Bio Fertilizers

For B. Sc III SEMESTER

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SKILL ENHANCE MENT COURSE
SEC-2A. BIOFERTILIZERS AND ORGANIC FORMING

Unit-1

1. Mannures and Bio fertilizers: Types of dertilizers. Mannure composition. Manures for crop productivity.
2. Differences between fertilizers and Bio fertilizers: pH changes and water contamination.
3. Bacterial Biofertilizers: General account on the microbes used as biofertilizers.
4. Algal Biofertilizers: Associative effect of different microorgnisms. Azolla and Anabaena- azollae association, Nictogen fixation, Factors affecting growth, Azolla in rice cultivation.

Unit-2

5. Fungal Biofertilizers: Mycorrhizal association, Types of mycorrhizal association, occurrence and distribution, Phosphorus nutrition, growth and its yield, colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.
6. Organic Farming and organicfertilizers, Recycling of bio-degradable municipal, aggricultureal and industrial wastes, Bio compost making- types, methods of vermicomposting, Panchakavya, Biological pest Control (Neem).

Question paper pattern

INTERNAL ASSESSMENT

Name of the Paper: **BIO FERTILIZERS**

Time: **45 Min.** Max. Marks: **20 Marks**

Answer ALL Questions.

Each question carries equal marks (2 Marks x 5 = 10 Marks)

SEMESTER

Time: **90 Min.** Max. Marks: **40 Marks**

Section-A

Write the short notes on any **Four** of the following 4x4=16.

2.

3.

4.

5.

6.

Section- B

Answer the following essays: 2x12=24

7. A or B

8. C or D

Manure

Manure is the decomposed form of dead plants and animals, which is applied to the soil to increase production. It is a natural form of fertilizer and is cost-effective. The human and animal excreta is also used as manure. The livestock manure is rich in nitrogen, phosphorus, and potassium.

Manure is fabulously rich in organic matter and humus and thus improves the soil fertility. These are better in the long run and does not cause any pollution. It is a valuable and renewable resource.

Manure can be obtained from various sources. The different sources of manure are mentioned below:

- Cattle dung, urine, and slurry from biogas plants.
- Wastes from human habitation such as human urine, night soil, sludge, sewage, domestic waste.
- Droppings of goat and sheep
- Waste from the slaughterhouses such as bones, meat, horn and hoof meal, fish waste
- By-products of agricultural industries
- Crop waste
- Weeds, water hyacinth

Types of Manure

Manure can be grouped as farmyard manure, green manure and compost manure. Following are the different types of manure used by the farmers:

Green Manure

Green manure increases the percentage of organic matter in the soil. The roots of such manures go deep into the soil. These help in the suppression of weeds and the prevention of soil erosion.

Farmyard Manure

Farmyard manure improves the soil structure and is used as a natural fertilizer in farming. It increases the soil capacity to hold more water and nutrients. It also increases the microbial activity of the soil to improve its mineral supply and also the plant nutrients.

Compost Manure

It improves the soil structure and water and nutrient holding capacity of the soil. Thus, it increases the nutrient value and thereby improves the health of the plants.

Advantages of Manure

- These are a good source of macronutrients.
- Improves soil fertility.
- Cost-effective
- Reduces soil erosion and leaching.

- Improves the physical properties of the soil and aerates the soil.
- Improves the water and nutrient holding capacity of the soil.
- It can be transported easily.
- Methane gas is evolved as the by-product of manure that can be used for cooking and heating purposes.
- The crops grown on the land treated with manure produces healthy crops.

Manure is an ideal soil amendment. When it is applied to the agricultural fields it acts as a field residue. Farmers can sell the manure to people who need to improve their soil fertility. Thus, it can bring income to farmers. They add to the overall soil ability and sustainability. Manure increases the water holding capacity of the soil. The organic content of the soil can also be improved by applying raw manure like biochar, compost, etc.

Different types of manure contain about 26% solid. The solid and liquid portions are segregated and the solids are used for bedding. The carbon content and other elements can be used to produce different biofuels. Manure also contains a large number of fibres. The undigested animal feed, straw, sawdust, or other bedding contains a lot of fibre.

Manure is environment-friendly and has contributed a great deal in increasing food production. It was very difficult to feed a growing population. Use of manure improved the fertility of the soil and increased the yield of the crops.

To know more about what is manure, its types and advantages, keep visiting BYJU'S website or download BYJU'S app for further reference.

Fertilizers

Fertilizers are chemical substances supplied to the crops to increase their productivity. These are used by the farmers daily to increase the crop yield. The fertilizers contain the essential nutrients required by the plants, including nitrogen, potassium, and phosphorus. They enhance the water retention capacity of the soil and also increase its fertility.

Types of Fertilizers
There are six different types of fertilizers that are mentioned below:

Inorganic Fertilizers
Inorganic fertilizers are chemical fertilizers that contain nutrient elements for the growth of crops made by chemical means. The inorganic fertilizers are of the following types:

Nitrogen Fertilizers
Nitrogen fertilizers contain nitrogen necessary for the development of crops. Nitrogen is the main constituent of chlorophyll that maintains a balance in the process of photosynthesis. It is also a part of amino acids in plants and constitutes protein. Nitrogen fertilizers improve the production and quality of agricultural products.

Phosphorus Fertilizer

The main nutrient in a phosphorus fertilizer is phosphorus. The efficiency of fertilizer depends upon effective phosphorus content, methods of fertilizing, properties of soil and crop strains. Phosphorus found in the protoplasm of the cell plays an important role in cell growth and proliferation. The phosphorus fertilizer is beneficial for the growth of roots of the plants.

Organic Fertilizers

Organic fertilizers are natural fertilizers obtained from plants and animals. It enriches the soil with carbonic compounds essential for plant growth. Organic fertilizers increase the organic matter content of the soil, promotes the reproduction of microorganisms, and changes the physical and chemical properties of the soil. It is considered to be one of the main nutrients for green food.

Organic fertilizers can be obtained from the following products:

- Agricultural Waste
- Livestock Manure
- Industrial Waste
- Municipal Sludge

Advantages of Fertilizers

The advantages of fertilizers are mentioned below:

- They are easy to transport, store, and apply.
- For supplying a specific nutrient we can select a specific fertilizer due to its nutrient specific nature.

- They are water-soluble and can easily dissolve in the soil. Hence, they are easily absorbed by the plants.
- They have a rapid effect on the crops.
- They increase the crop yield and provide enough food to feed the large population.
- They are predictable and reliable.

