

## Recycling coconut leaf-agro wastes mixture using *Eudrilus* sp. and growth promotion properties of coconut leaf vermicompost

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### ABSTRACT

The ability of the indigenous coconut leaf vermicomposting earthworm, *Eudrilus* sp., to degrade agro-wastes from pineapple, banana, glyricidia and sugarcane was evaluated individually and in 1:3 ratio (w/w) with coconut leaves. In large-scale trials in tanks, *Eudrilus* sp. was able to convert more than 50% of the agro-wastes tested to vermicompost when mixed with coconut leaves. The mixture of banana pseudostem with coconut leaves yielded highest earthworm recovery followed by coconut leaves alone and coconut leaves + glyricidia mixture. There appeared to be a direct relationship with moisture content of the material to the earthworm multiplication and dry matter content to the vermicompost output. The mixture of banana pseudostem with coconut leaves had higher organic carbon, major and micro nutrient contents compared to coconut leaves alone. The earthworm recovery too was highest in the same combination.

Analysis of the bacterial, actinomycetal and fungal content of the coconut leaf vermicompost and vermicast showed that it contained high numbers of *Arthrobacter*, *Bacillus*, *Pseudomonas*, *Aspergillus*, *Actinomyces* and *Streptomyces*. When mixed at 10, 20 and 30% in soil, coconut leaf vermicompost was able to improve the growth and robustness of coconut seedlings. Our findings clearly show the coconut leaf vermicomposting earthworm, *Eudrilus* sp., has broad-spectrum agro-wastes degrading capacity. Thus, the wastes produced from intercrops normally grown in coconut garden can also be mixed with coconut leaves to produce good quality vermicompost in the farm itself.

**Keywords:** *Eudrilus* sp., vermicompost, coconut leaves, coconut seedlings

### INTRODUCTION

Vermicomposting helps in converting the non-available form of plant nutrients present in organic matter to available form through the combined actions of the earthworms and microorganisms (Edwards and Fletcher, 1988). The three main classes of organic wastes suitable for vermicomposting are generated from animal, plant and urban settlements. Among plants, biomass wastes/residues from plantation crops such as coconut (Prabhu *et al.*, 1998), arecanut and cocoa (Chowdappa *et al.*, 2001), oil-palm (Singh *et al.*, 2011), coffee (Adi and Noor, 2009) and olive (Benitez *et al.*, 2002) have been utilized as substrates for vermicompost production.

Coconut palm, a tropical perennial tree crop, is grown in about 1.8 million ha in India. One hectare coconut farm is capable of generating 6-8 tonnes of high-lignin containing biomass wastes annually. Central Plantation Crops Research Institute (CPCRI), Kasaragod had developed an effective technology for recycling coconut leaves to vermicompost using an indigenous *Eudrilus* sp. earthworm (Prabhu

*et al.*, 1998). The vermicompost production from coconut leaves can be carried out throughout the year; however efficient turnover can be attained during the monsoon periods (Gopal *et al.*, 2004). The vermicompost produced from coconut leaves has been reported as good source of organic manure for improving the soil health and fertility of plantation crops (Thomas *et al.*, 2007).

Coconut as mono-crop fetches limited economic return; market trends dictating the price and thereby the farmers' earnings. To overcome this problem, it has been suggested to beneficially utilize the large inter-spaces between coconut palms by growing multi-tiered crops such as pineapple, banana, black pepper, nutmeg and tubers that can generate income regularly round the year (Fig.1). CPCRI has developed a number of highly productive remunerative cropping system models including inter cropping systems, mixed cropping systems and the high density multispecies cropping systems. Also, to enhance the fertility of soil in coconut gardens cultivation of cowpea and mimosa in the basin (Thomas and Shantaram, 1984) and glyricidia

(Subramanian *et al.*, 2005) in the alleys has been recommended. The intercrops also generate voluminous biomass residues, particularly from pineapple and banana.



