CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

“Nothing is more expensive than a start”.

-Nietzsche

The agricultural sector of India is facing the greatest challenges to produce the basic necessities of food, feed, fibre, fuel and raw material from minimum land per capita. While the use of mineral fertilizer is the easy and quick way of boosting the crop production, their cost and other constraints frequently deter farmers from using them in recommended quantities and in balanced proportions. As a consequence of this and other constraints, these seem to be no option but to fully exploit potential alternative source of plant nutrients. Complementary use of available renewable sources of plant biomass along with mineral fertilizers is of great importance for the maintenance of soil fertility, soil structure, soil bioactivity, soil ion exchange capacity and water holding capacity.

With the present growth rate in population, which is anticipated to cross billion mark by 2020 AD, for which 325 million tonnes food grain will be required (Kanwar, 1997). Since there is no scope for horizontal expansion of land area to achieve the targeted level of food grain production, the major emphasis has, therefore, been given on increasing the existing level of productivity of different crops through wider adoption of cost effective technologies, bringing more areas under high yielding varieties, hybrid and improved varieties of principal crop and increasing the cropping intensity with the help of irrigation facility along with use of different organic fertilizers.

The population of developing countries has been growing rapidly and demand for the food has always been able to keep up with population growth. The high yielding varieties were introduced during green
revolution era. During last four five decades cereal productions has been doubled and sufficient to feed ever rising population. The high yielding varieties need a higher dose of fertilizer and plant protection chemicals. The intensive use of production and protection chemicals led to many hazardous problems to environment. The ill effects of green revolution on ecosystem was observed during last decade like air, water and soil pollution. In recent years, more importance has been given to sustainable crop production. This is because of modern agriculture depended heavily on use of chemical fertilizers from last several years, which have many adverse effects on soil fertility. Therefore, the need of recent days is to popularize use of ecofriendly organic manures and biofertilizers.

Green revolution started in early sixties with an introduction of high yielding varieties, high analysis chemical fertilizers and pesticides to boost up agricultural production. Abundant use of chemical fertilizers without organic manures has resulted in increase of salinity, decrease in porosity and poor soil health (Singh and Shekhawat, 2000). Apart from this, the accumulation of free nitrates coming from the highly soluble nitrogenous fertilizers and pesticide residues have created water pollution leading to carcinogenic effect on human body and damage of important organs. Imbalance of soil reaction and nutrients supply had caused inbuilt plant resistance reduction against pests (Jadhav and Joshi, 1981).

Organic farming deals with the use of organic material for the cultivation e.g. organic manures, bio fertilizers, bio pesticides etc. In sustainable agriculture, use of chemicals is decreased upto certain level accompanied with the increased doses of organic material. The term eco-farming implies that the farming regions and individual farms must be treated as ecosystem and farming is based on relationship among the organisms and their environment in ecosystem. The recycling of organic wastes for increasing soil fertility has gained importance in recent years
due to high cost of chemical fertilizers. It improves humus content of soil, enhance microbiological activities and improves soil physical condition (Singh et al., 2000).

We prefer to follow the foot steps of sages whose principle was to be safe now, rather than to be sorry later. Nature warn human being that they must maintain to live in harmony with ‘Nature’. After all, it is said that nature had furnished us with natural means through which we may seek health, energy, vigour and vitality. Nature has also furnished us in greater or lesser degrees of intelligence with which to pursue our search of knowledge. If we use our intelligence nature smiles on us, if we do not use it, she stands by with infinite patience and compassion, wondering why her handwork should turn out to be so stupid.

The term biomass includes every organic matter, crop residues, wood and wood residue, leaf litter and animal manure. Since this type of biomass is a renewable source of organic carbon, there is no fear of its exhaustion by its continuous bioconversion into food, feed and fuel. Biomass is composed of mainly cellulose, hemi-cellulose and lignin and it also contains starch, protein and useful nutrients. The major part of biomass used is drawn from the land and provides the primary energy source as well as acts as foundation for all life forms. It is an important and major source of food, fodder for live stalk, timber for housing and furniture and many other plants needed for human existence, the world over. In addition, it contributes to daily fuel needs of major population in the developing world.

Integrated use of organic manures and fertilizers has been found to be promising not only in maintaining higher productivity but also for providing stability in crop production. The beneficial effects of organic manure are attributed to their positive role in improving the soil structure (Tondon, 1992).
Organic agriculture is natural in the Indian context. It is not just a philosophy but is also a mean to stabilize our food products through maintenance of soil health and avoiding the use of hazardous chemicals, fertilizers and pesticides which have been disturbing our eco-system on a large scale. Today, there is an urgent need to educate our farmers about this open treasure of nature i.e. leaf litter which we are wasting by burning carelessly at high rate.

Among different organic matter leaf litter is playing important role in rural life because leaves of most trees and garden plants contain twice as many minerals as manure. Since most trees of forests and garden plants are deep rooted and absorbs minerals from lower surface of the soil that is why leaves are most suitable for utilization and production of organic manure. At present, one of the most important threat for human and other living beings is the disposal of different organic wastes for manufacturing different composts.

Compost is one of the nature’s best mulches and soil amendments which encourages organisms whose activities helps to plants to grow strongly and healthy. It also provides nutrients and improves the drainage and water holding capacity. A compost pile keeps the organic matter handy for garden use and as an important added advantage, keeps the material from filling up over branched land fills. Compost is the end product of a complex feeding pattern involving hundreds of organisms, including bacteria, fungi, worms and insects.

Compost can be prepared from cattle shed waste, agricultural waste, domestic waste crop residues and other waste from wet and waste lands. It is necessary to remove the word ‘waste’ from our mental dictionary waste is wealth, a resourceful resource. Scientific and ecofriendly management promote civic health and hygiene. Agricultural
waste when looked upon as a resource, will open new horizons of economical and social opportunities.

When agricultural waste and leaf litter is used for composting, it will reduce the bulk and volume. Therefore, our motto is to reduce, reuse and recycle wastes, leaf litter and tree leaves for effective efficient and economical use of bio-resources for the preparation of compost which will give rugged, reliable, profitable and better solution for the maintenance of soil fertility and additional environment benefits that flow from compost use. So compost is an environmental tool, which expands the range of the potential applications. No organic substance can escape the onslaught of microbial activities in soil environment, which is powerful enough even to change the harmful characters of most organic waste material of agricultural, industrial and municipal origin.

Compost is a mixture of decayed organic material decomposed by micro-organisms in a warm, moist and aerobic environment releasing nutrients into readily available forms for plant use. The solid waste is biodegradable and can be used as a raw material for the preparation of vermicompost. The ecologically sound way for handling and disposal of agricultural waste and leaf litter along with tree leaves is converting them into a usable resource as compost through vermi-technology by using efficient species of earthworm in composting process.

The vermicompost is found to be rich in plant nutrients and an excellent growth promoter. It has significantly enhanced the growth of crop plants. Vermicompost will not only improve the soil fertility and water retention but also reduce the outlay on chemical fertilizers.

Attempts were made during present investigation to study the effect of different manures and leaf litter compost along with chemical
fertilizers to increase yield of crop per hectare and quality of crops by reducing high energy inputs and soil fertility.

The dissertation comprised with eleven chapters and discussed thoroughly.

Chapter I: - Introduction and review of literature.

It gives the brief introduction of subject along with review of literature.

Chapter II: - Topography and meteorological data of the region.

It covers the topography of the region and the data of daily temperature, humidity, rain fall and wind velocity during the experimentation.

Chapter III: - Information about the plants.

It gives detail information about the plants used during the investigation.

Chapter IV: - Composting by various method and its analysis

It gives information on preparation of leaf litter compost by various method and its chemical analysis.

