2.1. NUTRIENT DYNAMICS IN VERMICOMPOST

The most common Earthworm used for vermicomposting is *Eisenia fetida* although many other species have potential and may be suitable. Advantage of *E. fetida* are that it growth rapidly, feeds on almost any organic matter, it has a wide temperature tolerance, can be easily handled, has a high reproductive rate and has more known about its biology than any other species (Hartenstein, 1989; Edwards and Bater, 1992).

Several authors have compared species; Neuhauser *et al.*, (1988) studied all five and Edwards *et al.*, (1988) four of the following species: *Eisenia fetida, Eudrilus eugeniae, Perionyx excavates, Eisenia veneta* and *Amynthas corticis*. Edwards and Bater (1992) and Reinecke *et al.*, (1992) made comparisons between the first three in this list. In general, *Eisenia fetida* was found to be superior to the other species in terms of its wide temperature tolerance, high reproductive rate and efficiency in converting organic wastes. *Eudrilus eugeniae* and *Perionyx excavates* were also effective but their narrow temperature tolerances limits them to more tropical situations. The fecundity of *Eudrilus eugeniae* is lower than that of *E. fetida* but studies by Graff (1980) showed *E. eugeniae* had its highest reproduction when fed on sewage sludge.

In theory, maintaining a mixture of several species (polyculture) could accomplish greater sludge stabilization than culture of a single species due to variable partitioning of resources and environmental tolerances. However in experiments it
was not obvious that polyculture had any advantages in sludge stabilization compared to single cultures of *E. fetida* or *E. eugeniae* (Neuhauser *et al.*, 1988) and in mixed cultures *E. fetida* often becomes dominant (Edwards and Bater, 1992).

Several earthworm species are recommended for vermicomposting, such as the corophragic earthworms *Eisenia foetida* and *Eisenia andrei* (Dominguez *et al.*, 2001). Another is the epigeic *E. eugeniae*, a tropical earthworm with a high reproduction rate (Mba, 1983; Gajalakshmi *et al.*, 2001). The anecic *Lampito mauritii* (Tripathi and Bhardwaj, 2004) noted for its ability to withstand environmental stresses, and the epiendogeic *H. africanus* have also been recommended (Tondon *et al.*, 1998). These earthworms are capable of consuming a wide range of organic substrates from sewage sludge, animal wastes, crop residues (water hyacinth, mango leaves) to industrial refuse (Atiyeh *et al.*, 2000). They rapidly convert the wastes, through a non-thermophilic process, into a humus-like substance with smaller particle size than the starting material (Arancon *et al.*, 2003; Edwards and Burrows1988, Bieri 2002,). A similar rend was observed in *H. africanus* (Tondon *et al.*, 1998), although earthworms collected from the field had a lower survival rate than those hatched in the laboratory.

Optimal environmental conditions for the growth and reproduction of *E. fetida* fed on aerobic wastes are a temperature ranges of 15-25°C, moisture content of 43-90% and pH of 5-9 (Kaplan *et al.*, 1980a; Edwards, 1988; Neuhauser *et al.*, 1988; Edwards and Bater, 1992; Reinecke *et al.*, 1998). *E. eugeniae* has narrower optimum temperatures are 15-30% (Neuhauser *et al.*, 1988). Results of a study by Reinecke *et al.*, (1992) confirmed that *E. fetida* had a wider tolerance for temperatures than either *E. eugeniae* or *P. excavates*. Although temperature tolerances depend somewhat on
the acclimation of earthworms, temperature of 30° C were found to be detrimental to
the growth of five species by Neuhauser et al., (1988) and 35° C was fatal. Nevertheless, it may be possible to utilize heat generated by the composting processes
to enable heat tolerant species to survive in cooler climates.