**Fig. 1.** A coconut based high density multispecies cropping system with pineapple, banana, black pepper, nutmeg and clove as component crops

The present study was undertaken with the objectives to (i) evaluate the efficiency of coconut leaf vermicomposting earthworm, *Eudrilus* sp., to degrade agro-wastes from inter and mixed crops grown in coconut based cropping systems, (ii) to study the effect of mixing coconut wastes with other agro-wastes on conversion efficiency and quality of vermicompost and finally to (iii) assess the growth promotion ability of coconut leaf vermicompost on coconut seedlings.

## MATERIALS AND METHODS

### Earthworm species

Epigeic earthworm, *Eudrilus* sp. (**Fig. 2**) earlier isolated from decomposing coconut wastes in CPCRI farm and which was found to be very efficient in decomposing lignin-rich coconut leaf biomass, was used for the experiment. Earthworms were multiplied in coconut leaves + cow dung mixture at 1:1 ratio for a period of 50 days in plastic tubs to obtain sufficient number of earthworms needed for the study.

### Trials with individual crop residues

For effective recycling of residues, an attempt was made to evaluate the capability of the coconut leaf degrading *Eudrilus* sp. to use wastes of intercrops grown in coconut garden as substrates. Pineapple wastes, glyricidia leaves, banana wastes (pseudo-stem and leaves) generated from the high density multi-species cropping system plot of the Institute and sugarcane bagasse procured from nearby farm



**Fig. 2.** The CPCRI strain of *Eudrilus* sp. capable of degrading coconut leaves to vermicompost

were allowed to dry in the sun for few days until maximum moisture was removed. One kg of the dried wastes from each crop was mixed with 100 g of cow dung slurry and put into plastic basins separately. A control treatment of 1 kg dried and chopped coconut leaves with 100g cow-dung were also kept. Water was added to keep the moisture content of the substrates at 50% level. To achieve 50% moisture level, 500 ml of water added to all the treatments except for coconut leaves + banana pseudostem basins to which 300-400 ml water was sufficient as banana pseudostem had good moisture content by itself. The addition of water was done once in 4 days in the coconut leaves and sugarcane bagasse treatments whereas it was once in 5-6 days in the other three treatments (pineapple, glyricidia and banana pseudostem). Owing to their high moisture contents, the three treatments required less frequent watering to maintain 50% moisture content than coconut leaves and sugarcane bagasse. Three replications of each treatment were maintained. The substrates were allowed to pre-decompose for 15 days followed by introduction of 5 adult coconut leaf degrading *Eudrilus* sp. earthworms into each basin. For the next 45 days, water was added to maintain the moisture at 40% level. At the end of the study, the amount of substrate converted to vermicompost, number of worms and their biomass were recorded.

### Large scale experiment with mixture of crop residues

Once the ability of the earthworm was tested in small-scale experiment it was scaled up and tried in large vermicompost tanks of dimensions 7 x 2.5 x 1 m (l x b x h). In the Trial 1, taken up during June to August, banana pseudo-stem and glyricidia leaves were evaluated, and in Trial 2, during November to February, pineapple leaves and sugarcane

bagasse were evaluated. Each tank was filled with 750 kg of coconut leaves mixed with 250 kg of other crop wastes along with 100 kg of cow dung slurry. For each treatment, three replicates were maintained, *i.e.* three tanks per treatment. The substrates were kept at 50% moisture by regular addition of water and allowed to pre-decompose for 2 to 3 weeks. To obtain this moisture content status, water was added once in 4 days in similar proportion to the total substrate as in the trials with individual crop residues. This was followed by addition of 1000 adult earthworms into the tanks. At the end of the experiment, when the substrates were converted to vermicompost in 65-75 days time, the total number of earthworms present and the proportion of substrate converted to vermicompost were recorded.

### Nutrient analysis of the vermicomposts

All the five vermicompost types using different substrates (coconut leaves, sugarcane bagasse, pineapple wastes, glyricidia, and banana pseudostem) produced in the small scale experiment and three types *i.e.*, coconut leaves alone, coconut leaves + banana pseudostem and coconut leaves + glyricidia in the large scale experiment were analyzed for the major, secondary and minor nutrients and organic carbon contents, using standard procedures (Jackson, 1973).