Chapter V: - Effect of various types of gulmohar compost on fodder maize.

It has been devoted to study the effect of various types of gulmohar compost on fodder maize.

Chapter VI: - Impact of composts on rhizosphere mycoflora of maize.

In this chapter, the rhizosphere mycoflora was studied under the influence of various type of gulmohar composts.
Chapter VII: - Growth response of beet root to leaf litter compost.

It gives detailed information on growth response of beet root to the leaf litter compost.

Chapter VIII: - Effect of leaf litter compost on productivity of leafy vegetable Fenugreek.

It has been developed to study the effect of leaf litter compost on productivity of leafy vegetable Fenugreek.

Chapter IX: - Effect of leaf litter compost on leafy vegetable Spinach

It has been developed to study the effect of leaf litter compost on productivity of leafy vegetable spinach.

Chapter X: - Summary and conclusions

It consists of summary of the work undertaken along with the brief conclusions.

Chapter XI: - Bibliography.

It gives bibliography at the end, which covers the references cited in the text.

All the experimental results are presented in the form of tables, graphs and photographs. The data obtained has been statistically analyzed for obtaining useful conclusions.

**REVIEW OF LITERATURE**

This chapter deals with the review of research work carried out by various scientist on organic manure, vermicompost, leaf litter compost and its effect on soil, rhizosphere mycoflora and crop growth. An attempt was made to present the available literature under the following heads
1) Effect of organic manure on yield of crops.

Application of FYM with the inorganic fertilizers increased the dry matter yield as well as grain yield of maize crop (Kolodziej and Kostecka, 1994). Dhaincha as a green manure increased availability of potassium in soil and also yield of rice (Tiwari et al., 1980).

Green manuring with leguminous crop had positive influence on K availability of soils (Tiwari et al. 1980). The application of FYM, PMC and iron pyrite significantly increased the plant height, number of leaves, weight of cobs and dry matter yield of maize crop (Balasaraf, 1990).

Organic sources viz. vermicompost, FYM, sewage, sludge conjointly used with four levels of nitrogen viz. 0, 30, 60 and 90 Kg ha$^{-1}$ were studied for yield and quality of fodder Sorghum (Co.27). Results revealed that fresh as well as dry matter yield of crop was increased significantly by the application of vermicompost at 10 t ha$^{-1}$ with nitrogen 60 Kg ha$^{-1}$ (Malarvizhi and Faziull Khan, 1999). In acid sandy loam soil when (Ai saturation of 35 per cent) fertilized with either soluble, insoluble or partly soluble phosphorus sources amended with FYM, cowpea, dhaincha, paddy straw or lime and incubated for 75 days. The decomposition of organic residues was maximum between 30-45 days. After 45 days, available P in soil increased and increase was more in organic than lime amended soil (Mishra and Das, 2000).

Application of FYM increased dry matter and grain yield of maize than those from unmanured plots (Sen Gupta, 1966). It was observed that total dry matter yield of maize increased in the rate of manure from 0 to 6.13 Mg ha$^{-1}$ in the pot experiment (Hensler et al, 1970).

Application of FYM 17.4 Mg ha$^{-1}$ significantly increased the grain and stover yield of maize than the control (Biswas et al., 1971). Application of FYM alone or in combination with chemical fertilizers
significantly increased the dry matter, plant height, number of leaves, cob length, weight of cob, grain and stover yield of maize over control (Patil, 1974). Similarly, Application of FYM in combination with chemical fertilizers appeared to more effective in increasing grain and straw yield of wheat (Naphade and Bhoyer, 1975). Application of FYM alone or in combination with micronutrients significantly increased the grain and stover yield of maize as compared with control (Mann et al., 1978).

Comparative efficiency of FYM, poultry manure and rice straw on dry matter yield of maize was increased due to application of FYM (Singh et al., 1979).

In a green house experiment the dry matter yield of two successive crops of maize was increased by application of poultry litter of up to 144 Mg ha\(^{-1}\) in clay soil and upto 72 Mg ha\(^{-1}\) in sandy clay loam (Gianello et al., 1983). Application of FYM and biogas slurry increased the dry matter yield of maize (Bhatia and Ganguly (1984). Application of FYM @ 15 Mg ha\(^{-1}\) significantly increased grain and stover yield of maize (Krishnaswamy et al., 1984).

Application of graded levels of FYM, fertilizers and atrazine to a sandy loam soil before sowing maize markedly increased the fodder yields. (Patel et al., 1985) found that Application of FYM @ 17 Mg ha\(^{-1}\) with nitrogenous fertilizers significantly increased the dry matter yield of maize at tasseling and harvesting stages over control Singh and Brar (1985).

Application of FYM @ 20 Mg ha\(^{-1}\) with or without magnesium significantly increased plant height, number of leaves, weight of cobs, dry matter and grain yield of maize (Singh and Singh, 1985).
Pot trials with maize grown in a sandy loam soil was conducted by the application of 60 Kg N and FYM 5-10 mg ha\(^{-1}\) significantly increased the dry matter yield of maize (Baser et al., 1986).

The effect of FYM and cadmium on dry matter yield and nutrient uptake by maize was studied in the pot experiment. Then FYM significantly increased the dry matter yield of maize (Dahiya et al., 1987). Application of FYM @ 25 Mg ha\(^{-1}\) alone or in combination with zinc significantly increased the stover and grain yield of maize as compared with control (Devarajan et al., 1988). The application of FYM in combination with chemical fertilizers significantly increased the dry matter and grain yield of maize. Organic manures alone or in combination with fertilizers maintained the yield of maize (Lal and Mathur, 1988).

The highest significant grain and straw yield of wheat was obtained by application of FYM @ 10 Mg ha\(^{-1}\) (Mali et al., 1993). FYM @ 25 Mg ha\(^{-1}\) + press mud @ 20 Mg ha\(^{-1}\) was the best treatment for increasing yields of rice and wheat than rest of the treatments (More, 1994). FYM application had a significant positive effect on the grain yield of wheat over Control (Sharma and Gupta, 1994).

Total application of nitrogen @ 308 Kg ha\(^{-1}\) with 50 Kg P\(_2\)O\(_5\) ha\(^{-1}\) produced marked vigour, promoted branching and increased leaf area and yield than the nitrogen application alone (La Malfa, 1965). The application of nitrogen at various levels brought about a very large increase in plant height, number of branches, number of leaves and yield of tomato fruit. Besides, photosynthesis activity was also enhanced due to large leaf area (Baroah and Ahmed, 1962). The higher dose of nitrogen gives maximum number of flowers and fruits per plant of okra. As the level of nitrogen application increased from 22.5 Kg to 67.5 Kg ha\(^{-1}\), there was increase in yield (Chauhan and Gupta, 1962).
The effect of four levels of nitrogen (75, 100, 125 and 150 Kg ha$^{-1}$) and two levels of phosphorus (80 and 120 Kg P$_2$O$_5$ ha$^{-1}$) as soil application and combination with foliar sprays (75:25 and 50:50) on yield of tomato (var. pusa ruby). They were reported that 3/4$^{th}$ dose of fertilizer to soil and 1/4$^{th}$ dose of foliar spray was found to be best followed by soil application alone and combination (50:50). Phosphorus @ 120 Kg P$_2$O$_5$ ha$^{-1}$ yielded better than 80 Kg ha$^{-1}$ (Leela et al., 1973). The potassium application increased plant height and number of internodes of tomato. In cultivar CO-I more flowers and flushes per plant and maximum fruit weight and size were recorded in plant receiving 100 Kg K$_2$O ha$^{-1}$ (Anand and Muthukrishan, 1974). A maximum fruit yield of 26.89 tonnes by the application of 120 Kg N ha$^{-1}$ (Chakraborty et al., 1974).

