

21. CONCEPT OF SUSTAINABLE AGRICULTURE

- Primitive humans discovered agriculture about 12,000 years ago. Primitive hunters and gatherers moved to places near rivers. Such humans' settlements began farming.
- Agriculture is the process of producing food, feed, fibre and other desired products by cultivation of certain plants and rising of domesticated animals. Agriculture has changed dramatically, especially since the end of World War II.
- Urban populations are growing rapidly throughout the world. Almost half of the population lives in densely populated urban areas.
- Rural people migrate to urban areas in search of job, food, housing, and a better life style etc. and also impact on agriculture as well as environment.
- As expansion of cities, crop land, forests, wetland and wild habitat destroyed so there is a great need to improve the situation so that humans can enjoy a quality environment.
- **Impact of Modern Agriculture on Environment**
 - Deforestation to get land for agriculture
 - Top soil depletion
 - Soil pollution
 - Ground water contamination, polluted water.
 - Unemployment of farm.
 - Farm laborers migrating from village to cities resulting in urbanization.
- **Sustainable agriculture or sustainable farming** attempts to produce sufficient food exhausting soil fertility and irreversibly damaging environment.
- It is to be least toxic farmland and least energy intensive in operation and get maintain productivity and profitability.
- Grow sufficient food and retain soil quality for much subsequent generation to grow food.
- Sustainable agriculture can be achieved by various ways:
 - Protect and preserved environmental quality.
 - Use natural resources judiciously.
 - Decrease dependence on non-renewable energy.
 - Provide consumers with affordable high quality food stuff.
 - Support profitable agricultural production.
 - Enhance quality of life of farmers and rural population.
 - Lasts for many generations.
- Objective of Sustainable Agriculture:
 - Cultivation practices to increase biological and economic stability.
 - Selection of improved varieties to suit the need.
 - Soil management by proper method of tillage.
- Methods of Sustainable Agriculture:
 1. Mixed cropping or Diverse cropping
 2. Crop rotation
 3. Multiple cropping
- Mixed cropping or Diverse cropping is an old practice in India. In this method, two or more crops are grown on the same piece of land and at the same time.
- This removes the insecurity of total crop failure. When more than one crop is grown at least one will survive if not all.



- Other Plans for Mixed Cropping-
- **Polyvarietal cultivation :**
 - Several varieties of same crop grown together.
 - Different crops, one a leguminous crop which fixes nitrogen, other carbohydrate rich crop which uses soil nitrogen.

- Plants maturing at different times are grown together.
- Needs different so less inputs needed, natural predators control pests.
- yield per hectare much more.
- Of the two crops grown together, one is a long duration crop and other a short duration crop.
- Nutrients required by the two crops are different.
- Time of maturity is different.



- **Monoculture**

- It is cultivation of single crop on large scale which gives large yield but for a short period of time.
- It is expensive as lot of fertilizers and pesticides are needed.
- Monoculture is economically unsound and also environmentally harmful.



- **Crop Rotation**

- Growing different crops in succession, regularly, in the same field.
- Result: Controls insects and diseases, increases soil fertility, decreases soil erosion.



- Sowing a leguminous crops (eg. green gram) enhance nitrogen level in the soil due to their ability to fix atmospheric nitrogen, reduces the need for chemical nitrogen fertilizer.

- It is possible to grow two or sometimes three different crops in succession on the same land within a year is known as **multiple cropping**.

- **Mixed cropping**

- Optimum diversity may be obtained integrating both crops and livestock in the same farming operation. If pasture and leguminous forage crops are rotated, soil quality is enhanced.
- Livestock manure makes soil fertile.
- In case of rainfall, at least livestock provides milk.
- Takes marketing of multiple products easy cushions for farmers against price fluctuations.
- Farm labour gets utilized more effectively.

- **Soil Management**

- **The key component of sustainable farming is soil.**

Healthy soil + water + nutrients.



Healthy crop plants - less susceptible to pests.



Decreased yield crop and productivity of stability of soil.

- **Objectives of varietal improvement are:**

(i) development of high yielding varieties of crop plants.

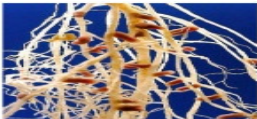
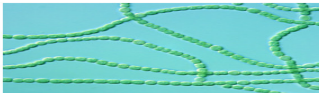

(ii) food crops developed for better and higher nutritional quality like protein quality in pulses, baking quality in wheat, preserving quality in fruits and vegetables, oil quality in oil seed producing plants.

(iii) development of crop varieties resistance to diseases and pests.

(iv) improving varieties for resistance against heat, cold, frost, draught and water logging.

- **Biofertilizers and its uses in Agriculture**

- Biofertilizers are substitutes for chemical fertilizers such as NPK. Their use reduces energy expenditure required to manufacture fertilizers. They do not cause pollution. Microorganisms like bacteria, algae and fungi fix atmospheric nitrogen.

