ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

Department of Agricultural Engineering

ADD ON PRINCIPLES OF ORGANIC FARMING

Course material

PRINCIPLES OF ORGANIC FARMING

Objectives:

To create awareness on various principles organic farming.
To teach cultivation practices for various crop cultivated using organic farming methods.
To provide in depth knowledge on importance of soil microbes in farming.

Course outcomes:

Students will be able to cultivate crops using principle of organic farming.
Students will be able to design, ecute the establishment and manage an organic farm for a crop.
Students gain knowledge about cropping methods and crop rotation.

Syllabus :

UNIT 1

Concept of different cropping systems in relation to Organic Farming - Organic Farming - Concept of farming system-Developing organic farms- Important steps & methods

UNIT 2

Sources of nutrients for Organic Agriculture- Organic Manure – FYM/Rural compost, City compost, Oil cakes, Animal wastes, Vermi composts, etc. Green Manure – Green Manure with Leguminous crops in crop rotation. In-situ incorporation of crop residues -Benefits Other Nitrogen contributing plants- Liquid Manure

UNIT 3

Importance of Bio fertilizers in soil productivity Nitrogenous, Phosphatic, Potassic. Preparation of Compost - Different Methods - Enrichment of compost - Nutrient composition

UNIT 4

Preparation of vermi compost - Pit construction - Raw materials - Availability of specific species of earth worm - Method of preparation.

UNIT 5

Quality improvement of finished vermin compost - Concept of farming system – developing organic farms – important steps and methods.

REFERENCES:

1. Organic farming-Theory and Practice by S.P. Palaniappan and K. Annadurai
2. Principles of organic farming by S. R. Reddy
3. Principles of Agronomy by S. R. Reddy
4. Organic crop production (Principles and practices Vol-I: Principles and General Aspects) by J. P. Sharma
5. Principles and practices of organic farming by R. Balasubramanian, K. Balakrishnan and K. Sivasubramanian

CHAPTER -1

INTRODUCTION, DEFINITION, CONCEPT, IMPORTANCE, ADVANTAGES AND DISADVANTAGES, OBJECTIVES, ESSENTIAL CHARACTERISTICS OF ORGANIC FARMING

1.1 Introduction:

Green revolution technologies such as greater use of synthetic agro chemicals like fertilizers and pesticides, adoption of nutrient responsive, high-yielding varieties of crops, greater exploitation of irrigation potentials etc… has boosted the production out put in most of cases. Without proper choice and continues use of these high energy inputs is leading to decline in production and productivity of various crops as well as deterioration of soil health and environments. The most unfortunate impact on Green Revaluation Technology (GRT) on Indian Agriculture is as follows:

1. Change in soil reaction
2. Development of nutrient imbalance /deficiencies
3. Damage the soil flora and fauna
4. Reduce the earth worm activity
5. Reduction in soil humus / organic matter
6. Change in atmospheric composition
7. Reduction in productivity
8. Reduction in quality of the produce
9. Destruction of soil structure, aeration and water holding capacity
10. Breeding more powerful and resistant pests and diseases

All these problems of GRT lead to not only reduction in productivity but also deterioration of soil health as well as natural eco-system. Moreover, to day the rural economy is now facing a challenge of over dependence on synthetic inputs and day by day it change in price of these inputs. Further, Indian Agriculture will face the market competition due to globalization of trade as per World Trade Organization (WTO). Thus apart from quantity, quality will be the important factor. Agriculture gave birth to various new concepts of farming such as organic farming, natural farming, bio-dynamic Agriculture, do-nothing agriculture, eco-farming etc.

The essential concept of these practices is “Give back to nature”, where the philosophy is to feed the soil rather them the crop to maintain the soil health. Therefore, for sustaining healthy ecosystem, there is need for adoption of an alternatives farming system like organic farming.

1.2 Definition of organic farming

Many scientists at different levels have elaborated the concept of organic farming; Lampkin (1990) Organic farming is a production system which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators and live stock feed additives.

Koferi (1992) (Korean organic farming environment Research Institute) It is the farming method by which we never use compound chemical fertilizers, agricultural chemicals, pesticides, growth hormones and uses natural sources such as organic matters, minerals, and microbes.

According to national organic standards board of the U.S. defines organic farming as an ecological production management system that promotes and enhances bio diversity, biological cycles and soil biological activity.

Organic farming refers to organically grown crops which are not exposed to any chemicals right from the stage of seed treatments to the final post harvest handling and processing (Pathak & Ram, 2003).

Organic farming relies on crop rotation, crop residues, animal manures, legumes, green manures, off-farming organic wastes, agricultural cultivation, mineral bearing rocks and aspect of biological pest control to maintain soil productivity and tilth to supply plant nutrients and also to control insects, weeds and other pests (Lamkin-1990). In a broader sense it includes biofertilizers, bio diversity and biotechnology.

1.3 Concept of organic farming

The basic concepts behind organic farming are:

1. It concentrates on building up the biological fertility of the soil so that the crops take the nutrients they need from steady turnover within the soil nutrients produced in this way and are released in harmony with the need of the plants.
2. Control of pests, diseases and weeds is achieved largely by the development of an ecological balance within the system and by the use of bio-pesticides and various cultural techniques such as crop rotation, mixed cropping and cultivation.
3. Organic farmers recycle all wastes and manures within a farm, but the export of the products from the farm results in a steady drain of nutrients.
4. Enhancement of the environment in such a way that wild life flourishes.

In a situation where conservation of energy and resources is considered to be important community or country would make every effort to recycles to all urban and industrial wastes back to agriculture and thus the system would be requiring only a small inputs of new resources to “Top Up” soil fertility.

1.4 Importance of Organic Farming

The agriculture today in the country is hampered by erosion of natural resources viz., land, water, biodiversity, fast declining soil fertility and use efficiency of inputs, such as water, fertilizer and energy. Demographic pressure accelerates the former and the faulty agronomic practices account for the latter problems. The modern agriculture with its

potential takes the country out of the food trap and to reach an era of self sufficiency in food grain production.

The present day for self sufficiency in food grain production may not last longer unless we develop a sustainable agricultural system which maintains and /or improves soil fertility and productivity with greater acceptance of biological principles so as to assure adequate/more food production in future. Besides plants are more prone to pest and diseases in intensive agriculture, use of chemicals can have residues on the produce, in the soil and in ground water. With more of purchased inputs cost of production is also mounting up. Pesticides use in paddy, cotton and vegetables which occupy less than 30 per cent of total area account for more than 80 per cent of the chemicals used.

Organic farming practices that reduces the pressure on land, water and bio-diversity without adverse effects on agricultural production and nutritive value of food comprise, judicious use of organic manure, viz. farm yard manure, compost, crop resides, Vermicompost etc. integrated is an efficient nutrient management practices, cropping systems, conjunctive use of rain, tank and under ground water, integrated pest management and conservation of genetic resources. Among them, soil fertility is give top attention due to its dynamic action with various physical, chemical and biological properties. Besides this, following advantages derived from organic farming:

1.5 Advantages of organic farming

1. Organic manures produce optimal conditions in the soil for high yields and good quality crops.
2. They supply all the nutrients required by the plant (NPK, secondary and micronutrients).
3. They improve plant growth and physiological activities of plants.
4. They improve the soil physical properties such as granulation and tilth, giving good aeration, easy root penetration and improved water holding capacity. The fibrous portion of the organic matter with its high carbon content promotes soil aggregation to improve the permeability and aeration of clay soils while its ability to absorb moisture helps in the granulation of sandy soils and improves their water holding capacity. The carbon in the organic matter is the source of energy for microbes which helps in aggregation.
5. They improve the soil chemical properties such as supply and retention of soil nutrients and promote favourable chemical reactions.
6. They reduce the need for purchased inputs.
7. Most of the organic manures are wastes or byproducts which on accumulation may lead to pollution. By way of utilizing them for organic farming, pollution is minimized.
8. Organic fertilizers are considered as complete plant food. Organic matter restores the pH of the soil which may become acidic due to continuous application of chemical fertilizers.

9. Organically grown crops are believed to provide healthier and nutritionally superior food for man and animals than those grown with commercial fertilizers.
10. Organically grown plants are more resistant to disease and insects and hence only a few chemical sprays or other protective treatments are required.
11. There is an increasing consumer demand for agricultural produces which are free of toxic chemical residues. In developed countries, consumers are willing to pay more for organic foods.
12. Organic farming helps to avoid chain reaction in the environment from chemical sprays and dusts.
13. Organic farming helps to prevent environmental degradation and can be used to regenerate degraded areas.
14. Since the basic aim is diversification of crops, much more secure income can be obtained than to rely on only one crop or enterprise.

