UTILIZATION OF WASTES FROM MUSHROOM CULTURE FOR VERMICOMPOSTING AND FOR THE GROWTH OF BEAN PLANT, *DOLICHOS LAB LAB* (L.)

BY

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CERTIFICATE

This is to certify that the dissertation entitled "UTILIZATION OF WASTES FROM MUSHROOM CULTURE FOR VERMICOMPOSTING AND FOR THE GROWTH OF BEAN PLANT, *DOLICHOS LAB LAB* (L.) " submitted to the Avinashilingam Institute for Home Science and Higher Education for Women – Deemed University, Coimbatore, in partial fulfilment of the requirements for the award of the degree of MASTER OF PHILOSOPHY in Life Sciences, is a record of original research work done by SANGEETHA, S. during the period of her study in the Department of Life Sciences, Avinashilingam Institute for Home Science and Higher Education for Women – Deemed University, Coimbatore, under my supervision and guidance and the dissertation has not formed the basis for the award of any Degree / Diploma /Associateship / Fellowship or other similar title to any candidate of any other University and it represents entirely an independent work on the part of the candidate

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DECLARATION

I hereby declare that the dissertation entitled "UTILIZATION OF WASTES FROM MUSHROOM CULTURE FOR VERMICOMPOSTING AND FOR THE GROWTH OF BEAN PLANT, *DOLICHOS LAB LAB* (L.)" submitted in partial fulfilment for the award of the degree of MASTER OF PHILOSOPHY in Life sciences is a record of original research work done by me during the period of my study in the Department of Life Sciences, Avinashilingam Institute for Home Science and Higher Education for Women – Deemed University, Coimbatore, under the supervision and guidance of Dr. (Tmt.) N. Krishnaveni, M.Sc. (Madras), Ph.D. (Annamalai), B.Ed. (Annamalai), Reader in Zoology, Department of Zoology and Life Sciences and that is has not formed the basis for the award of any Degree / Diploma / Associateship / Fellowship or other similar title to any candidate of any other University.

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CHAPTER I

INTRODUCTION

In sustainable agriculture practices, vermitechnology helps to create a healthy living soil that is less prone to erosion and moisture loss. In fact vermitechnology signifies the use of beneficial activities of earthworms for human welfare (Dinesh Mani and Gajendra Kumar, 2001). Over the last few years, as regulations for application and disposal of animal manure has become more rigorous, the interest in using earthworms as an ecologically sound system for manure management has increased tremendously (Atiyeih *et al.*, 2000).

In recent years, a lot of awareness and concern has been developed over the environmental pollution problem. Industries are the main source of pollution which increases with developmental process (Patel and Gadhia, 2000). All over the world from developed countries like China, Brazil and Philippines, vermiculture is being widely practiced in a big commercialised manner. Vermiculture is the technique of mass multiplication of earthworms.

India produces about 3000 million tonnes of organic waste annually which could be utilized for the recovery of fertilizer, fodder, fuel and food (Bhatnagar and Patla, 1996). In order to meet the increasing demand for food, farmers are now adopting scientific farming techniques. In addition to the use of high yielding varieties, farmers are in a condition to bombarded their land with higher doses of chemical fertilizers. It is well known that our agricultural production has jumped from 55 million tonnes in 1951 to 198.17

million tonnes today. At the same time, use of chemical fertilizers and pesticides has created a serious threat to the environment and resulted in irreversible damage to the ecosystem. Also the price of chemical fertilizers has risen to alarming level. Under this circumstances, the only way to help farmers and prevent environmental pollution is to increase the fertility of the available land, using the worm powered technology named "vermi tech" (Kumar *et al.*, 2000).

Vermitechnology is the promising aspect of biotechnology where application of earthworm is made for combating the waste disposal problems for minimising the pollution effect and to get useful product the "vermicompost" (Edwards and Lofty, 1980 and Grappelli *et al.*, 1985). Vermicompost / in situ vermiculture associated with other biological inputs have been applied to grow vegetables and other crops, successfully. These approaches have proved to be economic as well as productive (Alvares, 1996).

Vermiculture is a high grade organic manure containing vital plant macronutrients, secondary elements and micronutrients besides plant growth promoting substances. Use of vermicompost and earthworms helps to elevate soil fertility by improving various physio-chemical properties of the soil (Jadhav *et al.*, 1999).

Casts are rich in organic matter as compared to the surrounding soil. Earthworm casts have been shown to have increased microbial populations (Atlavintye, 1975) and enhanced nitrification (Parle, 1963). Earthworm excreta are an excellent soil conditioning material with a high water holding capacity and a "natural time release" for releasing nitrogen into the soil. The fertilizing value of earthworm castings and beneficial effects on crops, have been related to the presence of active mineral nutrient (Edwards, 1981) and plant growth regulators with phytohormonal action.

Vermiculture is a biological process intended to enrich the soil. Earthworms play a vital and pivital role in this aspect and already they are referred to as the "friends of the farmers" (Ramesh Babu, 1995). Vermicompost is a rich source of vitamin and growth hormones. Unlike chemical fertilizers it is economic and enhances productivity and nutritive value of soil.

Earthworm is known to be a good biological agent for the recovery of vermi-fertilizer and vermiprotein for the use in agroiecosystem and aquaculture respectively. Earthworms along with soil microorganisms play a major role in degrading organic waste materials and thus maintain the nutrient flux in the system. It is physically an aerator, crusher, mixer and chemically a degrader and biologically a stimulator in the decomposer system. Potentiality of exploiting earthworm activities for our economic interests are multiple.

Earthworms are nature's most useful converters of wastes. The earthworm has potential role of recycling organic waste, producing two commercial products, a horticulture compost and earthworm protein (Sharma *et al.*, 1987). The role of earthworms in maintaining soil fertility is known since ancient times. Aristotle called them "The Intestine of Earth" and considered them as agents to restore soil fertility (Divya, 2001).

The importance of earthworms was first stressed by Charles Darwin in this book, "The formation of vegetable mould through the action of worms" – one of the classics of soil science. Earthworms are omnivorous but they mostly derive nutrition from dead organic matter, which is generally does not occur abundantly in the soil.

Earthworm fauna in the Indian subcontinent comprises of 509 species placed under 67 genera and 10 families, which are classified as follows,

Epigeic: Litter or dung dwellers, uniform coloration and small body size 10 – 30cm.

Endogeic: Dwellers of top organo-mineral soil and construct horizontal and branching burrows, lightly pigmented, vary in size from small to large.

Aneciques: Deep burrows that construct vertical burrows, cast at surface and emerge from burrow at night to draw down organic materials, dark pigmented, large size 20 – 30cm.

Even though a large number of earthworm species are available in nature, most of them undergo a diapause period. Only on the arrival of rainy season they will be active. That's why only *Eudrilus eugeniae*, *Eisenia foetida* and *Perionyx excavatus* are recommended for vermicomposting. These races will not undergo diapause (Radha, 1995).

Eudrillus eugeniae (figure 1) an earthworm species of Nigerian origin known as African Worm or Night Crawlers is a large worm, voracious eater, grows extremely rapid and convert any decomposable / organic waste into valuable manure within a span of about six weeks. It is good for use under tropical conditions (Divya, 2001).

Earthworm plays a key role in the soil formation in the following four ways:-

1. Through their influence on soil pH
2. As agents of physical decomposition
3. By promoting humus formation
4. By improving soil structure

The exotic species of earthworm *Eudrilus eugeniae* was obtained from Germany and methodology of cultivation and production of organic manure and worm meal was evolved (Radha *et al.*, 1988) and was used for the vermicomposting in the present investigation.

A ton of earthworms produces upto one tonne of fertile soil daily and 400 tonnes of agricultural wastes are vermicomposted into 200 tonnes of granular manure per year (Zhao and Huang, 1991).

Vermicasts are excretory secretions of earthworms assuming various forms made up from (i) Ovoidal, subspherical or spherical pellets, (ii) Paste like slurries that form generally rounded but less regular shapes.

India is a major rice growing country. Rice produced has to be hulled to separate out the grain from straw. Today it is done in rice mills. These mills produces large quantities of agrowastes (paddy dust, chaffy grain and husk). Generation of agricultural wastes has been estimated by Bhawalkers to a tune of 320 million tonnes annually (Bhatnagar and Patla, 1996).

Saw dust is another potential by product of plant material, which is considered a waste. Saw dust being an organic wastes is suitable for biodegradation by earthworm and after vermicomposting, it is a good nutrient source to the plant.

In India water hyacinth, *Eichhornia crassipe* has been considered as an uncontrolled nuisance. It is of South American origin. It was because of the beautiful flowers that water hyacinth originally introduced into the tropics. But now they have become trouble some weeds. The annual yield of *E. Crassipe* is as high as 154 or 168 t/ha have been estimated (Bates and Hentges, 1976 and Wolverton and Mc Donald, 1976) depending on variable circumstances.

In the laboratories mushroom cultivation was carried out by using husk, straw, sawdust and *Eichhornia crassipe*. After cultivation, these husk, straw, saw dust and *E. crassipe* were thrown as wastes. In the present study these wastes were utilized and valuable vermicompost were prepared by vermicomposting technology, for the growth of the bean plant, *Dolichos lab lab*.

The nutritional composition as reported by Duke (1981) is that the dried seeds contain 21.5% protein, 98mg calcium, 345mg of phosphorus and 3.9mg of iron per 100gram while green pods contain 3.1% protein, 95mg of calcium, 50mg of phosphorus and 1.2mg of iron per 100 grams. Seeds contain trypsin and chynotrypsin inhibitors and is said to be rich source of catachol oxidase.

Hence, the present study aims to find out the possibility of *E. eugeniae* as a potential organism for decomposting and reusing of the husk, straw, saw dust and *E. crassipe* used for the cultivation of mushroom.

OBJECTIVES

The steps involved in the present study are

1. Collection of partially decomposed husk, straw, sawdust and *Eichhornia crassipe* after the cultivation of mushroom.
2. Maintenance of experimental set up for vermicomposting for the following in the university campus.
   a. Pot with red soil. (Control)
   b. Pot with red soil, partially decomposed husk, and ordinary soil.
   c. Pot with red soil, partially decomposed husk, earthworm *E. eugeniae* and ordinary soil.
   d. Pot with red soil, partially decomposed husk, earthworm *E. eugeniae* and equal proportion of cow dung and ordinary soil.
   e. Pot with red soil, partially decomposed straw and ordinary soil.
   f. Pot with red soil, partially decomposed straw, earthworm *E. eugeniae* and ordinary soil.
   g. Pot with red soil, partially decomposed straw, earthworm *E .eugeniae* and equal proportion of cow dung and ordinary soil.
   h. Pot with red soil, partially decomposed sawdust and ordinary soil.
   i. Pot with red soil, partially decomposed sawdust, earthworm *E. eugeniae* and ordinary soil.
   j. Pot with red soil, partially decomposed sawdust, earthworm *E. eugeniae* and equal proportion of cow dung and ordinary soil.
   k. Pot with red soil, partially decomposed *E. crassipe* and ordinary soil.

l. Pot with red soil, partially decomposed *E. crassipe*, earthworm *E. eugeniae* and ordinary soil.

m. Pot with red soil, partially decomposed *E. crassipe*, earthworm *E. eugeniae* and equal proportion of cow dung and ordinary soil.

3. Analysis of Nitrogen, phosphorus, potassium, (NPK) in the control, partially decomposed husk, straw, saw dust and *Eichhornia crassipe* and also in the vermicompost prepared from these wastes.

4. Comparison of the growth parameters of the *Dolichos lab lab*, grown in the control and 12 different compost and vermicompost treatments prepared from the wastes (husk, straw, sawdust and *Eichhornia crassipe*) to recommend the best treatment.

Figure-1

Earthworm Eudrilus eugeniae used for vermicomposting

Review of Literature

CHAPTER – II
REVIEW OF LITERATURE

The available literature pertaining to the studies on the "Utilization of wastes from mushroom culture for vermicomposting and for the growth of bean plant, *Dolichos lab lab* (L.)" as relevant to the present investigation is reviewed and presented in this chapter.

Edwards and Lofty (1980) in their studies have shown improved growth of roots of cereals grown in plots inoculated with earthworms. On using worm cast as manure for ornamental plants like Salvia, Asters and African violets, improved growth and flowering was observed. Edwards (1981) found that the fertilizing value of earthworm castings and the beneficial effects on crops had been related to the presence of active mineral nutrients.

Eudrilus eugeniae is a very good composer of organic materials capable of reducing the C/N ratio and C/P ratio very quickly. A similar reduction in C/N ratio and C/P ratio was reported by Senapati *et al.* (1980), Mba (1983) and Moreira *et al.* (1983).

According to Misra and Heirsa (1982) the compost prepared from farm/garden wastes were superior in organic matter and major nutrient status N, P and K. Tomati *et al.* (1985) studied that earthworms have a greater ability to consume all organic wastes, reducing their volume by about 50 per cent and expelling the digested materials as castings, which are useful soil amendment and may be easily stored for agricultural use.

Dkhar and Mishra (1986) also observed that worm casts contain more N, P and organic carbon than the surrounding soil. Similarly Gupta and Sakal (1967) have also found that garden soil casts were rich in organic matter as compared to the cultivated soil. It is concluded that the earthworm activities improve soil fertility and are helpful in waste land development and sustainable agriculture. Krishnamoorthy and Vajranabhaiah (1986), Grappelli *et al.* (1987) and Tomati *et al.* (1987 and 1990) reported that the vermicompost contain biologically active substances such as plant growth regulators.

Mba (1987) observed a great increase in nitrogen fixation during composting of ground Dallas grass *(Paspalum dilatalum)* by the earthworm *E.eugeniae*. The total nitrogen content of the substrate increased the presence of these earthworms and the activity of the nitrogen-fixing enzyme, nitrogenase, increased tenfold in earthworm casts relative to the grass substrate.

According to Sharma and Madan (1987) amongst the possible alternatives for improving the nutrient status of organic wastes, vermicomposting offers promise to increase agricultural bio-productivity. The investigation were undertaken to assess the effect of organic wastes alone and in combination with earthworms on plant growth. Maize and wheat were grown as test crops. The best results were obtained with treatments T_{23} (2% poultry waste), T_{32} (2% poultry waste with earthworms T_{26} (2% cattle dung) and T_{35} (2% cattle dung with earthworms) with wheat and maize respectively. The time of origin of earthworms is confirmed by the finding of fossilized earthworms cocoons (Piearce *et al.*, 1990)

Earthworm-processed organic wastes, often referred to as vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage and water holding capacity (Edwards and Burrows, 1988). Compared to their parent materials, vermicomposts have reduced amounts of soluble salts, greater cation exchange capacity and increased total humic acid content (Albanell *et al.*, 1988). Paul L.S.Chan and Griffiths (1988) stated that worm castings had a stimulating effect on the growth of *Glycine max* (soyabean) with an increase in root length, lateral root number, shoot length and internodal length of seedling plants.