Disadvantages of Fertilizers

Fertilizers have the following disadvantages:

- They are expensive.
- The ingredients in the fertilizers are toxic to the skin and respiratory system.
- Excessive use of fertilizers damages the plants and reduces soil fertility.
- Leaching occurs and the fertilizers reach the rivers causing eutrophication.
- Long term use reduces the microbial activity and disturbs the pH of the soil.

Biofertilizer

Biofertilizers are the substance that contains microbes, which helps in promoting the growth of plants and trees by increasing the supply of essential nutrients to the plants. It comprises living organisms which include mycorrhizal fungi, blue-green algae, and bacteria. Mycorrhizal fungi preferentially withdraw minerals from organic matter for the plant whereas cyanobacteria are characterized by the property of nitrogen fixation.

Nitrogen fixation is defined as a process of converting the di-nitrogen molecules into nitrogen compounds. For instance, some bacteria convert insoluble forms of soil phosphorus into soluble forms. As a result, phosphorus will be available for plants.

Also, read Nitrogen Fixation and Nitrogen Metabolism

Types of Biofertilizers

Following are the important types of biofertilizers:

Symbiotic Nitrogen-Fixing Bacteria

Rhizobium is one of the vital symbiotic nitrogen-fixing bacteria. Here bacteria seek shelter and obtain food from plants. In return, they help by providing fixed nitrogen to the plants.

Loose Association of Nitrogen-Fixing Bacteria

Azospirillum is a nitrogen-fixing bacteria that live around the roots of higher plants but do not develop an intimate relationship with plants. It is often termed as rhizosphere association as this bacteria collect plant exudate and the same is used as a food by them. This process is termed as associative mutualism.

Symbiotic Nitrogen-Fixing Cyanobacteria

Blue-Green algae or Cyanobacteria from the symbiotic association with several plants. Liverworts, cycad roots, fern, and lichens are some of the Nitrogen-fixing cyanobacteria. Anabaena is found at the leaf cavities of the fern. It is responsible for nitrogen fixation. The fern plants decay and release the same for utilization of the rice plants. Azolla pinnate is a fern that resides in rice fields but they do not regulate the growth of the plant.

Free-Living Nitrogen-Fixing Bacteria

They are free-living soil bacteria which perform nitrogen fixation. They are saprotrophic anaerobes such as *Clostridium beijerinckii*, Azotobacter, etc.

Among all the types of biofertilizers, Rhizobium and Azospirillum are most widely used.

Components of Biofertilizers

The components of biofertilizers include:

Bio Compost

It is one of the eco-friendly product composed of waste material released from sugar industries which are decomposed. It is magnified with human-friendly bacteria, fungi, and various plants.

Tricho-Card

It is an eco-friendly and nonpathogenic product used in a variety of crops as well as in horticultural and ornamental plants, such as paddy apple, sugar cane, brinjal, corn, cotton, vegetables, citrus, etc. It acts as a productive destroyer and antagonistic hyper parasitic against eggs of several bores, shoot, fruit, leaves, flower eaters and other pathogens in the field.

Azotobacter

It protects the roots from pathogens present in the soil and plays a crucial role in fixing the atmospheric nitrogen. Nitrogen is a very important nutrient for the plant and about 78% of the total atmosphere comprises of nitrogen.

Phosphorus

Phosphorus is one of the essential nutrients for plants growth and development. Phosphate solubilizing microorganisms, hydrolyze insoluble phosphorus

compounds to the soluble form for uptake by plants. Many fungi and bacteria are used for the purpose such as *Penicillium, Aspergillus, Bacillus, Pseudomonas, etc.*

Vermicompost

It is an Eco-friendly organic fertilizer comprises of vitamins, hormones, organic carbon, sulfur, antibiotics that help to increase the quantity and quality of yield. Vermicompost is one of the quick fixes to improve the fertility of the soil.

Also refer: Vermicomposting

Importance of Biofertilizers

Biofertilizers are important for the following reasons:

- Biofertilizers improve soil texture and yield of plants.
- They do not allow pathogens to flourish.
- They are eco-friendly and cost-effective.
- Biofertilizers protect the environment from pollutants since they are natural fertilizers.
- They destroy many harmful substances present in the soil that can cause plant diseases.
- Biofertilizers are proved to be effective even under semi-arid conditions.

Applications of Biofertilizers

Following are the important applications of biofertilizers:

Seedling root dip

This method is applicable to rice crops. The seedlings are planted in the bed of water for 8-10 hours.

Seed Treatment

The seeds are dipped in the mixture of nitrogen and phosphorus fertilizers. These seeds are then dried and sown as soon as possible.

Soil Treatment

The biofertilizers along with the compost fertilizers are mixed and kept for one night. This mixture is then spread on the soil where the seeds have to be sown.

Discover more about what is biofertilizer, types of biofertilizers and applications of biofertilizers, only at BYJU'S Biology.

Fertilizers vs Bio Fertilizers

Fertilizing is an essential part of a thick and healthy green lawn. Our lawns are like us when it comes to needing nutrients to thrive and combat illness. So, maybe you've come to the conclusion that a healthy lawn is important to you, but what do you use? With so many options on the market, the answer can be hard to find. We're going to break down the differences between organic and chemical fertilizers and weigh the pros and cons of each so that you can pick the option that's right for your lawn and garden.

Organic Fertilizers

Organic fertilizers consist of material that has been minimally processed rather than being extracted and refined so that the materials can retain their natural forms. Organic or natural fertilizers are typically made of plants, animal waste, and minerals. These can be purchased or made by yourself as they don't require any special equipment.

Pros:

i. Improves the structure of your soil which will lead to healthier lawns and gardens over time.
ii. Organic crops tend to be more nutrient dense and are more flavorful due to the nutrients they are pulling from healthy soil that hasn't been depleted of minerals and nutrients.
iii. You won't have to deal with a toxic buildup of chemicals in your plants because the organic material will fully decompose.
iv. You are less likely to harm or kill your plants because the fertilizer is slow working.

Cons:

i. Nutrients are not immediately available to plants because they need time to break down. You may have a period of time where the plants struggle before the fertilizer starts working its magic.
ii. They can typically be more expensive and less available than inorganic options.
iii. The amount of nutrients going into your soil can only be a guess as there are many factors to consider such as the age of the manure, where it came from, and weather conditions.