1.6 Disadvantages of organic farming.

1. **Small holding**: The average size of an operational holding is 1.57 ha and further decreasing gradually due to population pressure.
2. **Poor infrastructure facilities**: i.e. lack of sufficient soil testing laboratories.
3. Lack of technological knowledge, lack of knowledge for use of bio-fertilizers, bio-pesticides, bio-control, IPM and INM etc.
4. Organic farming takes four years for a farmer to free his land completely stopping the use of chemical as nutrients & crop savers.
5. The neighbouring farmers do not well co-operate regarding use of fertilizer, pesticides, weedicides etc.
6. Decrease in production of high yielding crops like rice, wheat which needs high fertility status to get potential yield.
7. The competitive uses of organic materials such as dung-cakes for domestic cook fuel in villages and bagasse as fuel in sugar factories & villages.
8. Wheat & rice straws are disposed by burning, instead of return to the soil.
9. Dung, slurry & pig manure and other waste used directly in the field (without compositing), which damage the crop & pollute the ground water.
10. Most of organic material is bulky in nature, hence very difficult to store, carry and use.
11. Sewage, sludge contains pathogens and, some of them survive more than six months, which may hazard the human life and prove fatal for the animal .
12. City garbage contains un-decomposed materials such as metal, plastic, glass, stones, needles etc. which causes many problems,
13. Bio control agents are available only for few selected insect pests.
14. Complicated organic certification process and also high cost of certification.
15. High price expectations, delayed delivery, quality restrictions, lack of certification & marketing net work are the major problems for organic producers.

16. Major Indian and multinational companies are not interested in bio pesticides, also dealer's interest in chemical pesticides.

1.7 Objectives of Organic Farming

The objectives of organic agriculture have been expressed in the standard document of the International Federation of Organic Agriculture Movement (IFOAM) as follows:

1. To produce food of high nutritional quality in sufficient quantity.
2. To work with natural systems rather than seeking to dominate them.
3. To encourage and enhance the biological cycles within farming system involving microorganisms, soil flora and fauna, plants and animals.
4. To maintain and increase the long term fertility of soils.
5. To use, as far as possible, renewable resources in locally organized agricultural systems.
6. To work as much as possible, within a closed system with regard to organic matter and nutrient elements.
7. To given all livestock, conditions of life that allow them to perform all aspects of their innate behavior.
8. To avoid all forms of pollution that result from agricultural techniques.
9. To maintain the genetic diversity of the agricultural system and its surroundings, including the protection of plant and wildlife habitats.
10. To allow agricultural producers for adequate return and satisfaction from their work including a safe working environment.
11. To consider the wider, social and ecological impact of the farming system.

1.8 Essential Characteristics of Organic Farming

The most important characteristics are as follows:

1. Maximal but sustainable use of local resources.
2. Minimal use of purchased inputs, only as complementary to local resources.
3. Ensuring the basic biological functions of soil-water-nutrients-human continuum.
4. Maintaining a diversity of plant and animal species as a basis for ecological balance and economic stability.
5. Creating an attractive overall landscape which given satisfaction to the local people.
6. Increasing crop and animal intensity in the form of polycultures, agroforestry systems, integrated crop/livestock systems etc to minimize risks.

CHAPTER-2

PRINCIPLES, SCOPE AND COMPONENTS OF ORGANIC FARMING

1. Principles of Organic Farming

To understand the motivation of organic farmers, the practices they use and what they want to achieve, it is important to understand the guiding principles of organic agriculture. These principles encompass the fundamental goals and caveats that are considered important for producing high quality food, fiber and other goods in an environmentally sustainable way. Principles of organic agriculture have changed with the evolution of the movement and are now codified. The principles apply to agriculture in the broadest sense, including the way people tend soils, water, plants and animals in order to produce, prepare and distribute food and other goods. They concern the way people interact with living landscapes, relate to one another and shape the legacy of future generations. The principles of organic agriculture serve to inspire the organic movement in its full diversity. They are the roots from which organic agriculture grows and develops. They express the contribution that organic agriculture can make to the world and a vision to improve all agriculture in a global context. **Principles of organic agriculture** serve to inspire the organic movement in its full diversity.

The **International Federation for Organic Agriculture Movement's (IFOAM)** definition of organic farming is based on:

1. The Principle of Health.
2. The Principle of Ecology.
3. The Principle of Fairness.
4. The Principle of Care.

Each principle is articulated through a statement followed by an explanation. The principles are to be used as a whole. They are ethical principles to inspire action.

1.1 : The principle of health

Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible. This principle points out that the health of indivisibles and communities cannot be separated from the health of ecosystems — healthy soils produce healthy crops that foster the health of animals and people.

Health is the wholeness and integrity of living systems. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being. Immunity, resilience and regeneration are key characteristics of health. The role of organic agriculture, whether in farming, processing, distribution or consumption, is to sustain and enhance the health of **ecosystems** and organisms from the smallest in the soil to human beings. In particular, organic agriculture is intended to produce high quality, nutritious food that contributes to preventive health care and well-being. In view of this it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.

1.2 : The principle of ecology

Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

This principle roots organic agriculture within living ecological systems. It states that production is to be based on ecological processes and recycling. Nourishment and well- being are achieved through the ecology of the specific production environment. For example, in the case of crops this is the living soil; for animals it is the farm ecosystem; for fish and marine organisms, the aquatic environment.

Organic farming, pastoral and wild harvest systems should fit the cycles and **ecological balances** in nature. These cycles are universal but their operation is site-specific. Organic management must be adapted to local conditions, ecology, culture and scale. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain or improve **environmental quality** and conserve resources.

Organic agriculture should attain ecological balance through the design of **farming systems**, establishment of habitats and maintenance of genetic and agriculture diversity.

Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, bio-diversity, air and water.

1.3 : The principle of fairness

Organic agriculture should build up relationship that ensures fairness with regard to the common environment and life opportunities.

Fairness is characterized by equity, respect, justice and stewardship of the shared world; both among people and in their relations to other living beings.

This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties — farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a good quality of life and contribute to food sovereignty and reduction of poverty. It aims to produce sufficient supply of good quality food and other products.

This principle insists that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behavior and well-being.

Natural and environmental resources that are used for production and consumption should be managed in a way that is socially and ecologically just and should be held in trust for future generation. Fairness requires systems of production, distribution and trade that are open and equitable and account for real environmental and social costs.

1.4 : The principle of care

Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. Organic agriculture is a living and dynamic system that responds to internal and external

demands and conditions. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being. Consequently, new technologies need to be assessed and existing methods reviewed. Given the incomplete understanding of ecosystems and agriculture, must be taken.

This principle states that precaution and responsibilities are the key concerns in management, development and technology choices in organic agriculture. Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound. However, scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge offer valid solutions, tested by time. Organic agriculture should prevent significant risks by adoption appropriate technologies and rejecting unpredictable ones, such as **genetic engineering**. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

2.0 SCOPE OF ORGANIC FARMING

The movement started with developed world is gradually picking up in developing countries. But demand is still concentrated in developed and most affluent countries. Local demand for organic food is growing. Success of organic movement in India depends upon the growth of its own domestic markets. India has traditionally been a country of organic agriculture, but the growth of modern scientific, input **intensive agriculture** has pushed it to wall. But with the increasing awareness about the safety and quality of foods, long-term sustainability of the system and accumulating evidences of being equally productive, the organic farming may emerge as an alternative system of farming which addresses the quality and sustainability concerns.

Large-scale use of inputs both organic and inorganic has been a common sight in many of the farming situations in the past several decades. However, in recent times the concept of organic farming is being forcefully projected as the method for sustaining the agricultural production in the country.

Organic farming is a form of agriculture which avoids or largely excluded the use of synthetic fertilisers and pesticides, plant growth regulators and livestock feed additives. Organic farming relies on **crop rotation, crop residues,** animal manures, **bio-fertilisers** and mechanical cultivation to maintain **soil productivity**, to supply plant nutrients and to control weeds, insects, disease and other pests.

Before jumping into organic farming bandwagon, we need to have answers to the following: What level of crop yield/productivity is acceptable? It is suitable for country like India with a large population to feed? Whether available organic sources of plant nutrients sufficient for pure organic farming? And, are organic farming technologies sustainable in long run?

Whether organic farming can address the multitude of problems faced by Indian agriculture at present is a major issue. Further, the virtues attributed to organic farming need to be rechecked before coming to any conclusions.

2.1: Issues of concern

Major issues to be considered for a decision on conventional agriculture or organic agriculture are:

- Organic farming and nutrient supply.
- Organic farming and plant protection.
- Organic farming and crop productivity.
- Organic farming and certification processes.
- Organic farming and heterogeneity of inputs.
- Organic farming and food quality.
- Organic farming products and marketing.
- Organic farming and switch over period.

2.1.1 Organic Farming and Nutrient Supply

At present, there is a gap of nearly 10 M t between annual addition and removal of nutrient by crops which are met by mining nutrients from the soil. A negative balance of about 8 M t NPK is foreseen in 2020, even if we continue to use chemical fertilizers, maintaining present growth rates of production and consumption. The most optimistic estimates at present showed that only about 25-30 per cent nutrient needs of Indian agriculture can be met by utilising various organic sources. These organic sources are agriculture wastes, animal manure etc.

2.1.2 Organic Farming and Plant Protection

Plant protection against the ravages of pests, diseases and weeds is an important issue if any modern high production system. Exclusion of pesticides for plant protection poses greater risk of yield losses. Options available under organic production systems are very few and crop specific. Often they are very slow and the success rate depends on the prevailing weather conditions leading to low to moderate effectiveness even in the recommended crops and situations. Thus, they limit the realization of full potential of crop yields. Any sudden outbreak of insect pests or plant disease can completely destroy the crops, unless requisite chemical pesticides are used.

2.1.3 Organic Farming and Crop Productivity

In general, it is observed that the crop productivity declines under organic farming. The extent of decline depends on the crop type, farming systems practices followed at present etc. The decline is more in high yielding and high nutrient drawing cereals as compared to legumes and vegetables and in irrigated systems as compared to rainfed and dryland farming systems. Without using fertilizers, the requirement of area to merely sustain the present level of food grain production will be more than the geographical area of India! This is simple neither possible nor sustainable.