The effect of temperature on the earthworm life cycle was evaluated by
growing *E. eugeniae* and *E. fetida* in dishes (12.5 cm diameter, 5 cm deep) containing
200 g of separated cattle solids (82% moisture content) (Dominguez et al., 2001). Earthworm cocoons reached sexual maturity most quickly when the temperature was
25 to 30° C, regardless of the population density. The same study also observed that
some *E. eugeniae* perished at 30° C, but *E. fetida* withstood higher temperatures.
Tripathi and Bhardwaj (2004) nevertheless recommend using a substrate with 70%
moisture content and a pH of 6.5 and a temperature of 25° C as optimal for *E. fetida*
growth and development. The same authors recommend a substrate with 60%
moisture content, pH 7.5 and a temperature of 30° C as optimal for breeding *L.
mauritii*. They also indicate that the maximum Vermicomposting rate was related to
earthworm biomass per unit waste, rather than the total number of earthworms.
Earthworm biomass growth is slower in densely populated vermi-reactors, explaining
why the cast output rates per earthworm are lower in high density vermi-reactors than
in low-density reactors (Jain et al., 2003; Gajalakshmi et al., 2005). Gajalakshmi et
al., (2001) nevertheless observed higher cast output rates per reactor volume in high-
density vermi-reactors than in low-density vermi-reactors operating over the same
period.

Plant treated with sludge compost or biosolid may still show N deficiency,
even when supplemental N-fertilizers are added. The N in sewage sludge is almost in
organic forms and resistant to mineralization because the more easily mineralizable N has already released during sewage sludge processing. Application of large amount of sewage sludge compost is necessary as the mineralization rate of organic N raises between 10 to 40% on first year of application. Therefore when applied at agronomic rates compost can support plant growth, in adequate amounts of supplemental N fertilizers are used (Sims, 1990). Composted urban refuses were studied as organic fertilizers by Villar et al., (1993). Most of the total N was in organic forms; NH$_4$ was more abundant than NO$_3$, and calcium was the most abundant nutrient followed by K, Na, Mg and P. Most of the Ca and Na were in available forms; available K and Mg were lower and available P very small.

Stabilized earthworm casts leached less dissolvable organic carbon than from undigested soil. Nutrient losses from casts that underwent several wetting / drying cycles show that there was a strong protection of nutrients in casts at first, but this was reduced as the aggregate structure was weakened (McInerney et al., 2000). After a 20 days long incubation of fresh casts a rapid increase in mineral N was observed during the first few days after deposition, and then a decrease to a level 4.5 times higher than in the soil. Also the NH$_4$ level was higher in fresh casts than in the control (Rangel, 1999). The decrease of mineral N in time in casts can be due to N becoming microbial biomass, volatilized, denitrified, or leached (Lavelle, 1992). In Haynes (1999) uningested soil and casts were incubated for 42 days, and extractable P levels were similar in casts and soils during the initial stages of incubation, but were larger in casts after 28 and 42 days. Activities of arylsulphatase and acid phosphates were lower in casts than in uningested soil; therefore the mineralization of organic matter during gut transit could be the reason for the increase in extractable P and S during incubation. Haynes (1999) concluded that mineral N increases because of
mineralization in the gut, but P and S levels increase due to mineralization after egestion. In Lavelle (1992) mineral N in casts was mostly in the form of ammonium, and after a 26 days long incubation NH$_4$ was nitrified or immobilized in biomass. The incubation of soil before ingestion increased NH$_4$ production in casts and being slightly acidic casts do not favor the denitrification of NO$_3$. Biomass N was stable (relatively) after an initial flush on one day. Gajalakshmi and Abbasi (2004b) observed an increase in vermicast output as various earthworms (*E. euginiae, L. mauritii, P. excavatus* and *D. willsi*) acclimatized to the feed, gained weight and bred.

### 2.2. MICROBIOLOGY

The vermicasts of *P. ceylanensis* showed 14 different fungal species belonging to the genera, *Aspergillus, Chaetomium, Cladosporium, Cunninghamella, Fusarium, Mucor, Penicillium, and Rhizopus* (Karmegam and Daniel 2000). The species *Eisenia fetida* may establish a symbiotic relationship with bacteria from the genus *Acidovorax*, given that these bacteria form nodules in the ampules of the nephridium of the Earthworms and help in the process of decomposition (Davidson and Stahl, 2006). Bhat et al. (1960) were the pioneer contributors to report on role of microorganisms in the gut of earthworms. Khambata and Bhat (1957) had made a detailed investigation on intestinal microflora of *Pheretima sp*. They had isolated *Pseudomonas, Corenyform bacteria, Nocardia, Streptomyces, and Bacillus* from the intestinal tract.