The maximum plant height of tomato when 150 Kg ha$^{-1}$ nitrogen was applied. The higher dose of phosphorus and potassium also promoted the growth of plant and also produced more marketable yield than control (Randhawa et al., 1977). The effects of different levels of nitrogen, phosphorus and potassium on chilli (var. cv N.P. 46 A). They were reported that the highest level of 120 Kg ha$^{-1}$ nitrogen with 45 Kg P$_2$O$_5$ and K$_2$O ha$^{-1}$ resulted in earlier flowering, maximum number of fruits per plant, maximum size in terms of length, girth and the highest yield (Khan and Suryanarayana, 1977). The nitrogen fertilizers increased plant growth, no of flowers, fruit yield and improved the fruit quality of tomato. The phosphorus fertilization also increased plant growth and fruit yield (Gupta et al., 1978).

The effect of NPK fertilizer, manures and green manures on productivity of cabbage, carrot and beet root and on soil chemical properties, showed that the vegetable production increased by 54 per cent by combination of all (Borisov et al., 1990). Effect of different kinds of manures as sheep, sores and cow manures were applied @ 10, 20, 30 and
40 t ha\(^{-1}\) to tomato crop. The highest yield of 2.10 Kg plant\(^{-1}\) was obtained with sheep manures @ 30 t ha\(^{-1}\) (Hilman and Suwandi 1989). Nitrogen fertilization in chilli was statistically significant for plant height, plant spread, fruit length, fruit girth, fruit number and total fruit yield. Though phosphorus showed significant effect on increases in fruit number, weight and total yield (Ahmed and Tanki 1991). The fruit yield of tomato was the best with swine and poultry manurie applied @ 10 t ha\(^{-1}\) (49 and 47 t ha\(^{-1}\)) (Oaken and Aslegba 1993). The MSW application to tomato crop showed greater canopy volume and fruit weight, MSW increased growth and yield of tomato (Ozores and Schaffer 1994).

Organic manure has various advantages like increasing soil physical properties, water holding capacity, organic carbon content apart from supplying good quality of nutrients (Amanullah et al. 2006). Thus organic source played very important role in plant growth and development. Organic manures alone and with chemical fertilizers have further shown good results on crop growth, yield and economy in the fertilizer usage.

2) Effect of vermicompost on yield of crops.

The term vermicomposting means the use of earthworms for composting organic residues. Earthworms can consume practically all kinds of partially decomposed organic matter and they can eat their own body weight per day, e.g.1 Kg of worms can consume 1 Kg of residues every day. The excreta (castings) of worms are rich in nitrate, available forms of P, K, Ca and Mg. The passage of soil through earthworms promotes the growth of bacteria and actinomycetes. The actinomycetes thrive in presence of worms and their content in worm casts is more than six times that in the original soil. So that vermicompost is one of the important growth promoter to crop growth.
Modern society, with its high population densities, each member trying to attain the so-called high standard of living. Sophisticated industries and intensive methods of agriculture produce ever-increasing quantities of solid wastes, which is causing environmental pollution. A substantial portion of this solid waste is non-toxic and organic in nature. India generates annually 25 MT of municipal solid wastes, 320 MT of agricultural residues, 210 MT of cattle manure, 3.3 MT of poultry manure and so on (Mitra, 1997). The ecologically sound way for handling and disposal of the wastes is converting it to usable resource as compost through vermitechnology or earthworm technology. Earthworms are important contributors to the fertility of the agricultural soil (Edwards and Lofty, 1977).

Vermicomposting is an appropriate technique for the disposal of non-toxic solid and liquid organic wastes by earthworms. This technology is applicable to the rural as well as the urban society. It helps in cost-effective and efficient recycling of animal wastes (poultry, horse, cattle dung and piggery excreta), agricultural residues and industrial wastes using low energy (Jambhekar, 1992). Vermicomposting increases the yield, pest resistance and improves the quality of produce. It is the application of earthworms in the manufacture of useful product (vermicompost) from organic wastes, thereby monitoring and maintaining the environmental quality.

Application of earthworm compost to wheat increases the plant height, number of tillers, number of leaves, early earheading, earhead length and dry matter per plant than control (Nijhawan and Kanwar, 1952). Addition of 5 cart loads of FYM with nitrogenous fertilizers in medium black soil was found to be very effective in increasing the grain yield and dry matter accumulation of maize (Naik and Ballal, 1962).
The effect of application of vermicompost and FYM on release of nutrients and their uptake and yield by maize in different textured soil. Their studies revealed that application of FYM and vermicompost resulted into significant increase in availability of N, P and K in clayey soil than in clay loam and sandy soils. Application of vermicompost significantly improved the physical properties of all the soil types under study. Application of FYM and vermicompost resulted into significant increase in electrical conductivity, organic carbon, available N, P and K contents of all the soil types. Whereas, pH of all soil significantly decreased (Patil, 1993). Vermicompost application showed the significant improvement in chemical properties of soil. Application of vermicompost at 5 t ha\(^{-1}\) significantly increased total N, available N, P and K and organic carbon, porosity of soil and decreased bulk density over control (Hapse \textit{et al.}, 1993). The effect of compost and vermicompost on soil properties and biomass production in maize showed that, the vermicompost had narrower C: N ratio as compared to compost. Vermicompost was found superior over compost as it releases available nutrients in soil since it contain higher amount of N, P, K, Mg, S and micronutrients as compared to compost (Rao and Dakhore, 1993).

In a pot culture experiment the dry matter production at silking stage, grain and stover yields of maize at harvest were significantly higher due to the application of vermicompost (Jatgar, 1994). FYM, spent slurry 3:1 and 5:1 composts and spent wash 6:1 compost resulted in significantly higher dry matter yield of maize than control (Patil and Shinde, 1995).

Vermicompost refers to a high grade organic manure which is rich in plant nutrients and an excellent growth promoter for plants. It contains 9.15 - 17.98 % organic carbon, 1.75 - 2.50 % nitrogen, 1.55 - 2.25 % phosphorus, 1.25 - 2.0 % potassium, calcium, magnesium and sulphate
3 - 5 times better than FYM (Singh and Singh, 2004). Also it is rich in several microfloras like *Azospirillium, Actinomycetes* and *Phosphobacillus* which multiply faster through digestive systems of earthworms. Vermicompost helps in multiplication of earthworms, which reduces the incidence of nematodes. It has significantly enhanced the growth of plants. Vermicompost gives higher yield of crops, which varies from 20.87 - 78.58 %. It influences the physico-chemical as well as the biological properties of soil which in turn improves its fertility. Vermicompost does not only improve the soil fertility and water retention but also reduce the outlay of chemical fertilizer (Reddy, 1999). The utilization of vermicompost results in several benefits to farmer, industries, environment and overall national economy.

Worm compost increased yields of potato, tomato, cabbage and silage maize. Effects on respiratory and photosynthetic activity of tomato, the activity of ascorbate oxidase, diphenol oxidase (catechol oxidase) and catalase in cabbage and the chemical composition of potato, tomato and maize are reported (Gorodni et al., 1994).

In a field experiment, groundnut (var. cv. Kokan gaurav) was given 25 kg N + 50 kg P₂O₅ ha⁻¹ alone or with 1.5 t ha⁻¹ vermicompost or 5 t ha⁻¹ FYM + 0.05 or 1 kg ha⁻¹ boron. Pod yield was significantly increased by the application of vermicompost and FYM (Dhane et al., 1996).