Chemical Fertilizers

Chemical, or inorganic fertilizers are widely available and are used more commonly than their organic counterpart. Manufacturers of chemical fertilizers

refine materials in order to extract nutrients before combining with chemical fillers. Common ingredients used are petroleum products and rocks, but organic sources are also used in many cases. While these fertilizers may use organic product, they are not considered organic because the materials are stripped down to their pure state.

Pros:

- Unlike organic fertilizers, nutrients are available to the plants right away because the materials have been stripped down. You can see improvement within days.
- They are an affordable and widely accessible option.
- Because of the process used to make the fertilizer, you will know the exact ratio of nutrients you are giving your lawn and garden.

Cons:

i- You plants will grow more quickly, but the fertilizer will do absolutely nothing to sustain the soil and improve it for future use. This could result in long-term damage to your soil.

ii- Using chemical fertilizers on a regular basis can result in a buildup of chemicals such as uranium,

arsenic, and cadmium. These chemicals could potentially leak into your fruits and vegetables.

iii- You can easily over fertilize because the nutrients will start working so quickly. This doesn't help your plants, and in fact, can actually kill them.

iv- Chemical fertilizers can deplete the nutrients and minerals that are naturally found in fertile soils which leads to food that will be less flavorful and nutrient dense.

v- The chemicals in the fertilizer can potentially damage the root of your plants.

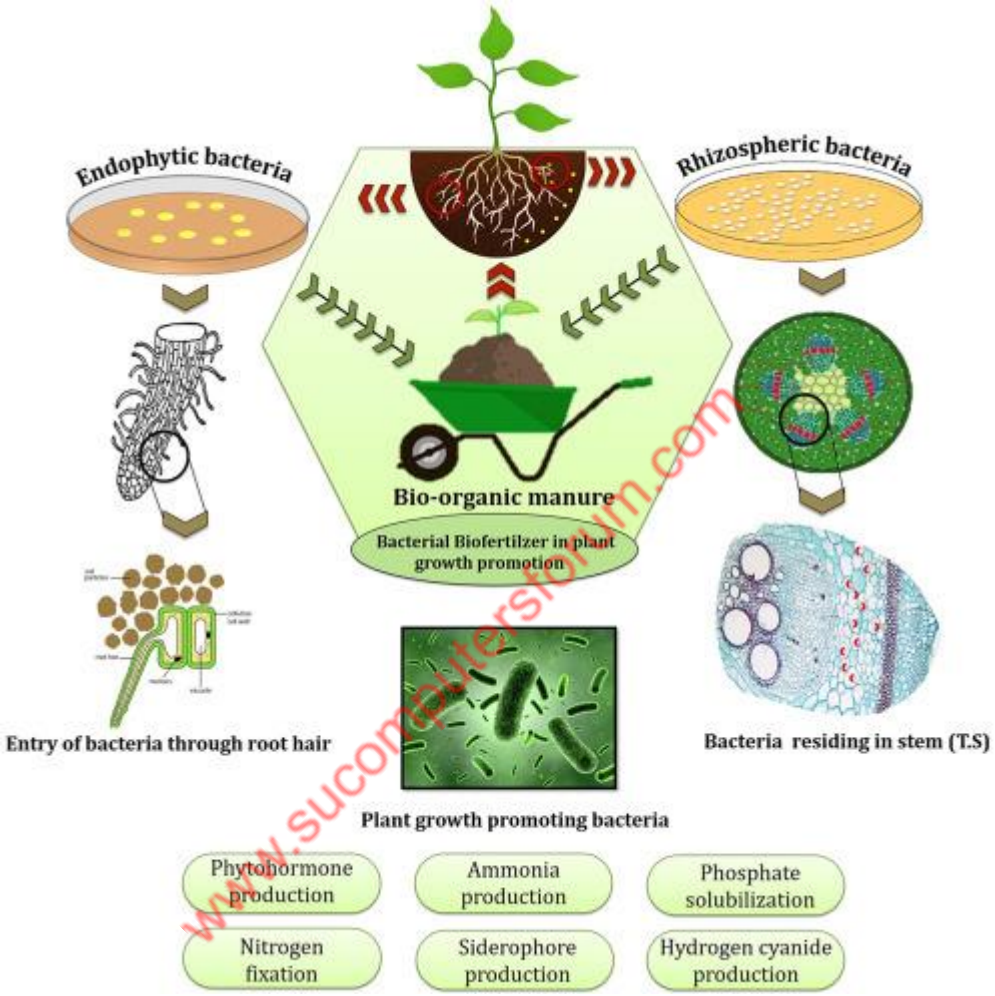
Bacteria as Biofertilizer

Biofertilizers are artificially maintained cultures of the soil microorganism that can be used as microbial or soil inoculants to improve fertility and productivity of plant and soil. In another words, biofertilizer or microbial fertilizer is a substance composed of living microorganisms and mixture of biodegradable substances applied to seed, plant surfaces, or soil, which colonizes the interior part of the plant, via various means such as rhizospehere, intercellular spaces, and enhanced the growth and yields by increasing availability of primary nutrients to the host plants.It is also considered as key factors to develop an integrated nutrient management system with very low environmental impact.

The commercial history of biofertilizer start with the introduction of "Nitragin" by Nobbe and Hiltner, a

laboratory culture of Rhizobia in 1895, followed by discovery of *Azotobacter* and then blue green algae.

The beneficial plant–microbiome interactions represent a promising sustainable solution to improve agricultural production instead of chemical fertilizers. Biopesticides and biofertilizers are a part of natural-based products being widely use to enrich the quality of the soil and as biocontrol agent. Currently different group of microorganisms have been identified, which belongs to bacteria, fungi, and protozoan kingdoms, these colonize rhizosphere or the internal plant tissues and used as biofertilizers for the enhanced agriculture production.



PGPB as biofertilizer has been proven as a safe and efficient methods of increasing crop yields. Recently from last few decades numerous bacterial genera such as *Azotobacter, Bacillus, Klebsiella, Enterobacter*, *Arthrobacter, Burkholderia, Bacillus, Pseudomonas, Azotobacter Serratia*,

etc. had been used as biofertilizers as reported by various authors and called these isolates as PGPB.

Algae Biofertilizer

Algae biofertilizer: As the agricultural sector focuses on research methods to find effective bio fertilizers which can promote crop yield and at the same time do not cause damage to the ecosystem. Large scale commercial production of crops faces several issues such as soil acidification, diseases and pest attacks. Environmental changes have caused the soil and water composition to change.

