# RECYCLING OF CASHEW (*Anacardium occidentale* L.) LEAF LITTER AND CASHEW APPLE THROUGH VERMITECHNOLOGY

**By**

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**(2012-11-181)**

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**VELLANIKKARA, THRISSUR – 680656**

**KERALA, INDIA**

**2016**

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**THESIS**

**Submitted in partial fulfillment of the requirement**

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**Kerala Agricultural University, Thrissur**

**Department of Soil Science and Agricultural Chemistry**

**COLLEGE OF HORTICULTURE**

**VELLANIKKARA, THRISSUR – 680656**

**KERALA, INDIA**

**2016**

# DECLARATION

I hereby declare that the thesis entitled **"Recycling of cashew (*Anacardium occidentale L.*) leaf litter and cashew apple through vermitechnology"** is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

Date: 07.04.2016

**Indu V K**

**(2012-11-181)**

# CERTIFICATE

Certified that thesis entitled**"Recycling of cashew (*Anacardium occidentale L.*) leaf litter and cashew apple through vermitechnology"** is a bonafide record of research work done independently by Indu V K **(2012-11-181 )**under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

Vellanikkara

Date: 07.04.2016

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# CERTIFICATE

We, the undersigned members of the advisory committee of Indu V K **(2012-11-181)**, a candidate for the degree of **Master of Science in Agriculture**, with major field in **Soil Science and Agricultural Chemistry**, agree that the thesis entitled **"Recycling of cashew (*Anacardium occidentale L.*) leaf litter and cashew apple through vermitechnology"** may be submitted by Indu V K **(2012-11-181)**, in partial fulfillment of the requirement for the degree.

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EXTERNAL EXAMINER

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*Indu V K*

*This thesis is dedicated to my beloved father*

*V. Kunchu*

*who live in eternal peace*

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# Introduction

# 1.Introduction

A revolution is unfolding in vermiculture studies for composting diverse organic wastes by waste eater earthworms into a nutritive 'organic fertilizer' and using them for production of 'chemical free safe food' both in quantity and quality without adding chemicals.

Cashew (*Anacardium occidentale L.*) is a high value commercial horticultural crop of India introduced from Brazil by Portuguese. During the $16^{th}$ century cashew is introduced to cochin state as a crop for soil conservation and afforestation . Later it spread to goa and other parts of india. Our state was in forefront in developing cashew cultivation and still continues its dominant role in the production and export of cashew.

Apart from that, nut which is the economic part, cashew apple also finds a place in processing industry. Cashew Research Station Madakkathra, Kerala Agricultural University has developed large number of technologies for the processing of cashew apple to value added products. The residue often goes as a waste together with those that fall naturally. A large amount of cashew leaf litter, approximately 25-30 kg $p^{-1}$ $year^{-1}$ falls on the soil as solid organic waste that are not properly utilized or managed.

The present study entitled "Recycling of cashew (*Anacardium occidentale* L.) leaf litter and cashew apple through vermitechnology" envisages effective management of cashew leaf litter and cashew apple which is gaining momentum as viable alternative for organic manure generation as well as organic waste management, in association with other degrading organisms to produce organic manures within a short time period. Once standardised as a component in the potting mixture it can extensively be used for producing organic cashew which is of great demand in domestic and international market. With the above aim, the study is proposed with the following three main objectives.

1. To study the efficacy of different enrichners on the manurial value of vermicompost prepared from cashew leaf litter and cashew apple using compost worm *Eseiniafoetida*
2. To identify the role of introduced microbes in decreasing compost maturity
3. To evaluate enriched vermicompost as a manurial source and potting mixture for raising cashew grafts.

# *Review of literature*

# 2. Review of literature

Cashew, *Anacardiumoccidentale* L. (Anacardiaceae) is a hard drought resistant, tropical tree widely grown for its nuts. The leaf litterfrom cashew plants is considered as waste in original form and causes environmental pollution, forest fire, nutrient loss etc. Leaf litter is a potential but unexploited source of nutrients and its decomposition enriches soil nutrient pool. Another unexploited component is the cashew apple residue. At present the potential of vermicomposting as a viable alternative for waste management is gaining momentum in India. In this chapter, an attempt has been made to review the overall research work carried out in this line and these are categorised and presentedunder seven sub categories as follows.

2. 1. Cashew plantations and litter fall

2. 2. Litter addition and the factors influencing litter decomposition

2. 3. Recycling of organic wastes using earthworms

2.3.1. Recycling of other wastes

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2. 4. Vermicomposting and influencing factors

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## 2.1 Cashew plantations and litter fall

Cashew is an evergreen species and the cashew growing regions specifically fall almost equidistantly far of the equator and are spread almost equally in the northern and southern hemisphere . The flushes are put forth twice in an year and the time and intensity of flushing and flowering is a varietal character (Pushpalatha, 2000).

The crop has enough litter fall that contributes organic matter to a large extent. The average litter addition in a ten year old cashew graft plantation ranged from 1656 to 8856 kg ha $^{-1}$ with an average of 5014 kg ha $^{-1}$on wet weight basis (Usha, 2001). The glabrous, thick and leathery leaves were found richer in cellulose, hemicellulose and lignin from studies conducted to evaluate resource quality of green leaves and litter fall of six commonly grown trees in the homesteads of Kerala (Issac and Nair, 2002). The litter contained 0.65% N, 0.22% P and 0.72% K, 0.19% Ca besides 369, 17, 15 and 283 ppm of Mg, Fe, Zn, Cu and Mnrespectively, thus incorporating 32.1kg N, 1.1 kg P, 36.5kg K, 10.9kg Ca, 9.5kg Mg, 2.1 kg Fe, 0.1 kg Cu and Zn and 1.2 kg Mn per hectare (Usha, 2001).

**2. 2. Litter addition and the factors influencing litter decomposition**

Planting tree species has been found to be ecologically sound, environmentally sustainable and economically profitable in that it increases soil organic matter and ensures efficient recycling of plant nutrients through leaf litter and plant turnover (Buresh and Tian ,1998 ). It also increases biological activities by providing biomass and suitable microclimate for various microorganisms responsible for the release of mineral nutrients in available form to the trees (Sunita and Uma, 1993).

Litter fall is an important pathway of flow of organic matter as well as nutrients from vegetation to soil. The major biogeochemical cycling processes are nutrient uptake by plants and its return by litter fall, stem flow and thorough fall (Switzer and Nelson, 1972).

Litter fall in a ten to forty year- old- cashew plantation ranged from 1.38 – 5.2 t $ha^{-1}$ in Karnataka (Kumar and Hegde, 1999). The average and annual fall out of biomass (leaves, twigs, flowers and apples) per hectare in a well established cashew orchard was reported to be 5 tons. Canopy biomass fallout of leaves, cashew apples and flowers and the subsequent nutrient release were estimated and nutrient balance sheets were developed by Richards (1992).

Soil organisms are assumed to be directly responsible for soil ecosystem processes, especially the decomposition of soil organic matter and the cycling of nutrients (Wardle and Giller, 1996). These processes are regarded as major components in the global cycling of materials, energy and nutrients. Wardle and Giller, 1996 have also reported that the soil biomass (25 cm top soil layer) is known to process over 100 t of fresh organic material each year per hectare in many agricultural systems.

Plant litter decomposition is considered as complex and important factor in controlling vegetative structure ( Liu*et al.*, 2004), ecosystem function (Xiong and Nilsson, 1999) and nutrient cycling and organic matter turn over with the ecosystem (Smith and Bradford, 2003).

Litter decomposition is a key process in elemental cycling in forest ecosystems. It depends on the interactions between soil, biota and environment. Leaves are the largest single source of soil organic matter and an important source of nutrients in soil. The role of leaf litter in the recycling of nutrients, especially nitrogen and phosphorus, is well known. Micronutrients such as Copper and Zinc are recycled through root uptake, litter fall and decomposition (Bergkvist, 1987).

Cashew leaves normally resist decomposition by general soil microbes owing to its high content of lignin (134 g/kg) and cellulose (459g/kg) (Deo Bold and Rawford, 1997 Raja and Ramalingam, 2007). The rate of decomposition of cashew litter was recorded as 0.9 percent per month (Usha, 2001).

The positive influence of cashew leaves-pressmudmixture in combination with nitrogen sources and lignocellulolytic fungi in culturing the compost earthworm *Eudrilus euginea* has been reported by Raja and Ramalingam (2007).

Exotic worms (*Eudrilus eugeniae*) were found to degrade the coffee pulp faster (112 days) as compared to the native worms (165 days) but the vermicomposting efficiency (77.9%) and vermicompost yield (389kg) were found to be significantly higher with native worms. The multiplication rate of earthworms (280%) and worm yield (3.78kg) recorded were significantly higher with the exotic earthworms. Vermicompost and vermicasts from native earthworms recorded significantly higher functional microbial groups of population as compared to the exotic worms.

Microbial activity was differently influenced by different crops that produced specific root exudates and organic components from root systems and crop residues (Tian *et al.*, 1992).

Gosz *et al* (1976) indicated that in a decomposition cycle, there are critical carbon/ element and element/ P ratios for many nutrients. These ratios reflect nutrient demand by decomposers and only after these ratios are reduced below critical levels, the end products of mineralization appear in soil.

Hendrickson (1985) suggested that initial plant leaf residue with C:N ratios greater than 25:1 has been identified as the threshold value controlling immobilization while that for mineralization, the ratio should be less than 25:1. Plant materials above these thresholds are expected to decompose slowly and to immobilize nitrogen due to the formation of stable polymers between polyphenolic and amino groups.

According to Rao *et al* (1996) the higher potassium content in the surface layers of soil could be due to more intense weathering, addition of leaf litter from different crops in cropping system, release of liable potassium from organic residues, application of potassium fertilizers or upward translocation of potassium from lower depths with capillary rise of ground water. The availability of soil potassium is directly correlated with the soil texture and the type of clay minerals (Raychaudhary and Sanyal, 1999).

Reversat and Loumeto (2002) reported that leaf litter fall serves three main functions in the ecosystem *viz.,* energy input for soil micro flora and fauna, nutrient input for plant nutrition, and material input for soil organic matter building up. According to them, the first two functions are completed through decomposition and mineralization, and the third one through decomposition and humification.

Among the different decomposing agents, which act on the litter, bacteria and fungus have a dominant role due to their greater biomass and respiratory metabolism (Torres *et al*., 2005).

**2. 3. Recycling of organic wastes using earthworms**

**2.3.1. Recycling of other wastes**

In present days “organic farming” is gaining momentum as a technology to yield clean and safe food and hence organic manures are of immense value, though they are very scarce. In this context exploitation of the possibility of converting organic waste which would otherwise remain idle, into a quality manure by employing microbial cultures or earthworms, which are organic feeders is of immense value. Wastes from plantation crops like coconut, arecanut and cocoa (chowdappa *et al.*, 1999), coffee (orazco *et al*., 1996) and accasia (Sankarganesh *et al*., 2009), which contains high percentage of lignin and phenol have been successfully converted into vermicompost using different species of epigeic earthworms.

Vermicomposts prepared from different sources of green leaf materials were differed in their nutrient status. Substrate combination of banana pseudostem: glyricidia leaves: coconut leaves: cowdung in the ratio 2:2:2:1 registered the least C:N ratio of 12.25 which attained the compost maturity at 47 days and was identified as the best substrate controlled environment for vermicompost production. Banana pseudostem favoured the flourishment of microbial and higher worm population (Thankamony, 2005).

Banana pseudostem and leaves were cut into pieces and mixed with cattle dung at different proportions to raise earthworms (*Eisenia foetida*) for maximum production of organic fertilizer and high protein animal feed. The result of this study indicated that the mixture with 80% banana pseudostem and leaves produced higher number of the earthworms and the resultant organic fertilizer contained the highest level of nitrogen and the mixture with 90% of banana pseudostems and leaves produced a slightly fewer number of earthworms than the 80% mixture, but with no remarkable difference in the worm's weight, and consumed more banana pseudostems and leaves, and the resultant organic fertilizer contained higher organic matter (Shaoming and Qiquan, 2008).

In vegetable- market solid waste vermicomposting caused a decrease in organic C (12.7-28%) and C:N ratio (42.4-57.8), while increase in total N (50.6-75.8%), available P (42.5-110.4%), and exchangeable K (36.0-78.4%) contents. This concluded that the vermicomposting could be an efficient technology to convert negligible vegetable- market solid wastes into nutrient-rich biofertilizer if mixed with bulking materials in appropriate ratios (Suthar, 2008).

### 2. 3. 2. Recycling of cashew apple

Conversion of agricultural urban and industrial refuge into vermicompost by employing specific earthworms is quick and favoured method of waste's recycling in many countries (Edward 1998 and Sangwan *et al*., 2008)

Cashew apple is a pseudo fruit formed by the swollen receptacle. Ripe cashew apple has bright yellow, red or reddish yellow colour. It is soft and fibrous and has a characteristic flavour. The apple contains astringent principles, which gives an unpleasant biting sensation when raw apple is consumed. This in fact limits the utilisation of cashew apple as a fresh fruit as well as a raw material in the fruit processing industry.

Yield of cashew apple is six to eight times that of cashew nut. With the cashew nut production of 7.2 lakh tons per year, an estimated 60 lakh tons of cashew apple is produced in india Sobhana *et al*., (2013). In spite of the excellent nutritional qualities, medicinal value and potential material for conversion to various fruit products and fermented beverages, cashew apple has not gained commercial importance. Except in few production centers like Goa where cashew apple is utilised for making fermented products, the entire quantity of cashew apple available in major cashew producing tracts are being wasted at present.

Sobhana *et al*., (2013) reported that large number of technologies has been developed by various research stations in India, especially Cashew Research Station, Madakkathara, for the economic utilization of cashew apple by processing it into various value added products like syrup, RTS, soda, jam, candy, pickle, vinegar, chocolate etc. They also reported that the apple residue after juice extraction could be effectively utilized for the production of vermicompost.

Cashew apple is a highly perishable commodity. It is highly susceptible to physical injury, which leads to microbial spoilage within a very short period after harvest. Ripe cashew apples suffer severe damage by insect and non-insect pests as well as pathogens. More than 63 per cent of cashew apple collected at ripe stage suffers from moderate to heavy damage. Cashew apples collected from fallen fruits suffer heavily due to mechanical damage (Kutty, 2000). When bulk quantities of cashew apple is utilised for product preparation, considerable amount of residue were obtained as waste. Very often this waste is dumped into the surroundings making the environment unhygienic, inviting fly menace.

A work on this line was undertaken by Mini *et al* (2005) in the Cashew Research Station, Madakkathara, where value addition of cashew apple is going on in a large scale, leaving abundant residue with no specific after use. The otherwise wasted residue could be converted into a valuable manure within a period of 95 days employing organic residue feeding earthworms.

**2. 4. Vermicomposting and influencing factors**

Composting basically being a microbiological process, enzymatic activities can be part of a reliable measure of compost stability and maturity. Assay of different chemical and biochemical changes during composting is important for the optimization of the process and the quality of the end product. Vermicomposting is preferred over composting to overcome the deficiencies in the long duration for decomposition apart from low nutrient status in composting. Total organic carbon (TOC) and C/N ratio decreased while total N content increased with the progressof time during composting in all the organic residues (Sitaramalakshmi *et al*., 2013).

