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Research Article

Bioconversion of predecomposed coirpith and mixed weeds using *Eudrilus eugeniae* for raising vegetable nursery

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Abstract

Investigations were made to recycle agricultural and industrial wastes for the production of vermicompost using earthworms (*Eudrilus eugeniae*). Vermicompost was prepared from mixture of bioinoculants using predecomposed coirpith (30 days), predecomposed weed mixture (15 days) and cowdung. The vermicompost caused a decrease in organic carbon (16.7%), while increase in total nitrogen (1.20%), phosphorous (0.92%) and potassium (0.89%) contents. An increase of two fold times more CFU×10^7 g^{-1} of bacteria in the worm worked substrates than the worm unworked substrates. The effects of vermicompost on the growth of *Vigna unguiculata* (Cow pea), *Lycopersicum esculentum* (Tomato), *Ablemoschus esculenus* (Ladies finger) were investigated in a greenhouse experiment. Triplicate treatments were applied combining vermicompost (50% and 100%) and soil. Growth parameters were measured interval of 7 days after transplanting. The results indicate that the 100% Vermicompost enhanced *Ablemoschus esculenus* shoot length, root length, number of leaves, chlorophyll content of leaves and total chlorophyll, fresh weight of the plant and dry weight of the plant significantly higher when compared to the other treatments and control.

Keywords: Coirpith; Vermicompost; *Eudrilus eugeniae; Vigna unguiculata.*

Introduction

The green revolution has increased the agricultural production substantially but it has also led to several new challenges like decline in productivity, degradation of soil and water resources, diminishing of biodiversity and increase in environmental pollution. Under such situation, organic farming has assumed paramount importance for improving productivity of crop and fertility of soil. Maintenance of soil organic matter in agricultural soils is very important for the maintenance of soil fertility. Generally, the farmers use inorganic fertility which mainly contain NPK and neglect the use of organic manures and bio fertilizers and hence have paved the way for deterioration of soil health and in turn ill effects on plants, livestock and human beings [1].

Coirpith, one of the agricultural wastes is produced and heaped in large quantities as waste material from the coir industry. Annual production of waste coirpith is around 7.5 million tons in India. Coirpith has wide C:N ratio and its lignin rich nature does not permit natural composting process as in other agricultural wastes. In nature organic wastes are recycled by a variety of soil decomposer organisms involving mainly bacteria and fungi as well as detritus feeding invertebrates especially earthworm [2].

The decomposition of complex organic waste resources into odor free humus like substances through the action of earthworms is termed vermicomposting. Vermicompost has very 'high porosity', 'aeration', 'drainage' and 'water holding capacity'. They have a vast surface area, providing strong absorbability and retention of nutrients. They appear to retain more nutrients for longer period of time. Study showed that soil amended with vermicompost had significantly greater 'soil bulk density' and hence porous & lighter and never compacted. Increase in porosity has been attributed to increased number of pores in the 30-50 µm and 50-500 size ranges and decrease in number of

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pores greater than 500 µm [3]. Vermicompost is an effective replacement for chemical fertilizers. In recent years the waste decomposition potential of some humus feeder earthworms has been proven in literature. The high bacterial growth in the earthworm intestine improves soil fertility and stimulates plant growth. The aim of the present study was to recycle the coirpith waste using composting earthworms, *Eudrilus eugeniae* (Kinberg) under laboratory condition and conduct greenhouse experiments at the Biology Department, Gandhigram Rural Institute have demonstrated that vermicomposts can increase the germination and growth of various vegetable plants significantly and consistently.

Materials and methods

Collection and predecomposition of coirpith

Coirpith was collected from coir industry at Sholavandan, Dindigul District, Tamilnadu, India and sieved using 75-150 µm sieve and washed with water for two times. Washed coirpith was dried in shade and pretreated with lignolytic and cellulolytic microbes such as *Bacillus* sp. and *Trichoderma* sp. (1:1) for 30 days for thermal stabilization, initiation of microbial degradation and softening of waste.