Harmful chemicals used as pesticides and fertilizers accumulate in the food chain and are toxic to the habitat. Water scarcity, pollution, greenhouse gases and natural disasters have significantly reduced the area of agricultural land.

Algae Biofertilizer represent a large group of microorganisms which are beneficial in enhancing soil productivity. They serve the purpose by fixing atmospheric nitrogen and synthesizing plant growth promoters. Bio-fertilizers are effective replacements for chemical fertilizers and are more cost effective.

Algae Biofertilizer is Cost Effective

An Algae Biofertilizer is a natural, organic and renewable energy source. They help retain essential nutrients and water in the soil which is required for the proper growth of the plants. When chemical fertilizers are used they change the soil composition causing contamination and pollution.

Algae extracts have been researched for several years to be used as fertilizers. Beneficial effects of using algae have been reported in various parts. Possibility of using liquid preparations and powdered extracts has been reported to have positive effects on cereal crops including increased crop yield, improved nutrient uptake and resistance to pests.

BGA synthesizes and liberates plant growth promoting substances such as auxins and amino compounds which stimulate plant growth. They have been used particularly for rice crops.

Cyanobacteria are one of the major components of paddy fields. The agricultural importance of BGA in rice crops is related directly with their ability to fix nitrogen and other beneficial effects for plants and soil. Nitrogen content of the soil is the second major factor affecting plant growth after

water. Deficiency of nitrogen content in the soil is overcome by the addition of algae biofertilizers.

Azolla-Anabaena Relationships

The N_2-fixing *Azolla-Anabaena* symbiotic association is characterized in regard to individual host and symbiont contributions to its total chlorophyll, protein, and levels of ammonia-assimilating enzymes. The phycocyanin content of the association and the isolated blue-green algal symbiont was used as a standard for this characterization. Phycocyanin was measured by absorption and fluorescence emission spectroscopy. The phycocyanin content and total phycobilin complement of the symbiotic algae were distinct from those of *Anabaena cylindrica* and a free-living isolate of the *Azolla* endophyte. The algal symbiont accounted for less than 20% of the association's chlorophyll and protein. Acetylene reduction rates in the association (based solely on the amount of algal chlorophyll) were 30 to 50% higher than those attained when the symbiont was isolated directly from the fern. More than 75% of the association's glutamate dehydrogenase and glutamine synthetase activities are contributed by the host plant. The specific activity of glutamate dehydrogenase is greater than that of glutamine synthetase in the association and individual partners. Both the host and symbiont have glutamate synthase activity. The net distribution of these enzymes is discussed in regard

to the probable roles of the host and symbiont in the assimilation of ammonia resulting from N_2 fixation by the symbiont.

Fungi As Bio Fertilizers

Mycorrhiza (Pl. Mycorrhizae, Frank, 1885):

The mycorrhiza is a mutually beneficial or symbiotic association of a fungus with the root of a higher plant. The most common fungal partners of mycorrhiza are *Glomus* species. Mycorrhizal roots show a sparse or dense wooly growth of fungal hyphae on their surface. Root cap and root hairs are absent.

Mycorrhiza is a potential biofertilizer which mobilizes P, Fe, Zn, B and other trace elements. It supplies moisture from far-off inches and is ideal for long duration crops. It can be stored up to 2 years and is dry powder resistant.

Depending upon the residence of the fungus, mycorrhizae are of two types— ectomycorrhiza and endomycorrhiza.

Ectomycorrhiza (= Ectotrophic Mycorrhiza):

The fungus forms a mantle on the surface of the root. Internally, it lies in the intercellular spaces of the cortex. The root cells secrete sugars and other food ingredients into the intercellular spaces that feed the fungal hyphae. The exposed fungal hyphae increase the surface of the root to several times. They perform several functions for the plant as follows:

- Absorption of water,
- Solubilisation of organic matter of the soil humus, release of inorganic nutrients, absorption and their transfer to root,

- Direct absorption of minerals from the soil over a large area and handing over the same to the root. Plants with ectomycorrhiza are known to absorb 2–3 times more of nitrogen, phosphorus, potassium and calcium,
- The fungus secretes antimicrobial substances which protect the young roots from attack of pathogens. Ectomycorrhiza occurs in trees such as Eucalyptus, oak (*Quercus*), peach, pine, etc. The fungus partner is generally specific. It belongs to Basidiomycetes.

Endomycorrhiza (Endotrophic Mycorrhiza):

Fewer fungal hyphae lie on the surface. The remaining live in the cortex of the root, mostly in the intercellular spaces with some hyphal tips passing inside the cortical cells, e.g., grasses, crop plants, orchids and some woody plants. At the seedling stage of orchids, the fungal hyphae also provide nourishment by forming nutrient-rich cells called pelotons. Intracellular growth occurs in order to obtain nourishment because, unlike ectomycorrhiza, the cortical cells do not secrete sugars in the intercellular spaces.

Vesicular Arbuscular Mycorrhizal (VAM) fungi possess special structures known as vesicles and arbusculars. VAM fungi are intercellular, obligate endosymbionts and, on establishment on the root system, act as an extended root system. Besides harvesting moisture from deeper and faraway nitches in the soil, they also harvest various micronutrients and provide them to the host plants. VAM facilitates the phosphorus nutrition by not only increasing its availability, but also increasing its mobility. VAM are obligate symbionts and improve the uptake of Zn, Co, P and H_2O. Its large-scale application is limited to perennial crops and transplanted crops. A single fungus may form a mycorrhizal association with a number of plants, e.g., *Glomus*.

The different types of biofertilizers are preparations made from natural beneficial microorganisms. They are safe for all plants, animals and human beings. Being beneficial to crops and natural nutrient cycles, they not only are environmentally friendly, but also help in saving of chemical inputs.

Main roles of biofertilizers:

- Make nutrients available.
- Make the root rhizosphere livelier.
- Growth-promoting substances are produced.
- More root proliferation.
- Better germination.
- Improve the quality and quantity of produce.
- Improve the fertilizer use efficiency.
- Higher biotic and abiotic stress tolerance.
- Improve soil health.
- Residual effect.
- Make the system more sustainable.

Organic Farming

Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, genetically modified organisms and livestock food additives. To the maximum extent possible organic farming system rely upon crop rotations, use of crop residues, animal manures, legumes, green manures, off farm organic wastes, biofertilizers, mechanical cultivation, mineral bearing rocks

and aspects of biological control to maintain soil productivity and tilth to supply plant nutrients and to control insect, weeds and other pests.