Vermicomposts were produced by processing activated sludges from the purification plants of municipal sewage alone or with sawdust or meat processing factory waste. These vermicomposts or farmyard manures were applied to crops of tomato cultivars, Jowar (dwarf) and Zorza (tall) at rates equivalent to 15 g N m⁻². Yields of both cultivars were the highest (1.93 and 3.15 kg plant⁻¹) with the vermicompost containing sawdust (Kalembasa, 1996).
Compost and vermicompost produced from the organic fraction of municipal solid wastes were studied as components of potting media for tomato seedlings production. Both compost and vermicompost increased seed germination and plant growth (Alves and Passoni, 1997).

In a pot experiment, rice (var. cv. RTN-1) was given different combinations of urea fertilizer with farmyard manure and vermicompost. Dry matter production and uptake of major nutrient elements (N, P, K and Mg) was highest from 75 kg N ha\(^{-1}\) as urea + 25 kg N ha\(^{-1}\) as vermicompost (Jadhav et al., 1997).

The number of non-wrapper leaves was the highest in the control plots. The polar and equatorial diameters of cabbage heads and net weight were also significantly influenced by applying organic manures (Mahendran and Kumar, 1997).

Vermicompost produced from organic wastes was tested in pot experiments for its ability to replace a proportion of the urea fertilizer applied to rice. Compared with N fertilizer alone, supplying one-third or one-quarter of N as vermicompost increased plant height, grain yield and yield components of rice (Rani and Srivastava, 1997).

The treatment of full dose NPK fertilizers (300:120:120 kg ha\(^{-1}\)) plus vermicompost of 6000 kg ha\(^{-1}\) and half dose of farmyard manure of 10 cart lodes ha\(^{-1}\) was significantly better than the untreated control for increasing the maximum number of branches, height, number of leaves per plant and leaf yield per plant (Murarkar et al., 1998).

The utility of urban solid waste either freshly composted or vermicomposted for improvement of plant growth in soil B-horizon was investigated. Growth and mineral nutrition of cucumber and red clover plants were studied using different mixtures of soil and comports as plant substrates. Results showed that amendment of soil with 10 or 50 %
vermicompost significantly increased dry matter yields of red clover and cucumber plants compared to treatments where soil was the only substrate. Addition of vermicompost also increased Olsen-P and other mineral elements in soil and shoot P, Ca, Mg, Cu, Mn and Zn concentrations (Sainz et al., 1998).

Different rates and combinations of NPK fertilizers, vermicompost and farmyard manure were applied to forage oats (var. cv. Kent) at several sites in India (Rabi) during 1996 - 1997. Mean fresh and dry forage yield was highest with 75% NPK + 10 t vermicompost/ha (Singh et al., 1998).

Maximum dry matter production of mungbean and N and P uptake were given by compost prepared from a 3:7 mixture of cattle manure and rice straw inoculated with earthworms, although the benefit of worms in this compost was not statistically significant (Bansal et al., 1999).

In a field experiment conducted during 1993 - 1995 in Andhra Pradesh, maize cv. DHM-105 was given 25, 50, 75 or 100% of recommended N as a combination of vermicompost (VC), poultry manure (PM), biogas slurry (BGS) or farmyard manure (FYM) + inorganic N and a basal dressing of P and K. Soybean cv. Hardee, grown on the same plots after maize in the rabi season received an application of 40:50:40 kg NPK ha⁻¹. Micronutrient availability was the highest in treatments with VC closely followed by PM, BGS and FYM (Reddy and Reddy, 1999).

The effect of biodigested slurry (BDS) and vermicompost (VMC) on growth and yield of cowpea was investigated in a pot experiment. Fresh weight, dry weight and yield of cowpeas were the highest in soil amended with vermicompost (Karmegam and Daniel, 2000).

Studies at Hisar (Haryana), in winter 1997 - 1998 and 1998 - 1999 examined the integrated use of organic manures with NPK fertilizers for
wheat production. Among organic manures, 15 t vermicompost/ha\(^{-1}\) gave the best results and 2.5 t pressmud/ha (filter cake) the worst (Nehra et al., 2000).

The growth of tomato seedlings in the potting mixtures containing 100% pig manure vermicompost was reduced, possibly as a result of high soluble salt concentrations in the vermicompost and poorer porosity and aeration. The growth of tomato seedlings was greatest after substitution of Metro-Mix 360 with 25 and 50% pig manure vermicompost, with more growth occurring in combinations of pig manure vermicompost treated regularly with a liquid fertilizer solution than in those with no fertilizer applied (Atiyeh et al., 2001).

Investigations were made to recycle agricultural and agro-industrial wastes for the production of vermicompost using earthworms (Eudrilus eugeniae). Its response was studied in a rice-legume cropping sequence. The studies indicated that integrated nutrition comprising vermicompost, fertilizers N and biofertilizers could be applied to rice-legume cropping system to achieve higher yields and to sustain soil health (Jeyabal and Kuppuswamy, 2001).

The effects of earthworm processed pig manure (vermicompost) on the growth and productivity of French marigold (Tagetes patula) plants evaluated under glasshouse conditions. Marigolds were germinated and grown in a standard commercial greenhouse container medium (Metro-Mix 360), substituted with 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100% (by volume) pig manure vermicompost. The control consisted of Metro-Mix 360 alone without vermicompost. The greatest vegetative growth resulted from substitution of Metro-Mix 360 with 30 and 40% pig manure vermicompost and the lowest growth was in the potting mixtures containing 90 and 100% vermicompost (Atiyeh et al., 2002).
Some effects of humic acids formed during the breakdown of organic wastes by earthworms on plant growth were evaluated. The incorporation of both types of vermicompost (pig manure and pig manure + food wastes) derived humic acids, into either type of soil less plant growth media, increased the growth of tomato and cucumber plants significantly in terms of plant heights, leaf areas, shoot and root dry weights (Atiyeh et al., 2002).

Study was carried out in okra and brinjal with seven treatments, each having hundred adult earthworms in one unit and it was found that C:N ratio increases with time of treatment and was found maximum in case of cowdung because this treatment contain least amount of nitrogen during composting process. The results show that yield of okra and brinjal is increased more with vermicomposts as compared to other treatments (Gupta et al., 2002).

The effect of vermicompost (VC), farmyard manure (FYM) and chemical fertilizers (CF) was studied singly and in combinations on the growth and yield of wheat (Triticum aestivum L. var. HD- 2643). Applications of VC in all treatments increased the total biomass production and yield of wheat plants over its control. Use of VC in combination with FYM is recommended for higher wheat production. Application of VC in crop production resulted double benefits by enhancing crop yield reduced disposal problem of organic waste (Agrawal et al., 2003).

Field experiment was carried out to evaluate the relative efficacy of organic manures in improving the productivity and pest tolerance of rice growing in a lateritic soil. The effects of three commercial manures: processed city waste (PCW), vermicompost (VC) and oil seed cake pellets (OCP) were assessed in comparison to farmyard manure (FYM) and inorganic fertilizer all at the same level of total N applied. Among the
organic manures tested, FYM produced the maximum straw and grain yields and also tolerance of rice plants to attack by pathogens and pests (Bhadoria et al., 2003).

The cellulosic substances, bagasse, vegetable waste and leaf litter, were mixed with cowdung and treated with *Eudrilus eugeniae*, *Eisenia fetida*, *Perionyx excavatus* and *Megascolex*. The highest yield of vermicastings was obtained when the compost was treated with *P. excavatus*; the same compost exhibited higher concentration of NPK and other plant nutrients. The seedlings of *Albizia lebbeck*, *Azadirachta indica*, *Pterocarpus santalinus* and *Tamarindus indica* exhibited significantly high growth and biomass in vermicompost obtained from *P. excavatus* compared to control and so used as potting medium (Mastan et al., 2003).