Ronald *et al.* (1990) observed that during the first day of decomposition of *Eichhornia* there is a high level of polyphenols from the detritus and this causes an increase in the palatability of the remaining organic matter.

Lee (1992) stated that the vermicomposting enhances the soil structure and improves the water holding capacity and porosity to facilitate the root respiration and growth. Robinson *et al.* (1992) found that the availability of nutrients in soil tilled by earthworms is considerably increased. Shinde *et al.* (1992) stated that the vermicompost is known to contain growth promoting substances.

The effect of earthworm treatment on the survival and growth of maize plants were studied by Spain *et al.* (1992). Ismail (1993) suggested the use of local varieties of earthworms comprising the epigeic and anecic varieties for the combined process of litter and soil management. It was found that vermicompost had a favourable influence on all yield parameters of sugarcane and paddy and that vermicompost can be effectively utilized as a carrier medium for azospirillum phosphate solubilizers and rhizobium bio-fertilizers, in this association application of vermicompost has been found to enhance sugar content (Reddy *et al.*, 1993).

Kalembasa *et al.* (1993) demonstrated the content of nitrogen and carbon in different fractions of vermicompost. Vermicompost produced by *Eisenia foetida* from farmyard manure, wastes from meat processing plants, sludges from sewage purification plants and a mixture of wastes with saw dust were studied for their N and C contents. Results showed that mineral N constituted 20.2% of the total N, easily hydrolysable 20.0%, non-easily hydrolysable 27.4% and non-hydrolysable 32.2%. There was a significantly negative relationship between mineral M and non-hydrolysable compounds. The C content in acid hydrolyzates was low and did not exceed 10 mg/g of day matter vermicompost. Studies on recycling of organic wastes by *Eisenia foetida*, has been done by Moreira *et al.* (1993). Changes in composition of a mixture of husks of sugarcane and cow-manure along with earthworms *(Eisenia foetida)* and of the resulting vermicompost were recorded: the C:N ratio decreased the cassava peels into valuable vermicompost. Vermicomposting and field investigations in Nigeria were set up to assess the impact of three agricultural wastes: Poultry droppings (Capo), cow-dung (caco) and guava *(Psidium guajava)* leaves (Ciag) on Eug's ability to vermicompost cassava peel (Cas). The biofertilizer value of the vermicomposts produced highlighted the beneficial effects of the waste treatments and the efficacy of the bio-fertilizers in field plots cropped with cowpea *(Vigna unguiculata)*. Cowpea aerial biomass increased significantly five fold, two fold and 1.6 fold with capo, cas and cag, over the untreated field plots.

Maynard (1993 and 1995) reported that tomato yields in field soils amended with compost were significantly greater than those in the unamended plots.

Szczech and Brzeski (1994) conducted experiments with tomatoes and cabbages in addition of vermicompost. The growth media inoculated with *Heterodera schactii*, *Plasmoolisphora brassicae*, *Fusarium oxysporum* and *Nedoidogyne hepta* suppressed the development of plant diseases and showed a positive effect on yields.

The ability of the earthworms, *Aporrectrodea rosea* and *Aporrectoda trapezoides* increase the foliar concentration of a range of elements which increase plant productivity in the field were studied by Stephens *et al.* (1994). The use of inorganic NPK fertilizer in combination with organic manure has significantly greater effect on earthworm activities than NPK alone and therefore the addition of organic matter appears to be advisable in order to obtain maximum benefits from NPK fertilizer in soil (Tiwari, 1994).

According to Venkataratnam (1994) the earthworms convert biodegradable garbage into useful vermicompost. This organic vermicompost can help to produce additional yield of crops to an extent of 30% more than normal yield. Radha (1995) stated that the vermicompost application provide balanced nutrition, gives resistance against pest attacks, produce better luster, colour, taste and keeping quality, better root growth, profuse flowering and yield increases. Significant increase in dry matter and yield of green gram due to the application of vermicompost and farm yard manure was reported by Srinivasa Reddy and Uma Mahesh (1995).

Basavaraj and Manju (1996) recommended soil amendments like compost, coirpith, gypsum, pressmud and farm yard manure to reclaim the productivity of tannery polluted soil. Elvira *et al.* (1996) found that solid paper-pulp mill sludge and primary sewage sludge at a ratio of 3:1 was a suitable medium for optimum growth and reproduction of the earthworms. The presence of earthworms accelerated the mineralization of organic matter favoured the breakdown of structural polysaccharides and increased the humification rate. Consequently, the C/N ratio and the degree of extract ability of heavy metals were lower in the worm – worked end product.

According to Ravignanam and Gunathilagaraju (1996), higher nutritional levels of mulberry is attributed to the increased root growth resulting in greater uptake of nutrients from the soil due to earthworm activity. Recent investigations by Mba (1996) highlighted the ability of earthworm, *Eudrilus eugeniae* (Eug) to partially de-toxify the toxic wastes, and transform vermicompost/ha with 75% RDF, 5t vermicompost/ha with 50% RDF or with in situ vermiculture with 2000 earthworms/ha (Kulkarni *et al.*, 1996).

Nayak and Rath (1996) demonstrates vermicompost as a biofertilizer and it has tremendous potential to wrest the present day agriculture. There are abundant evidence that concentration of exchangeable calcium, sodium, magnesium, potassium, available phosphorus and molybdenum are higher in earthworm castings than the surrounding soil. These plant nutrients promotes plant growth.

Bcyle *et al.* (1997) reported that cumulative grass yields were 89% higher in organically fertilized soils and 19% higher in inorganically fertilized soils with earthworms than in similarly fertilized soils without earthworms. This could be due to the fact that grass growth responses were mainly due to enhanced organic matter decomposition and mineralization which could be brought about by the activity of earthworms. Increase in the yield of Oats or grass test crops associated with earthworm activity were as high as 60 or 80% where as the yield of grain sorghum was doubled. (Blakemore, 1997). *Aporrectodea trapezoides* and *Aporrectoedea rosea* caused a significant increase in the dry weight of barley plants, root growth, number of tillers and grain yields in the sandy loamy soil (Doube *et al.* 1997).

According to Hitoichi Shiga (1997) the accumulation of organic matter in soil is greater when 2.5mt/ha of straw compost and cattle manure compost are applied, than when 5mt/ha of these same materials are applied fresh without composting. Katterings *et al.* (1997) opined that earthworm activity could increase soil structure and stability. An important aspect of quality of soil structure is the stability of aggregates.

Nainawat (1997) found that the application of vermicompost to two cultivators of wheat Raj 3077 and Raj 1482 resulted in higher total dry matter production and increased grain yield in comparison to organic manure and chemical fertilizers. Sita Janaki and Sree Hari (1997) reported that application of vermicompost increased the yield of rice by increasing almost 2 times the ears/plant and grains/plant in rice.

Van-Vliet *et al.* (1997) concluded that among the different species available, enchytraeids contributed more to the development of soil structure than other species. The activity of most burrowing soil organisms tend to increase soil porosity, pore size and the variability of porosity. Wessells *et al.* (1997) have reported that earthworms had significant effects on soil respiration, though their effect varied seasonally and were greatest in plots with increased populations and lowest in plots with decreased populations.

Radha (1998) reported that vermiwash as a foliar spray was effective in increasing the growth and yield of Anthurium and was even better than 0.5% urea spray. Landgraf *et al.* (1998) compared humic acid isolated from vermicompost with humic acid sample extracted from peat with respect to its chemical interactions and absorption with metribuzin. He inferred that VHA (Vermicompost Humic Acid) showed a higher concentration of nitrogen, the bond could be assigned mainly to V (C-N) of amine groups.

An experiment on mulberry crop to investigate the effect of vermicompost in comparison with farmyard manure and fertilizer on mulberry leaf yield were studied by Muraker *et al.* (1998). He proved significant increase in the number of branches, height of the plant, number of leaves and leaf yield as compared to control. Singh (1999) explained the need of vermiculture for horticulture crops in new era.

According to Riheiro *et al.* (1998) by the application of vermicompost and cattle manure growth rate was increased in lettuce. Subler *et al.* (1998) investigated vermicompost plays a significant role in plant growth when added to soil. Thus, vermicomposted sludge is recommended for adoption for profitable horticulture practices.

Atiyeh *et al.* (2000) reported that substitution of metro-mix 360 with 20%, 30% and 40% pig manure vermicompost increased the rate of germination of tomato seeds significantly. Tomato seedlings grown in potting mixtures containing 50% pig manure vermicompost had more leaves and weighed more than those grown in the metro-mix 360 controls. The dry weights of tomato seedlings increased significantly.

According to Chaudhuri *et al.* (2000) most of the research on utilization of earthworms in waste management has been focused on the final product, (ie.) the vermicompost.

Ameena (2001) stated that water hyacinth can readily absorb and concentrate heavy metals such as lead, cadmium, mercury and nickel. Tomatoes, cucumber, corn, peas, sorghum etc., had been successfully grown using decomposing water hyacinths as the sole source of soil and food. The water hyacinth can produce tremendous quantities of biomass that is high in proteins and minerals such as potassium, calcium, and phosphorus.

Rajinder Kumar Dhall (2001) studied that growth of earthworms can be increased up to 150% when the soil is supplemented with water hyacinth, cattle dung and biogas plant effluents with integrated vermiculture. They not only produce valuable compost but also various vegetable varieties like gourd, cucumber, beans etc.

Sree Krishna Bhat (2001) reported that the vermicompost is 5 times richer in N, 7 times in P, 11 times in K, 2 times in Mg,2 times in Ca and 7 times in actinomyces than ordinary soil. It is a gibberlin which regulate the growth of plant and microbes.

The amount of total extractable N, orthophosphates, dehydrogenase enzyme activity and the microbial bio-mass were usually greater in the soils from the vermicompost-treated tomato plots. Marketable tomato yields in vermicompost treated plots were consistently greater. (Arancon *et al.*, 2002).

Hangarge *et al.* (2002) reported that yields of green chilli and spinach were significantly increased due to the application of soil conditioner and vermicompost along with organic booster as compared to recommended dose of NPK.

Jat and Mahesh Kumar (2002) reported that increase in crop yield and quality has often been recorded in plant growth in the presence of earthworm casts. It is evident that originally produced seed, straw etc., are nutritionally superior, good in taste, good luster and better in keeping quality in vermicompost applied crop.

Manonmani and Anand (2002) found that the growth and yield of lady's finger was maximum in plot which was supplemented with vermicompost.

Padma *et al.* (2002) found that vegetable waste collected from hostels were converted into compost by using earthworms (*Eudrilus eugeniae*). The nitrate (0.25%), phosphates (0.32%) potassium and calcium (0.49% and 0.14%) constitute organic matter suitable for plant growth.

Vermicompost contain 1-1.5% nitrogen, 0.8% phosphorus and 0.7% potassium. Besides a number of micronutrients in easily available forms, a large population of beneficial microorganisms and biologically active metabolites, particularly gibberlins, cytokinins and auxins were found in the vermicompost. (Wani, 2002).

In strawberries, leaf areas, numbers of suckers, number of flowers, shoot dry weights and marketable fruit yields were all significantly greater in plots that received vermicompost treatments. Food waste vermicomposts has greater effects on growth and yields of straw berries (Arancon *et al.*, 2002).

Materials and Methods

CHAPTER - III

MATERIALS AND METHODS

The materials used in the present investigation are earthworm of the species *Eudrilus eugeniae*, partially decomposed husk (fig 2), straw (fig 3), saw dust (fig 4) and *E. crassipe* (fig 5).

Collection of *Eudrilus eugeniae*

The earthworm *Eudrilus eugeniae* was collected from the Avinashilingam Trainers Training centre, Coimbatore. It is commonly called as "African Night Crawler" and it is Nigerian origin. The worms are glittering violet when alive. It is large in size, grows rapidly, breeds fast and is capable of decomposting large quantities of organic materials into usable vermicompost. It is world's most widely used earthworm in vermitechnology for vermicomposting.

Collection of partially decomposed wastes

Partially decomposed husk, straw, sawdust and *E. crassipe* were collected after the mushroom cultivation form zoology laboratory, Avinashilingam Deemed University, Coimbatore. NPK were estimated in the red soil and partially decomposed wastes.

Pot culture experiment

Pot culture studies were carried out, to understand the effect of different compost and vermicompost prepared from the wastes for the growth of bean, *Dolichos lab lab*.

Wastes were placed in earthen pots where they are treated like compost heaps and earthworms were released. This was maintained for 30 days. A control containing only red soil without introducing earthworm was also maintained simultaneously.

The nitrogen, phosphorus and potassium were estimated in the red soil and the animal waste (cow dung) are given in the Table I and Figure 6. Random samples of the partially decomposed husk, straw, saw dust and *E. crassipe* were also analysed for nitrogen, phosphorus and potassium by following the method of Subbiah and Asija (1956), Stanford and English (1979) and Jackson (1973) respectively.

I. Estimation of nitrogen

Procedure

Twenty gm of soil in 1 litre round bottom distillation flask (preferably long necked) was taken. Twenty ml of distilled water followed by 100ml of each 0.32% $KMNO_4$ and 2.5% NaoH was added. The frothing ring boiling was prevented by adding 1ml of liquid paraffin (or paraffin wax peels 1gm) and bumping was prevented by adding a few glass beads. Distill the contents of steady rate and liberated ammonia was collected in a 250ml conical flask or breaker containing 20ml boric acid with absorption of ammonia the colour turns to green. After cooling it was titrated against N/50 H_2SO_4.