Organic methods can increase farm productivity, repair decades of environmental damage and knit small farm families into more sustainable distribution networks leading to improved food security if they organize themselves in production, certification and marketing. During last few years an increasing number of farmers have shown lack of interest in farming and the people who used to cultivate are migrating to other areas. Organic farming is one way to promote either self-sufficiency or food security. Use of massive inputs of chemical fertilizers and toxic pesticides poisons the land and water heavily. The after-effects of this are severe environmental consequences, including loss of topsoil, decrease in soil fertility, surface and ground water contamination and loss of genetic diversity.

Organic farming which is a holistic production management system that promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity is hence important. Many studies have shown that organic farming methods can produce even higher yields than conventional methods. Significant difference in soil health indicators such as nitrogen mineralization potential and microbial abundance and

diversity, which were higher in the organic farms can also be seen. The increased soil health in organic farms also resulted in considerably lower insect and disease incidence. The emphasis on small-scale integrated farming systems has the potential to revitalize rural areas and their economies.

Advantages of organic farming

1. It helps to maintain environment health by reducing the level of pollution.
2. It reduces human and animal health hazards by reducing the level of residues in the product.
3. It helps in keeping agricultural production at a sustainable level.
4. It reduces the cost of agricultural production and also improves the soil health.
5. It ensures optimum utilization of natural resources for short-term benefit and helps in conserving them for future generation.
6. It not only saves energy for both animal and machine, but also reduces risk of crop failure.
7. It improves the soil physical properties such as granulation, good tilth, good aeration, easy root penetration and improves water-holding capacity and reduces erosion.

8. It improves the soil's chemical properties such as supply and retention of soil nutrients, reduces nutrient loss into water bodies and environment and promotes favourable chemical reactions.

Nutrient management in organic farming

In organic farming, it is important to constantly work to build a healthy soil that is rich in organic matter and has all the nutrients that the plants need. Several methods viz. green manuring, addition of manures and biofertilizers etc can be used to build up soil fertility. These organic sources not only add different nutrients to the soil but also help to prevent weeds and increase soil organic matter to feed soil microorganisms. Soil with high organic matter resists soil erosion, holds water better and thus requires less irrigation. Some natural minerals that are needed by the plants to grow and to improve the soil's consistency can also be added. Soil amendments like lime are added to adjust the soil's pH balance. However soil amendment and water should contain minimum heavy metals. Most of the organic fertilizers used are recycled by-products from other industries that would otherwise go to waste. Farmers also make compost from animal manures and mushroom compost. Before compost can be applied to the fields, it is heated and aged for at least two months, reaching and maintaining an internal temperature of 130°-140°F to kill

unwanted bacteria and weed seeds. A number of organic fertilizers / amendments and bacterial and fungal biofertilizers can be used in organic farming depending upon availability and their suitability to crop. Different available organic inputs are described below:

1. Organic manures

Commonly available and applied farm yard manure (FYM) and vermicompost etc. are generally low in nutrient content, so high application rates are needed to meet crop nutrient requirements. However, in many developing countries including India, the availability of organic manures is not sufficient for crop requirements; partly due to its extensive use of cattle dung in energy production. Green manuring with Sesbania, cowpea, green gram etc are quiet effective to improve the organic matter content of soil. However, use of green manuring has declined in last few decades due to intensive cropping and socioeconomic reasons. Considering these constraints International Federation of Organic Agriculture Movement (IFOAM) and Codex Alimentarius have approved the use of some inorganic sources of plant nutrients like rock phosphate, basic slag, rock potash etc. in organic farming systems. These substances can supply essential nutrients and may be from plant, animal, microbial or mineral origin and may undergo physical, enzymatic or microbial processes and

their use does not result in unacceptable effects on produce and the environment including soil organisms.

2. Bacterial and fungal biofertilizers

Contribution of biological fixation of nitrogen on surface of earth is the highest (67.3%) among all the sources of N fixation. Following bacterial and fungal biofertilizers can be used as a component of organic farming in different crops.

A. ***Rhizobium*** : The effectiveness of symbiotic N_2 fixing bacteria viz. Rhizobia for legume crops eg. *Rhizobium, Bradyrhizobium, Sinorhizobium, Azorhizobium,* and *Mesorhizobium etc* have been well recognized. These bacteria infecting legumes have a global distribution. These rhizobia have a N_2-fixing capability up to 450 kg N ha–1 depending on host- plant species and bacterial strains. Carrier based inoculants can be coated on seeds for the introduction of bacterial strains into soil.

B. ***Azotobacter:*** N_2 fixing free-living bacteria can fix atmospheric nitrogen in cereal crops without any symbiosis. Such free living bacterias are: *Azotobacter* sp. for different cereal crops; *Acetobacter diazotrophicus* and *Herbaspirillum* spp. for sugarcane, sorghum and maize crop. Beside fixing nitrogen, they also increase germination and vigour in young plants leading to an improved crop stand. They can fix 15-20 kg/ha nitrogen per year. *Azotobacter* sp. also has ability to produce anti

fungal compounds against many plant pathogens. *Azotobacter* can biologically control the nematode diseases of plants also.

C. ***Azospirillum:*** The genus *Azospirillum* colonizes in a variety of annual and perennial plants. Studies indicate that *Azospirillum* can increase the growth of crops like sunflower, carrot, oak, sugarbeet, tomato, pepper, cotton, wheat and rice. The crop yield can increase from 5-30%. Inoculum of *Azotobacter* and *Azospirillum* can be produced and applied as in peat formulation through seed coating. The peat formulation can also be directly utilized in field applications.

D. ***Plant growth promoting rhizobacteria*** : Various bacteria that promote plant growth are collectively called plant growth promoting rhizobacteria (PGPR). PGPR are thought to improve plant growth by colonizing the root system and pre empting the establishment of suppressing deleterious rhizosphere microorganisms on the roots. Large populations of bacteria established in planting material and roots become a partial sink for nutrients in the rhizosphere thus reducing the amount of C and N available to stimulate spores of fungal pathogens or for subsequent colonization of the root. PGPR belong to several genera viz.*Actinoplanes, Azotobacter, Bacillus, Pseudomonas, Rhizobium, Bradyrhizobium, Streptomyces, Xanthomonas* etc. Bacillus spp. act as biocontrol agent because their endospores are

tolerant to heat and desiccation. Seed treatment with *B.subtilis* is reported to increase yield of carrot by 48%, oats by 33% and groundnut upto 37%.