2.1.4 Organic Farming and Certification Processes

There are no standard certification processes uniformly applicable across different agro-climatic conditions. Both process and product certification procedures are still evolutionary stage and need further progress they can be effectively adopted. Due to biological nature of both processes and products, there is always an element of dynamism subject to temporal and spatial conditions. Presently available certification procedures are very cumbersome and expensive and out of reach for the common farmer. Due to highly fragmented holdings of the farmers, there is possibility of "contamination" from the neighbouring farms-besides the temptation to use chemical inputs to boost yields.

2.1.5 Organic Farming and Heterogeneity of Inputs

There is large variability in the inputs used in organic farming. Due to biological nature of the inputs, prescribing uniform standards and maintaining them in different agro - climatic conditions is beyond ones control. Thus leads to arbitrariness on the part of organic farmers as far as input management is concerned.

2.1.6 Organic Farming and Food Quality

It is often opined that the quality of the organically produced food is superior to that of conventionally produced food. However, there is no such conclusive proof to justify the nutritional superiority of the organically produced food over conventionally produced food. If the conventionally produced foods are blamed to contain traces of chemical residues, the organically produced foods are equally to be blamed for their contamination with harmful bacteria and other organism inimical to the health of the consumers.

2.1.7 Organic Farming Products and Marketing

There are no diagnostic techniques available as of now to distinguish products from different farming systems. The perceived belief that organic products are good for health is fetching them premium prices. However, unscrupulous hawkers may sell anything and everything as organically produced to unsuspecting buyer at higher prices resulting in outright cheating.

2.1.8 Organic Farming and Switch over Period

A transition period of 3-4 years is generally required to convert a conventional farm into an organic farm. In this period, the produce is not considered as organically produced. The reduced yield and lack of benefits of premium for the produces is a double blow for the farmers leading to financial losses which are substantial for the small to medium farmers.

2.2: THE POSSIBLE OPTIONS

With all the above concern, *organic farming is not feasible as* ***an alternative to conventional farming*** *under all circumstances in Indian context*. The shortfall in inorganic nutrient supply, uneconomic returns to inorganic inputs under dry land and **rainfed farming** systems, inherent better response to organic farming in crops like vegetables, legumes and millets under traditional farming systems paves way for integration of conventional farming with organic farming. Such integration on sound scientific basis will be effective in

addressing the problems of micronutrients deficiencies, recycling of crop residues, farm wastes, rural and urban waste, besides effectively meeting growing food demands of rising populations. There will also be scope for practicing organic farming on case basis in traditional strongholds like hilly areas, rainfed and dryland farming system to cater to the demands of organic produces in urban areas that would pay premium prices for such commodities.

Organic farming should be considered for lesser endowed region of the country. It should be started with low volume high value crops like spices and medicinal and aromatic crops. A holistic approach involving integrated nutrient management, integrated pest management, enhanced input use efficiency and adoption of region-specific promising cropping systems would be the best farming strategy for India.

Organic foods are a matter of choice of the individuals or enterprises. If somebody wants to go for organic farming, primarily on commercial consideration/profits motive, to take advantage of the unusually higher prices of organic food, they are free to do so. Organic farming is essentially a marking tool and cannot replace conventional farming for food security, quality and quantity of crop outputs. With a growing population and precarious food situation, India may not afford to take risk with organic farming alone as of now.

3.0 COMPONENTS OF ORGANIC FARMING

The components of organic farming are discussed in this section:

3.1: Organic Manures

Organic materials such as farm yard manure, biogas slurry, compost, straw or other crop residues, biofertilisers, green manures and cover crops can substitute for inorganic fertilisers to maintain the environmental quality. In addition, the organic farmers can also use sea weeds and fish manures and some permitted fertilisers like basic-slag and rock phosphate. Crop rotation with legumes as well as green manuring also provides nutrients and improves the soil fertility.

3.2: Non-chemical weed control measures

Compared to conventional farmers, the organic farmers use more of mechanical cultivation of row crops to reduce the weed menace. No herbicides are applied as they lead to environmental pollution.

3.3: Biological pest management

The control of insect pests and pathogens is one of the most challenging jobs in tropical and sub-tropical agriculture. Here again non-chemical, biological pest management is encouraged. The conservation of natural enemies of pests is important for minimising the use of chemical pesticides and for avoiding multiplication of insecticide-resistant pests. Botanical pesticides such as those derived from neem could be used. Selective microbial pesticides offer particular promise, of which strains of *Bacillis thuringiensis* is an example.

CHAPTER:3
COMPONENTS OF ORGANIC FARMING AND THEIR ROLE IN SUSTAINABLE CROP PRODUCTION

1. Crop and Soil Management

Organic farming systems encourage the use of rotations and manures to maintain soil fertility. Crop rotations with legumes add to soil fertility. Green manuring and intercropping of legumes is another important aspect for organic farming system not only in regard to weed control, but also in reducing the leaching of nutrients and in reducing soil erosion. Carefully managed soils with 2a high proportion of humus offer essential advantages with respect to water retention, ion exchange, soil erosion and animal life in the soil. A high proportion of humus in the soil gives uniform distribution of nutrients and also plant hygiene.

2. On Farm Waste Recycling

The recycling of various forms of residues has advantage of converting surplus farm wastes in to useful products for meeting nutrient requirement of crops besides maintaining the soil productivity and improving the ever all ecological balance.

Cereals, pulses, oilseeds commercial crops one animal dropping are the major source for recycling source for recycling of valuable plant nutrients for sustainable crop production in India. The estimate of ministry of finance 1990-91 and FAO the available plant residue is to an extent of 350 million tomes. This potential of crop residues helps to recycle valuable plant nutrient to an extent of 5 million tonnes of NPK.

Increasing prices of chemical fertilizers have enable organic wastes to regain an important role in the fertilizer practices on the farm. Good manure management means improved fertilizer value of manure and slumy and less nutrient losses. Composting of all organic waste in general, and of farm yard manure or feedlot manure in particular is important in organic farming (Dahama, 1996).

3. Non-chemical Weed Management

Weed management is one of the main concerns in organic agriculture. To day, herbicides lead other pesticides in world pesticide trade with 43 % share. The use rate is particularly high in developed nations. The increased use of pesticides, however, has resulted in multiple problems. Because of their slow and low degradability the environmental safety has been doubted. That apart, weed species are developing resistance to chemical toxicants (Gautam and Mishtra, 1995). e.g. In India, *Phalaris minor* in wheat belt has developed resistant to isoproturon herbicide. There is also problem of secondary pest and resurgence of weeds. In view of all these, developed nations are already taking measures to reduce chemical load and are trying to find out chemical free means of weed management.

The elements to consider in preventing and control of weeds problems are tillage practices, irrigation management, competitive crops intercropping, crop rotation, plant geometry, solarization, thermal methods (flame gun's), biological control, green manuring and manure management. Mulching on a longer scale by using manure spreaders may also be useful in weed control.

4. Biological Pest Control

4.1 Cultural Practice

Cultural practice is the oldest form of deliberate biological pest control. It is the baseline, the prime technique which every good farmer uses to protect his products. However, fine tuning by cultural practices is extremely complex. One can determine the precise action to maximize yield for each crop with every seed quality in soil types of varying

textures and quality with every alternative method and timing of ploughing and tillage with possible addition of natural fertilizers at various times, with every possible planting and harvesting date, under varied conditions of residue removal and destruction, crop rotation, intercropping, with pretreatments like flooding and lastly, under weather conditions that lack extremes that are unpredictable and never follow the same pattern twice.

4.2 Resistance

Plant resistance is also included in the definition of biological control. Plant breeders have had many successes in production varieties resistant to disease and occasionally to insets, although not so far weeds. Resistance to soil pathogens may also be provided by the use of resistant root stocks and grafting. Recent research has shown that plant can locally accumulate antimicrobial compounds (Phytoalexins) in response to invasion by disease.

Crop	*Tolerant/Resistant variety*	*Pest/Disease*
Cotton	(a) LK-861, NI-1280, Kanchana (b) H-8, NHH-44, NHH-390,L-603 (c) Narasimha	White fly Jassids Helicoverpa
Groundnut	(a) ICGS-11, ICGS-44,Vemana (b) ICGS-10, ICGS-4	Bud rot Root rot

4.3 Growing Trap Crop

Crop plants more preferred by the pest for egg laying and feeding are grown as trap crops on the bunds of the main crop or one row after every 10 rows.

Crop	*Pest*	*Trap crop*
Cotton, Groundnut	*Spodoptera*	Castor, sunflower
Cotton, Chickpea	*Helicoverpa*	Marigold
Pigeonpea	*Helicoverpa*	Marigold
Sesamum	Red hairy caterpillar	Cowpea
Green gram	Red hairy caterpillar	Sunnhemp

Removal and destruction of egg masses and small caterpillar from trap crop.

4.4 Monitoring Pest Population

(a) Pheromone traps
(b) Light traps: Use one light trap for five hectare area

4.5 Erecting Bird Perches

Bird perches help in attracting birds, keep water in a small bowl and spread cooked yellow rice to attract insectivorous birds.