Growth of *Amaranthus dubius* was studied in the vermicomposted sludge of wastewater treatment units of seafood processing plants. Among the treatments, the best growth parameters like plant height (28.1 cm), number of leaves (27) and leaf length (3.9 cm) were observed in vermicomposted sludge. All the growth parameters showed significant positive correlation with duration of experiment. The vermicomposted sludge positively promoted the growth of *A. dubius* (Kumar, 2004).

In transplanted kharif rice, combined application of 40 % recommended dose of N as vermicompost + 60 % recommended dose of N as urea produced the highest level of growth attributes, yield attributes and significantly higher grain yield of rice (52.7 q ha\(^{-1}\)) when compared with 100 % recommended dose of N entirely from urea (Barik et al., 2004). In potato also, a significant response was obtained from all the treatments towards growth attributes, yield attributes and tuber yield. Highest plant height, leaf area index, dry matter, number of tubers plant\(^{-1}\), tuber weight plant\(^{-1}\) and tuber yield were recorded in the treatment having
60 % recommended N as vermicompost + 40 % recommended dose of N as urea rather than in the treatment using 100 % recommended dose of N as urea or farmers practice or other combinations of vermicompost and urea (Das et al., 2004).

Vermicomposting of neem (Azadirachta indica A. Juss) was accomplished in highrate reactors operated at the earthworm (Eudrilus eugeniae) densities of 62.5 and 75 animals per litre of reactor volume. Contrary to the fears that neem, a powerful nematicide might not be palatable to the annelids, the earthworms fed voraciously on the neem compost, converting upto 7 % of the feed into vermicompost per day. Another set of experiments on the growth, flowering, and fruiting of brinjal plants (Solanum melongena) with and without fertilization with vermicompost, revealed that the vermicompost had a significantly beneficial impact (Gajalakshmi and Abbasi, 2004).

Significant increase was observed in plant height, number of branches per plant, leaf area and yield due to various fertility treatments. The treatment T₇ was found best for growth analysis, yield and economics than the rest of treatments. The net returns were also highest in treatment T₇ (50 per cent N through urea + 50 per cent N through poultry manure) followed by treatment T₁₁ (50 per cent N through urea + 50 per cent N through vermicompost) and minimum returns were in unfertilized control (Yadav et al., 2004).

Commercially processed vermicomposts produced from food wastes, paper wastes and cattle manure were applied to 8.25 m⁻² field plots at rates of 10 and 20 t ha⁻¹ in 1999 and 5 and 10 t ha⁻¹ in 2000 to evaluate their effects on the growth and yields of peppers (Capsicum annuum var. King Arthur). The vermicompost applications increased the growth and yield of peppers significantly including increased leaf area,
plant shoot biomass, marketable fruit weights and decreased yields of non-marketable fruit (Arancon et al., 2005).

Effect of NPK alone and in combination with different organic manures (farmyard manure, composted coir pith, vermicompost and neem cake) on germination percentage, vigor index, chlorophyll content and yield parameters of bhendi (Abelmoschus esculentus var. Arca anamica) was studied through a pot culture experiment. Of the six treatments, NPK + neem cake treatment showed good germination percentage on 7, 14, 21 and 28 (77.7, 83.0, 88.0 and 95.0) days after sowing. Vigor index was more (6618) in NPK + FYM on 60 DAS. Chlorophyll contents were high in NPK alone (1.40, 1.33 and 2.66 mg/g) on 30 DAS. Single fruit weight (9.4 g), fruit length (12.5 cm) and fruit diameter (5.5 cm) were more in NPK treatment (Shanthi and Vijayakumari, 2005).

The application of 120 kg N ha$^{-1}$ to maize, ¼ through different organic manures (FYM, compost, vermicompost) + ¾ through urea + BNF significantly increased the leaf area and dry matter production resulting in significant improvement in grain and dry fodder yield than application of 40 and 80 kg N ha$^{-1}$, ¼ through different organic sources + ¾ through urea + BNF (Chaudhari et al., 2006).

A field experiment was conducted at Tamilnadu Agricultural University, Coimbatore during 2002 - 2003 to identify the optimum quantity of vermicompost for maize under different levels of fertilization. The results revealed that optimum dose of vermicompost application to maize in addition to recommended fertilizer was 5.0 t ha$^{-1}$ as it recorded similar growth and yield (5560 kg ha$^{-1}$) as that of vermicompost application @ 7.5 t ha$^{-1}$ (5725 kg ha$^{-1}$) (Lourduraj, 2006).

Field experiments were carried out at the Indian Agricultural Research Institute, New Delhi, India. The principal findings revealed that application of 3 t vermicompost ha$^{-1}$ to chickpea improved dry matter
accumulation, grain yield and grain protein content in chickpea, soil N and P and bacterial count, dry fodder yield of succeeding maize, total N and P uptake by the cropping system over no vermicompost (Jat, 2006).

3) Effect of leaf litter compost on yield of crops.

In terrestrial ecosystems, the litter decomposition is an important functional process, governing the cycling of nutrients (Swift et al., 1979) and thereby regulating the vegetational productivity. Moreover, litter is the main component of detritus food chain, which enters the decomposition subsystem and is broken down by an array of decomposing organisms. Freshly fallen leaves pass through several stages from surface litter to well decomposed humus partly mixed with mineral soil which contains 50 to 80 % of the nutrients, releases back into the soil.

Incorporation of leaves of white popinac or subaboooul (*Leucaena lastisiliqua* L.), (*L. leucocephala* Lam.) and madre tree (*Gliricidia sepium* Jacq.) in the soil led to higher dry matter production, leaf area, N uptake and yield of Sorghum compared with the equivalent amount of N as urea. Grain yield of Sorghum increased by 94, 181 and 229 % respectively compared with the control. However, the lowest dry matter, grain yield and yield components were recorded on application on pearl millet (Subba Reddy, 1991).

Studies on relative performance of NADEP and Bangalore system of composting in relation to time of maturity and quality compost showed that, although the time required to prepare compost by NADEP as well as Bangalore method is almost same, quality of final compost prepared in NADEP pit was found to be better a compared to Bangalore pit as revealed by narrow C:N ratio and high cation exchange capacity value (Dad, 1992).

Garden waste (leaf litter) was composted over a number of weeks in a windrow and fumed regularly to maintain aerobic conditions. The
physical parameters of the composting material were measured and at 1, 2, 3 and 4 weeks of processing, samples were removed and incorporated into growth media. Ryegrass was grown over 1 year and harvested regularly for measurement of dry matter and N content. It was shown that the younger composts (1 and 2 week processing) gave higher dry matter and N yields (Keeling et al., 1995).

Pine (*Pine roxburghii*) litter was pre-decomposed for 75 days with 0.5 % suspension of urea, DAP (di-ammonium phosphate), lime, molasses, urea + lime + molasses, biogas slurry and daily urine as separate treatments. A significant increase in yield of ragi (Finger millet, *Eleusine coracana*) was recorded with all the treated pine litter material. The overall best effect showed by urea treated litter (Pal, 1995).

The annual application of 1.5 kg dry matter ha\(^{-1}\) of leaf litter differed in the breakdown rate from a legume crop and three kinds of trees for five seasons resulted in an increase in rice grain yield of 23 - 48 % above the no leaf litter control (Whitbread et al., 1999).

Two piles were prepared with one pile (pile A) just constituted of pig manured sawdust at a mixing ratio 3:2 while other one (pile B) was of pig manure : saw dust : leaves in 3:1:1 ratio. This demonstrated that the addition of leaves enhanced the humification process and shortened the time required for maturation and stabilization of pig manure composting. Therefore, it was recommended to co-compost pig manure with leaves to provide a means to reutilize this waste and at the same time to reduce the dependence on sawdust as a bulking agent (Huang et al., 2001).