II. Estimation of phosphorus

Procedure

a. Extraction

Five gm of soil in a 250ml conical flask was taken and 1 teaspoon of carbon black was added followed by 50ml of olsen's reagent. The content was shaken for 30 minutes on a platform type shaker. Titration was carried out with a whatman No.1 filter paper. More activated carbon was added if necessary to obtain clear filtrate. The flask was shaken immediately before pouring the suspension into the funnel. If the filtrate is turbid, pour the suspension to the maximum level of the 5cm funnel along with the filter paper.

b. Colour development (Ascorbic acid method)

Pipette 5ml of the filtrate into 25ml volumetric flask, with $5NH_2SO_4$ to pH 5.0. This can be easily done by taking 5ml of 5m sodium bicarbonate in a separate 25ml standard flask and determining the volume of acid. This is required for the pH of the solution to 5.0 using P- nitrophenol indicator. When the pH is brought down to 5.0 by the addition of $5NH_2SO_4$ the quantity of acid determined was added to individual aliquot pipetted out. After the pH adjustment, the content was diluted with 20ml of distilled water. Four ml of freshly prepared reagent B was added and made up to a volume of 25ml with distilled water. The solution was shaken to make it homogeneous and was kept for 10 minutes. (This gives a stable blue colour with in 24 hours). The intensity of blue colour developed was measured in photoelectric calorimeter of 650 nm filter (red filter). Run a blank. A known standard of 0.2 to 0.4ppm for 20 samples was introduced to verify the correctness of meter. The phosphorus content of the sample from standard curve was found out.

III. Estimation of potassium

Five gm of sample was added in 100ml conical flask. Twenty five ml of neutral normal ammonium acetate was added. The contents were shaken for 5 minutes in a medium speed in a horizontal shaker and the entire solution is filtered through whatman No.1 filter paper into a 500ml plastic beaker. The flame photometer was set by atomizing 0 to 100ppm potassium solution alternatively 0 to 100 meter readings respectively till the instrument is steady. Sample extract reading was noted under 20, 50ppm. The solutions meter reading was noted. The potash content of the sample was found from the standard curve drawn.

Pot designed for the experiment

The pots designed for vermicomposting comprised each of three layers. A layer of red soil was used as the bedding material. This is the lower most layer. Water is sprinkled on the bed to get a moisture level of 30–40%. Then earthworms are spread gently on the surface of bedding.

The vermicompost pot containing three different layers with different materials used were mentioned below:-

Treatments	Lower layer	Middle layer	Upper layer
Control	Red soil (6) L = litre		
T1	Red soil (2L)	Partially decomposed husk (2L)	Ordinary soil (2L)
T2	Red soil (2L) + 40 earthworms	Partially decomposed husk (2L)	Ordinary soil (2L)
T3	Red soil (2L) + 40 earthworms	Partially decomposed husk (1L) + cow dung (1L)	Ordinary soil (2L)
T4	Red soil (2L)	Partially decomposed straw (2L)	Ordinary soil (2L)
T5	Red soil (2L) + 40 earthworms	Partially decomposed straw (2L)	Ordinary soil (2L)
T6	Red soil (2L) + 40 earthworms	Partially decomposed straw (1L) + cow dung (1L)	Ordinary soil (2L)
T7	Red soil (2L)	Partially decomposed sawdust (2L)	Ordinary soil (2L)
T8	Red soil (2L) + 40 earthworms	Partially decomposed sawdust (2L)	Ordinary soil (2L)
T9	Red soil (2L) + 40 earthworms	Partially decomposed sawdust (1L) + cow dung (1L)	Ordinary soil (2L)
T10	Red soil (2L)	Partially decomposed *Eichhornia crassipe*(2L)	Ordinary soil (2L)
T11	Red soil (2L) + 40 earthworms	Partially decomposed *Eichhornia crassipe*(2L)	Ordinary soil (2L)
T12	Red soil (2L) + 40 earthworms	Partially decomposed *Eichhornia crassipe* (1L) + cow dung (1L)	Ordinary soil (2L)

In the top most layer small holes were made for aeration. Then the pots were covered with moist gunny bags to reduce moisture loss and prevent the entry of rats and toads and save worms from extra movements. The temperature and moisture was maintained at optimum. The upper and middle layer were turned over for uniform composting at regular interval and at the end of the 31st day vermicompost was harvested. NPK was recorded in the control and all other treatments (Table II and figure 7).

Worm cast production and harvesting

The worms feed actively and assimilate only 5 – 10% for their growth and the rest is excreted as loose granular moulds of worm cast. When the compost is ready watering was stopped for 2 – 3 days, when all the worms retire to the bed below where some water still exists. Then the vermicompost is harvested through the following technique.

The vermicompost was dumped on plastic sheet for all the treatments. A number of cone shaped piles were made under bright sun light. Earthworms moved to the bottom to avoid bright light. The compost from the top layer/sides were removed. Masses of earthworms at the bottom of the piles were removed in a container. The number of worms in each pot were separated and counted (Table III and Figure 8). The compost free of earthworms was then sieved to remove the cocoons and baby worms. After harvesting the vermicompost was shadow dried and used for the growth of bean, *Dolichos lab lab*.

Study of growth parameter

The shadow dried compost were utilized for the experimental work undertaken for growing bean, *Dolichos lab lab*. The seeds of *Dolichos lab lab* were collected from super nursery, Coimbatore.

Seeds were grown on all the twelve compost treatments and the control to analyze the growth of bean, *Dolichos lab lab*. After 60 days, the various parameters were analysed in *Dolichos lab lab* grown in the control, all the compost and vermicompost treatments. The various biometric

Figure 2

Partially decomposed husk
For vermicomposting

Figure 3

Partially decomposed straw
For vermicomposting

Figure 4

Partially decomposed sawdust
for vermicomposting

Figure 5

Partially decomposed *E. crassipe*
for vermicomposting

Results and Discussion

CHAPTER - IV
RESULTS AND DISCUSSIONS

The results of the present investigation on the "Utilization of wastes from mushroom culture for vermicomposting and for the growth of bean plant, *Dolichos lab lab* (L.)" is presented and discussed in this chapter.

The number of earthworms *Eudrilus eugeniae* introduced in various treatments (T_2, T_3, T_5, T_6,T_8, T_9, $T_{11}$and T_{12}) and the number of earthworms harvested after 30 days of experiment were listed in the Table III and Figure 8.

The number of earthworms *E. eugeniae* introduced in T_2, T_3, T_5, T_6,T_8, T_9, $T_{11}$and T_{12} treatments were 40. After 30 days of experiment the maximum number of 69 earthworms were collected in vermicompost of red soil, partially decomposed straw, cow dung with ordinary soil (T_6), followed by vermicompost of red soil, partially decomposed sawdust, cow dung with ordinary soil (T_9) where 63 earthworms were harvested. The harvested earthworms in the vermicompost of red soil, partially decomposed *Eichhornia crassipe*, cow dung with ordinary soil (T_{12}) were 61, where as 59 earthworms were harvested from red soil, partially decomposed husk, cow dung with ordinary soil (T_3).

The harvested earthworms in the vermicompost of red soil, partially decomposed straw, with ordinary soil (T_5) were 58, where as 56 earthworms were harvested from red soil, partially decomposed sawdust with ordinary soil (T_8). In the vermicompost of partially decomposed *Eichhornia crassipe*, with ordinary soil (T_{11}), 53 earthworms were collected. The minimum number of 50 *E.eugeniae* were collected in the T_2 treatment.

The maximum number of *E. eugeniae* observed in the T_6 and T_9 treatments were due to the availability of higher organic content (in T_6, NPK = 4.50%, 0.35%, 1.06% and in T_9 NPK = 3.8%, 0.28%, 0.98%) and also the consumption of biologically degradable and decomposable organic wastes. Similar findings were recorded by Harender Raj and Bhardwaj (2001) and inferred that earthworms can double their population in one month in ideal conditions of temperature, moisture and food (Organic matter). Similar observation was found in *perionyx excavatus* where large aggregation of worms observed in compost heaps or in soils rich in organic effluents. The type of food plays a major role in determining the population density of earthworms (Radha, 1988).

The maximum number of earthworms were harvested in T_6, T_9 and T_{12} treatments. In these treatments the nitrogen content were 4.50%, 3.8% and 3.22% respectively. The moderate number of earthworms were harvested in T_{12} (61 earthworms), T_3 (59 earthworms), T_5 (58 earthworms), T_8 (56 earthworms) and T_{11} (53 earthworms) treatments. It is evident from the findings that nitrogen level was also moderate (from 2.78% to 3.22%) in these treatments. Bhatnagar and Patla (1996) discussed that the earthworms produced more cocoons when fed on decaying organic matter or on nitrogen rich diets.

The minimum number of earthworms (50) in the T_2 treatments were due to the unavailability of organic wastes for their consumption. According to Graff (1953) worms on the organic surface horizon mature rapidly, produce large number of cocoons and have several generation in a year.

Earthworm acclimatize themselves and maintain their population using decayed organics and plant debris as food. An earthworm established soil can sustain itself and help not only to increase crop production but also productivity (Ramesh *et al.*, 2000). Earthworms have important function by virtue of their feeding, digesting, excreting decomposting microorganisms and supporting further decomposition of biodegradable matters (Ganeche *et al.*, 2000).

Earthworms have a great ability to ensure all organic wastes, reducing their volume by about 50% and expelling the digested material as castings which are a useful soil amendment and may be easily stored for agricultural use (Tomati *et al.*, 1985).

Piearce *et al.* (1990). concluded that protozoa and fungi were the major sources of nutrients for earthworms and that bacteria were of minor nutritional importance and soil algae were of moderate importance. The time of origin of earthworms is confirmed by the finding of fossilised earthworm cocoons.

Comparison of NPK in the animal wastes before treatment

The NPK was estimated before treatment and were summarised in Table I and Figure 6. In the animal waste (cow dung) 3.30% of nitrogen, 0.83% of phosphorus and 0.59% of potassium were analysed.

Comparison of NPK in the partially decomposed wastes before vermicomposting

The NPK was estimated in the partially decomposed wastes before vermicomposting and were summarised in Table I and Figure 6. Maximum nitrogen was found in partially decomposed straw (0.38%) followed by partially decomposed saw dust (0.32%) and partially decomposed *Eichhornia crassipe* (0.30%) and minimum nitrogen was estimated in partially decomposed husk (0.25%). The phosphorus content in the partially decomposed wastes was found to be highest in straw (0.38%) followed by sawdust (0.35%), *Eichhornia crassipe* (0.29%) and husk (0.28%) respectively. Maximum level of potassium (0.52%) was found in partially decomposed straw which declined in partially decomposed saw dust (0.25%), *Eichhornia crassipe* (0.20%) and husk (0.19%).

Comparison of NPK in the treatments

The concentration of nitrogen, phosphorous and potassium were estimated and were summarised in Table II and Figure 7. Table II shows the highest level of nitrogen (4.50 %) in T_6 treatment followed by T_9 (3.8%), T_{12} (3.22%), T_3 (3.12%), T_5 (2.98%), T_8 (2.92%), T_{11} (2.78%), T_2 (2.62%), T_4 (2.4%) and T_7 (2.39%) respectively. The nitrogen content in T_{10} treatment was 1.67% and T_1 treatment was 1.65%. The lowest level of nitrogen was observed in the control (0.28%).

Maximum value of phosphorus was estimated in T_6 treatment (0.35%) followed by T_9 (0.28%), T_{12} (0.28%), T_3 (0.25%), T_5 (0.15%), T_8 (0.13%),

T_4 (0.11%), T_7 (0.10%), T_2 (0.06%), T_{10} (0.05%) and T_1 treatment (0.04%). The minimum value of phosphorus was observed in the control (0.002%). Similar trend was observed in potassium content.

Maximum amount of potassium was analysed in T_6 treatment (1.06%) followed by T_{12} 0.98%, T_9 (0.98%), T_{11} (0.91%), T_5 (0.86%), T_3 (0.82%), T_4 (0.78%), T_2 (0.72%), T_8 (0.62%), T_{10} (0.60%), T_1 (0.52%) and T_7 treatment (0.50%). The minimum value of 0.23% was observed in the control.

The growth and yield of bean, *Dolichos lab lab* in the control and in twelve different treatments were studied and compared (Figure 9 and 10).

Root length, shoot length and total length of the plant

The length of the root, shoot and the total length of the bean, *Dolichos lab lab* were recorded and the results were given in the Table IV, V and VI and Figures 11, 12 and 13. The plant grown in the control showed minimum root length (17.1667 ± 0.1178cm), shoot length (51.50 ± 0.3535 cm) and total length (68.66 ± 0.4714 cm). The bean grown in the T_1treatment showed the length of 20.083 ± 0.424cm, 60.25 ± 1.2747cm and 80.33 ± 1.6996cm as length of the root, length of the shoot and total length of the plant respectively. The plant grown in T_2 treatment showed 21.00 ± 0.612cm, 63.50 ± 0.935cm and 84.00 ± 2.449cm as length of the root, shoot and total length of the plant respectively. The plant grown in T_3 treatment showed the length of the root, shoot and total length of the plant as 21.416 ± 0.1178cm, 64.25 ± 0.3535cm and 85.66 ± 0.4714cm respectively. The growth rate observed in T_5 treatment were 21.166 ± 0.424cm, 63.00 ±

1.837cm and 84.66 ± 1.699cm as length of the root, length of the shoot and total length of the plant respectively. The plant grown in T_6 treatment showed length of root, shoot and total length of the plant as 22.33 ± 0.235cm, 66.75 ± 0.612cm and 89.00 ± 0.8164cm respectively. The plant growth observed in T_7 treatment was 20.75 ± 0.2041cm, 62.25 ± 0.612cm and 83.000 ± 0.816cm as length of the root, shoot and total length of the plant. The plant grown in T_8 treatment showed 21.1667 ± 0.3118cm, 63.500 ± 1.274cm and 84.66 ± 1.2472cm as length of the root, shoot and total length of the plant respectively. The plant grown in T_9 treatment showed length of the root, shoot and total length of the plant as 22.083 ± 0.117cm, 66.25 ± 0.353cm and 88.33 ± 0.4714cm respectively. The plant grown in T_{10} treatment showed 20.41 ± 0.3118 cm, 61.25 ± 0.935cm and 81.66 ± 1.247 cm as length of the root, shoot and total length of the plant. The growth rate observed in the T_{11} treatment were 21.00 ± 0.735cm, 63.00 ± 1.224cm and 84.00 ± 2.943cm as length of the root, length of the shoot and total length of the plant respectively. The plant grown in T_{12} treatment showed 21.500 ± 0.2041cm, 64.50 ± 0.612cm and 86.000 ± 0.816cm as length of the root, shoot and total length of plant respectively.

Length of the root, shoot and total length of the bean, *Dolichos lab lab* in all the twelve treatments showed significant difference.

In the present study the higher growth rate of bean, *Dolichos lab lab* in the T_5 treatment was due to the availability of organic matter which had high nutrient content as food and release a part of carbon as CO_2 during respiration which is ultimately utilized by the plants.