Preparation of vermicompost

Weed mixture was collected from around Gandhigram, chopped into small pieces, dried in shade and subjected to predecomposition for 15 days. Appropriate moisture (65%) was maintained during predecomposition by periodically, sprinkling adequate quantity of water [4]. The coirpith and weed material was turned periodically (once in 3 days) for aeration and to remove odor from the decomposing wastes. The predecomposed coirpith, weed mixture and cowdung were mixed in1:1:1 ratio and adult *Eudrilus eugeniae* were introduced at 20 worms/kg of this organic waste mixture. Cowdung medium served as the control proper replicates were maintained. The moisture level in all the substrates in vermibeds were maintained at 60-80 percentage throughout the study period by sprinkling adequate quantity of water. This setup was maintained 45 days.

Physicochemical and microbial analysis of vermicompost

The pH and EC were found out Systronics digital pH meter and conductivity bridge. Organic carbon and total nitrogen contents were estimated by Walkey – Black method and Microkjeldhal method respectively. The microbial colony forming units of bacteria, fungi and actinomycetes were enumerated using Nutrient agar medium, Martin's Rose Bengal medium and Kenknight's medium respectively.

Pot culture studies

Germination and Plant growth study (21 days) were conducted in green house plant growth parameters such as shoot length, root length, number of leaves, leaf index area, chlorophyll a and b content, total chlorophyll content, fresh weight of the plant, dry weight of the plant were measured for *Vigna unguiculata* (cow pea), *Lycopersicum esculentum* (tomato) and *Ablemoschus esculenus* (ladies finger). The results were subjected to analysis of standard deviation (SD)

Results and discussions

Vermicompost prepared from pretreated coirpith, weed mixture and cowdung waste by lignolytic and cellolytic microbes *Bacillus* sp and *Trichoderma* sp. and predecomposed weed mixture and cowdung. Vermicompost was much darker in colour than the control and had been humified rapidly through the fragmentation of the coirpith mixture processed after 45 days of *E.eugeniae* earthworm's activity, thereby increasing the surface area for colonization by microorganisms. Suther [5] also observed similar results in their experiments.

Biochemical changes in the degradation of organic matter are carried out through enzymatic digestion, enrichment by nitrogen excrement and transport of organic and inorganic materials. Cellulase is a multi-enzyme complex, which cleave β- 1,4- glucosidic linkages in cellulose and chemically or physically modified cellulose, in cellodextrin and in cellobiose. A cellulosic enzyme system consists of major components and they are endo-β-glucanase, exo-β-glucosidase.

The production of cellulose, hemicellulose and lignin degrading enzymes by the inoculated microbes during pre-decomposition might have accelerated the degradation process. Similar results were also reported by Rasal *et al*. [6] who reported rapid decomposition of sugarcane trash with a mixture of cellulolytic fungi. The earthworms digest long chains of polysaccharides, enhancing microbial colonization. Simultaneously the structure of lignin changes, probably due to microbial oxidation and demethylation. The microbial cleavage of the aromatic rings of lignin leads to new polysaccharide and humins in the organic matter [7].

The pH had slow decrease during vermicomposting on 45 days. It shows that the alkalinity of the vermicompost is slowly reducing in the process, due to the Co_2 and organic acids produced during microbial metabolism. The electrical conductivity of the vermicompost was found to be increased than in the worm unworked compost. The increase in EC and NPK in worm worked substances showed that the activity of *E. eugeniae* along with microorganisms have brought out rapid mineralization process and made the nutrients available for plant growth [4]. Organic content was lower in vermibeds than initial materials. A reduction in organic carbon was 16.7% (worm worked 45^{th} day), 28.3% (control). However, carbon loss pattern in CD could be attributed to the rapid respiration rate [5] than other substrates.

The total N of the vermicompost increased with time, due to mineralization of organic nitrogenous compounds. The nitrogen was maximum at 45 days of vermicomposting had a slightly higher (1.20%) than the treatments without earthworms (0.90%). There was more dehydrogenase activity in earthworm inoculated treatments than in treatments without worms. There was more N in worm-worked compost than in worm unworked compost. Some workers have reported higher content of N, P, K and micronutrients in vermicompost [8].