A field experiment was conducted to study the effects of ramial chipped wood (RCW) and litter compost (LC) of *Casuarina equisetifolia* on tomato growth and soil properties. The RCW and LC was applied to a sandy soil at three different levels i.e. 10, 20 and 40 t ha\(^{-1}\) and compared to reference control and recommended fertilizer mixture. Soil and plant
samples were taken at 45 days of tomato growth and at harvest time for analysis. Residual effects of the material were also evaluated through the establishment of a second tomato crop on the same plots. Application of RCW depressed tomato growth and yield during the first cropping and improved during the second cropping. Incorporation of LC improved tomato growth and yield during both the cropings and also improved soil levels and tomato uptake (Soumare et al., 2002).

Two field experiments were carried out to evaluate the effect of composts prepared from different organic wastes on two vegetable crops. Poultry litter with each of the following organic wastes, maize residues, leaf litter, urban waste, weed biomass and soybean residue were composted using three methods of composting—passively aerated composting technique in a pile (PACT-1), passively aerated composting technique in a plastic pot (PACT-2) and windrow (Wdr.). Tomato (Lycopersicon esculentum Mill.) and Amaranthus (A. cruentus) were planted as test crops. The results indicated that the effectiveness of the composts on Amaranthus productivity could be rated in the ascending order of soybean, leaf litter, weed, maize and urban waste composts. For tomato, the composts from maize and soybean residues were more effective than other composts. Mostly, the effectiveness of the composts on the productivity of the vegetable crops varied according to methods of composting and followed in the ascending order of Wdr., PACT-1 and PACT-2 (Adediran et al., 2003).

The addition of leaf litter improved growth of seedlings using dipterocarp species. Three dipterocarp species with contrasting ecologies (Parashorea tomentella, Hopea nervosa and Dryobalanops lanceolata) were grown in a nursery in forest soil with or without the addition of litter. Litter addition improved the growth of all the three species (Brearley et al., 2003).
Three kinds of composts were assessed for their capacity to support tomato growth. Agricultural compost (poultry manure and cranberry press cake), sewage compost (biosolids and woodchips) and yard waste (leaves) were evaluated alone and in combination with peat moss and soil. Tomato (*Lycopersicon esculentum* Mill.) plants were grown until fruit initiation in the media. Based on vegetative production, the agricultural compost gave the highest growth and the yard waste gave the least growth (Hu and Baker, 2004).

Four organic amendments: leaf compost (LC), vegetable compost (VC), poultry manure (PM) and sewage sludge (SSL) applied as four doses (40, 80, 100 and 120 t ha\(^{-1}\)) were evaluated for their effect on the herbage yield and essential oil content on three varieties of Java citronella, *Cymbopogon winterianus* Jowitt. (Manjusha, Mandakini, and Bio-13). PM applied at 100 t ha\(^{-1}\) followed by SSL increased the herbage and dry matter yield significantly (Tanu *et al.*, 2004).

Experiments were performed on Cheshire fine sandy loam. Unscreened leaf compost was applied @ 50 T/A (one inch on the surface), 25 T/A and 10 T/A. Compost was rotated into the soil to a depth of six inches. Compost was produced in a passive pile turned four or five times yearly for two years. In all three years of compost applications, virtually no difference was found in soil nutrients between the compost treatments and the control. However, differences were found in organic matter percentage and pH between the treatments in all three years (Maynard, 2005).

Decomposition of the litter as well as comparison between two methods- bag and non-bag were investigated under teak plantation of age 30 years by Rajagopal *et al.* (2005). The freshly fallen leaf litter of *Tectona grandis* was collected. In bag method, 25 g samples were kept in nylon bags of size 30 cm x 30 cm and in non-bag method, same amount
was placed on the forest floor of the sample plot in direct contact with soil. The periodic retrieval of samples from both experiments was done at an interval of 30 days. The observations were continued for a period of one year. A steady decline in decomposition of the litter occurred in both cases, the rate of decomposition was faster in the non-bag method than that of bag method.

Comparison between windrow and pit composting methods of poultry wastes, leaves and garbage of municipal solid waste in the city of Damghan, Iran. Waste proportioning was done based on C: N ratio (25:1) and moisture content (55 %). Mixed wastes were located in windrow and pit with natural aeration tunnel. Finally, it was indicated that pit method was better for maintaining moisture and nutrient contents (Yaghmaeian et al., 2005).

The efficiency of pill millipede (*Arthrosphaera magna*) compost on growth and dry matter yield of black gram (*Phaseolus mungo*) and finger millet (*Eleusine coracana*) in comparison with farmyard manure (FYM). Five combinations of composts employed: farmyard manure (FYM), areca compost (pill millipede compost produced from 1:1 w/w areca leaf litter and areca nut husk), mixed litter compost (pill millipede compost produced from 1:1:1:1 w/w areca, acacia, cocoa and cashew leaf litter), FYM + areca compost (1:1 w/w) and FYM + mixed litter compost (1:1 w/w). The study revealed that pill millipede compost has a definite positive effect on plant growth as well as dry matter yield with or without FYM (Ashwini and Sridhar, 2006 a).

Pill millipedes (*A. magna*) to generate compost from plantation crop residues on a pilot-scale. Three combinations of residues (w/w), viz. areca leaf litter and areca nut husk (1:1), cocoa leaf litter and cocoa pod husk (1:1) and mixed leaf litter (areca, acacia, cocoa and cashew) (1:1:1:1) in cement tanks were offered to millipedes with adequate
moisture up to two months for composting. Total nitrogen, phosphate and C: N ratio significantly differed between control and treated residues (Ashwini and Sridhar, 2006 b).

The effect of single leaf litter (*Cunninghamia lanceolata* (Lamb.) Hook) and mixed leaf litters (*C. lanceolata*, *Liquidamba formosana* Hance and *Alnus cremastogyne* Burk) on soil chemical properties and soil microbial properties during 2 years decomposition was investigated. The results demonstrated that the mixed leaf litter could improve forest soil quality and soil microbial properties (Hu *et al.*, 2006).

In present scenario of nutrient management through application of organic source like compost, FYM and green manuring coupled conjunctive use in organic fertilizer has been advocated for integrated nutrient supply and management for sustainable crop production (Madhavi *et al.*, 1995). On combine effect of FYM, poultry manure, vermicompost and biofertilizer on growth and yield of maize was studied and it was observed significant increase in plant height, leaf area index (LAI), grain and stover yield of maize due to the application of organic manure (Pathan *et al.*, 2007).

The use of organic and inorganic fertilizers is beneficial for the better yield and quality of baby corn (Bhondave *et al.*, 2007; Thakur, 1997; Pathak *et al.*, 2002; Reddy *et al.*, 1991).

The efficiency of leaf litter compost geared up by aerobic (NADEP) and anaerobic (Banglore) pit method was observed on yield and nutrient contents of spinach. The leaf litter compost improved the yield and the nutrient uptake of spinach (Chamle and Jadhav, 2007).

The yield and nutritive values of fenugreek improved due to the application of NADEP as well as the compost prepared along with dung (Sarwade and Jadhav, 2008).
4) Effect of rhizosphere mycoflora on crops.