Soil is the key system in the functioning of terrestrial ecosystem. Vital processes take place within this system: decomposition and nutrient flow (Loreno-Osi et al., 2004) biological activities control these processes, among them, prokaryotes and earthworms (Fragoso et al., 1992 Mascolo et al 1999). The existence or physical
contact between some filamentous, segmented bacteria and intestinal mucus of the species *Octolasion lacteum* and *Lumbricus terrestris*. The results showed bacterial filaments joined to the intestinal walls of the earthworms by means of hook structures. Therefore, it is concluded that the bacteria may be adapted to live within the intestines of the earthworms. Thus diverse studies of the main bacteria within the intestinal walls of earthworms have been conducted.

Earthworms possess a grinding gizzard that fragments the organic residuals. They ingest microorganisms and depend on them as their major source of nutrients (Edwards and Bohlen, 1996), but also, the earthworm gut secretes mucus and enzymes that selectively stimulates beneficial microbial species (Doube and Brown, 1998). Earthworms promote further microbial activity in the residuals so that the faecal material, or casts that they produce, is much more fragmented and microbially active than what the earthworms consumed (Edwards, 1995). Effectively, earthworms inoculate the soil, or organic matter, with finely ground organic residuals and beneficial microorganisms which increases the rate of decomposition and enables further ingestion of microorganisms by earthworms.

The gut environment is anoxic, pH 6.9 with about 50% water content. The gut bacteria are enriched in total carbon, organic carbon and total nitrogen with a carbon to nitrogen ratio of 7 (Horn, 2003). The bacteria isolated from vermicasts and earthworm skin were endospore forming gram positive Bacilli (Munnoli, 2007). The bacterial counts in gut vermicompost was higher than the surrounding soil (Edwards and Lofty, 1977; Edwards and Bohlen, 1996; Munnoli, 1998, 2000, 2007; Suthar, 2008a; Nechitaylo *et al.*, 2010) and as the organic matter ingested passes through the
gut, it undergoes biochemical changes effected by gut inhabiting bacteria (Munnoli, 2007).

Applying Vermicompost to soil increases microbial biomass Nitrogen and orthophosphate levels (Arancon et al., 2003) while improving seed germination, seedling growth and crop productivity in a variety of cereals, legumes, vegetables, fruits, ornamental and flowering plants grown in greenhouses (Atiyeh et al., 2001). Addition of N fixing microorganisms; *Azotobacter* and *Azospirillum*, and P solubilizing microorganisms; *Pseudomonas striata*, with rock phosphate, will increase the plant available N and P content of vermicompost further. Vermicompost is also characterized by a more abundant and diverse microbial community than compost (Atiyeh et al., 2001). The greatest plant growth responses were observed when vermicompost occupied 10 to 40 % of the total volume of plant growth medium (Atiyeh et al., 2001). Incorporating larger proportions of vermicompost into growth media had little positive effect on plant growth, and past a threshold point, will reduce crop production indices. Vermicompost is also thought to be more pathogen free than compost (Szczech, 1999) and has the ability to suppress plant disease (Szczech, 1993). Studies at the Ohio Agricultural Research and Development Center on soils under strawberries and grapes observed a larger population of fungivorous and bacterivorous nematodes in soils where vermicompost was applied than in soils with inorganic fertilizer treatments (Arancon et al., 2004a). Vermicompost derived from sewage sludge suppressed arbuscular mycorrhizal fungi (AMF) colonization of clover and cucumber, although AMF colonization of Salvia and Aster roots, growing in a garden soil mixture, was enhanced by vermicompost (Kale et al., 1998a). It may be that the vermicompost produced from sewage sludge contained metals that impaired
the AMF symbiosis, since excessive levels of heavy metals can reduce AMF colonization and fungal persistence in soils.