Earthworm excreta are an excellent soil conditioning material with a high water holding capacity and 'natural time release' for releasing nitrogen into the soil. Maximum level (4.50%) observed in this mixture (Partially decomposed straw, cow dung with ordinary soil) was due to the earthworm activity which also accelerated the highest growth rate. The higher concentration of nitrogen in vermicompost coupled with its greater availability would have been the cause for making it a superior soil amendment for plant growth (Harris, 1990). The vermicompost contains humine (organic matter) characterised by high molecular weight and an enzymatically active humic fraction which stimulates plant germination and growth (Dell' Amico *et al.*, 1994).

Selvakumari *et al.* (1992) confirmed an increase of 17.2% in plant height in turmeric (*Curcuma longa L.*). Pushpanathan and Veerabadran (1992) confirmed that the application of coir waste enhanced the length and spread of roots in sorghum plants. Annamail (2001) reported that the application of pressmud 5t/h and 10t/h and rice husk (10t/h) significantly increased the grain yield and root growth. The agrowaste such as composted sugarcane trash and pressmud proved to be very effective in improving the growth and yield of the legume crop black gram.

According to Thanunathan *et al.* (1997) vermicompost coirpith increased the root length of onion. This might be due to favourable physical conditions of soil and availability of plant nutrients in sufficient quantities. Observation by Radha *et al.* (1987) showed that when vermicompost was used as a substrate for China aster, the stem girth was increased. This is in conformity with the present investigation.

Similar to the present result, increase in shoot length was also noted by Krishnamoorthy *et al.* (1992) in sunflower on the application of coirpith compost. Root and shoot developments were greatest in 100% compost and least in those grown in 100% soil (Leng and Ordera, 1995). According to Riheiro *et al.* (1998) vermicompost and cattle manure showed the best results regarding plant growth of lettuce.

Paul L.S.Chan and Griffiths (1988) stated that worm castings had a stimulating effect on the growth of *Glycine max* (Soyabean), with an increase in root length, lateral number, shoot length and internodal length of seedlings plants.

Fresh weight of the shoot and fresh weight of the root

The fresh weight of the shoot and root of the bean, *Dolichos lab lab* were recorded in the Tables VII and VIII and Figure 14 and 15.

The minimum fresh weight of the shoot and root of the bean, *Dolichos lab lab* were recorded in the control (16.333 ± 1.6779gms and 1.4967 ± 0.2718gms). The bean grown in T_1 treatment showed the fresh weight of 27.423 ± 2.374gms and 1.4633 ± 0.191gms as fresh weight of the shoot and root respectively. The plant grown in T_2 treatment showed 30.313 ± 1.036gms and 2.520 ± 0.066gms as fresh weight of the shoot and root. The plant grown in T_3 treatment showed the fresh weight of the shoot and root as 3.460 ± 0.480gms and 3.000 ± 0.226gms respectively. The growth rate observed in the T_4 treatment were 29.980 ± 1.326gms and 2.336 ± 0.325gms as fresh weight of the shoot and root. In T_5 treatment the weight of the shoot and root were 33.236 ± 0.841gms and

2.960 ± 0.043gms. The plant grown in T_6 treatment showed 35.933 ± 0.684gms and 3.253 ± 0.182gms as fresh weight of the shoot and root. The fresh weight of the shoot and root in the T_7 treatment were 29.750 ± 1.323gms and 2.2767 ± 0.2916gms. The plant grown in T_8 treatment showed the fresh weight of the shoot and root as 30.923 ± 0.954gms and 2.856 ± 0.196gms respectively. The growth rate observed in the T_9 treatment were 35.4133 ± 1.0372gms and 3.073 ± 0.111gms as weight of the shoot and root. The plant grown in T_{10} treatment showed 29.296 ± 0.605gms and 2.236 ± 0.196gms as weight of the shoot and root. The plant grown in T_{11} treatment showed the weight of the shoot and root as 0.510 ± 0.540gms and 2.600 ± 0.102gms respectively. The growth rate observed in the T_{12} treatment were 33.490 ± 0.693gms and 3.010 ± 0.029gms as fresh weight the shoot and root.

Fresh weight of the shoot and fresh weight of the root in the bean, *Dolichos lab lab* in all the twelve treatments showed significant difference. The maximum weight of *Dolichos lab lab* in T_5 treatment was due to the release of certain vitamins (Gavrilor, 1963) or some provitamin D (Zraghers, 1957) or some free amino acids (Dubash and Ganti, 1964) into the soil. These macro nutrients were utilized by the *Dolichos lab lab* thereby increasing in its weight.

Edwards (1981) who inferred that the fertilizing value of earthworm casting and the beneficial effects on crops have been related to the presence of active mineral nutrients and plant growth regulators with phytohormonal action (Greene, 1980). The vermicomposting contains humified organic matter characterized by high molecular weight and the enzymatically active humic fraction which stimulates plant germination and growth (Dell' Amico *et al.*, 1994 and Garciar *et al.*, 1992).

The present results were also supported by Sharma and Madan (1988) and Chan and Griffitsh (1988), by treating maize, wheat, soyabean, sugarcane and paddy with vermicompost and observed its beneficial effect by the highest yield. Similar observation was noticed in the tall and dwarf varieties of tomato (Jawar and Zarca) and observed the highest yield in both the cultivators (Kalembasa, 1996).

include in reference

Leaves

The number of leaves at the end of the experiment in bean, *Dolichos lab lab* were noted and given in the Table IX and Figure 16.

The minimum number of leaves were counted in the control (38.3333 ± 2.0548) followed by T_1 (41.0000 ± 2.9439), T_{10} (43.3333 ± 2.8674), T_7 (45.0000 ± 1.6329) and T_4 (46.6667 ± 4.1899) treatments respectively. The number of leaves counted in T_2, T_{11}, T_8, T_5, T_3, T_{12} and T_9 treatments were 47.3333 ± 1.2472, 48.6667 ± 1.2472, 49.0000 ± 3.5590, 50.0000 ± 3.7416, 50.6667 ± 2.3570, 53.3333 ± 4.921 and 55.6667 ± 2.4944 respectively. The maximum number of leaves (56.0000 ± 3.5590) were recorded in T_6 treatment.

Significant differences were observed in the number of leaves among twelve different treatments.

Termen *et al.* (1973) observed that an increase in the yield of maize crops in the application of earthworms in combination with organic wastes is possibly due to increased mineralization and optimum nutrient supply. Senapati and Dash (1982) suggested that earthworms along with organic manures is used as an alternative to costly inorganic fertilizers for enhancing crop production.

Ismail (1993) reported the effect of vermicompost on all yield parameters of paddy and sugarcane. The increased growth rate in all the vermicompost treatments was due to the release of humic acids comprising of the NPK nutrients by the earthworm, *Eudrilus eugeniae* into the compost.

Number of Pod

In bean, *Dolichos lab lab* the number of pod at the end of the experiment was noticed and given in Table X and Figure 17.

The Table X showed the minimum number of 2.3333 ± 0.4714 pod in the control, followed by 3.0000 ± 0.8164, 5.6667 ± 1.2472 and 5.3333 ± 0.4714 pod in T_1, T_7 and T_{10} respectively. In T2, T_{11}, T_8 and T_5 6.333 ± 1.2472, 6.6667 ± 1.2472, 8.3333 ± 1.2472 and 8.6667 ± 0.4714 pod were noticed.. In both the treatments T_3 and T_{12} 9.0000± 0.8164 pod were found. The maximum number of 9.6667 ± 1.2472 and 10.3333 ± 0.4714 pod were recorded in T_5 and T_8. The number of pod in all the twelve treatments showed significant differences.

Significant increase in dry matter and yield of green gram due to the application of vermicompost and farm yard manure was reported by Srinivasa Reddy and Uma Mahesh (1995). The increased yield would have been due to the quick nutrient absorption of vermicompost organic components. The increased number of vegetables in the vermicompost mixed with partially decomposed straw and cow dung was due to the excellent facility provided by the high nutrient content in these organic manure, essential micro organisms and nutrients present in this treatment.

Fresh weight of the pod

In bean, *Dolichos lab lab* the fresh weight of the pod at the end of the experiment was noticed and was given in Table XI and Figure 18.

Table XI showed the minimum fresh weight of the pod (0.6333 ± 0.04719) in the control, which increased to 1.6333 ± 0.1247g, 1.9000 ± 0.0816g in T_1 and T_{10}. This increased to 2.0333 ± 0.0471g in T_7 followed by 2.2000 ± 0.1414 g in T_4. In T_5, T_{11}, T_8, T_{12}, T_3 and T_6 the fresh weight of the pod was recorded as 2.3333 ± 0.0942 g, 2.2333 ± 0.471g, 2.3333 ± 0.0471g, 2.3333 ± 0.3399g, 2.333 ± 0.1247g and 2.4667 ± 0.1247g respectively. The maximum pod weight of 2.3667 ± 0.0471g was recorded in T_9.

Bhirde (1988) reported that increased number and thickness of branches in grapevine were due to the application of the vermicompost. The present findings are also confirmed by Kalembasa *et al.* (1998). Maximum yield of bhindi due to 100% vermicompost has been presented by Govindan *et al.* (1995).

Experiments by Kavitha Garg and Nagendra Bharadwaj (2000) revealed that there was significant effect on number of grains per plant in both the varieties that there was significant effect on number of grains per plant in both the varieties of wheat Cv. Raj 3777 and Cv. Raj 3765 due to the application of vermicompost. The maximum number of grains per plant was obtained in the vermicompost treatment and minimum in the control.

Similar results were obtained in maize and rice, where in the organic composts recorded higher yield over NPK alone (Ramaswamy, 1997) who observed that vermicompost increased radish and sweet pepper yield markedly. Similar findings were also recorded by Devanesan (1996) in Amaranthus caudatus and Jayanthiswari (1999) in tomato, Lycopersium esculentum by the application of casuarina vermicompost.

Root volume

In bean, *Dolichos lab lab* the root volume was recorded and given in Table XII and Figure 19.

Table XII showed the minimum root volume (0.1000 ± 0) in the control, in T_1, T_4, T_7 and T_{10} similar root volume was observed (0.1667 ± 0.0471). In T_2, T_8 and T_{11} the root volume was recorded as 2.3333 ± 0.0471. Treatment T_5 showed the root volume as 0.2333 ± 0.1247. In the treatment T_3 the root volume was slightly increased to 0.2667 ± 0.0471. The maximum root volume (0.3000 ± 0.0816) was recorded in T_6, T_9 and T_{12}.

The result is in agreement with Inder Singh (1991) who recorded an increase in plant height with increasing N levels in tomato. According to Liyanage *et al.* (1993), application of coirdust and coconut husk to coconut resulted in greater number and weights of roots.

In bean, *Dolichos lab lab* the root volume in all the twelve treatments showed significant differences.

Number of nodules

The number of nodules in bean were recorded in the Table XIII and Figure 20. The minimum number of nodules were counted in the control and T_1 treatments (2.3333 ± 0.4714). In the treatments T_2, T_4, T_7, T_8, T_{10} and T_{11} the number of nodules were similar (3.0000 ± 0.8164). The number of nodules in T_3, T_5 and T_{12} were 3.3333 ± 0.4714. The increased number of nodules was noted in treatment T_9 (3.6667 ± 0.4714). The maximum number of nodules (4.0000 ± 1.6329) were seen in T_6 treatment.

According to Pate and Dart (1961), small amounts of nitrogen to legumes has been reported to stimulate nodule formation. The application of potassium and nitrogen in combination stimulated nodulation in legumes (Ssali and Keya, 1983; Pereira and Bliss, 1987; Talevera, 1989). Similar result was observed by Mahalakshmi Priya (1994) who noted that the addition of CCP gave significant increase in the number of nodules of soyabean.

All the vermicompost treatments were found to have a significant influence on all the growth parameters of bean, *Dolichos lab lab* than the control. This was supported by the studies on the effect of vermicompost on all yield parameters of paddy and sugarcane by Ismail (1993).

Protein content in bean, *Dolichos lab lab* in the control and twelve different treatments

The amount of protein content in the seed of *Dolichos lab lab* grown in the control and twelve different treatments were analysed and given in Table XIV and Figure 21. In the analysis it was found that the seed grown in T_6 contain the maximum amount of protein (0.9333 ± 0.0249g). The minimum protein level was observed in the control (0.7067 ± 0.0634g).

According to Ravignanam and Gunathilagaraju (1996) the higher nutritional level of mulberry is attributed to the increased root growth resulting in greater uptake of nutrients from soil due to the earthworms activity.

Dighe *et al.* (1996) proved that N application in 3 spits and P application as basal was better than other treatments in the N uptake in aestivum and durum wheat in black clay soils of malwa plateau. They also found the application of N and P in 2 splits increased the protein content in wheat.

Chlorophyll 'a' content in bean, *Dolichos lab lab* in the control and twelve different treatments

The amount of chlorophyll 'a' present in the leaves grown in the control and twelve different treatments were analysed and presented in the Table XV and Figure 22. In the analysis it was found that the leaves grown in T_6 contain the maximum amount of chlorophyll 'a' (1.1878 ± 0.1687g).

The minimum chlorophyll 'a' was observed in the leaves grown in the control (0.8681± 0.1204g).

Chlorophyll 'b' content in bean, *Dolichos lab lab* in the control and twelve different treatments

The amount of chlorophyll 'b' present in the leaves of *Dolichos lab lab* grown in the control and twelve different treatments were estimated and given in Table XVI and Figure 23. In the analysis it was found that the leaves grown in T_6 showed maximum amount of chlorophyll (1.8736 ± 0.2008g). Minimum value was found in the leaves grown in the control (0.5969 ± 0.0740g).

Total Chlorophyll content in bean, *Dolichos lab lab* in the control and twelve different treatments

The amount of total chlorophyll content present in the control and twelve different treatments were analysed and given in the Table XVII and Figure 24. The leaves grown in T_6 contain the maximum amount (2.8429 ± 0.0530g) of total chlorophyll and minimum was analysed in the control (1.6700 ± 0.0941g).

Organic manures containing auxins and essential amino acids increase the chlorophyll content of leaf, which in turn enhances metabolite synthesis resulting in crop productivity (Ghosh and Das, 1998).

Chlorophyll content was significantly increased with increase in dose of P_2O_5 expect at 100kg over 75kg P_2O_5 ha^{-1}. Total chlorophyll content in leaves of treated plants was significantly increased with 5.73 and 22.20% with 25 and 125kg P_2O_5 ha^{-1} over control (Nimje and Pot kile, 1997).