The term rhizosphere, which is derived from the Greek word ‘rhiza’, meaning root and ‘sphere’, meaning field of influence. He defined the rhizosphere as the zone of soil immediately adjacent to legume roots that supports high levels of bacterial activity (Hiltner, 1904). However, more recently the term has been broadened to include both the volume of soil influenced by the root and the root tissues colonized by micro-organisms (Pinton et al., 2001). The rhizosphere is a very dynamic environment, which harbors variety of micro-organisms with different types of metabolic and adaptive responses. Micro-organisms in the rhizosphere react to the many metabolites released by plant roots. The micro-organisms and their products, also interact with plant roots in positive, negative and neutral ways. Such interactions can influence plant growth and development, change nutrient dynamics and alter a plant’s susceptibility to disease and abiotic stress. Rhizosphere micro-organisms have direct and indirect impacts on plant nutrient uptake, morphology and development of the roots and number of physiological and developmental processes of plants.

Study done on the micro flora of roots of a variety of crops pointed out the differences in microflora between 'inner rhizosphere' (root surface) and outer rhizosphere' (soil adhering to the roots) and soil distant from the roots (control). She found that, the bacterial counts were higher on the root surface. The number increased during the period of growth and declined during the ripening period and at harvest. She also noted that, the increase in the total number was least in the case of grains and the highest with legumes (Graf, 1930). An increase in the total number of micro-organisms in the rhizosphere of wheat, maize, sunflower and soyabean. Similarly soyabean had greatest number and the wheat the least (Krassilkmkov et al., 1936). The rhizosphere population in manured soils
were generally greater than in unmanured soils though the effect of manuring was much more pronounced in soil away from the root (Clerk, 1939). The rhizosphere microbial population of wheat, oat, alfalfa and peas, and found that, the bacteria and actinomycetes were from 7 to 71 times greater in number in the rhizosphere as in the soil. He observed an increased rhizosphere effect with advancing age of the seedlings (Timonin, 1940).

The microbial population in the rhizosphere of wheat, oat, alfa-alfa and peas and found abundance of bacteria (Timonin, 1940). The rhizosphere microflora in some of the important crop plants like pigeon pea, cluster bean, cotton, Sorghum, Sesamum, French bean and sunhemp and claimed that the microbial population was more in rhizosphere than in non rhizosphere (Agnihothrudu, 1953).

The quantitative changes in the bacteria of the rhizosphere of wheat were primarily dependent on the physiological activity of the plant, and not on the type of soil or the agronomical methods applied (Pantos, 1958). The bacterial population of rhizosphere found to be increased with the development of cotton plants to above 4 months by which time the plants attained maximum vegetative development. During further development of the plant after flowering and boll stage, the bacterial population declined (Iyer, 1961).

The rhizosphere fungal count increased for seven months. Thereafter it decreased, especially during flowering in case of Celotropsis gigentea (Agate and Bhat, 1964).

The rhizosphere and rhizoplane microflora of three potato varieties increased with age of the plant and was maximum in 6-8 weeks old plants (Sudha Mall, 1979). The rhizosphere microflora of high yielding of Pennisetum typhoides and concluded that micro-organisms showed
positive rhizospheric effect and increase in population with age of the plant (Vaidhehi, 1979).

Rhizosphere micro flora of groundnut and stated it is different at soil type. Rhizosphere harbors the highest number in organic clay loam soil and the lowest in the lateritic clay loam soil (Baruoh and Baruoh, 1972). The analysis of phyllosphere micro flora with resistant cultivar, and concluded that there was a significantly higher population of fungi, gram positive and gram negative bacteria, than to susceptible cultivar(Promod Chandrakumar, 1981). The diversity and abundance of fungal species in the rooting zone of Jowar were greater in the rhizosphere than in non-rhizosphere (Bohra and Panwar, 1981).

Rhizosphere fungi were noticed to be gradually increased with increase in growth of the plant and it was maximum at the time of maximum vegetative growth of the plant (Starkey, 1929).

In case of Sorghum bicolar that maximum growth of fungi was at flowering stage while actinomycetes and bacteria at fruiting stage while Azatobacter at both vegetative and fruiting stages (Stephan et al. 1985). In case of a pulse crop that among rhizosphere microflora the bacterial population was the highest than Rhizobium, actinomycetes and fungi (Bandyopadhyay, 1988). The rhizosphere microflora of pigeonpea was influenced by crop age (Reddy and Rao, 1991).

Amarjit Singh and Khara, 1997 studied the rhizosphere mycoflora of cotton and concluded that the total number of rhizosphere fungi increased with increasing plant age up to 90 days after which it decreased. Similarly, Parkinson and Thomas (1969) recorded Fusarium spp., Mucor spp., Humicolac grisea, Vericosporium elodea were more abundant fungi in Cluster bean in rhizosphere than non rhizosphere.
Soil is the most fertile habitat for the survival, perpetuation and multiplication of micro-organisms. The fertility of soil depends not only on its chemical composition but also on the qualitative and quantitative nature of micro-organisms inhabiting it and the behavior of microbes in soil is mainly influenced by the soil conditions, environmental factors as well as nutrient status of the soil (Dwivedi, 1980). The microorganisms inhabiting soil can be classified into bacteria, actinomycetes, fungi, algae and protozoa.

The plant and animal remains are converted into humus by bacteria and fungi. Soil organic matter may be distinguished from humus, which is helpful for increasing productivity of the crop. Organic manures considerably affect the number of individuals or the population of micro-organisms called as microbial community.

Neem cake (Azadirachta indica), mustard cake, linseed cake (Linum usitatissimum), mahua cake (Madhuca longifolia), compost, gober (cattle dung), gas product (biogas) and saw dust were added to soil in micro plots by Pandey and Singh (1990). These plots were sown with Cicer arietinum seeds, 15 days after the addition of amendment. Neem cake caused maximum reduction in the number of root-knot nematodes (M. incognita) followed by saw dust. Maximum soil fungal colonies and the best plant growth were recorded from plots amended with neem cake followed by mahua cake.

Application of Azolla decreased the total number of bacteria in the rhizosphere of rice at the early tillering stage. Azolla and ammonium sulphate had a synergistic effect on nitrogen fixing bacteria and soil nitrogen content. Azolla at 1 t ha\(^{-1}\) grown as a duel crop with the rice plants and incorporated after 20 days increased total nitrogen content and nitrogen fixing power of the rhizosphere soils (Dey and Sannigrahi, 1991).
Identified 32 species belonging to 19 genera in the rhizosphere of a medicinal plant *Strychnos nux-vomica* in Karnataka, India. The most abundant species were *Aspergillus* spp. followed by species of *Rhizopus*, *Mucor*, *Penicillium* and *Fusarium* (Nagaraja, 1990). Isolated 29 fungi from the rhizosphere of soyabean grown in pots. *Fusarium* spp. *Aspergillus flavus* and *A. niger* were dominant (Ali and Gaffar 1991).

The possibility of reducing the use of chemical fertilizers by using vermicompost as organic fertilizer on the summer crop of paddy variety "HAMSA". The control plot received the recommended dosage of farmyard manure and the chemical fertilizers. The experimental plot received half the recommended dosage of chemical fertilizers and the vermicompost. At the time of seed setting and 2 months after the harvest of the crop, the soil samples were analyzed for total microbes, N-fixers, actinomycetes and spore formers. The percent of mycorrhizal colonization in the plant system was also assessed. Significant increase in the colonization of these microbes in the experimental plot over the control plot was observed. It could be deduced that the vermicompost application has enhanced the activity of these selected microbes in the soil system (Kale et al. 1992).

In all 24 fungal species belonging to 18 genera from rhizosphere and rhizoplane mycoflora of test plants. The population and frequency of fungi was found to be the highest in rhizosphere than in rhizoplane. *Aspergillus niger*, *A. flavus* and *Penicillium spp.* were abundant in both while *Alternaria spp.*, *Aspergillus candidus*, *A. fumigatus*, *A. terreus*, *Drechslera spp.*, *Trichoderma spp.* and *Fusarium spp.* were abundant in rhizosphere mycoflora (Shah et al. 1994).