Earthworms mechanically mix mineral particles and organic matter through their digestive system which carries out disintegration, grinding and digestion of the ingested material, increasing or decreasing the activity and number of beneficial or pathogenic microorganisms (fungi, Actinimycetes and bacteria) (Winding et al., 1997). The participation of microorganisms within the digestive tracts of earthworms is of great importance given that a lot of these involved in the degradation of organic matter (Byzov et al., 2007). For studies on bacteria within the intestines of earthworms, diverse methods and techniques have been used which have helped in identifying species of the genuses *Bacillus, Pseudomonas, Klebsiella, Azotobacter, Serratia, Aeromonas and Enterbacter* (Valle-Molinas et al., 2007; Byzov et al., 2007; Singleton et al., 2003). These bacteria are mainly plant growth promoters, free living nitrogen fixers and phosphate solubilizers (Loreno-Osti et al., 2004; Martinez-Romero, 2001). Some researchers have indicated the existence of a possible type of mutualism between these two organisms (Brown et al., 2000; Barois and Lavelle, 1986).

An observation was made for the species *Eisenia fetida* coming from contaminated soil in an industrial zone. There was an increase in 91 colonies, further divided into 12 groups: *Aeromonas* 6%, *Agromyces* 3%, *Bacillus* 31%, *Bosea* 1%, *Gordonia* 6%, *Klebsiella* 6%, *Microbacterium* 7%, *Nocardia* 2%, *Pseudomonas* 10%, *Rhodococcus* 19%, *Tsukamurella* and *Streptomycetes* 7%. The genus *Bacillus* was the dominant group in the intestines of the earthworms.
On the other hand, Valle-Molinares et al., 2007 indentified seven species of bacteria from the genus Bacillus (B. insolitus, B. megaterium, B. brevis, B. pasteurii, B. sphaericus, B. thuringiensis and B. pabuli) within the intestines of Onychochaeta borincana. All these species are typical soil bacteria. In addition, it was found that the microbial weight of the intestinal region decreased from the anterior to posterior section. Additionally, it was observed that some bacteria increased in the posterior section of the intestines, may be because for many bacteria this portion presents adequate conditions for their development.

The microbiological components of compost consist of bacteria and fungi. The uniqueness of Actinomycetes presents them as the third microbiological component, though in actuality actinomycetes are a particular kind of bacteria (Compost Microbiology and Soil Food, 2008). The microorganisms needed for composting are found throughout the natural environment. They are present in compost feedstock, water, air, soil as well as machinery the feedstock and compost are exposed to during processing sources ensure a high diversity of microorganisms, which help to maintain an active microbial population during the dynamic chemical and physical processes of composting such as shifts in pH, temperature, water, organic matter, and nutrient availability. Only on rare occasions will the addition of microorganisms be warranted. (Compost Microbiology and the Soil Food Web, 2008).

2.3. PRODUCTION OF VERMIWASH

Thangavel et al., (2003) showed that both vermiwash and vermicast extracts increased the growth and yield of paddy. Maximum plant height (68.5 cm), grain yield (6.7 t/ha) and straw yield (7.65 t/ha) were achieved with 100 per cent Vermiwash extract. No much published literature is available pertaining to utility of
Vermiwash, a liquid nutrient obtained in Vermicomposting in pest management. However, Giraddi et al. (2003) observed significantly lower leaf curl of chilli applied with vermiwash (soil drench 30 DAT), foliar spray 60 and 75 DAT) and higher yields vis-à-vis untreated crop.