Crop residues are important organic source of plant nutrients which is easily available at low/ no cost. Approximately 600-700 million tonnes of agricultural wastes are produced annually in India, most of which remain unutilized. In some cases, the residues are left in the field for natural degradation, which is a slow process and takes many months for completion. Proper management of these residues is very essential as these wastes can be converted into useful substances by recycling process in agriculture because they contain different types of plant nutrients. Farm residues can be converted into valuable wealth by applying vermicomposting technology.

Different agricultural wastes can be converted into useful substances by recycling process in agriculture, because they contain different types of plant nutrients (Karmakar *et al*., 2012). Composting and vermicomposting are both recommended widely as biological processes for transforming organic wastes into useful soil amendments (Domínguez *et al*., 1997).

Although various physical, chemical and microbiological methods of organic solid wastes disposal are currently in use, these methods are time consuming and involve high costs. Therefore, there is a pressing need to find out cost-effective alternative method of shorter duration particularly suited to Indian conditions. In this regard, vermicomposting has been reported to be a viable, cost-effective and rapid technique for the efficient management of the organic solid wastes (Hand et al., 1988).

Vermicomposts, which are stabilized organic materials produced by interactions between earthworms and microorganisms, in a non-thermophilic process, is an important method of farm waste conversion to useful manures and has been reported to enhance plant germination, growth and yields of crops (Edwards and Arancon, 2004), soil conditioning and fertility management (Bindhu, 2010), plant beneficial microorganisms (Gopal, *et al*, 2009). The worm casts was found to have five times more organic matter, total N, and exchangeable cations than soil and the nutrient composition is dependent on the kind of substrate (Hari and Sushama, 2005).

The pseudostem of banana an important food crop of the world, takes several months for natural degradation( Kavitha *et al*., 2010) and could be effectively utilized for producing higher earthworm biomass and a nutrient rich vermicompost when used along with cowdung as an enrichment material (Bindhu, 2010).

**The important factors that influences the production as well as maturity of vermicompost are:**

1. C:N ratio 2. pH 3. Temperature 4.Moisture
5.Aeration 6. Particle size 7. Microbial presence.

**2. 4. 1. Carbon Nitrogen ratio**

Low concentration of carbon and enhanced nitrogen level as a consequence of microbial activity during humification process resulted in reduction of C:N ratio at the end of composting process (Hamoda *et al*., 1998). A C:N ratio ranging from 10-12 was usually considered to be an indicator of stable and decomposed organic matter (Jimenez and Garcia, 1992).

**2. 4. 2. pH**

According to Wilson (1989), most well stabilized compost had a pH between 6.5 and 7.5. Zacchariah (1994) reported that vermicompost always showed a pH ranging from neutral to alkaline. Studies conducted by Thomas (2001) revealed that maximum pH during composting was observed at the thermophilic stage. The substrate was unsuitable for worms if it was too acidic or too alkaline.

**2. 4. 3. Temperature**

According to Nair (1997) peak value of temperature, ($66.3^0$C) was attained during thermophilic stage of composting. Eghball *et al*., (1997) reported that during composting of cattle manure the temperature reached $65^0$C within 24 hours at all depths within the compost pile. After thermophilic stage, the microbial activity was decreased. This leads to maturation phase of the compost and it started to fall within the ambient temperature (Zibilske,1999). The heat was released by the oxidative action of microbes during the conversion of organic matter (Peigne and Girardin, 2004).

**2. 4. 4. Moisture**

Hand (1988) reported thatan moisture of 50-60% was ideal for vermicomposting process. High initial moisture content in compost hindered aeration and induced undesirable anaerobic condition during composting resulted in occurrence of foul odour (Haug, 1980).

### 2. 4. 5. Aeration

Parr *et al.,* (1998)reported that by adequate aeration, temperature in compost pile could be increased to greater than $60^0$C. It resulted in complete destruction of pathogens, parasites and weed seeds.

### 2. 4. 6. Particle size

Matured compost had a tea brown colour, no noxious smell and good stability (Kalaiselvy and Ramaswamy, 1996). They also found that maximum diameter of compost should not exceed 10mm, with 5mm as optimum.

### 2. 4. 7. Microbial presence in worm cast

The presence of large number of micro organisms as surface and gut micro flora in earth worms were reported by Galli *et al*., (1990). Edward and Burrows (1988) reported that vermicompost was rich in fungi, bacteria, and actinomycetes as compared to soil. According to Ismail (1993), the enzymes and gut micro organisms took active part in earth worm digestion and after absorption of nutrients for its own metabolism, the cast ejected through anus. Earthworm casts had higher microbial biomass which had implications on soil fertility and wider ecosystem functions (Scullion, 2002).

### 2. 5. Vermicomposting of cashew apple residue and leaf litter

According to Yadukumar (2014), use of earthworms for production of vermicompost from cashew biomass is a low cost technology for adoption in the cashew orchard and cost of vermicompost produced from cashew biomass came to Rs. 1.1 per Kg.

According to Swift *et al* (1979)leaf litter has potential but unexploited source of nutrientsand the rate of decay and pathways of decomposition are determined by the quality of litter material, the physical environment and the qualitative and quantitative composition of decomposer organisms.

Kale (1994) opined that it becomes mandatory to employ specific microbes that are lignocellulolytic in nature together with *Eudrilus eugeniae*, an African epigeic (surface dwelling) earthworm for decomposing organic wastes in India.

While working out the possibility of producing vermicompost from the organic wastes, both from cashew orchard and processing unit, Mini *et al* (2005) observed that both apple residue and leaf litter could be effectively turned into a quality manure with 1.69% N, 0.44% P, 0.58% K in a period of 95 days.

The unutilised cashew leaf litter and underutilized sugar mill waste pressmud in combination with gramwaste, urea and lignocellulolytic fungi, *Trichoderma viride* and *Pluerotus platypus*, were found beneficial on culturing to compost earthworm *Eudrilus eugeniae* (Raja and Ramalingam, 2007).

**2. 6. Quality of vermicompost**

Overall effect of vermicompost is reflected in improving soil properties, enhancing plant growth right from seed germination, harnessing income by reducing waste flow to land fills and maintaining a clean environment. The ultimate composition of a matured vermicompost varies as it is dependent on the nature of substrate used (Sushama *et al*., 2010).

Despite this, part A of the Fertilizer Control Order 1985 has insisted that the total content of nitrogen, phosphates and potassium limits as one percentage, each in a standard vermicompost, apart from specifying other physical properties and heavy metal content (FCO, 1985).

**2. 7. Effect of vermicompost ongrafted plants**

Application of vermicompost rejuvenates the depleted soil fertility, enriches the available pool of nutrients, maintains soil quality and conserves more water and biological resources. The vermicompost contains enzymes like amylase, lipase, cellulose and kitenase which helpsto breakdown the organic matter in the soil, releasing nutrients for plant uptake. They also increase the levels of soil enzymes like dehydrogenase, acid and alkaline phosphatases and urease ( Sinha *et al*., 2010).

Vermicompost, the living soil amendment serve as an excellent organic seedling fertiliser and soil conditioner. The nutrients in worm castings are water soluble making them immediately available for plants to use.

Johann (2007) reported that vermicompost could be an environmentally friendly substitute for peat in potting media with similar or beneficial effects on seedling performance and fruit quality.

The favourable effect of vermicompost as a component of potting mixture on crop growth and disease resistance have been reported in vegetable crops like beets, broccoli, cabbage, cauliflower, okra, cucumber and tomato

Potting soil containing a 20% or more of vermicompost, increased growth of plants and led to fuller plants of dwarf *Thumbelina zinnias* and more flowers.

Lazcano *et al* (2009) attempted studies on the feasibility of replacing peat, the most often used amendment in commercial potting substrates, by compost/ vermicompost for the production of tomato plants in nurseries, by increasing the proportion of these substrates @ 0, 10, 20, 50, 75 & 100%. High doses of vermicompost produced significant increases in aerial and root biomass of tomato plants in addition to significantly improving the plant morphology and plant quality.

The time required for composting cashew biomass using *Eudrilus sp* of earthworms was only 95 days. But in the present study though the composting period was more by 25 days. The addition of enrichners helped to improve the quality of the manure. The production cost was mainly involved that of cowdung, and so on per Kg basis the overall cost was below 1 Rs. Per Kg which is quite economical.

# Materials and methods

# 3. Materials and Methods

The study titled "Recycling of cashew (*Anacardium occidentale L.*) leaf litter and cashew apple through vermitechnology" was conducted at College of Horticulture, Vellanikkara situated at an altitude of 22.25 m above MSL at latitude $10^0$ 32' N and longitude $76^0$ 10' E and at Cashew Research Station, Madakkathara. Both the locations enjoy typical humid warm tropical climate.

## 3.1. Objectives:

The experiment was carried out during 2012-2014 with the following objectives in view viz;

1. Preparation of enriched vermicompostand
2. Assessing suitability of the enriched vermicompost as a component in potting mixture of cashew grafts

### 3. 1.1. Preparation of enriched vermicompost:

The materials intended for composting were heaped on ground and exposed to sun for two weeks for killing unwanted organisms, removing foul smell and for reducing moisture content. The air dried material was then transferred to circular ferrocement tanks of one cubic meter dimension and 300 kg capacity available in the vermicompost unit of department of Soil Science and Agricultural Chemistry, College of Horticulture. Over a layer of coconut husk (spread at the bottom of the tank for moisture absorption). Basic Feed Mixture (BFM) comprising cashew leaf litter, cashew apple, sawdust and cow dung in the 3:3:2:6 ratio (on dry weight basis) @ 140 Kg/tank. This was allowed for partial decomposition for a period of two weeks. Each of the tanks was then added with organic enrichners and microbes as detailed in Table 3.1. The materials were turned on alternate days to increase oxygen flow and to ensure proper mixing of the material.  After two weeks of decomposition 200 adult compost worms of *Eisenia foetida* were released in all the tanks except $T_2$ to which the *Eudrilus euginiae* was introduced.

Plate 1. Heaping compost materials on ground

Plate 2. Turning compost materials

Table 3.1. Materials used for preparing enriched vermicompost

| Sl.No | Materials used | Source | Function |
|---|---|---|---|
| 1. | Cashew leaf litter | Cashew Research Station, Madakkathara | As Components of Basic Feed Mixture |
| 2. | Cashew apple | | |
| 3. | Sawdust | Local collection | |
| 4. | Cowdung | | |
| 5. | *Eisenia foetida* | Vermicompost unit, Dept. of SS&AC | As Compost worms |
| 6. | *Eudrilus euginiae* | | |
| 7. | Glyricidia | Local collection | As Organic enrichners |
| 8. | Coconut leaf | | |
| 9. | Poultry manure | KVASU Poultry Farm, Mannuthy | |
| 10. | *Bacillus sp* | Dept. of Agricultural Microbiology, COH | As lignocellulose degraders |
| 11. | *Pluerotus sajarcaju* | Dept. of Plant Pathology, COH | |
| 12. | *Trichoderma viride* | BCCP, Dept. of Agricultural Entomology,COH | |

Table 3.2 Treatment details

Design: CRD Treatments: 9 Replications: 3

| Treatments (Notations) | Details |
|---|---|
| $T_1$ | Control (BFM) |
| $T_2$ | $T_1$+ 100 adult compost worms of *Eudrilus euginiae* |
| $T_3$ | $T_1$+ glyricidia leaf (10:1 on weight basis) |
| $T_4$ | $T_1$+ coconut leaf (10:1 on weight basis) |
| $T_5$ | $T_1$+ poultry manure (10:1 on weight basis) |
| $T_6$ | $T_1$+ *Trichoderma viride* + *Pleurotus sajar caju*@ 500 mg $kg^{-1}$ each |
| $T_7$ | $T_1$ + *Bacillus sp* @ 2 kg $m^{-3}$ |
| $T_8$ | $T_1$+ *Trichoderma viride* + *Pleurotus sajarcaju*@ 500 mg $kg^{-1}$ each + *Bacillus sp* @ 2 k $gm^{-3}$ |

| | |
|---|---|
| $T_9$ | $T_1$+ glyricidia leaf+ coconut leaf+ poultry manure+ *Trichoderma viride* + *Pleurotus sajarcaju* @ 500 mg $kg^{-1}$ each+ *Bacillus* sp@ 2 kg $m^{-3}$ |

Organic enrichners are included from treatment T3 to T9

The tanks were covered with damp gunny bags to maintain moisture level to 60% throughout the composting period. In addition cowdung slurry in 1:1 ratio was sprinkled in all the treatments at three days intervalto hasten the composting process.

Initial properties and nutrient status of substrates constituting the Basic Feed Mixture *ie*, pH, organic C, N, P, K, Ca, Mg, Fe, Mn, Zn, Cu was estimated using standard procedures as outlined in Table.3.3.

The substrates were air dried initially after which they were transferred to moisture cans and dried in an oven at $80^0$C till it attained constant weight. Dried samples were then ground into powder using a mechanical grinder and subjected to analysis.

Table 3.3 Initial nutrient status of substrates constituting the basic feed mixture

| Substrate | Parameter | Methodology | Reference |
|---|---|---|---|
| Cashew leaf litter, cashew apple and sawdust | pH | 1:1 suspension (w/v) measured using pH meter | Piper, 1966 |
| | Total C | Ashing | |
| | N | Microkjeldahl digestion and distillation | |
| | P | Diacid extract- Spectrophotometry | |
| | K | Diacid extract- Flame photometry | |
| | Ca, Mg, Fe, Mn, Zn, Cu | Diacid extract- Atomic Absorption Spectrophotometry | |
| Cowdung | pH | Compost: distilled water extract (w/v) measured using pH meter | Jackson, 1973 |
| | Organic C | Ashing | FCO, 1985 |
| | N | Microkjeldahl digestion and distillation | |
| | P | Ashing- 25% HCl extract- Bray 1 extractant- Spectrophotometry | |
| | K | Ashing- 25% HCl extract- Flame photometry | |



Plate 3. Compost transferred to ferrocement tanks inside vermicompost unit

| | | | |
|---|---|---|---|
| | Ca, Mg, Fe, Mn, Zn, Cu | Ashing- 25% HCl extract- Atomic Absorption Spectrophotometry | |

The content of cellulose, phenol and tannin, lignin, protein and total carbohydrate in cashew leaf litter and cashew apple was estimated using the procedure outlined in Table 3.4. The samples were also air dried and oven dried at 80$^{o}$C to constant weight as done for components of Basic Feed Mixture of the compost.

Table 3. 4 Biochemical analysis of cashew leaf litter and cashew apple

| Substrate | Secondary metabolites | Methodology | Reference |
|---|---|---|---|
| Cashew leaf litter and Cashew apple | Cellulose | Extraction using acetic-nitric acid mixture and estimation by spectrophotometry | Sadasivam and Manikkam,1992 |
| | Phenol | Folin phenol method | Malick and Singh, 1980 |
| | Tannin | Folin Dennis method | |

3. 1. 2**. Observations recorded**

3.1.2.1 Temperature and moisture:

Daily measurements of temperature and moisture of compost were made using a multichannel temperature monitor and a multichannel moisture meter respectively.

