Chapter - 19
Sustainable Agriculture

The title of this chapter comprises of two words. The first word sustainable means – capable of being supported or upheld, as by having its weight borne from below. In true sense word sustainable pertains to a system that maintains its own viability by using techniques that allow for continual reuse. The second word is agriculture, which means – culture of crop plants and live stock. Thus, in this chapter we will study such agriculture and agricultural procedures which can be employed for long term without any adverse effects.

Definition

Sustainable agriculture has been defined as "an integrated system of plant and animal production practices having a site-specific application that will last over the long term". The aim of sustainable agriculture is to satisfy human food and fibre needs, to enhance environmental quality and the natural resources base, upon which the agricultural economy depends. It also aims to make the most efficient use of non-renewable and on-farm resources and integrate natural biological cycles and controls. Also to sustain the economic viability of farm operations and to enhance the quality of life of farmers and society as a whole.

History of agriculture is as old as the human civilization. It may be mentioned here that since ancient time, there have been three basic needs of man i.e. food, clothing and shelter. All these three needs were met out by the plants. But as the time passed, there has been a multi fold increase in human needs. Along with this, uncontrolled, unlimited growth of human population, accelerated industrial development, enormous growth in transport facilities have exerted enormous pressure on all the natural resources present on the earth. Due to over-exploitation, many natural resources are depleting at a very fast rate. It is feared that the generations to come will have to face dire paucity of natural resources. If this rate of over-exploitation of natural resources continues, it is quite possible that there will be dearth of fresh air to breath, unavailability of good quality potable water and paucity of nutrient rich food materials. Therefore attention is now being paid at global level that how can we feed and meet the ever-increasing human population without making further lose to the natural resources. Hypothesis of sustainable agriculture has emerged due to this type of attitude and thinking.

As a result of application of many modern practices in the field of agriculture during the last few decades, such as use of chemical fertilizers, insecticides, pesticides, over-exploitation of underground water for irrigation, composite farming, use of petro-products and such other practices, with the lose of natural resources, environmental pollution has become a serious problems today. For the solution of these problems, by the practices of sustainable agriculture, we can properly use the renewable resources, protecting the non- renewable resources and environmental pollution can also be checked.

Methods of sustainable agriculture

Sustainable agriculture can be achieved by adopting the following practices –

1. Organic agriculture
2. Mixed farming
3. Mixed cropping
4. Crop rotation
5. Use of biopesticides

1. Organic farming

In today's time, the main problems of the man are shelter and food. Although there has been good progress in the production of food materials, but with this progress, the human population has also increased with a very fast rate. For getting more yield from agriculture, irrational use of chemical fertilizers and pesticides is being practiced. Due to this continuous use of chemical fertilizers and pesticides, soil fertility is decreasing day by day. Production of chemical fertilizers is a costly practice and it uses our natural energy sources such as coal, petroleum etc. Due to the production of chemical fertilizer the level of air pollution is also increasing continuously.

The subject of organic agriculture aims at making the Nature pollution free together with conserving the soil fertility, to make availability of essential micro-nutrient elements and conservation of biodiversity. Soil is a living system, in which enormous number of beneficial microbes live. These microbes play an important connecting link among plants, animals and man. There is an important role of these microbes in the process of procuring nutrient elements by the plants. The main concept of organic agriculture is to make this microbial cycle more strong and efficient.

Basically, organic agriculture is a technique of natural way of agriculture. It does not incorporate artificial methods.

Objectives of Organic Agriculture

Following are the objectives of organic agriculture –

1. Increase in soil fertility and to maintain it stable for long period of time.
2. To promote biological processes of microbes, soil organisms, plants and organisms in relation to agricultural system.
3. To make friendly use of natural system instead of suppressing them.
4. To use local agricultural procedures and renewable resources of energy.
5. To increase the yield of high quality food materials.
6. To remove the pollution originated by the use of new techniques of agriculture.

These days, the scientists are engaged to culture such micro-organisms, at industrial level, which can fulfill the need of nitrogen and organic materials in the soil. Those micro-organisms which help to increase soil nutrients, are known as bio-fertilizers.