In the present study on "Utilization of wastes from mushroom culture for vermicomposting and for the growth of bean plant, *Dolichos lab lab* (L.)" as compared to the control, all the twelve different treatments were rich in both organic and inorganic nutrients and were found to be very effective biofertilizers and had a favourable influence on all the growth parameters, protein, chlorophyll 'a', 'b' and total chlorophyll of bean, *Dolichos lab lab*.

TABLE I

Nutrient content (%) in the red soil, partially decomposed wastes and animal waste

S. No	Nature of the Samples	N	P	K
1.	Red soil	3.68	Nil	0.33
	Partially decomposed wastes			
2.	Husk	0.25	0.28	0.19
3.	Straw	0.38	0.38	0.52
4.	Sawdust	0.32	0.35	0.25
5.	*Eichhornia crassipe*	0.30	0.29	0.20
	Animal waste			
6.	Cow dung	3.30	0.83	0.59

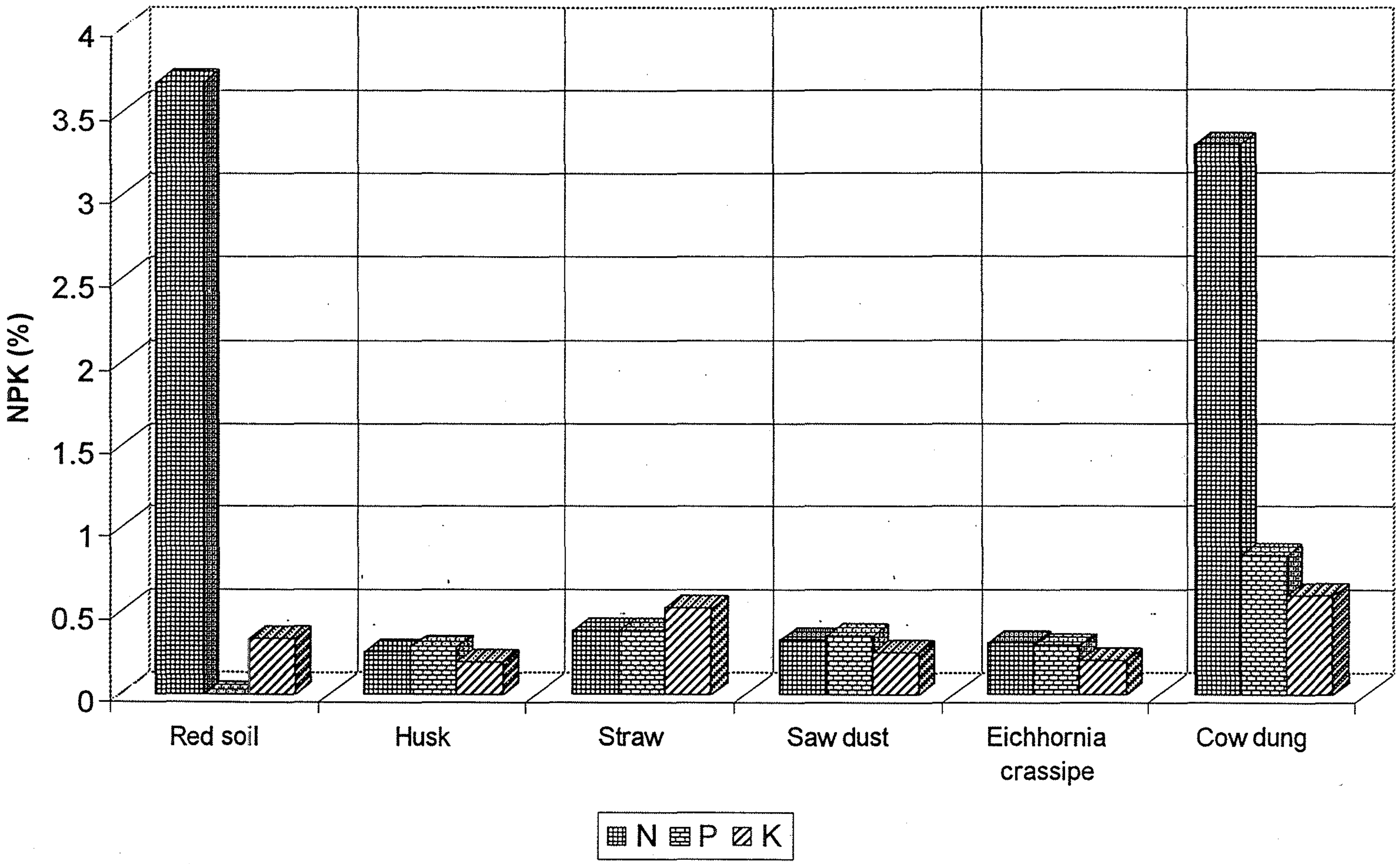


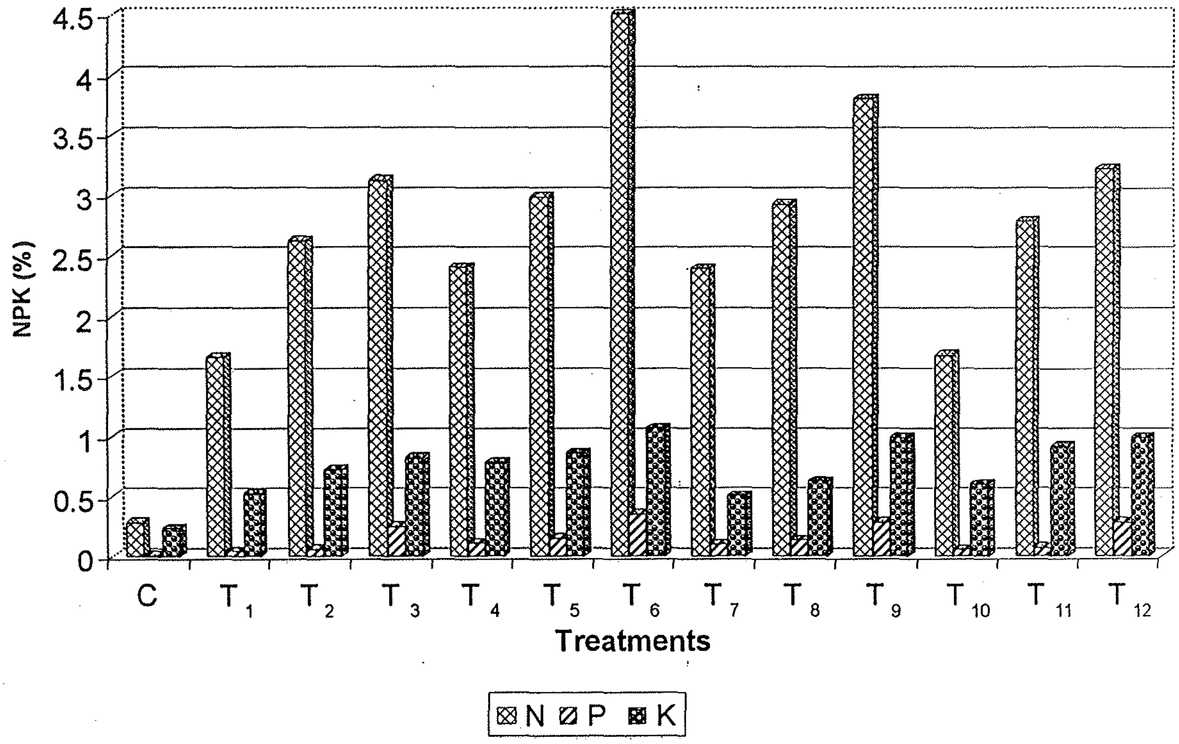
Figure 6

Comparison of nutrient content (%) in the red soil, partially decomposed wastes and animal waste

TABLE II

Nutrient content (%) in the control (C) partially decomposed wastes and vermicompost treatments ($T_1 - T_{12}$)

S. No	Treatments	N	P	K
1.	Control (Red soil) C	0.28	0.002	0.23
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	1.65	0.04	0.52
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	2.62	0.06	0.72
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	3.12	0.25	0.82
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	2.40	0.11	0.78
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	2.98	0.15	0.86
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	4.50	0.35	1.06
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	2.39	0.10	0.50
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	2.92	0.13	0.62
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	3.8	0.28	0.98
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	1.67	0.05	0.60
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	2.78	0.07	0.91
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	3.22	0.28	0.98



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 7

Comparison of nutrient content (%) in the control (C) partially decomposed wastes and vermicompost treatments ($T_1 - T_{12}$)

TABLE III

Number of earthworms introduced in various treatments and the number of earthworms harvested after 30 days of experiment

S. No	Treatments	Number of earthworms introduced in to the pot	Number of earthworms harvested after 30 days of experiment
1.	Control (Red soil) C	-	-
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	-	-
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	40	50
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	40	59
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	-	-
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	40	58
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	40	69
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	-	-
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	40	56
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	40	63
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	-	-
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	40	53
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	40	61

Figure-9

comparison of bean , *Dolichos lab lab* in the control (C) and treatments T_1-T_6

Figure-10

comparison of bean , *Dolichos lab lab* in the control (C) and treatments T_7–T_{12}

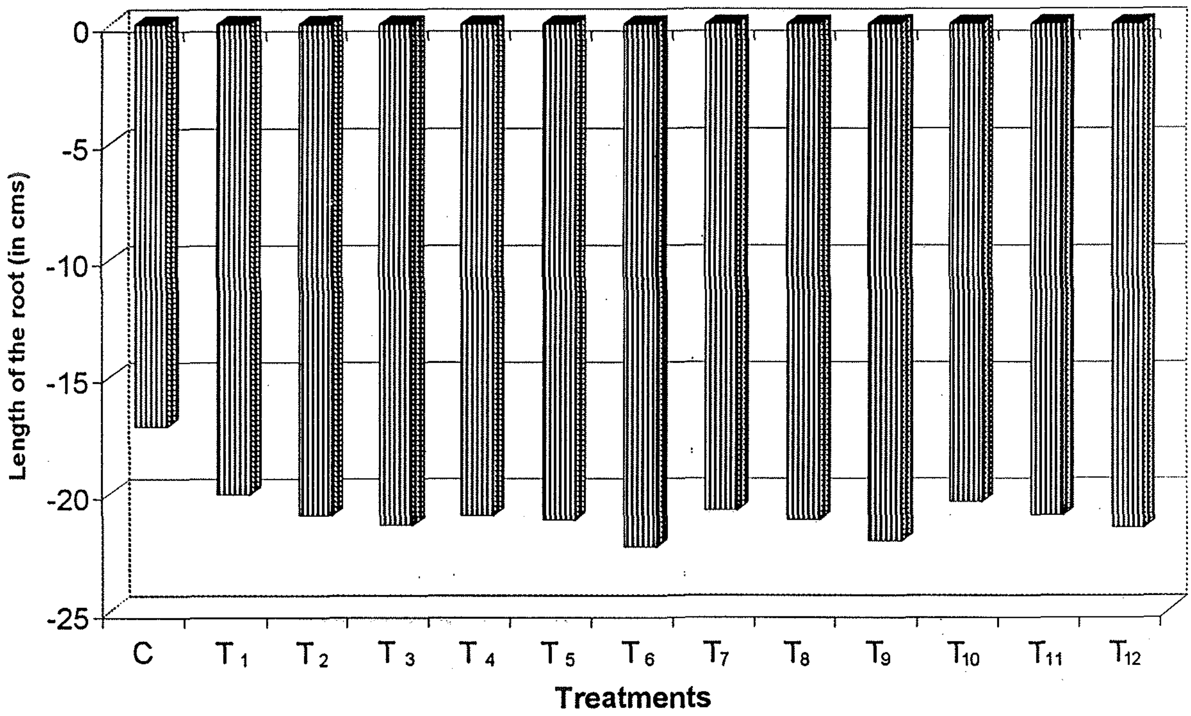
TABLE IV

Root length of bean (in cms), *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Length of the root (in cms)
1.	Control (Red soil) C	17.1667 ± 0.1178
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	20.0833 ± 0.4249
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	21.0000 ± 0.6123
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	21.4167 ± 0.1178
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	21.0000 ± 0.3535
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	21.1667 ± 0.424
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	22.3333 ± 0.2357
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	20.7500 ± 0.2041
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	21.1667 ± 0.3118
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	22.0833 ± 0.1178
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	20.4167 ± 0.3118
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	21.0000 ± 0.7359
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	21.5000 ± 0.2041
	"F" Ratio	22.7277**
	SEd	0.3741
	CD (5%)	0.7690

Values are means of six replications.

** Significant at one per cent level .



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 11

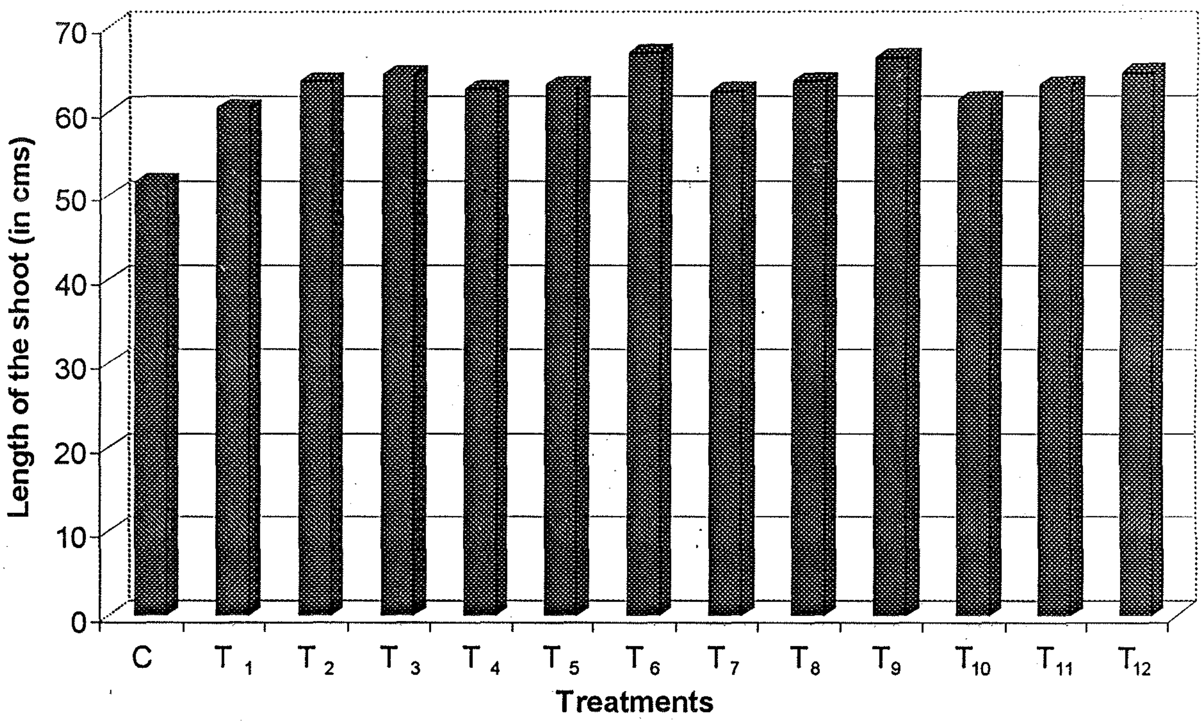
Comparison of the root length of bean (in cms), *Dolichos lab lab* in the control and all other treatments

TABLE V

Shoot length of bean (in cms), *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Length of the shoot (in cms)
1.	Control (Red soil) C	51.5000 ± 0.3535
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	60.2500 ± 1.2747
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	63.5000 ± 0.9354
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	64.2500 ± 0.3535
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	62.5000 ± 0.3535
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	63.0000 ± 1.8371
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	66.750 ± 0.6123
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	62.2500 ± 0.6123
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	63.5000 ± 1.2747
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	66.2500 ± 0.3535
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	61.2500 ± 0.9354
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	63.0000 ± 1.2247
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	64.5000 ± 0.6123
	"F" Ratio SEd CD (5%)	31.9112** 0.9405 1.9333

Values are means of six replications.
** Significant at one per cent level.