3.1.2.2 pH:

pH changes during the period of composting was recorded using a pH spear at weekly intervals.

3.1.2.3 Microbial count:

Total count of bacteria, fungi and actinomycetes, were recorded using the procedure outlined by Rao (1986) using serial dilution technique at both initial and final stages of composting. Ten grams of soil was added to 90 ml of sterile water and agitated for 20 minutes in a rotary shaker. One ml of the solution was transferred to a test tube containing

9 ml sterile water to get $10^{-2}$ dilution. Similarly, $10^{-3}$, $10^{-4}$, $10^{-5}$ and $10^{-6}$ dilutions were also prepared. Enumeration of total microbial count was carried out in appropriate media as detailed in Table 3. 5.

Table 3.5 Media used for enumeration of soil microorganisms

| Soil micro organisms | Culture media | Dilution | Reference |
|---|---|---|---|
| Actinomycetes | Kenknight and Munaier's medium | $10^{-5}$ | Rao, 1986 |
| Bacteria | Nutrient agar | $10^{-6}$ | |
| Fungi | Martin's rose bengal agar | $10^{-4}$ | Martin, 1950 |

3.1.3. Maturity period of composting and harvest:

Maturity of the vermicompost was adjudged from thedark colour noticed in top layers and the particles appearing granular. At this time, sprinkling of water was withheld for a period of 2-3 days and vermicompost was collected from the top layers, heaped in partial shade and left undisturbed for 1-2 days to allow adult worms, if any, to move down. Adult worm count was then taken from compost collected from each treatment manually.

3.1.4. Nutrient analysis of matured compost:

Nutrient contents and pH of the matured compost was estimated using the procedure outlined in Table 3.6.

Table 3.6. Nutrient analysis of matured compost

| Parameters | Methodology | Reference |
|---|---|---|
| pH | 1:1 Suspension (w/v) measured using pH meter | FCO, 1985 |
| Total C | Ashing | |
| N | Microkjeldahl digestion and distillation | |
| P | Ashing- 25% HCl extract- Bray 1 extractant-Spectrophotometry | |
| K | Ashing- 25% HCl extract- Flame photometry | |

Plate 4. Serial dilution technique for the enumeration of total microbial count

| | | |
|---|---|---|
| Ca, Mg, Fe, Mn, Zn, Cu | Ashing- 25% HCl extract- Atomic Absorption Spectrophotometry | |

**3.2. Suitability of the enriched vermicompost as a component in potting mixture of cashew grafts**

3.2.1. Selection of enriched vermicompost:

Manurial value of compost was assessed in terms of major nutrients obtained from all the nine treatments of experiment No. 1 for arriving at the best treatment.

3.2.2. Pretreatment:

The manure decided as the best from experiment No.1 was heaped and thoroughly air dried for 7-10 days in order to make it free of young ones and cocoons. It was then taken for inclusion as a component of potting mixture.

3.2.3.Preparation of potting mixture for sowing cashew nuts:

Design: CRD Crop: CashewVariety: Dhana

Treatments: 4

Replications: 4

No.of pots/replication: 5

The treatment details on different potting mixture are furnished in Table 3.7

Table 3.7.Preparation of potting mixture – Treatment details.

| Treatments (Notation) | Details |
|---|---|
| $T_1$ | Control (potting mixture containing sand, soil and FYM in 1:1:1 ratio) |
| $T_2$ | Potting mixture containing sand, soil and enriched vermicompost in 1:1:1 ratio |
| $T_3$ | Potting mixture containing sand, soil and enriched vermicompost in 1:1:2 ratio |
| $T_4$ | Potting mixture containing sand, soil and enriched vermicompost in 1:1:3 ratio |

Preparation of potting mixture

Filling potting mixture in polybags

Sowing cashew seeds

Watering the polybags

Mulching polybags with coconut fronds

Germinated cashew seed

Plate 5. Phases of experiment II


Plate 6. Cashew seedlings

The potting mixture consisting of sand, soil and FYM in 1:1:1 ratio and those in which FYM was substituted with enriched vermicompost, rated as the best from Experiment No.1 was transferred to poly bags of 25cmx15cm size and sown quality cashew nuts collected from Cashew Research Station, Madakkathara. Moisture content of potting mixture was monitored and maintained regularly. These bags were kept in field for $1^1/_2$ months in open air.

3.2.4. Grafting of cashew seedlings:

Soft wood grafting was done in $1^1/_2$ months old seedling using scions of the variety Dhana collected from Cashew Research Station, Madakkathara. After grafting the seedlings, the graft union was properly protected using sip up covers and then keptin polyhouse to increase the success percentage. The sip up cover moistioned at three days interval to maintain the humidity. The grafts were watered regularly and constantly monitored for their health, vigour and phytotoxicity, if any. Once sprouted, the sip up covers were removed and the plants were kept in the polyhouse with regular watering. After one month they were transferred to open field situation for taking further observations.

3.2.5. Observations

3.2.5.1. Analysis of potting mixture:

Chemical analysis of potting mixture was done before and after applying vermicompost for parameters furnished in table.3.8. The samples were initially air dried and then oven dried at $105^0$C and subjected to chemical analysis.

Table 3. 8. Analysis of potting mixture

| Parameters | Methodology | Reference |
|---|---|---|
| pH | 1:2.5 suspension (w/v) measured using pH meter | Jackson, 1958 |
| Organic C | Wet oxidation | Walkey and Black, 1934 |
| Available N | Alkaline permanganometry | Subbiah and Asija, 1956 |
| P | Bray extract No.1 | Bray and Kurtz,1945 |
| K | Neutral normal ammonium acetate extraction followed by flame photometry | Jackson, 1958 |

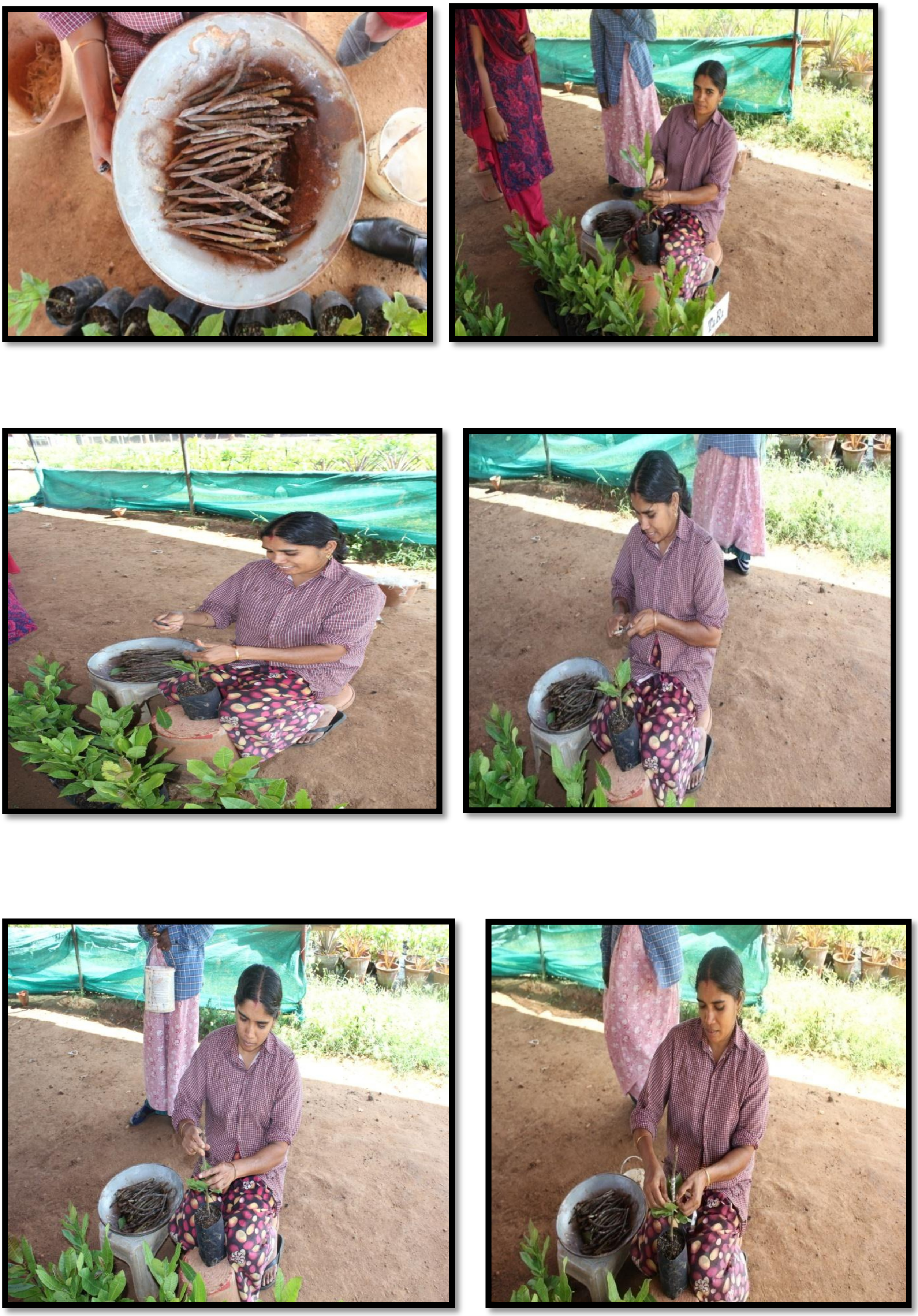

Plate 7. Different Steps in grafting

Palte 8. Aftercare of grafted plants


Plate 9. Cashew grafts in the field

Plate 10. Grownup seedlings in the field

| | | |
|---|---|---|
| Ca, Mg | Neutral normal ammonium acetate extraction followed by Atomic Absorption Spectrophotometry | |
| Fe, Mn, Zn, Cu | DTPA extraction followed by Atomic Absorption Spectrophotometry | Lindsay and Norvell, 1978 |

3.2.5.2. Biometric observations:

a) Days for seed germination
b) Number of leaves
c) Plant height (cm)
d) Collar girth (cm)

All biometric parameters were recorded for a period of three months at one month interval after grafting.

**3.3. Statistical analysis:**

The data obtained from experiment No.1 and 2 was subjected to statistical analysis by using the analysis of variance technique (ANOVA) (Panse and sukhatme, 1985). The effect of treatments and the differences among the treatment were examined, to prove the significant differences as the 95% probability level. Further comparison of means was accomplished using the Duncan's Multiple Range Test ($\leq 0.05$).

# *Results*

# `4. Results

The experiments was conducted with the following three objectives:

1. To study the efficacy of different enrichners on the manurial value of vermicompost prepared from cashew leaf litter and cashew apple using the compost worm *Eiseniafoetida.*
2. To identify the role of introduced microbes in decreasing compost maturity.
3. To evaluate enriched vermicompost as a manurial source in the potting mixture for raising cashew plants.

Two experiments were conducted for realizing these objectives.

## 4.1 Experiment No:1

### 4.1.1 Preparation of enriched vermicompost:

The enriched vermicompost obtained from cement tanks of $1m^3$capacity was taken and the following observations/analysis was carried out.

The result obtained under each parameter is present below.

4.1.1.1 Initial nutrient status of substrate:

. The basic feed mixture comprised of cashew leaf litter, cashew apple, sawdust and cowdung mixed in 3: 3:2:6 on weight basis. To this basic feed mixture different substrates were added according to treatments. Before composting the substrates were analysed. The initial status of all these component with respect to organic carbon primary and secondary nutrients was estimated and results are furnished in table 4.1

Table 4.1 :Initial nutrient status of substrates

| Substrates | pH | OC (%) | Total N (%) | C/N ratio | Total P (%) | Total K (%) |
|---|---|---|---|---|---|---|
| Cashew leaf litter | 6.1 | 41.0 | 0.67 | 61.1 | 0.21 | 0.75 |
| Cashew apple | 4.5 | 43.0 | 1.82 | 23.49 | 0.37 | 0.98 |
| Sawdust | 5.0 | 48.3 | 0.12 | 402.5 | 0.18 | 0.20 |
| Cow dung | 7.6 | 27.4 | 0.96 | 28.54 | 0.28 | 1.20 |
| Glyricidia leaf | 5.7 | 45.6 | 3.1 | 14.70 | 0.39 | 1.4 |
| Coconut leaf | 5.6 | 48.8 | 0.80 | 61 | 0.40 | 0.93 |
| Poultry manure | 7.6 | 23.3 | 1.03 | 22.62 | 0.21 | 0.65 |

| Substrates | Total Ca (%) | Total Mg (%) | Total Fe (mg $kg^{-1}$) | Total Mn (mg $kg^{-1}$) | Total Zn (mg $kg^{-1}$) | Total Cu(mg $kg^{-1}$) |
|---|---|---|---|---|---|---|
| Cashew leaf litter | 0.23 | 0.18 | 370 | 280 | 18.0 | 14.0 |
| Cashew apple | 0.30 | 0.19 | 162.4 | 74.50 | 69.97 | 12.36 |
| Sawdust | 0.12 | 0.03 | 164.9 | 13.30 | 24.63 | 1.13 |
| Cow dung | 0.34 | 0.28 | 352.4 | 24.22 | 36.16 | 33.33 |
| Glyricidia leaf | 1.83 | 0.83 | 700.0 | 84.0 | 33.0 | 7.0 |
| Coconut leaf | 0.5 | 0.3 | 25 | 175 | 22.46 | 9.11 |
| Poultry manure | 0.07 | 0.015 | 367.0 | 224.0 | 45.6 | 34.6 |

The pH of different substrates was recorded prior to the start of experiments. The pH value ranged from 4.5 to 7.6 with cowdung and poultry manure were observed a typically alkaline pH. pH of substrate is very important since the decomposing micro organism will survive better underalkalinemedium.

4.1.1.2 Organic carbon:

Organic carbon content of the material is important in deciding the ultimate quality of compost. Carbon provides both energy and serve as the basic building blocks of the microbial cells. (about 50% of the microbial cellmass). The substrates recorded carbon content of 23.3 to 48.8%. The high carbon containing material proves its suitability for better decomposition by the living organism provided other substrates are available.

4.1.1.3 Major nutrients (N,P,K)

The manurial value of compost is dependent on the content of N,P,K. Based on the substrate the elemental composition will vary in the matured compost. N content in the substrate, registered a value between 0.67 and 3.1%. The maximum value obtained for glyricidia leaf(3.1%) followed by cashew apple (1.82%) and poultry manure (1.03%). With respect to P content,the value ranged from 0.18 to 0.40 (%). The maximum value of P content was obtained for coconut leaf (0.40%), followed by glyricidia leaf (0.39) and cashew apple(0.37%).

4.1.1.4 Content of cellulose, phenol and tannin in cashew leaf and apple:

It is the high content of cellulose, tannin and phenol which normally resist the decomposition of cashew leaf by common or soil microbes. The content of cellulose and other secondary metabolites is given in table 4.2.