4.6 Releasing Parasites and Predators

For management of boll worm of cotton, egg-larval parasites viz., *Trichogamma sp.* and *Chelonus sp.* and predators viz. crysopa were found effective. For the control of pyrilla, *Epiricania melanoleuca* and for top borer and stem borer *Trichodermma chelonis* and *Trichodermma japonicum* should be released in sugarcane field.

4.7 Biological Chemicals

Another definition of biological control is the use of natural chemical. The identification of natural chemicals and subsequent formation of their derivatives can open new areas of pest control. Chemicals which do not kill the insects, but either attract, repel modify their usual behavior, may also be regarded as biological control agents. Behavior modifying chemicals which reduce mating frequency or release large number of sterile insects, control pests biological by reducing their numbers.

Pest	*Biochemical*	*Action*
Spodoptera, Helicoverpa Leaf folder, all defoliator and sucking pest.	Control by neem oil	Azadirection active ingredient act as a repellent and antifident
White fly, Aphids, Jassids, Helicoverpa	Tobacco decocting (Not be used more than two times)	Nicotine Sulphate acts as a contact poison and fumigants.

4.8 Biological Disease Control

A major success in plant disease control has been the discovery. Development and marketing of *Agrobacterium rediobacterium* for the prevention of crown gall caused by *Agrobacterium temufaciens.* When root pruned seedlings are dipped in liquid suspensions of *A. radiobacter*, crown galls do not develop on the newly planted seedlings even in fields infested with *A. temufaciens*. Trichogramma has potential as a preventive agent against *Sclerotium* and *Rhizoctonia.*

4.9 Bioherbicides

Bioherbicides are biological control agents applied in similar ways as chemical to control weeds. The active ingredient in a bio-herbicide is a living organism, mostly a micro organism. A herbicide made of mycelia fragments or spore of fungi is called mycoherbicide. Commercial bioherbicides first appeared in the market in the USA in the early 1980's with the release product "Devine" in 1981 and "Collego" in 1982.

The Bureau of Plant Pathology of the division of plant industry in Gainsville, Florida has developed the use of *Phytophthora palmivora* for the control of milk weed vine in citrus orchards.

Aeschynomene virginica, a leguminous weed in rice, can be effectively controlled by collecting *Trichum gloeosporidis* Sp. *Aeschynomene*.

4.10 Bio-insecticides

Biological control of insects by microorganisms has been the subject of most research and development efforts in the past and is consequently the most successful aspect of biological control. At present 3000 organisms have been reported to cause disease in insects. In viruses, two most important subgroups are (i) Nuclear Polyhedrosis Viruses (NPV) (ii) Granulosis virus (GV). In Bacteria, *Bacillus thuringiensis* (BT) is known to infect of the caterpillars and few beetle grubs. *Bacillus thuringiensis* has been commercially available for the last 30 years. Improvements in the strain and formulations have led to a substantial in the market size for the control of over 100 insect species. A new strain of *B. thuringiensis* var. *israclienesis* available for control of mosquitoes including Anopheles.

Chapter-3.
Initiatives for Promoting Organic Farming

In ability of Indian agriculture to meet the demand for food in the country during the two and a half decades immediately after independence had been a matter of concern at those times. The system of our agriculture based on traditional knowledge and practices handed down from generation to generation could not produce enough to feed the increasing population. The ignominy of our dependence for food on the western developed nations and the politics of food aid practiced by them added to our determination to be self- sufficient in food production by modernising agriculture. The **"Green Revolution"** fulfilled our aspirations by changing India from a Food importing to a food exporting nation.

However, the achievement was at the expense of **ecology** and environment and to the determent and of the well-being of the people. Agriculture system adopted from the west has started showing increasing unsustainability and once again the need for appropriate method suitable to our requirements is being felt.

The practice of organic farming, said to the best known alternative to the conventional method, also originated in the west, which suffered from the ill — effects of chemical agriculture. However, organic farming is based on the similar principles underlying our traditional agriculture. **Organic agriculture** aims at the human welfare without any harm to the environment which is the foundation of human life itself.

Conventional farming had helped India not only to produce enough food for own consumption but also generated surpluses for exports. However, the increasing population and income will lead to further increase in demand for food and also for raw materials for industry. The modern system Of farming, it is increasingly felt, is becoming unsustainable as evidenced by declining crop productivities, damage to environment, chemical contaminations etc. The necessity of having an **alternative agriculture** method which can function in friendly ecosystem while sustaining and increasing the crop productivity is realized now Organic farming is recognised as the best known alternative to the conventional agriculture.

The first conference of NGOs on organic farming in India was organized by the Association for Propagation of Indigenous Genetic Resource (APIGR) in October 1984 at Wardha. Several other meetings on organic farming were held at different places in the country towards the end of 1980s. Here, mention must be made of the **Bordi Conference** in Maharashtra, the state which was the focal point for the organic farming movement in India. The Rajasthan College of Agriculture with the support of the state government organized a meeting on organic agriculture in 1992. The United Planters' Association of South India **(UPASI)** organized two national level conference on organic farming in 1993 and 1995. Then **ARISE** (Agricultural Renewal in India for a Sustainable Environment) is a major organization in the country engaged in the Promotion of organic farming. The ARISE comprises of a supporting network of regional groups aiming at sustainable environment by protecting **bio – diversity** and promoting organic agriculture practices. The selection of Auroville for the conference was apt as it housed the Arabindo Ashram and pioneering work

under its auspices on building technology, alternative energy research, wasteland development, afforestation and organic agriculture.

By 1980, three groups of Indians had taken to Organic farming. The first one consisted of urban educated technocrats for peripheral interest, which did not last long. Educated farmers consisted of the second group whose farming practices were based on scientific knowledge. The third group practiced organic farming through trail and error. Successful organic farmers in India are those who have access to sufficient natural resources like, water and other organic inputs mostly on their own farms. These farms Produce crops like sugarcane, areca, cocoa, coconut, pepper, and spices. Many of them have shown that switch over to organic farming to do not affect yields and income and more importantly, knowledge/expertise is available for successful adoption of organic farming in the country.

The International Federation of Organic Agriculture Movements (IFOAM) estimates that an area of about 42,000 has in India is under organic farming representing about 0.18 per cent of the world organic acreage as in the year 2015. Non — Governmental Organisations (NGOs) are spearheading organic farming in India. About 15,000 tonnes of organic products have been raised in India. They include tea, coffee, rice, wheat, pulses, fruits, spices and vegetables. India exports organic agricultural products to European Union, USA, Canada, Saudi Arabia, UAE, Japan, Singapore and Australia, among others.

The international conference on "Indian Organic Product-Global Markets" at the end of 2002 was the first to be held in India. IFOAM predicts that India and China have great potential to be organic farm produce exporters in the future. An important event in the history of the modern organic farming in India was the unveiling of the National Programme for Organic Production **(NPOP)** on 8th May, 2000 and the subsequent **Accreditation** and **Certification Programme** in October, 2001. The logo "Indian Organic" was released on 26th July 2002 to support the NPOP.

3.1 INDIA ADVANTAGE

India is endowed with various types of naturally available organic form of nutrients in different parts of the country and it will help for organic cultivation of crops substantially. There is diversity in climates: 100 – 10,000 mm rainfall, hill, desert, strong traditional farming stem – crop – tree animal, innovative farmers, vast dry lands (60% agriculture land), least use of chemicals. In fact, the rainfed, tribal, north — east and hilly regions of the country where egligible chemicals used are practicing subsistent agriculture for a long period.

These areas are organic by default. As regards the availability of major organic nutritional inputs (NPK) in India, the estimate of National Centre of Organic Farming, Ghaziabad is as follows:

- **Crop residue = 3.865 million tonnes.**
- **Animal dung = 3.854 million tonnes.**
- **Green manure = 0.223 million tonnes.**

- **Bio – fertilizer = 0.370 million tonnes.**

Besides, there is enough scope of using **bio –dynamic** preparation, vermicompost, Amrit pani etc. on on-farm production basis.

An appropriate national agriculture policy, giving a prominent place to organic farming addressing the issues related to its coverage, financial support during the **conversion period**, creation of linkages among the farmers, processors, traders and consumers, inspection and certification and organic products and increasing the public awareness of the benefits of organic agriculture along with the ill effects of the conventional system, should be designed. This must be followed by concrete action on the ground if we do not want to miss the far reaching changes all over the world heralded by the organic farming movement.

3.2 GOVERNMENT POLICY ON PROMOTING ORGANIC FARMING

Organic farming appears to be one of the options for sustainability. Starting of organic agriculture in India in 1900 by Sir Albert Howard, a British agronomist in North India, Development of Indore Method of **aerobic compost** (Howard 1929), Bengaluru method of **anaerobic compost** (Archarya 1934), NADEP Compost (ND Pandari Panda, Yeotmal 1980) initiated organic agriculture in India.

The year 2000 is very important year for India from organic point of view. The four major happenings were made during the year 2000. These are:

1. The Planning Commissions constituted (2000) a steering group on agriculture who identified organic farming as national challenge and suggested that it should be taken in the form of a project as major thrust area for 10^{th} Plan. The group recommended organic farming in NE region, rainfed areas and in the areas where the consumption of agrochemical is low or negligible.
2. The National Agricultural Policy (2000) recommended promotion of tradition knowledge of agriculture relating to organic farming and its scientific up gradation.
3. The Department of Agriculture and Cooperation (DAC), Ministry of Agriculture constituted (2000) a Taskforce on Organic farming under the chairmanship of Shri Kunwar ji Bhai Yadav and this task force recommended promotion of organic farming.
4. The Ministry of Commerce launched the National Organic Programme in 2000 and Agricultural and Processed Food Products Export Development Author **(APEDA)** is implementing the National Programme for Organic Production (NPOP) Under the NPOP, documents like national standards, accreditation criteria accrediting inspection and certification agencies, accreditation producer, inspect and certification procedures have been prepared and approved by National Steen Committee (NSC).