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 12

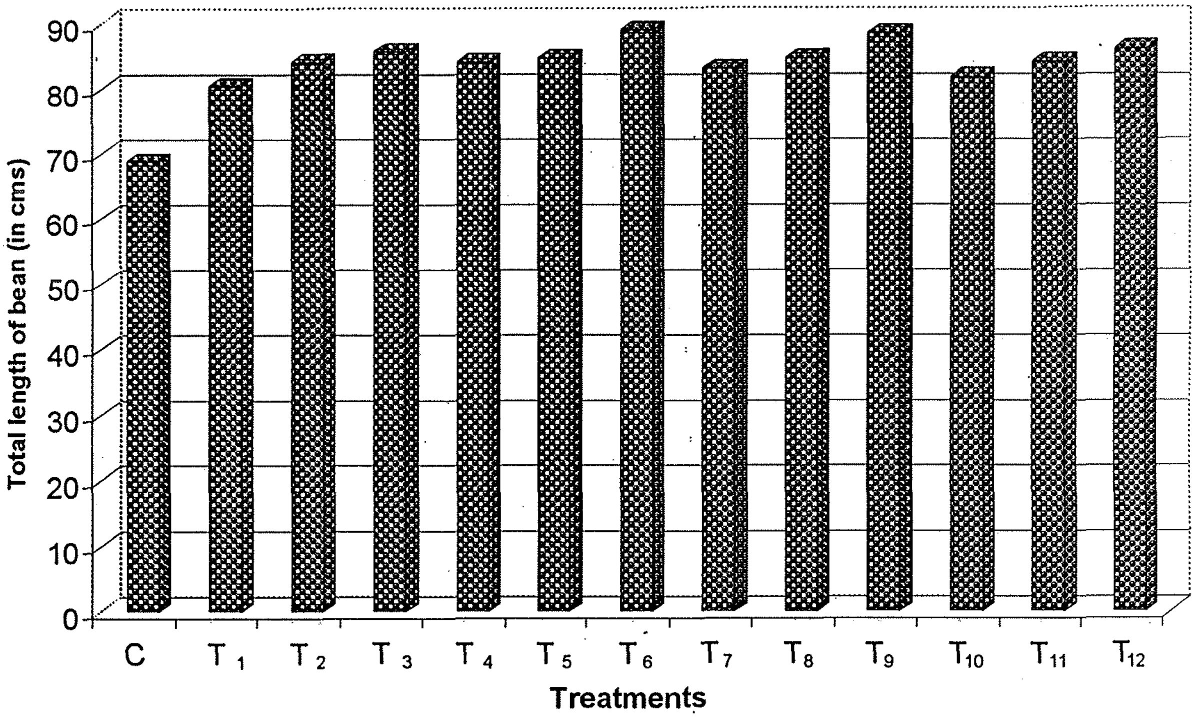
Comparison of the shoot length of bean (in cms), *Dolichos lab lab* in the control and all other treatments

TABLE VI

Total length of the bean (in cms), *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Total length of the plant (in cms)
1.	Control (Red soil) C	68.6667 ± 0.4714
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	80.3333 ± 1.6996
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	84.0000 ± 2.4494
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	85.6667 ± 0.4714
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	84.0000 ±1.6329
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	84.6667 ± 1.6996
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	89.0000 ± 0.8164
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	83.0000 ± 0.8164
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	84.6667 ± 1.2472
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	88.3333 ± 0.4714
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	81.6667 ± 1.2472
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	84.0000 ± 2.9439
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	86.0000 ±0.8164
	"F" Ratio SEd CD (5%)	22.6141** 1.4907 3.0642

Values are means of six replications.
** Significant at one per cent level.



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 13

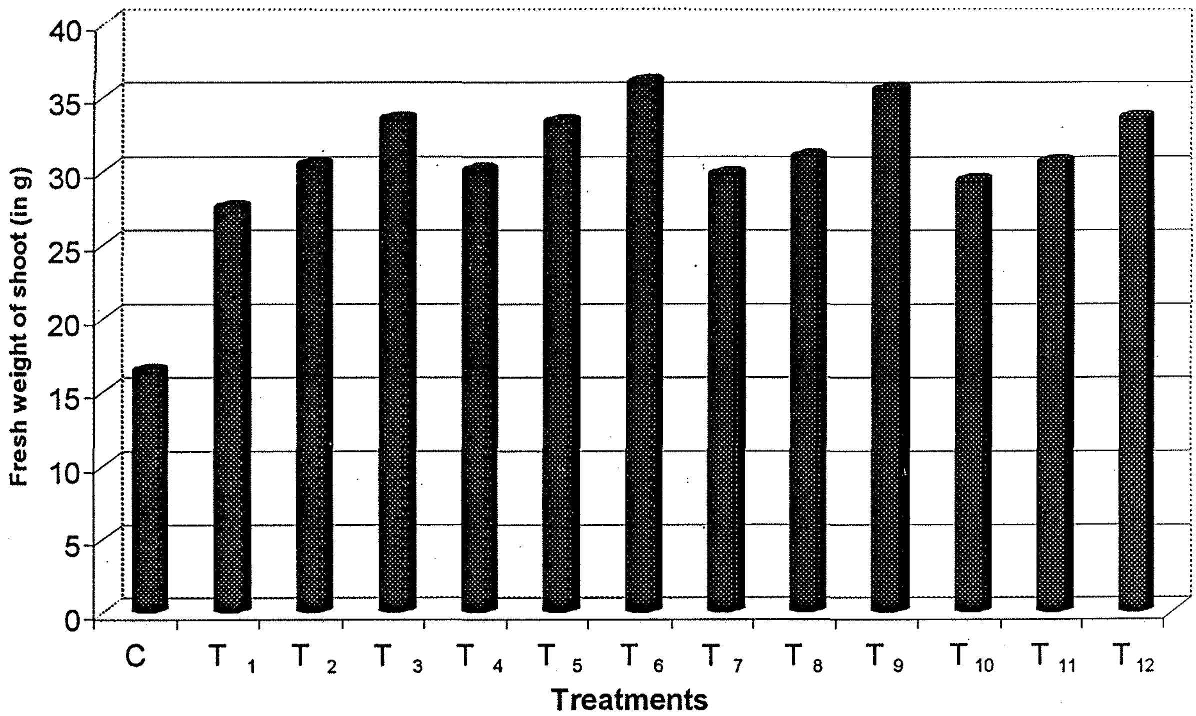
Comparison of the total length of bean (in cms) , *Dolichos lab lab* in the control and all other treatments

TABLE VII

Fresh weight of the shoot of bean (in g), *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Fresh weight of shoot (in g)
1.	Control (Red soil) C	16.333 ± 1.6779
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	27.4233 ± 2.3742
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	30.3133 ± 1.0361
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	33.4600 ± 0.4808
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	29.9800 ± 1.3262
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	33.2367 ± 0.8411
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	35.9333 ± 0.6847
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	29.7500 ±1.3235
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	30.9233 ± 0.9544
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	35.4133 ± 1.0372
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	29.2967 ± 0.6053
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	30.5100 ± 0.5400
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	33.4900 ± 0.6931
	"F" Ratio	36.0194**
	SEd	1.1614
	CD (5%)	2.3872

Values are means of six replications.
** Significant at one per cent level.



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 14

Comparison of fresh weight of the shoot of bean (in g), *Dolichos lab lab* in the control and all other treatments

TABLE VIII

Fresh weight of the root of bean (in g), *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Fresh weight of the root (in g)
1.	Control (Red soil) C	1.4967 ± 0.2718
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	1.4633 ± 0.191
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	2.5200 ± 0.0668
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	3.0000 ± 0.2264
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	2.3367 ± 0.3252
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	2.9600 ± 0.0432
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	3.2533 ± 0.1826
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	2.2767 ± 0.2916
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	2.8567 ± 0.1960
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	3.0733 ± 0.1114
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	2.2367 ± 0.1960
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	2.6000 ± 0.1023
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	3.0100 ± 0.0294
	"F" Ratio	17.3919**
	SEd	0.1947
	CD (5%)	0.4003

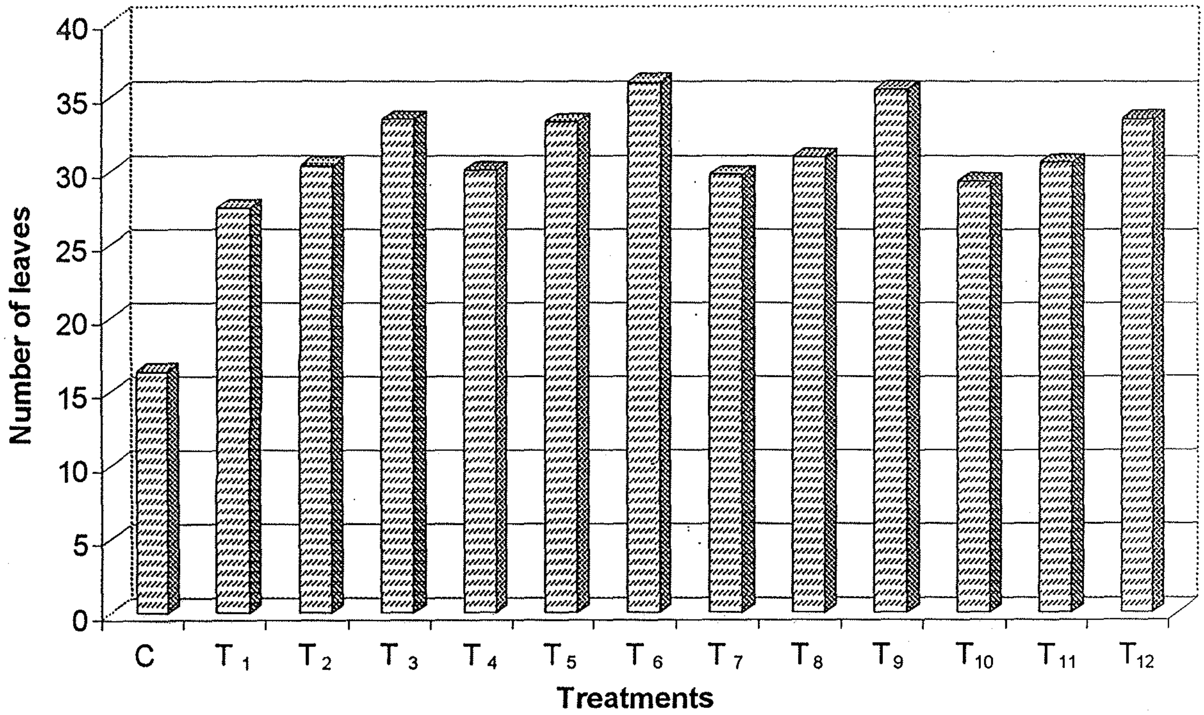
Values are means of six replications.
** Significant at one per cent level.

TABLE IX

Number of leaves in bean, *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Number of leaves
1.	Control (Red soil) C	38.3333 ± 2.0548
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	41.0000 ± 2.9439
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	47.3333 ± 1.2472
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	50.6667 ± 2.3570
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	46.6667 ± 4.1899
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	50.0000 ± 3.7416
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	56.0000 ± 3.5590
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	45.0000 ± 1.6329
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	49.0000 ± 3.5590
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	55.6667 ± 2.4944
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	43.3333 ± 2.8674
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	48.6667 ± 1.2472
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	53.3333 ± 4.9216
	"F" Ratio	6.1348*
	SEd	3.0354
	CD (5%)	6.2394

Values are means of six replications.
** Significant at one per cent level.