Biofertilizers accelerate the process a mineralization with increasing the soil fertility. Some bacteria, blue green algae and fungi are main biofertilizers. Important biofertilizers are of following six types:

(i) Symbiotic Bacterium – *Rhizobium* **:-** *Rhizobium* bacteria live in the root nodules of leguminous plants, as symbionts *Rhizobium* bacteria obtain nutrition from the roots and convert atmospheric nitrogen into ammonia. This ammonia is released from the rhizobial cells, which is absorbed by the host plant.

About 50-150 Kg/hectare nitrogen is fixed by *Rhizobium* every year. By this fixed nitrogen there is about 15 to 20% increase in the crop yield. With this, the subsequent crop grown in such field, high yield is obtained due to rich soil fertility.

(ii) Non-symbiotic bacteria - *Azotobacter, Azospirilum*, *Clostridium* etc non-symbiotic bacteria fix free nitrogen present in soil and make it available to the plant. These bacteria absorb free nitrogen present in soil and convert it into nitrogenous compounds. After the death of bacteria with fixed nitrogen compounds, the decomposing bacteria decompose them and convert liberated ammonia to nitrite and finally to nitrate, which is used by the plants. When *Azotobacter* is grown with the crops of rice, cotton and maize, an increase of

upto 20% in their yield may take place.

(iii) Blue green algae or cyanobacteria - Cyanobacteria such as *Anabaena*, *Nostoc*, *Plectonema* etc prokaryotic non-symbiotic organisms function as nitrogen fixing agents. In blue green algae there are some specialized cells, known as heterocysts. Nif gene present in the heterocyst fixes nitrogen. The environment of paddy fields is suitable for the growth of blue green algae. By the use of blue green algae in the field of paddy, the yield of paddy increases.

These days, along with blue green algae, an aquatic pteridophyte – *Azolla* is being used as biofertilizer is south and south-east Asia. *Azolla* is a free-floating aquatic fern. *Anabaena azollae*, a blue green, nitrogen fixing algae is found in its leaves, which fixes, atmospheric nitrogen. *Anabaena azollae* is also an excellent biofertilizer, its use with *Azolla* in the paddy, may result into upto 50% higher yield.

In the Central Rice Research Center, Cuttak *Anabaena azollae* is being produced on a large scale.

(iv) Mycorrhiza - Symbiotic association of fungi with the plant roots is known as mycorrhiza. Fungi provides nutrients absorbed from the soil to plant roots and in return fungi gets nutrition from the roots.

(v) Phosphate dissolving bacteria- Some bacteria like *Pseudomonas, Microbacterium, bacillus* etc. Convert the non-available inorganic phosphate present in the soil; into available organic phosphate Thus phosphate becomes easily available to the plants.

(vi) Organic manure - Organic waste materials are abundantly available in India. Domestic waste, urban waste, sewage, crop residues, dung and urine of domestic animals, bone pieces etc. are such organic wastes. These organic wastes can be used as organic manure after their decomposition by micro-organisms.

Economic and Ecological importance of organic agriculture : -

1. It is a cheap and simple method, which can be utilized by even small scale farmers.
2. Water holding capacity and aeration of soil gets increased by the use of organic manures.
3. Soil temperature, its pH etc remain controlled by the use of biofertilizer, due to which bacteria present in soil remain active.
4. By adopting organic agriculture, the toxicity of chemicals present in soil decreases, whereby environmental balance is maintained.
5. Improvement in alkaline soils also takes place by the use of organic manures. By the decomposition of organic manures, organic acids are produced, which lower down the soil alkalinity.
6. Organic farming is pollution free therefore there is no loss to the soil fertility power.
7. Soil erosion can be controlled by organic agriculture.
8. By the use of biofertilizers, balanced nutrient elements are available, which increase soil fertility.
9. By organic agriculture practice, soil fertility remains as such for a very long time. Thus production increases for a long time.
10. Cost of crop production is lowered down by the use of biofertilizers, thus there is direct economic benefit.

2. Mixed Farming

Farming means agriculture. The word farming or agriculture is used for many functions such as dairy farming, fish farming, poultry, piggery etc. In these farming practices although the products are different kinds of animals which provide, milk, ghee, butter, meat, eggs, fishes etc. but for these animals, plants are the only source of food. Mixed farming in such a system in which different types of farming functions such as dairy farming, poultry and crop productions are carried out simultaneously on a single farm (site).