E. ***Phosphorus-solubilizing bacteria (PSB):*** Phosphorus is the vital nutrient next to nitrogen for plants and microorganisms. This element is necessary for the nodulation by *Rhizobium* and even to nitrogen fixers, *Azolla* and BGA. The phospho microorganism mainly bacteria and fungi make available insoluble phosphorus to the plants. It can increase crop yield up to 200-500 kg/ha and thus 30 to 50 kg Super Phosphate can be saved. Most predominant phosphorus-solubilizing bacteria (PSB) belong to the genera *Bacillus* and *Pseudomonas*. At present PSB is most widely used biofertilizer in India. PSB can reduce the P requirement of crop up to 25%.

F. ***Mycorrhizal fungi:*** Root-colonizing mycorrhizal fungi increase tolerance of heavy metal contamination and drought. Mycorrhizal fungi improve soil quality also by having a direct influence on soil aggregation and therefore aeration and water dynamics. An interesting potential of this fungi is its ability to allow plant access to nutrient sources which are generally unavailable to the host plants and thus plants may be able to use insoluble sources of P when inoculated with mycorrhizal fungi but not in the absence of inoculation.

G. ***Blue green algae (BGA):*** BGA are the pioneer colonizers both in hydrosphere and xerosphere. These organisms have been found to synthesize 0.8 x 1011 tonnes of organic matter, constituting about 40 percent of the total organic matter synthesized annually on this planet. BGA constitute the largest, most diverse and widely distributed group of prokaryotic microscopic organisms that perform oxygenic photosynthesis. These are also known as cyanophyceae and cyanobacteria. These are widely distributed in tropics; and are able to withstand extremes of temperature and drought. The significance of the abundance of BGA in Indian rice soils has been well recognized. Multi-location trials conducted under varying agro climatic conditions have indicated that the algal inoculation could save 30 kg N /ha, however, it depends upon the agro ecological conditions. BGA has been reported to reduce the pH of soil and improve upon exchangeable calcium and water holding capacity. The recommended method of application of the algal inoculum is broadcasting on standing water about 3 to 4 days after transplantation. After the application of algal inoculum the field should be kept water logged for about a week's time. Establishment of the algal inoculum can be observed within a week of inoculation in the form of floating algal mats, more prominently seen in the afternoon.

H. ***Azolla:*** A floating water fern 'Azolla' hosts nitrogen fixing BGA *Anabaena azollae*. Azolla contains 3.4% nitrogen

(on dry wt. basis) and add organic matter in soil. This biofertilizer is used for rice cultivation. There are six species of Azolla viz. *A. caroliniana, A. nilotica, A. mexicana, A.filiculoides, A. microphylla* and *A. pinnata*. Azolla plant has a floating, branched stem, deeply bilobed leaves and true roots which penetrate the body of water .The leaves are arranged alternately on the stem. Each leaf has a dorsal and ventral lobe. The dorsal fleshy lobe is exposed to air and contains chlorophyll. It grows well in ditches and stagnant water. Azolla can be easily grown throughout the year in India if water is not a limiting factor and climatic conditions are favourable for its growth. This fern usually forms a green mat over water. Azolla is readily decomposed to NH_4 which is available to the rice plants. Field trial have shown that rice yields increased by 0.5-2t/ha due to Azolla application. In India and China, about 20 and 18% increase in rice yield, respectively has been reported due to Azolla application.

Composting

Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions. Raw organic materials such as crop residues, animal wastes, food garbage, some municipal wastes and suitable industrial wastes, enhance their

suitability for application to the soil as a fertilizing resource, after having undergone composting.

A mass of rotted organic matter made from waste is called compost. The compost made from farm waste like sugarcane trash, paddy straw, weeds and other plants and other waste is called farm compost. The average nutrient contents of farm compost are 0.5 per cent N, 0.15 per cent P2O5and 0.5 per cent K2O. The nutrient value of farm compost can be increased by application of superphosphate or rock phosphate at 10 to 15 kg/t of raw material at the initial stage of filling the compost pit. The compost made from town refuses like night soil, street sweepings and dustbin refuse is called town compost. It contains 1.4 per cent N, 1.00 per cent P2O5 and 1.4 per cent K2O.

Farm compost is made by placing farm wastes in trenches of suitable size, say, 4.5 m to 5.0 m long, 1.5m to 2.0 m wide and 1.0 m to 2.0 m deep. Farm waste is placed in the trenches layer by layer. Each layer is well moistened by sprinkling cow dung slurry or water. Trenches are filled up to a height of 0.5 m above the ground. The compost is ready for application within five to six months.

Composting is essentially a microbiological decomposition of organic residues collected from rural area (rural compost) or urban area (urban compost).

Methods of composting

In **Coimbatore method**, composting is done in pits of different sizes depending on the waste material available. A layer of waste materials is first laid in the pit. It is moistened with a suspension of 5-10 kg cow dung in 2.5 to 5.0 I of water and 0.5 to 1.0 kg fine bone meal sprinkled over it uniformly. Similar layers are laid one over the other till the material rises 0.75 m above the ground level. It is finally plastered with wet mud and left undisturbed for 8 to 10 weeks. Plaster is then removed, material moistened with water, given a turning and made into a rectangular heap under a shade. It is left undisturbed till its use.

In the **Indore method** of composting, organic wastes are spread in the cattle shed to serve as bedding. Urine soaked material along with dung is removed every day and formed into a layer of about 15 cm thick at suitable sites. Urine soaked earth, scraped from cattle sheds is mixed with water and sprinkled over the layer of wastes twice or thrice a day. Layering process continued for about a fortnight. A thin layer of well decomposed compost is sprinkled over top and the heap given a turning and reformed. Old compost acts as inoculum for decomposing the material. The heap is left undisturbed for about a month. Then it is thoroughly moistened and given a turning. The compost is ready for application in another month.

In the **Bangalore method** of composting, dry waste material of 25 cm thick is spread in a pit and a thick suspension of cow dung in water is sprinkled over for moistening. A thin layer of dry waste is laid over the

moistened layer. The pit is filled alternately with dry layers of material and cow dung suspension till it rises 0.5 m above ground level. It is left exposed without covering for 15 days. It is given a turning, plastered with wet mud and left undisturbed for about 5 months or till required.