Table 4.2:Content of cellulose, phenol and tannin in cashew leaf and apple

| Substrates | Cellulose(mg/100g) | Phenol(mg/100g) | Tannin(mg/100g) |
|---|---|---|---|
| CLL | 45.9 | 1.62 | 0.66 |
| CA | 0.21 | 0.41 | 0.21 |

CLL: Cashew leaf litter ; CA: Cashew apple

Cellulose content in cashew leaf was 45.9 mg/100g of sample where as the cashewapple contain 0.21 mg/100g of cellulose. Cashew leaf was found to contain more quantity of phenols (1.62 mg/100g) as against the cashew apple (0.41 mg/100g). A comparison of cashew leaf and cashew apple with regard to tannin content revealed the superiority of cashew leaf over the cashew apple.

4.1.2 Nutrient analysis of matured compost:

Similar to the initial analysis on nutrient status of the substrate the matured compost obtained from the nine treatments was analysed for the parameters which are pH, OC, N, P, K Ca, Mg, Fe, Mn, Zn and Cu. The results are presented in table 4.3.

Table 4.3:Nutrient contents and other properties derived parameters of matured compost

| Treatments | pH | OC (%) | Total N (%) | C/N ratio | Total P (%) | Total K (%) |
|---|---|---|---|---|---|---|
| $T_1$ | $6.15^{e}$ | $32.16^{h}$ | $0.83^{fg}$ | $38.30^{a}$ | $0.26^{g}$ | $0.60^{h}$ |
| $T_2$ | $6.45^{cd}$ | $31.53^{g}$ | $0.80^{g}$ | $38.43^{a}$ | $0.46^{f}$ | $0.81^{gh}$ |
| $T_3$ | $6.38^{de}$ | $32.63^{f}$ | $1.33^{d}$ | $23.10^{d}$ | $0.51^{de}$ | $0.98^{g}$ |
| $T_4$ | $6.68^{bc}$ | $31.20^{f}$ | $1.13^{e}$ | $26.13^{c}$ | $0.53^{d}$ | $1.68^{ed}$ |
| $T_5$ | $6.71^{b}$ | $26.56^{e}$ | $0.93^{f}$ | $28.03^{b}$ | $0.68^{cd}$ | $1.70^{d}$ |
| $T_6$ | $6.70^{bc}$ | $27.06^{d}$ | $1.72^{b}$ | $15.46^{f}$ | $0.64^{c}$ | $1.57^{c}$ |
| $T_7$ | $6.72^{b}$ | $24.80^{c}$ | $1.55^{c}$ | $15.76^{e}$ | $0.48^{c}$ | $1.63^{c}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| $T_8$ | 6.87[b] | 27.26 [b] | 1.75 [b] | 15.13 [g] | 0.55 [b] | 1.92 [b] |
| $T_9$ | 7.31 [a] | 28.66 [a] | 2.46 [a] | 11.06[h] | 0.90 [a] | 2.06 [a] |
| CD (0.05) | 0.25 | 0.276 | 0.106 | 0.216 | 0.21 | 0.03 |

| Treatments | Total Ca (mg kg$^{-1}$) | Total Mg (mg kg$^{-1}$) | Total Fe (mg kg$^{-1}$) | Total Mn (mg kg$^{-1}$) | Total Zn (mg kg$^{-1}$) | Total Cu (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|
| $T_1$ | 754.2 [c] | 753 | 107.2 | 103.0 | 17.6 [d] | 1.3 [c] |
| $T_2$ | 1275 [b] | 1134 | 166.0 | 157.8 | 27.8 [bc] | 4.0 [b] |
| $T_3$ | 1331 [b] | 1135 | 171.6 | 161.2 | 27.5 [bc] | 4.4 [b] |
| $T_4$ | 1378 [b] | 1139 | 168.9 | 150.6 | 27.4 [bc] | 4.8 [ab] |
| $T_5$ | 1480 [ab] | 1152 | 177.1 | 160.3 | 28.1[bc] | 4.7[b] |
| $T_6$ | 1489 [ab] | 1150 | 179.0 | 166.5 | 26.4 [c] | 4.5 [b] |
| $T_7$ | 1479[ab] | 1147 | 179.9 | 168.9 | 28.4 [b] | 5.5 [ab] |
| $T_8$ | 1556 [ab] | 1158 | 182.0 | 173.8 | 28.2 [b] | 5.5[ab] |
| $T_9$ | 1834 [a] | 1185 | 185.0 | 176.5 | 31.6 [a] | 6.3[a] |
| CD (0.05) | 401.2 | NS | NS | NS | 1.7 | 1.53 |

4.1.2.1pH:

The pH of the matured compost was slightly alkaline in all the nine treatments. The most favourable pH recommended for organic manures is 6.5 to 7.5. Among the treatments $T_9$ recorded maximum pH of 7.31 while the compost from treatment $T_1$ was found to have the lowest value. Statistical significance was obtained with respect to favourable pH value in matured compost. Compared to the initial value, the process of composting enhanced the pH of the final product.

4.1.2.2 Organic carbon:

The values for organic carbon in different compost treatments ranged between 24.9 and 32.3 (%). It was highest for the treatment $T_1$ (32.2%). The lowest value of organic carbon was recorded for the treatment $T_7$ (24.9%). In all the compost materials the carbon status was showed a significant reduction as compared to the initial level.

Among the major nutrients nitrogen is very critical in the composting process since it's content in the composted material is directly related to the source. The N content of the composted material ranged from 0.82 to 2.9 (%). The compost obtained from $T_6$, $T_7$, $T_8$, $T_9$ contain more amount of N as compared to other treatments. The compost obtained from $T_1$, $T_2$, $T_3$, $T_4$, $T_5$ was low with respect to N status. The data given in table 4.3 revealed that the compost from $T_9$ was superior in terms of P and general range was from 0.26 to 0.90 (%). The amount of K contained in the matured compost was lesser than the initial status with $T_9$ registering the highest value of 2.06 (%) and $T_1$ the lowest 0.60(%).

4.1.2.3 Secondary nutrients (Ca, Mg):

Results on the content of secondary nutrient mainly Ca, Mg are given in table 4.3. The process of composting brought about changes in the amount of Ca, Mg as against that contained in the original substrate. The content of Ca varied from 754.2 to 1834(mg $kg^{-1}$) while that of Mg was in between 753 and 1185 (mg $kg^{-1}$). The highest amount of Ca was present in the matured compost in $T_9$ supporting its suitability for application in acidic soil. Mg content was maximum for the matured compost from treatment $T_9$ and minimum in treatment $T_1$. Higher amount of Ca, Mg is added advantage from the point of quality applicable to all organic manures.

4.1.2.4 Temperature:

Daily observations on temperature were recorded from day one to the day of compost maturity.

Table 4.4: Temperature changes during composting

| Temperature at 10 days interval | Treatments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 |
| 1 | 28.2 | 28.1 | 27.5 | 27.6 | 28.5 | 28.8 | 29.7 | 29.1 | 31.7 |
| 10 | 28.7 | 28.2 | 27.9 | 27.8 | 28.3 | 28.3 | 30 | 29.8 | 31.9 |
| 20 | 28.8 | 28.3 | 28.2 | 28 | 28.5 | 28.1 | 30.1 | 29.6 | 31.8 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 30 | 28.7 | 28.5 | 28.3 | 28.3 | 28.8 | 28.6 | 30.2 | 29.6 | 31.8 |
| 40 | 28.7 | 28.3 | 27.8 | 28.1 | 29.1 | 29 | 30.4 | 29.8 | 32.4 |
| 50 | 28 | 27.8 | 27.8 | 27.4 | 27.9 | 28.2 | 28.7 | 28.5 | 29.3 |
| 60 | 27.8 | 27.6 | 27.7 | 27.5 | 27.6 | 27.9 | 28.3 | 28.2 | 28.6 |
| 70 | 28 | 27.7 | 27.9 | 27.6 | 27.8 | 28.1 | 28.6 | 28.4 | 28.8 |
| 80 | 28.6 | 28.1 | 28.2 | 27.9 | 28.3 | 28.5 | 28.7 | 28.7 | 29.3 |
| 90 | 28.5 | 28.4 | 28.1 | 28.2 | 28.5 | 28.7 | 29.5 | 29.1 | 29.5 |
| 100 | 28.1 | 28 | 27.9 | 27.9 | 28.1 | 28.2 | 29.4 | 28.6 | 28.6 |
| 110 | 28.2 | 28 | 28 | 28 | 28.3 | 28.4 | 29.5 | 28.7 | 28.7 |
| 120 | 28.1 | 28.2 | 28 | 28 | 28.2 | 28.3 | 29 | 28.6 | 28.5 |

The data on temperature given in table 4.4 showed that there was drop in temperature in the compost preparation correlating with the four important stage with Mesophilic, Thermophilic, cooling down and maturation stages. Initially the compost piles recorded a value of $28^0$Cwhich finaly declined. Among the different treatments the changes in temperature werequite uniform and it was significantstatistically. The maximum temperature was recorded for $T_9$ ($32.4^0$C) and minimum $T_1$($27.8^0$C).

4.1.2.5 Weekly pH:

The pH of matured compost was determined on weekly basis. The mature compost from all the nine treatments registered a higher value, as compared to initial periods. However treatment $T_9$ is registered the maximum pH of 6.98 and $T_1$ recorded the lowest value (5.91).

Table 4.5: Variation in pH at 20 days interval

| pH at 10 days interval | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 |
| 1 | 5.91 | 5.92 | 6.01 | 5.91 | 5.91 | 5.91 | 5.91 | 5.91 | 5.91 |
| 20 | 5.91 | 6.2 | 6.3 | 6.41 | 6.43 | 6.42 | 6.44 | 6.01 | 6.98 |
| 40 | 5.91 | 6.23 | 6.39 | 6.43 | 6.41 | 6.45 | 6.48 | 6.21 | 6.98 |
| 60 | 5.91 | 6.15 | 6.23 | 6.43 | 6.49 | 6.5 | 6.52 | 6.15 | 6.98 |
| 80 | 5.91 | 6.49 | 6.62 | 6.63 | 6.69 | 6.69 | 6.71 | 6.23 | 6.98 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 100 | 5.91 | 6.59 | 6.62 | 6.63 | 6.69 | 6.7 | 6.74 | 6.51 | 6.98 |
| 120 | 5.91 | 6.15 | 6.15 | 6.15 | 6.15 | 6.15 | 6.15 | 6.15 | 6.98 |

Analysis of above data showed the superiority of treatment $T_9$ over others.

4.1.2.6 Total microbial count:

Composting is a process mediated by micro organisms. In the present experiment microbes like *Trichoderma viridae*, *Pleurotus sp* were applied together along with other plant residues, poultry manure and *Bacillus* sp. The total microbial count recorded during initial and final stage of composting, is given in table 4.6 and 4.7 respectively.

Table 4.6:Total microbial count of initial substrates

| Treatments | Bacteria($x10^{-6}$) (cfu/g) | Fungi($x10^{-4}$) (cfu/g) | Actinomycetes($x10^{-5}$) (cfu/g) |
|---|---|---|---|
| CLL | 6 | 10 | 7 |
| CA | 9 | 12 | 6 |
| Sawdust | 5 | 7 | 4 |
| Cowdung | 44 | 18 | 5 |

CLL: Cashew leaf litter, CA: Cashew apple, cfu/g: Colony forming unit per gram

Table 4.7:Total microbial count at final stage of composting

| Treatments | Bacteria ($x10^{-6}$) (cfu/g) | Fungi ($x10^{-4}$) (cfu/g) | Actinomycetes($x10^{-5}$) (cfu/g) |
|---|---|---|---|
| $T_1$ | $8.66^{h}$ | $127.6^{h}$ | $8.00^{f}$ |
| $T_2$ | $9.00^{gh}$ | $139.6^{g}$ | $8.66^{f}$ |
| $T_3$ | $12.66^{g}$ | $143.3^{g}$ | $11.66^{e}$ |
| $T_4$ | $17.66^{f}$ | $164.6^{f}$ | $13.66^{e}$ |
| $T_5$ | $23.33^{e}$ | $173.0^{e}$ | $16.66^{d}$ |
| $T_6$ | $32.66^{d}$ | $181.6^{d}$ | $19.33^{c}$ |
| $T_7$ | $48.66^{c}$ | $204.0^{c}$ | $22.66^{b}$ |
| $T_8$ | $66.00^{b}$ | $221.6^{b}$ | $27.00^{a}$ |
| $T_9$ | $114.3^{a}$ | $272.6^{a}$ | $28.33^{a}$ |

| | | | |
|---|---|---|---|
| CD(0.05) | 3.934 | 4.863 | 2.008 |

cfu/g: Colony forming unit per gram

An increase in microbial count was observed towards the end of composting as compared to the initial values. Among the microbes, the population of fungi was highest followed by bacteria and actinomycetes.

A comparison on total microbial count in different treatments at final stage of composting revealed a significant difference and was maximum for the treatment $T_9$ and minimum for the treatment $T_1$ for all the three categories of microbes.

Among the different microbes counted, $T_9$ recorded the maximum population of fungi, bacteria and actinomycetes.

4.1.2.7 Maturity period of compost:

Maturity of compost is an important factor which decides its suitability for application to the soil. Compost is considered matured when energy and nutrient containing material have been combined into stable mass. The time required to obtain matured compost is vested with many factors and may range from a couple of weeks to more than one year. The result obtained on maturity period of composting is furnished in table 4.8. Significant difference was noticed with respect to the treatments on maturity period. In general maturity period varied from 120 to 135 days. Fastest maturity was attained in the treatment $T_9$ where different plant residues, organic manures and microbes were included. Treatment $T_1$ took the maximum time to attain maturity of 135 days.

Table 4.8: Maturity period of compost

| Treatments | Maturity period (Days) |
|---|---|
| $T_1$ | 135 |
| $T_2$ | 134 |
| $T_3$ | 126 |
| $T_4$ | 128 |
| $T_5$ | 128 |
| $T_6$ | 124 |

| | |
|---|---|
| $T_7$ | 127 |
| $T_8$ | 123 |
| $T_9$ | 120 |
| CD (0.05) | 3.4 |

Analysis of data showed a significant compost maturity period among treatments. The treatment $T_9$ was superior to all others treatments.

4.1.2.8 Earthworm count at maturity:

After the compost attain maturity, the earthworm count was taken in all the treatments. Drastic difference was noticed on the number of earthworms under different treatments.Many methods are available for harvesting of which the simplest and commonly used is the dumb and hand sort method. Here the composted material is heaped under partial shade during which the live worms if any will move downward leaving the top portion totally free of worms.

The top portion sieved using the mesh to ensure the compost free from worms. The worms remaining at the bottom portion of the heap and on the sieve are separated from adhering compost and the population of earthworms is taken after sorting with hand.

The data is provided in table 4.9 and a comparison of different treatments clearly shown the influence of substrate on earthworms count. Usually in a vermicompost pit, earthworm multiplies two to three times of its original population unless the factors of compost making are adverse. In this experiment, wide variations prevailed among the treatments with respect to earthworm count and maturity. Population of earthworms was highest in the treatment $T_9$ and this was significantly superior to all others. The control treatment $T_1$ registered the minimum population of earthworms.