Total P in vermicomposted material was higher than control treatment at the end. The increase in available P content was in vermicompost 45^{th} day (0.92%) and followed by (CD (0.76%). The earthworm affects phosphorus mineralization in wastes if reared for long periods in it [9].

Phosphorus mineralization varied significantly among different vermibeds possibly due to quality and proportion of bulking materials in feedstock. According to Lee [10] if organic matter pass through the gut of earthworm, results in some amount of phosphorus is being converted with more availability to plants. The release of phosphorus in available form is performed partly by earthworm gut phosphatases, and further release of P might be attributed to the P solubilizing microorganisms present in worm casts. The difference among vermireactors for P mineralization rate could be due to different chemical structure of substrate material [11]. Total K content in ready vermicompost was higher than initial substrate material.

Increase in K content was higher in vermicompost (0.89%) than control (0.73%). However, when organic waste passes through the gut of worm the some quantity of organic minerals are than converted into more available forms through the action of enzymes produced by gut associated microflora. The vermicomposting plays an important role in microbial mediated nutrient mineralization in wastes. The results of this study agree with previous reports that that the vermicomposting process accelerates the microbial populations in waste and subsequently enriches the end product with more available forms of plant nutrients.

The microbial colony forming units (CFU) of bacteria, fungi and actinomycetes observed in the worm worked and worm unworked substrate. All the microbial colonies were higher in the worm worked substrate than worm unworked substrate. The introduction of earthworms *E.eugeniae* has contributed for the increase of the microflora of the organic matter which is essential for composting, soil fertility and soil health. An increase of two fold times more $CFU \times 10^7$ g^{-1} of bacteria were recorded (Fig.1) in the worm worked substrates than the worm unworked substrate.

Earlier studies have revealed that earthworm can mineralize cattle dung more easily than organic wastes because it contains a greater population of decomposing communities e.g. vermicompost is rich in microbial populations, particularly fungi, bacteria and actinomycetes [12].

The evaluation of germination percentage and vigour index of *Ablemoschus esculenus* indicates 100% vermicompost carry more ability to enhance the germination percent (100) and Vigour index (3152.7) when compared to the

50% vermicompost (Table 1 and 2) and control. Similar kind of work has also been done by Sheela *et al*. [13].

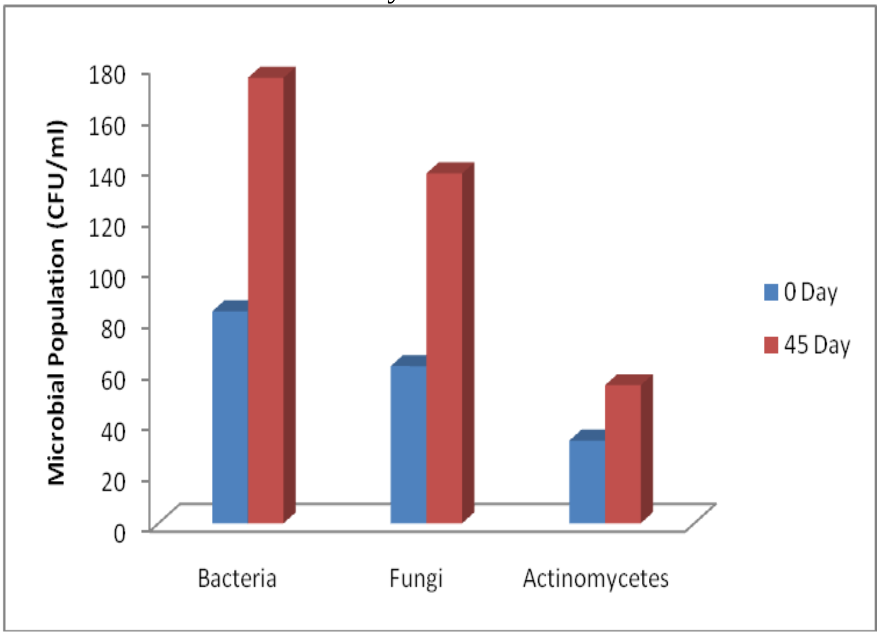

Figure 1. Microbial population in vermicompost

Table 1. Vigour index of the plants in 50% of vermicompost

S. No	Name of the plant	50% of vermicompost		
		7 day (cm^2)	14 day (cm^2)	21 day (cm^2)
1.	*Vigna unguiculata* (Cow pea)	791	1694	2086
2.	*Lycopersicum esculentum* (Tomato)	342	515.7	594
3.	*Ablemoschus esculenus* (Ladies finger)	1247.2	1656	2086.8