<p>Rhizobium Biofertilizers</p>  <ul style="list-style-type: none"> • Enhance growth and yield of crops. • Improve soil fertility. • Symbiotic bacteria form root nodules in leguminous plants and live there. They can fix atmospheric nitrogen up to 200 kg N/ha/year. • Surplus nitrogen remains in soil and enhances soil quality. 	<ul style="list-style-type: none"> • Azospirillum • Aerobic free living Nitrogen fixing bacteria. • Associate symbiotic bacteria, live on root surface of host plant and increase crop yield. • Supplying growth hormones and vitamins. • Commonly used in commercial inoculation
<p>Azotobacteria</p> <ul style="list-style-type: none"> • Aerobic free living nitrogen fixing. • Grow around roots of cereals and fix Nitrogen. • Produce growth promoting hormones which helps in enhancing growth and yield of plants. 	<p>Blue Green Algae</p> <ul style="list-style-type: none"> • Nostoc and Anabaena, common blue green algae or cyanobacteria. • Free living and photosynthetic, they fix nitrogen. • Used in flooded rice fields as Nitrogen biofertilizers. 
<p>Azolla</p> <ul style="list-style-type: none"> • is a water fern inside which grows nitrogen fixing BGA-Anabaena • Azolla-Anabaena combine is used as fertilizer in all over the world. • It grows in summer. 	<ul style="list-style-type: none"> • Phosphorus Solubilizing Biofertilizer • Phosphorus is a needed for plant growth. • Also for nodule formation in Rhizobium. • Certain microbes solubilise Phosphorus and make it available for plants to absorb.
<p>Mycorrhiza</p> <ul style="list-style-type: none"> • Fungi that occur on roots of forest trees and crops plants. In soils low in available nutrients there is an increased absorption of nutrients by plants infected with Mycorrhiza. The fungus has the ability to dissolve and absorb phosphorus that plant roots can not readily absorb. 	

• **Organic Farming and its Benefits:**

- Organic farming in agriculture relying on crop rotation, crop residues, animal manures, legumes, green manure, organic wastes and bio fertilizers, mechanical cultivation, mineral bearing crops biological pest and weed control.
- Organic farming does not use any chemicals or artificial substances for agriculture. Thus organic farming creates a sustainable lifestyle for generations to come.

• **Method of Organic Farming**

- Nourishing microbes in soil to provide it nutrients . Soil organic matter gives the soil good structures and water holding capacity.
- Organic farmers grow these microbes and add compost and biologically based soil nutrients so that plants grown in organic farms are disease and pests resistant.

- Organic farmers use crop rotation to enrich soil continuously and keep away pests prefers specific crops.

- To keep pests away predators are used (Biological control), mating is disrupted and traps and barriers are used.

• **Benefits of Organic Farming and its Products**

- Can be learnt easily by farmers.
- Reduces production cost as expensive fertilizers and pesticides not used.
- Reduces soil erosion; increases crop yield five-fold.
- Entire ecosystem along with ground water is improved.
- Dairies benefits as the cattle are fed organic feed and grazes on organic fields. These cattle are more healthy and give tasty milk.

- Soils remain healthy with living microbes that provide the soil with micro nutrients.
- Soil gets inexhaustible nutrients for many generations of crops grown in the organic field.
- Quality of products enhanced as they are free from harmful chemicals, artificial flavours, colours and preservatives.
- **Vermicompost** can be prepared at the backyard of your home, in one corner to your school field or may be public park which will produce manure as well as clean up the environment from garbage accumulation.
- **Vermicomposting** efficiently recycles organic waste, crop residues and Agro- Industrial wastes. Earthworms and microbes (bacteria, fungi) together turn organic waste into useful organic manure.
- Organic material that can be required agricultural residues, dry organic wastes (like sorghum straw, rice straw after feeding cattle, dry leaves, groundnut husk and wheat husk);waste vegetables; Weeds, Sugarcane trash, dairy and poultry wastes etc. for vermicompost.
- **Integrated Pest Management (IPM)**
- Hormones are used that disrupt the insect's normal life cycle, thereby preventing it from reaching maturity and reproducing and multiplying.
- **Biotechnology in Agriculture**
- Modern agriculture ushered in 'Green Revolution' with hybrid seeds, fertilizers, pesticides and improvement in agricultural practices.
- Genetic Engineering or Recombinant DNA technology brought in 'second' green revolution with genetically modified (GM) crops or transgenic crops or GMOs
- **Transgenic crops have been produced with the following aims:**
 - Crop resistance to herbicides.
 - Crop resistance to insects and diseases.
 - Atmospheric nitrogen fixation by cereal crops.
 - Tolerance to high salt soils and to flooding in crops.
 - Drought resistance in crops.