Mixed farming depends on many factors such as quality of soil, nature of live-stock, availability of water, technical assistance, financial resources etc.

Following systems can be established under mixed faming –

(i) **Food-Fodder Farming System –** Under this system, food crops such as rice, wheat, maize and fodder crops like alfalfa, jowar etc. can be cultivated.

(ii) **Agro-Forestry System –** Under this system along with the farming of trees, crop plants can be cultivated.

(iii) **Horti-Pastoral system –** Under this system grasses can be produced along with the fruit trees and shrubs.

Thus mixed farming is a concurrent attempt with the help of which sustainable production can be achieved.

3. Mixed Cropping

Cultivated of more than one crops at a time in the field is termed as mixed crop production or mixed cropping. This process is an age old practice. This method is mostly adopted in the rain-fed areas. The main object of this agriculture is to reduce the loss of crops due to paucity of rains, so that if one crop remains poor or is destroyed, even then second crop can at least contribute towards economic benefits to some extent.

In the mixed cropping method it is necessary to take care of the nature of both the crops to be grown, availability of soil and water. There are many benefits of mixed cropping. For example, if one crop production fails, still there is no total loss. Also more than one agricultural products are obtained at a time by mixed cropping. Increase in productivity, enrichment of soil fertility and decreased loss due to pests etc are also its benefits.

Following are some of the examples of such crops which can be cultivated as mixed crops –

Soyabean + Pigeon pea; Maize + Black gram; Pigeon pea + Green gram; Ground nut + Sunflower; Wheat + Chick pea; Wheat + Mustard.

4. Crop Rotation

Many problems arise due to growing only one type of crop in a field continuously for many years. The main problems due to this practice are – Lowering down of the quantity of particular type of mineral nutrients in the soil and incidence of soil borne plant diseases. A simple solution to these problems is crop rotation. Cultivation of different crops alternately every year in a particular field is called crop rotation. Because the requirement of mineral nutrients in different crop plants is slightly variable, thus there will be no decline in the availability of specific nutrient in the soil. Similarly the pathogens present in the soil also are eradicated due to non-availability of specific host during next cropping season.

Bi-annual and tri-annual crop rotations for different crops have been fixed. For example

	First year	Second year
(i) Annual crop rotation	Maize	Mustard
	Rice	Fallow
(ii) Bi-annual crop rotation	Maize	Mustard – sugarcane – Fenugreek
		Maize-Potato-Sugarcane-Peas
(iii) Tri-annual crop rotation	Rice	Wheat-green gram mustard sugarcane alfalfa
	Cotton	oats – sugarcane – peas – maize- wheat

5. Biopesticides

Those animals and plants, which harm the crops and their products are known as pests. Fungi, insects and large animals may be pests. Those biotic factors which are used to destroy insects, weeds and pathogens are known as biopesticides. Viruses, bacteria, fungi, protozoa etc. are used as boipesticides.

Many microbes, such as viruses, bacteria, fungi etc attack the insects and destroy them. These organisms are being used at commercial level. One of the best examples of this is *Bacillus thuringiensis* bacterium. From the spores of this bacterium, an insecticide crystal protein is synthesized. Therefore

its spores are used to destroy the eggs of some insects. Biopesticide made from this bacterium was used at commercial level for the first time. For the control of weeds and diseases of many crops, other bacteria and fungi are also used. Destroying the pests and pathogens by bacteria fungi and pesticides is termed as biocontrol

Resistant varieties of crop plants against pests produced by breeding can solve the problem of pests to some extent. Crop rotation can also help to get rid of many pests. Such parasites and predators must be searched and promoted to attack the pests, create diseases in them and destroy. By reducing the reproduction where by lowering the population of pest may also help control the pests to some extent. Some other methods of biocontrol are as follows –

1. By adopting planned crop rotation.
2. By sterilization of male members of pests through radiations and chemicals.
3. By obstructing the life-cycle of pests by the use of hormones.
4. By infecting the pests by their parasites.