Vermiwash is the watery extract of Vermicomposts, extracted in the presence of rich population of earthworms. It contains several enzyme, plant growth hormones, vitamins along with micro and macronutrients (Shield, Earl, 1982) which increases the resistance power of crops against various diseases and enhance the growth and productivity of crops (Anand et al., 1995; Pathak, 2004; Suthar et al., 2005; Umamaheswari et al., 2003; Yadav et al., 2005). Karuna et al., 1999 have studied the stimulatory effect of vermiwash on crinkle red variety of Andurium reanum. The treatment of Vermiwash of Vermicompost has been shown to reduced disease by necrotrophs as well as biotrophs (Fokkema, 1993; Al-Dahmani et al.,2003) and significantly decreases in soil born pathogens and various pests (Szczech et al., 1993; Nakasone et al., 1999; Orlikowski, 1999; Rodriguez et al., 2000). Generally, foliar spray of Vermiwash of Vermicomposting would offer a method of supplying nutrients to higher plants more rapidly than methods involving soil and root application (Marschner, 1995). In dry condition with a lack of water in the top soil and corresponding decline in nutrients available foliar application of nutrients is much more effective than soil application (Grundon, 1980). Foliar spray containing nutrients can also compensate for the decline in nutrients uptake by roots with the onset of the reproductive stage a result increase in number of fruit (Buckerfield, 1999). It was demonstrated that growth of ornamental plant after adding Vermiwash showed similar growth pattern as with addition of auxines, gibberellins and cytokinines through the soil (Grappelli et al., 1987; Tomati and Gallii, 1995).
The action of worms all over the layers of the soil results in the formation of castings and burrows. As water passes through these layers it gets mixed with earthworm excreta, mucus secretions and soil ingredients, the filtered water is collected as Vermiwash (Ismail, 1997a). Earthworms contribute several nutrients in the form of nitrogenous products either through their nephridial excretions or through their body secretions. As most of these components are either water-soluble or can be suspended in water, these are drained in the percolating water (Lalitha et al., 2000). The nutrients in Vermiwash are in a readily available form. The coelomic fluid, nitrogenous excreta and castings of earthworms synergize with each other enabling uptake of these available nutrients by plants in a profusely rapid manner Vermiwash, if collected properly is a clear and transparent pale yellow colored liquid (Ismail, 1997b; Karuna et al., 1999). Organic manures like Vermicompost and vermiwash, when added to soil, augment crop growth and yield Lalitha et al., (2000). Vermiwash has been proved very efficiently on vegetable plants like okra, tomato, beans, eggplants, lawns, golf courses and orchids (Ismail, 1997a). Ansari, (2002) demonstrated a significant improvement in soil qualities in plots treated with Vermiwash and Vermicompost. The yield of spinach and onion has been reported to be significantly higher in plots treated with Vermiwash. Growth and yield of *Abelmoschus esculentus* have shown significant results on using Vermiwash (Lalitha, 2000; Sosamma, 1998). Vermiwash also showed pronounced effect on the yield of *Arachis hypogaea*, both in their numbers and in their weights (Karuna et al., 1999; Lalitha, 2000) have shown that Vermiwash as foliar spray is effective in inducing vegetative growth like number of suckers, length and breadth of leaves and length of the petiole and also initiated early flowering in *Anthurium andreanum*. 
There is not much information on substrate or earthworm effect on nutrients in Vermiwash except a couple of reports. Ismail (1997a) studied the physio-chemical characteristics of vermiwash. It contained nitrogen (2.00 ppm) inorganic phosphate (50.90 ppm), potassium (69.00 ppm), alkalinity 70.00 ppm, chloride 110.00 ppm, sulphates 171.00 ppm and dissolved oxygen 1.14 ppm. Todkari (2001) studied the effect of Vermiwash prepared by two methods viz., (i) percolating water through the drillosphere of decomposing organic residues from a Vermiwash unit and (ii) dipping and agitating earthworms in luke worm water for 5 min and assessed the nutrient status of Vermiwash. First method recorded 34 ppm of N, 14 ppm of P, 91 ppm of K and pH of 8.2 and second method recorded 33 ppm of N, 72 ppm of P, 89 ppm of K and pH of 7.6. Different feed substrates and two species of earthworms were evaluated for their influence on quality of Vermiwash. Both macro and micro nutrients were assessed using *L. terrestris* and *E. fetida* (Swetha, et al., 2004)