Table 4.9:Earthworm count at maturity

| Treatments | Earth worms (No) |
|---|---|
| $T_1$ | 1022 |
| $T_2$ | 972 |

| | |
|---|---|
| $T_3$ | 1239 |
| $T_4$ | 1371 |
| $T_5$ | 1451 |
| $T_6$ | 1512 |
| $T_7$ | 1510 |
| $T_8$ | 1675 |
| $T_9$ | 1935 |

## 4.2 Experiment II

### 4.2.1 Suitability of enriched vermicompost as a component in the potting mixture for cashew grafts.

Based on manurial value (NPK) of the vermicompost obtained from experiment I the best treatment was selected. This was designated as the enriched compost and was considered as a suitable component in the potting mixture of cashew seedlings for graft production. Soil chemical analysis was taken up before and after applying the vermicompost for pH,organic carbon, available N, P, K, Ca, Mg, Fe, Mn, Zn and Cu. Besides chemical analysis, biometric observations of cashew grafts raised under different treatmentswere recorded. This included days for seed germination, number of leaves, plant height and collar girth. The results are presented in Table 4.10 and 4.11.

Table 4.10pH and nutrient status of potting mixture with and without application of vermicompost

| Treatments | pH | OC(%) | N (g/kg) | P(g/kg) | K(g/kg) |
|---|---|---|---|---|---|
| $T_1$ | 5.7 $^{c}$ | 0.7 $^{ab}$ | 0.24 $^{b}$ | 0.17 $^{c}$ | 0.38 $^{d}$ |
| $T_2$ | 5.8 $^{c}$ | 0.6 $^{b}$ | 0.28 $^{b}$ | 0.18 $^{c}$ | 0.45 $^{bc}$ |
| $T_3$ | 6.1 $^{b}$ | 0.7 $^{b}$ | 0.28 $^{b}$ | 0.23 $^{b}$ | 0.53 $^{b}$ |
| $T_4$ | 6.9 $^{a}$ | 0.9 $^{a}$ | 2.75 $^{a}$ | 0.34 $^{a}$ | 0.72 $^{a}$ |
| CD(0.05) | 0.135 | 0.264 | 0.197 | 1.27 | 3.17 |

4.2.1.1 Organic carbon (OC):

The OC status before and after applying vermicompost showed significant variation. In general, the values ranged from 0.7% to 0.9%. The highest content was registered in the treatment $T_4$ and lowest in the treatment $T_2$. Statistical significance was observed among the treatments with respect to organic carbon content.

4.2.1.2 Available NPK:

Available NPK status of soil before and after applying vermicompostwas remarkably higher after applying vermicompost. Available N content was maximum in the treatment $T_4$. With respect to P and K, the values varied between 0.17g/kg to 0.34g/kg and 0.38g/kg to 0.72g/kg to respectively. Treatments had a significant effect with respect to content of primary nutrients P and K consequent to applying vermicompost.

4.2.1.3 Secondary nutrients:

The secondary nutrients Ca and Mg were significantly influenced by vermicompost application. The treatment$T_4$ recorded the highest value for Cawhere as the lowest value was found with the treatment $T_1$. In the case of Mg also the trend was same. Here highest value was obtained in treatment$T_4$ whereas the lowest content was registered in $T_1$. Here also treatment effects were statistically significant.

Table 4.11 Secondary and micronutrient contents in potting mixture with and without applying vermicompost

| Treatments | Ca (g/kg) | Mg (g/kg) | Fe (mg/kg) | Mn (mg/kg) | Zn (mg/kg) | Cu (mg/kg) |
|---|---|---|---|---|---|---|
| $T_1$ | $0.5^{c}$ | $0.1^{c}$ | $12.2^{bc}$ | $10.2^{d}$ | $6.7^{d}$ | $11^{c}$ |
| $T_2$ | $0.7^{b}$ | $0.1^{c}$ | $12.5^{b}$ | $13.5^{c}$ | $6.8^{bc}$ | $11^{c}$ |
| $T_3$ | $0.8^{ab}$ | $0.1^{b}$ | $12.3^{bc}$ | $17.4^{b}$ | $7^{b}$ | $12.2^{ab}$ |
| $T_4$ | $0.7^{a}$ | $0.2^{a}$ | $15.7^{a}$ | $21.4^{a}$ | $7.7^{a}$ | $12.7^{a}$ |
| CD(0.05) | 0.20 | 0.31 | 0.084 | 0.110 | 0.029 | 0.050 |

4.2.1.4 Micronutrients:

The micronutrient status of the vermicompost filled polybags ($T_2$-$T_4$) recorded pronounced increase compared to the initial value. The maximum value of Fe, Mn, Zn, Cu was found in $T_4$ as compared to other treatments.

4.2.1.5 pH

pH of the soil was estimated before and after applying vermicompost and the results are presented in table 4.10. The pH value ranged between 5.7 and 6.9 among the four treatments. Near neutral pH was recorded in treatment $T_3$ and $T_4$. Compared to the intial value all treatment responded positive towards ashiest in pH towards neutral. The effect of different treatments on pH was significant. Among the four treatments $T_4$ i.e, potting mixture containing sand, soil and enriched vermicompost in 1:1:3 ratio was superior with minimal change in pH before and after the experiment was observed in $T_1$ (control).

4.2.1.6 Biometric observation:

Days for seed germination, Number of leaves, plant height and collar girth were the important observations made under experiment II. Details are furnished in table 4.12 and 4.13.

Table 4.12 Days for seed germination

| Treatments | Days for seed germination |
|---|---|
| $T_1$ | 19 |
| $T_2$ | 17 |
| $T_3$ | 17 |
| $T_4$ | 15 |
| CD(0.05) | 0.11 |

a) Days for seed germination

The no. of days taken by the seed to germinate is an important character. Treatment effects was prominent on this aspect although the observation period is dependent on quality of seed as well as that of the medium which determine the germination period. Among the four treatments, $T_4$ containing enriched vermicompost in three parts by volume along with a potting mixture registered the minimum period for the seeds to germinate. This treatment was significant statistically also. Maximum number of days for seed germination was associated with T1 (Control).

b) Number of leaves

Number of leaves is an indication of seed vigour. Among the four treatments maximum leaf production was noticed in treatment $T_4$ which was significantly superior. This was closely followed by $T_3$. Here also lowest leaf number was recorded in the seedling under treatment $T_1$ (absolute control).

Table 4.13Details on number of leaves, plant height and collar girth

| Treatments | No. of leaves | | | Plant height (cm) | | | Collar girth (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Months after grafting | | | Months after grafting | | | Months after grafting | | |
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| $T_1$ | 5.5 | 9.5 | 32.4 | 28.65 | 32.35 | 38.12 | 2.32 | 2.92 | 4.15 |
| $T_2$ | 5.7 | 11.2 | 31.7 | 28.37 | 31.72 | 37.27 | 2.42 | 2.90 | 4.35 |
| $T_3$ | 6.5 | 10.7 | 32 | 28.27 | 32.02 | 37.52 | 2.25 | 2.77 | 4.20 |
| $T_4$ | 9.7 | 15.2 | 35 | 31.40 | 35.02 | 40.37 | 2.60 | 3.45 | 5.30 |
| CD (0.05) | 1.50 | 1.73 | 2.19 | 1.08 | 2.19 | 1.83 | NS | 0.36 | 0.44 |

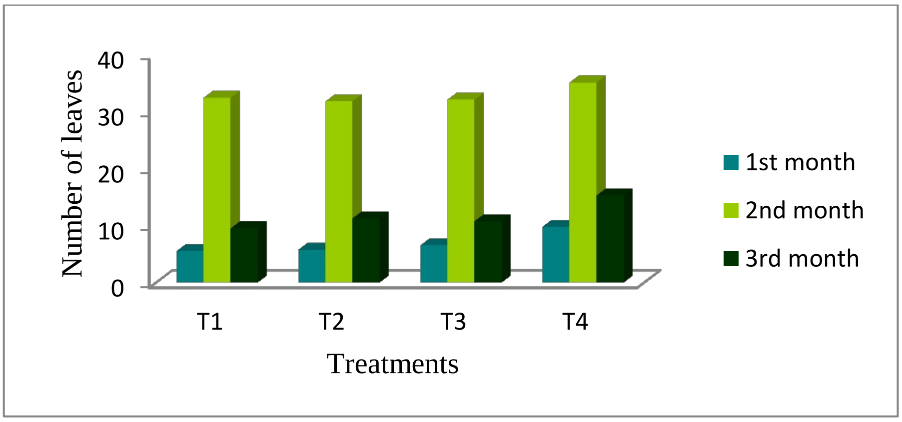


**Fig 4.1 Effect of treatments on number of leaves**

c) Plant height:

Plant height was recorded after $1^1/_2$months. Maximum plant height was noticed in $T_4$ and minimum in $T_1$ Statistical significance was noticed with respect to treatments on plant height.

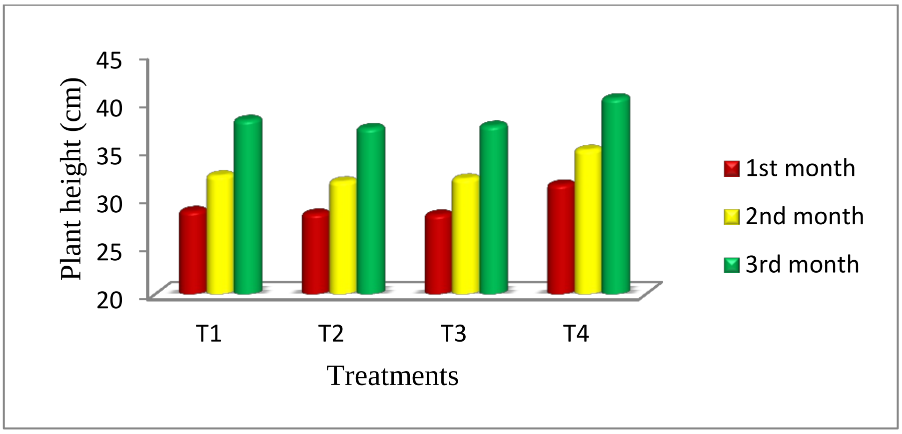


**Fig 4.2. Effect of treatments on plant height**

d) Collar girth:

Collar girth also reflects plant vigour. This was a measured after $1^1/_2$ months of growth. The treatments showed a significant difference on their effect towards collar girth which was highest in $T_4$ and lowest in $T_1$. The treatment $T_2$ and $T_3$ were on par in terms of collar girth.

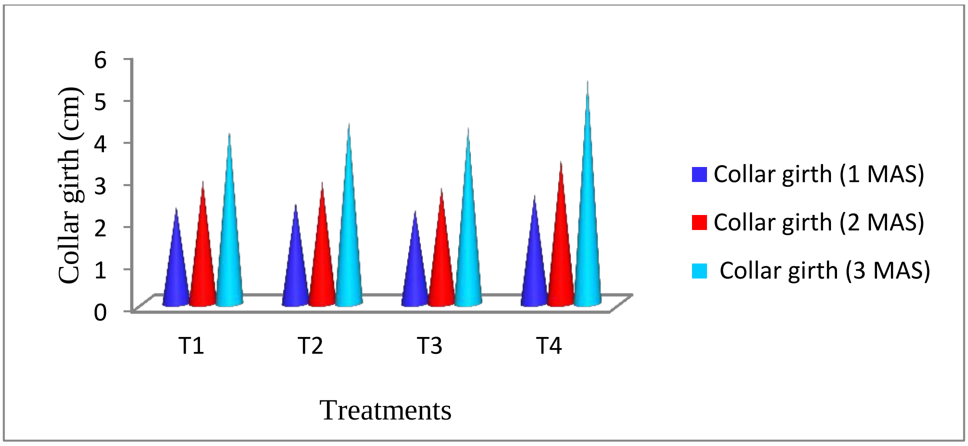


**Fig 4.3 Effect of treatments on collar girth**

# Discussion

# 5. Discussion

The study entitled “Recycling of cashew (*Anacardium occidentale L.*) leaf litter and cashew apple through vermi technology” was intended to study the efficacy of different enrichners on the manurial value of vermicompost prepared from cashew leaf litter and cashew apple using the compost worm *Eisenia foetida*, to identify the role of introduced microbes in decreasing compost maturity and to evaluate enriched vermicompost as a manurial source in the potting mixture for raising cashew grafts. The results obtained from this study are discussed in this chapter under two major titles.

## 5.1 Preparation of enriched vermicompost:

Initial parameters and nutrient status of substrates : This included pH, OC, N, P, K,Ca, Mg, Fe, Mn, Zn and Cu. Table 3.3 explains physico chemical composition of substrate, pH, OC, N, P, K, Ca, Mg, Fe, Mn, Zn and Cu.

### 5.1.1 Content of cellulose, phenol and tannin in cashew leaf and cashew apple:

The main problem related with decomposition of cashew leaf and cashew apple is the high content of cellulose, secondary metabolites viz. phenol, and tannin which the general soil micro organism cannot degrade. In order to overcome this problem, organisms like *Trichoderma viridae*, *Pleurotus sp* and *Bacillus sp* were introduced in vermicomposting. A drastic reduction was noticed in the content of cellulose, phenol and tannin withprogress in composting process which is considered as the net effect of introduced microbes which are capable of degrading the hazardous components. Presences of Microbial colonies of bacteria, fungi, actinomycetes were the special feature of compost obtained from $T_6$, $T_7$, $T_8$ and $T_{9.}$ The fungal population increased in treatments of $T_6$, $T_8$ and $T_9$which may be due to the introduction of *Trichoderma* whereas *Pleurotus* a relative increase in fungal population *Plerotussp* was pointed out as a common feature. Whenever the substrate gets richer in cellulose which normally happen towards the final stages of compost production. This is in agreement with the findings of Bertoldiet *et al*., (1983). The contribution of actenomycetes towards attacking cellulose cannot be ruled out. The decomposition of cellulose is unable by fungi which provides really available C to the bacteria. Which amply support the present result were in treatment 9 which is the combination of plant residue poultry manure and microbes which produce the best quality compost.

The content of cellulose, phenol and tannin in cashew leaf and cashew apple before and after composting with different organic residues, organic manure and microbes are presented in Table 4.2. The high content of lignocellulosic materials in cashew leaf litter has been reported to resist decomposition by general microbes (Deobald and Crawford, 1997). This has been further supported by many researchers ( Benitez *et al*., 2002). This probably limits its scope for recycling. The content of phenol and tannin in cashew leaf and cashew apple are also high. Interms of phenol and tannin, cashew leaf contains the maximum compared to cashew apple. Interms of cellulose, phenol and tannin content of cowdung was rated second. Since all the treatments contained both cowdung and cashew components, the effects caused can be considered equivalent. On comparing the values of the polysaccharide and secondary metabolites in the initial substrates and the matured compost, it could be seen that there was drastic reduction in their contents after composting, high lighting importance of treatment effects in the decomposition of organic materials.