Chemical control of pests exerts harmful effect on animals including man. These chemicals are toxic and pollutants. The presence of these chemical residues in the agricultural products in harmful for human health. Thus, by use of biopesticides, there will be reduction in the use of these chemical pesticides. Therefore bio control of pests is useful.

Important Points

1. Sustainable agriculture means the adoption of such agricultural practices which do not pollute the components of environment and agricultural production remains on suitable level for a very long period of time.
2. By using the renewable resources in sustainable agriculture, maximum yield is obtained by minimum pollution.
3. Soil fertility is deteriorating by irrational use of chemical fertilizers and pesticides.
4. Important methods of sustainable agriculture are : organic agriculture, mixed farming, mixed cropping, crop rotation and use of biopesticides.
5. Organic agriculture is basically the technique of traditional agriculture .
6. Microbes which are helpful in increasing the nutritional value of soil are called biofertilizers.
7. Symbiotic bacteria – *Rhizobia* fix the atmospheric nitrogen and make it available to leguminous plants.
8. By growing *Azotobacter* with the rice crop, increase in rice yield by 20% may be achieved.
9. Cyanobacteria function as nitrogen fixers.
10. Mycorrhiza is helpful in the absorption of nitrogen, phosphorus, potassium, calcium etc.
11. Such an agricultural method under which various types of agricultural activities such as dairy farming, poultry, crop production can be performed on a single site (farm), is termed as mixed farming.
12. Mixed cropping means cultivation of more than one crop on a farm at the same time.
13. Cultivation of crops changing them every year on a field is known as crop rotation.
14. Those biological factors which are used to destroy insects, weeds and pathogens are called biopesticides.
15. A bacterium, *Bacillus thuringiensis* is used to destroy the eggs of pests.

Practice Questions

Multiple Choice Questions –

1. An alga, used as biofertilizer is –
   (a) Cladophora (b) *Nostoc*
   (c) *Spirogyra* (d) All of the above
2. Bacterium found in the root nodules of legume plants is –
   (a) *Anabaena* (b) Cyanobacterium
   (c) *Rizobium* (d) *Lactobacillus*
3. Heterocyst is related to which of the followings-
   (a) Virus (b) Bacteria
   (c) *Nostoc* (d) *Rhizobium*

4. Which non symbiotic bacterium fixes free atmospheric nitrogen?
   (a) *Rhizobium* (b) *E. coli*
   (c) *Azotobacter* (d) All of the above
5. Which of the following is not a method of sustainable agriculture?
   (a) Mixed farming
   (b) Composite agriculture
   (c) Crop rotation
   (d) Organic agriculture
6. Those biological factors which are used to destroy the insects, weeds and pathogens, are called-
   (a) Biopesticides (b) Chemical fertilizers
   (c) Chemical insecticides
   (d) None of the above

Very Short Answer Questions –

1. For higher yield (i) ..... and (ii) ..... are abundantly and irrationally used.
2. (i) ..... is basically a technique of traditional agriculture.
3. Those microbes which are helpful in increasing the soil fertility are known as (I) .....
4. Write the name of a phosphate dissolving bacterium.
5. What term is used for those animals and plants which harm the crops and other products?
6. Crystal protein is manufactured from which bacterium?
7. At which research center, *Anabaena azollae* is being produced?
8. Write the name of non-symboitic bacteria which fix nitrogen.

Short Answer Questions –

1. What do you mean by sustainable agriculture?
2. Why the need of organic agriculture was felt? Explain.
3. What are biofertilizers?
4. Write two uses of blue green algae in agriculture.
5. What are biopesticides?
6. In what form *Bacillus thuringiensis* is used as biopesticide.

Essay type Questions –

1. Write an essay on biofertilizers.
2. Explain organic agriculture and write its objects.
3. What is the importance of blue green algae in the form of biofertilizers? Explain.
4. What is mycorrhiza, explain its importance.
5. Explain the economic and ecological importance or organic farming.

Answer Key–

1. (B) 2. (C) 3. (C)
4. (C) 5. (B) 6. (A)

Very Short Answer Questions –

1. (i) Chemical fertilizers
   (ii) Pesticides
2. (i) Organic farming
3. (I) Biofertilizers