Adams (1986) reported that Vermiwash application had a positive effect in bringing colour to tomato fruits, since nitrogen is the main component for synthesis of lycopene along with other micronutrients. Ismail (1995a) reported that Vermiwash was very effective for foliar application of nurseries, lawns and orchids. Buckerfield *et al.* (1999) reported that weekly applications of vermiwash improved plant growth and significantly increased the radish yield up to 20 per cent. Lozek and Gracova (1999) reported that vermisol application increased yield by 7.3 per cent and resulted in decrease in fruit nitrate content by 15 per cent. Among the various yield attributes studied, yield and number of seeds per fruit were significantly influenced by various levels of vermiwash, but not fruit size. Maximum number of seeds per fruit was produced under vermiwash 50% + full NPK applied plots. Highest fruit yield of 18.35 t/ha was obtained in the treatment receiving 50% concentration of Vermiwash and full
dose of NPK (Ranijasmin et al., 2003). Vermiwash is the watery extract of Vermicomposts, extracted in the presence of rich population of earthworms. It contains several enzyme, plant growth hormones, vitamins along with micro and macronutrients (Shield, Earl, 1982) which increases the resistance power of crops against various diseases and enhance the growth and productivity of crops (Anand et al., 1995; Umamaheswari et al., 2003; Yadav et al., 2005; Pathak, 2004; Suthar et al., 2005;).

2.4. FIELD STUDIES

Several reports deal with field involving the application. Kale et al., (1982) studied vermicompost in a rice paddy in India. Significant increase in the colonization of soil by microbes occurred in the experimental plots compare to the control plots without added vermicompost. Higher levels of total N in the experimental plots where vermicompost was added was attributed to higher counts of N fixing microbes. Lee(1985) mentions findings by Khan (1966) that the growth of maize on a loamy soil in Pakistan was enhanced by the addition of casts of Metaphire posthuma and that their effect was greater than was obtained with the addition of farmyard manure. In India, Reddy (1988) compared the growth of an ornamental shrub, Vinca rosea and Oryza sativa, in soils with or without the casts of Pheretima alexandri. Those V. rosea plants in cast grew better and produced flowers and fruits earlier than plants in soil alone. Rice growing for 4 months in pots with highest concentrations of added casts grew best, the whole plant lengths being 81.3 cm in soil mixed with casts compared to 62.8 cm in soil alone.

Lavelle et al., (1992) found a release of large amount of nutrients from the freshly deposited cast of earthworms compost as one of the principle ingredients of a
balanced growth medium. The stimulatory effects of earthworm body fluid on crinkle red variety of *Anthurium andreanum* Lind was studied by Karuna *et al.*, (1999).

Asiegbu and Oikeh (1995) found that NPK fertilizers were more efficient than the organic manures in supplying N, P and K at least in the short run, while the organic manure had an advantage in supply of other macro and micro nutrient elements not contained in NPK fertilizer. Noor *et al.*, (2002) suggested that addition of 10t/ha cowdung instead of 50% recommended dose of chemical fertilizer can able to produce satisfactory higher yield of cauliflower.

Casts produced from soil have increased nitrate and exchangeable calcium, magnesium, potassium and phosphorus than the original soil (Lunt and Jacobson, 1944). Other chemical and physical changes in earthworm casts compared to parent soil are given by Zhang and Schrader (1993) and changes in microbial population are covered by Satchell (1983). Edwards and Burrows (1988) also compared the nutrient contents of several organic wastes before and after being worked by earthworms all had increased nitrate, soluble P and exchangeable potassium, calcium and magnesium when worm worked. These authors found that emergence and growth of a range of seedlings in pots was frequently enhanced in these worm worked compared to unworked media. Fresh earthworm casts may contain high salt soluble concentrations, especially of Na+, sufficient to damage plants. Stark *et al.*, (1978) found that leaching cast with water reduced these salts to tolerable levels while still retaining most of the plant beneficial nutrients. Some physic-chemical changes imposed on sludge in conversion to vermicompost are given by Hatenstein and Hartenstein (1981). Chemical analyses by Buchanan *et al.*, (1988) of vermicompost from a municipal sewage sludge had 48 ppm N-nitrate, 11 ppm available P, 2442 ppm available K,
4354 ppm available Ca and 1858 available Mg. These values were comparable to a commercial compost mix although the compositions of the source sludge were not given.