In Coimbatore method, there is anaerobic decomposition to start with, following by aerobic fermentation. It is the reverse in Bangalore method. The Bangalore compost is not so thoroughly decomposed as the Indore compost or even as much as the Coimbatore compost, but it is bulkiest.

Compost is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil. As a result of these improvements, the soil:

(i) becomes more resistant to stresses such as drought, diseases and toxicity;
(ii) helps the crop in improved uptake of plant nutrients; and
(iii) possesses an active nutrient cycling capacity because of vigorous microbial activity.

These advantages manifest themselves in reduced cropping risks, higher yields and lower outlays on inorganic fertilizers for farmers.

Advantages of Composting

- Volume reduction of waste.
- Final weight of compost is very less.
- Composting temperature kill pathogen, weed seeds and seeds.
- Matured compost comes into equilibrium with the soil.
- During composting number of wastes from several sources are blended together.
- Excellent soil conditioner
- Saleable product
- Improves manure handling
- Redues the risk of pollution
- Pathogen reduction
- Additional revenue.
- Suppress plant diseases and pests.
- Reduce or eliminate the need for chemical fertilizers.
- Promote higher yields of agricultural crops.
- Facilitate reforestation, wetlands restoration, and habitat revitalization efforts by amending contaminated, compacted, and marginal soils.
- Cost-effectively remediate soils contaminated by hazardous waste.
- Remove solids, oil, grease, and heavy metals from stormwater runoff.
- Capture and destroy 99.6 percent of industrial volatile organic chemicals (VOCs) in contaminated air.

- Provide cost savings of at least 50 percent over conventional soil, water, and air pollution remediation technologies, where applicable.

Drawbacks of Using Composts

Agricultural use of composts remains low for several reasons:

- The product is weighty and bulky, making it expensive to transport.
- The nutrient value of compost is low compared with that of chemical fertilizers, and the rate of nutrient release is slow so that it cannot usually meet the nutrient requirement of crops in a short time, thus resulting in some nutrient deficiency
- The nutrient composition of compost is highly variable compared to chemical fertilizers.
- Agricultural users might have concerns regarding potential levels of heavy metals and other possible contaminants in compost, particularly mixed municipal solid wastes. The potential for contamination becomes an important issue when compost is used on food crops.
- Long-term and/or heavy application of composts to agricultural soils has been found to result in salt, nutrient, or heavy metal accumulation and may adversely affect plant growth, soil organisms, water quality, and animal and human health

The Benefits of Using Composts to Agriculture

Compost has been considered as a valuable soil amendment for centuries. Most people are aware that using composts is an effective way to increase healthy plant production, help save money, reduce the use of chemical fertilizers, and conserve natural resources. Compost provides a stable organic matter that improves the physical, chemical, and biological properties of soils, thereby enhancing soil quality and crop production. When correctly applied, compost has the following beneficial effects on soil properties, thus creating suitable conditions for root development and consequently promoting higher yield and higher quality of crops.

Improves the Physical Properties of Soils

- Reduces the soil bulk density and improves the soil structure directly by loosening heavy soils with organic matter, and indirectly by means of aggregate-stabilizing humus contained in composts. Incorporating composts into compacted soils improves root penetration and turf establishment.
- Increases the water-holding capacity of the soil directly by binding water to organic matter, and indirectly by improving the soil structure, thus improving the absorption and movement of water into the soil. Therefore, water requirement and irrigation will be reduced.
- Protects the surface soil from water and wind erosion by reducing the soil-dispersion action of beating raindrops, increasing infiltration, reducing water

runoff, and increasing surface wetness. Preventing erosion is essential for protecting waterways and maintaining the quality and productivity of the soil.

- Helps bind the soil particles into crumbs by the fungi or actinomycetes mycelia contained in the compost and stimulated in the soil by its application, generally increasing the stability of the soil against wind and water erosion.
- Improves soil aeration and thus supplies enough oxygen to the roots and escapes excess carbon dioxide from the root space.
- Increases the soil temperature directly by its dark color, which increases heat absorption by the soil, and indirectly by the improved soil structure.
- Helps moderate soil temperature and prevents rapid fluctuations of soil temperature, hence, providing a better environment for root growth. This is especially true of compost used as a surface mulch.

Enhances the Chemical Properties of Soils

- Enables soils to hold more plant nutrients and increases the cation exchange capacity (CEC), anion exchange capacity (AEC), and buffering capacity of soils for longer periods of time after composts are applied to soils. This is important mainly for soils containing little clay and organic matter.
- Builds up nutrients in the soil. Composts contain the major nutrients required by all plants [N,P,K, calcium (Ca), magnesium(Mg), and S] plus essential

micronutrients or trace elements, such as copper (Cu), zinc (Zn), iron (Fe), manganese (Mn), boron (B), and molybdenum (Mb).

- The nutrients from mature composts are released to the plants slowly and steadily. The benefits will last for more than one season.
- Stabilizes the volatile nitrogen of raw materials into large protein particles during composting, thereby reducing N losses.
- Provides active agents, such as growth substances, which may be beneficial mainly to germinating plants.
- Adds organic matter and humus to regenerate poor soils.
- Buffers the soil against rapid changes due to acidity, alkalinity, salinity, pesticides, and toxic heavy metals.

Improves the Biological Properties of Soils

- Supplies food and encourages the growth of beneficial microorganisms and earthworms.
- Helps suppress certain plant diseases, soil borne diseases, and parasites.
- Research has shown that composts can help control plant diseases (e.g. Pythium root rot, Rhizoctonia root rot, chili wilt, and parasitic nematode) and reduce crop losses. A major California fruit and vegetable grower was able to cut pesticide use by 80% after three years of compost applications as part of an organic matter management system. Research has also indicated that some composts, particularly those

prepared from tree barks, release chemicals that inhibit some plant pathogens. Disease control with compost has been attributed to four possible mechanisms:

- 1) successful competition for nutrients by beneficial microorganisms;
  2) antibiotic production by beneficial microorganisms;
  3) successful predation against pathogens by beneficial microorganisms;
  4) activation of disease-resistant genes in plants by composts; and
  5) high temperatures that result from composting kill pathogens.
- Reduces and kills weed seeds by a combination of factors including the heat of the compost pile, rotting, and premature germination.

Economic and Social Benefits of Composting

The economic and social benefits of composting include the following:

- Brings higher prices for organically grown crops.
- Composting can offer several potential economic benefits to communities:
- Extends current landfill longevity and delays the construction of a more expensive replacement landfill or incinerator.