The policy of Ministry of Agriculture seeks to promote technically sound, economical viable, environmentally non-degrading and socially acceptable use of natural resources favour of organic agriculture. The policy seeks to actualize the area and crop potential strengthening rural economy, promoting value addition, accelerating growth of agribusiness and securing a fair standard of living for the farmers and agricultural and their families.

3.2.1 NATIONAL PROJECTS ON ORGANIC FARMING

The Department of Agriculture and Cooperation (DAC), Ministry of Agriculture, Government of India has launched a new Central sector scheme ' National Project on Organic Farming' (NPOF) with an outlay of ₹ 57.05 crore for production, promotion and market development of organic farming in the country during 10th Plan on pilot basis. The project is operation since 1st October, 2004. Its Headquarter is NPOF, Ghaziabad which has six regional centers (RCOFs) at Bengaluru, Bhubneshawar, Hisar, Jabalpur, Imphal and Nagpur.

The unique feature of this scheme is to promote group certification by capacity build through service provider where the service provider will help organic farmers by providing training, educating on record management, supervising internal control system, assisting certification and market access. One Service provider will be registered with 1500 farmer working in identical geographical condition with similar type of crop. The group certification will reduce cost of certification.

3.2.2 FAO-DAC PROJECT ON ORGANIC FARMING

The Ministry of agriculture has taken up the Technical Cooperation Program (TCP) of FAO (TCP/IND/3003 — Development of Technical capacity Base for the Promotion of Organic Agriculture in India) to overcome the knowledge gap by quickly production basic information tailored to various ecological zones of the country on the current state knowledge on organic crop productivity packages, input production and utilization and certification issue including legal and institution aspects. The project is operational since April, 2005.

3.2.3 CONSTITUTION OF ORGANIC EXPERT PANEL BY DAC

There are many issues on crop productivity and input use under organic farming which have been raised by various concerns. To address all these issues, the Ministry Of Agriculture constituted (July, 2005) an organic expert's panel under the chairmanship Of Dr.
H.P. Singh, Dean, G.B. Pant Agricultural University. Based on the recommendation of this panel, the approach towards organic farming could be reviewed.

3.2.4 ORGANIC FARMING APPROACH BY NAAS

The National Academy of Agriculture Science (NAAS) has issued a Policy Paper on Organic Farming, Which concludes that while synthetic pesticides can be avoided, complete exclusion of fertilizers may not be advisable under all situations. The NAAS recommends

that a "holistic approach Involving Integrated Nutrient Management **(INM)**, Integrated Pest Management **(IPM)**, enhanced input use efficiency and adoption of region-specific promising **cropping system** would be the best organic farming strategy for India". To begin with, the practice of organic farming should be foe low volume, high value crops like spices, medicinal plants, fruits and vegetables. The NAAS has also emphasized the need for intensive research on **soil fertility** and plant health management and on issues relating to microbial contamination of food arising from the use of **farm yard manures**.

3.3 GLOBAL SCENARIO OF ORGNIC FARMING

The negative effects of modern chemical based farming system were first experienced by those countries, which introduce it initially. So, naturally, it was in those countries organic farming was adopted in relatively large scales. There are very large organizations promoting the organic farming movement in European countries, America, Australia etc. These organizations, for example, the International Federation of Organic Agriculture Movements **(IFOAM)** and Greenpeace have studied the problems of the chemical farming methods and compared the benefits accruing to the organic farming with the former. Organic farming movements have since spread to Asia and Africa too.

3.3.1 PRE – WORLD WAR II

Organic Agriculture (as opposed to conventional) began more or less simultaneously in Central Europe and India. The British botanist **Sir Albert Howard** is often referred to as the **father of modern organic agriculture.** From 1905 to 1924, he worked as an agricultural adviser in Pusa, Bengal, where he documented traditional Indian farming practices and came to regard then as superior to his conventional agriculture science. His research and further development of these methods is recorded in his writings, notably, his 1940 book, An Agricultural Testament, which influenced many scientist and farmers of the day.

In Germany, **Rudolf Steiner's** development, **bio-dynamic agriculture**, was probably the first comprehensive organic farming system. This began with a lecture series Steiner presented at a farm in Koberwitz (now in Poland) in 1924.

In 1909, American agronomist **FH King** toured China, Korea and Japan, studying traditional fertilization, tillage and general farming practice. He published his findings in Farmers of Forty Centuries (1911, Courier Dover Publication). King foresaw a "World movement for the introduction of new and improved methods" of agriculture and in late years his book became an important organic reference.

The term **organic farming** was coined by **Lord Northbourne** in his book Look to the Land (written in 1939, published 1940). From his conception of "the farm as organism", described a holistic, ecologically balanced approach to farming.

In 1939, influenced by Sir Albert Howard's work, Lady Eve Balfour launched Haughley Experiment on farmland in England. It was the first scientific, side — by — side

comparison of organic and conventional farming. Four years later, she published The soil, based on the initial findings of the Haughley Experiment.

In Japan, **Masanobu Fukuoka,** a microbiologist working in soil science and plant pathology, began to doubt the modern agricultural movement. In 1937, he quit his job as research scientist, returned to his family's farm in 1938 and devoted the next 60 years developing a radical no-till organic method for growing grain and many other crops, no known as **Nature Farming** (Natural Farming), 'do-nothing' farming or **Fukuoka Farming**.

3.3.2 POST – WORLD WAR II

Technological advance during World War II accelerated post — war innovation in aspect of agriculture. At the same time, increasingly powerful and sophisticated farming machinery allowed a single farmer to work larger areas of land and fields grew bigger.

In 1944, an international campaign called **green revolution** was launched in Mexico with private funding from the US. It encouraged the development of hybrid plants, Chemical controls, large-scale irrigation and heavy mechanization in agriculture around the world.

During the 1950s, **sustainable agriculture** was a topic of scientific interest, but research tended to concentrate on developing the new chemical approaches. In the US, began to popularize the term and methods of **organic growing** particularly to consumed through promotion of organic gardening.

In 1962, **Rachel Carson,** a prominent scientist and neutralist, published Silent spring chronicling the effects of DDT and other pesticides on the environment.

In the 1970s, global movements concerned with pollution and the environment increase their focus on organic farming. As the distinction between organic and conventional food became clearer, one goal of the organic movement was to encourage consumption of local grown food.

In 1975, Fukuoka released his first book, The One-Straw Revolution, with a strong impact in certain areas of agricultural world. His approach to small — scale grain production emphasized meticulous balance of the local farming ecosystem and a minimum of human and labor.

In the 1980s, around the world, farming and consumer groups began seriously pressuring government regulation of organic production. This led to legislation and certification being enacted through the 1990s and to date.

Since the early 1990s, the retail market for organic farming in developed economies has growing by about 20 per cent annually due to increasing consumer demand. Concern the quality and safety of food and the potential for environmental damages from conventional culture are apparently responsible for this trend.

In approximately 150 countries of the world, organic farming is being practiced and the under organic management is continuously growing.

TABLE 3.1 Land area of major countries under organic management (2017)
(FiBL Survey – 2019)

No.	Name of country	Area under organic (m ha)	No.	Name of country	Area under organic (m ha)
1.	Australia	35.65	7.	China	3.01
2.	Argentina	3.39	8.	Japan	0.009
3	USA	2.03	9.	India	1.7
4.	UK	0.49	10.	Pakistan	0.05
5.	Germany	1.37	11.	Sri Lanka	0.17
6.	South Africa	0.41	12.		
	All World	**69.85**			

Standard

Globally there are more than 60 standards which include IFOAM basic standard CODEX Alimentations Commission guidelines, **EU Regulation** 2029/91, **NOP** of USA.

SOME FACTS ON INTERNATIONAL STANDARDS

1 IFOAQM	• Established in 1972 • Headquarters in Germany • Umbrella for organization Organic Agricultural Association • Developed internal basic standards of organic agriculture • Set up International Organic Accreditation Service (IOAS) July 2001
2 CODEX	• Codex Alimentarious Commission – A joint FAO/WHO • Intergovernmental body • Established in 1962 • Produce a set of guidelines for organic production
3 EU REGULATION	• Laid out a basic regulation for European Union organic standard in counsel Regulation No 2092/91 (June 1991)
4 DEMETER	• Demeter internationals is worldwide network of 19 International certification Bodies in Africa, Australia, Europe • Developed guidelines for biodynamic preparation
5 JAS	• A set of guidelines Japan Agricultural Standards For organic Farming

Certification

As per Organic Certification Dictionary, 2003 as published by Grolink, there are 3 certification bodies across the world, but they are unevenly spread. Around 300 of them located in European Union, USA, JAPAN, Canada and Brazil. There is IFOAM accreditation programme, launched in 1992, by initiating International Group accreditation Service **(IOAS)**

CHAPTER :5
NUTRIENT MANAGEMENT IN ORGANIC FARMING

Introduction

In order to realize the potential of production systems on a sustained basis, efficient management of resources is crucial (essential). A successful farming system relies on the management of organic matter to enhance physico-chemical and biological properties of the soil. The effects of soil organic matter are dynamic as it is a source of gradual release of essential plant nutrients; improves soil structure, its drainage, aeration and water holding capacity (WHC); improves soil buffer capacity; influence the solubility of minerals and serves as a source of energy for the development of micro-organisms.