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 16

Comparison of the number of leaves in bean, *Dolichos lab lab* in the control and all other treatments

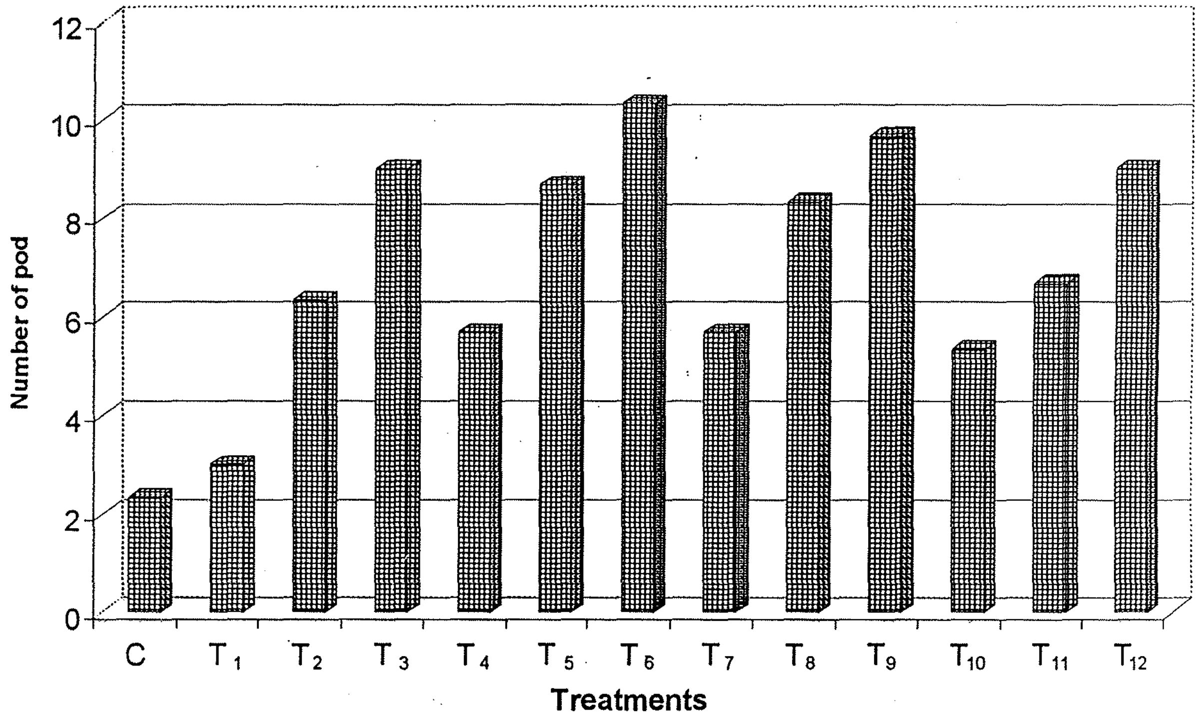
TABLE X

Number of pods in bean, *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Number of pods
1.	Control (Red soil) C	2.3333 ± 0.4714
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	3.0000 ± 0.8164
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	6.3333 ± 1.2472
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	9.0000 ± 0.8164
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	5.6667 ± 1.2472
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	8.6667 ± 0.4714
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	10.3333 ± 0.4714
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	5.6667 ± 1.2472
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	8.3333 ± 1.2472
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	9.6667 ± 1.2472
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	5.3333 ± 0.4714
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	6.6667 ± 1.2472
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	9.0000 ± 0.8164
	"F" Ratio	13.3606**
	SEd	0.9696
	CD (5%)	1.9931

Values are means of six replications.

** Significant at one per cent level.



C-Control -Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 17

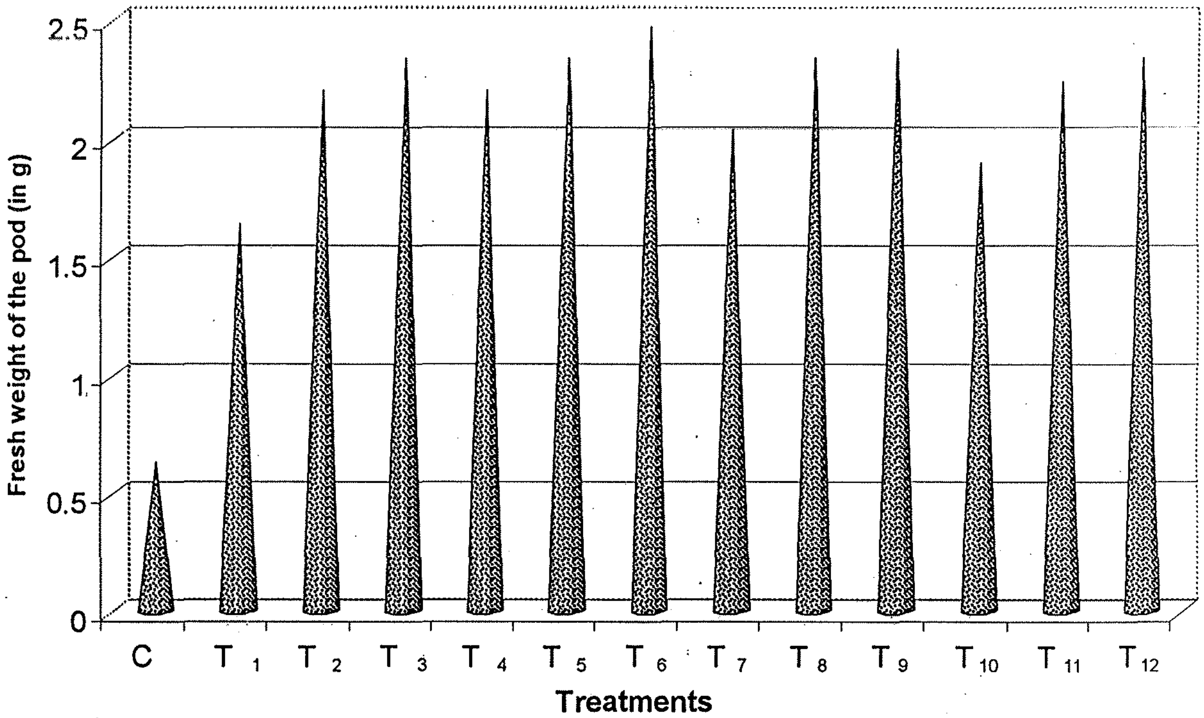
Comparison of number of pod in bean, *Dolichos lab lab* in the control and all other treatments

TABLE XI

Fresh weight of the pods in bean (in g), *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Fresh weight of the pods (g)
1.	Control (Red soil) C	0.6333 ± 0.0471
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	1.6333 ± 0.1247
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	2.2000 ± 0.1414
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	2.3333 ± 0.1247
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	2.2000 ± 0.1414
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	2.3333 ± 0.0942
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	2.4667 ± 0.1247
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	2.0333 ± 0.0471
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	2.3333 ± 0.0471
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	2.3667 ± 0.0471
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	1.9000 ± 0.0816
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	2.2333 ± 0.0471
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	2.3333 ± 0.3399
	"F" Ratio	29.7429**
	SEd	0.1268
	CD (5%)	0.2606

Values are means of six replications.
** Significant at one per cent level.



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 18

Comparison of fresh weight of the pod of bean (in g), *Dolichos lab lab* in the control and all other treatments

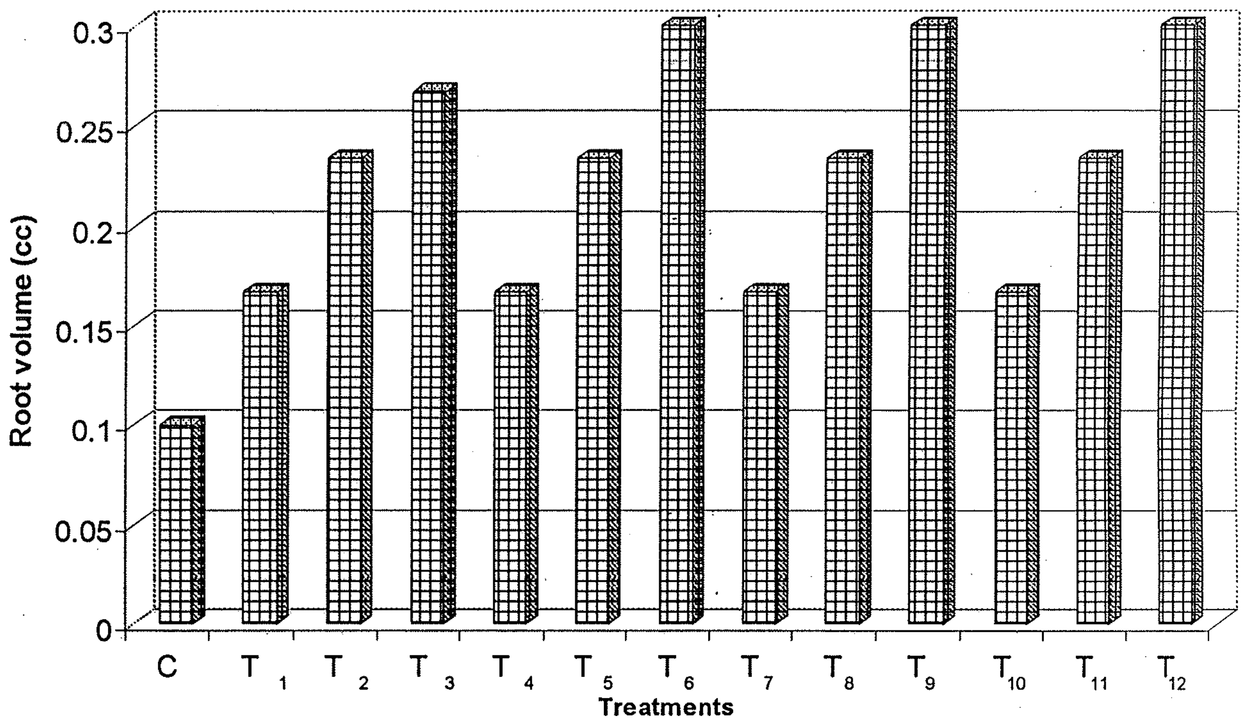
TABLE XII

Root volume of bean (cc), *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Root volume (cc)
1.	Control (Red soil) C	0.1000 ± 0
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	0.1667 ± 0.0471
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	0.2333 ± 0.0471
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	0.2667 ± 0.0471
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	0.1667 ± 0.0471
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	0.2333 ± 0.1247
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	0.3000 ± 0.0816
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	0.1667 ± 0.0471
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	0.2333 ± 0.0471
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	0.3000 ± 0.08160
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	0.1667 ± 0.0471
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	0.2333 ± 0.0471
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	0.3000 ± 0.0816
	"F" Ratio	2.5926*
	SEd	0.0555
	CD (5%)	0.1140

Values are means of six replications.

* Significant at five per cent level.



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

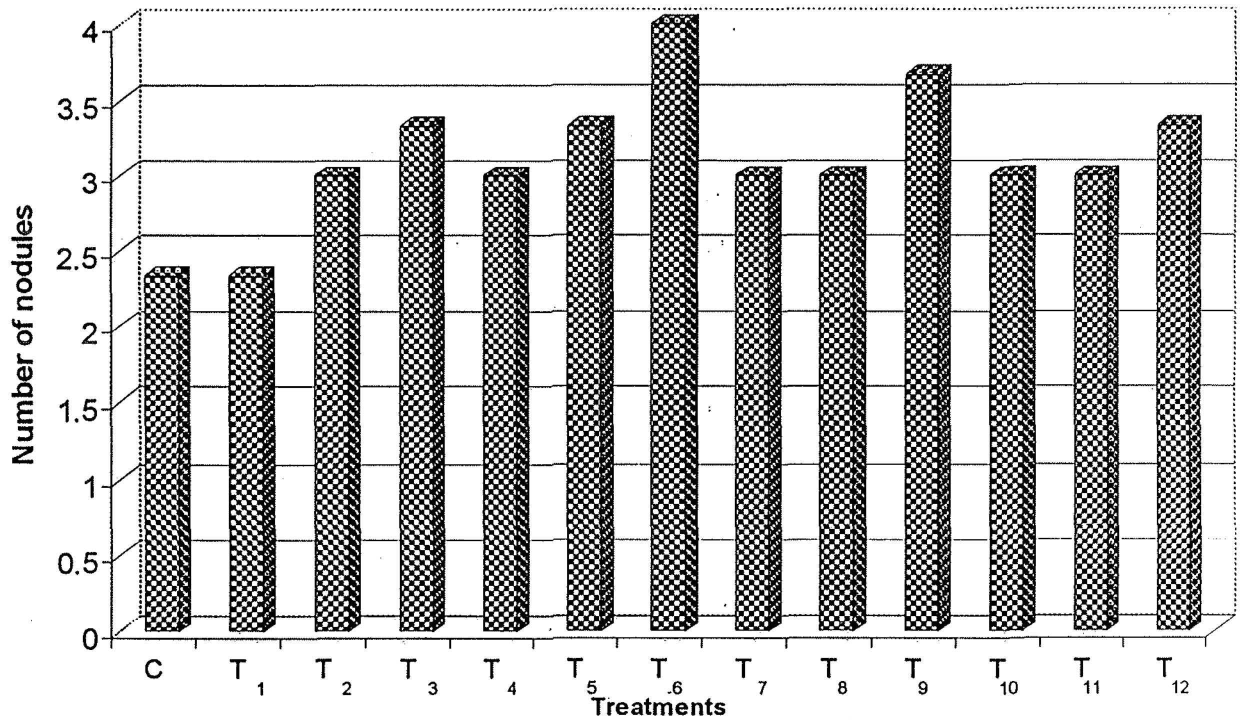
Figure 19

Comparison of root volume of bean (cc), *Dolichos lab lab* in the control and all other treatments

TABLE XIII
Number of nodules in bean, *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Number of nodules
1.	Control (Red soil) C	2.3333 ± 0.4714
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	2.3333 ± 0.4714
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	3.0000 ± 0.8164
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	3.3333 ± 0.4714
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	3.0000 ± 0.8164
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	3.3333 ± 0.4714
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	4.0000 ± 16329
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	3.0000 ± 0.8164
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	3.0000 ± 0.8164
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	3.6667 ± 0.4714
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	3.0000 ± 0.8164
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	3.0000 ± 0.8164
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	3.3333 ± 1.2472
	"F" Ratio	0.5873
	SEd	0.8473
	CD (5%)	1.7417

Values are means of six replications.
** Significant at one per cent level.