- Reduces or avoids landfill or combustor tipping fees, and reduces waste disposal fees and long-distance transportation costs.
- Offers environmental benefits from reduced landfill and combustion use.
- Creates new jobs for citizens.
- Produces marketable products and a less-cost alternative to standard landfill cover, artificial soil amendments, and conventional bioremediation techniques.
- Provides a source of plant nutrients and improves soil fertility; results in significant cost savings by reducing the need for water, pesticides, fungicides, herbicides, and nematodes.
- Used as an alternative to natural topsoil in new construction, landscape renovations, and container gardens. Using composts in these types of applications is not only less expensive than purchasing topsoil, but it can also often produce better results when establishing a healthy vegetative cover.
- Used as mulch for trees, orchards, landscapes, lawns, gardens, and makes an excellent potting mix. Placed over the roots of plants, compost mulch conserves water and stabilizes soil temperatures. In addition, it keeps plants healthy by controlling weeds, providing a slow release of nutrients, and preventing soil loss through erosion.

2. Crop Residue Composting

Crop residues are the non-economic plant parts that are left in the field after harvest. The harvest refuses include straws, stubble, stover and haulms of different crops. Crop remains are also from thrashing sheds or that are discarded during crop processing. This includes process wastes like groundnut shell, oil cakes, rice husks and cobs of maize, sorghum and cumbu. The greatest potential as a biomass resource appears to be from the field residues of sorghum, maize, soybean, cotton, sugarcane etc. In Tamil Nadu 190lakh tones of crop residues are available for use. These residues will contribute 1.0 lakh ton of nitrogen, 0.5 lakh ton of phosphorusand2.0 lakh tons of potassium. How ever crop residues need composting before being used as manure.

Waste collection

Crop residues accumulated in different locations are to be brought to compost yard. The compost yard is located in anyone corner of the farm with accessibility via good road. Water resource should also be available in sufficient quantity. The crop residues that are brought to compost yard should be heaped in one corner for further processing.

Shredding of waste materials

Particle size is one of the factors that influence the composting. It is advisable to shred all the crop residues that are used for composting. Shredding the waste manually is labour intensive. Shredder machine can be employed to

shred all the crop residue biomass. Particle size of 2 to 2.5 cm is recommended for quick composting.

Mixing of green waste and brown waste

Carbon and nitrogen ratio decides the initiation of composting process. If C:N ratio is wide (100:1) composting will not take place. Narrow C:N ratio of 30:1 is ideal for composting. To get a narrow C:N ratio, carbon and nitrogen rich material should be mixed together. Green coloured waste materials like glyricidia leaves, parthenium, freshly harvested weeds; sesbania leaves are rich in nitrogen, whereas brown coloured waste material like straw, coir dust, dried leaves and dried grasses are rich in carbon. In any composting process these carbon and nitrogen rich material is to be mixed together to make the composting quicker rather than putting green waste alone or brown color waste alone for composting. Animal dung is also a good source of nitrogen. While making heap formation, alternative layers of carbon rich material, animal dung and nitrogen rich material are to be heaped to get a quicker result in composting.

Compost heap formation

Minimum 4 feet height should be maintained for composting. The composting area should be elevated one and have sufficient shade. While heap formation, all the crop residues should be mixed together to form a heterogeneous material rather than a single homogenous material.

Alternate layers of carbon and nitrogen rich material with intermittent layers of animal dung are essential. After heap formation the material should be thoroughly moistened.

Bioinputs for composting

TNAU Biomineralizer consortium contains groups of microorganisms, which accelerate the composting process. If this inoculum is not added to the composting material, natural microorganisms establish on the waste material on its own and do the composting work. This process takes longtime. But if external source of inoculums is added, the microbial activity starts earlier and composting period will be reduced.

For one ton of crop wastes 2 kg of TNAU Biomineralizer is recommended. This two kg Biomineralizer should be mixed with 20 liters of water and made slurry. When the compost heap is formed in between layers the slurry should be inoculated, so that it mixes with the waste material thoroughly for uniform coating of microorganism on the waste material. Cow dung slurry is also a good source for microbial inoculum. But it carries unwanted microorganisms also which may compete with composting organism. But when TNAU Biomineralizer is not available, cow dung slurry is a good source material. For one ton crop residues40 kg fresh cow dung is required. This 40 kg fresh cow dung is mixed with 100litres of water and it should be thoroughly poured over the waste material. Cow dung

slurry acts as nitrogen source as well as source of microbial inoculum.

Aerating the compost material

Sufficient quantity of oxygen should be available inside the compost heap. For this external air should be freely get in and comes out of the material. Normally to allow the fresh air to get inside, the compost heap should be turned upside down, once in fifteen days. In this process top layer comes to bottom and bottom layer goes to top. This process also activates the microbial process and compost process is hastened. In some cases air ventilating pipe maybe inserted vertically and horizontally, to allow the air to pass through. The wood chip that is available as waste in wood processing industry may also be used as bulking agent in the composting process. This bulking agent gives more air space to the compost material.

Moisture maintenance

Throughout the composting period 60% moisture should be maintained. On any situation, compost material should not be allowed to dry. If the material becomes dry, all the microorganisms present in the crop residues will die and the compost process gets affected.

Compost maturity

Volume reduction, black colour, earthy odor, reduction in particle size are all the physical factors to be observed for

compost maturity. After satisfying with the compost maturity index, the compost heap can be disturbed and spread on the floor for curing. After curing for one day, the composted material is sieved through 4 mm sieve to get uniform composted material. The residues collected after composting has to be again composted to finish the composting process.

Compost enrichment

The harvested compost should be heaped in a shade, preferably on a hard floor. The beneficial microorganisms like *Azotobacter* or *Azospirillum, Pseudomonas,* Phosphobacteria (0.2%) and rock phosphate (2%) have to be inoculated for one ton of compost. Forty per cent moisture should be maintained for the maximum growth of inoculated microorganism. This incubation should be allowed for 20 days for the organism to reach the maximum population. Now the compost is called as enriched compost. The advantage of enriched compost over normal compost is the quality manure with higher nutrient status with high number of beneficial microorganisms and plant growth promoting substances.

Nutritive value of Biocompost

The nutritive value of Biocompost varies from lot to lot because of varying input materials. But in general Biocompost contains all the macro and micro nutrients required for crops, which is given in the following

table. Even though the quantity available is low it covers all the requirements of the crop.