5.1.2. Nutrient analysis of matured compost:

The matured compost was analyzed for pH, OC, primary, secondary and micro nutrients like Fe, Mn, Zn and Cu. The pH of the matured compost was increased by two units as compared to all the original substrates. Significant increase in pH consequent to composting is a general feature. This can be attributed to the intense microbial activity in general, in all treatments. The four major stages during composting involves different types of microbes and this brings about substantial changes in acidity. The compost produced registered an alkaline pH (6.15 to 7.3) which can be attributed to the effect of introduced microbes. The action talk used as a carrier in the preparation *Trichoderma viridae* and also the excretion of calcium, from the calciferous glands of earth worms would also have resulted in alkaline pH. The pH becoming neutral towards maturity of compost can also be due to the conversion of organic acids to $CO_2$ by microbial activity (Iqubal *et al*., 2012). The change in pH observed in experiment no.1 is desirable and is in agreement with the quality specification prescribed for vermicompost by FCO, 1985. A compost with alkaline pH is of great value when applied as a manure to acid soils of Kerala.

The different treatments significantly influenced the pH. Among the treatments Treatment 9 consisting of a combination of organic manures and introduced microbes was significantly superior since the conditions present was highly congenial for the activity of both earthworms and the introduced microbes. Comparing $T_2$ with other treatments, it can be observed that the increase in pH was relatively less. This may be due the specific nature of the worms *Eudrilus euginiae* which could not accommodate with the substrates as against *Eisenia foetida*. Treatment 1 (T1) which contained the basic feed mixture alone also registered a lower pH (6.15) change as against $T_9$.

5. 1.2.1 OC and Major nutrients:

Reduction in carbon content consequent to the composting was found as a common feature in all treatments. This might be due to the its use by the microbes as an energy source. Reduction in carbon content is in conformity with the findings of (Parthasarathy, 2000 and Suthar, 2007). An increase in N content was noticedproportion in all treatments. Increase in N is due to the increased population of organisms which could have contained large quantity of ammonical and nitrate forms of nitrogen. Quantity and quality of the organic wastes also decide the onset and rate of reproduction and recovery rate of vermicompost (Parthasarathi, 2000). It has been experimentally proved the existence of significant relationships between biomass of earth worm in general the oligocheta and the nutritional quality of substrate. The growth and reproduction in earthworms require OC, N and P, which are obtained from the litter, guts of microbes (Parthasarathi, 2000; Satchell and Martin, 1984; Suthar, 2007). The main index to assess the rate of organic matter decomposition is the reduction of C/N and C/P ratio during the composting process. C/N ratio is one of the criteria to assess the rate of decomposition of organic materials. The reduction in C/N and C/P ratio indicates increased rate of decomposition (Suthar, 2007; Parthasarthi, 2000) had also reported a reduction in carbon compared to phosphorus while trying the effects of fungal culture on rural residue composting.

The increased rate of mineralization brought about by the cellulose degraders, nitrogen fixers and P solubilizers, groups of microbes present in the earthworms guts, which is much higher than soil around, would have also contributed substantially to the higher nitrogen and phosphorus content of matured compost. The significant reduction in N during the vermicomposting process may probably be due to excretion of ammonia and secretion of mucus. N incorporation into the earthworm tissue and its leaching into the media with their death and decayis also reasonable for this phenomenon (Chaudhari *et al.,* 2000). Higher level of transformation of P from organic to inorganic state and their appearance in available form during vermicomposting. This aspect together with the introduced bacteria and fungi would have led to the highest P content in treatment 9 ($T_1$ to $T_9$ ). The rise in level of P content during vermicomposting due to the mineralisation and mobilization of P due to bacteria and fecal phosphatase activity of earthworms. The substrates used in the present study contained substantial amount of P required for microbial activity.

5.1.2.2.Potassium:

Vermicomposting increased the K content in the final product irrespective of the substrates. It was the highest (2.06 %) in treatment 9 (the combination of organic manures and introduced microbes). This might be ascribed to the direct activities of worm gut enzymes. The bio-oxidation and stabilization of organic materials by the joint action of microorganism and earthworms would have led to the increased K content in the compost treatments $T_6$, $T_7$ and $T_8$. The physical disintegration of organic matter of the wastes due to biological grinding during passage through the gut and also due to enzyme activity that prevails in worms gut was another supporting factor. Similar results were also obtained by Rao *et al*., 1996.

5.1.2.3. Secondary nutrients (Ca and Mg):

The Ca content in the matured compost was found to be the highest in treatment 9 (1834 mg $Kg^{-1}$). This was followed by treatment 8 (1556 mg $Kg^{-1}$). The higher content of calcium may be due to its contribution from the calciferous glands of earthworms and from poultry manure present in $T_8$. Similar results have also been reported by Iqbal *et al*., 2012. The increased content of Mg may be related to the faster decomposition brought about by earthworms and the introduced microbes which in turn increased the net mineralization rate. This is in line with the findings of Sinha *et al.,* 2010.

5.1.2.4.Micro nutrients (Fe, Mn, Zn and Cu):

Micronutrient status of manures is of great significance. All these elements are essential to plant growth much alike the primary and secondary nutrients though the quantity required is less. Among the four micronutrient analyzed, the content showed significant variation with regard to treatments. From table 4.3, it could be seen that Fe, Mn, Zn and Cu were highest 185.0%, 176.5%, 31.61% and 6.27%respectively in treatment $T_9$. Compared to the initial values there was significantly increase in the value of all micronutrientsanalysed. The presence of enzymes and co-factors in the earth worm gut would have increased the Fe content in vermicompost (Suthar, 2007). Similar results were also reported by Lakshmi Prabha *et al*., 2015. The higher level of Cu content in vermicompostfrom all treatmentsmight be due to the presence of Cu containing oxidizing enzymes. In any crop is responsible for healthy vigorous growth and necessary for the formation of plant protein. Compost obtained from different treatments of the present study contained good amount of copper though there was variation with regards to treatments. The results falls in line with that of Suthar (2007) who reported elevated levels of copper in vermicompost.

As given in table 4.3, the matured compost in general recorded high level of Zn. This was more true with respect to compost from T9. The highest content of Zn, which is essential for carbohydrate transformation and which also regulates the consumption of sugars may be due to its increased mineralization by the earthworms and the introduced microbes. Similar results of vermicompost with enriched with Zn has been reported by Sinha *et al.,* 2010 and Lakshmi prabha *et al.,* 2015.

5.1.2.5.Manganese:

The content of Mn in matured compost obtained from different treatments revealed a higher Mn content in treatments from $T_3$ to $T_9$(Table 4.5). The reduced Mn level in treatment $T_2$ may be due to the decreased population of the specific earthworms. Treatment 9 was significantly superior over all others with respect to Mn content which is a catalyst for many enzymes apart from facilitating chlorophyll production and photosynthesis.

The introduction of lignin and cellulose decomposing organisms would have hastened the decomposition of cashew leaf litter and cashew apple which areother-wise difficult to get degraded or rather restricts microbial decay. The ideal conditions developed in resultant compost in treatment 9 would have positively enriched the levels of all the micro nutrients. Improvement in Mn status consequent to vermicomposting obtained in the present study confirms the findings of Lakshmi prabha *et al.,* 2015 where in the nutrient content of vermicompost obtained from different sources, was analyzed for Mn content.

5.1.3.Temperature:

Temperature and moisture changes was recorded daily. The details are furnished in Appendix I and Figure 5.1 respectively

With regards to temperature, the variation followed a sigmoid curve which is true with the composting process, which is exothermic in reaction. Among the treatments, the highest peak was obtained for treatment 9 that contained maximum quantity of organic sources together with introduced fungi and bacteria which could have accelerated the decomposition rate that resulted in more of heat release.Maximum temperature of 32.4°C was recorded after 40 days of composting in $T_9$. In control, the temperature recorded was only 28.7°C, with the same composting period.

The reduction in temperature noticed towards the maturity of composting is directly related with the reduced availability of carbon source and it reflected the effectiveness of composting process. The temperature changes during the current study of vermicomposting is adequately supported by the findings of Finstein *et al*., 1986.

The differential values of temperature recorded from the beginning to the end of composting is in fact brought about by the different types of organisms involved at each stage. The changes in the microflora like bacteria, actinomycetes and fungi during composting have been well studied by Ansari, 2007; Ansari and Ismail, 2001; Ansari 2011a ; and Ansari, 2011b. The rise in temperature also helps to kill the harmful microbes and augment its suitability as manure.

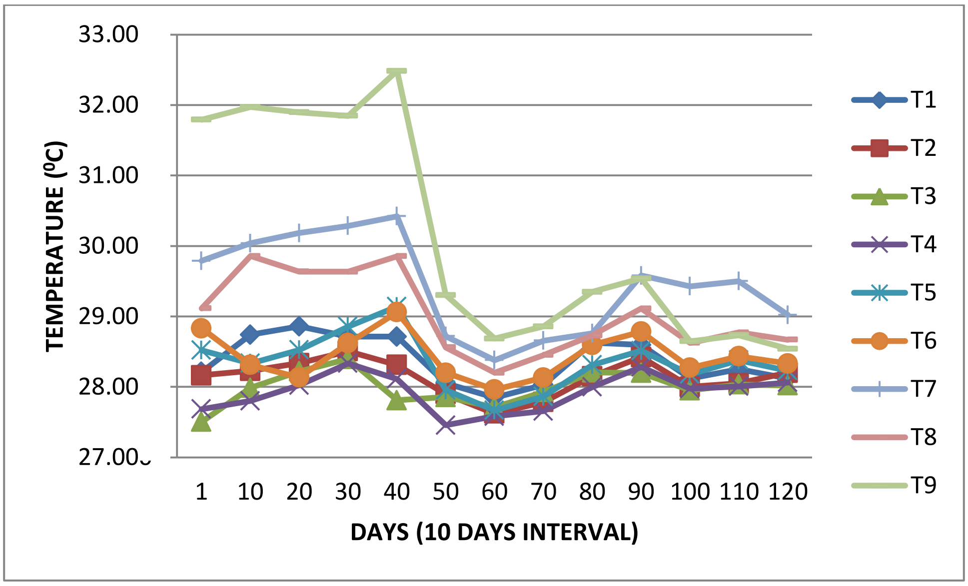


**Fig 5.1: Temperature changes during composting**

5.1.4. Weekly pH:

pH recorded on weekly basis showed the variations in values of initial substrates varied from 6.1 to 7.6. After composting it fluctuated between 6.15 and 7.30. The variation in pH during the entire period of composting as shown in Fig 5.2, indicates the changes in pH was noticed corresponding to the different stages involved. It reached neutral to alkaline values when the compost was harvested. Ammonia which forms a large portion of nitrogenous matter excreted by the earthworm might have caused a rise in pH. This would have made a temporary rise in pH .The pH of compost was acidic at the beginning and neutral to alkaline towards the end of the composting period. Different treatment had a significant effect on pH of matured compost. The combination of organic manures and other microbes provided favourable environment for composting process. All the treatments were superior over the control ($T_1$). In soil, it is the pH, which regulate the rate of dissolution of substances and its absorption of nutrients by the plants. In fact it can be considered as single most important soil property affecting nutrient availability. An ideal pH of compost is incitable pH help nutrients absorption by plants (Suthar *et al*., 2008). The pH changes observed in the present study agrees fully with the findings of previous researchers.

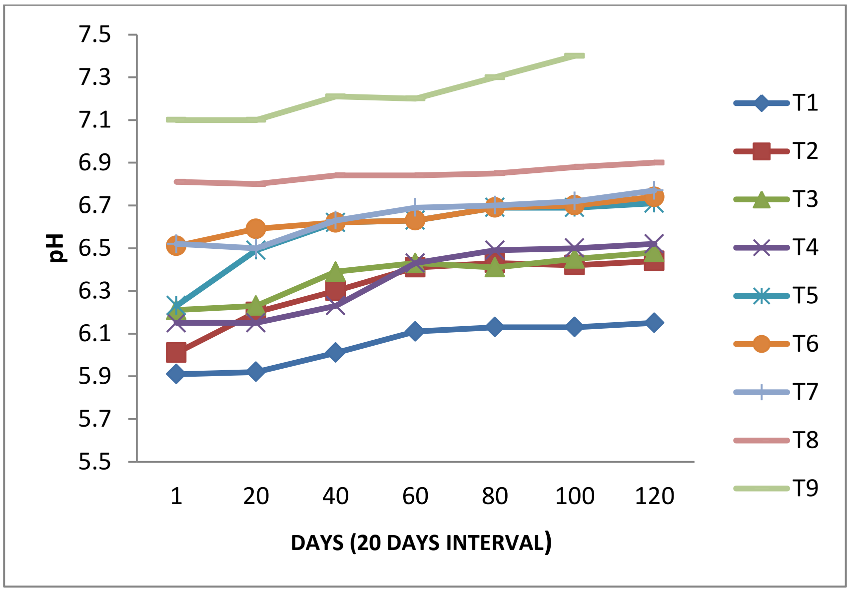


**Fig 5.2 : Variation in pH**

5.1.5. Maturity period of composting and earthworm count:

The time taken for conversion of different substrates in its original form toa finished product of quality compost is considered as the maturity period. This is dependent on factors like substrate composition, availability of standard pH, temperature, moisture, aeration and the microbial load. Relative effects of treatment weremore pronounced in deciding the maturity period of compost. Minimum time span is the most desirable one. In the present study, the components used included cashew leaf litter and cashew apple which normally resist degradation by soil organisms due to high content of cellulose, lignin and tannin. However this lacuna could very well be managed by introducing the lignocellulose degrading organisms like *Trichoderma viridae*, *Plerotus platypus* and *Bacillus* sp. with the quantity prescribed under materials and methods (Table 3.1). Treatment 9 which provided of organic manures and introduced microbes yielded nutritionally rich compost within 120 days and this was advantageous over other treatments. Among the different crop residues (glyricidia leaf, coconut leaf) and organic manures tried, treatment $T_9$was faster than the others in terms of decomposition period. In terms of nutrient value, $T_9$was found to be richer. The treatments $T_6$, $T_7$ and $T_8$ produced the matured compost within124, 127and 123 numberof days respectively. The nitrogen content of the compost obtained was 1.72% in $T_6$ and 1.55% in $T_7$ which could be due to the combined effect of the organisms in $T_6$.

No single microbe can bring about a complete degradation or breakdown of lignocellulosic material. Often it requires a consortia of specific microbes like *Trichoderma* sp and *Pleurotus sp*. When these organisms were introduced along with other organic source, the multiplication of *Eisenia foetida* was facilitated as, observed from the higher earthworm counts in treatments $T_6$, $T_8$ and $T_9$. The combined activity of *Trichoderma viridae, Pleurotus sp, bacillus sp* in $T_9$ might have accelerated the biodegradation of cashew leaf and cashew apple, thereby making nutrients available for earthworms in addition to the contribution of nutrients from glyricidia leaf, coconut leaf and poultry manure. (Raja and Ramalingam, 2007). Inthe same treatment $T_{9,}$ a combination of organic manures and introduced microbes also recorded the highest population of earthworms at compost maturity.