Table 2. Vigour index of the plants in100% of vermicompost

S. No	Name of the plant	100% of vermicompost		
		7 day (cm^2)	14 day (cm^2)	21 day (cm^2)
1.	*Vigna unguiculata* (Cow pea)	1227.1	1984	2428
2.	*Lycopersicum esculentum* (Tomato)	470.7	968.8	2168.1
3.	*Ablemoschus esculenus* (Tadies finger)	1713	2457	3152.5

The result of the pot culture study showed that the 100% vermicompost enhanced the shoot length, root length, number of leaves, chlorophyll content of leaves and total chlorophyll, fresh weight of *Vigna unguiculata* (cow pea), *Lycopersicum esculentum* (tomato) and *Ablemoschus esculenus* (ladies finger) and dry weight of the plants sample significantly when compared to the 50% vermicompost and control (Table 3,4 and 5). The potential of vermicomposts to improve plant growth may be due to changes in the physicochemical properties of soils, overall increases in microbial activity or to the effects of plant growth regulators produced by the microorganisms. The use of organic amendments to soil has long been recognized as providing a more balanced and better timed source of nutrition for plant growth, through the gradual decomposition of the organic matter by microorganisms, and slower mineralization and release of nutrients that it contains [14]. The organic matter in vermicomposts can usually provide plants with a balanced source of nutrients that can influence the composition and physiology of plants. Cantanazaro [15] demonstrated the importance of the synchronization between nutrient release and plant uptake and showed that slower release fertilizers can increase plant yield and reduce nutrient leaching

Table 3. Growth performance in different dosage of cow pea Vigna unguiculata vermicompost (21 days)

Treatments	Growth parameters (21 days)							
	Shoot length (cm)	Root length (cm)	Leaf index area (cm_2)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)	Fresh weight (g)	Dry weight (g)
To	7.5±0.10	5.73±0.15	2.95±0.05	1.21±0.01	1.23±0.02	2.13±0.16	0.19±0.01	0.10±0.15
T1	15.4±0.10	10.44±0.28	5.95±0.12	1.51±0.02	1.80±0.01	3.36±0.08	2.02±0.66	0.39±0.01
T2	17.5±0.32	17.46±0.06	6.3±0.10	1.91±0.02	3.6±0.10	4.56±0.21	2.3±0.10	0.51±0.02

T0 = control; T1 = 50% vermicompost; T2 = 100% vermicompost

Table 4. Growth performance of different dosage of tomato Lycopersicum esculentum vermicompost (21 days)

Treatments	Growth parameters (21 days)							
	Shoot length (cm)	Root length (cm)	Leaf index area (cm^2)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)	Fresh weight (g)	Dry weight (g)
To	1.16±0.55	1.32±0.04	1.20±0.01	0.61±0.15	1.2±0.1	2.06±0.15	0.2±0.1	0.1±0.01
T1	3.04±0.66	3.02±0.07	5.19±0.06	3.59±0.40	4.01±0.17	3.8±0.1	1.30±0.9	0.76±0.15
T2	12.42±0.1[illegible]	12.44±0.13	7.24±0.50	4.25±0.28	5.33±0.66	6.2±0.1	1.69±0.05	1.2±0.08

T0 = control; T1 = 50% vermicompost; T2 = 100% vermicompost

Conclusions

This study provides vermicomposting can be as potential technology to convert into value added materials. Plant nutrients content of vermicompost was significantly higher than control.

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Conflict of interest

Authors declare there are no conflicts of interest

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