### Microbial analysis of vermicompost and vermicast produced from coconut leaves

The bacterial, fungal and actinomycetal distribution in the vermicompost and vermicasts produced from coconut leaves by *Eudrilus* sp. was also analyzed by using selective media, Nutrient agar, Rose Bengal agar and Kuster's agar respectively. Morphologically distinct isolates were purified and identified to genus level in the following manner.

### Identification of bacteria

Cultural characteristics, Gram staining, motility test, tests for production of indole from tryptophan, acid production from glucose fermentation by methyl red test, nitrate

reduction, hydrolysis of lipid, starch and gelatin, production of catalase and urease enzymes.

### Identification of actinomycetes

Cultural characteristics, Gram staining, Acid fast staining, biochemical tests for production of indole from tryptophan, urease, catalase, hydrolysis of starch and gelatin, sugar fermentation and cellulose hydrolysis.

### Identification of fungi

Colony morphology, morphological features of vegetative and reproductive structures by staining.

### Effect of coconut leaf vermicompost on the growth of coconut seedlings

A poly-bag experiment was carried out to evaluate the effect of coconut leaf vermicompost mixed at 10%, 20% and 30% doses with 20 kg soil on the growth parameters and dry weight production of West Coast Tall (WCT) coconut seedlings. A control treatment without addition of vermicompost was also maintained. Each treatment had 20 replications. Just sprouted seedlings of WCT variety were planted in poly-bag containing the above mentioned soil+vermicompost mixture. The plants were watered uniformly once in four days. After 12 months, the plant height, girth, number of leaves and length of petiole were recorded. Five seedlings were randomly picked from each treatment; uprooted and the dry weight of stem and leaves as well as the roots were recorded.

## RESULTS AND DISCUSSION

Perusal of data with individual agro-wastes (Table 1) showed preference of the *Eudrilus* sp. in degrading the substrates in the order coconut leaves > sugarcane bagasse > pineapple wastes > glyricidia leaves > banana pseudostem. The multiplication of the earthworm was also highest in coconut leaves followed by sugarcane bagasse. However, in pineapple, banana and glyricidia wastes, no earthworm was observed at the end of the experiment. The experiment

**Table 1.** Ability of coconut leaf vermicomposting earthworm, *Eudrilus* sp., to degrade other agro-wastes (values are average of three replicates)

Treatment	Initial weight of substrates (g)	Initial no. of worms added	Final no. of worms	Final biomass of worms (g)	Compost generated (g)	Percent conversion
Coconut leaves + cow dung (control)	1100	5	57 <sup>a</sup>	25 <sup>a</sup>	673 <sup>a</sup>	61.0
Sugarcane bagasse + cow dung	1100	5	51 <sup>ab</sup>	22 <sup>a</sup>	315 <sup>b</sup>	29.0
Pineapple wastes + cow dung	1100	5	20 <sup>bc</sup>	7 <sup>b</sup>	250 <sup>b</sup>	23.0
Glyricidia leaves + cow dung	1100	5	0 <sup>c</sup>	0 <sup>b</sup>	230 <sup>b</sup>	21.0
Banana pseudostem + cow dung	1100	5	0 <sup>c</sup>	0 <sup>b</sup>	177 <sup>c</sup>	16.0
CD (P=0.05)	—	—	34.0	10.50	181.27	—

Means followed by the same letter are not significantly different at  $P \geq 0.05$  using analysis of variance and mean separation (LSD)