The earthworm count was minimum in $T_2$ containing the waste feeder *Eudrilus euginae*. As against control, the earthworm count at maturity was more in $T_9$ as compared to the control containing only the basic feed mixture. This again substantiate the role of microflora in accelerating organic matter decomposition rate.

**Experiment II**

**5.2 Suitability of enriched vermicompost as a component in potting mixture of cashew grafts**

Based on manurial value, the best treatment was selected from experiment I and included as a component in potting mixture for assessing early growth of cashew grafts. Soil chemical analysis was done before and after applying the enriched vermicompost in the potting mixture. The contentsof organiccarbon, available N, P, K Ca, Mg, Fe, Mn, Zn and Cu of the potting mixture before and after analysis are analyzed as in Table 4.11 and 4.12. All the soil parameters registered an increase with the addition of enriched vermicompost which is due to the high status of nutrientscontained in it as well as its release. In addition to the high population of nitrogen fixers, cellulose degraders and P solublisers and high worm count would have contributed positively towards increasing the nutrient content of the resultant potting mixture. This result is in agreement with the findings of Zaller, 2006 and 2007 who tried the effect of vermicompost in the potting media for raising 3 varieties of tomato. Among the ratios compared, maximum nutrient status was reported in treatment $T_4$ which contained three parts of enriched vermicompost together with one equal partseach of sand and soil. Including enriched vermicompost which contained a balanced proportion of all nutrients in higher amounts than FYM makes it a prominent for making potting mixture.

5.2.1 pH:

The pH of the resultant potting mixture supplemented with enriched vermicompost obtained from the $9^{th}$ treatment(the combination of organic manures and introduced microbes) of experiment I recorded ideal pH 7.4 for crop growth. Increased addition of enriched vermicompostto equal proportion of sand and soil did not make proportionate change in pH. However treatment effectwasstatistically significant. This may be due to the release of calcium from the calciferous glands of earthworms as reported by Debold and Rafold, 1997 and also from Ca rich poultry manure used as a component for compost production. Cashew leaf litter and cashew apple could be effectively broken down by the lignocellulose degraders thus maturing it equivalent to compost produced from any other substrate with the help of earthworms. The biometric observation reflected the outstanding quality of resultant potting mixture. The studies of Zaller 2006 and 2007 substantiated the choice of vermicompost in seedling potting media of tomato on germination, morphological characters, yield of fruit quality. Work conducted on vermin bio waste composting for agriculture soil improvement revealed significant improvement in the yield, biometric characters and quality of bananas. The findings of present study matches well with the above mentioned research reporters. The influence of vermicompost on plant growth characterstics of cucumber seedlings under favourable condition was reported by Sallaku *et al*., 2009.

The results of the present study matches well with the mentioned investigations.

5.2.2 Biometric observations:

Days for seed germination, number of leaves, plant height and collar girth were the important biometric observations recorded in the cashew grafts plants after $1^{1}/_{2}$ months of grafting. The impact of enriched vermicompost addition on the above mentioned parameters is depicted in Fig 4.1, 4.2 and 4.3. Compared to $T_1$(control) all treatments were superior in terms of all biometric characters. Cashew seeds normally germinate within 10-15 days when sown in potting mixture. In this study, the numberof days required for seed germination was found to be minimumin treatment 4 containing 3 parts of enriched vermicompost along with equal proportion of sand and soil. Statistical analysis also revealed the significant effect of this treatment on the parameters studied. In treatment 3, seeds germinated in a period of 17 days, as same asseeds sown in $T_2$ (sand, soil and enriched vermicompost in 1:1:2 ratio). Number of leaves, which is another factor deciding selection of cashew grafts, was also highest in treatment 4. The high nutrient content in $T_4$ would have resulted in more production of leaves. Here also treatment effect was significant with respect to the control. Number of leaves in the grafts raised in potting mixture containing 4 parts of enriched vermicompost was 35 after 3 months whereas it was only 32 in $T_1$ potting mixture. Height of the plant and collar girth also contributes to the quality and performance of cashew grafts. The maximum plant heightof 40.37cm and collar girth of 5.30cm was obtained in $T_4$. These results showed the promising effect of enriched vermicompost produced from cashew leaf litter and cashew apple in the presence of organic rich eater earthworms *Eisenia foetida* together with microbial consortium and organic enrichners. Increasing quantity of enriched vermicompost showed a linear effect on all biometric characters except number of days for seedgermination. The positive effect of vermicompost has been reported by PadmavathyAmma e*t al*., 2008. However information on performance of cashew seedlings in potting mixture fortified with enriched vermicompost is made fromcashew leaf litter and cashew apple. But it can be propounded beyond doubt that the growth promoting substances contained in the wormcasts, the disease suppressing microbes and accelerators of nutrient mineralization process would have bestowed greatly for best crop performance.

During the entire period of crop growth, phytotoxicity was not visualized in any of the plants raised in the potting mixture added with enriched vermicompost in different ratios, thereby improving its scope as a manure source much similar to FYM. Here also production of antibiotics by the earthworms and this would have rolledout the chances of phytotoxicity.

# Summary & Conclusions

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- The substrate analysis for pH at initial stage showed variation from 4.5 (Cashew apple) to 7.7 (Cow dung and poultry manure)
- Organic carbon content ranged from 23% in poultry manure to 49% in coconut leaf
- C/N ratio ranged between 402.5 (saw dust) and 22.62 (poultry manure) among the different materials used.
- The biochemical constituents viz., cellulose, phenol, tannin and lignin were highest in cashew leaf litter (45.9, 1.62,0.62 and 13.4 mg/100g respectively) among the components of basic feed mixture.
- Microbial count recorded at compost maturity revealed maximum poulation of fungi (272.6 cfu/g) followed by bacteria (114.3 cfu/g) and actinomycetes (28.3 cfu/g)
- Temperature recorded on daily basis revealed a pattern to similar normal composting. In all the treatments, it increased initially reached a peak and then declined gradually towards compost maturity.
- Among the treatments $T_9$($T_1$+ glyricidia leaf+ coconut leaf+ poultry manure+ *Trichoderma viride*+ *Pleurotus sajarcaju* @ 500 mg $kg^{-1}$ each + *Bacillus* spp @ 2 kg $m^{-3}$ ) recorded the highest initial temperature (32.5$^{0}$C).
- A change in pH of composted material was observed throughout the composting period
- $T_9$ registered a pH of 7.31 which is considered ideal .
- The population of earthworms increased from 200 prior to composting to 1935 in $T_9$ whereas it was only 972 in $T_2$ which contained *BFM+Eudrilus euginea* as the facilitator.
- Chemical analysis of the soil after applying vermicompost indicated higher values for all the elements analysed, more notably.
- The biometric observations (plant height -40.37cm; No. of leaves- 35; Collar girth- 5.3cm) were found high in treatment 4 where the potting mixture contained higher proportion of enriched vermicompost.
- Phytoxicity was not observed in any of the treatments.

# Future line of work

# Future line of work

- To identify a effective microbial consortium and its dose of application which can hasten the decomposition of cashew leaf litter and cashew apple wastes.
- To test the efficacy of enriched vermicompost from cashew leaf litter and cashew apple for raising crops other than cashew
- To find out the individual effect of cashew apple and cashew leaf litter as substrates for vermicomposting in association with introduced microbes and enrichners.