- Farmers develop a control progame that includes cultivation, biological and chemical methods applied in proper sequence and with the proper timing.
- The aim of IPM is not to eradicate the pest population completely but to keep the crop damage to economically tolerable level.
- Farmers monitor the field and when they find the pest level to be high enough, they first use biological methods and cultivation practices to control and then use small amounts of insecticides, mostly insecticides derived from plants as a last resort.
- Biological controls include natural predators, parasites and pathogens of the pests are used
- Examples are:

1.	• Pest on cucumber plant called red spider mite is controlled by using a predatory mite that feed on red spider mite.
2.	• Citrus fruits in California heavily damaged by scale insects which were controlled by Australian ladybird which ate away the insects.
3.	• Mealy bug pest of Cassava plant were controlled by a parasitoid wasp which was its natural enemy.

- Improving nutritional quality of crops.
- Prolonging shelf life of fruits and vegetables.
 1. Bt cotton produced by incorporating Bt gene which encodes for BT toxin (insecticidal protein in Bacillus thuringiensis) in the cotton plant. The plant becomes insect resistant and this gene has been incorporated in brinjal, corn, potato, tomato, tobacco etc. making them insect resistant (bio pesticides).
 2. “Golden Rice” a transgenic with enhanced vitamin A content producing nutritionally rich rice to save many lives.
 3. By slowing down and controlling ripening in tomato by introducing a bacterial gene that prevents ethylene formation thus delaying ripening. Such tomatoes are easy to handle during transportation and remains on the shelf for a long time.
- Plant biotechnology can help to make intensive agriculture less damaging to the environment as well as help the country to spend less money on fertilizers, pesticides, herbicides etc.

Benefits and controversies on GM products

Benefits:

<p>(i) Crops</p> <ul style="list-style-type: none"> • Enhanced taste and quality. • Reduced maturation time. • Increased nutrients, yields, and stress tolerance. • Improved resistance to disease, pests, and herbicide. • New products and growing techniques. 	<p>(iii) Environment</p> <ul style="list-style-type: none"> • “Friendly” bioherbicides and bioinsecticides. • Conservation of soil, water and energy. • Bioprocessing for forestry products. • Better natural waste management. • More efficient processing..
<p>(ii) Animals</p> <ul style="list-style-type: none"> • Increased resistance, productivity, hardness, and feed efficiency. • Better yields of meat, eggs, and milk. • Improved animal health and diagnostic methods. 	<p>(iv) Society</p> <ul style="list-style-type: none"> • Increased food security for growing populations

Controversies :

<p>(i) Safety</p> <ul style="list-style-type: none"> • Potential human health impact: allergens, transfer of antibiotic resistance markers, unknown effects. • Potential environmental impact: unintended transfer of transgenes through cross-pollination, unknown effects on other organisms (e.g., soil microbes) and loss of flora and fauna biodiversity. 	<p>(iii) Ethics</p> <ul style="list-style-type: none"> • Violation of natural organisms’ intrinsic values. • Tampering with nature by mixing genes among species. • Objections to transferring animal genes in plants and vice versa. • Stress for animal.
<p>(ii) Access and intellectual property</p> <ul style="list-style-type: none"> • Domination of world food production by a few companies. • Increasing dependence on industrialized nations by developing countries. • Biopiracy—foreign exploitation of natural resources. 	<p>(iv) Labeling</p> <ul style="list-style-type: none"> • Not mandatory in some countries (e.g. United States). • Mixing GM crops with non-GM confounds labeling attempts.
<p>(v) Society</p> <ul style="list-style-type: none"> • New advances may be skewed to interests of rich countries. 	



Check Yourself

1. The process of producing food, fodder, fibres and other desired productions by cultivation of plants and rearing of domesticated animals is termed as-
 - a. Intensive agriculture
 - b. Shifting cultivation
 - c. Nomadic farming
 - d. Sustainable agriculture
2. Growing practice of different crops in regular succession at the same field is known as:
 - a. Multiple cropping
 - b. Mixed cropping
 - c. Crop rotation
 - d. Poly varietal cultivation
3. Living or biologically active products which are able to enrich the soil with different nutrients is known as:
 - a. Manure
 - b. Biofertilizer
 - c. GMOs
 - d. Compost
4. Which organism does play an important role in preparing vermicompost?
 - a. Ascaris
 - b. Neries
 - c. Leech
 - d. Earthworm
5. Golden rice, a transgenic product is rich in:
 - a. Golden rice
 - b. Soluble vitamin C
 - c. Vitamin A
 - d. Vitamin B₁₂

Ans: 1. d. 2.c 3.b 4.d 5.c



Stretch Yourself

1. How does Azolla biofertilizer helpful in agriculture?
2. What is the aim of integrated pest management?
3. What is healthy soil?
4. Which organism is important for producing vermicompost?
5. Give examples of transgenic crops or GMOs.



Test Yourself

1. Define sustainable agriculture and mention its advantages.
2. Differentiate between mixed cropping and crop rotation.
3. Describe importance of organic farming and organic foods
4. Why do we consider biofertilizers good for agro-based industries?
5. How do natural predators help to control pest in agriculture? Give examples in support of your answer