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 20

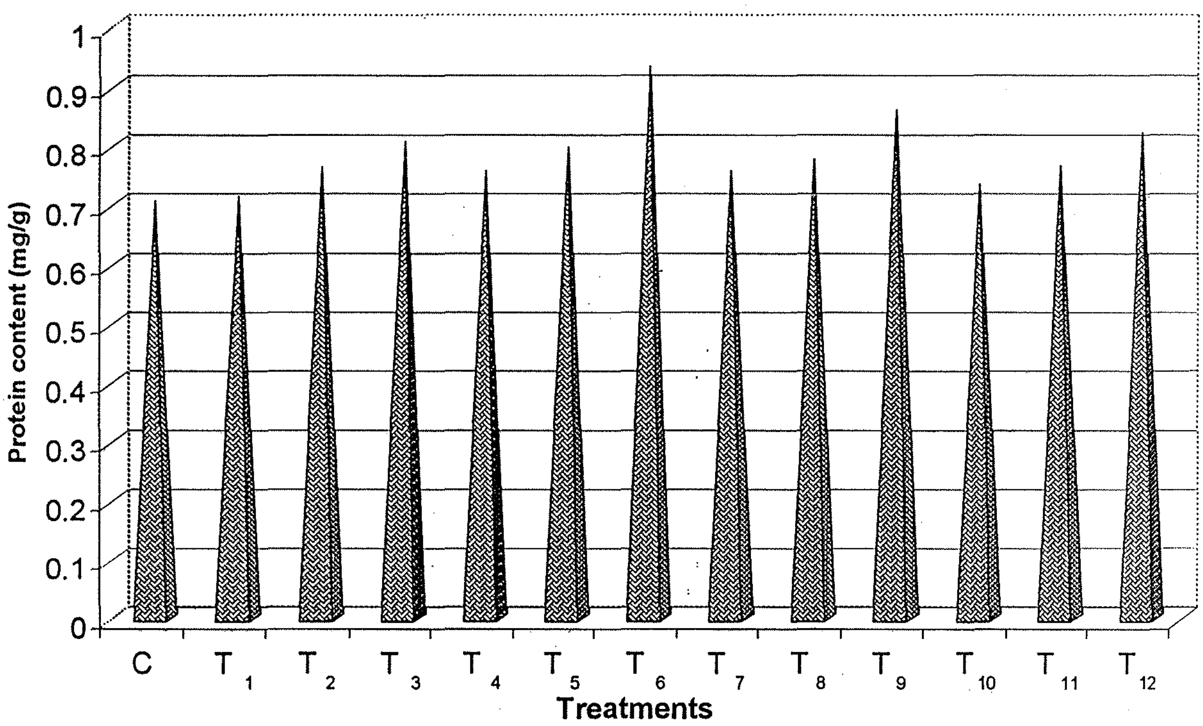
Comparison of number of nodules of bean, *Dolichos lab lab* in the control and all other treatments

TABLE XIV

Protein content in bean (mg^{-g}), *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Protein content (mg^{-g})
1.	Control (Red soil) C	0.7067 ± 0.0634
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	0.7133 ± 0.0169
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	0.7633 ± 0.0385
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	0.8067 ± 0.0825
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	0.7567 ±0.634
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	0.7967 ± 0.0946
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	0.9333 ± 0.0249
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	0.7567 ± 0.0402
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	0.7767 ± 0.0262
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	0.8600 ± 0.0216
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	0.7333 ± 0.0368
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	0.7667 ± 0.0339
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	0.8233 ± 0.0464
	"F" Ratio	2.9678**
	SEd	0.0509
	CD (5%)	0.1046

Values are means of six replications.
** Significant at one per cent level.



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 21

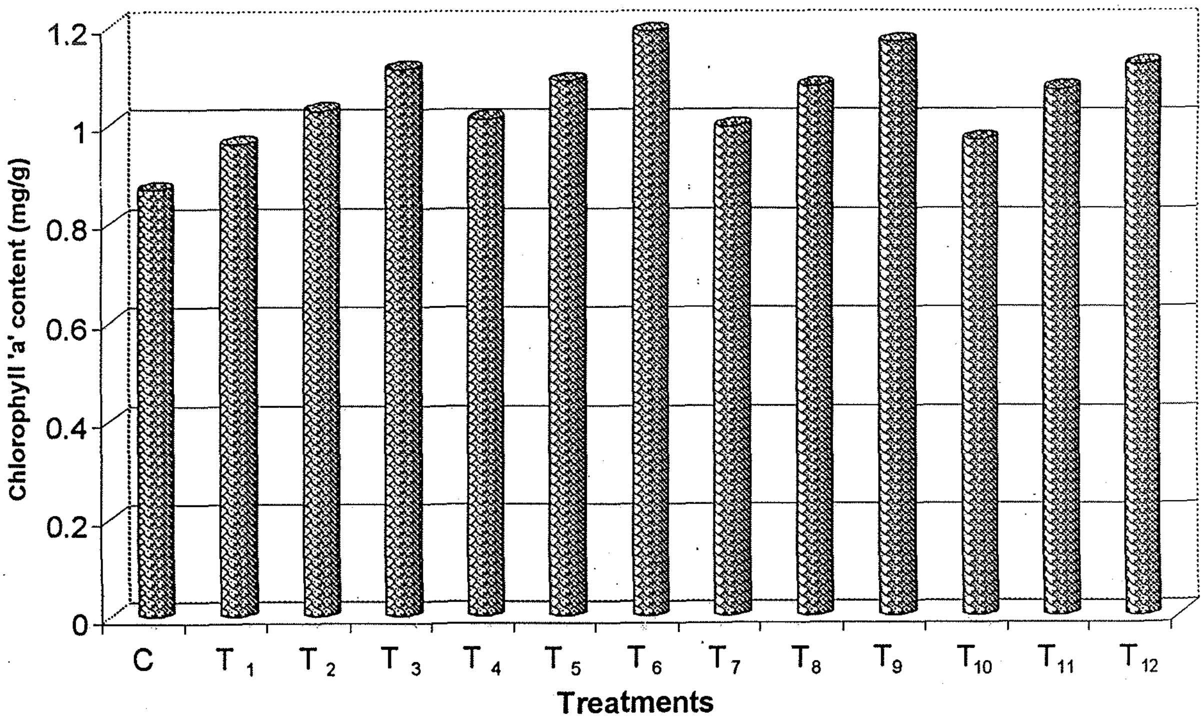
Protein content (mg/g) in bean, *Dolichos lab lab* in the control and all other treatments

TABLE XV

Chlorophyll "a" content (mg^{-g}) in bean, *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Chlorophyll "a" Content (mg^{-g})
1.	Control (Red soil) C	0.8681 ± 0.1204
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	0.9601 ± 0.1715
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	1.0268 ± 0.1818
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	1.1112 ±0.0772
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	1.0101 ± 0.1528
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	1.0874 ± 0.1367
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	1.1878 ± 0.1687
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	0.9958 ± 0.628
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	1.0771 ± 0.0870
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	1.1666 ± 0.1187
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	0.9674 ± 0.0689
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	1.0704 ± 0.0547
13.	Red soil + 40 earthworms + partially decomposed + cow dung + ordinary soil (T_{12})	1.1209 ± 0.0818
	"F" Ratio	3.0695**
	SEd	0.0726
	CD (5%)	0.1472

Values are means of six replications.
** Significant at one per cent level.



C-Control - Red soil
T_1-Red soil + partially decomposed husk + ordinary soil
T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil
T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil
T_4-Red soil + partially decomposed straw + ordinary soil
T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil
T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil
T_7-Red soil + partially decomposed sawdust + ordinary soil
T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil
T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil
T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil
T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil
T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 22

Chlorophyll "a" content (mg/g) in bean, *Dolichos lab lab* in the control and all other treatments

TABLE XVI

Chlorophyll "b" content (mg^{-g}) in bean, *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Chlorophyll "b" Content (mg^{-g})
1.	Control (Red soil) C	0.5960 ± 0.0740
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	0.6034 ± 0.0934
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	1.2785 ± 0.5001
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	1.4733 ± 0.2008
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	1.1523 ± 0.1408
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	1.4673 ± 0.1587
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	1.8736 ± 0.2098
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	1.1211 ± 0.0135
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	1.3703 ± 0.3434
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	1.6735 ± 0.0272
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	1.1108 ± 0.1710
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	1.3692 ± 0.4141
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	1.5988 ± 0.0993
	"F" Ratio	5.0727**
	SEd	0.2359
	CD (5%)	0.4848

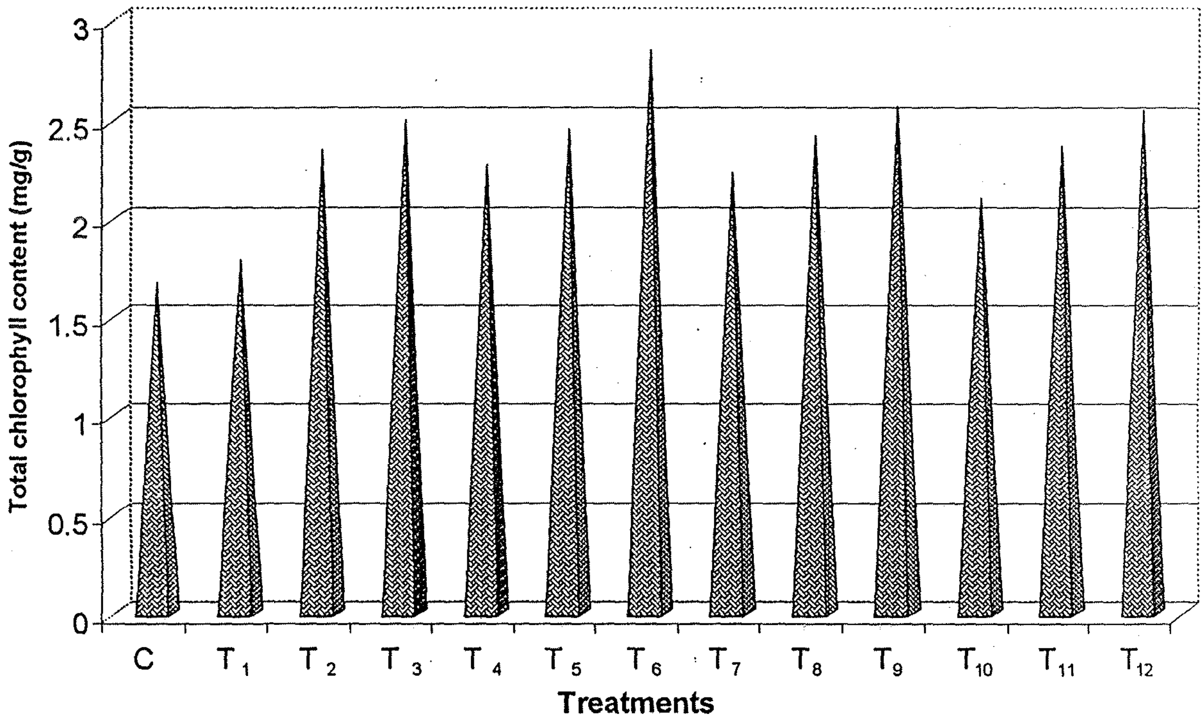
Values are means of six replications.
** Significant at one per cent level.

TABLE XVII

Total Chlorophyll Content (mg^{-g}) in bean, *Dolichos lab lab* in the control and all other treatments

S. No	Treatments	Total Chlorophyll Content (mg^{-g})
1.	Control (Red soil) C	1.6700 ± 0.0941
2.	Red soil + partially decomposed husk + ordinary soil (T_1)	1.7838 ± 0.1933
3.	Red soil + 40 earthworms + partially decomposed husk + ordinary soil (T_2)	2.3433 ± 0.2642
4.	Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil (T_3)	2.4939 ± 0.1528
5.	Red soil + partially decomposed straw + ordinary soil (T_4)	2.2728 ± 0.0707
6.	Red soil + 40 earthworms + partially decomposed straw + ordinary soil (T_5)	2.4467 ± 0.0370
7.	Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil (T_6)	2.8429 ± 0.0530
8.	Red soil + partially decomposed sawdust + ordinary soil (T_7)	2.2317 ± 0.0907
9.	Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil (T_8)	2.4163 ± 0.2087
10.	Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil (T_9)	2.5658 ± 0.0420
11.	Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{10})	2.0962 ± 0.1056
12.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil (T_{11})	2.3656 ± 0.3711
13.	Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil (T_{12})	2.5427 ± 0.1336
	"F" Ratio	5.1954**
	SEd	0.1971
	CD (5%)	0.4052

Values are means of six replications.
** Significant at one per cent level.



C-Control - Red soil

T_1-Red soil + partially decomposed husk + ordinary soil

T_2-Red soil + 40 earthworms + partially decomposed husk + ordinary soil

T_3-Red soil + 40 earthworms + partially decomposed husk + cow dung + ordinary soil

T_4-Red soil + partially decomposed straw + ordinary soil

T_5-Red soil + 40 earthworms + partially decomposed straw + ordinary soil

T_6-Red soil + 40 earthworms + partially decomposed straw + cow dung + ordinary soil

T_7-Red soil + partially decomposed sawdust + ordinary soil

T_8-Red soil + 40 earthworms + partially decomposed sawdust + ordinary soil

T_9-Red soil + 40 earthworms + partially decomposed sawdust + cow dung + ordinary soil

T_{10}-Red soil + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{11}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + ordinary soil

T_{12}-Red soil + 40 earthworms + partially decomposed *Eichhornia crassipe* + cow dung + ordinary soil

Figure 24

Total Chlorophyll content (mg/g) in bean, *Dolichos lab lab* in the control and all other treatments

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation was undertaken to view the effect of vermicompost on the growth rate of *Dolichos lab lab.*

The salient findings of the study are as follows:

1. *Eudrilus eugeniae*, a common earthworm was used in the present study for composting process and a soil friendly vermicompost was prepared.

2. A total of twelve different treatments and control were taken for conducting the experiment.
    a. Among the treatments, the bean, *Dolichos lab lab* grown in partially decomposed husk, straw, sawdust and *Eichhornia crassipe* without earthworms showed lesser growth rate than the plants grown in all other treatments. This revealed that the conventional compost had inferior quality of available nutrients than the other vermicompost treatments but better than the plant grown in the control.

    b. The bean, *Dolichos lab lab* grown in the vermicompost of partially decomposed husk, straw, sawdust and *Eichhornia crassipe* recorded an increased growth rate which indicates the availability of nutrients in moderate level.

    c. The bean, *Dolichos lab lab* grown in partially decomposted husk, straw, sawdust and *Eichhornia crassipe* vermicompost mixed with animal waste (cow dung) showed maximum growth rate which revealed the presence of all the essential inorganic and organic nutrients.

Through the present investigation it has been possible to suggest an alternative methodology of transforming partially decomposed husk, straw, sawdust and *Eichhornia crassipe* into a useful organic fertilizer. The use of vermicompost provides an alternative means of using costly chemical fertilizers which inturn affect the sustainability of Indian Agriculture. In addition, vericompost comprises rich source of vitamin and growth hormones, thus enhances productivity and nutritive value of the soil. The usage of this organic fertilizer also stresses the importance of ecofriendly utilization.

Vermitechnology is the promising aspect of biotechnology where application of earthworm is made for combating the waste disposal problems for minimizing the pollution effect and to get useful product the "vermicompost".

Vermicompost / in situ vermiculture associated with other biological inputs have been applied to grow vegetables and other crops, successfully. These approaches have proved to be economic as well as productive.

Vermiculture as a vital component of sustainable agriculture may be explored and to achieve this goal, the industrial waste, city sewage sludge and weeds which pollute this environment and create a gigantic problem of disposal, can suitably be converted to economically and environmentally sound products. It is a novel proposal to encourage because it not only abates environmental pollution but it also ensure recycling of nutrients to cultivated lands.

The government and non-government financial institutions should come forward to provide adequate funds to the entrepreneurs installation of vermicast units, which in addition to generating good income will also solve the unemployment problem to a great extent.

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