clearly indicated that the *Eudrilus* sp. was capable of digesting different wastes tried, albeit with different degrees of conversion; vermicompost recovery was significantly high from coconut leaves compared to all other substrates. From this study, it appeared that the conversion rates were directly correlated to the lignocellulose and inversely to the moisture contents of the substrates; coconut leaves and sugarcane bagasse having more of the former was most preferred by the *Eudrilus* sp. Our findings support the work reported by Suthar (2007) which mentions that the quality of the food sources play a key role for preference of growth and reproductive performance of the epigeic earthworms that result in waste recycling to compost. Though not exactly similar, Hayawin *et al.* (2010) tested *Eudrilus euginae*'s capacity to degrade oil palm fibre wastes such as empty fruit bunch (EFB), oil palm frond (OPF) and oil palm trunk (OPT) and found that the EFB was the best substrate for the vermicompost production. In more similar kind of study, Gunadi and Edwards (2003) found that among the cow and pig manure as well as fruit and vegetable wastes from markets, the epigeic earthworm *Eisenia fetida* grew and multiplied well in the pig manure compared to other substrates.

Our work, therefore, is the only kind that tried to evaluate the capability of the *Eudrilus* sp. in degrading agro-waste substrates originating from totally different types of plant sources and the results confirmed the broad spectrum consumption capacity of the coconut leaf degrading earthworm. The major nutrient and the organic carbon contents in the vermicompost produced from small scale experiments are given in **Table 2**. It can be clearly seen that the vermicompost produced from coconut leaves had the highest OC content followed by sugarcane bagasse vermicompost. However, the major plant nutrient contents were highest in the vermicompost produced from glyricidia leaves and from banana pseudostem. The potash content appeared less than the expected level in coconut leaves and sugarcane bagasse. The reason was addition of water more frequently to maintain the moisture to 50% during the vermicomposting process. The addition of water would have

leached the water soluble potash thus reducing it in the compost. The trial with individual agro-wastes gave an indication about the capability of the *Eudrilus* sp. for degrading other agro wastes. However, as the conversion was below 50% it was decided to mix the wastes at the rate of 25% with 75% coconut leaves and then evaluate if the earthworms can improve their efficacy in degrading the mixed substrates. The vermicomposting period in the large scale trials was same for all the treatments as coconut leaves was the major component used. The other agro wastes formed only 25% of the substrate on w/w basis. No significant difference in the composting time was observed. However, there was marked difference in the compost turnover and earthworm multiplication. The results of mixing agro-wastes such as pineapple waste, banana pseudo stem and leaves, sugarcane bagasse and glyricidia green manure with coconut leaves in 1:3 proportion on vermicompost production and multiplication of *Eudrilus* sp. is given in **Table 3**. Vermicompost recovery to the tune of 60% and above was recorded when agrowastes were mixed with coconut leaves at 1:3 ratio, w/w basis. The maximum compost recovery was in treatment that had coconut leaves alone and the least in coconut leaves + banana pseudostem. The difference in dry matter and moisture content in the substrates would have resulted in this outcome. Coconut leaves having high dry matter content and lesser moisture content resulted in significantly highest recovery. The treatments coconut leaf + pineapple wastes and coconut leaves + sugarcane bagasse also had compost recovery at par with the coconut leaves treatment. The trials also revealed that mixing of banana pseudo stem and coconut leaves supported significantly highest level of *Eudrilus* multiplication when compared to other agro-wastes tested and the treatment of coconut leaves alone. One of the main reasons for high earthworm recovery in the coconut leaves + banana pseudostem treatment was the presence of optimum moisture content for the worm reproduction and multiplication. Transfer of the biomass from substrates to earthworms' body weight could also be partially responsible for lesser vermicompost recovery in

**Table 2.** Nutritional characteristics of vermicompost produced from different crop residues

Treatment	N %	P %	K %	OC %	C:N ratio
Coconut leaves + cow dung (control)	1.38 <sup>b</sup>	0.27 <sup>c</sup>	0.28 <sup>b</sup>	25.4 <sup>a</sup>	18.4 <sup>a</sup>
Sugarcane bagasse + cow dung	1.44 <sup>b</sup>	0.48 <sup>b</sup>	0.46 <sup>b</sup>	23.9 <sup>a</sup>	16.6 <sup>b</sup>
Pineapple wastes + cow dung	1.24 <sup>b</sup>	0.51 <sup>b</sup>	2.10 <sup>a</sup>	16.8 <sup>c</sup>	13.6 <sup>c</sup>
Glyricidia leaves + cow dung	2.14 <sup>a</sup>	0.79 <sup>a</sup>	2.69 <sup>a</sup>	20.6 <sup>b</sup>	9.7 <sup>d</sup>
Banana pseudostem + cow dung	1.24 <sup>b</sup>	0.72 <sup>a</sup>	2.91 <sup>a</sup>	16.6 <sup>c</sup>	13.4 <sup>c</sup>
CD (P=0.05)	0.22	0.12	0.81	2.7	1.34