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# *Appendix*

# Appendix I

Daily variation in temperature during the period of composting

| Days | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 27.9 | 28.2 | 28.0 | 27.8 | 28.1 | 28.8 | 29.9 | 29.2 | 31.0 |
| 2 | 27.5 | 27.6 | 27.1 | 27.4 | 28.6 | 28.4 | 29.1 | 28.7 | 31.3 |
| 3 | 28.4 | 28.1 | 27.3 | 28.0 | 28.8 | 29.3 | 30.3 | 29.4 | 33.1 |
| 4 | 28.3 | 28.3 | 27.1 | 26.3 | 27.7 | 28.3 | 29.6 | 28.7 | 31.4 |
| 5 | 28.8 | 28.6 | 27.5 | 27.8 | 28.4 | 28.8 | 29.4 | 29.4 | 31.2 |
| 6 | 29.3 | 28.8 | 28.0 | 28.6 | 29.5 | 29.3 | 30.3 | 29.2 | 32.8 |
| 7 | 27.9 | 28.2 | 28.0 | 27.8 | 28.1 | 28.8 | 29.9 | 29.2 | 31.0 |
| 8 | 27.5 | 27.6 | 27.1 | 27.4 | 28.6 | 28.4 | 29.1 | 28.7 | 31.3 |
| 9 | 28.4 | 28.1 | 27.3 | 28.0 | 28.8 | 29.3 | 30.3 | 29.4 | 33.1 |
| 10 | 28.2 | 28.2 | 27.5 | 27.7 | 28.5 | 28.8 | 29.8 | 29.1 | 31.8 |
| 11 | 28.3 | 28.3 | 27.1 | 26.3 | 27.7 | 28.3 | 29.6 | 28.7 | 31.4 |
| 12 | 28.8 | 28.6 | 27.5 | 27.8 | 28.4 | 28.8 | 29.4 | 29.4 | 31.2 |
| 13 | 29.3 | 28.8 | 28.0 | 28.6 | 29.5 | 29.3 | 30.3 | 29.2 | 32.8 |
| 14 | 29.3 | 28.1 | 28.4 | 27.7 | 28.2 | 27.1 | 29.9 | 29.4 | 31.6 |
| 15 | 28.6 | 27.7 | 28.6 | 28.6 | 28.8 | 28.0 | 30.3 | 29.5 | 33.0 |
| 16 | 28.5 | 28.1 | 28.2 | 27.0 | 27.9 | 28.2 | 30.1 | 30.2 | 31.8 |
| 17 | 28.5 | 28.2 | 27.7 | 27.2 | 27.9 | 28.3 | 30.1 | 31.0 | 30.8 |
| 18 | 29.4 | 28.5 | 28.3 | 28.4 | 28.7 | 28.5 | 31.1 | 31.2 | 34.5 |
| 19 | 28.1 | 27.7 | 28.3 | 28.4 | 28.4 | 28.5 | 30.5 | 30.9 | 33.2 |
| 20 | 28.6 | 28.3 | 27.6 | 27.9 | 27.9 | 28.1 | 29.0 | 29.0 | 29.4 |
| 21 | 28.7 | 28.2 | 28.0 | 27.8 | 28.3 | 28.3 | 30.0 | 29.9 | 32.0 |
| 22 | 28.4 | 28.3 | 28.0 | 27.9 | 29.2 | 28.7 | 29.3 | 28.8 | 32.0 |
| 23 | 28.3 | 28.0 | 26.8 | 27.0 | 27.6 | 27.8 | 29.1 | 28.0 | 30.3 |
| 24 | 29.1 | 28.8 | 28.6 | 28.6 | 28.8 | 28.2 | 30.7 | 29.2 | 30.2 |
| 25 | 29.8 | 29.1 | 29.1 | 29.2 | 29.3 | 28.5 | 30.3 | 29.4 | 32.1 |
| 26 | 28.5 | 28.6 | 28.4 | 28.6 | 28.9 | 28.1 | 31.0 | 29.7 | 32.6 |
| 27 | 29.3 | 28.1 | 28.4 | 27.7 | 28.2 | 27.1 | 29.9 | 29.4 | 31.6 |
| 28 | 28.6 | 27.7 | 28.6 | 28.6 | 28.8 | 28.0 | 30.3 | 29.5 | 33.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 29 | 28.5 | 28.1 | 28.2 | 27.0 | 27.9 | 28.2 | 30.1 | 30.2 | 31.8 |
| 30 | 28.5 | 28.2 | 27.7 | 27.2 | 27.9 | 28.3 | 30.1 | 31.0 | 30.8 |
| 31 | 29.4 | 28.5 | 28.3 | 28.4 | 28.7 | 28.5 | 31.1 | 31.2 | 34.5 |
| 32 | 28.9 | 28.3 | 28.2 | 28.0 | 28.5 | 28.1 | 30.2 | 29.6 | 31.9 |
| 33 | 28.1 | 27.7 | 28.3 | 28.4 | 28.4 | 28.5 | 30.5 | 30.9 | 33.2 |
| 34 | 28.6 | 28.3 | 27.6 | 27.9 | 27.9 | 28.1 | 29.0 | 29.0 | 29.4 |
| 35 | 28.4 | 28.3 | 28.0 | 27.9 | 29.2 | 28.7 | 29.3 | 28.8 | 32.0 |
| 36 | 28.3 | 28.0 | 26.8 | 27.0 | 27.6 | 27.8 | 29.1 | 28.0 | 30.3 |
| 37 | 29.1 | 28.8 | 28.6 | 28.6 | 28.8 | 28.2 | 30.7 | 29.2 | 30.2 |
| 38 | 29.8 | 29.1 | 29.1 | 29.2 | 29.3 | 28.5 | 30.3 | 29.4 | 32.1 |
| 39 | 28.5 | 28.6 | 28.4 | 28.6 | 28.9 | 28.1 | 31.0 | 29.7 | 32.6 |
| 40 | 27.6 | 28.9 | 28.8 | 28.3 | 29.6 | 29.5 | 30.8 | 29.8 | 31.8 |
| 41 | 29.1 | 29.3 | 29.0 | 28.9 | 29.8 | 29.6 | 30.5 | 30.2 | 34.0 |
| 42 | 29.6 | 28.2 | 28.9 | 28.8 | 29.4 | 29.0 | 31.0 | 30.6 | 33.0 |
| 43 | 28.7 | 28.4 | 28.8 | 28.1 | 28.4 | 28.9 | 30.9 | 30.4 | 31.8 |
| 44 | 28.7 | 28.5 | 28.4 | 28.3 | 28.9 | 28.6 | 30.3 | 29.6 | 31.8 |
| 45 | 29.5 | 28.6 | 28.3 | 28.9 | 29.3 | 29.2 | 31.5 | 30.1 | 34.0 |
| 46 | 29.2 | 28.5 | 28.2 | 28.1 | 29.4 | 29.6 | 31.4 | 30.1 | 32.8 |
| 47 | 28.8 | 28.3 | 27.0 | 27.5 | 29.1 | 29.1 | 30.0 | 29.4 | 32.2 |
| 48 | 28.8 | 28.5 | 28.0 | 28.2 | 29.7 | 28.9 | 30.6 | 30.3 | 33.1 |
| 49 | 29.3 | 28.3 | 28.2 | 29.0 | 29.3 | 28.9 | 30.0 | 30.8 | 33.2 |
| 50 | 28.7 | 28.3 | 28.0 | 27.7 | 29.1 | 28.8 | 30.0 | 29.9 | 30.5 |
| 51 | 29.0 | 28.6 | 28.1 | 28.5 | 30.0 | 29.6 | 31.3 | 30.5 | 33.6 |
| 52 | 27.9 | 28.2 | 28.0 | 27.8 | 28.1 | 28.8 | 29.9 | 29.2 | 31.0 |
| 53 | 27.5 | 27.6 | 27.1 | 27.4 | 28.6 | 28.4 | 29.1 | 28.7 | 31.3 |
| 54 | 28.4 | 28.1 | 27.3 | 28.0 | 28.8 | 29.3 | 30.3 | 29.4 | 33.1 |
| 55 | 28.7 | 28.3 | 27.8 | 28.1 | 29.1 | 29.1 | 30.4 | 29.9 | 32.5 |
| 56 | 28.3 | 28.3 | 27.1 | 26.3 | 27.7 | 28.3 | 29.6 | 28.7 | 31.4 |
| 57 | 28.8 | 28.6 | 27.5 | 27.8 | 28.4 | 28.8 | 29.4 | 29.4 | 31.2 |
| 58 | 27.4 | 27.3 | 27.7 | 27.3 | 27.4 | 27.7 | 28.0 | 27.9 | 28.5 |
| 59 | 27.5 | 27.6 | 27.5 | 27.3 | 27.7 | 27.8 | 27.6 | 28.0 | 28.5 |
| 60 | 28.0 | 27.9 | 27.7 | 27.6 | 27.8 | 28.0 | 28.3 | 28.4 | 28.8 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 61 | 28.4 | 27.8 | 28.7 | 27.8 | 28.5 | 28.1 | 29.0 | 29.0 | 29.3 |
| 62 | 28.4 | 28.1 | 28.7 | 28.1 | 28.2 | 28.6 | 29.3 | 28.9 | 29.7 |
| 63 | 28.0 | 27.9 | 27.8 | 27.6 | 28.1 | 28.3 | 28.5 | 28.4 | 28.7 |
| 64 | 27.9 | 27.9 | 27.9 | 27.5 | 28.0 | 28.1 | 28.7 | 28.5 | 28.8 |
| 65 | 27.9 | 27.9 | 27.8 | 27.3 | 28.0 | 28.2 | 28.7 | 28.5 | 28.9 |
| 66 | 28.1 | 27.7 | 28.1 | 27.4 | 27.7 | 28.3 | 28.7 | 28.4 | 28.6 |
| 67 | 28.1 | 27.9 | 27.9 | 27.5 | 28.0 | 28.2 | 28.7 | 28.6 | 29.3 |
| 68 | 28.2 | 28.0 | 27.9 | 27.6 | 27.9 | 28.2 | 28.7 | 28.6 | 29.0 |
| 69 | 27.9 | 27.4 | 27.2 | 27.4 | 27.3 | 27.8 | 28.3 | 28.0 | 28.3 |
| 70 | 27.8 | 27.3 | 27.2 | 27.4 | 27.3 | 27.8 | 28.3 | 28.1 | 28.2 |
| 71 | 27.8 | 27.7 | 28.4 | 28.4 | 27.7 | 28.1 | 28.6 | 28.1 | 29.1 |
| 72 | 28.1 | 27.7 | 27.9 | 27.6 | 27.9 | 28.1 | 28.6 | 28.4 | 29.3 |
| 73 | 28.0 | 27.7 | 27.9 | 27.5 | 27.8 | 28.2 | 28.6 | 28.2 | 28.9 |
| 74 | 27.8 | 28.0 | 28.1 | 27.8 | 28.1 | 28.2 | 28.6 | 28.6 | 29.1 |
| 75 | 27.9 | 27.6 | 27.8 | 27.6 | 28.0 | 27.9 | 28.4 | 28.4 | 28.3 |
| 76 | 27.9 | 27.4 | 27.2 | 27.4 | 27.3 | 27.8 | 28.3 | 28.0 | 28.2 |
| 77 | 27.4 | 27.3 | 27.7 | 27.3 | 27.4 | 27.7 | 28.0 | 27.9 | 28.5 |
| 78 | 27.5 | 27.6 | 27.5 | 27.3 | 27.7 | 27.8 | 27.6 | 28.0 | 28.5 |
| 79 | 27.8 | 27.6 | 27.7 | 27.6 | 27.7 | 28.0 | 28.4 | 28.2 | 28.7 |
| 80 | 28.0 | 27.9 | 27.7 | 27.6 | 27.8 | 28.0 | 28.3 | 28.4 | 28.8 |
| 81 | 28.4 | 27.8 | 28.7 | 27.8 | 28.5 | 28.1 | 29.0 | 29.0 | 29.3 |
| 82 | 28.4 | 28.1 | 28.7 | 28.1 | 28.2 | 28.6 | 29.3 | 28.9 | 29.7 |
| 83 | 28.0 | 27.9 | 27.8 | 27.6 | 28.1 | 28.3 | 28.5 | 28.4 | 28.7 |
| 84 | 27.9 | 27.9 | 27.9 | 27.5 | 28.0 | 28.1 | 28.7 | 28.5 | 28.8 |
| 85 | 27.9 | 27.9 | 27.8 | 27.3 | 28.0 | 28.2 | 28.7 | 28.5 | 28.9 |
| 86 | 28.1 | 27.7 | 28.1 | 27.4 | 27.7 | 28.3 | 28.7 | 28.4 | 28.6 |
| 87 | 28.2 | 28.0 | 27.9 | 27.6 | 27.9 | 28.2 | 28.7 | 28.6 | 29.0 |
| 88 | 27.9 | 27.4 | 27.2 | 27.4 | 27.3 | 27.8 | 28.3 | 28.0 | 28.3 |
| 89 | 27.8 | 27.3 | 27.2 | 27.4 | 27.3 | 27.8 | 28.3 | 28.1 | 28.2 |
| 90 | 27.8 | 27.7 | 28.4 | 28.4 | 27.7 | 28.1 | 28.6 | 28.1 | 29.1 |
| 91 | 28.0 | 27.8 | 27.9 | 27.7 | 27.9 | 28.1 | 28.7 | 28.5 | 28.9 |
| 92 | 28.1 | 27.7 | 27.9 | 27.6 | 27.9 | 28.1 | 28.6 | 28.4 | 29.3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 93 | 28.0 | 27.7 | 27.9 | 27.5 | 27.8 | 28.2 | 28.6 | 28.2 | 28.9 |
| 94 | 27.8 | 28.0 | 28.1 | 27.8 | 28.1 | 28.2 | 28.6 | 28.6 | 29.1 |
| 95 | 27.9 | 27.6 | 27.8 | 27.6 | 28.0 | 27.9 | 28.4 | 28.4 | 28.3 |
| 96 | 27.9 | 27.4 | 27.2 | 27.4 | 27.3 | 27.8 | 28.3 | 28.0 | 28.2 |
| 97 | 28.0 | 27.7 | 27.6 | 27.5 | 27.9 | 28.1 | 28.4 | 28.7 | 28.4 |
| 98 | 29.4 | 28.2 | 28.3 | 28.2 | 28.4 | 29.3 | 28.6 | 28.6 | 30.0 |
| 99 | 29.8 | 29.0 | 28.6 | 28.7 | 29.3 | 29.7 | 29.4 | 29.6 | 30.6 |
| 100 | 29.3 | 28.8 | 29.3 | 28.3 | 29.3 | 29.1 | 29.3 | 29.5 | 30.3 |
| 101 | 30.0 | 29.3 | 29.3 | 29.4 | 29.2 | 29.5 | 29.3 | 29.5 | 30.3 |
| 102 | 28.6 | 28.2 | 28.2 | 28.0 | 28.3 | 28.6 | 28.8 | 28.7 | 29.3 |
| 103 | 29.8 | 29.3 | 29.3 | 28.9 | 29.5 | 29.6 | 31.3 | 29.7 | 30.3 |
| 104 | 29.2 | 28.8 | 28.3 | 28.0 | 28.9 | 29.0 | 29.1 | 29.3 | 30.2 |
| 105 | 28.8 | 28.4 | 28.4 | 28.5 | 28.6 | 28.6 | 29.9 | 29.1 | 30.3 |
| 106 | 28.3 | 28.4 | 28.3 | 28.7 | 28.7 | 29.2 | 29.3 | 29.4 | 29.9 |
| 107 | 28.2 | 27.9 | 27.7 | 27.4 | 27.9 | 28.2 | 29.5 | 28.2 | 28.5 |
| 108 | 28.3 | 28.3 | 28.0 | 28.0 | 28.2 | 28.4 | 29.3 | 28.8 | 29.0 |
| 109 | 28.2 | 27.9 | 28.2 | 28.0 | 27.7 | 28.2 | 29.7 | 28.5 | 29.3 |
| 110 | 28.2 | 28.2 | 28.3 | 28.2 | 28.1 | 28.2 | 29.7 | 29.4 | 29.3 |
| 111 | 28.1 | 28.5 | 28.1 | 28.5 | 28.6 | 29.2 | 29.5 | 28.9 | 29.4 |
| 112 | 27.8 | 28.2 | 27.1 | 28.2 | 29.0 | 29.5 | 28.4 | 28.9 | 29.1 |
| 113 | 29.6 | 28.7 | 28.4 | 28.8 | 28.3 | 28.5 | 29.7 | 30.1 | 29.6 |
| 114 | 28.6 | 28.4 | 28.2 | 28.3 | 28.5 | 28.8 | 29.6 | 29.1 | 29.5 |
| 115 | 28.3 | 28.1 | 28.0 | 28.4 | 28.2 | 27.8 | 29.9 | 28.8 | 29.5 |
| 116 | 28.1 | 27.9 | 28.1 | 28.0 | 28.1 | 28.4 | 29.6 | 28.4 | 28.6 |
| 117 | 27.7 | 27.7 | 27.6 | 27.5 | 27.7 | 27.9 | 29.1 | 28.0 | 28.1 |
| 118 | 27.9 | 27.9 | 27.6 | 27.8 | 27.9 | 28.1 | 28.9 | 28.4 | 28.3 |
| 119 | 28.1 | 28.1 | 28.2 | 27.9 | 28.1 | 28.4 | 29.6 | 28.7 | 28.7 |
| 120 | 28.2 | 28.1 | 28.0 | 28.0 | 28.4 | 28.4 | 29.5 | 28.8 | 28.7 |

# *Abstract*

# RECYCLING OF CASHEW (*<u>Anacardiumoccidentale</u>*L.) LEAF LITTER AND CASHEW APPLE THROUGH VERMITECHNOLOGY


**By**

**INDU V K**

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**ABSTRACT OF THESIS**

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**Kerala Agricultural University, Thrissur**


**Department of Soil Science and Agricultural Chemistry**

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**2016**

# Abstract

The present study entitled “Recycling of cashew (*Anacardium occidentale* L.) leaf litter and cashew apple through vermitechnology was undertaken in the Department of Soil Science and Agricultural Chemistry and at Cashew Research Station,Madakkathara during 2012-2014.

The objectives were to study the efficacy of different enrichners on the manurial value of vermicompost prepared from cashew leaf litter and cashew apple using compost worm *Eisenia foetida*, to identify the role of introduced microbes in decreasing compost maturity time and to evaluate enriched vermicompost as a manurial source in the potting mixture for raising cashew grafts.

The objectives were achieved through two experiments viz., (1) preparation of enriched vermicompost and (2) adjudging suitability of enriched vermicompost as a component in potting mixture for cashew grafts. Ferro cement tanks of $1m^3$ dimension, 300 Kg capacity and lined with jute bags were used for producing vermicompost.

All the tanks were initially added with basic feed mixture (cashew leaf litter, cashew apple, sawdust and cowdung in 3:3:2:6 ratio on weight basis. Along with the basic feed mixture, different substrates were added according to the treatments. The experiment was carried out in a Completely Randomized Design with three replications with five tanks per replication. Nutrient status of substrates and that of matured compost was recorded initially and after compost maturity. In addition, pH was also recorded before and after composting, pH ranged from 4.5 in cashew leaf litter to 7.6 in cow dungand poultry manure respectively. Organic carbon content varied from 23% in poultry manure to 49% in coconut leaf. C:N ratio was found between 402.5 in sawdust to 22.62 in poultry manure. The biochemical constituents viz, cellulose, phenol, tannin and lignin were highest in cashew leaf litter (45.9, 1.62, 0.62 and 13.4 mg/100 g respectively) as compared to cashew apple. The compost obtained from $T_9$($T_1$+ glyricidia leaf+ coconut leaf+ poultry manure+ *Trichoderma viride* + *Pleurotus sajarcaju*@ 500 mg $kg^{-1}$ each of substrate+ *Bacillus sp* @ 2 kg $m^{-3}$of substrate) on maturity (120 days), recorded a pH of 7.4, OC (28.6%), N (2.9%), C:N ratio (11), P (0.90%), K (2.0%), total Ca and Mg (1834 & 1185 mg $kg^{-1}$ respectively) which was highest among other treatments. Earthworm population increased from the initial 200 numbers to1935 numbers in $T_9$ as against 972 in $T_2$which contained *Eudrilus euginiae*as the facilitating worms.

Daily observations on temperature, weekly observations on pH, total microbial count (initial and final stages), days for compost maturity and earth worm count at maturitywere theother important observations studied in the first experiment. Different treatments was found to have significant effect on temperature. It increased in all the treatments with the composting process, reached a peak and then decreased coinciding with maturity or cooling phase. Highest peak was attained for $T_9$ with $32.5^{O}C^{.}$ pH of compost mixture were also influenced by the treatments. pH value increased in all the treatments with progress in composting and shifted towards a neutral condition. Maximum pH was associated with $T_9$ (7.3). Number of days required for compost maturity was minimum in $T_9$(120Days) whereas it was maximum in $T_1$(135Days) and the count of earthwormpopulation was nearly nine fold in $T_9$whereas it was only six fold in $T_{1.}$ The lowest multiplication level was observed with $T_2$ which contained *Eudrilus eugineae* as the compost worms.

Based on manurial value assessed by high content of major nutrients (2.4%,0.90% and 2.06% NPKrespectively), compost from $T_9$ of experiment I was selected as the best and designated as enriched vermicompost. Its suitability as a component in potting mixture of cashew grafts was assessed in another experiment. The study consisted of four treatments in four replication with five poly bags (25 x 15cm and 300 gauge) per replication in a CRD Design. The scion for grafting was collected from variety 'Dhana'.

Performance of the grafted seedlings was evaluated for a period of three months. Observations included chemical analysis with and without applying vermicompost for OC, available N, P, K,Ca, Mg, Fe, Mn, Zn and Cu.In addition pH was also recorded. Among the four treatments studied,$T_4$ (sand, soil and enriched vermicompost in 1:1:3 ratio) recorded highest nutrient status (2.75, 0.34 and 0.72 g $kg^{-1}$ of NPK respectively).The number of days for seed germination was minimum in $T_4$ (15) as against 20 days recorded for seed germination for $T_1$. Other biometric observations like plant height (40.37cm), number of leaves (35) and collar girth (5.3cm) were observed maximum in plants grown in $T_4$. Phytotoxicity was not seen in any of the treatments during the three months of evaluation.

By employing the epigeic earthworms *Eisenia foetida*, the enormously available but untreated lignocellulotic solid organic resource, cashew leaf litter and cashew apple, could be effectively converted to nutrient rich vermifertilizer by suitably admering with various organic enrichners. The vermifertilizer thus produced could be efficiently used as a component in the potting mixture for raising cashew plants. Crop performance was the best when the vermifertilizer was mixed at three parts on volume basis with one part each of sand and soil. Based on results vermicomposting could be established as a ecofriendly and ecologically sound method for manure from cashew leaf litter and cashew apple.