According to a conservative estimate, around 600 to 700 m t of agricultural waste is available in the country but it is not managed properly. We must convert waste into wealth by converting this biomass into energy, nutrient to starved soil and fuel to farmers. India produces about 1800 m t of animal dung per annum. Even if ⅔ of the dung is used for biogas generation, it is expected to yield about 440 m t/ annum of manure, which is equivalent to 2.90 m t N, 2.75 mt P_2O_5 and 1.89 m t K_2O.

CONCEPT AND DEFINITION OF INM

The concept of biological INM is the continuous improvement of soil productivity on long-term basis through appropriate use of organic manures, green manures, BGA, biofertilizers and other biological derived materials and their scientific management for optimum growth, yield and quality of crops and intensive cropping systems in specific agro- ecological situations.

Definition of Biological INM

According to Sanchaz (1994). It should relay on biological processes by adapting germplasm to adverse soil conditions, enhancing soil biological activity and optimizing nutrient, cycling to minimize external inputs and maximize the efficiency of their use.

It can also be defined as “a system for approaching of soil nutrient management which maintain soil health, soil fertility, sustaining agricultural productivity and improving farmers profitability through effective, judicious and intensive use of biological based nutrient management resources”. The resources are biofertilizers, organic manures green manuring crop rotation, N-fixing organisms, mycorrhizae, PSM etc.

Role of different sources for biological INM

4.1 ORGANIC MANURES

Term ‘manure’ was used originally for denoting materials like cattle manure and other bulky natural substances that were applied to land, with the object of increasing the production of crops. Therefore, manures are defined as the plant and animal wastes which are used as sources of plant nutrients.

Urine is normally low in phosphorus and high in potash, where as about equal parts of nitrogen may be excreted in faeces and urine of the cattle. Hence the manure in which the proportion of the urine was allowed to drain away would be relatively low in N and K. Poultry manure is very important for organic farming due to there will be no loss of urine, since both liquid & solid portions are excreted together.

Fresh poultry manure creates local alkalinity, it may hamper the standing crop. Therefore, it is recommended to preserve the excreta at least for six months with suitable amendments and appropriate microbes.

ADVANTAGES OF MANURING

Manures supply plant nutrients including micro nutrients
They improve soil physical properties
Increase nutrient availability
Provide food for soil micro organisms

Provide buffering action in soil reaction

Improve soil tilth, aeration and WHC of the soil

On the basis of concentration of nutrients, manures can be grouped into two categories-

(A) Bulky organic manures

Contain small percentage of nutrients and they applied in large quantities like FYM, compost, green manure, biogas slurry, night soil, sewage and sludge, poultry manure, sheep & goat manure, animal waste, crop residue etc.

A.1 FARM YARD MANURE (FYM)

Most commonly used organic manure in India. It refers to the decomposed mixture of dung and urine of farm animals along with litter and left over materials from roughages or fodder fed to the animals. It contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O. Urine contains 1% N and 1.35% K_2O. *Litter is the straw, peat, sawdust and dry leaves used as bedding material for farm animals and birds.* The N present in urine is mostly in the form of urea which is subjected to volatilization losses. Chemical preservatives are used to reduce losses and enrich FYM e.g. gypsum, kainite and super phosphate. These preservatives absorb urine and prevent volatilization loss of urea and also add nutrients.

A.2 COMPOST

Compost means 'a product obtained by the controlled decomposition of organic wastes (*composting*), finally used as organic manure'. Composting is the process of reducing animal and vegetable refuse (except dung) to a quickly utilizable condition for improving and maintaining soil fertility. The final well decomposed manure having lower C: N ratio is termed as 'compost'. The recycling of organic materials by biological decomposition as manure is very important for organic farming as it kills weed seeds, pathogenic organisms, and dispose off agricultural / industrial wastes to produce a uniform, slow release organic fertilizer which stimulates soils life, improve soil structure and control insect-pests and diseases. Compost contains 0.5-0.15-0.5 N,P,K, respectively.

A.3 BIOGAS SLURRY

Instead of directly using the animal dung for composting it can be used for production of biogas by feeding through Biogas Plants. It contains (1–1.8% N, 0.4–0.9% P_2O_5 and 0.6- 1% K_2O) due to low volatilization losses of ammonia.

A.4 NIGHT SOIL (Poudrette)

Night soil is human excreta, both solid and liquid. It contains 5.5% N, 4% P_2O_5 and 2% K_2O. The dehydration of night soil, as such or after admixture with absorbing materials like soil, ash, charcoal and sawdust produces a poudrette that can be used easily as manure. Poudrette contains about 1.32% N, 2.8% P_2O_5 and 4.1% K_2O.

A.5 SEWAGE AND SLUDGE

1.1.1 The solid portion in the sewage (human excreta + water) is called *sludge* and liquid portion is *sewage water*. It can be recycled for crop fertilization, irrigation to the crop, aquaculture production, application to forest land, biogas production and land reclamation. It was estimated that total waste generated by 217 million people in urban areas is 39 mt/ year (2001). The total NPK content of this would be 2.5 lac tone of N, 2.6 lac tone of P and 2.6 lac tone of K. Both the components are separated and are given a preliminary fermentation and oxidation treatments to reduce bacterial contamination and offensive smell, otherwise soil quickly becomes "**sewage sick"** owing to the mechanical clogging by colloidal matter in the sewage and the development of anaerobic organisms which not only reduce the nitrate already present in the soil but also produce alkalinity. These defects can be removed by thoroughly aerating the sewage in the settling tank by blowing air through it. The sludge that settles at the bottom in this process is called "**activated sludge"** (3.6% N, 2% P_2O_5 & 1% K_2O).

A.6 SHEEP & GOAT MANURE

The droppings of sheep and goat contain higher nutrients than FYM and compost. On an average, the manure contains 3% N, 1% P_2O_5 & 2%K_2O). It is applied to the field in two ways- i) Sweeping of sheep and goat sheds are placed in pits for decomposition and it is applied later to the field. ii) Sheep penning- wherein sheep and goats are allowed to stay over night in the field and urine and faecal matter is added to soil.

A.7 POULTRY MANURE

Poultry manure can supply higher N and P to the soil than other bulky organic manures. The average nutrient content is 2.87% N, 2.93% P_2O_5 & 2.35% K_2O.

A.8 GREEN MANURING

Green un-decomposed plant material used as manure is called green manure. By growing green manure crops (usually leguminous crops) are grown in the field and incorporating it in its green stage in the same field is called green manuring. It adds organic matter and nitrogen to the soil. On an average green manuring gives 60-80 kg N/ha.

(B) Concentrated organic manures

These have required in small quantities and contain higher nutrients as compared to bulky organic manures. The most commonly used are oil cakes, fish meal, meat meal, blood meal, horn & hoof meal, bird guano, raw bone meal etc. which act a good source of organic manures for organic farming system.

B.1 OIL CAKES

Oil cakes are generally grouped into two groups, viz., *edible* oil cakes suitable for feeding the cattle and other domestic animals and *non-edible* oil cakes exclusively used as manure due to their higher content of plant nutrients. It has been estimated that India produced about 2.5 million tones of oil cakes annually

Non-edible oil cakes are used as manure especially for horticultural crops. Nutrient present in oil cakes, after mineralization, are made available to crops 7-10 days after application. Oil seed cakes need to be well powdered before application for even distribution and quicker decomposition. **Neem cake** acts as **Nitrification Inhibitor**.

Average nutrient content of different oil cakes

Oil cakes	Per cent composition		
	N%	P%	K%
Edible oil cakes (feed for livestock)			
Safflower (decorticated)	7.9	2.2	1.9
Groundnut	7.3	1.5	1.3
Cotton seed (decorticated)	6.5	2.9	2.2
Non-edible oil cakes (not fed to livestock)			
Safflower (un-decorticated)	4.9	1.4	1.2
Cotton seed (un-decorticated)	3.9	1.8	1.6
Caster	4.3	1.8	1.3
Neem	5.2	1.0	1.4

B.2 FISH MEAL

Sea food canning industries are present in almost all coastal states of India, Fishes which is not preferred for table purposes due to their small size, bonny nature and poor taste can be converted into very good organic manure. The fish is dried, powdered and filled in bags. It contains average nutrients are 4-10, 3-9 & 0.3-1.5 NPK. These manures are highly suitable for fruit orchards and plantation crops.

B.3 MEAT MEAL

An adult animal can provide 35 to 45 kg of meat after slaughter or death. It contains 8-9% N and 7% P_2O_5.

B.4 BLOOD MEAL

Blood manure contain about **13-20%N**, rich in **Iron** and its application gives a deep rich colour to foliage,.

B.5 HORN & HOOF MEAL

A healthy animal can give about 3 to 4 kg of horn and hoof. These materials are dried, powdered, bagged and marketed as manure. It contains 13% N.

B.6 GUANO (Bird / Fish)

The excreta and dead remains of the bird is called *bird guano* (11-14% N & 2-3% P_2O_5) and the refuse left over after the extraction of oil from the fish in factories, dried in cemented yards and used as manure is called as *fish guano* (7% N & 8% P_2O_5).