Means followed by the same letter are not significantly different at  $P \geq 0.05$  using analysis of variance and mean separation (LSD).

**Table 3.** Effect of mixing other agro-wastes with coconut leaves on vermicompost production and earthworm multiplication in large scale trial (Values are average of three replicates)

Treatment	Initial substrate weight (kg)	Vermicompost recovery (kg)	Earthworm Recovery (No.)
Coconut leaves	1000	725 <sup>a</sup>	6000 <sup>b</sup>
Coconut leaves + glyricidia leaves	750+250	650 <sup>b</sup>	6000 <sup>b</sup>
Coconut leaves + banana pseudostem	750+250	600 <sup>c</sup>	10000 <sup>a</sup>
Coconut leaves + pineapple wastes	750+250	700 <sup>a</sup>	4000 <sup>b</sup>
Coconut leaves + sugarcane bagasse	750+250	700 <sup>a</sup>	3000 <sup>c</sup>
CD (P=0.05)	—	45	2226

Means followed by the same letter are not significantly different at  $P \geq 0.05$  using analysis of variance and mean separation (LSD)

the same treatment. This result was totally different from the individual agro-wastes experiment where we failed to get good recovery. Very high moisture in the compost produced from banana pseudostem alone must have driven the earthworms away from the basin. Similar was the results with glyricidia in the small-scale and large scale studies. The nutritional properties of the mature vermicompost produced from large scale experiments are given in **Table 4**. It could be seen that the major and minor nutrient contents, organic carbon and C:N ratio of the three types of vermicomposts

vermicompost, more the number of parameters gave significantly higher values. However, a careful perusal showed that at 4 kg dose, most of the values recorded were higher. Thus, for getting quality coconut seedlings, mixing coconut leaf vermicompost @ 20% with soil will be the ideal dose. It can be concluded that the coconut leaf degrading epigeic earthworm, *Eudrilus* sp., is capable of consuming banana pseudostem, pineapple wastes, glyricidia leaves and sugarcane bagasse when admixed with coconut leaves at 1:3 ratio and produce vermicompost with low C:N,

**Table 4.** Nutrient composition of vermicompost produced from coconut leaves mixed with other agro-wastes

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Zn (ppm)	OC (%)	C:N ratio
Coconut leaves	1.34	0.22	0.41	1.48	0.27	13.20	892.0	86.3	17.15	12.5
Coconut leaves + glyricidia leaves	1.23	0.26	0.48	1.24	0.31	16.70	846.5	83	15.84	13.2
Coconut leaves + banana pseudostem	1.51	0.24	0.29	1.52	0.32	15.5	808.5	90.1	19.96	12.3

are comparable to each other. C: N ratio below 20 is one of the best indicator of maturity of composts and it indicated that the nutrient present could be immediately available to the plants. The distribution and population of various microbial genera in the vermicompost and vermicasts produced from coconut leaves by the *Eudrilus* sp. is given in the **Table 5**. Among bacteria, *Arthrobacter* spp. was predominant in vermicasts and the vermicompost produced from coconut leaves, followed by the *Bacillus* and *Pseudomonas* spp. Among fungi, *Aspergillus* spp. was present in highest number in vermicasts whereas *Trichoderma* was recorded highest in vermicompost. In the case of actinomycetes, the vermicasts seemed to have only the *Actinomyces* and *Streptomyces* in it while the vermicompost had three more genera in addition viz. *Micromonospora*, *Nocardia* and *Thermoactinomyces*. The results of poly-bag experiment conducted to evaluate the effect of mixing coconut leaf vermicompost with soils as potting mixture is given in **Table 6**. It can be noted that addition of vermicompost significantly improved various parameters recorded barring the height of the seedling and length of the leaves. Higher the dose of application of the