Haimi and Huhta (1987) made comparison between the physical, chemical and biological nature of worm worked and wormless sewage sludge and between vermicompost and conventional compost. Whereas the sludge remained as compact clump, the worms produced a mass of castings. Physico-chemical analyses revealed only minor difference between worm worked and other products and these authors concluded that vermicompost was superior to ordinary compost with regards to its physical structure. Handdreck (1986) compared the porosities, salinities, nutrient contents, pH values and trace elements of several vermicomposts and potting mixes. Vermicompost varied widely in total nutrient content most had negligible amounts of soluble N-nitrates but had ample amounts of P and some had high concentrations of Zn and Cu. Plant (Matthiola incana) growth in potting mixes reflected the nutrient status of the vemicompost; in general plants were N deficient and some were further affected by toxic levels of trace elements although there was adequate P and trace elements.

A glasshouse trial by Springett and Syers (1979) in New Zealand grew ryegrass seedlings for 8 days in soil in pots with without added phosphorous (P) fertilizer and with or without casts of Aporrectodea clinginosa or Lumbricus rubellus, the soil and casts they collected from the same pasture site. Their results showed a consistent increase in plant growth in the presence of earthworm casts in addition that obtained from added fertilizer of between 5% to 50% in root length and 5% to 49% in shoot length relative to growth in the soils without casts. In Germany, Graff and
Makeschin (1980) grew ryegrass in soil in pots which had either contained and then had removed after 11 days specimens of *L. terrestris*, *A caliginosa* and *E. fetida* or had held no earthworms. The grass was harvested three times and total plant yields were compared. Dry matter and root production were significantly higher in the worm worked soils for each species than in the control soils. The increased yields, relative the controls for *L. terrestris*, *A. caliginosa* and *E. fetida* were: for shoot dry matter, 100%, 68% and 52% respectively and for total root production, 59%, 38% and 24% respectively. It is assumed that some contribution to these increased yields is attributed to the presence of casts but that earthworm burrows and exudates also had an influence.

As reported by Lee (1992), collier (1978) planted sunflower, tomatoes and corn in three treatments: (i) *E. fetida* casts derived from sewage sludge, (ii) in unprocessed sludge that was ground to a similar size to the casts and (iii) in untreated soil. All plants in (ii) treatment died within 2 month whereas they thrived in the other two treatments and plants in treatment (i). In contrast, Frederickson and Knight (1988) found that tomatoes grown in sludge worked by *E. fetida* showed a reduced rate of development after 109 days compared to tomatoes grown in a commercial compost. This they attributed to a high pH and excess nutrients in the worm worked material.

Many scientists reported the effect of shrimp wastes compost on barley (*Hordeum vulgare*) applied alone or with NPK, and he concluded that the main effect of compost on straw yield, numbers of tillers, plant height, and number of ears was more important than that of fertilizer. Compost was considered as a fertilizer by when composted green yard and landscape waste and peat were evaluated as to plant nutrient supply. Both were mixed with perlite and added to pots planted with
tomatoes and marigolds at a volume ratio of 1:1. Fertigation regimes of 0, 50, or 100 mg L$^{-1}$ of 15N-13P-12K). Compost was equivalent or superior to peat in plant growth and it contributed to crop macronutrient nutrition, but the highest fertigation rate was required for optimum growth. In experiments conducted by Chan et al. (1988) deciduous ornamental shrubs were grown in 33%, 67%, and 100% of three different sources of compost. Despite large variation in species growth response to sources and levels of compost, most grew equally well or better in the compost-amended regimes than in the control and were influenced little, or not at all, by initial or prevailing salt levels in the media. Shoot and root dry weight of some plants increased with increasing compost levels. The reverse relationship occurred (all sources) in shoot and root dry weight of privet and root dry weight of weigela and potentilla. Leaf nutrients (N, P, K, Ca, Mg, Fe, Mn, and Zn) tended to increase with increasing compost levels, but not all species showed this response with all nutrients. Regardless of compost source or level, all shrubs were of marketable quality when harvested, except privet, which showed leaf chlorosis in all compost-amended regimes (Nielson, 1965). Many observed that the efficiency of organic N uptake from organic fertilizers varies with the type of fertilizer, and organic N sources can cause short-term crop yield decreases. 10-30% of N was taken up when poultry manure or pea vine residues were added. Goswani, (2001) Bioconversion of municipal solid waste through vermicomposting..Live stocks excreta management through vermicomposting using an epigeic earthworm Eisenia fetida, Garg Yadav, (2005).