B.7 RAW BONE MEAL

An excellent source of organic phosphorus. It contains 3 to 4% N and 20 to 25% P_2O_5.

4.2 VERMICOMPOSTING

Definition: The process of composting organic wastes through domesticated earthworms under controlled conditions is vermicomposting.

Earthworms have tremendous ability to compost all biodegradable materials. Waste subjected to earthworm consumption decompose 2 to 5 times faster than in conventional composting. During composting the wastes are deodorized, pathogenic micro-organisms are destroyed and 40 to 60 % volume reduction in organic wastes take place. It is estimated that the earthworms feed about 4 to 5 time their own weight of material daily.

Earthworms bears both male and female reproductive organs. However, two worms are needed for successful copulation. The self fertilization does not occur generally in the earthworms. Fertilization take place in the egg case or cocoon.

Earthworm species such as Eisenia foetida, Eudrilus eugeniae, lumbricus rubellus, L. mauritee and perionix excavatus have been recommended for vermiculture technology. Vermicompost is the compost which is prepared by earthworms. It is a mixture of worm casting (faecal excretions) organic materials including humus, live earthworms, their cocoons and other micro organisms.

Vermiculture : It is the process of rearing and breeding of earthworms in controlled condition and presently it is known as earthworm biotechnology. It is estimated that 1800 worms which is an ideal population for one sq. meter can feed on 80 tonnes of humus per year. Faecal matter or excretions of earthworms is known as vermin cast. Vermi wash is a liquid fertilizer collected after the passage of water through a column of worm activation, which is useful for foliar spray. It may be diluted with water before use. It can also be diluted with 10% urine of cow. The average nutrient content of vermicompost is about 0.5 to 0.9-

0.1 to 0.2- 0.67 % N,P,K respectively.

***VERMIWASH* – A liquid manure**: It is a transparent pale yellow coloured fluid collected after the passage of water through a column of worm action **or** it a collection of excretory products and mucus secretions of earthworm along with nutrients from the soil organic molecules. It is very useful as a foliar spray to enhance the plant growth and yield and to check development of diseases.

BENEFITS OF VERMICOMPOST

1. When added to clay soil, loosens the soil and provides the passage for the entry of air.
2. The mucus associated with it being hygroscopic, absorbs water and prevents water logging and improves water holding capacity.
3. In the vermicompost, some of the secretions of worms and the associated microbes act as growth promoter along with other nutrients.
4. It improves physical, chemecal and biological properties of soil in the long run on repeated application

5. The organic carbon in vermicompost releases the nutrients slowly and steadily into the system and enables the plant to absorb these nutrients.
6. The multifarious effects of vermicompost influence the growth and yield of crops.
7. Earthworm can minimize the pollution hazards caused by organic waste by enhancing waste degradation.

APPLICATION OF VERMICOMPOST

In orchards the dose depends on the age of the tree. It can be used @ 500 g in small fruit plants and 3 — 4 kg/tree whereas for vegetable crops @ 3 kg/10 m^2 area. For general use in agriculture, vermicompost should be applied @ 5 t/ha. Vermicompost is mixed with equal quantity of dried cow dung and used as broadcast when seedlings are 12-15 cm height and water should be sprinkled.

4.3 GREEN MANURING

4.3.1 Definition : Crops grown for the purpose of restoring or increasing the organic matter content in the soil are called *green manure crops* while there green undecomposed plant material used as manure is called *green manure*. Their use in cropping system is generally referred as *green manuring*. It is obtained in two ways-either by grown *in situ* or brought from out site. In both ways, the organic material should be worked into the soil while they are fairly young for easy and rapid decomposition.

i) *In situ green manuring*: Growing of green manure crops in the field and incorporating it in its green stage in the same field (i.e. *in situ*) is termed as *green manuring*.

ii) *Green leaf manuring*: is the application of green leaves and twigs of trees, shrubs and herbs collected from nearby location and adding to the soil. Forest tree leaves are the main source of green leaf manuring. Legumes are usually utilized as green manure crops as they fix atmospheric nitrogen in the root/stem nodules through symbiotic association.

4.3.2 ADVANTAGES OF GREEN MANURING

1. It adds organic matter to the soil. This stimulates the activity of soil micro organisms
2. Green manuring concentrates plant nutrient in the surface layer of the soil
3. It improve the structure of soil by deep rooting system
4. It facilitates the penetration of rain water, thus decreasing run off & soil erosion.
5. It holds plant nutrients that would other wise be lost by leaching (eg.N)
6. It increases the availability of certain plant nutrients like P,Ca,K,Mg & Fe.
7. It checks weed growth by quick initial growth
8. It aid in reclamation of sodic soils by release of organic acids.

DESIRABLE CHARACTERISTICS FOR GREEN MANURE CROPS

The criteria for which green manure crops are selected should have following characters,

It should be high biomass production
It should be deep rooting system
It should be leguminous family
It should be fast initial growth
It should be more leafy than woody
It should be low C/N ratio
It should be non-host for crop related pathogens
It should be easy and abundant seed producer
It should be useful for 'by-products'

4.3 RECYCLING OF ORGANIC RESIDUES

A variety of organic residues include crop residues in the form of straw, husk, forest litter; animal wastes like dung urine, bones etc., guano, city or household residues, oil cakes, bye products of food and sugar industries, pond silt, marine wastes, sea weeds and human habitation wastes. There are two major components of crop residues available, i. e.

harvest refuse (straw, stubbles, haulm of different crops) and *process wastes* (nut shell, oilcakes and cobs of maize, bajra and sorghum). *Crop residues* are defined as 'the non-economic plant parts that are left in the field after harvest and remains that are generated from packing sheds or that are discarded during crop processing'. The *benefits* of proper organic residue recycling are that they supply essential plant nutrients, improve soil properties, protect the soil from erosion hazards, reducing residue accumulation at the sites they produced, providing employment as well as income to many, enhancing environmental qualities and illustrate that man is not a waste generator but also its wise 29tilizer/ manager.

4.4 BIO-FERTILIZERS (*Microbial inoculants*)

The atmosphere over an hectare of land consists of 80,000 tones of N. Though atmospheric N is present in sufficient quantity (80%), it is not available to plants since it exists in inert form. Biological nitrogen fixation is the conversion of atmospheric N by living organisms into forms that plants can use. This process is carried out by a group of bacteria and algae which fix atmospheric Nitrogen (N_2) in to assimilable forms of nitrogen (NH_3)

It can be defined as bio-fertilizers or microbial inoculants are preparations containing live or latent cell of efficient strain of N-fixing or P-solubilizing micro organisms used for seed or soil application with the objectives of increasing the numbers of such micro organisms in the soil or rhizosphere and consequently improve the extent of microbiologically fixed N for plant growth.

4.5:1 Use of bio-fertilizers

Azospirilum is applied as seed treatment or soil application in crop like rice, sugarcane, pulses, soybean and vegetables. It increase in root length, top dry weight, root dry weight, total leaf area and yield were reported. The inoculants like nitroplus (legume inoculants) and VAM (*Vesicular Arbuscular Micorrhizae*) are also effective for crop yield improvement. The *Bacillus* sp. and *pseudomonas* sp. are help full in synthesizing the insoluble form of phosphorus. The combined application of phosphobacteria, rock phosphate and FYM to commercial crops have greatly unhanced biomass production, uptake of nutrients and yield

4.5.2 Enrichment of compost with microbial inoculants.

Compost prepared by traditional method is usually low in nutrients and there is need to improved its quality. Enrichment of compost using low cost nitrogen fixing and phosphate solubilizing microbes is one of the possible way of improving nutrient status of the soil. It could be achieved by introducing microbial inoculants, which are more efficient than the native strains associated with substrate materials. Both the nitrogen fixing and phosphate solubilizing microbes are more exacting in their physiological and ecological requirements. The only alternative is to enhance their inoculum potential in the composting mass.

4.5.3 Benefits of bio- fertilizers in organic farming

- Bio-fertilizers are eco-friendly and do not have any ill effect on soil health and environment.
- They reduce the pressure on non-renewable nutrient sources/fertilizer.
- Their formulations are cheap and have easy application methods.
- They also stimulate plant growth due to excretion of various growth hormones.
- They reduce the incidence of certain disease, pathogen and increase disease resistance.
- The economic benefits to cost ratio of bio-fertilizers is always higher.
- They improve the productivity of waste land and low land by enriching the soil.

CHAPTER :6
DISEASE AND PEST MANAGEMENT IN ORGANIC FARMING

Introduction:-

The use of synthetic chemicals to manage pests has a number of disadvantages which cause environmental pollution, phytotoxicity, ground water contamination and adversely affect the soil and its biotic environment. Indiscriminate use of synthetic pesticides resulted in insecticide resistance, resurgence and accumulation of pesticide residues in food, fruits and vegetables.

Integrated pest management measures are either preventive or curative. Control of insect pest relies on understanding of the pest life cycle, behavior and ecology. It involves natural enemies, host resistance and cultural practices.

A. CULTURAL METHODS

Cultural control is just a modification or manipulation of the environment to the disfavour of pests by disrupting their reproductive cycles, eliminating their foods, destroying their weed hosts or making the environment more favourable for predators, parasitoids and antagonists. The important cultural practices suitable for organic production to reduce the severity of insects, pests and diseases are as follows.