**Table 5.** Distribution of various microbial genera (CFU g<sup>-1</sup> sample) in vermicompost and vermicasts from coconut leaves

Genera	Vermicompost	Vermicasts
<b>Bacteria</b>		
<i>Bacillus</i>	2 x 10 <sup>6</sup>	2 x 10 <sup>6</sup>
<i>Xanthomonas</i>	4 x 10 <sup>5</sup>	1 x 10 <sup>6</sup>
<i>Micrococcus</i>	4 x 10 <sup>6</sup>	-
<i>Arthrobacter</i>	16 x 10 <sup>6</sup>	4 x 10 <sup>6</sup>
<i>Pseudomonas</i>	1 x 10 <sup>6</sup>	2 x 10 <sup>6</sup>
<i>Flavobacterium</i>	-	1 x 10 <sup>6</sup>
<i>Alcaligenes</i>	-	2 x 10 <sup>6</sup>
<b>Fungi</b>		
<i>Penicillium</i>	3 x 10 <sup>3</sup>	1 x 10 <sup>4</sup>
<i>Fusarium</i>	1 x 10 <sup>4</sup>	-
<i>Trichoderma</i>	3 x 10 <sup>4</sup>	1 x 10 <sup>3</sup>
<i>Aspergillus</i>	1 x 10 <sup>3</sup>	5 x 10 <sup>4</sup>
<i>Mucor</i>	1 x 10 <sup>4</sup>	1 x 10 <sup>4</sup>
<b>Actinomycetes</b>		
<i>Actinomyces</i>	4 x 10 <sup>5</sup>	1 x 10 <sup>5</sup>
<i>Streptomyces</i>	1 x 10 <sup>5</sup>	1 x 10 <sup>5</sup>
<i>Micromonospora</i>	2 x 10 <sup>5</sup>	-
<i>Nocardia</i>	2 x 10 <sup>5</sup>	-
<i>Thermoactinomyces</i>	1 x 10 <sup>5</sup>	-

**Table 6.** Effect of application of vermicompost on growth parameters of coconut seedlings (Values for dry weight analysis are average of 5 replicates while it is 20 replicates for others)

Treatment	Height of seedling (m)	Girth of seedling (cm)	No. of leaves	Length of leaves (cm)	Breadth of leaves (cm)	Stem and leaf dry wt. (gm)	Root dry wt. (gm)
Control (20 kg soil)	2.24 <sup>a</sup>	15.90	8.2	97.08	27.50	381	46.0
2 kg VC + 18 kg soil	1.98 <sup>b</sup>	18.27	8.11	87.57	33.55	330	58.0
4 kg VC + 16 kg soil	2.05 <sup>b</sup>	18.87	8.81	93.15	34.21	357	65.0
6 kg VC + 14 kg soil	1.85 <sup>c</sup>	21.61	9.11	86.28	31.14	419	81.0
CD (p=0.05)	0.18	1.97	0.62	8.27	4.82	NS	NS

Means followed by the same letter are not significantly different at  $P \geq 0.05$  using analysis of variance and mean separation (LSD)

high organic carbon and high content of major and micro nutrients. These crops, barring sugarcane, are commonly grown in coconut garden as intercrops. The broad-spectrum substrate degrading capacity of the earthworm, proven in our studies, provides the small and marginal coconut farmers a good option to effectively recycle the wastes to valuable manure at farm level from the biomass wastes generated from main coconut crop as well as the inter crops. The coconut leaf vermicompost harbours high population of microorganisms, many of them with plant-beneficial attributes. Mixing coconut leaf vermicompost @ 20% with soil helps in production of robust coconut seedlings. The utilization of multiple wastes for vermicompost production could become one of the ideal bio-resource management technologies for organic farming in coconut based cropping systems (Thomas *et al.*, 2004).

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