody petiole to vermicompost in similar fashion of the chopped coconut leaves minus the woody petiole.

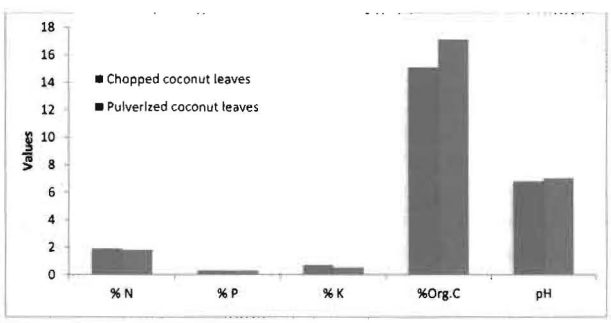


Fig.1. Chemical properties of vermicomposts produced from chopped and pulverized substrates in basin trials

Table 1 : Microbiological status of chopped and pulverized substrate treatments in basin trials

Method	Bacteria	Fungi	Acti-no-my-cetes	N2-fixers	Fluo-rescent pseudo-monads
Manual cutting of leaves	147 x 106	52 x 104	193 x 105	215 x 102	17 x 102
Pulveri-zation of leaves	149 x 106	77 x 104	282 x 105	218 x 102	37 x 102

*All values are mean of nine replications and represent cfu/g of vermicompost

Based on the results obtained in small scale trial, further scaling up of the process was taken up in large cement tanks.

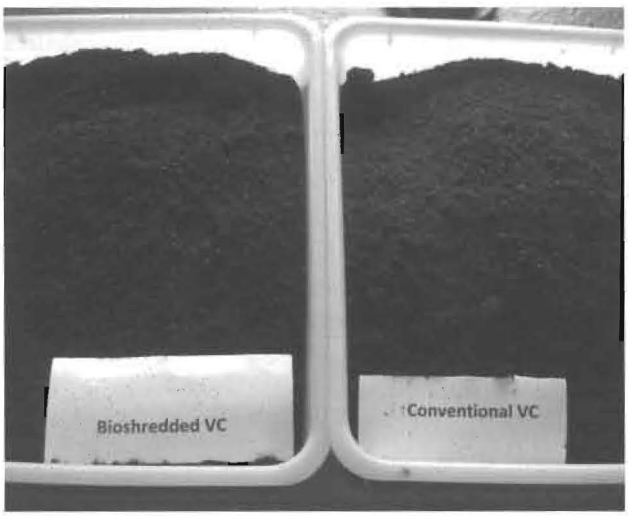
Large scale trials in cement tanks

Cement tanks with dimensions of (8.8 x 1.0 x 0.7 m) having three compartments were used in large scale vermicomposting studies. In one tank, coconut leaves,

chopped into two or three pieces manually using knife, were filled. Cow dung slurry was spread above the stacked leaves. Three such layers were filled inside the tanks. About 400 kg of chopped coconut leaf substrate was accommodated in each compartment. In another tank, pulverized coconut leaves were filled in similar fashion. Per compartment, a maximum of 350 kg of pulverized coconut leaf substrate could be accommodated. Watering was done regularly to keep the substrates moist in both the tanks and allow pre-decomposition of the material. After three weeks of pre-decomposition period, earthworms were added @ one adult coconut leaf degrading worm per kg of substrate. The tanks were covered with net to prevent rodent/insect entry. Watering was done regularly to keep the substrate sufficiently moist so as to allow the earthworms to carry out their composting activity. At the end of the vermicomposting period, the decomposed material was separated from partially decomposed material, earthworm numbers were counted and the vermicompost produced from chopped and pulverized treatments were analyzed for physico-chemical and microbial properties.

Advantages of vermicomposting pulverized coconut leaves

Vermicomposting of coconut leaves by conventional method of chopping and filling the tanks takes approximately 60-75 days. By pulverization too, the vermicompost is produced in same period of time. But the advantage is that even the hard petiole portion which takes more than two to three cycles of composting for decomposition in the conventional chopping method will be completely converted to vermicompost in one cycle by the pulverized method. Table 2 gives the information on input to output details for both the methods. It can be observed that in case of chopping method, the conversion efficiency is slightly above 60% and it is as high as 80-85% in case of pulverizing method. Higher efficiency of vermicomposting by pulverization method can help in recycling higher quantities of residues, on an annual basis, with the same set of available facilities.



Mature vermicompost produced from pulverized (left) and chopping (right) method

Table 2 : Comparative input and output data on different vermicomposting methods

Biomass treatment	Substrate Input (kg)	Vermi-compost harvested (kg)*	Earthworms added (nos.)	Earth-worms har-vested (nos.)*
Manual cutting of leaves	400	230	400	1340
	400	250	400	1620
Pulveri-zation of leaves	350	290	350	1600
	350	300	350	1670

* Values are mean of three replications

The nutrient content and microbial make up of coconut leaf vermicompost produced by both the methods are given in Tables 3 and 4. It can be seen that the vermicompost produced from pulverized coconut

leaves is slightly superior in terms of nutrient contents compared to chopping method. However, the pH is in alkaline range. This makes the pulverized coconut leaf vermicompost more suitable for the acid soils of Kerala and other regions where coconut is commonly grown. In terms of microbial composition too, the vermicompost produced from pulverized coconut leaf was superior in harbouring higher populations of general (bacteria, fungi) and plant-beneficial microbes (nitrogen fixers, phosphate solubilizers and fluorescent pseudomonads).

Table 3 : Physico-chemical characteristics of vermicompost produced by two different methods

Coconut leaves	Total N %	Total P %	Total K %	OC %	pH %	Moisture %
Manual cutting	1.85	0.25	0.16	16	6.3	61
Pulverization	1.73	0.25	0.26	18	7.4	68

*All values are mean of six replications

Table 4: Microbial analysis of vermicompost produced by two different methods

Coconut leaves	Bacteria	Fungi	Actinomycetes	N2-fixers	Phosphate solubilizers	Fluorescent pseudomonads
Manual cutting	94 x 106	75 x 104	27 x 105	64 x 103	49 x 104	25 x 103
Pulverization	100 x 106	101 x 104	28 x 105	86 x 103	56 x 104	38 x 103

*All values are mean of nine replications and represent cfu/g of vermicompost

Overall, pulverization results in reducing the coconut leaves to small sized substrate with higher surface area that leads to quicker conversion to vermicompost having higher nutrient and microbial populations that will be more beneficial as soil amendment.

Disadvantages

Some disadvantages of vermicomposting using pulverized material are also noticed. One of them is compaction of the substrates inside the tank during the process that reduces proper aeration as well as easy movement of the earthworms. However, no adverse effect was observed on their multiplication. This can, however, be easily overcome by adding intermediary layers of chopped coconut leaves that will prevent compaction to good extent.

Conclusion

Pulverization of coconut leaves including its woody petiole base improves the recycling efficiency of vermicomposting unit by 20-25% compared to using chopped coconut leaves minus the woody petiole base. The vermicompost produced by this method has better physico-chemical and microbiological properties which will be suitable for acid soils. The method can be adopted conveniently by farmers' groups or societies to do vermicomposting in a cooperative mode.

In nutshell, 20-25% more coconut leaf residues can be converted to vermicompost on an annual basis by pulverization method, without loss in any of the analyzed properties, which is beneficial for soil health and its fertility.

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