1. **Tillage operation :-**
   Plowing or hoeing helps to expose stages of soil inhabiting insects to sun or predatory birds. Earthing up of soil in sugarcane reduces seedling borer infestation.
2. **Field and plant sanitation: -**
   Regular removal of weeds, pest-affected plant parts, crop stubbles and their destruction will eliminate the sources of infestation of the diseases and pests. Distraction of bored shoots and fruits of brinjal, okra prevents further build up of the pest population. Many virus diseases like leaf curl, bud and stem rot of tomato, groundnut and sun flower can be minimized by uprooting the infected plants.
3. **Crop rotation :**
   Growing of a non host crop after a host crop of the pest will break the breeding cycle of pest species and reduce their population. Like wise, crop rotation prevents the build up of plant pathogen in soil.
4. **Growing of pest resistant varieties** :
   Certain varieties of crops are less damage or less infested than other by insects. The resistant varieties have physical and physiological features, which enable to avoid pest attacks. *i.e.*

Crop	Tolerant / Resistant variety	Pest/Disease
Cotton	L.K.861, Kanchana	White fly
	L-603, L-604,	Jassids
	Narsimha	Helicoverpa
Groundnut	Vemana, Tirupathi, ICGS-11	Bud rot
	Kadiri, ICGS-10	Leaf spot
	ICGV-86325	Multiple resistant to pests & diseases
Red gram	ICPL-332 (Abhaya)	Pod borer
Castor	JI-144	Capsule borer

5. **Trap cropping**
   Some crops are more preferred by the pests for feeding and egg laying are grown as trap crops on the bunds of the main crop or 1 row after 10 rows. Removal and

destruction of egg masses and small larvae from trap crop reduce the pest population

i.e.

Crop	Pest	Trap crop
Cotton, Groundnut	Spodoptera	Castor, sunflower
Cotton, chickpea, pigeonpea	Helicoverpa	Merigold
Sesamum	Red hairy cater pillar	Cowpea
Green gram	Red hairy cater pillar	Sunn hemp

6. **Water management** :

Flooding of field whenever possible; kills root grubs, termites and soil borne plant pathogens. Draining of water for a few days in paddy fields supprss brown plant hopper population

7. **Adjusting time of sowing** :

The simultaneous sowing of crops in a locality helps in reducing pest damage. Many a times early sown crops escape pest attack i.e. Jowar crop sown before the end of June months usually escapes attack by shootfly.

B. MECHANICAL METHODS :

Hand picking of egg masses, gregarious larvae and sluggish/ lazy adults and their destruction helps in reducing of pest population

1. **Use of phenomones and light traps** :

sex pheromones are mostly emitted by female insects to attract the male insect for matting. Such chemical compounds can be prepared in the laboratory and make available as lures for use in traps. These pheromones & also light traps attract the insects in large numbers to the traps, where they get trapped and killed. Pheromones are non toxic, species specific, safe to other organisms, plants and environment. Generally at least 5 traps/ha are recommended for monitoring for each pest species.

2. **Use of yellow sticky traps** :

It is used to monitor aphids and white fly.

3. **Erecting bird perchase** :

Bird perches helps in attracting birds, keep water in small bowl and spread cooked yellow rice to attract insectivorous birds.

4. **Soil solarization** :

Soil solarization by mulching the soil with polythene cover for 3-4 weeks during summer months results in killing of soil borne pathogens and weed seeds.

5. **Use of nylon net**

Growing of vegetable nurcery under nylon net drastically reduces pest population and virus/ mycoplasma diseases by preventing the entry of vectors.

6. **Hot water treatment** :

For the control of nematode problem in planting stock of banana suckers soaked in hot water for 25 minits at 55^0 C temperature.

C. BIOLOGICAL METHODS

Biological control means “The utilization of any living organisms for the control of insect-pests, diseases and weeds. This means use of any biotic agent for minimizing the pest population either directly or indirectly. Conservation of these biotic agents in the field or multiplying in the laboratory and releasing in the fields is called biological control.

ADVANTAGES OF BIOLOGICAL CONTROL

1. Bio-control is exercised in a wide range of area and it is safe for human as well as animal health.
2. Application of biotic agent is easy and possible even in inaccessible areas like forests, tall trees, podns, rivers, lakes, revines etc.

3. The bio agents survive in nature till the pests is prevalent and self perpetuating in nature.
4. There is no need for any special equipments like sprayer, duster except for some microbial preparation
5. No waiting period is required for harvesting of the crops.
6. Biological agents like parasitoids and predators, etc may be multiplied at farmer's level.
7. This method is very economical ones the method is developed, it is usually free of charges for the farmers.

Some of the important bio-control agents are,

1. **Predators:** The predators are feeding several of the insect-pests during their life cycle and hold a key role in minimizing pest population under field conditions. The common predators are birds, spiders, dragonflies, ladybird beetles, ground beetles, ants, chrysoperla etc; are helps to control sucking pests, pod borer eggs and larvae i.e.

Sr. No.	Predators	Pest controlled
1.	chrysoperla	Soft body insects like aphids, White hay, leaf hoppers, thrips etc.
2.	lady bird beetle	Aphids, mealy bugs
3.	Spiders	Insects

2. **Parasitoids** : These insects are always require passing at least one stage of their life cycle inside the host. The tiny adults of parasitoids search for the host eggs and parasitise them, i.e. they lay their own eggs within the egg of the pests. On haching, the parasitoid larva feed on the embryonic content of egg. Thus kill only one host insect during their life. However, due to their high multiplication rate they are of vital importance in the bio-control agents. For ex.

Crop	Pest	Parasitoids	Dosage/ha
Cotton	Boll warms	*Trichograma chilonis*	1,50,000
Sugarcane	Early shoot borer, stock borer	--"--	50,000
Paddy, Maize	stem borer	*T. japonicum*	50,000

3. **Biological chemicals :** The pesticides derived from living organisms are biopesticides. These products are more selective, eco-friendly and leave no toxic residues in the environment. The Identification of natural chemicals open new era of pest control. These chemicals do not kill the insects, but either attract, repel or modify their usual behaviour. Behaviour modifying chemicals which reduce matting frequency or release large numbers of sterile insects, control pests biologically by reducing their numbers.

Biochemical	Pests	Action
1. Nim oil	Grass hopper, leaf minor, white flies, scales, mealy bugs pod borer, moth etc.	Azadiractin acts as a repellent antifident (Azadirecta indica)
2. Nicotin sulphate	White flies, Aphids, Jassids, Helicoverpa	Nicotin sulphate acts as a contact poison and fumigant
3.Pyrethrum/ pyrethrins	Ants, aphids, fliees, ticks	The trade name pyrenone is a contact poison act as pyrethroids

4. Limonene	Pests of pet animals such as fleas, lice, mites, ticks etc.	Trade name d-limonene and linalool extracted from orange or citrus fruit-peels act as contact and fumigant

4. **Microbial insecticides**: These products are obtained from micro organisms such as bacterium, soil borne actinomytes and fungal pathogens. The insecticidal crystal proteins produced by the bacterium, *Bacillus thuringiensis kurstaki* are effective against lepidopterous pest species. These toxins are very specific in their action, easily biodegradable and being stomach poisons, safe for non-target organisms they are as follows.

No.	Bio control agent	Crop	Pest/ disease	Remarks
1.	Trichoderma harzianum Trichoderma viridae	Tomato, chille, Brinjal, G.nut	Root rot, stem rot, blight, damping-off, wilt, nematodes	Fungal antagonists, soil treatment
2.	Pseudomonas florescenes	Banana Tomato Potato Chilli	Wilt Wilt, white rot Tuber rot Fruit rot Die back	Sucker Treatment Soil treatment Seed treatment Seed & Seedling treatment
3.	Bacillus thurengensis	Cotton Cabbage, Tomato, Gram etc.	Lepidopterous pests	Foliar application
4.	Verticillum lecanii	Cotton, Vegetable crops	Aphid, whitefly	--"--
5.	Beauveria bassiana	Gram, Tobacco Cotton Tomato	Pod borer, cater pillar, thmps aphids, mealybugs	Spray application
6.	Nuclear polyhedrosis viruses (NPV) Granylosis Viruses (GV)	Chickpea, Maize, sunflower pigeon pea	Heliothis spodoptera	Spray the extraction of 250 crushed larve/ha

5. **Mineral Insecticides**: Sulphur : Sulphur is the oldest known pesticide & currently it is used. It can be used as dust, wettable powder, paste or liquid for control powdery mildews, rusts, leaf blight etc. Sulphur damage the plants, when it is applied in hot (above 90^0 F) and dry weather. Do not use sulphur where recently oil compound have been sprayed, it reacts with the oils to make a more phytotoxic combination.

BIOFERTILIZERS

Biofertilizers are the substances containing variety of microbes having the capacity to enhance plant nutrient uptake by colonizing the rhizosphere and make the nutrients easily accessible to plant root hairs. Biofertilizers are well known for their cost effectiveness, environment-friendly nature, and composition. These are effective alternatives to the hazardous synthetic fertilizers. This chapter covers various types of microbial biofertilizers pronouncing symbiotic and free-living nitrogen-fixers, phosphorus-solubilizer and mobilizers, their formulations, applications of few commercially available biofertilizers toward sustainable agriculture, and recent

approaches to develop next-generation biofertilizers.