Contaminated soil was mixed with uncontaminated soil or with compost to determine the impact of compost compared to soil on plant establishment and growth, rhizosphere populations and development of
soil microbial populations and activity. Plants were established and grew well in pesticide containing soil when consideration was given to compatibility between plant herbicide tolerance and the specific herbicide present. Soil bacterial populations were significantly higher in compost containing mixes when compared to contaminated soil alone while populations in soil mixes were not affected by any treatment. Fungal populations were significantly higher in planted mixes and in unplanted mixes with compost than they were in contaminated soil alone (Cole et al. 1994).

Four commercial composts were added to soil to study their effect on plant growth, total rhizosphere microflora and incidence of plant growth promoting rhizobacteria (PGPR) in the rhizosphere of tomato plants. Three of the compost treatments significantly improved plant growth while one compost treatment significantly depressed it. Compost amendments caused only small variations in the total number of bacteria, actinomycetes and fungi in the rhizosphere of tomato plants (Brito Alvarez et al. 1995).

In a long-term experiment, the effect of fertilizer use on microflora was studied by Sriramchandrasekharan et al. (1995). Application of 100 % NPK + FYM produced greater population of bacteria, fungi, actinomycetes and azotobacter as compared to other treatments. Maize and cowpea had greater populations of bacteria, actinomycetes and fungi.

The rhizosphere mycoflora of cotton was studied and recorded species of *Aspergillus* and *Penicillium* as dominant fungi among total rhizosphere (Amarjit Singh and Khara, 1997).

Influence of organic amendments on the colonization of arbuscular mycorrhiza (AM) symbiosis and rhizosphere microfungal population in *Vigna unguiculata* Walp. grown on sandy loam by Udaiyan et al. (1998). *Pongamia glabra* leaves (PL) and goat pellets (GP) were applied @ 5, 10
and 15 kg\textsuperscript{-1} soil. Plant dry weight, nodulation and tissue nutrient differed with AM fungi, types of organic matter and their concentrations. Among plant nutrients, potassium content increased. Microfungal populations were higher in PL amended soil than in GP amended soil. Among the various types of microfungal genera isolated, \textit{Aspergillus} had the most diverse species.

Studies were carried out in Russia by over four years on the influence of green manures and their simultaneous application with mineral fertilizers on the reproduction of rhizosphere microflora including producers of vitamin and auxins and also on the absorptive capacity of roots and yield of rye, oats and barley. These treatments resulted in increased yield of the plants and an increase in reproduction of the rhizosphere microflora including microorganisms stimulating plant metabolism and processes affecting yield formation (Voznyakovskaya and Popova 1999).

In long-term field experiments on loamy sand and sandy loam, legumes (pea and lupine) stimulated microbial activity in the rhizosphere more than cereals (winter rye, winter wheat and spring barley) maize and oil flax. In the rhizosphere of winter wheat and maize, microbial activity and the bacteria species \textit{Pseudomonas, Agro-bacterium and Xanthomonas} were more stimulated by organic manuring than by mineral fertilization. Various mineral nitrogen applications had no influence on the rhizosphere microflora (Hoflich \textit{et al.} 2000).

The impact of different forms of organic manures (Sapropel and biohumus) on the abundance of soil microflora and the composition of fungus species was studied using tomato cv. Ausriai. Microbiological investigation of soil from the tomato rhizosphere was carried out in the middle of harvesting. It was found that organic manures are important for the distribution of microorganisms in soil rhizosphere and they had
positive effect on microorganisms. The higher amount of microorganisms (38.20 mm g\(^{-1}\)) was found in the variants fertilizer with 300 g of biohumus (Karbauskiene, 2000).

In a newly cultivated sandy soil, sugar beet haulms composted by highly effective cellulose decomposing microorganisms (\textit{T. viride} NRC6 or \textit{Streptomyces aureofaciens} NRC22) were evaluated as organic manure for tomato plants (\textit{Lycopersicon esculentum} L. var. cv. Supermarmment). The treatments were control with NPK, farmyard manure (FYM), uninoculated compost, compost inoculated with \textit{Glomus} sp. NRC212, composts produced by \textit{T. viride} NRC6 and \textit{S. aureofaciens} NRC22. The organic amendments differed in their effects on total microbial counts in the rhizosphere of tomato plants. However, the amendment of soil with compost produced by highly effective cellulose decomposing microorganisms or compost inoculated with arbuscular mycorrhizal (AM) fungi decreased the proliferation of the total bacteria in the rhizosphere of tomato plants as compared with FYM or compost (Badr EL-Din \textit{et al.}, 2000).

Microbial population, both in diversity as well as numbers, in soil is influenced by the amount and type of various compounds entering soil through plant litter, root exudates and management factors like mineral and organic fertilizers. This in turn affects crop production and sustainability of soil. Halle (Germany) having different mineral and organic fertilizer treatment in unplanted and planted soils with two crops viz. \textit{Secale cereale} and \textit{Medicago sativa}. High number of total microorganisms, nitrogen fixers and phosphate solubilizers were observed in the rhizosphere of \textit{M. sativa} and \textit{S. cereale} compared to bulk soils. Microbial counts were especially higher in treatments of NPK + FYM and NPK in \textit{Secale} (Narula \textit{et al.}, 2002).
In a field microcosm study compared effects of mulching with composted yard waste, ground wood pallets or a bare soil control, with or without chemical fertilizer on soil mineral, chemical, biological and rhizosphere bacterial community properties. Populations of culturable heterotrophic bacteria and fluorescent pseudomonas in the rhizosphere of cucumber (Cucumis sativus L.) were significantly greater in the composted yard waste plots than the bare soil fertilized mulched plots. The data show clearly that mulching with compost strongly influenced the structure of the microbial rhizosphere community (Sonia et al., 2002).

The population of bacteria, fungi and actinomycetes was affected significantly with different treatments in three crops (finger millet, maize, and cowpea) of the cropping system. Bacteria, fungi and actinomycetes proliferated well under continuous applications of NPK and FYM treatments. Among the microbes, bacterial population was the highest compared to fungi and actinomycetes in the soil after all crops of cropping sequence. The application of 100 % N alone and control recorded lower values of microbial population (Selvi et al., 2004).

Field experiment was conducted to find out the effect of various industrial and urban solid wastes on microbial population at different growth stages of rice. Results indicated that the population of bacteria (27.31 x 10^5), fungi (17.26 x 10^5) and actinomycetes (10.92 x 10^5) in terms of number of colonies per gram of oven dry soil was the highest in the treatment of pharmaceutical industry waste at harvest stage. The pharmaceutical waste, which maintained higher level of microbial population, could be exploited beneficially for availability of soil nutrients with increased rice yields (Unamalai et al. 2004).

Composts were produced from rice straw enriched with rock phosphate and inoculated with Aspergillus niger, Trichoderma viride and farmyard manure (FYM). The resulting composts were evaluated as
organic phosphate fertilizers for cowpea plants in pot experiments. The highest phosphate dissolving fungi numbers in rhizosphere soils of cowpea plants were obtained after fertilization with composts which received *A. niger* and *T. viride* treatments while the highest phosphate dissolving bacterial numbers were found after fertilization with composts which received FYM treatments (Gaber and Heba 2005).

In a recent study, association of mycoflora in rhizosphere under the influence of different green manures has been investigated in case of maize (*Zea mays* L.) plant. The analysis of soil samples from all the treated as well as control plants showed that the saprophytic fungi were more frequent than pathogenic fungi due to the effect of green manures (Mogle *et al.*, 2005).